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PAPERS
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TRAUMATOLOGY

Collected Papers

in EMERGENCY MEDICAL SERVICES and TRAUMATOLOGY

R Adams Cowley, M.D., Editor

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Papers Presented at

The U.S.A. Bicentennial

Emergency Medical Services

and

Traumatology

Conference and Exhibition

May 9 – 12, 1976

Baltimore, Maryland 1976

Foreword

The First International Symposia on Emergency Medical Services Systems Development, Traumatology and Trauma Nursing afforded opportunities to pause and reflect on progress in the past decade in implementation of essential components of an emergency health care system. A bench mark for comparison with the status ten years ago is the "white paper" published by the National Academy of Sciences, National Research Council in 1966 entitled, ***Accidental Death and Disability — The Neglected Disease of Modern Society.*** That report is widely acclaimed as the catalyst which stimulated nationwide concern and improvement in every component of emergency care of the victim of trauma. The fact that this conference is devoted to trauma does not limit contributions to the care of the trauma victim only. The proper care of such victims integrates all facets of improved emergency care applicable to the non-trauma victims as well — most of which had developed in the past decade.

The avalanche of topics and the large number of participants in the plenary sessions and workshops attest not only to the progress of the past decade, but also to the many remaining problems in every component of the emergency medical services system.

The symposium on emergency medical services systems development included workshops on the harbor disaster response and exercise planning criteria; emergency medical services system manpower needs and training criteria; clinical emergency medical services/critical care sub-systems; new problems of medical, social, and legal emergency phenomena affecting the emergency medical services system; research in emergency medical services; basic life support communications; primary and secondary emergency medical services transportation; the role of foundations and associations in emergency medical services; disaster and civilian emergency response systems; advanced life support biomedical telemetry; facilities integration for medical services, the role of federal organizations in emergency medical services; special rescue operations under difficult environmental conditions; how media theory fits the practicality of developing public education and information in emergency medical services systems; emergency medical services legislation; airport disasters and the community disaster / emergency medical services response system.

The symposium on traumatology included not only extensive plenary sessions, but also workshops on field management at the scene and in transit; burn management; psychiatry — the patient, the family, the trauma center setting; respiratory insufficiency; fluid replacement — blood coagulation and component therapy; the injured cell — mechanism in the pathophysiology of traumatic shock; clinical research — urgent solutions needed; radiology — practical techniques in evaluating the trauma patient; rehabilitation — why wait; hand — emergency care including replantation; and renal failure — prevention, recognition, and therapy.

The trauma nursing portion of the conference involved the expanded role of this new clinical specialist in various aspects of the trauma patient such as: initial assessment of the trauma patient, physiological monitoring, arterial blood gases and pulmonary ventilation, special pulmonary problems, management of the acute spinal injury patient, head injuries, burn management, contemporary resuscitative devices, educational opportunities for the trauma nurse, legal considerations, and research in trauma nursing. Those attending the sessions on trauma nursing participated in general plenary sessions and a number of workshops of other symposia.

A unique and significant feature of the conference was the international participation of government officials and experts in emergency medical services under the direction of NATO's Committee on Challenges of Modern Society, who presented status reports on progress made since 1971 in development of programs designed to cut across all segments of society and societal institutions and to cover all kinds of emergency medical situations. The views presented by these experts in plenary sessions and in workshops represent a concensus of 15 participating nations and the International Red Cross convened under the auspices of NATO.

Sam Seeley, M.D.

Preface

The articles in this volume were collected from the participants in the U.S.A. Bicentennial Emergency Medical Services and Traumatology Conference and Exhibition, May 9-12, 1976, in Baltimore, Maryland.

The Conference and Exhibition were sponsored by the U.S. Department of Health, Education and Welfare, Division of Emergency Medical Services; the State of Maryland Division of Emergency Medical Services, Department of Health and Mental Hygiene; the University of Maryland Institute for Emergency Medicine; the NATO Committee on Challenges of Modern Society, International EMS Subcommittee; the American Trauma Society; and the Program for Continuing Education, University of Maryland School of Medicine. A sizeable number of other organizations served as affiliate sponsors.

Due to lack of funds, an official Proceedings was not possible. However, at a later date we received federal permission to use unexpended funds realized from unanticipated savings on equipment purchases. These funds were available through HEW grant 1204-2 (#03-H-000, 398-03) and make the printing of this collection of papers possible.

The Conference was divided into three simultaneous tracks. Emergency Medical Services Systems Development, directed by David R. Boyd, M.D.C.M.; Traumatology, directed by R Adams Cowley, M.D.; and Trauma Nursing, directed by Elizabeth Scanlan, R.N., M.S. Participants in each track, listed, if they contributed a paper, in the positions they held at the time of the conference, were nationally and internationally recognized experts in their respective fields. Their contributed articles, which have not been substantively edited, represent the forefront of knowledge presented at the conference and remain valuable to those in EMS, traumatology and trauma nursing. This compilation provides an invaluable overview of the wide and increasingly important fields.

I am indebted to all of the participating authors for their patience while funds were developed for the publication of this book. I also wish to acknowledge and thank Dottie McCaleb and Jim Faulkner for their assistance in production of this volume.

R Adams Cowley, M.D.

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TRACK I

EMERGENCY MEDICAL SERVICES SYSTEMS DEVELOPMENT

Harbor Disaster Response and Exercise Planning Criteria
INTRODUCTION

Alexander J. Gretes

Objectives:

To present a description of the Inner Harbor Exercise.

To offer presentations from the principal planners involved in preparation of the Exercise.

To emphasize the coordination of the many agencies required to carry out the Exercise.

To describe the evaluation methods to be utilized.

Panel consists of the principals of the Steering Committee of the Inner Harbor Exercise. Each expressed their views and experiences in preparation of the Exercise, thus offering insight into the detailed planning necessary and the problems encountered.

THE TEXAS CITY DISASTER — 1947

Roy S. Popkin

The Texas City explosion of April 16, 1947, was the great granddaddy of harbor tragedies in the United States. Although other ship disasters on American rivers have taken a greater toll of lives, nothing in the annals of the American Red Cross surpasses the Texas City explosion for horror concentrated within a few city blocks.

The catastrophe occurred at 9:12 in the morning. The dead and missing totalled 512, more than 2,000 were injured, and property losses were approximately 50 million dollars. The initial explosion occurred aboard a French freighter, the *Grandchamp*, where shipworkers and firemen had been fighting a fire in the hold. This was followed by a tremendous blast that wrecked the portside industrial section and part of the residential section of the city. The Fire Department of Texas City was practically wiped out. Twenty-seven of their men were killed; only four of their bodies were recovered.

Let me quote a paragraph from the official Red Cross report on this disaster, to give you a picture of what happened when the *Grandchamp* blew up. "Steel the size of shrapnel to plates of several tons were hurled through the air. A 100-pounder slithered through an automobile, decapitating both the driver and his wife who sat beside him, while a child in the rear seat was unharmed. A steel gasoline barge was hurled from its moorings and came to rest 200 feet from its pier. Roofs a mile away were punctured by steel or torn apart by the force of vibrations. The industrial section of Texas City immediately burst into flames, and in this inferno could be seen scores of dead and dying, while many others struggled for life; but no human hand could reach them. Frantic people ran through the streets, some screeming in wild hysteria, others silenced by shock. Many were bleeding from wounds, still others had been made totally dead, all in a wild race to rescue relatives or to reach points of safety. Into this blazing catclysm and the tumult that surrounded it moved hundreds of rescuers. Some wore the arm band of the Red Cross, others had no insignia at all, but each and every one worked shoulder to shoulder, tenderly handling the wounded and the dead. During the days that followed, these heroes, many unknown to any agency, recovered mutilated bodies — an arm here, a hand there, or just the charred flesh that had once been a human being with life and soul."

Texas City, a few miles from Galveston and 50 miles from Houston, had a population of 18,000. It was heavily industrialized, the harbor area lined with refineries, oil and gasoline tank farms, and chemical plants.

The organized emergency medical response began with a doctor in Galveston who was chairman of the medical and nursing committee of the Galveston Red Cross. He was standing at the window of his Galveston office when he saw the smoke rising from the burning ship before it exploded. An instant after the blast, which he saw destroy the Monsanto Chemical Plant, he and his secretary were on the telephone alerting hospitals and all doctors in the city. Minutes later, ambulances and cars with doctors and Red Cross personnel were speeding toward Texas City. At the same time the Army sent a convoy of vehicles with personnel and emergency medical supplies. They took initial charge of the evacuation of the wounded and established traffic control and established field kitchens, working closely with the Red Cross.

The Texas City Hospitals were small, and those in Galveston quickly reached capacity. Many ambulances were routed to Houston, Alvin, Dickinson and other cities. Ultimately, the 852 patients requiring hospital treatment were cared for in 22 hospitals, including one temporarily reopened at Fort Crockett. These hospitals were scattered over a 50-mile radius.

Urgently needed supplies and personnel came from greater distances. Every Red Cross chapter within a 100 miles sent nurses, first aiders, doctors and medical supplies. Given responsibility for coordinating the relief operation by the governor of Texas, the Red Cross obtained help from the Army and Navy, from medical supply houses throughout the country. Whole blood was brought in from Houston, Dallas and San Francisco. Large amounts of surplus plasma were provided from Red Cross supplies and supplies given earlier by the Red Cross to the State of Texas Health Department. Vast quantities of Penicillin — more than five billion units, tetanus antitoxin, Streptomycin, cots and blankets, gas masks, litters, surgical dressings were brought in from nearby resources and from greater distances by plane, ship and truck and distributed to the hospitals to which the wounded were taken. Much of this vast supply arrived the same day, or within 48 hours.

At the same time, doctors and nurses poured into the area—it is believed the number of 2,000 — to assist at aid stations, at the disaster scene and in the hard-pressed hospitals. The utilization and assignment of such personnel was quickly organized to prevent facilities from being swamped with people they might not need.

Several aid stations were operated for several days in Texas City and nearby Lamarque, but soon it became apparent that many people with minor injuries had been given first aid and had gone home, and that there were others who had possibly never been treated. Hundreds were treated in doctors offices because the hospitals were treating only the seriously injured. Working closely with the state and county health departments, the Red Cross arranged for public health nurses to do a house-to-house canvass to find unlisted casualties or people who had been treated but needed additional medical help. They visited more than 2,100 homes, found 1,722 people with disaster-caused injuries. Some had been treated, some had not. Many needed some medical help.

Among the survivors, two patterns of injury were found. Those who were inside buildings suffered multiple perforating wounds, especially from splintered glass, and major contusions or crushing injuries. Those caught in the open at the time of the explosions suffered blast effects and compound injuries from flying missiles. Fatal injuries were due to major contusions or crush. Head injuries accounted for many of the early deaths among the immediate suvivors. Surprisingly, there were few burns, but there were many cases of ruptured ear drums from the concussion. Among the types of injuries that meant some degree of permanent disability were hearing impairment, loss of arms, loss of legs and loss of eyes. While there were only 61 people treated for burns, there were 289 with fractures, 1,060 with lacerations and almost 900 with other types of injuries. Many, of course, had multiple injuries.

Very quickly, the military doctors who responded identified signs of gas gangrene in wounds, which was the reason so much Penicillin and anti-gas gangrene toxin were called for. Two of the nation's leading experts on treatment of gas gangrene were flown to Texas City. Eventually, only three to five actual gangrene cases were identified; most of the suspected cases were actually patients whose bodies were deeply penetrated by blast-driven petroleum products such as oil.

Other problems facing the Red Cross, the emergency medical teams and public health authorities included sheltering the homeless and other evacuees. The night after the explosion, the Red Cross sheltered over 4,000 people, some more than 50 miles away. Ultimately, the mass shelter was consolidated at Camp Walter, 12 miles from Texas City, where the population finally reached almost 1,400. Round the clock medical coverage and public health supervised sanitary measures were maintained in the shelters. As a result, disease was at a minimum. This, incidentally, is standard Red Cross practice.

Identification of the dead was harrowing and complex. The police quickly called for Red Cross nurses to assist families at the temporary morgues. There were many problems. Texas City attracted many so-called drifters — men who came to work in the plants or on the docks but who had no families in Texas City. Also, in many of the plants the personnel people had been killed and/or the personnel records had been destroyed so there was no way of telling who should have been working at the time of the blast. Survivors scattered all over the landscape; it was days before the missing list could be winnowed down. Finally, 63 unidentified dead were buried in a mass grave. The final report shows 113 listed as missing.

During the days immediately following the blast the Red Cross received 41,000 wires and phone calls inquiring about more than 8,200 people who lived in Texas City or who were thought to have been there at the time.

There were also problems with water and sanitation throughout the affected area. People were instructed to boil their drinking water until it finally tested safe, and a special rat control program was required because the blast had scattered garbage over a large area.

I have concentrated on medical and health-related aspects of the disaster, but obviously there were problems with families who needed rehousing, whose jobs were interrupted, and there were 844 survivors who were widowed, orphaned or left as dependent parents without the children who had supported them.

Which leads to the question of paying for the medical care. Of the more than $1,106,000 spent by the Red Cross, over $361,000 was spent for medical and nursing care and sanitation. The Red Cross had an arrangement with the two Galveston hospitals which received the most patients to pay a standard daily rate for each patient and for those who came to special out-patient clinics established for followup treatments by thse hospitals. Would you believe, the daily rate then was $8.26. Many doctors agreed to treat the patients for a standard cost. A problem arose when the leading insurance company involved in coverage for dead or injured workers in Texas City said it would only pay 50 percent of the costs. The hospitals and doctors objected, and decided to wait until a legal test case was made. However, the Red Cross agreed to make up any difference. The amount needed by each family to pay its uninsured or uncompensated medical costs was determined by Red Cross caseworkers and nurses.

The presence of many military medical personnel — Army and Navy — was an important factor in the carrying out of triage and the expeditious treatment of the injured. Commenting on what happened, Dr. Harold A. Wood, Red Cross medical director for the Texas City relief operation, noted, "It is important to recognize certain factors responsible for their splendid medical accomplishment. In the first place, the pattern of injury reduplicated experience in the recent war. Secondly, many of the attending physicians, nurses and rescue workers were only recently released from the Armed Services. Significantly, the effective management of casualties followed military precedent. Once again, it has been demonstrated that the military program of catastrophe management is applicable to civilian disasters. Early recognition of the overall pattern of injury and the effective liaison of national and local agencies are important factors."

Now this disaster happened 29 years ago. There would not be that many medical people with recent military experience available today, but certainly the principles of military mass casualty treatment are still applicable with modifications to a civilian disaster. I would say those modifications would apply largely to the simultaneous existence of a variety of family problems which impact on the casualties which I described earlier, and the fact that the disaster occurs within a less-controlled civilian environment.

You may ask, what if the disaster happened today? What would be different in Texas City? There will be some differences, but perhaps not enough. Residential areas still abutt the harborfront industrial complex. Federal safety rules for loading nitrates have been tightened, but the potential for an explosive disaster still exists in Texas City and in many other communities along the Houston Ship Channel. This same potential exists in a great many communities with active, industrialized waterfronts, and near railroad yards, truck terminals, and industrial areas. In fact, hardly a week goes by without any evacuation of some area because of potential hazards created by an industrial or transportation accident.

But back to Texas City. The hospital facilities have improved in Texas City and nearby cities, and the State of Texas has implemented an excellent emergency medical technician program in which the EMT teams are responsible for providing initial medical help and triage. However, the EMT teams in Texas City are responsible to the Fire Chief, work with the Fire Department, and in another explosion could be wiped out as was the Fire Department back in 1947. From what information I could get, there does not seem to be a strong back-up system. The local hospital council, comprising hospitals in the Houston-Galveston-Texas City area had instituted shortwave radio communications between the institutions but has still to develop a full-blown mass casualty disaster plan applicable to the 1947 type of situation.

Although our discussions here are focussing on harbor disasters, the problem is applicable to almost any type of sudden catastrophe — an industrial explosion, railyard blast, tornado hit — which results in a large number of casualties.

Interestingly enough, Texas City had many of the same problems they had in Brooklyn nine and a half years later. The one main highway into Texas City from Galveston was quickly blocked by sightseers and people rushing to the scene along with emergency vehicles. This results from the fact that in both instances people could see and feel the blast and quick broadcasting of the news of the disaster. It was not until the police and the Army instituted traffic control measures that the situation was somewhat alleviated.

There was also the problem of "hidden casualties" in the adjacent residential areas. And there were the same worries about who would pay the bills. There was a mass over-supply of drugs, plasma, doctors and nurses rushed to the scene — one report indicates that almost the entire national supply of Penicillin was sent to Texas City.

It would seem to me that planning for the mass casualty emergency medical program for harbor areas or other industrial areas should include establishing an alert system that would tell the emergency medical people whenever there was a fire or serious accident in such a location. This would be like a tornado or hurricane watch — an official notification that there was the potential for a serious disaster.

If proper preplanning had been done, the emergency medical planners, the Red Cross and other agencies could anticipate the problems which might arise, the types of injuries, the need for blood and blood products, the types of special medications that might be needed in large quantities. With good information, they would know what would be likely to explode and what its impact could be. Under such an alert system, the right people could be placed on stand-by notice, some teams and supplies shifted to appropriate locations and stand-by access controls put in place. If nothing serious happened, it was a good, realistic drill. If the worst did happen, then the implementation of the emergency medical and other disaster plans would be quicker and more effective. This is done now for weather-caused disasters, why not for harbor or other industrial situations which potentially threaten large numbers of workers and residents? A plan is much more effective if its implementation begins before the fact than it is if the plan is pulled out of a file drawer after something happens. And, of course, each plan should include all of the aspects mentioned earlier — not only treatment of casualties, per se, but triage, transportation, communications, morgues and identification of the dead, movement of supplies and personnel, public health and sanitation members, traffic control, family services and resolution of who will pay for what.

What happened in Texas City happened 29 years ago. What happened in Brooklyn happened 20 years ago. Medical practice and emergency medical systems have advanced a long way since then, but how far, really, have they advanced in your state and community? That's a question only you can answer. It would be tragic if communities had to find out by going through their own Texas City to discover what they should have known all along. And what they should have done somethng about.

ROLE OF AMERICAN RED CROSS IN MARITIME DISASTERS

Roy S. Popkin

When planning for emergency medical services for victims of harbor disasters, the planners must take into account a variety of external — or nonmedical — influences which have a marked impact on how the medical services are provided. The experience of the American Red Cross in responding to maritime disasters will give you an idea of what some of those influences can be and how they affect not only the medical response but the total response to the human needs created by a harbor disaster.

In some ways, the problems involved in harbor disasters are not very different from those resulting from other industrial catastrophies — plane crashes, factory explosions, trainwrecks, building collapses, mine disasters, and the like — for the extent of need and how those needs are met will be directly related to such factors as the existence of company disaster plans, company liability, insurance, workmen's compensation laws, good samaritan laws, union benefits and, surprisingly but unfortunately who is allowed access to the disaster scene if it is on private or government property.

They will also be impacted upon by the geography of the situation, the convergence of sightseers and others, the other problems of the injured — damage to homes, loss of income, difficulty of identification, concern over other family members, the lack of planning for emergency medical services or overplanning for medical services without regard to other very real problems that are nonmedical in nature but definitely affect the ability of the medical practitioners to do their jobs efficiently and effectively.

Let me illustrate what I have been saying by telling you about two major maritime disasters with which I was personally involved as a Red Cross disaster administrator.

To begin with, the American Red Cross disaster program is designed to meet the immediate needs of disaster victims. This may start with providing food for emergency workers and victims at the disaster scene, opening shelters, or otherwise housing the homeless, distributing clothing, supplementing the available health services with first-aiders, nurses, aid stations, and by making blood and blood products available to hospitals where the casualties are being treated. As individual family needs can be determined, the Red Cross will also help with funds for food, for household essentials, temporary housing if not provided by government programs, the cost of health services including the replacement of lost prescription drugs, dentures, eyeglasses and prosthetic devices or burial costs, minor repairs, transportation and the replacement of lost personal occupational supplies and equipment. To support this program, the Red Cross has its own emergency communications system, sometimes established in conjunction with local citizens band or shortwave radio amateurs.

Not every harbor disaster will require this panapoly of services, but if you look beyond the actual scene of the disaster, you will find that many of these needs will exist, and that families are worrying about them even as the medical teams are trying to provide emergency medical services.

For example, there was a major pier explosion at the Luckenbach Pier in Brooklyn in December, 1956. It occurred just before the evening rush hour began. Ten people were killed, 72 had major injuries and were hospitalized and 186 had minor injuries. Some of those who were killed or injured were spectators who had been watching firemen fight a fire on the pier just before the explosion. Some of the injured worked in a large industrial complex which took the brunt of the concussion and, by so doing, prevented a major catastrophe in the blocks of tenements beyond the factories. Some of the injured were little children whose eyeballs were slashed by flying glass when the blast concussion shattered the windows in their homes, several blocks from the actual explosion site. Eighty-one homes were damaged.

Red Cross workers reporting to the disaster scene worked closely with the police, firemen and emergency medical units, but because New York City at the time had no real emergency plans for this kind of situation, there was great confusion.

The injured wound up in ten hospitals, some of them many miles from the scene of the explosion because drivers of the ambulances and passersby took patients to hospitals with whose location they were familiar. Sometimes this meant driving almost right by closer hospitals with adequate, unused facilities and staffs who were standing by to treat explosion victims. There was no real triage. In fact, the children with the slashed eyeballs were taken first to one hospital, then transferred to another before they finally got to the Brooklyn Eye and Ear Hospital where they should have been taken in the first place. Also, rush hour and spectator traffic made the movement of emergency vehicles and ambulances extremely difficult.

For the Red Cross, the explosion meant providing canteen service at the scene all through the night, assisting with first aid, recruiting nurses to assist in hard-pressed hospitals, and as the situation sorted itself out, visiting all of the hospitals to see if there were victims who needed help with paying medical bills or other kinds of assistance. In addition, Red Cross workers scoured the neighborhood to make certain all of those who were injured were found and treated. We did find also at least one victim who was self-employed and had no insurance or workmen's compensation coverage and who needed help with money for food and rent as well as his medical bills. We assisted families with funeral expenses.

After it was all over, the Red Cross and the Brooklyn Hospital Council had a meeting to plan for the future. The various city departments, including the police and fire departments were represented. All of the kinds of problems I've mentioned were discussed and recommendations made, and some steps were taken toward better response in the future.

One step that was taken at the time was to centralize the coordination of medical response to waterfront or other major disasters in the New York City Department of Hospitals. Prior to that time, 20 years ago, about the only part of the medical response which had been coordinated related to emergency appeals for blood donors. This, too, resulted from experience with a disaster — a major trainwreck. One blood bank went to the air and appealed for blood donors for the trainwreck victims. Even as refrigerated trucks with a supply of blood from the Red Cross were parked outside the two hospitals taking the brunt of the casualties, donors were flocking into those hospitals, blocking access by ambulances and greatly overburdening already overworked staff.

The lack of coordination and direction at the scene of the Brooklyn pier explosion did not particularly hamper the Red Cross relief operation, but it did have a serious impact on delivery of emergency medical services and the movement of patients to places of treatment. It was fortunate, however, that the Red Cross made an immediate effort to contact all the hospitals and their explosion-related patients and their families so that the problem of who would pay for treatment could be worked out. This is a question which doctors working amid the smoke and debris and noise of an explosion scene don't worry about, but, believe me, patients do, and so do their families, and so do hospital administrators and admitting offices. In fact, it became a very critical problem in the Texas City explosion. Today, with widespread hospital insurance, workmen's compensation, Medicaid, Medicare, the problem may not be as great. Perhaps one thing emergency medical service planners in this country can do is to plan with the Red Cross so that Red Cross health services people can quickly develop the necessary information and understandings which remove financial worries as a barrier to providing adequate care, and can assure patients facing long-term medical care and possible loss of income that their needs will be taken care of without undue hardship.

There is another kind of harbor disaster situation which should be reviewed here. That is the one involving the landing of survivors from a marine accident on the high seas. Just a few months prior to the Brooklyn pier explosion, New York Harbor was the place to which survivors, and some of the dead, of the tragic collision of the *Andrea Doria* and the *Stockholm* were brought.

This kind of disaster poses both similar and different problems. As you may recall, 51 people were killed and 200 were injured or became ill from shock and exposure. One hundred of the survivors were hurt badly enough to require hospitalization once they reached land.

In this instance, there was a certain amount of lead time for planning, but even so there were many problems as 1,701 survivors came to docks in Manhattan and Brooklyn and to a hospital on Nantucket Island off the coast of Massachusetts. All told, the Red Cross assisted 1,400 survivors, with clothing, transportation, financial help, food on the piers, and cables or other messages sent to anxious friends and relatives. I might say here that the problem of anxious friends and relatives is one that compounds of any disaster operation, particularly in a spectacular disaster. After the Brooklyn pier explosion, we received hundreds of inquiries about casualties and about crew members on ships that had been towed away from the fire scene just before the explosion. In connection with the *Andrea Doria-Stockholm* Disaster, the Red Cross received 5,000 such inquiries about 800 individuals and families.

This anxiety can bring relatives to the disaster scene where they get in everyone's way as they search for survivors. Failing to find their loved ones at the scene, they then descend on the hospitals, and on temporary morgues. Here, too, medical support is required as shocked families seek to identify often badly burned and mangled bodies. It is one of the hardest jobs our Red Cross nurses have to face, because shock and grief are compounded by the grisliness of the injuries.

Reuniting separated families was another problem with which the Red Cross and public officials had to cope in the landing of the *Andrea Doria* survivors. Many of the survivors went over the side of the ship into the water or into lifeboats. Children, including infants, were separated from their mothers. One child, a passenger of the *Andrea Doria*, was found alive in the wrecked bow of the *Stockholm*. They arrived on different ships, at different piers. Because of difficulties with spelling of names, we did not always know who was on what ship . . . with infants, the description usually was unidentified baby. There were many heart-tugging situations as these children were ultimately united with their parents.

Another problem was that of the news media. When the first two ships arrived at piers in Manhattan, the news media swarmed all over the place, thoroughly disrupting efforts to establish orderly procedures. In Brooklyn, where the survivors arrived at the Brooklyn Army Terminal, there was greater control and the news media representatives themselves policed the situation, apparently embarrassed by the television coverage of the chaos in Manhattan.

From the medical point of view, there was some confusion. The city of New York had its disaster units and ambulances available at each pier to move the injured to hospitals and to transport bodies to the morgue. However, the Italian Lines had made different arrangements, and wanted all the patients taken to one or two specific hospitals. Actually, the casualties wound up in several hospitals. Other hospitals had set up special staffs in anticipation of receiving casualties were quite critical of the decision to take patients to other, more distant locations — but the Italian Line was in charge. Coupled with this was the fact that information radioed ahead about the nature of the casualties was not that specific. Also, the Red Cross found that nurses assigned to the operation were needed to assist shocked and distraught families. One mother, missing a child, was accompanied by a nurse when she came to Brooklyn to try to find her infant, and had to be heavily tranquilized against the shock of disappointment or the over-joy of reunion. A nurse went on board to carry off the child and stayed with both of them for a considerable period of time.

Actually, the first Red Cross chapter to have direct contact with the disaster was on Nantucket Island, 50 miles from the sinking ship. In the middle of the rescue operation, five critically injured were brought to the hospital in Nantucket by Army and Coast Guard helicopters. The chapter was ready with volunteer doctors, nurses and blood when the victims arrived, but when the doctors saw the extent of the injuries they sent four of the five on to Boston. The fifth died in the Nantucket Hospital. Another child died in Boston. The Red Cross provided a burial gown and Bible for the child and paid for the funeral.

Whether or not the two who died might have lived if they had been taken directly to Boston without the loss of time in Nantucket is questionable, but this, as does what happened in the Brooklyn pier explosion, serves to reemphasize the need for expert triage and "traffic management". At the Brooklyn pier explosion, ambulances came from many places. Their drivers were not necessarily aware of the location of nearby hospitals so they took the casualties to the hospitals from which they originally came. Considering the traffic congestion caused by the disaster, this meant a considerable time lag before the hospital care and facilities were available to some of the patients. Hence, the recommendation that the triage teams include a transportation director — in radio communication with all hospitals — to tell ambulance drivers where to take specific patients.

To sum up, the Red Cross response to harbor disasters includes first aid and canteen service at the scene; assistance with triage and transportation of casualties; supplementing the nursing staffs and supplies of hospitals and emergency health units handling the wounded; assisting families identifying bodies at temporary morgues; help with clothing, burial costs and other financial assistance; communication to relatives; transportation for survivors; and comparable assistance for the hospitalized and their families. There may also be a need for long-term financial assistance with the repair of homes damaged by a dockside explosion, replacement of some uninsured contents, family maintenance while a casualty is undergoing vocational retraining or while survivors of the dead are rearranging their lives to become self-supporting without the income from a dead wage-earner, and, of course assistance with medical costs if such help is needed.

Our experience with harbor disasters indicates some other important considerations which should be taken into account in predisaster planning for emergency medical services.

First, study the geography of your harbor area, and map out access routes which the police can quickly block off. Harbor areas are generally congested, so this is a difficult problem which needs careful attention.

Second, know the hospital facilities closest to the harbor area, especially if they have capabilities for specialization — such as treatment of eye injuries — and be ready to direct ambulance drivers to the appropriate hospitals. Development of simple maps showing the most direct routes would be helpful.

Third, study also the surrounding areas so that you know what casualties you might expect not only in the harbor and on the piers but in private homes, places of business and other buildings — such as nursing homes — in the close-by vicinity. This is particularly important in the case of an explosion.

Fourth, try to determine insofar as possible the kinds of potentially explosive materials that move through your harbor areas or might be carried on ships docking there so that you are prepared to deal with the effects of dangerous chemicals, gasses and, possibly, radiation exposure.

Fifth, do work closely with your local Red Cross chapter, so that your plan for providing emergency medical services also takes into account the need for other important services related to the human needs of the disaster victims and their families. The Red Cross responds to 32,000 disasters a year in the United States. There is plenty of expertise available to help you, including disaster planning, blood and blood product distribution, first aid training, and the recruitment and training of nurses for disaster assignments.

Because some of you come from other countries, you may find different support capabilities within your own national Red Cross Society. Some of them actually operate hospitals, ambulance services and man first aid stations, along with running blood programs and other activities. This will vary, but I am sure you can work your own Red Cross societies into your plans.

U.S. COAST GUARD RESPONSIBILITIES IN HARBOR DISASTERS

Captain L.T. Dankiewicz

In the section of the federal law describing the duties of the Coast Guard, the phrase "for the promotion of safety on, under, and over the high seas and waters subject to the jurisdiction of the United States" appears twice. The first time it crops up, it is preceded by the words "shall administer laws and promulgate and enforce regulations". The second time it occurs, it is preceded by the words "shall develop, establish, maintain, and operate . . . rescue facilities". The dual nature of the Coast Guard is thus established. It is both a regulatory organization with enforcement authority and an operational component of the Federal establishment. The citizens of the United States acting through the Congress have directed the Coast Guard to apply "an ounce of prevention" in the marine environment, but should that prove insufficient, to finish the job by providing "a pound of cure".

The Coast Guard uses a systems approach to prevent marine casualties. We require United States flag vessels to be designed and constructed in accordance with international and federal safety standards. We periodically inspect these vessels during their lifetime to ensure that they remain safe and seaworthy. An examination and licensing program is administered by the Coast Guard to provide these ships with competent and qualified seamen. The Coast Guard also endeavors to minimize the risks of operation in our navigable water by maintaining a comprehensive aids to navigation system, keeping our waterways clear of obstructions to safe passage, operating vessel traffic services in areas where the activity, operating environment or other special circumstances require extra precautions, and conducting patrols and terminal inspections.

The final element in the effort to prevent casualties is the investigative function. The Coast Guard is the agency tasked by law to investigate marine incidents resulting in loss of life or significant damage. Over the years these investigations have provided important information on the causes of marine accidents which has led to improvements in design, operation and licensing. Many regulations promulgated by the Coast Guard under which the maritime industry operates have been developed through this feedback system. It is through the "school of hard knocks" that we learn our lessons best, and the Coast Guard is no exception.

The best safety programs in the world will not eliminate accidents, only reduce them. Humans make mistakes, and machinery has yet to achieve 100 percent reliability. And even when man and his machines are in proper working order, they can be overwhelmed by natural forces such as tidal wave, hurricane or earthquake. Whatever the reason, accidents will occur in spite of the best precautions. It is at such time that the Coast Guard's operational forces are called into action.

To conduct its operations, the Coast Guard maintains a substantial number of ships, boats, aircraft and shore stations. We have over 250 ships, ranging from 82 foot patrol boats on up to large polar icebreakers and 378 foot high endurance cutters. Over 160 aircraft, approximately two thirds of which are helicopters, are distributed among 25 air stations. We have over nineteen hundred small boats, many of which are located at the 160 search and rescue shore stations and the 53 port safety facilities located along our coasts and major rivers, and within our harbors.

To facilitate the administration and operation of these units, the Coast Guard has subdivided the country into 12 districts, similar to, but not identical with, the standard federal regions. Each district commander maintains a rescue coordination center through which he can monitor ongoing events of interest and direct the response of his forces to those events. The rescue coordination center is continuously manned by trained search and rescue and communications personnel, and has the facilities to communicate rapidly with key federal, state or other organizations as well as its own Coast Guard forces.

A good illustration of the Coast Guard's response to a harbor disaster is the collision between the chemical carrier *Edgar M. Queeny* and the tanker *Corinthos* in the Delaware River at Marcus Hook, New Jersey. The resulting fire and explosions destroyed the *Corinthos*, killed 26 persons, injured 11, caused extensive pollution in the Delaware River, and posed a severe threat to the British Petroleum Refinery and nearby residents.

Shortly after midnight on January 31, 1975, the tanker *American Sun* called the Coast Guard Base at Gloucester City to report a collision and fire at the British Petroleum oil dock. This report, which was sent by VHF-FM radiotelephone, was also copied by the Coast Guard Group at Cape May who immediately notified the district rescue coordination center in New York and deployed a helicopter from our Cape May air station to the scene. At the same time, Base Gloucester City deployed all of its available boats and vessels. As these Coast Guard units converged on the scene, they were joined by Philadelphia fire boats and several Navy and commercial tugs. The first of approximately 90 pieces of firefighting apparatus were also dispatched by the shoreside firefighting companies.

The *Edgar M. Queeny*, carrying over 20,000 tons of volatile and toxic chemicals, was able to maneuver clear, anchor and extinguish the fires which had broken out on her forecastle.

The *Corinthos*, with only one-third of her cargo of 400,000 barrels of Algerian crude oil unloaded, exploded into a raging inferno. Early firefighting efforts were directed towards containment and controlled burning to prevent the spread of destruction and pollution.

The first Coast Guard helicopters on scene reported extensive oil pollution and requested ambulance service be provided at Philadelphia International Airport to receive possible survivors. The Coast Guard Captain of the Port for Philadelphia ordered the affected portion of the Delaware River closed to marine traffic, and called in commercial pollution cleanup companies to boom off the threatened areas.

Fourteen crewmen from the *Corinthos* were able to swim to an adjacent dock and ultimately were transported by ambulance to various hospitals. Twenty five others did not survive. On the *Edgar M. Queeny* several injured crewmen were transferred ashore by a commercial tug.

For the next several days firefighting and pollution forces worked diligently to contain the threat to adjacent areas. On the third of February, the fire was essentially extinguished and the Coast Guard established a security zone around the remains of the *Corinthos* to protect evidence for a marine board of inquiry. Coast Guard vessels during this period provided firefighting and pollution control assistance, controlled traffic and patrolled the security zone. The first boarding party inspected portions of the vessel on the fourth and encountered smoke and hot plates. On the fifth, a boarding team was able to search the hulk more extensively, and located three bodies in the auxiliary generator room. The Coast Guard officially closed the case on February 8th, although residual clean-up efforts and the board of inquiry continued.

The Coast Guard's efforts in the *Queeny/Corinthos* disaster were concentrated in firefighting, pollution control, vessel traffic control and coordination with other agencies involved. In some harbor disasters the Coast Guard is called upon for survivor search and rescue, medical evacuations, night illumination, communications, transportation of equipment and personnel, area surveillance, dewatering, towing and relocation of vessels. In addition to our regular personnel, we can call on the Coast Guard Reserve and Coast Guard Auxiliary to provide supplementary assistance.

As with any natural disaster, a major harbor disaster brings together a variety of organizations with individual capabilities and limitations. Their disparate functions offer little excuse for routine day-to-day contact. It is doubly important therefore to have written plans and conduct periodic liaison and exercises to ensure an effective response when a major disaster strikes.

The Commandant of the Coast Guard has promulgated disaster preparedness plans which provide the broad guidelines for our districts and individual units. Each district commander has been charged with the direction and administration of the disaster preparedness program within his geographic area of responsibility. This program includes a written plan with the responsibilities for disaster response assigned to various units within the district, coordination of unit training and planning, exercising operational control of Coast Guard forces employed in disaster response operations within the district, maintaining liaison with the Regional Emergency Transportation Coordinator, federal, state and local agencies with disaster response functions, and concluding support agreements with other agencies as needed.

In our busy ports, particularly those which handle large amounts of hazardous cargo, the Coast Guard is keenly aware of the importance of detailed planning and liaison. In such areas the Coast Guard Captain of the Port is expected to maintain an up-to-date disaster response plan which includes support agreements, tabulations of key personnel knowledgeable in hazardous materials, identified sources of firefighting and recovery equipment, and a description of other agencies in the area which may be involved in a harbor disaster. Close liaison between all such agencies is needed to insure that planning documents are current and consistent with each other. Periodic exercises are a valuable method of maintaining high levels of readiness, simultaneously serving as a validation technique for the plan itself.

The potential for a large-scale disaster exists in most United States ports, characterized as they are by maneuvering vessels, transfer facilities, bulk storage sites, processing facilities, and concentrations of people. A relatively minor incident can quickly escalate out of control. Coast Guard port security and search and rescue forces are on call 24 hours a day, ready to work side-by-side with local and state disaster response forces. I would suggest an analogy between a good harbor disaster response organization and a successful football team. Talented individuals alone do not guarantee success. Teamwork, motivation, training, a game plan and good coaching are required. Let's work together to ensure a successful team in every port.

PREPARATION AND ORGANIZATION OF EMERGENCY MEDICAL PREPAREDNESS EXERCISE

Alexander J. Gretes

The key to preparation and organization of an Emergency Medical Preparedness Exercise is detailed Planning and Coordination.

The Inner Harbor Emergency Medical Preparedness Exercise as a part of the First Emergency Medical Services/Trauma Symposium was conceived by Dr. R Adams Cowley. At a staff meeting, Dr. Cowley described the Symposium and envisioned the Exercise desired.

First, the objectives of the Exercise were stated:

1) Demonstrate and evaluate the techniques used in emergency medical mass casualty situations: medical control and management; triage; casualty control; and transportation and evaluation.

2) Provide an opportunity for governmental agency coordination in accordance with the Baltimore City Civil Emergency Plan, as well as other emergency plans existing in the area.

3) Offer local hospitals a mechanism for testing their individual Emergency Medical Preparedness Plans.

4) Through evaluation, recommend revisions to existing plans and concepts.

After the objectives, came decisions as to a realistic precedence for the Exercise, an appropriate site was selected.

At this point, all was only wishful dreaming, since no firm support for implementation had surfaced. Consequently, after some necessary protocol meetings, there were only sympathetic ears — no action. The term most frequently heard was, "That's almost impossible, good luck, keep us informed."

In order to secure a foundation of affirmative support, the United States Army at Fort George G. Meade, Maryland, and the United States Coast Guard at Curtis Bay, Maryland, were contacted informally and unofficially. Both services suggested that support was feasible and formal requests should be made to the appropriate Headquarters. At last, a definitive support foundation was apparent.

As a member of Mayor Schaefer's Professional Advisory Council, Dr. R Adams Cowley was able to obtain interest and the personal commitment of Dean Clifford James. Through this learned gentleman's efforts, Mayor William Donald Schaeffer issued a memorandum to all city agencies recommending their participation. Mr. Paul J. Marino, Office of Disaster Control, City of Baltimore, was designated liaison officer for the Mayor, and Mr. Gary Greenhut of the Baltimore Promotion Council was advised to assist.

An early draft of the "Scenario" was completed and a Steering Committee Meeting was scheduled. Invitations were sent to the following local groups:

Ambulance Associations
Explorer Scouts
Fire Rescue Associations
Health Department
Hospital Association
Hospitals
Law Enforcement Agencies
Medical Society
Physicians
Public Safety Agencies
Red Cross
United States Army at Fort George G. Meade, Maryland
United States Coast Guard at Curtis Bay, Maryland
United States Park Police

In planning for this first meeting, an agenda was prepared that gave the necessary precedence and "Scenario" for the Exercise, plus the subcommittees necessary. The most critical part of this initial planning was the identification of the subcommittees necessary, and the choice of chairpersons. The required responsibilities of each committee were enumerated and a chairperson was designated. The chairperson then chose the members to assist, and independently proceeded with the assigned tasks. Assignments and chairpersons were:

Chief Medical Officer - Field Medical Operations - Robert J. Wilder, M.D.
Triage Officer - Frank Barranco, M.D.
Mortuary Officer - Russell S. Fisher, M.D.
Evaluation and Critique - Elliott Fishel, M.D.
Health Officer - John DeHoff, M.D., M.P.H.
Medical Supplies - Mr. Dennis Grote

Hospitals - Ms. Jennifer Rhodes
Moulage and Casualty Simulation - Mr. Richard Ayd
Victim Volunteers - Mr. James L. Murray
Aviation - Lt. R.R. Raffensberger
Communications - Mr. Monty Manning
Disaster Site Traffic Control - Mr. Norbert Nitsch, Jr.
American Red Cross - Mr. James O'Donnell
Fire/Rescue/Ambulance - Deputy Chief Edward J. Callahan
Inner Harbor Liaison - Mr. John Davis
Logistics and Transportation - Mr. Gary Greenhut
Publicity - Dean Clifford James
Police Department - Captain J.R. Bolesta
Water Front Coordination - Sgt. John Duffy
United States Army Liaison - Mr. John McLaughlin
United States Coast Guard Liaison - Lt. K.L. Indermuehle

The second Steering Committee Meeting was scheduled and the progress reports of each subcommittee were solicited. It was most gratifying to hear the reports and the amount of work and coordination that was already completed, as well as the enthusiasm that had been generated.

The third, and final Steering Committee Meeting was held two weeks prior to the Exercise. At this meeting, activities were finalized and an inventory of "tasks to be completed" was reviewed.

The Exercise you will observe this evening is the summation of the efforts of many individuals. It had been a true learning experience and a post-graduate course in human behavior.

How did we accomplish it? We poured our sweat into the bricks of planning and the mortar of coordination.

ROLE OF MEDICAL STAFF IN DISASTER PLANNING AND OPERATIONS

Alan Dimick, M.D.

Physicians must be involved in disaster planning and operations. This is not their primary mission, but they must understand the overall disaster plan and how they fit into it.

The mission of disaster management is basically the prevention and minimization of death, disability, suffering and loss. The methods of carrying out this mission will vary with the type of disaster, its location, and the professional background of the individual. Thus, the doctor and nurse are likely to concentrate on different aspects than a policeman, fireman, or civil defense volunteer. However, there are certain fundamental principles which should be thoroughly understood by everyone who may have a responsibility for helping the victims of a disaster. Furthermore, it is important that these principles be applied in the proper sequence, lest they lose effectiveness or even cause more injuries and deaths.

Experience and training in nondisaster situations do not ordinarily qualify a person to take a position of leadership in a disaster — an observation that has been made who have studied disasters. It has been shown in many disasters that the effectiveness of individuals or groups depends not only on how well they do their own jobs but also on how well they allow others to do theirs. In other words, persons who might be called upon to render disaster aid should have a clear understanding of the capabilities and roles of other individuals and groups in disaster work; to facilitate such understanding we will be discussing several ways in which persons or groups can be most helpful.

Basic principles regarding disaster management are: (1) minimize the number of casualties; (2) prevent further casualties from occurring after the initial impact of the disaster; (3) rescue the victim; (4) provide first aid to the injured; (5) evacuate the injured to medical installations; (6) provide definitive medical care.

The provision of first aid to the injured and evacuation and rescue of the injured is not primarily a medical responsibility. However, the provision of definitive medical care is obviously a responsibility of the medical staff, both in planning and in actual operation. The usual training of doctors and nurses is seldom enough for efficient handling of a large number of disaster victims. Under the pressures of large numbers of casualties, ordinary procedures break down. Surgeons, for instance, have become confused, have abandoned sound operative procedures and sutured contaminated wounds. One Chief of Surgery did not recognize the fact that his greatest contribution to victims would have been the supervision of surgery. Instead, he spent his time carrying litters, a job which many unskilled, untrained onlookers could have handled.

In many disasters, lack of planning or poor planning by the medical staff has resulted in unnecessary delays in furnishing definitive medical care. The primary role of physicians should be to function as physicians. They should not be diverted into tasks, such as carrying stretchers, which can be done by ordinary volunteers. The role of an individual doctor may vary depending on his training and experience. Most surgeons should report to hospitals to perform surgery. However, to have several experienced surgeons at casualty collecting points to assign evacuation priorities to different types of casualties would be a great help. Other physicians should set up first aid stations and organize groups of volunteers as helpers.

Physicians who have had military or disaster training or experience could exert major leadership functions in organizing and directing large segments of the relief operation.

The ability of hospitals to handle disaster victims is usually exaggerated by the general public. This explains why local hospitals are generally swamped after a disaster, a condition which often results in confusion and inefficiency.

Clearly, the experience in past disasters throughout the nation shows that an average hospital is seldom, if ever, able to handle the load of emergency cases following a moderate disaster. In part, this is due to confusion, lack of planning, and lack of realistic training for emergencies. However, it is also due to a basic lack of understanding of the capabilities of hospitals. A 200-bed hospital can handle 200 assorted patients who come and go in a staggered fashion, but even if 20 seriously injured patients come in at one time, the hospital would be unable to handle them unless there has been some unusual foresight, planning, and training.

Obviously, the physician must understand the intricacies of disaster planning and operations. The interaction of the multiple agencies and governments usually involved in a disaster can be very complex. In disaster planning the physician should insure that casualties will be handled and treated expeditiously and that the medical facilities are optimally utilized.

IMPORTANCE OF LOCAL HOSPITAL PARTICIPATION

Nicholas F. Desien

It is extremely critical to insure active hospital participation and involvement in the planning of any disaster exercise.

The hospital community must be involved in two aspects of the planning process. The first aspect relates to overall community planning of the exercise. The second aspect relates to internal hospital planning.

Community Planning

The major roles for the hospital in community planning are to be aware of all activities that will take place up to the delivery of patients to the hospital and to insure that the activities being developed lend themselves to a smooth and efficient overall exercise.

The hospital needs to have input into the communications system being utilized, the front line triage system being employed, transportation mechanisms in effect, security, public relations and so on. Suffice it to say, that is critical for the hospital to be involved in all aspects of the planning of the exercise.

Internal Hospital Planning

If the exercise is to be successful it is important for the hospital to organize itself internally to deal effectively with the disaster. The hospital needs to consider various elements in planning for a disaster.

DISASTER COMMITTEE

The hospital needs to establish a disaster committee. The purpose of the committee is to plan for and coordinate activities relating to an eventual disaster.

DESIGNATE DUTIES AND RESPONSIBILITIES

The duties and responsibilities must be established in preparation for a disaster. In most cases, the duties should parallel individuals day-to-day functions. If possible, a functional organizational chart should be developed pinpointing responsibilities of various personnel.

ONGOING TRAINING FOR PERSONNEL

Trained personnel are, of course, the strength of any hospital disaster plan. Therefore, disaster exercises should be held periodically as a training tool for employees.

TRANSPORTATION

Transportation arrangement should be considered. The hospital should have an understanding of the local transportation systems and how they will be utilized in a drill.

COMMUNICATION

The internal and external communication system should be evaluated and steps taken to insure that both systems are operable in case of a disaster.

When a Disaster Takes Place

ESTABLISH A COMMUNICATION INFORMATION CENTER

An information center should be established in a central location. If there is no public relations director or if he is unavailable, the senior administrator in charge should appoint someone to serve in this capacity.

The information center also should function as a rumor-squelching center. Such a center should aid the hospital in coordinating all activities of the various departments so as to avoid duplication and to effect smooth continuity of necessary work.

Telephone inquiries regarding patients should be handled at this information center, where a roster of casualties (including name, sex and condition, as received from the admissions area) should be maintained.

Because hospital personnel have been known to make regretable statements under stress, the center should assume charge of press relations. The Administrator should work closely with the information officer in providing policy statements to be adhered to during the disaster.

SET UP A SORTING (TRIAGE) CENTER

A sorting (triage) center should receive all incoming patients. All sorting at this center should be the responsibility of a physician especially qualified to function in this type of crisis. The physician should assess arrivals according to these categories: those for immediate treatment and release; those for immediate treatment, admission, and follow-up care; those for admission without immediate treatment; and those for the morgue.

STREAMLINE RECORD KEEPING

In cooperation with the director of the medical record and admissions department, the hospital administrator should implement an expedient method of initiating medical records. This is to ensure that proper record keeping will not cause lengthy waits and unnecessary anguish for disaster victims. Provision should be made for safekeeping patients' valuables.

MAKE DECISIONS ABOUT EVACUATION

Patients or personnel are evacuated to remove them from actual or threatened danger, and to free hospital beds and facilities for incoming casualties.

A system for selection and discharge of patients, to make room for disaster victims, should be set up and approved by the medical staff.

APPROXIMATE THE INPATIENT/ OUTPATIENT RATIO

The hospital should attempt to determine when and how many casualties are to be received and approximately what percentage will require inpatient care as distinguished from outpatient care. For example, fire victims are likely to produce higher admission rates and have greater demands than vicrims of civil disturbances.

In planning for patients' transfers or evacuation, the hospital should include procedures to insure simultaneous transfer of patient charts and to facilitate diagnosis and treatment at the facilities to which the patients are moved.

REVIEW AND CRITIQUE

Learn from mistakes.

Suggested Readings

American Hospital Association, "Disaster Management, A Planning Guide for Hospital Administrators," 1973

American Hospital Association, "Readings in Disaster Preparedness for Hospitals," 1974

MED-EX '76: EVALUATION AND CRITIQUE

Elliott R. Fishel, M.D., F.A.C.S.

Evaluating and critiquing an operation the magnitude of Med-Ex '76 is a complex problem. Because it was a composite of so much planning, involving so many different specialties and simultaneous interweaving of so many varied activities, it was felt that experts in several fields were needed to give a good critique. With this in mind, the evaluation teams were made up of two major groups: an on-site team and the in-hospital evaluators. The on-site team was developed with the cooperation of Mr. Lou Jordan, Training Specialist in the Division of Emergency Medical Services. This team consisted of Eileen Foster, Alice Epstein, Katari Stokes, Carole Ann Katsaros, James R. Miller, Dr. Gina Glick, James O. Dawson, Benjamin Grimes, Peggy Miller and C.B. Melton, III.

It was felt best that each of the hospitals provide their own evaluators for the in-hospital evaluation. The Director of the Emergency Room or the person in charge of disaster planning was asked to head that team. Following is a list of the various hospitals that helped us in this evaluation with their evaluators:

University Hospital — Dr. Homer House
Mercy Hospital — Dr. Paul Mueller
Maryland General Hospital — Dr. Salvatore Donahue
Bon Secour Hospital — Dr. W.E. Beavin
Kimbrough Army Hospital — Capt. Ian Natkin
Johns Hopkins Hospital — Dr. Donald Gann
South Baltimore General Hospital — Dr. Jean Thorn
U.S. Public Health Service Hospital — Dr. Aldred
Church Hospital — Dr. John Sobotka

Each member of the team received a critiquing form prior to the exercise which they were asked to return with any added comments. In addition, we contacted them personally immediately after the exercise to see what their criticisms and comments were.

In addition to these two major teams, we also contacted the various members in other aspects of the exercise such as communications, press release, etc. to see what developed in their areas and to get their comments.

The committee would like to go on record as congratulating all of those people who were involved in setting up Med-Ex '76. This was all arranged in a very short period of time at the request and direction of Dr. R Adams Cowley. Mr. Paul J. Marino, Operations Coordinator for the City of Baltimore and Mr. Alex Gretes from the Division of Emergency Medical Services, were the two who supervised the planning and coordination of this entire project. They did a miraculous job of getting all the people, all the equipment together and dovetailing all the myriad details that had to be worked out in such a way that the exercise came off almost without any hitches. This can be considered a minor miracle.

Med-Ex '76 started off with an explosion of the *S.S. Primrose*, which was planned and carried out by the Coast Guard. Simultaneously, two cars collided. This had been set up in a very realistic fashion with casualties inside the vehicles. A passer-by sounded the first alarm. All of this went off without a hitch with the exception of a 13 minute delay because of the increased number of "patients" who had to be moulaged. Moulage was carried out under the direction of Mr. Frank Ayd of the Franklin Square Hospital who was in charge of Moulage and Casualty Simulation. An excellent job was done in a short period of time including the almost 100 extra "victims" who showed up. This was a matter of pride with these people. They could have just simply tagged these people as such and such, but did take the time and did have the necessary equipment to moulage everyone. This was very helpful in the latter part of the exercise in the in-hospital part as it taxed most of them to the limit. From that point on, the exercise was carried out in a very life-like manner and with a deft precision.

Communications throughout the entire procedure was more than adequate. Telephone communications from the communications center to the various hospitals through the Sinai Communications Center was carried out in a lauditory manner. There was only one criticism made by one evaluator, and that was for a few minutes there was no one in the communications command post. In addition to this process, there were "ham" operators with their radios in the hospitals who could communicate with the command post at the disaster site. Several of the hospitals were very complimentary about how they could get directly through to the command site by both methods. In this particular exercise, there was no significant problem in communications. There was some question of communication between the helicopter with the ground guide.

The first individuals who were present at the scene of the disaster were the Fire Department personnel. They got there within five minutes. One team went immediately to the automobile wreck and began their process of extrication. A criticism was that, since they were one of the earliest ones to arrive that some of them at least should have been dispatched to the other area to begin triage of the other critically ill patients. However, in this exercise, these teams were particularly earmarked for the automobile accident and they were principally to demonstrate how they go about extricating the patients from this type of vehicular disaster. So, therefore, this criticism is really made only in regard to what would develop in a real catastrophe. The manner in which they worked in extricating the patients and applying first aid was an admirable demonstration of how this should be carried out.

The other members of the Fire Department who first arrived on the scene did dispatch themselves among the critically injured patients. There was some question as to how they were to tag. These were new tags and unfamiliar to some of them, so that when they first got there, some of them put on the wrong portion of the tag. This was quickly corrected and the proper portion of the tag was applied. The categorization was not perfect, however, in that some people were overcategorized, *i.e.*, made more critical than they actually were, and others were undercategorized, made less critical than they were. Those people who came later retagged some of the victims. There was not enough information put down on the tags. This criticism was also made by the medical teams that came from City and Sinai Hospitals as well as criticisms which came from the receiving hospitals. In addition, some of the triage people bypassed some of the life-threatening situations which were amenable to immediate first aid treatment such as reestablishment of an airway, to pack a seriously bleeding wound or a sucking wound of the chest.

One major criticism by all of the evaluators was that the triage people did not spread themselves out among all of the wounded but tended to work in localized areas. Some of the very critically ill patients who were on the periphery of the disaster were not "found" until the last portions of the drill and then they were discovered, tagged and evacuated. In addition, a lot of the treatment given by some of the workers on the field was given to those people who were not red tagged but were tagged in a lower category. These were people who were easier to treat and consisted of such things as a fractured leg rather than severe shock, chest wounds, spinal cord injuries, etc. It was felt that this may have been done because some of the firemen who were there on the scene of the accident were not the ones who handle medical emergencies but firefighters and felt more comfortable and safer in treating the less seriously ill patients.

The teams from Sinai Hospital led by Dr. Joseph Berman and from Baltimore City Hospitals led by Dr. Bernard Schlossberg, did an admirable job. They were effective in giving first aid treatment. They actually did not really triage in the sense that they were handling the critically ill patients as they were brought to them, but they were triaging in the sense that they were loading them onto the ambulances in the order of the severity of the injury. Some of them, however, even helped to carry stretchers, whch we feel was not a part of their duties and really wasted their talents. Drs. Wilder and Barranco were very effective in directing the patients into the loading site, putting them in their proper order and seeing that they were moved on quickly. They were active in keeping things moving in a very exemplary fashion. Chief McElhinney and his group, in loading and dispatching the ambulances, did an excellent job. There were practically no hitches. We timed several of them, and it seems that the turn-about time, *i.e.*, the time the ambulance came, loaded and departed, averaged less than five minutes. One of the techniques tried in this drill was to take one of the expert EMS or CPR technicians off the ambulance and help in the care of the wounded at the scene. This worked well. Drs. Wilder and Barranco made excellent use of the walking wounded and those who were only very minimally injured as stretcher bearers to move the more seriously injured patients to the loading and treatment sites. They also made excellent use of the plan of the stand-by people to act as stretcher bearers.

The people who were taken by helicopter, were categorized before hand, as far as the Army was concerned. The triage teams categorized those taken by State helicopters. They handled the evacuation very well. The helicopter personnel demonstrated the proper way of triaging and loading their patients. The medically trained co-pilot left the helicopter while the pilot remained. He examined the patients and helped to load the helicopter. It showed how the approaches to the helicopter should be done, how the whole procedure should be carried out correctly. There was only one criticism and this was immediately corrected by the pilot himself. That was when the first Huey helicopter took off, it went over the command area and the area where most of the seriously injured were, causing debris to fly around. The next time they took off, they went up, hovered, turned around and went the other direction.

The heart attack episode was also a good demonstration of how such a problem should be handled. It occurred as planned, suddenly, in the middle of the disaster. They could not evacuate the victim immediately. They brought the equipment to the victim, demonstrated very well how they use it, then evacuated the victim to the ambulance when things were more stable.

There was one actual casualty, one of hyperventilation at the scene of the accident. The EMS instructors who were there specifically for this purpose, answered the call immediately, took over the problem, straightened the whole thing out at the scene but did send the patient on to University Hospital where he was again seen. By that time, he was completely well and the doctor at the hospital did not believe that he was a real victim and not one of the actors.

The Baltimore City Police Department, with their security and traffic management along with the Bureau of Traffic Control, did an excellent job. We realize that there was some dispersement of the spectators around the victims, but as was mentioned before, this was really a pageant and this would not have occurred in a real disaster. They did keep the traffic moving in the directions they were supposed to and kept the traffic away from the disaster site. In the main, the job they did was superb.

The press section in the communications center also worked well. The reporters did go among the crowd which would not occur in a real disaster and did question the people who were working which again would not occur in a real disaster. We did have a press release section set up; this would function in a real disaster to handle the entire problem.

The Coast Guard Firefighting was brought out and demonstrated their activities very well. We did not test oil pollution in the water for various reasons, but this was not only thought of being tested, but how to handle the situation if it arose.

The hospitals in general were very pleased with the way their hospitals were tested. Dr. House at University Hospital reported on 54 patients, 2 of which were supposed to go to Shock Trauma Unit. Only one went and the other one was sent to the minimally injured area. He was concerned with one ambulance speeding through the triage area.

Several of the patients would have had to go to the Operating Room, many others would have been admitted. They were quite well equipped to handle what they had received. They had enough personnel, enough fluids, etc. to handle all of those problems. His criticism of the "victims" used, however, was that they were too young and that several of them became nauseated because of the realness of the moulage.

Dr. Donald Gann at the Johns Hopkins Hospital states they received 42 patients. At first they came rather slowly and were no problem at all, then a truck load arrived. They were put on what they call "Operation Yellow" which brought in extra personnel. They had sufficient staff, they had all of the equipment, blood, other fluids, etc., that they needed. They had sufficient room. They cleared their Emergency Room by 9:00 p.m.

He expressed an opinion that the hospital felt they would be one of the hospitals receiving the majority of casualties in a real emergency. They would also like to have multiple pediatric injuries.

Dr. Bevin of Bon Secour Hospital reported on the approximately 35 patients that they received. Some of them were badly injured, others were not. They felt that the approach to the hospital in the ambulance was not sufficient. The ambulance personnel performed well. They had a good response as far as their doctors, nurses, and other medical personnel were concerned. In addition, they tested their operating room, x-ray equipment, fluids and all other ancillary services and supplies. They felt that they had been thoroughly tested and had reached their limit.

Dr. Aldred at the U.S. Public Health Service Hospital, a stand-by hospital, was told that they were not going to get patients and were just going to test their communications, and so they did not mobolize their people except by phone. They got in touch with about three quarters of the people they needed to contact. However, around 8:00 p.m., five people came to the Emergency Room; three with compound fractures that would require surgery, none in shock, the other two were simple fractures. He then called his team in the hospital, mobolized his nurses and residents. They went through the whole process of taking them through the Emergency Room, getting the blood work up, checking them out to see what was needed, etc. If necessary, they were prepared to bring in the teams that were available. Although they had only one orthopedist and the rest were surgeons, they felt they could handle the problem. After these five patients, they received two more cases; a walking burn case and a minor cut. They do not have an Emergency Room and they felt that this was about the maximum they could handle. They would like to be tested even more thoroughly in the next disaster. Also, they mentioned they would like to have some surprises.

South Baltimore General Hospital was considered a secondary hospital for this exercise, but they did receive 48 patients. Dr. Thorn, who was the evaluator at the hospital, was very pleased that they came in big loads. They were able to test their triage system and they had to alert all of their medical and paramedical personnel. Most of the casualties they received were orthopedic and this is one of the areas in which they feel that they do not have sufficient coverage. She pointed out that this is an area that they are going to try to improve. She also wants to be considered as a primary hospital if another drill is set up.

Dr. Mueller at Mercy Hospital felt that the exercise tested them quite well. He felt that they were able to handle what they received as far as the Emergency Room, Operating Room personnel, equipment, fluids, etc. He said that they really did not stress their blood bank sufficiently.

Dr. Donahue at Maryland General Hospital felt that they had benefited by this exercise. Particularly, he liked the "ham" operator in the Emergency Room because they would get right to the on-site area. They also used the telephone communication. They did reach the maximum load. They had 31 cases which came all at once. He felt that they could handle these types of major injuries, but he felt that this was the limit. He did call the triage people at the scene of the accident and told them to send the other casualties elsewhere. He pointed out that in an accident of this sort, there would have been more people who would have been in hysterics and other types of problems and they would like to have this included in the next disaster.

Church Hospital received 29 patients. They had no problems with the ambulance approaches or the delivery of the patients. They did comment that on several cases, the diagnosis was not made on the tag. They estimated they would have needed 31 units of blood. They had 35 on hand and were able to order 38 from the Red Cross. They did have trouble with the x-ray department because of renovations that were going at the time. They had enough personnel of all types and could have called more if necessary. The hospital was full at the moment, but they estimate they could have made 60 beds available. They were well pleased with the exercise.

Captain Ian Natkin at the Kimbrough Army Hospital at Fort Meade was very well pleased with the exercise. The only criticism that they had at the scene was the lack of assistance in helping to load their victims on the busses and other vehicles. They felt the moulage was excellent and evacuation was carried out speedily. They classified their casualties as "expectant," *i.e.*, as possibility of the patients suffering immediate death as opposed to "critical" who would be side-tracked for a short period of time. These would be those who had fractures of the legs, etc. They went into the whole exercise from Emergency Room to Operating Room to Recovery, ICU, etc.

In summary, this exercise was carried out to almost pinpoint perfection for the purpose it was set up. It would seem that most of the mechanisms that we had set up to handle a real disaster situation would have worked very well. In particular, the communications system we believe is reaching its point of being more than an adequate system. The responses of the various Fire Departments, helicopters and other ancillary services were also performed in a very satisfactory, professional manner.

We felt that the triage system still needs to be improved. It is my personal opinion that we should train the Fire Department officer groups who are involved daily in emergency medical situations as the triage officers. They will be on call 24 hours a day, 7 days a week. They will be available and ready to respond to the disaster scene faster than anyone else I know of. Their personnel will not always be changing. This is their lifetime activity. I think courses should be set up to certify them in this area.

The mechanism of moving the patients out of the area also will be done by professional people like Chief McElhinney. I think this is an area where training on how to do it and being intimately familiar with the communications systems adds another plus factor in the field so that they can communicate with all the hospitals and begin to disperse patients in order of need and he is able to keep track so that they can receive immediate help in the hospitals to which they are sent.

The ambulance services were carried out very well. The suggestions made by Dr. Wilder and Mr. Jordan that the part of the trained ambulance personnel should be left at the scene of the disaster to provide triage and treatment was excellent and was utilized here. It should be tested more thoroughly.

We feel that the new tag will probably be the permanent tag. All the people who will in any way be involved, that is, the Fire Department, Police Department, etc. should be thoroughly schooled in the use of the tag. In addition, we feel that some of the people in the Fire Department and Police Department should be upgraded in EMS training and CPR since they are almost invariably the first at the scene of the accident. We realize of course that they have a very busy life and that it is, from a practical point of view, difficult for them to be re-trained every year. Since the importance of the first few minutes of any tradgedy determines the morbidity or mortality of that case, we feel it is a necessary part of their duties.

The performance of all the helicopter services which took part in this exercise was extremely highly professional. However, their major role that we see in a disaster of this sort is to transport those patients past the overcrowded hospitals near the site of the disaster to further out medical facilities where personnel will be available to handle them immediately.

We feel that perhaps in the next disaster we ought to try using some older victims. The police cadets and those people who were EMS trainees who were used at the Sheppard Pratt disaster may be more realistic, although we would not be able to get them in as great a number to utilize as victims. This is not a criticism of the Explorer Scouts; their performance was of the Academy Award type. It was also suggested that other disasters should be carried out on a lesser scale such as pediatric disasters where a school bus overturned and a chemical plant exploded. We ought to test a smaller group of hospitals in a certain locality. We should have the element of surprise.

In summary, we feel that this exercise was carried out in a most exemplary fashion. The criticisms as mentioned above are those one would anticipate having since these disasters are primarily set up to see what our deficiencies are and where we need to improve our delivery services as well as our training programs. It also pointed out our good points. In addition, it was an excellent pageant for the International Symposium.

EMS Manpower Needs and Training Criteria

INTRODUCTION

Charles Frey, M.D.

A measure of the strides made in the development of emergency medical services is that we have gathered here today in a National Forum for the first time all the major organizations, private and governmental which contribute in the planning and provision of emergency medical services on a National scale.

This gathering is indeed symptomatic of the recognition of the need for increased coordination and a clearer definition of the roles these groups can effectively contribute to improving the care of the acutely ill and injured. The movement forward in this field in the past 10 years has been dramatic. Achievement has been monumental and surpasses all that preceded it in the century before. The technology, the recognition of need, the impetus from many concerned individuals and professional organizations, many of whom, because the field is so young, are with us today or represented today have made such rapid progress possible.

Today, many of the goals of the white paper, ***Accidental Death and Disability, The Neglected Disease of Modern Society***, published in 1966 have been attained or set in motion. Now is a time to take stock of where we have been, where we are now and where we are going. Let us move forward in the spirit of the Bicentennial, in the tradition of a proud free people who know how to work together, not because they are coerced as in some societies, but because as free men they recognize the needs of their fellow men and respond spontaneously and voluntarily in an appropriate and usually selfless manner. We, also, see a great partnership in the meeting today between the individuals and professional organizations who initiated much of the change and progress we are so proud of and our government. We should never forget the contribution of these individuals and organizations who took it upon themselves to awaken government at the local, state and national level of the needs for regional planning and implementation of emergency service, but which only the Government can implement and operate. We must be sure, and doubly sure in the next 5 years these individuals and professional organizations who have done so much in the past, continue to have in this new partnership with government, a significant and meaningful role in a field in which local and state government will be assuming more responsibility.

The enthusiasm, knowledge, experience and initiative of the individuals and professional organizations so vital to the recent progress in emergency medical services must be retained in this new partnership if progress in emergency medical service is to be continued.

EDNA — FILLS A NEED IN EMS

Anna Mae Ericksen, R.N.

In 1970, individual nurses across the country became aware of each other's interest and activities in emergency care. Anita Dorr, R.N., of Buffalo, New York, stepped forward as the leader, acting as a catalyst in an already fermenting situation. Ms. Dorr initiated the formalization of the Emergency Department Nurses Association.

Objectives

Anita Dorr envisioned a national organization serving the needs of emergency nurses as professionals. It would be a forum for discussion of common problems, a focal point for professional development, and a fulcrum for influencing the wider areas of emergency medical services and health care delivery.

The emergency medical services system is the total community preparedness and response to the need for emergency health care at the time of sudden illness or accident. The Emergency Department Nurses Association is committed to the proposition that all persons suffering from sudden illness or trauma have a right to the highest quality of emergency health care.

This standard of care can only be achieved when each and every element of the emergency medical services system functions effectively. If but one link in the chain of emergency health care is weak or ineffective, the entire system is in danger of failure — failure which may result in the death or disability of a human being.

Although EDNA's primary responsibility as a professional nursing organization is to provide optimum emergency care to patients in emergency departments by promoting, assisting, and developing competencies of our member emergency department nurses, EDNA is also vitally concerned with the performance of the entire emergency medical services system.

The Emergency Department Nurses Association has been deeply concerned with the improvement of emergency medical services since its inception almost six years ago, and we have established the following goals as our continuing standard of involvement:

1) To provide optimum emergency care to patients in emergency departments, by helping to establish standards

2) To promote, encourage, and implement a positive attitude toward education at all levels within the emergency department, using resources available on both local and national levels

3) To study, analyze, and make recommendations regarding the transportation of the sick and injured of the community

4) To promote and participate in programs of education for the public on emergency care

5) To support, promote, and participate in formal programs of instruction for emergency techniques, research,

and development of postgraduate courses on a professional level

6) To promote official community, state, and national representation for the emergency departments in organized and academic nursing

7) To foster cooperative liaison activities with other organizations dedicated to the improvement of emergency medical care.

Nine thousand emergency nurses have joined together to achieve these objectives. One hundred thirty-four chapters throughout the continental United States, Hawaii, Canada, the Canal Zone, and as far away as Saudi Arabia, bring EDNA activities to emergency nurses in their home communities. Alternately, the individual nurse is recognized on the national scene with EDNA acting as spokesman and agent for its members in the world of organized nursing, government, and academe.

Emergency Medical Services System

The emergency medical services system may be conceived of as including *all* health care professionals and paraprofessionals, as well as the lay public. No one is immune to the potential need for emergency medical attention. Likewise, no on is protected against the possible need to respond to an emergency situation. As friend or relative, as paraprofessional first responder, or as hospital staff, we are all intimately interrelated in the emergency medical services system.

The emergency nurse enjoys a major role in the community emergency medical services system. The emergency nurse's responsibility for patient care begins with the training of paraprofessional personnel. Those first aiders, emergency medical technicians, and paramedics, who will encounter the patient in the field, must be trained to identify patient needs, provide initial stabilization, and transport the patient to the hospital with maximum efficiency. With the advances in communications technology, the nurse may literally extend her influence to the field. In addition, the new mobile intensive care vehicles may be staffed by nurses, rendering more sophisticated patient care at the scene and en route to a hospital.

Within the hospital itself, the nurse is responsible for motivating nonprofessional staff to maintain adequate skill levels; and nurses may be responsible for ensuring that education is adequate. The nurse's own educational needs are receiving wide-spread attention.

There is no status quo in emergency medical services! With the introduction of emergency medical technicians and paramedics in the field, patients are being brought to the emergency department who would have been unsalvageable in the past. This new emergency patient puts an added stress on emergency department personnel. As new techniques are developed, and new medications are marketed, emergency nurses must be in the know.

Continuing Education

With institutions of formal higher education failing to meet the needs of emergency personnel, the focus has been, and will continue to be, on short term postgraduate continuing education experiences. EDNA is building and strengthening its continuing education programs, at the national and local levels.

In 1974, EDNA received a federal contract, PHS-R4-74-18, to underwrite the development of a national *Continuing Education Curriculum*. Emergency nurses and consultants in continuing education worked together to prepare a document encompassing the entirety of emergency nursing. For each of the 25 contact areas or modules, the *Curriculum* provides behavioral objectives, an outline of the content needed to achieve each objective, suggested teaching methods, and suggested methods of evaluating learning. In the first six months, without advertising, 600 copies of the *Curriculum* have been sold. EDNA has recommended that EMS training funds for nursing personnel be administered, with the core curriculum as the standard.

This summer the first of several workshops for *Curriculum* users will be offered at the EDNA Headquarters. Meeting management, working with faculty and teaching skills will be featured. As the *Curriculum* is introduced and accepted around the country, more and more workshops and full length courses will be based upon those materials. Use of these materials will help EDNA members prepare for the planned certification examination. EDNA at the national level is also planning to help its members prepare for certification. For the next three years, the national Scientific Assembly will be developed around the modules of the *Curriculum*. This year, seven modules have been identified to be the basis for postgraduate courses. Roundtables are also being based on objectives stated in the *Continuing Education Curriculum*.

EDNA has recently instituted a continuing education contact hour program. This involves the review and approval of courses before they are actually offered. A set of criteria has been developed and is used consistently with each program that applies for approval. There are two levels of credit that are being applied to continuing education programs. Continuing education contact hours are awarded to courses that have successfully passed very close scrutiny. The educational objectives and entire content outline, the teaching methods and proposed method of evaluating each participant's learning, are reviewed in addition to questions being asked about the facilities, the faculty, and the ability of the sponsoring organization to plan and conduct meetings. Less formal continuing education programs may be awarded continuing education activity hours. A less complex application process is required for activity hours. The national Scientific Assembly will carry these two levels of credit. Continuing education activity hours will be awarded for attendance at postgraduate courses only. Continuing education activity hours will be awarded for attendance at all the other sessions at the Scientific Assembly.

Professionals in the health care fields are faced with an increasing public pressure for accountability: quality assurance. It's chart audits, review committees, policy manuals, criteria statements, and a multitude of other catchwords, all highlighting a demand for improved health care delivery. As individuals we are limited in our ability to respond to this demand. We know we must continue our education, but where? We know we must demonstrate our competence, but how? The public no longer accepts the care we have given in the past as proof that we will continue to serve their needs adequately in the future.

As individuals, we join the public in demanding the most of our peers. We form professional associations in order that, as a group, we can meet those demands. The professional association focuses our activities in continuing education, developing standards, and other channels through which we can demonstrate our competence.

Specialty Certification

EDNA is working toward the development of specialty certification examiniations. EDNA leaders have chosen to follow a nontraditional approach to testing. Essentially, there are two approaches to testing: norm-referenced and criterion-referenced. EDNA has chosen to follow the criterion-referenced approach. This implies that all candidates' scores are compared to a predetermined standard of acceptable performance. This philosophical decision will influence all the following test development processes. Under this approach, the entire field to be tested is defined. A statement, which will look somewhat like a list of skills and knowledge, will be generated. This list will include all the skills and knowledge that are required of emergency nurses. A test committee of emergency nurses will then determine what areas will be tested and how important each of those areas will be on the test. The test agency will work with these test specifications to develop testing formats. We anticipate that there will be traditional multiple choice questions and patient management problems. Patient management problems are paper cases, with a series of questions. A question might be: "What laboratory tests would you order for this patient?" The candidate would choose the tests he or she would order from a list, and then would be given information about the test results. In working with these problems, it is possible to harm the patient, give essentially neutral treatment, or to give optimal treatment. Another testing format that is being considered is skill demonstration. A voucher system would allow the test committee to set standards for performance. The nurse candidate would perform the skills in his or her home community with an, as yet, unnamed evaluator. The nurse's performance would be judged against the predetermined standards. The evaluator would mail the results to the test committee to be added to the nurse's score on the rest of the examination.

The EDNA Subcommittee on Certification has formed a recommendation that will be presented to the EDNA Board of Directors in June. They recommend that EDNA contract with the American College Testing in Iowa City, Iowa, for the development of this test. Once test development is begun, it will take approximately two years to complete. But, test development cannot begin until the necessary funds are identified. It will cost approximately $350,000.00 to develop this test. The search for funding is underway.

For emergency nurses, the process of specialization is expansionary rather than restricting. It fortells the continued development and acceptance of wider responsibilities and new role definitions. The triage nurse, the nurse scribe, the nurse who sutures, and the more independent emergency nurse practitioner are being introduced to emergency departments around the country. Within these highly specialized roles, the emergency nurse provides an even more valuable resource to the community emergency medical services system. Physicians acceptance of and dependence on nurses in these new roles is documented. Nurses are adding new dimensions to their traditional positions. Through specialization, nurses are accepting new responsibilities, thus helping the system to provide better patient care.

EDNA In The Health Care Arena

EDNA provides a frame work within which emergency nurses can explore their new opportunities and meet the demands of the public. EDNA also provides a vehicle through which individual emergency nurses can have an impact on legislation and the formal structure of organized nursing. EDNA is a member of the Federation of Specialty Nursing Organizations and the American Nurses' Association. As such, a formal liaison is established between emergency nurses and other nursing groups. The interrelationship of emergency health care and specialty emergency nursing can be explored in contrast to the response to urgent health problems as they face other nursing specialties.

EDNA also serves a liaison function with physician and paraprofessional associations in the emergency health care field. This exchange among all members of the health care community is essential. Relationships and responsibilities must be understood before trust can be developed. Without this trust, health care personnel work in opposition. It is our responsibility to constructively channel the energies of the professional and paraprofessional in the field. EDNA is meeting that challenge through continuing education, certification, specialization, and liaison functions. In emergency medical services, and in general health care delivery systems, EDNA represents emergency nurses.

THE NATIONAL ASSOCIATION OF EMERGENCY MEDICAL TECHNICIANS: THE EMERGENCY MEDICAL TECHNICIAN AS A HEALTH CARE PROFESSIONAL

Jeffrey S. Harris, B.S.B.A., R.E.M.T.

As I look out at the assembled people before me, I see many Emergency Medical Services Leaders from across this country who have given birth to the Emergency Medical Technician (EMT).

On behalf of all EMTs, I thank you. However, as I stand before you, I want to announce that the EMT has come of age. Just as an infant grows into adolescence and adolescence into adulthood, the Emergency Medical Technician is now ready to become a productive member of the Emergency Medical Services Team.

The National Association of Emergency Medical Technicians was organized to meet the professional needs of the Emergency Medical Technician. In just eight short months the Association has grown to over 5,000 members in 11 state affiliates and 45 chapters.

Through our affiliates, a number of different programs are now on-going for EMTs. In one state, over 60 percent of all continuing educations courses for EMTs are being provided by the state affiliating EMT Association. In another, the Association provided important lobbying support to help pass a Emergency Medical Services Law. State affiliates have also provided EMT leaders to serve on EMS councils and committees. We hope that you will look upon this Association for EMT leadership representatives.

In conclusion, the Emergency Medical Technician is ready to be a productive member of the EMS Team. The time has come for the EMT not to ask what you can do for us, but what can the Emergency Medical Technician do for you? To help bring about quality emergency medical care.

FIRST RESPONDER-EMERGENCY MEDICAL CARE TRAINING

Robert E. Motley

The Highway Safety Act of 1966 authorized the establishment of eighteen highway safety standards, one of which is Standard 11, Emergency Medical Services (EMS). The purpose of Standard 11 is to provide financial assistance to States, through a matching grant program, to upgrade the prehospital phase of emergency medical services.

The matching grant program of the National Highway Traffic Safety Administration (NHTSA) is one of the few federal programs that has established a standard of excellence which must be agreed upon before the grant recipient is awarded funding assistance.

During the past seven years, following passage of the Act, the Emergency Medical Services Branch of NHTSA has directed its efforts to the upgrading of ambulance services. This effort has included training programs at the basic and paramedic levels for ambulance personnel and the purchase of ambulances meeting design criteria, communications equipment, and patient care equipment.

The present effort of the HNTSA-EMS program is to develop systems and guidelines in which emergency medical care will be brought more promptly to the victims of trauma and acute illnesses. The programs will encompass first responder programs for both professional agencies and the general public.

Research studies indicate that 50 percent of those who die from traumatic injuries die outside the hospital emergency department. Seventy percent of our nation's traffic fatalities occur in rural areas. However, rural areas represent only 40 percent of the nation's population. The ACT Foundation (Advanced Coronary Treatment) reported that the chances for recovery of the victim in ventricular fibrillation is 25 out of 100 when the ambulance response time is within five minutes. This rate drops to one out of 100 when the ambulance response time is 10 minutes. A victim of a "Cafe Coronary" may die in 4 to 6 minutes.

There are few city ambulance services that can claim an average response time of five minutes or less. For those services who do claim a five minute response time the data may be misleading. Response time is often recorded between the time the ambulance leaves its quarters until it arrives at the address of the accident or illness, not when the EMTs reach the victim on the 20th floor of a high-rise office building or the dress shop in a large shopping mall. The time between the detection of the accident or illness and the notification of the dispatcher is rarely included as part of the response time. If these factors are considered, the five minute response is more than likely a seven to ten minute response. The rural ambulance service cannot be expected to have a response time of less than 20 to 30 minutes. It is not economically feasible to establish more ambulance services in the rural areas for the purpose of reducing this response time. A number of State and local EMS programs have developed systems whereby emergency medical care is delivered to the victim prior to the arrival of the ambulance, thus reducing the response time and the time between the detection and reporting of an accident or illness to the proper agency.

Thr Wisconsin Emergency Medical Services program has developed a dual response system to better serve the rural areas of the State. There are two methods of operation. First, is the rescue truck and the ambulance service. The rescue trucks are generally housed at fire stations. They are equipped with extrication equipment, two-way radio communications and a limited amount of medical supplies. They are staffed by EMTs but do not transport patients. The ambulance services are volunteer, municipal and privately operated. When a call is received both units respond. The rescue unit generally arrives at the scene first. They treat, stabilize and observe the patient until the ambulance arrives. The second method is the ambulance and auxiliary response. The auxiliaries are volunteers trained and certified as EMTs. They are strategically located in small towns, at industrial plants, on farms or other places of business within the ambulance response district. The auxiliaries are equipped with two-way portable radios and a medical jump kit. They respond to the accident or illness in their private automobiles. The auxiliary and the ambulance are dispatched at the same time.

It was not reported in the Wisconsin article, but under certain conditions the auxiliary could transport the patient in his car to the hospital or to a local physician. He would not transport if the patient's illness or injury was life threatening, requiring continuous emergency care and observation en route to the medical facility. He could transport, for example, if the patient had a minor fracture or minor lacerations where bleeding could be easily controlled with pressure bandages. If the auxiliary transported the patient, he would contact the dispatcher to place the ambulance back into service.

Wyoming is one of our most rural States, with a population of 332,000 and 98,000 square miles. There are 71 ambulance services in operation with approximately 100 ambulances, all are volunteer services but one. This averages out to one ambulance service for each 1,380 square miles. In Wyoming it is not unusual for an ambulance response time to be one hour or more. There are 640 certified EMTs who man the ambulances. There are an additional 1,000 volunteers trained as EMT first responders. The volunteers operate much the same as the auxiliaries in Wisconsin. A 24 hour ambulance dispatch service is provided through the Statewide Highway Patrol communication frequency.

There is a potential legal problem with either Wisconsin or Wyoming response methods, as with any first response system. The first EMT at the scene of the accident or illness must make certain that the crew transporting the patient is as well trained in emergency medical care as he is. If not, he should accompany the patient to the hospital in the ambulance, otherwise, he may be subject to suit for abandonment of his patient.

In 1974 the Public Safety Officers Foundation of Chicago launched a "Downtown Chicago" CPR training program. The aim of this program is to have two employees trained in basic life support per floor in high rise office buildings. The switch board operator is supplied with a directory of the CPR response teams, their rooms and phone numbers. The operator is also notified when a team member is on leave. In this case a member of a team on another floor is placed on call. Each office telephone has a decal affixed to it identifying the emergency number. Practice sessions are scheduled periodically to assure that the teams maintain their proficiency in basic life support.

The Lincoln Nebraska's football stadium advanced life support program has been in operation for about eight years. Rescue teams are stationed at various locations in the stadium which enables them to respond to an emergency in a matter of minutes. Data indicates that 90 percent of the collapsed spectators were successfully resuscitated on long term basis.

In 1974 at the Annual meeting of the American College of Emergency Physicians and the Emergency Department Nurses Association, in Washington, D.C., an advanced life support team was established to serve the emergency care needs of the attendees. Three of the eighteen attendees requiring emergency care had life threatening problems, all survived. ACEP recommends that one or two physicians and two EMTs be on duty for every 2,000 attendees to man the advanced life support response system.

The local Heart Association and the American National Red Cross in cooperation with the local fire departments or ambulance services are usually available to provide CPR and first aid training courses. Seattle, Washington, for example through the fire department EMTs has trained approximately 100,000 of its citizens in CPR. It was reported that 20 percent of resuscitations in Seattle this past year were initiated by private citizens.

Training in emergency medical care of the highway injured should be encouraged in high-school driver education programs. This type of training is a prerequisite in many European countries before its citizens are issued drivers licenses.

There are other potential resource groups in the rural community who could be trained as first responders, such as school bus drivers, rural mail carriers, sheriffs, and agricultural agents. These individuals travel the back roads on a scheduled basis and become familiar with the activities and habits of the local citizens. Anything out of the ordinary can be immediately investigated such as an elderly person, living alone, that has not picked up his mail. An investigation may reveal that the individual has suffered a stroke or had fallen and broken his hip. Broken shrubs by the side of the road or skid marks leading off the road may indicate an off-the-road accident. If these individuals were equipped with a two-way radio, they could report the accident or illness. With proper training and emergency medical supplies they could stabilize the patient until the ambulance arrived.

The first responder type program and the training of local citizens are fundable, on a matching basis, under the National Highway Traffic Safety program of the Department of Transportation. This program is administered by the Governor's Highway Safety program in each State. We have developed and published a first responders training course titled, "Crash Injury Management."

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EMERGENCY MEDICAL SERVICES TRAINING AND EDUCATION IN THE RURAL WILDERNESS AREA

J. Cuthbert Owens, M.D.

Introduction

Studies in areas of low population density have revealed that knowledge of the management and care of acutely ill and injured patients should be more widely disseminated, that quality trained emergency medical personnel and facilities should be more readily available and that professionals already identified in the field should receive additional education in the management and care of life-threatening emergencies. Practice in a rural community is no excuse for ineffective initial emergency care. Although studies on the wilderness area have not been reported the same concept can, within the limits of nonprofessional capabilities, be expected to apply.

There are many factors which influence the quality of care in a rural community, several are of major importance: the infrequency of actual emergency cases, the public is uninformed and few have been trained in first aid or emergency medical care, the ambulance attendants and their dispatchers have had little if any training or exposure to quality emergency medical care, the previous training of physicians and nurses and their inability to participate in continuous medical educational programs, the distances involved, the nonexistence of a coordinated emergency medical services (EMS) system in the area; and the scarcity of medical personnel and resources. Such situations are serious enough to warrant attempts towards their correction.

Therefore rural/wilderness areas must not be regarded as small versions of cities and suburbs. They require different approaches to education relating to emergency care than are relevant to urban areas.

Objectives

The objectives of an optimum emergency medical training system in the rural/wilderness area should include the development of:

(1) The training and performance guidelines and standards for all health personnel, volunteer and professional, involved in the delivery of emergency care, and (2) the facilities, equipment and instructors necessary to train, prepare, assess and periodically review and critique all levels of personnel providing emergency medical services.

Manpower

Emergency medical services manpower in the urban and rural communities are the resource pools of trained personnel capable of supplying care together with the basic and continuing education mechanisms to support the necessary training level of EMS personnel. Rural/wilderness areas must be assured that sufficient personnel will be trained so that they will be readily available and adequately prepared to provide patient care at the scene of a medical emergency, en route to the hospital, and on arrival at the emergency facility. Although the rural areas themselves can provide much of the training for their emergency medical personnel, some training and experience requires an urban environment. Other aspects of training may necessitate visits to the rural areas by urban personnel and equipment.

Guidelines and Standards

Training and performance guidelines and standards must be implemented for all personnel providing emergency medical care. These guidelines and standards should be based on national reports as well as those which are state-determined as to needs, requirements and training capabilities.

Levels of Training

GENERAL PUBLIC

Meaningful participation by the general public is essential. Therefore, the primary element of planning for an adequate EMS system is public awareness.

The participants of every well-functioning EMS system must make a serious effort concerning education. In its absence the system will not succeed in achieving all of its objectives and the degree of successful implementation will be consistently inhibited.

The objectives of public education of EMS are to: stress and demonstrate that an optimum system is a community responsibility and requires coordination of all of the communities' EMS resources; minimize the delay of detection and reporting of the emergency event to the responsible source of emergency medical assistance; and improve emergency capabilities by certification of basic and advanced first aid skills.

Contacts include: American Red Cross, Safety Associations, EMS Councils, medical society, nursing society, service organizations, teachers including teacher coaches, newspapers, radio and television, advertising, communication facilities, trucking industry, and airport personnel.

PUBLIC SAFETY AGENCY PERSONNEL

The public safety agency personnel who operate police, sheriff, highway patrol cars and fire equipment are frequently first to arrive at the scene of an emergency event. Basic EMT courses and refresher training and minimal equipment should be provided to these people which would permit administration of life-sustaining actions prior to the arrival of an ambulance unit with more complete resuscitative and emergency treatment capabilities. Responsibility for developing and maintaining a state-of-readiness to assume the initial care of emergency patients must be uniformly accepted by law enforcement, fire protection agencies and all other rescue units in low population density areas.

A partial list of public safety agencies to assist and implement these objectives are: county and local law enforcement, State Patrol, fire departments, search and rescue teams, dispatchers, beach and ski patrols, Civil Air Patrol, Department of Parks and Outdoor Recreation, U.S. Forest Service, and State Forest Service.

TRANSPORTATION PERSONNEL

We are just beginning to see a lowering of our nation's mortality and morbidity in acute illness and injury in rural/wilderness areas where all ambulance attendants are trained Emergency Medical Technicians. Due to the delay in locating and reporting the emergency, the distances involved and the scarcity of medical personnel and resources, these dedicated individuals who are most often volunteers are directly responsible for patient care much longer than their urban counterparts to whom the hospital is available a few minutes from the site of the emergency. Basic training programs need to be followed regularly by refresher courses.

Advanced EMT programs should be available to a few carefully chosen members of each ambulance unit. However, justifiable objections are voiced when most of these units have infrequent exposure to critical emergencies and have limited support from the local physician. Advanced EMT courses would be hazardous without an identifiable, interested, well-trained and capable medical advisor(s) who is willing to assume the responsibility for the level of care provided by the local ambulance service.

Presently EMT course availability and the quality of education has been governed by instructor personnel and training equipment limitations. State, regional, and local health-related organizations should constantly strive to improve these training programs so that the small community can be assured that every EMT is quality trained in emergency care.

NURSES

Frequently the nurse is the only health professional in the rural community hospital or clinic who is immediately available to institute emergency care. This is more evident in wilderness areas where the nurse practices alone. Therefore, appropriate practices for nurses exposed to emergencies in low population densities should be standard inclusions in any statewide emergency medical personnel training. Physicians should encourage and support this concept.

Multiple skills involving direct emergency care should be included in nursing curricula, especially for those planning to practice in the rural/wilderness area are: initial assessment via medical history and physical examination, pulmonary and cardiac resuscitation, recognition and treatment of warning and fatal arrythmias, cessation of hemorrhage, monitoring and treatment of shock, institution of IV fluid therapy, use of nasogastric tubes, splinting and initial care of wounds, and initiation of electrocardiogram, X-rays, blood studies and other diagnostic tests as indicated. The Critical Care Nurse Programs presented in many urban centers in the nation is a progressive approach toward the fulfillment of this objective. Much of this training can and should be made available in the rural setting so that nurses may be able to attend without extensive travel.

ALLIED HEALTH PERSONNEL

Nurse aides, orderlies and other hospital personnel provide valuable services in small community hospitals and may be the only individuals to assist the nurse and/or physician and may be the only person available in the hospital when the physician and the only nurse on duty are busy in the operating room or elsewhere. They should be trained as emergency medical technicians, not only to provide daily assistance in the hospital when a multiple casualty situation arises but also to be available for ambulance duty. Administrators of rural hospitals should also be included in such training programs.

PHYSICIAN

Many of the rural physicians who attend the large number of emergency medical care courses being conducted regularly throughout the nation are the same year after year. This gives documentary proof that only a small segment of rural physicians are receiving additional education in this field. Although many rural hospitals have regularly scheduled visiting speakers and conduct their own courses, the total number of small community physicians receiving continuing education in emergency care is very small. These scientific meetings and postgraduate courses are admittedly educational. However, the weak link in their educational objectives is readily apparent because participants are not required to demonstrate their knowledge of and ability to perform diagnostic skills and essential emergency procedures.

A recent study was made of a training program in Colorado and Wyoming which 302 rural physicians in fourteen rural areas were exposed to a comprehensive tutorial program in the management and care of the critically injured patient. The educational program involved two-full days and offered additional diagnostic skills and procedures and ideas on how the physician could upgrade the EMS system in his own area. Surgical resident(s) from the University of Colorado Medical Center covered all emergent-urgent patient needs during the course. The study concluded that new and different approaches in continuing education of rural physicians must be undertaken before optimal improvement is noted in how rural physicians handle emergencies. A few brief preliminary observations made from this program are:

In twelve of the fourteen rural areas 90 to 100 percent of the area physicians were in attendance at the two-day programs for a total of 16 hours.

In some communities as many as 60 percent of the physicians had not attended a clinical meeting for up to 20 years. This void in meeting educational needs was not generally considered to have occurred from lack of motivation or other critical reasons but because of the burden of necessary work in their practice. New procedures and approaches in the care of patients, especially in the emergency field, are being established so rapidly in the urban areas that the rural physician cannot keep abreast of these expected skills. Therefore, many physicians are falling behind in their capabilities to provide necessary care. They tend to transfer patients, some of whom are not given optimal care before transfer. In some communities where this is a frequent occurrence not only do the emergency patients leave town but many non-emergency patients also seek care elsewhere. The local hospital census therefore drops and the community loses some if not all of their physicians. The rural community is a victim of "leaching" of patients by urban communities.

Many physicians had a feeling of insecurity about their inability to perform procedures such an endotracheal intubation, chest tube drainage, central venous pressure monitoring, emergency diagnostic abdominal taps, defibrillation, etc. This insecurity appeared to be due to a lack of training in emergency procedures. In turn this lack of confidence instilled in them a fear of any complication which would engender local criticism and possibly a threat of malpractice. Their image within the community sometimes appeared to be more important than their delivery of quality care.

The results of tests and manipulative skills presented during the course demonstrated that many practical approaches to patient care were less well-known than esoteric material.

It is apparent from this study that medical educators are not reaching a large number of physicians in rural communities.

In every community where the physician population was found to have limited knowledge and training in emergency care, the educational programs for nurses and ambulance attendants were limited in scope and critiques in prehospital care were non-existent. Further, community emergency system planning either had not been developed or had not been fully implemented.

This training course confirmed that rural physicians will attend an educational program in their community if: it is well planned and designed to meet his or her educational needs; if the instructors do not "talk down" to the small town physicians; if the program is not designed as a catchment for patients; and if the course is planned and constructed so that the rural physicians does not lose what he guards most—his independence within his own community.

PROJECT COORDINATORS AND DIRECTORS

Project coordinators and directors of EMS programs need a thorough indoctrination from well-informed persons representing multiple disciplines in the area for which they are responsible. This orientation must be supported by a voluminous amount of data relating to the rural/wilderness area. The instructors' responsibility is to assist in and provide support for the training and education recommended by advisors who are themselves EMS providers. The primary objective of education is to eliminate the gap between what is known and what is delivered. Several basic decisions must be made about individual responsibility, the curriculum needed to develop competence, and the mechanism for certification to ensure continuing competence. Strong support is necessary from all health professionals involved, especially the medical community which has the mandate to provide and/or recommend the level quality care can and should be offered.

Conclusion

Every study of emergency care has demonstrated that education is and will be the key to lowering the mortality and morbidity for the acutely ill and injured. The gap between what is known and what is delivered in the emergency field can be bridged only by proper education. Medical Centers have increased the state of the art but have not disseminated it in a coherent way—only in "bits and pieces."

Rural physicians are included in efforts to eliminate incompetence in the medical field. Recertification of licensed individuals in all fields, professional and otherwise, is endorsed as a concept needing to be implemented at intervals. The reasons are: a realization that the rapidly expanding body of information has made the knowledge on which original certification was based relatively obsolete; the demand of certain consumer groups for evidence of continuing competence by physicians and other health professionals; proposed legislation endorsing this stance; and, the announcement by all specialty boards that recertification is a mandatory part of their certification process.

The delivery of emergency medical care in this nation can be no better than the educational system designed to meet its challenge.

EMERGENCY AND CRITICAL CARE MEDICINE RESEARCH CENTERS

Peter Safar, M.D.

Introduction

"Emergency and critical care medicine" (ECCM) comprises those aspects of patient care, teaching, research, and organization concerned with the needs of critically ill or injured patients in all components of the emergency medical services (EMS) delivery system — namely, at the scene, during transportation, and in the hospital. ECCM (Europeans call it "reanimation") includes both emergency resuscitation and long-term life support (intensive care). The *science* of reanimation or ECCM, called "reanimatology" in Europe, is concerned primarily with the pathophysiology and management of acute dying and its reversal.

It has been estimated that in the U.S.A. each year about 150,000 deaths and much morbidity and suffering could be prevented, and the cost of expensive intensive care and custodial care reduced, if all that is known in ECCM were implemented nationwide by ideally organized regional systems. This, however, requires researching more effective means of ECCM delivery. Moreover, in order to advance ECCM from its present emphasis on "half-way technology" (L. Thomas) to the high technology which has much greater cost-effectiveness, we must conduct research on fundamental mechanisms, prevention and casuative treatment.

As in all fields of medicine, ECCM service and educational programs require, to maintain their effectiveness and vitality, an ongoing search for new knowledge. A deeper understanding of pathophysiology, new techniques of care, improved methods of acute care delivery and systems evaluation must all be actively pursued if ECCM is not to become a stagnant and mediocre venture.

No area of medical practice should be exempt from scientific inquiry. If there has been a trend in EMS toward mediocrity, dishonesty, misdirected ego games and political priorities, it is perhaps because the method and the ethic of science as a force for truth, scholarship and excellence have not been sufficiently brought to bear on this field. And if CCM suffers from the territorial problems among clinicians of differing disciplines, perhaps it is because the researchers and clinicians of the various disciplines and institutions have not been drawn together to communicate and collaborate toward common goals. A concerted and multidisciplinary research effort in ECCM — in the laboratory, in clinical settings, in the classroom, in the community — is urgently needed to insure that this young and vitally important field remains a worthwhile and legitimate endeavor.

Unlike areas of inquiry such as cancer research (where a great deal of fundamental knowledge is still lacking and therefore clinical application still remote), reanimatology is in a position to make significant clinical gains and discoveries right *now* — by building upon existing knowledge of physiology, pathology, pharmacology, biochemistry and engineering. The transition from art to science in ECCM, and the application of basic research to clinical practice, require more development than fundamental breakthroughs. For this reason, we believe that funding priority should be accorded ECCM research efforts — through sponsorship of ECCM programs, centers or institutes — which would appear at this time to promise an earlier and greater yield in terms of benefits to society.

In this country to date, the application of biomedical science to the study of dying and its reversal has not received the attention it deserves. While many individuals and groups have conducted bedside and laboratory research on topics related to acute medicine (e.g., trauma, cardiac failure, respiratory failure), none have focused systematically on the study of acute multiple organ failure (acute dying processes) and its reversal. Nowhere in this country is there a structured milieu in which all aspects of ECCM research — laboratory research, clinical research, educational research, health care delivery research — and practice are coordinated and integrated into a "mission."

Our own experience demonstrates both the potentials and the current handicaps of ECCM research. My associates and I have studied reanimatology for the past 20 years — first at the Baltimore City Hospitals and, since 1961, at the University of Pittsburgh. Our efforts, funded first by the U.S. Army and later by NIH and other sources, included:

human volunteer and patient studies of artificial ventilation in the 1950s, leading to a worldwide transition from manual to mouth-to-mouth artificial ventilation;

animal research on cardiopulmonary resuscitation (CPR), resuscitation from blood volume loss, and near-drowning;

CPR teachability studies leading to national medical, paramedical, and lay CPR training programs;

laboratory and patient studies on prolonged artificial ventilation and other intensive care techniques;

unpublished studies on the pathophysiology of natural dying in old age (Kunkel, Robin, Safar, 1963);

community EMS studies;

brain resuscitation research, disclosing effective methods for ameliorating postischemic-anoxic brain damage (1970s);

the realization that acute CNS injury (brain and spinal cord) is extraordinarily time-limited, and that rapid efficient transportation and treatment in a fully developed center is critical for optimal results.

In all these ventures, however, we were hindered from developing the full potential of available ideas because priority fell to development of new patient care and educational programs of our base specialty (anesthesiology) and ECCM, and because funding was negligible for such mission-oriented research. There is no doubt that had there been separate financial support of an ECCM research center or institute, promising investigators could have been freed from overwhelming teaching and patient care commitments and research progressed more rapidly and in greater depth. We have learned from this experience, however, that ECCM research programs within or side-by side with a large clinical department of a university hospital can significantly facilitate and accelerate application of laboratory discoveries to patient care.

The concept of mission-oriented research and teaching in resuscitation is not new. I first became familiar with such an approach in the early 1960s while visiting Professor Vladimir Negovsky's reanimation research institute (U.S.S.R. Academy of Sciences, Moscow), founded in the late 1930s. There, clinicians and researchers from many disciplines work in concert to explore the various facets of dying and its reversal.

This approach has impressed many who have had occasion to examine it. Senator Hubert Humphrey, after a visit to the Moscow institute in the early 1960s, recommended to the U.S. Congress that the United States adopt a similar mission-oriented effort in resuscitation research. The late Claude Beck of Cleveland wrote, along the same lines, "Our attitude must be revolutionized, because the experiment is far beyond the clinician. This revolution would be facilitated if we had in this country an institute for the study of the environment of death. One such institute (comparable to our many cancer institutes) would focus attention on the prevention of death, the reversal of death, and the complex biological problems of the dying process. There is scarcely any more pressing medical problem. Strange indeed that America needs this nudge from Russia — and fortunate that we have had it."

In the 1960s, and more recently with my 1973 and 1976 testimonies before the Senate Health Subcommittee, I have proposed the development of solidly funded ECCM research centers. There, clinicians and scientists would not only investigate aspects of pathophysiology in the laboratory, not only innovate therapeutic approaches to the critically ill and injured patient in clinical settings — but also could provide national guidelines in the education of physician and non-physician EMS leaders, in health care delivery trial projects, in evaluation, and in educational research. Such an institute would serve as a national resource where those involved in ECCM might come for seminars, apprenticeships, or research experience among specialists of various disciplines. It would be a clearinghouse for ECCM information and a catalyst for ECCM research nationwide. Furthermore, such a center could function as a mission-oriented "think tank," where established scientists might find a protected yet stimulating environment. Leaders of centers could form an advisory committee for the government.

To date, no such institute exists. Despite recommendations and proposals for over a decade there has been little response from medical community, public, or government. The organ system-oriented NIH still has no home for an ECCM study approach, nor is an alternative center currently available or considered. And yet, I believe that we have in this country today, sufficient numbers of researchers and scholars committed to ECCM to warrant establishment of about five to ten such centers. The need is unquestionable. The resources are available. The potential benefits are enormous. We have waited too long already.

Recommendations

OVERALL APPROACH

The ECCM research centers or institutes proposed here should be more than isolated laboratories pursuing investigations into pathophysiology. The interests of individuals forming such centers should encompass all aspects of the care of the critically ill and injured — from the time of the initial insult outside the hospital through the patient's recovery or demise on an intensive care unit. Thus, development of resuscitation and life support techniques and equipment, EMS systems research, evaluation of care delivery, development of educational materials and methods in emergency and critical, could all fall within the scope of such centers.

ECCM research centers should be based in universities, which have the resources to attract and concentrate talents in this field and tangentially related areas; to provide guidance to regional ECCM service programs; to serve as regional referral centers for difficult or complicated cases; and to conduct educational programs to facilitate prompt transfer of research discoveries into clinical practice. Close communication, and at times even cooperative studies among the various ECCM centers in the United States should accelerate research and discourage the wasteful tendency toward "re-inventing the wheel." Examples of cooperative studies include a national trauma registry for outcome evaluation; investigation of outcome after severe brain insults; and clinical trials in brain resuscitation.

CONCEPT, ORGANIZATION AND GOVERNANCE

The following thoughts are presented as a stimulus for discussion and planning by peers and government, not as a master plan for the organization of such centers, which would have to be much more focused and specific, and adjusted to local circumstances.

In the past, most breakthroughs in medical science have come from chance discoveries and good, simple ideas systematically pursued by individuals. There are now fewer unexplored areas, and special expertise is required to master modern investigative techniques. In the future, relevant new knowledge will increasingly come from research systematically pursued by goal-oriented groups. Progressive, flexible team coordination and leadership will still allow individuals the opportunity to make chance discoveries, enhanced by the team environment. In ECCM research centers, there should be no competition between laboratory and clinical research, but only a requirement for *good* research — targeted and non-targeted, applied and basic, directed and non-directed, and clinically- and non-clinically-oriented (Comroe and Dripps.) Under such circumstances all research efforts are enhanced, complementing and stimulating one another.

The environment of ECCM research centers should permit solo investigators to pursue their own ideas, and to submit their ideas to the challenge of peers in the center. Physical proximity, frequent conferences and reports, and the coordinating and stimulating influence of the center's leaders should enhance the likelihood of discoveries and breakthroughs. Yet, the center must also provide a milieu in which imaginative persons may think and work without constant pressure to generate data or crank out publications.

The above probably requires an organizational plan which defines the authorities and responsibilities of investigators vis-a-vis the entire institute, and which ensures communication and consultation (but only suggests, not enforces, collaboration) between groups of investigators and research sections. Some of the following research sections may be considered: laboratory research on the CNS, the cardiovascular system, the respiratory system; ICU patient research; mobile ICU patient research; education research; health care delivery research.

The centers require visionary leadership, talented and committed staff, money, space, and access to patients inside and outside hospitals. Projects and programs should cross interdisciplinary, interdepartmental, and interinstitutional barriers. Cross-fertilization among laboratory, bedside, educational, and community research should be encouraged, to shorten the hiatus between discovery and implementation. Mobile ICU ambulance services and regionalized hospital critical care services as part of health care delivery projects, for example, could be utilized in trials of those life-saving measures disclosed by prior animal research on dying processes.

Research on patients may benefit from a special extramural board of physicians, scientists, and lay persons, to screen patient trial protocols. The present public and political attitude toward safeguards in human studies may otherwise negatively influence patient research in the acute setting. Clinical research in critical care often represents justifiable therapeutic trials in acute hopeless situations when the emergency state is one of "nothing to lose, perhaps something to gain" for the patient, and when patient consent may be impossible to obtain because of the urgency of the actions required.

The centers should build on existing programs and personnel concerned with acute medicine. The mechanisms for additional appointments should take into account that people with similar interests attract each other and work well together, and that the variety of talents needed in such a center should complement each other.

The investigators of such centers should be committed to cross-fertilization of patient care teaching and research, although directly responsible for the latter. In the clinical setting of the institutions where such ECCM research centers are located, every patient contact should be regarded as a scientific experience for trainees and faculty. This approach has the dual purpose of teaching critical clinical observations and improving patient care by innovating techniques and equipment.

Emphasis on multidisciplinary research programs coordinated with clinical leadership training should create an environment fostering development of a new type of physician-scholar, who is needed in greater numbers in EMS. Such clinician-scholars should have learned the scientific approach by having pursued a narrow field in depth, and have gained experience as clinicians, humanitarians, teachers, coordinators, and community leaders. The world needs such broadly-based leaders — not only in medicine.

It is hoped that such centers would also — by promoting understanding, communication, respect, and in some instances, collaboration between emergency department-based physicians, ICU-based physicians, traditional clinical specialists, and basic scientists — narrow the territorial schisms which have held back the development of acute medicine nationwide, particularly in academic institutions.

The physician faculty of such institutes should exemplify a healthy mix of the science and art of medicine, which is the basis for good patient care. Scientific work, i.e., accumulating and classifying knowledge (facts) and discovering the truth and laws (or mechanisms), as well as technologic developments, would be the prime concern of such centers. However, artistic performance (based on skills, experience and perfection), although acquired primarily in clinical training and practice, can also be enhanced by experimental research. The impact of such centers or institutes, then, would depend primarily on those who, by virtue of their keen interest and commitment in acute medicine, their tenacity, self-discipline, honesty and imagination, are appointed as staff members and research fellows.

While staff project leaders (senior investigators) should have maximal freedom in the choice of questions they wish to pursue, graduate students (fellows) who come for research training should tailor their projects as much as possible to ongoing programs — with sufficient flexibility, however, to permit young investigators to deviate from targeted research if their ideas look promising. Research fellows should be appointed for periods sufficiently long to permit completion of their projects.

The leaders of ECCM research centers should be competent in some aspect of this large field, be committed to the ultimate goal of the mission (decreasing mortality, morbidity or cost from acute life-threatening illness or injury), have vision and imagination, and the ability to stimulate, coordinate, and administrate. They should promote communication between various institute investigators and avoid overplaying particular research projects to the detriment of individual investigators' freedom and ideas.

Finally, these centers or institutes should provide a microcosm of the unique environment a university should (but rarely does) furnish to society — an environment whch fosters the pursuit of truth and a stimulating, free exchange among individuals and programs. University faculty, staff, and trainees should be enabled happily and effectively to fulfill the requirements of teaching, learning, service, and inquiry, and to enjoy the beauties of life as well.

TOPICS IN NEED OF INVESTIGATION

Research and development of expensive "half-way technology" having little potential to decrease mortality, morbidity, or cost, should be discouraged. Fundamental "high technology" research with breakthrough potentials of either immediate or ultimate relevance to society should be supported. Simple, inexpensive innovations of equipment and techniques have usually had greater life-saving potential than the complex expensive ones. Each center or institute, although possibly exploring several of the research areas listed below (or additional questions not listed, depending on investigators' interests) would nonetheless focus on one or a few of these topics.

Investigators and organizations will differ in their ranking of research priorities. Several of my colleagues in emergency and critical care medicine, however, agree on the following list of questions which urgently need answering, and which I have listed *in order of priority for funding*, as determined by combining *public needs* (as I see them) *and* the opportunity for breakthroughs, i.e., *feasibility*:

(1) *Delivery* of regional advanced ECCM systems (planning, organization, education). Short of an "ideal" regional ECCM "czar," methods must be found to overcome the present, seemingly insurmountable, obstacles of a lack of authority for coordination and quality control, and the mediocrity resulting from governance by vested interests.

(2) *Resuscitation of the CNS*. Search for measures which could be applied immediately after a cerebral insult and would prevent or ameliorate the crippling caused by cardiac arrest, asphyxia, trauma, inflammation, hemorrhage and infarction. The human brain, the target organ of resuscitation and life support, is the most challenging area for future research. Spinal cord injury, because of its tremendous crippling effect, also needs high priority.

(3) *Criteria for termination of life support*. While brain death determination and certification are becoming common practice, objective criteria for termination of expensive life support efforts in coma and the vegetative state in patients without brain death, but with severe and irreversible brain damage, must be sought. Decisions of the utmost importance to patient, family and society — such as when "to let him die" or when to commit "passive euthanasia" require scientific foundations. For example, we need the ability to prove the irreversibility of coma; this may help avoid the many tragic absurdities illustrated by the widely publicized Quinlan case, and reduce exorbitant rates for catastrophic health insurance. Such research is basic in our efforts to humanize critical care.

(4) *Bioengineering* in resuscitation and life support. Collaboration between bioengineers, ECCM physicians, and researchers can open new horizons. There is need for develop-

ing new, non-invasive monitoring techniques; closing the loop to semiautomation of some life support; and extending intensive care life support into the pre-hospital setting. For example, the implantable automatic defibrillator in patients with hearts at risk is more than science fiction!

(5) *Cellular metabolism and function* and closely related questions on the *microcirculation* (e.g., bleeding/clotting mechanisms) including cell membrane failure, need basic investigation with a view to the terminal state and the post-resuscitative period. Still poorly understood alterations of cellular metabolism and structural changes, with causative or resulting derangement of capillary blood flow and capillary and cell membrane permeability, often determine the irreversibility of dying processes.

(6) *Pulmonary failure* due to edema and consolidation (shock lung) and related potentially reversible conditions are still not sufficiently understood. Research into their prevention and treatment should include development of experimental models; improvement of extracorporeal oxygenation techniques; renewed study of lung transplantation; and evaluation of outcome in survivors. Studies on lung healing and the potentials of direct treatment of the lungs are also needed.

(7) Long-term management of *heart failure* (pump failure), including investigation into assisted circulation, the implantable artificial heart, and cardiac transplantation.

(8) *Evaluation* of (a) the *quality* of care; (b) the *outcome* of care; and (c) the *cost effectiveness* of ECCM systems, are in need of scientific foundations and methods. Simple, inexpensive, clinically meaningful outcome evaluation methods have not yet been found. Evaluation research will remain difficult without uniformity of recording within systems and availability of records to investigators.

(9) *Education research* is closely related to care evaluation (8), which is the ultimate measure of the quality and value of teaching efforts. Education research includes methods to evaluate students and teaching programs, and to develop accordingly more effective teaching methods and materials. This is also in need of scientific foundations.

(10) *Disaster medical care*. A global scope of evaluation research could come from studying retrospectively and concurrently disaster preparedness, responses in actual disasters, and outcome of victims, in order to find better ways of bringing the potential of modern resuscitation to bear through immediate worldwide response by systems as recommended for instance through the "Club of Mainz" (R. Frey).

(11) Research into the pathophysiology and therapy of selected but potentially reversible *acute dying processes*. For instance, dying and reversibility of death in certain embolic phenomena, infections, and hemorrhagic diatheses are still poorly understood.

(12) A study of *natural dying*, pathophysiologic and psychologic considerations. The former is mainly of theoretical interest to biology in general, the latter is of practical importance as well, because of the right of everyone to approach the end of a full life with dignity and without undue suffering.

How much ECCM centers should pursue the *prevention* of acute illness or injury would depend on the interests and resources of individual investigators. Certainly, the study of mechanisms of dying and crippling (e.g., in trauma) should lead to recommendations on prevention (e.g., automobile and highway design).

All these topics and questions need multidisciplinary approaches. Topics (3), (8), and (12) would benefit from the input of philosophers, theologians, sociologists, lawyers and economists, while topics (1), (8), (9) and (10) need the talents of government and public health officials, educators, community developers, engineers, and other non-physicians.

FUNDING

I have recommended that the federal government invest approximately $100 million over the next ten years (about $10 million/year) with about $1-2 million per year for each of five to ten institutes or centers. Viewed in perspective, this is a rather modest sum to dedicate to some of the most humanitarian aspects of inquiry, when compared with the vast expenditures wasted on armaments, bureaucracy, and misdirected research.

ECCM institutes would require multiple funding sources. Long-range funding for at least ten years is essential to give continuity and security to committed investigators. Such long-term funding could come from various sources. If the EMS Systems Act of the HEW has longevity, it should support core budgets for these centers. Research projects or programs could be funded by a joint commitment of the National Institutes of Health and the National Science Foundation, symbolizing the need of cross-fertilization of the life sciences with the physical sciences.

Center grants would permit joint laboratory and backup services for several projects. Unfortunately, most NIH support has been directed toward organ-oriented research; studies on multiple organ failure still do not have a fiscal home in the federal grant framework. ECCM does not have a stable and committed base for research support at the federal level. Acute medicine-related research is supported by the NIH Institutes of General Medical Sciences, Heart and Lung, and Neurological and Communicative Disorders and Stroke; the Armed Forces, the EMS Systems Act of HEW (if renewed); and some private agencies. Anesthesiology research centers of the NIGMS include "resuscitation and intensive care," but are inadequate in number, ECCM orientation, and funds. Since a recent policy statement negates the establishment of new NIH institutes or sections, solid funding of multiple systems-oriented ECCM research should be made administratively possible within the existing structure, by combining funding from several programs.

In addition to stable long-term funding, there should also be provision for rapid and flexible short-term funding to permit imaginative investigators to pursue pilot projects immediately, without having to go through enervating, frustrating, time-consuming applications for priming funds. Such necessary speed and flexibility are not provided at this time by any funding mechanism of government, and private sources are scarce and unpredictable.

While some of the centers' faculty could earn some funds through clinical and/or laboratory services, evaluations or teaching, such distractions from the research mission can become self-defeating. Therefore, service commitments must not become the primary basis of fiscal support.

Philosophic Conclusions

So long as the *evolution* of life is viewed merely as a statistical matter, species-oriented, resuscitation of a few individual humans assumes trivial significance. The increasing change from a species-oriented toward an individual-oriented society, however, makes resuscitation evolutionarily positive, as long as restoration of human mentation (i.e., brain function) is its ultimate goal. Reanimation of those whose dying occurs from potentially reversible conditions imposed by the arbitrary mischances of Nature, before they have had time to live "full lives," indeed supports the evolution of human values. Those who fear that resuscitation of a handful of the "unfit" will exert a negative impact on evolution of the species might better concern themselves with eradication of war, violent crime, and man-made disasters which destroy primarily the young and fit.

Science and medicine, products of the cultural evolution of man, have influenced and should continue to influence, human values. Research on the mechanisms of dying and its reversibility — to date less advanced than research on the beginnings of human life — should be fostered, not only for medical and public health reasons, but also for the acquisition of new knowledge per se. Socrates said, "The unexamined life is not worth living." I might add that only the examined death is worth fighting or accepting.

But, quite aside from evolutionary and scientific considerations, resuscitation implies a commitment on the side of life. For to devote one's energies to the restoration of lives cut short before fulfillment is to assert that life is of inestimable value. And while the therapeutic impact of resuscitation may affect only a few, the *moral impact* of this endeavor and the commitment it represents may have a much broader influence in a world where life has too often been regarded as cheap.

Medicine in general and ECCM in particular require research programs which will transfer these ideals and commitments into concrete action in patient care. The ECCM research institute offers an environment where advances in both the technical and humane aspects of critical care may be stimulated and accelerated.

The focus of our efforts is Homo sapiens — with a healthy mind in a healthy body. This applies to our patients, our students, and ourselves. With high goals and routes chosen on the basis of reason and compassion we can support human evolution.

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THE ROLE OF THE AMERICAN COLLEGE OF EMERGENCY PHYSICIANS IN EMS MANPOWER

Harris B. Graves, M.D.

The American College of Emergency Physicians is an organization of some 7,600 physicians actively interested in emergency medicine. With members in every state in the union as well as several Canadian provinces and a number of other foreign countries, ACEP is truly international in scope. Since its inception in 1968, the college has shown remarkable growth and viability. Indeed, the past twelve months have shown the largest growth percentage of any period in its short history.

ACEP is dedicated to better emergency care and believes that proper education and training of physicians is an essential element in the improvement of that care. To that end, the college has always devoted a major amount of its energy and programs towards undergraduate, graduate and postgraduate medical education. One of the requirements for membership in ACEP is 150 hours of continuing medical education each three years. ACEP has established rigid standards governing the acceptability of programs that our members attend for continuing medical education credit. These requirements have recently been made more explicit and more stringent so that our members may be assured of excellent quality courses in emergency medicine. The recording of our members' attendance at meetings has been computerized and each member will be notified annually of his status.

The college perceives the role of the emergency physician to be one of leadership in the organization and management of hospital emergency departments. In addition, we see the emergency physician's responsibility extending into all areas that have impact on the provision of competent, efficient and compassionate care to the patient in need.

The emergency physician is often the point of entry into the health care system for millions of Americans. In 1975, more than 70 million emergency department visits were recorded.

The emergency physician, working either by contact with the patient's own physician or by referral to an appropriate physician for in-hospital or office care, is a vital part of this important health care system. As provider of first care to the seriously injured and acutely ill, the emergency physician must be trained in the recognition and management of such problems.

In addition, the emergency physician should be actively involved in emergency medical services councils and community disaster plans. He should have a key role in the training of emergency medical technicians, nurses and the general public. In cooperation with other medical specialty areas, the emergency physician can help provide the finest emergency care available anywhere in the world.

The college has, from its beginning, provided high-level postgraduate education programs for its members and has cooperated with other organizations, particularly the Emergency Department Nurses Association, to present a broad spectrum of educational programs in emergency medicine.

It has been estimated that there are 15,000 physicians practicing emergency medicine today. There is a pressing need to properly educate and train emergency physicians to provide adequate 24-hour a day coverage that will be available to every American, wherever he or she may live.

The vast majority of today's emergency physicians are in their "second career" and have received their training in emergency medicine "on the job" or through continuing education seminars. It is readily apparent that as these physicians retire from active medical practice they must be replaced. They should be replaced by physicians trained in the domain of emergency medicine by educators experienced in emergency medicine.

There are, at the present time, 35 residency programs in emergency medicine with approximately 185 residents in training.

Standards for emergency medicine residencies were approved by the A.M.A. House of Delegates in June of 1975 and are now being applied by the Liaison Residency Endorsement Committee, which is a combined function of the American College of Emergency Physicians and the University Association for Emergency Medical Services. In the meantime, these standards have been referred to the Liaison Committee in graduate medical education of the A.M.A. to be used in developing essentials for an A.M.A. approved residency program.

It is our opinion that there is an immediate need for at least a three-fold increase in the number of emergency medicine residency programs. Some present residency programs report as many as 100 applicants for each available position. This need must be resolved if we are to provide adequate emergency care for all who need it.

Along with the development of residency programs, and in accord with ACEP's desire for excellence in emergency medicine, must come a mechanism for the certification of competency in emergency medicine.

The American College of Emergency Physicians has been working for the past two years to develop an innovative examination to certify emergency physicians. A contract to develop this examination has been given to the Office of Medical Education, research and development of Michigan State University and it is believed the examination will be available for use by the fall of 1977.

In March of 1976, an application was presented to the American Board of Medical Specialties asking that emergency medicine be named as primary specialty. In accord with that application, the American Board of Emergency Medicine has been founded. We will, of course, eagerly await the results of that application.

Much has been done in emergency medicine in a very short time. Equally as much remains to be done. The American College of Emergency Physicians stands ready to fulfill its obligations to American medicine and to the American public.

EMERGENCY MEDICAL SERVICES AND THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

Charles A. Rockwood, Jr., M.D.

While one of the primary goals of The American Academy of Orthopaedic Surgeons is the continued education of its members, it was 1964 when the Committee on Injuries instituted plans for the education of ambulance personnel, firemen, policemen and other emergency care attendants. The first three day Emergency Medical Care Course was held in Portland, Oregon in 1964, and through 1975, 100 courses have been given to 12,260 emergency medical personnel. In 1967 the Committee on Injuries began development work on a standardized manual for use in the courses, and in 1971 the text entitled, "Emergency Care and Transportation of the Sick and Injured" was published. Accompanying the text was a set of 1600 2 x 2 teaching slides and a descriptive syllabus which was coordinated for use with the 58 chapters of the text.

In 1969, the Academy continued its interest in EMS by co-sponsoring the Airlie House EMS Conference with The American College of Surgeons. The American Academy of Orthopaedic Surgeons was an active participant in the 1971 AMA Categorization Conference and an early and continuous representative to the AMA's Commission on Emergency Medical Services. The Committee of Injuries, in 1971, sponsored a "National Workshop on the Training of Emergency Medical Technicians." In attendance were representatives of the major medical and governmental organizations involved in EMS, and the proceedings were published by the U.S. Department of Transportation in 1972. In 1974 the committee published the essential equipment list for the Department of Transportation's "Crash Injury Management" course and has given active support to the development and growth of the National Registry of Emergency Medical Technicians and the American Trauma Society.

In cooperation with the U.S. Department of Transportation, a complete EMS training package is available in Spanish. This includes translations of the Emergency Care Text, the set of teaching slides and syllabus, the Course Guide and the Instructor's Lesson Plans.

Because the Academy has had primary interest in the education and continuing education of the Emergency Medical Technician, a second edition of the Emergency Care Text was produced in the fall of 1976. Accompanying this second edition is a "Student Workbook" designed, through the use of goals, objectives and multiple questions, to aid the student with his learning process.

BURN HEALTH SYSTEM: PRE-HOSPITAL EMERGENCY DEPARTMENT AND HOSPITAL PHASES

Richard F. Edlich, M.D., Ph.D., George T. Rodeheaver, Ph.D., James W. Fox, IV, M.D., Gerald T. Golden, M.D., John M. Hiebert, M.D., Mary S. Allen, B.S., R.N., and Milton T. Edgerton, M.D.

The Emergency Medical System in the Commonwealth of Virginia is faced with increasing numbers of critically ill patients with burns. Each year, more than 200 lives are lost in this state as a result of this injury. Today, many of these lives might be saved if a system of health care is designed and implemented to care for these seriously ill victims of fire. To this end, guidelines for a burn health care system have been devised. In this system, personnel, facilities and equipment are coordinated to deliver optimal health care to burn victims. An organized systems approach to the burn victim involves three phases of patient care: prehospital, emergency department and hospital.

Prehospital

Care of the critically ill patients at the scene of an injury is provided primarily by rescue squad personnel in the Commonwealth of Virginia. Most of the ambulance personnel in this state are capable of delivering basic life support using specific non-intervention treatment (fracture stabilization, hemorrhage control, etc.). Only a few communities in Virginia have progressed to an Advanced Life Support System that has a more sophisticated level of operation which can successfully identify and agressively treat life threatening emergencies and shock. As a result of this, the guidelines for the prehospital treatment of the burn victim have been developed for the Emergency Medical Technician Ambulance (EMT-A) rather than the extensively trained EMT-paramedic. The guidelines have been prepared in pamphlet form and distributed to all rescue squads in Virginia.

CARE OF THE BURN PATIENT AT SCENE OF THE INJURY

1. Stop the Burn Process

Extinguish the fire by rolling the victim on the ground. Remove clothing from and around the burned area. Do *not* remove burned clothing that is tightly adherent to the underlying skin and tissue.

Treat Breathing Difficulty

The most common cause of airway obstruction in the unconscious burn patient is the tongue. An airway obstructed by the patient's tongue can be opened by hyperextending his neck. The major cause of death as a result of a fire is asphyxiation. The asphyxiated burn patient will have considerable difficulty breathing. Inhalation of toxic fumes by the victim may also result in respiratory problems. Fires occurring indoors result more often in inhalation injuries than outdoor fires. With the patient's neck hyperextended, *look* for a rise in the patient's chest, *listen* for breath sounds, and *feel* the patient's breath against your cheek. If breathing is not detected, the rescuer must begin mouth-to-mouth resuscitation. If the patient is breathing, look for signs for inhalation injury. These are singed nasal hairs, sooty sputum, brassy cough, and an increased respiratory rate (more than 16 breaths per minute). If one or more of these signs are present, administer oxygen via a reservoir mask at a rate of 10 to 12 liters per minute. If possible, the oxygen should be humidified.

3. Establish Circulation

The rescuer must then palpate the patient's pulse (the carotid or femoral artery). If the pulse is absent, begin cardiac compression. Victims of an electrical burn often have no palpable pulse as a result of electrically induced ventricular fibrillation. In these cases, make sure the victim is no longer in contact with the energized electrical current before attempting resuscitation. The current should be switched off, if possible, or a long *dry* wooden pole may be used to separate the victim from the power source.

4. Prevent Burn Shock

As a result of the burn injury, there is considerable loss of intravascular fluids from the vessels of the burn wound that may result in burn shock. Signs of shock are low blood pressure (systolic blood pressure less than 90mmHg) and a rapid pulse rate (more than 100 beats per minute). Treatment of burn shock includes elevation of the patient's feet, humidified oxygen and reassurance.

5. Perform History and Physical Examination

Determine the mechanism of burn injury (i.e., thermal, chemical) and estimate the depth of the burn (Table 1). The extent of the body surface involved in a burn injury is commonly estimated by the "Rule of Nines" (Figure 1). This is accomplished by dividing the major anatomic portions of the body into multiples of 9 percent of the major body surface area. This is not a precisely accurate method of measuring body surface area, but more exact measurements are so complicated that they have little practical value. In estimating the extent of the burn, individual anatomic areas such as the arm or head must be calculated separately and the total derived from the simple addition of the different areas. The small difference between the surface areas of the adult and the infant reflects the surface area of the infant's head which is

TABLE 1

Depth of Burn	Appearance of Skin	Sensation
Full thickness	White, brown, leathery with clotted vessels	Absent
Partial thickenss	Red with blisters	Present

(This work is supported in part by DHEW Grant No. 08-A-000023-01-0).

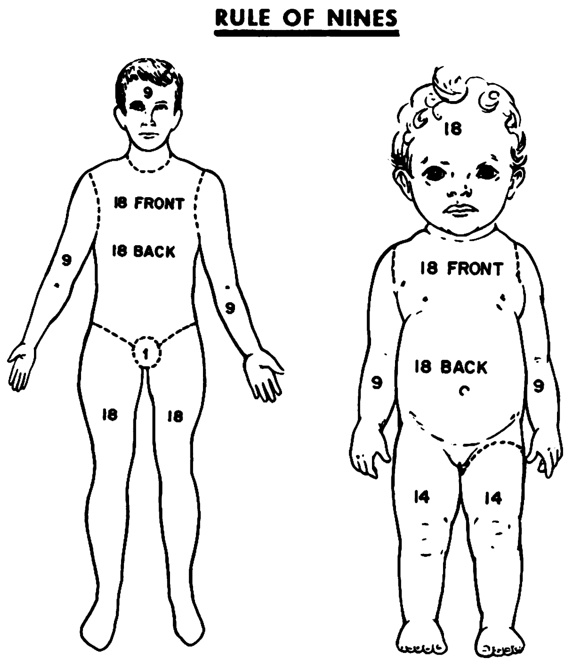

FIGURE 1: The extent of body surface involved in a burn injury is commonly estimated by the "Rule of Nines."

proportionally larger than that of the adult. Before searching for other injuries, remove all clothing and jewelry, especially rings, from the burned limb.

6. Prevent Chilling of Patient

The burn patient will usually complain of being chilled and cold as a result of the loss of heat from the burned skin. This heat loss can be minimized by first placing a clean sheet under the patient and then covering the patient with another clean sheet followed by clean blankets. The inside of the transport vehicle should be heated enough to make the victim comfortable.

7. Relieve Pain

Apply towels wet with cool water to painful partial thickness burns. Cooling of the burn surface should be limited to less than 10 percent of the body surface area. Surface cooling of a larger burn surface area results in a dangerous drop in body temperature. Ice should never be applied to burns, since it may produce frostbite.

8. Contact Hospital Base Station

Pertinent information to be communicated should include the patient's age and sex, mechanism of burn, location of the burn, respiratory rate, pulse rate, blood pressure, as well as other injuries.

Emergency Department

Precisely at this juncture, the patient must arrive at a hospital emergency department that can establish and maintain the patient's life support systems following the initial care given at the scene and en route. The personnel in the Emergency Department must be prepared to undertake the specific interventive measures (endotracheal intubation, nasogastric intubation, intravenous therapy) necessary to stabilize the severely burned patient. Guidelines for the initial care of the severely burned patient in the Emergency Department have been distributed in poster form to all hospitals in Virginia (Figure 2).

1. Treat Breathing Difficulty

Swelling of the larynx is usually a late cause of airway obstruction (8 to 24 hours after burn injury). In this event, preferably nasotracheal intubation may be attempted. If difficulties are encountered in performing intubation, tracheostomy is necessary to maintain a patent airway. The compressive effect of neck eschar may also contribute to the breathing difficulty. In the absence of a tracheostomy, the tight eschar of neck skin accentuates pharyngeal edema and draws the neck into flexion compressing the pharyngeal airway. A vertical incision from the sternal notch to the chin will relieve this compressive eschar. Escharotomies are performed without local anesthesia.

Respiratory embarrassment may be caused by a constricting eschar of the anterior thorax that limits respiratory excursion. Escharotomy is imperative in this situation. Lateral incisions are made that extend from 2 cm below the coronoid process along the anterior axillary line to 2 cm below the eleventh rib. The top and bottom of the incisions are joined transversely so a square is formed.

Inhalation of toxic fumes is another cause of breathing difficulty. Respiratory difficulties secondary to toxic fumes may be alleviated by nasotracheal intubation. In the event of continued respiratory embarrassment despite intubation, positive pressure ventilation is indicated. If arterial blood gas measurements are available, they may be used to confirm the necessity for nasotracheal intubation and mechanical ventilatory support. These measurements should be made after the patient breathes room air for at least 3 minutes. The presence of arterial pO_2 that falls below 80 mmHg combined with the clinical symptoms consistent with respiratory embarrassment confirm the need for intubation.

2. Establish Circulation

Advanced life support measures will be necessary for patients with electrical burns with cardiopulmonary complications (ventricular fibrillation, etc.).

3. Prevent Burn Shock

The cardinal feature of thermal injury is an accumulation of fluid within the injured area and to a lesser degree in unburned skin. Capillaries and venules become immediately permeable to allow large size molecules to leak from the circulation at a rate similar to that of the smaller albumin fractions. Capillary integrity is restored 24 hours later, after which colloids can be administered.

Patients with burns of the following sizes require fluid resuscitation: children 0-10 yrs > 10%, adults 11-50 yrs > 20%, and elderly > 51 yrs > 10%. Administer Ringer's Lactate without glucose intravenously through a percutaneous plastic catheter inserted in a hand or forearm vein. When an intravenous line is started, it is essential to ensure that it is not dislodged during transport and that the calculated amount of fluid is infused. If it is anticipated that the percutaneous catheter may be dislodged in transit, insert a plastic catheter through a cutdown site. A cutdown through burned skin would be preferred rather than starting the intravenous in the leg or using scalp vein needles.

Administer 2 ml of Ringer's Lactate x weight of patient in kilograms (2.2 lbs = 1 kg) x % Burn Surface Area (Rule of Nines) in the first 8 hours *after time of injury*. It is important

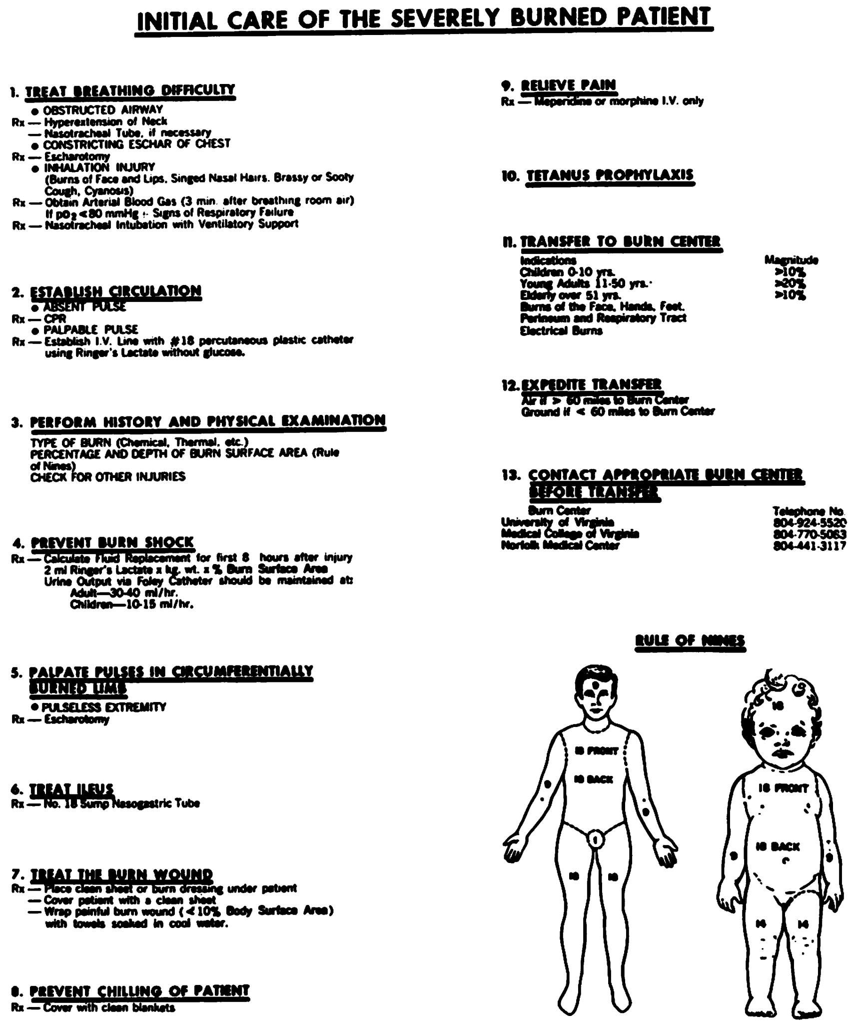

FIGURE 2: Burn poster.

to emphasize that considerable intravascular fluid may be lost into the burn wound before the patient is transported to the emergency facility. This fluid loss must be calculated and replaced immediately with Ringer's Lactate once the patient with a major burn arrives at the emergency facility. The residual calculated intravenous fluids are administered over the remaining part of the 8 hour time interval.

The adequacy of fluid resuscitation is determined by monitoring urine output every hour via Foley catheter. Urine output should be maintained at 40 ml/hr for adults and 10-15 ml/hr for children.

4. Palpate Pulses in Circumferentially Burned Limb

Full thickness burned skin has a leathery consistency which resists stretch. When edema develops beneath a circumferentially burned extremity, the leathery skin exerts a tourniquet-like effect on the extremity embarrassing its circulation. Progressive loss of sensation or impaired joint proprioception are reliable clinical signs of vascular insufficiency. If this complication seems likely, escharotomy through the burnt skin can restore the embarrassed circulation. Anteriolateral and anteriomedical incisions are carried over involved joints, avoiding the superficial vessels whenever possible.

5. Treat Ileus

In patients receiving fluid resuscitation, a No. 18 nasogastric (sump) tube should be inserted. The tube should be attached to continuous suction (40 mmHg).

6. Care of Burn Wound

A clean sheet or non-adherent burn dressing should be placed under the patient. The patient should be kept warm by first covering him with a clean sheet followed by clean blankets. Intact blisters should be left alone. The burn wound should not be contacted by either ice water, ice or ointments.

7. Relieve Pain

The requirement for sedation is inversely proportional to the depth of the burn. The intrinsic sensory nerve endings of full thickness burns are destroyed, leaving them painless. In contrast, the partial thickness burns have intact nerve endings and are painful. In patients with partial thickness burns, analgesia can provide considerable relief. Once the patient's condition has stabilized, narcotics may be administered by an intravenous route over a 4 to 5 minute period to assure predictable

TABLE 2: Guide to Tetanus Prophylaxis in Burn Patients

History of Tetanus Immunization (Doses)	BURN WOUNDS Tetanus and Diptheria Toxoid ("Td") (Adult Type)	Tetanus Immune Globulin (Human)
Uncertain	Yes	Yes
0-1	Yes	Yes
2	Yes	No[1]
3 or more	No[2]	No

[1]Unless burn more than 24 hours old

[2]Unless more than 5 years since last dose

When tetanus toxoid and globulin are given concurrently, separate syringes and separate sites should be used.

action. Narcotics should be given cautiously since they can depress respiratory and cardiac function.

8. Tetanus Prophylaxis

Dead burn tissue supports the growth of *Clostridium tetani.* For that reason, tetanus prophylaxis is essential in all burn patients, but may be deferred until the patient reaches the Burn Center (Table 2).

9. Transfer to Burn Center

The extent of the total body burn and the age of the patient serve, in part, as guidelines for the selection of a treatment facility to which the patient is sent (Table 3). The mortality of the burn patient is directly related to the size of the burn. The young adult (10 to 50 yrs of age) tolerates a thermal injury somewhat better than any other age group. The 51+ age group shows the least tolerance for burn injury and must be given special consideration. Since children with major thermal injuries frequently fail to respond normally to the initial burn therapy, their refractoriness to care necessitates treatment in a specialty burn care center.

Even though the depth of the burn exerts considerable influence on patient outcome, its influence on patient triage is often minimal since it is difficult to determine accurately soon after injury. Assessment of the depth of injury can usually be accomplished two to four days post-burn.

The extent of the burn, in terms of burn surface areas, is meaningless as an index of severity in burns in special locations. Patients with burns of either the face, neck, hands, feet or genitalia are serious burns that necessitate treatment at a specialty burn center. Fractures associated with thermal injury also deserve special care and the presence of a burn necessitates modification of fracture management.

The mechanism of burn injury is another important triage consideration. An electrical burn injury is a case in point which demands management in a specialty burn center. This injury is unique to the field of burn care in that underlying tissue destruction is usually considerably more extensive than the skin injury. For that reason, the quantity of fluid sequestered in areas of electrical injury is often grossly underestimated. In addition, electrical injuries often result in multi-system derangement. Bone destruction, nervous system injury, eye damage, renal dysfunction and cardio-respiratory complications are frequently encountered. The sequelae of electrical injury may occur as long as one to three years after injury, emphasizing the delayed effects of the injury.

TABLE 3: Indications for Transfer to a Burn Center

Age of Patient	Size of Burn (% Body Surface Arra)
Children 0 - 10 yrs	>10
Adults 11 - 50 yrs	>20
Elderly over 51 yrs	>10

10. Expedite Transfer

When the emergency department facility is less than 60 miles from the specialty burn center, the patient is transported by ambulance. Fixed wing air transport utilizing a commerical airline is accomplished when the distance between the burn center and the Emergency Department is greater than 60 miles.

11. Contact Appropriate Burn Center Before Transfer

Three burn centers are located in the Commonwealth of Virginia which are prepared to care for the severely burned patient. The telephone number of each center is listed on the burn poster. The referring physician is requested to contact the personnel at one of the burn centers prior to transfer of the patient. This advanced warning is essential to assure that the patient's condition is stable enough to permit transfer. A contraindication to transfer is, of course, failure to respond to a well-planned resuscitative program as a result of other injuries that demand more immediate attention than the thermal injury. Prior to transfer, the physician completes a transfer medical record which accompanies the patient en route to the Burn Center.

Specialty Burn Center

Regionalization of care has important implications for the burn victim. In each locale, the physicians must decide the magnitude of burn injuries which they are equipped to treat and those that they are prepared to transfer to a specialty burn center for proper definitive intensive care. A specialty burn facility is directed by a board certified general or plastic surgeon, assisted by a full-time multidisciplinary staff (nurses, social workers, psychologists, psychiatric nurses, physical therapists, occupational therapists, teachers) dedicated to burn care. Management of the victims of thermal injury is accomplished in an identifiable ward with adjacent hydrotherapy facilities. In addition to care, there is a special emphasis in a burn center on research and teaching which are conducted by a team of basic science and clinical investigators. The intensive care environment of a burn center is an ideal classroom for the student interested in the complexities of burn care and for the investigator who examines the many unanswered and challenging problems involved in the management of the severely burned patient. Educational programs coordinated by the burn center staff focusing on burn prevention provide an excellent opportunity for consumer participation in the burn health care system. The therapeutic regimen employed at our medical center is designed to correct the main pathophysiologic consequences of the burn injury.

As a result of thermal injury, the skin undergoes coagulation necrosis and becomes susceptible to assault by the host microorganisms. Normal skin not subjected to thermal injury contains relatively few bacteria except in the anatomically vulnerable perineum. Subsequent to burn injury, the skin bacteria proliferate and colonize in the superficial layers of skin, increasing to 100,000 bacteria per gram of tissue by 48 to 72 hours after thermal injury. At this level, they begin to invade adjacent subcutaneous tissue resulting in burn wound sepsis. It is axiomatic, therefore, that early excision of the burn eschar with immediate coverage of the wound is the goal in each patient, since it closes the major portal of bacterial entry.

In the early post-burn period, removal of areas of full thickness burn by excisional therapy is employed and the resultant defect immediately covered by autograft. Aggressive removal of full thickness burnt skin of up to 20 percent of body surface area is accomplished at each operative procedure. This excisional therapy is repeated every third day. Hypotensive anesthesia is routinely used to minimize blood loss. Excision of the burn wound is carried down to muscle fascia in all regions of the body except the perineum, face, hands and feet. For burns of the hands and feet, the eschar is tangentially excised followed by immediate coverage of the underlying dermis with autograft skin. When the burn wounds are large and the donor sites limited, it becomes necessary to stretch the available donor sites for complete autograft wound coverage. The skin can be meshed with a Tanner-Vandeput machine so that the initial sheet of skin can be extended in length several times its original length. In patients with a large thermal injury in which the meshed skin does not cover the defect, allograft skin is employed as a temporary skin dressing. The continual need for allograft skin in a burn center must be met by the availability of donors. Processing of the skin to permit prolonged storage becomes, therefore, an essential part of the burn health care system. Topical antibacterial agents are employed to suppress the growth of bacteria growing in the residual unexcised eschar. The selection of the appropriate topical antibacterial agent is based upon the results of immediate antibiotic sensitivity testing.

Hypermetabolism, weight loss and severe protein wasting characterize the metabolic response to a burn injury. Catecholamines appear to mediate the response by increasing energy production and by interacting with insulin and other hormones to promote loss of intracellular constituents. As a result of this catabolic state, loss of body weight occurs following injury. Associated with this weight loss is diminished resistance to infection, an invitation to burn wound sepsis. This weight loss can be diminished or essentially prevented by vigorous enternal-parenteral nutritional support following injury.

Contractures and hypertrophic scars are the two most common sequelae of the healing wound after thermal injury. The burn wound heals in a manner that favors the development of these complications, the position of comfort of the burn patient being the position of contracture. These deformities can be reduced considerably by positioning and splinting in the pregrafting phase, and by splinting with custom-formed splints and continuous and controlled pressure utilizing elastic support in the post-grafting phase. These custom-made splints are designed and developed by specially trained occupational therapists.

Evaluation of our treatment methods is being accomplished by the National Burn Information Exchange (NBIE), which is an organization designed to collect and analyze data on all aspects of burn care. There are 91 burn centers, units and programs that analyze their patient records and send data to the NBIE. Even though each member of NBIE follows a consistent plan or program for burn treatment, they do not employ the identical treatment methods. When sufficient data are accumulated on each method to permit comparison, the benefit of the treatment modalities can then be identified using morbidity and mortality as outcome measures.

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VALUE OF TELEMETRY

Costas T. Lambrew, M.D.

Death from acute coronary events is primarily due to arrhythmia with progression to cardiac arrest in most instances through the mechanism of ventricular fibrillation. The central concept of prehospital emergency cardiac care is, therefore, early monitoring of the electrocardiogram for disturbances and stabilization of rhythm through use of appropriate drugs so as to prevent the development of cardiac arrest. Stabilization of the patient at the scene of the incident and enroute to hospital through development of the Mobile Cornonary Care Unit (MCCU) has resulted in increased survival from cardiac arrest, a decrease in frequency of occurrence of ventricular fibrillation, decrease in hospital mobidity and mortality from myocardial infarction, as well as a decrease in community mortality from coronary artery disease.

In most areas of the United States it is not possible to staff the MCCU with physicians. The use of paraprofessionals, commonly known as paramedics, trained to advance life support capability has been found to be effective in the experience of nearly 200 such programs throughout the United States. Medical supervision of the activities of these paramedics in most instances is provided by a voice communications capability between the paramedic in the field and the supervising physician in conjunction with a treatment protocol. In view of the critical importance of electrocardiographic monitoring to effective emergency cardiac care, telemetry of the electrocardiogram has been used as an adjunct to voice communications for the purpose of medical control. There is universal agreement that the electrocardiogram must be monitored for rhythm at the scene of the incident and en route to the hospital. There is, however, considerable disagreement as to the necessity or value of telemetry of these electrocardiographic signals to the supervising physician for interpretation. Some physicians maintain that the well trained paramedic is capable of interpreting disturbances or rhythm with enough accuracy to justify his reporting them by voice and initiating therapy on this basis without requiring telemetry of the electrocardiogram to the supervising physician. They furthermore feel that development of the capability for telemetry of biological signals presents significant technical obstacles, is unreliable and imposes an inordinate financial burden on the medical communications system. I would submit that the capability for telemetry of biological signals is an invaluable adjunct to the delivery of optimal prehospital emergency cardiac care.

It is universally acknowledged that coronary care nurses and paramedics can become quite good in arrhythmia recognition. Their expertise is not only a result of their initial training but in the case of the coronary care nurse and the paramedic in an urban program carrying a large volume of patients, also a reflection of reenforcement of training through frequent exposure to the monitoring of arrhythmias. However, since there is frequently a considerable range of disagreement between cardiologists in the interpretation of abnormal electrocardiograms; including rhythms, we cannot expect the paramedic treating the patient in the field, often under stressful conditions, to perform at the level of a physician in this regard. Indeed, in rural areas where frequency of exposure to the need to monitor rhythm may be low, and elapsed time from the onset of the acute problem to arrival in the hospital long, interpretation of the electrocardiographic changes by supervising physician becomes almost mandatory if we are to expect optimal care. Even in a busy urban program, however, the good paramedics feel most comfortable when their observations are confirmed by physicians. This is not only true of volunteer rescue personnel but also of full time salaried personnel. Furthermore we could not utilize volunteer rescue personnel in such programs without telemetry capability since the period of training required to give them an acceptable ability in arrhythmia analysis and to maintain this ability would be beyond the time available to them. We would acknowledge that what is done to stabilize the patient early after the onset of symptoms of an acute coronary event or in the early stages of any acute illness or injury may be the critical determinant of subsequent morbidity and mortality.

Therefore, if we consider the need of the patient in the prehospital phase, it is essential that the training and judgement of the physician be brought to bear in the care of the patients. The paramedic is not a physician but can effectively function as the eyes, ears and hands of a physician. The availability of telemetry gives the physician the capability to critically evaluate patient requirements at the time of the emergency. Retrospective analysis of electrocardiographic interpretations may provide some evaluation of the paramedics capability, but has no impact on what was done for the reviewed patients during the acute phase of the illness.

In most prehospital MCCU programs telemetry has been utilized primarily for rhythm analysis of a single lead of the electrocardiogram. The emphasis as in coronary care units has been early detection of arrhythmias and stabilization of rhythm through administration of appropriate drugs. This limitation may be rather myopic. We are coming to recognize that preservation of ischemic myocardium is an extremely important aspect of emergency coronary care. Definitive intervention in this regard may be especially important when the time required to bring the patient to the hospital is prolonged. In this event monitoring of the twelve leads of the electrocardiogram, as well as other biological signals such as pressures would be necessary, as would telemetry of these signals to the supervising physician. Intervention such as this cannot be governed by rigid protocol but must reflect the judgement of a physician based on as much objective data as possible.

Some critics have noted that problems imposed by terrain and immature technology prevent the effective incorporation of telemetry into their communications system or make the cost of doing so prohibitive. However, the technology that would allow transmission of high quality biological signals has existed for a considerable period of time. In most instances problems with transmission of biological signals are not a reflection of an immature technology but of inadequacies in systems design. An inordinate cost usually is reflection of unnecessary engineering imposed upon the communications plan by a well meaning but uneducated physician or systems administrator or by an eager manufacturer. A base station at every receiving hospital in a region not only fragments communications coordination and promotes competition for frequencies but also adds significantly to cost. There is agreement that establishment of an ultra high frequency (UHF) communications network that links the emergency technician in the field and in the ambulance to receiving hospitals is mandatory. If this be the case then there should be no difficulty in superimposing the capability for telemetry of biological signals on this network at relatively modest cost. This would require a monitoring console at a single regional base hospital at a cost of approximately five to six thousand dollars and a telemetry module in each rescue vehicle at a cost of approximately $1,000 per vehicle if the engineering is kept as simple as it should be. Electrocardiographic monitor, defibrillator and radio must be available in any event. If we consider the money that is wasted on inappropriately elaborate vehicles and unnecessary equipment then there is no validity to objection to telemetry based on inordinate expense. Telemetry of biological signals can open new horizons in the area of advanced prehospital care.

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ASSESSMENT OF PREHOSPITAL EMERGENCY CARDIAC CARE: ACQUIRING A DATA BASE FOR EVALUATION OF COMMUNITY WIDE IMPACT.

Richard S. Crampton, M.D., F.A.C.P., F.A.C.C.

Introduction

The prehospital component of the emergency medical services system, analyzed for the influence of prompt preventive treatment and prompt resuscitation in the acute coronary attack, has halved ambulance fatalities, prevented clinical deterioration, and reversed cardiac arrest before and during ambulance transport. Prehospital care of the airway with and without cannulation has reduced hospital intensive care stay and duration of hospitalization. Both prehospital treatment and resuscitation have reduced prehospital, hospital, and community morbidity and mortality from coronary disease. Long-term lifesaves attributable to prehospital resuscitation have ranged from 5.8 to 8.6 per 100,000 people. In those aged 30-69 years, the lifesaves totaled 13.4 per 100,000 people. A careful definition of the coronary syndromes preceding sudden death has led to acute prevention and prompt resuscitation. Meticulous study of the survivors of prehospital cardiac arrest has shaped logical plans for long-term medical and surgical treatment. Furthermore, at low cost to the community, prehospital basic and advanced cardiac life support has yielded high benefits in saved livelihoods.

Sources

To collect data, one must identify useful sources and build in reliable automatic crosschecks. Assessment of short- and long-term outcome for cardiac patients begins with inspection of the ambulance-patient interface. Sources include the dispatcher's log, the clinical record of the emergency medical technician, strip chart record of the electrocardiogram, tape record of the electrocardiogram in systems using radio telemetry and telephone transmission, and tape record of voice communication. To provide the best in clinical care and relevant information, the emergency medical technician's clinical record should enter the patient's hospital chart.

The hospital's major useful records come from the emergency department, cardiac intensive care unit, operating room, convalescent center, and pathology department. In the emergency department, the clerk's log and clinical record from the hospital chart provide names and initial triage diagnoses for identification of cardiac emergencies. In the cardiac and other special care units, the admission log and clinical records are important. The electrocardiogram with recorded dysrhythmias, presence or absence of new Q waves, active S-T and T wave changes, and its correlation with cardiac isoenzymes to distinguish cardiac from skeletal muscle injury are needed to rule in or out the diagnosis of myocardial infarction. In the pathology department, autopsy correlation with the clinical picture of the emergency event with proof of cardiac anatomical abnormality excludes or includes those individuals with chronic or terminal illness who are not candidates for resuscitation despite sudden cardiac arrest.

The medical examiner's office provides autopsy and death certificate to correlate with each decedent's clinical picture and the population survey of the community. Members of the family, friends, co-workers, and eyewitnesses should be interviewed about the sudden collapse or sudden cardiac death, particularly those individuals who have observed the decedent in the 24 to 48 hours before death. These individuals should be questioned even if they did not actually witness the sudden death. Physicians and other medical professionals in contact with the patient in the month before death should be identified and interviewed.

Measuring Outcome

When emergency episodes confronting the prehospital cardiac care system are reviewed, the quality of preventive treatment in crisis intervention and the long and short term outcomes provide the best indices of the impact of prehospital basic and advanced life support. Success and failure at all levels of the emergency medical services system must be identified. While prospective observation of comparable subjects receiving and not receiving prehospital basic and advanced life support obviously might yield the highest quality data, such observations are more often than not made before and after upgrading prehospital care. The ethics of human experimentation make it very difficult to enforce random prehospital selection of patients for status quo emergency care and for high quality basic and advanced life support. Those patients treated for acute myocardial infarction outside the hospital by a cardiac emergency care team have shown an 8 to 10 percent hospital mortality. In contrast, those hospitalized by conventional ambulance service or left at home had an 18 to 26 percent mortality.

In the ambulance, outcome should be related to whether or not resuscitation and drugs or procedures to avert cardiorespiratory arrest were needed. Those individuals dead upon arrival of the emergency technician at the prehospital scene should be clearly noted. The conduct and circumstances of resuscitation outside hospital should be clarified. It should be noted if basic life support was started before or after arrival of emergency personnel by trained or untrained individuals, health care professionals, or others. If ventricular fibrillation was present, did transthoracic electrical countershock remove it? Was another cardiac rhythm established? Was mechanical cardiac action restored? Annotations about the airway should include the level of consciousness of the patient, whether or not the airway was obstructed, and whether noncannulated or cannulated, whether endotracheal or esophageal should be recorded. A list of the drugs used with doses given should be recorded. If prehospital resuscitation failed, the time and location of failure should be noted.

In the individual resuscitated outside the hospital and dying during ambulance transport, the record should read dead on arrival at the emergency department. This should be a rare event because worldwide par for mobile intensive cardiac units is no death cause worldwide par for mobile intensive cardiac units is no death during transport. If the individual was resuscitated in the emergency department, it should be noted if he was delivered alive, if he died there, or if he was admitted to the hospital cardiac or other special care unit. Mortality in the cardiac or other special care unit and the convalescent phase of hospitalization should be noted. If cardiogenic shock or left ventricular failure occurred, these should be noted.

How the emergency episode's time elapsed should be dissected. The time from onset of symptoms to call for help constitutes patient and observer delay in recognizing the cardiac emergency. Use of the media to educate the public and physicians about early cardiac symptoms and how to use the emergency service has shortened prehospital delay. Measurement of patient delay should be made before and after education campaigns, improvement of prehospital basic and advanced life support, and community-wide dissemination of citizen training in basic life support. The response time from the receipt of a call for help to arrival of the emergency team outside the hospital, the time spent at the scene treating and stabilizing the patient, the transport time from the out-of-hospital treatment site to the hospital emergency department, the time spent in the emergency department, and the time to transfer the patient to the hospital cardiac or other special care unit should each be recorded.

If the patient was delivered alive to the cardiac or other special care unit, survival, shock, left ventricular failure, number of days in the special care unit, total duration of hospital stay, and frequency of complications such as surgical intervention or aspiration pneumonia should be tabulated. The number of patients admitted yearly with cardiac emergencies at the ambulance, emergency department, and cardiac intensive care unit level should be noted before and after upgrading prehospital basic and advanced life support. Where a rural, suburban or urban hospital district, or other segment of the community can be carefully defined the epidemiology of sudden cardiac death and its modification by upgraded prehospital emergency service can and should be surveyed. Posthospital outcome should list the quality of the patient's life 3,6, and 12 months after the prehospital episode. The patient should then be followed at least 5 years after hospital stay to ascertain longevity. The patient's return to work or to active retired lifestyle or failure to do so should be recorded.

Peer Review

Review of the impact of the emergency system should be done continuously. Trained professional workers must regularly listen to active contemporary emergency communications with attention directed to diagnosis and treatment. If necessary, intervention by radio or telephone should be made to assist or to correct tactfully the emergency team in the field. All prehospital emergency episodes should be regularly scheduled for review in conferences. Depending upon the emergency case load, emergency medical technicians, nurses, and doctors should review the short and long-term results daily, biweekly, or weekly. In the conference, detailed review should be made of all suspected cardiorespiratory episodes, all serious (near miss) clinical episodes, all attempts at both basic and advanced life support, all fatalities, and outcomes at the ambulance, emergency department, hospital and post-hospital levels. Finally, the peer group must examine the actions of the emergency team as related to outcome and quality of service. This analysis should include for each emergency case the distance from the emergency department and the appropriate clinical category of the emergency department and of the hospital.

Cost-Benefit

Cost-benefit of the cardiac emergency service to the community can be assessed using as a baseline the 1969 predicted value of $21,000 per 100,000 population for the saved livelihood. Since the 1969 consumer price index of 109.8 for all services rose by 52 percent to 167.1 in February 1976, the value of the saved livelihood increased to $31,920 per 100,000 population at that time. Future measurements of cost-benefit will have to take into account subsequent changes in the consumer price index as it influences the value of the saved livelihood per 100,000 population. Then the capital and running costs of prehospital emergency cardiac care above the status quo emergency medical service can be balanced against the annual observed value of lifesaves.

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EMERGENCY MEDICAL SERVICES AND POISON CONTROL

Sylvia Micik, M.D.

Introduction

Emergency medical care has become a major issue at all government and professional levels. This has occurred because of the enormous amount of death, disability, and cost created by sudden illness and injury, and the recognition that a significant impact on this death and disability could be made with proper regional planning and coordination of existing resources and technology.[1]

Experience in pioneering programs in Illinois, San Diego, Charlottesville, and others has made it apparent that only a comprehensive Emergency Medical Services System (EMS) of patient care, linking the prehospital, hospital, interhospital (critical care centers), and rehabilitation phases can decrease death and disability from medical emergencies. This need for a "systems approach" to emergency medical care delivery planning across the nation led to the passage of the Emergency Medical Services Systems Act of 1973 (PL 93154). The implementation of this Act has provided a national strategy for emergency medical services systems development and regional planning to meet the needs of all emergency patients, particularly those who are critically ill or injured. Fifteen components of a comprehensive emergency medical services system have been identified[2] and are:

1. Manpower
2. Training
3. Communications
4. Transportation and prehospital care
5. Categorization of facilities (for specific patient care capability)
6. Critical care units
7. Integration of public safety agencies
8. Consumer participation
9. Accessibility to care
10. Transfer of patients (between facilities and critical care units)
11. Standard medical record keeping
12. Consumer information and education
13. Independent review and evaluation
14. Disaster planning
15. Mutual aid agreements

In addition, *specific* critical patient groups have been identified for which *specific* systems of patient care incorporating the 15 components are to be developed. These critical patient groups for whom initial planning efforts should be directed are:

Poison
Trauma
Burns
CNS injury
Acute cardiac
High-risk mothers and infants
Behavioral

Each of these patient groups can be clinically identified and has very specific critical care needs. Specific patient care systems must be developed for each condition if these patients' needs are to be met. Although the initial responsibility of an emergency medical services system is the same for all patient groups (i.e., dispatch of a prehospital response team with basic or advanced life support capabilities) as soon as the identity of the patient's problem occurs, additional specific treatment must occur in both the prehospital and hospital phases. Patients must be directed to facilities specially designated as capable of meeting the definitive critical needs of each patient category. For the critically ill, the needs are such that resources (particularly manpower) in any region must be pooled or consolidated so as to provide the necessary care.

In order to develop a comprehensive emergency medical services system with specific clinical patient care systems, a lead agency must be identified and given the responsibility and authority to initiate regional planning and integrate the prehospital, hospital, and critical care center manpower and resources. A government health agency in its traditional role as the responsible agency to assure the *availability* of health services is an appropriate lead agency and should be identified at the state and local levels.

The lead agency staff should have physician leadership. It is a *medical* patient care system that is being developed and the physician's knowledge of clinical problems, existing resources, and health system is extremely valuable. With physician leadership, the lead agency can better define the problem, mobilize the medical expertise (trauma, poison, cardiac, etc.), access the data sources, interpret medical input, high risk mother and infant, etc.) must classify the patient according to the magnitude of the illness or injury, determine patient's needs at each severity level, and also the necessary resources to meet those clinical needs.

Utilizing these criteria for patient care, the lead agency with its regional emergency medical planning committees can designate facilities according to specific care capabilities and work out system linkages and transfer agreements between facilities. Specific regional protocols for care and triage of emergent patients should result from these planning efforts and establish a smooth flow of patients in each step of the system.

Current Status — Poison Control Centers

The national emergency medical services program has identified poisoning as a specific patient category for which a patient care system must be developed because poisoning creates a significant emergency medical problem nationally. It is responsible for 10 percent of all emergency room visits,

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9 percent of ambulance transportation and 5 - 10 percent of medical admissions.

Although efforts over the past 25 years since the development of the first poison control center in Illinois have been made to solve this problem, the incidence, mortality, and morbidity of poisoning is increasing.

Efforts to date have included the development of over 600 isolated poison centers, most of which can meet neither the needs of the patients nor the professionals treating them. They have developed haphazardly, without regional planning. Resources, particularly manpower, are spread over too many centers resulting in inadequate staff, expertise, experience, and budget. Few centers have any staff and existence independent from the emergency room. Information calls are answered by an emergency department clerk, or available nurse or physician, many of whom are simply rotating through the emergency department and know little more than the caller.

There is a long delay before new products and new treatment protocols reach each center's information file. Most have no access to a clinical laboratory for toxicology studies. They rely on cards sent to them by the National Clearinghouse and a few texts for their information file. These sources, alone, are incomplete and cannot provide up-to-date product information and clinical management. As a result, detailed treatment protocols and consultation and rehabilitation services are not readily available to the emergency and critical care physicians. Antiquated procedures that may be harmful are still recommended. Follow-up procedures for telephone treatment or public information and prevention programs are not available. The number of calls handled by these centers is usually too small to justify a financial investment and to maintain expertise or benefit from clinical experience.

In addition, unlike other critical care categories, such as cardiac and trauma where manpower is adequate but poorly distributed and organized, with poisoning there is a distinct manpower shortage. At the present time, few physicians are trained as clinical toxicologists and few poison centers are staffed by them. Dr. Eric Comstock, in his paper presented at the AAPCC and AACT meetings in Seattle in August 1976, estimates that approximately 500 clinical toxicologists are needed to meet the needs of poisoned patients.

Few centers have attempted to link the information and/or control center with the treatment facilities of their region, nor have they seen themselves as having responsibility for the treatment of all poisonings within their region.

Federal involvement over the past 20 years through the National Clearinghouse has also not fostered regionalization of poison control centers nor provided the impetus for professionals dealing with poisoning to plan effective care systems.

Regionalization of Poison Control Centers

Although interest in improving the organization of resources for the care of the poisoned patient has recently been generated by the national emergency medical services program, the need for regionalization has been well identified by leaders in poison control over the past ten years. Teitelbaum's[8] paper in the first issue of *Clinical Toxicology* in 1968 discusses these issues and proposes solutions. Lovejoy's[4] survey of poison control centers in 1969 and Meester's[5] survey in 1975 point out the remarkable lack of organization, uniformity, and quality of our nation's poison control centers and emphasize the need for standards and consolidation of resources into effective programs. Temple and Done in 1972[6] proposed an organizational framework for emergency facilities for the treatment of acute poisonings that is applicable today. In spite of these significant papers, little has been done to solve the problems they identified or utilize the approaches they suggested.

Several model programs, however, in Salt Lake (Dr. Anthony Temple), Denver (Dr. Barry Rumack), Grand Rapids (Dr. Walter Meester), and San Diego (Dr. Sylvia Micik) are implementing regional poison patient care systems in conjunction with their emergency medical services systems lead agency, and have reported on them at several national HEW-EMS symposia[7]. These programs have illustrated the basic system design and organizational structure that are needed to develop and organize regional programs that significantly reduce the mortality and morbidity of poisoned patients.

DETERMINATION OF A REGION

The region served by a patient care system for poisoning should be based on population and geography, and existing patient flow patterns among facilities. Most often the EMS or HSA regions that have been determined on this basis are most appropriate, but in some circumstances it may be necessary to include several of these regions, a state, or several states.

The suggested population base for a regional center is between two and five million. Data from the San Diego Poison Center suggest that approximately 20,000 episodes occur per year, per one million population. The number of critical cases per 100,000 episodes is unknown but estimated to be approximately 5000.

Since contiguous EMS regions have been designated nationwide, all existing poison control centers, clinical toxicologists, and other personnel treating poisoned patients are within one of these regions. They now have a base from which to begin the planning, coordination, and/or consolidation of their resources or to expand their region to include other regions where resources are not adequate.

Within each poison control region only one regional information and treatment center and many subregional and area treatment centers should be developed. The regional information and treatment center should be designated as such by active participation of all facilities and professionals involved in the treatment of poisoned patients in that region. It should be ultimately responsible for all poisonings in that region, providing:

1. Comprehensive information services to public and health professionals
2. Treatment of identified patients at home by telephone including appropriate follow-up care
3. Treatment consultation for patients being managed in subregional or area centers
4. Treatment of the critically ill poisoned patients
5. Quantitative toxicologic services either directly or in association with a regional laboratory
6. Education of the region's physicians, nurses, and allied health personnel
7. Education of the public in access and prevention
8. Coordination of inter-hospital transfers of patients

The regional center also has the responsibility of providing the medical leadership in the planning process for poisoned patients within the EMS or HSA agency. It should work with these agencies to classify poisoned patients according to severity and define their needs (telephone management, subregional or area treatment center, or regional treatment center). The regional center staff should assist in the development of area treatment protocols, and in the development of patient flow patterns and transfer agreements between area, subregional, and regional treatment facilities.

To fulfill these responsibilities the regional information and treatment center must have:

1. An information center with full-time professional staff. This staff should include a medical director (preferably a clini-

cal toxicologist), information specialists, and public education and evaluation personnel.

2. A comprehensive information file, which should include a *Poisindex*, textbooks, special files, specialized consultants and linkages to the vast array of agencies dealing with toxic substances.

3. A treatment facility which has adult and pediatric intensive care units staffed with in-house pediatricians and internists and the 24-hour availability of the medical director of the poison center. The intensive care units should have monitoring capability including measurement of intracranial pressure, and the personnel and equipment for renal dialysis, exchange transfusion, charcoal hemoperfusion, and endoscopy. It should have all known antidotes. In addition there should be complete laboratory capability for quantitative toxicology, radiology, and chemistry.

4. A communication system that permits easy access for all public and professional personnel and linkages between the center and the prehospital, subregional, and area centers and consultant staffs.

5. A team of transport professionals who can provide continuous intensive care to patients during transport from the subregional or area hospital to the regional center.

6. A data retrieval system to assist in the management of the activities of the center, provide epidemiologic data on the poison population and their needs, and evaluate the effectiveness of the program. It is appropriate that the regional information and treatment center engage in clinical and systems research. Subregional and area centers should be capable of treating 95% or more of poisonings entering their facility in consultation with the regional center. They should not provide information and phone management of patient because they have neither a comprehensive information file nor the staff to provide follow-up.

In urban areas where there are many resources, patients needing hospital care should be directed to hospitals designated as subregional centers which can provide definitive care for most patients. Subregional centers should have an emergency department staffed with full-time physicians and nurses trained in the initial management of the poisoned patient. (The regional center should assume responsibility for this training and also for recommending the necessary drugs and equipment to be available in the emergency department.) The subregional center should have an intensive care unit with monitoring capability and access to laboratory services for drug screens, selected quantitative drug levels, radiology, and chemistry. Any specialized services available in these subregional centers such as pediatric endoscopy should be identified and utilized on referral by the regional and area centers.

Subregional centers should have a close liaison and transfer agreements with the regional center so that if the need arises for services available only in the regional center, the patient can be effectively transferred under continuous care.

In the rural areas, of necessity, poisoned patients needing hospital care must be referred to the local hospital (area center) which often does not have the resources of the subregional or regional centers. The area hospitals, however, can deal with the minimally or moderately ill poisoned patient by consulting with the regional center, and transferring the critically ill patient to a subregional or regional center, as indicated.

The emergency department of the area center should be staffed at least with a nurse trained in the initial management of the poisoned patient. He or she should have a close liaison with the regional center for consultation and disposition of the patient. Transfer agreements with the subregional and regional centers assure rapid and effective transfer.

PREHOSPITAL CARE

Approximately 80-85% of poisoning incidents, if properly identified, can be treated completely in the prehospital phase of a poison system, thereby significantly decreasing cost and morbidity. These patients must have immediate access to the regional poison center where trained staff can assess the patient and establish a treatment plan for home management. If emesis is indicated, Syrup of Ipecac should be used. The patient must be followed at approrpiate time frames to determine if emesis has occurred (30 min) and to evaluate his or her clinical status (1 hr, 4 hr, 24 hr). The 24-hour follow-up call should also be used to evaluate compliance with the system, provide education, determine need for family conselling, and aid reentry into continuing health care. The patient's primary care physician should be notified of the episode so he or she can assess it in terms of the total health of the patient.

The remaining 15% of incidents require referral to the regional, subregional, or area centers, either directly or via the prehospital's EMS transport system. Direct communication between the regional center and the public safety and emergency ambulance dispatch centers is essential.

The personnel on these prehospital response and transport units should be trained and equipped to provide advanced life support, and administer specific antidotes (naloxone, atropine, cyanide kit). The regional center should be responsible for this training and provide the technical assistance in developing the prehospital treatment protocols.

Each prehospital team must be under the medical control of a designated base hospital and receive instructions for patient case from "on line" physicians and nurses. The base hospital must have direct communications with the regional poison center to assist in patient management and to determine the appropriate facility for that patient. In this way the regional poison center can provide continuous consultation as the patient moves through the prehospital, hospital, and interhospital phases of care.

Discussion

Considerable improvements are being made in the care of emergency patients as a result of the many regional EMS programs that have been initiated. These programs are successfully utilizing the systems approach to meet the needs of most emergency patients and to decrease their mortality and morbidity. Most have been developing patient care systems for the cardiac, trauma, high-risk mother and infant, burn, and CNS injury patient groups, and have not yet effectively approached the problems of the poisoned patient. This lower priority for poisoning is most likely due to the relative lack in most regions of sophisticated information resources and clinical toxicologists or physicians with special interests in the poisoned patients who could serve as leadership for the EMS system planners.

The time has come for a national effort to coordinate and consolidate resources and initiate planning for the systematic care of the poisoned patient. It is no longer defensible for patients to be treated without the benefit of modern clinical toxicology because of a lack of organization and regionalization. The national EMS program provides an opportunity and framework whereby the professional organizations (AAPCC, AACT, American Academy of Pediatrics), their members, and others interested in improving the care of poisoned patients can develop such comprehensive systems.

These organizations should jointly establish standards for regional poison centers, and competency and certification processes for their personnel. They should sponsor training programs for physicians in clinical toxicology and assist regional EMS planners in consolidating the many existing centers into functioning units that meet the needs of both patients and the professionals treating them.

The success of any system is dependent on the wisdom of its leadership. The time has come for professional leaders in poison control to work diligently in their regions to develop sound clinical systems for all poisoned patients.

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THE BEHAVIORAL EMERGENCY: PATIENT CARE GUIDELINES FOR ALCOHOL, DRUG ABUSE AND MENTAL HEALTH CRISES

Stuart L. Nightingale, M.D.

In the past, Emergency Medical Services for the behavioral emergency have been fragmented and not a part of the total health care system. Indeed, the term "behavioral emergency" is one which has only been recently designated to include various similar, yet distinct, types of emergency medical presentations. The so-called psychiatric emergencies, alcohol-related emergencies, and drug abuse-related emergencies are all viewed in different perspectives by those health care professionals who categorically and traditionally care for these specific disturbances. For example, crisis intervention for the person with an emergency psychiatric disturbance has been generally well-recognized and considered an important event by general emergency physicians. Such care is a well-recognized part of any community mental health program and when such specialized facilities are not available, general hospitals have attempted to provide care or refer to such specialized facilities swiftly. The alcoholic, on the other hand, although commonly seen in emergency medical facilities, has a long history of being rejected or shunted off to other, often inappropriate, facilities. Personnel dedicated to the care of the alcoholic, however, have vigorously fought to get the point across that emergency care was not only rendered, but orchestrated with other components of their treatment and rehabilitation categorical system. Drug abuse has been even more fragmented in terms of the interface of the various portions of the total intervention and treatment system. Drug abusers have been generally more unwelcome in emergency facilities and there has been even less in the way of referral to intermediate and long-term care facilities, particularly since it has been only over the past five to seven years that these categorical community intervention services and treatment and rehabilitation services for the drug abuser have existed at all. Indeed, drug abuse has benefited from the coordinated efforts of those involved in the care of the psychiatric patient and the alcoholic patient. Activities at the Federal, state, community and program level have benefited drug abusers. Identification and recognition of the problem, coordination of services, and laws and regulations which have mandated appropriate treatment for the drug abusing individual has occurred only recently. On the other hand, drug abuse has lead the way in certain areas and has actually benefited the psychiatric and alcoholic patient through model legislation mandating emergency treatment of drug abusing patients and the need to observe strict confidentiality in any service setting as mandated by legislation and regulations.

Finally, the fields of drug abuse, alcohol and mental health have all benefited by their inclusion as national priority areas which must be dealt with in the emergency medical service system networks. Indeed, identification and reporting, resource coordination, mobile medical, and non-mobile medical, and evaluation are all categories which serve to focus attention on the real needs of individuals who show physical and mental problems and who, at some time or other, have needs which must be serviced by a comprehensive Emergency Medical Service network.

System Response to the Behavioral Emergency

The various components of the currently categorical approaches to the behavioral emergencies can be viewed within a perspective of commonality as the Emergency Medical Services system itself is defined.

It has been pointed out that the entire medical/social service system can be activated if serious consideration is given by planners and clinicians to the following areas of Emergency Medical Services (Jamieson): provision of a primary access point, coordination of multiple resources, and training for acute intervention

Each of the "behavioral emergency" service delivery systems has a different array of services in these areas in any specific community. Planners and clinicians must deal with various problems in each of these areas to negotiate viable linkages and a high quality service.

PRIMARY ACCESS POINTS

What role do telephone "hotlines" play? Should Emergency Medical Services coordinate suicide and drug abuse "hotlines" through a central telephone number? How, if at all, should referrals to non-traditional emergency services be made? These are complex local issues which must be dealt with.

COORDINATION OF MULTIPLE RESOURCES

Should "crisis managers" respond to a facility site where a "behavioral emergency" is being processed to help decide on the treatment of the psychosocial aspects of a so-called relatively "pure" medical emergency (such as a drug overdose)? Or should each facility have the on-site expertise to treat and refer the patient who presents himself there. Emergency Medical Services system managers and clinicians must agree on the coordination and then develop and implement on-going training to appropriately effectuate this. All services provided must be evaluated. Training courses must be developed based on how the community deals with the above areas.

TRAINING FOR ACUTE INTERVENTION

When answers are given to the above questions, the level of training to be provided by the specific type of health manpower at the specific facility or mobile unit becomes clear. This involves the local situation — first responders (citizens and law enforcement officials), EMT's and paramedical personnel, and coordination personnel. We are fortunate that, at the persent time, the Joint Commission on Accreditation of Hospitals has developed criteria for care at treatment facilities in alcoholism and drug abuse and is currently developing these for Community Mental Health Centers. Emergency services are dealt with to varying degrees in the optimal achievable standards developed in these categorical areas. It is to be hoped that any accreditation of general hospital emergency rooms to be done in the future by the JCAH would incorporate the appropriate portions of the categorical behavioral emergencies dealt with in the criteria in these individual areas.

The EMS local planning bodies, those created under P.L. 93-641 (Health Resources Planning and Development Act), and PSRO activities as well as the categorical Single State Agencies (e.g., Single State Agency for Drug Abuse Prevention established under P.L. 92-255) should all help to define acceptable patient care guidelines in the major program areas and, together with cost concern, force documentation of the availability and utilization of what are, in some cases, scarce resources but, in other, duplicative.

Drug Abuse

Using drug abuse as the prototype of the behavioral emergency, we will examine the following problems or challenges confronting the EMS local system:

Detecting and reporting: Drug abusers are sometimes obvious casualties with severe medical problems which can be simply dealt with through skills relatively easily acquired.

On the other hand, the drug abuser may be unlabelled, be suffering multiple-drug overdose, including alcohol, or may be delirious and confused with a pure psychiatric emergency *or* organic brain damage. Differential diagnosis may be difficult, or diagnosis quite simple.

The number of drug abusers and where they enter the service system is highly variable and depends on the availability of drugs, "fads," and experience of the user.

Resources in any community can vary from a single hospital emergency room and/or hotline or Rap Center to a sophisticated multi-modality spectrum of prevention, early intervention, treatment and rehabilitation services. The interface between these facilities varies in different localities from outright hostility to smooth coordination—often depending on existent local, county or state interest, administrative expertise and fiscal resources.

Mobile-Medical: EMS have done a great deal to facilitate the development of services to help the drug abuser with an overdose. EMS training is extremely important to furthering this and has, in some cases, "mimicked" services provided by well-trained peers with extensive drug experience.

Non-Mobile Medical: Great strides have been made in this area in the past decade due to the vast increase in Emergency Service presentations of intoxicated drug abusers and addicts in withdrawal. Many excellent emergency drug abuse treatment manuals exist; drug abuse specific training courses for emergency room personnel are under development, and specialists in drug abuse from community programs have assisted medical personnel in the emergency services in the areas of identification, treatment, and referral.

Evaluation: The results of all the above rest on the quality of response. The interest and attitude of EMS staff, relevant planning and legislation ensuring patients' rights, and the utilization of training manuals and courses which are available. Basic to the quality of the medical community's approach to behavioral emergencies is society's views of behavioral disorders themselves.

In short, identification of the abuser, appropriate access and then emergency treatment with appropriate referral for long-term treatment and rehabilitation and aftercare must rest on the presence of these resources in the community as well as the will to coordinate them in a local EMS network. Treatment of the behavioral disorders in general, even when not involving true emergencies, will benefit greatly by EMS planning and implementation.

Improving the EMS Response to the Behavioral Emergency

Some recent advances in approaching behavioral emergencies have been summarized in a paper by Huddleston. He states that the present system of emergency medical services is inadequately structured to give proper care to patients with behavioral emergencies and concludes that no change will occur unless there is a national "grass roots" effort to restructure the system into a comprehensive model. Little has been done to date to incorporate psychiatric services into planning for general emergency medical services, but the Emergency Medical Services Systems Act of 1973 and the designated high priority areas which include alcohol, drug abuse and mental health are important advances. Huddleston reaffirms the view that all psychiatric emergency room presentations, because of the unpredictability of psychiatric trauma, should be labelled "emergencies." The six areas which must be addressed to provide comprehensive care for psychiatric emergencies are: (1) identification and coordination of all community treatment resources, (2) community awareness and acceptability, (3) centralized communication system, (4) quality care control mechanism, (5) case management assignment, and (6) follow-up evaluation procedures. He makes specific recommendations in each area. The most relevant to behavioral emergencies are: Studies should be performed by local EMS councils to identify all potential providers of emergency psychiatric services, since there is poor distribution and utilization of available resources, rather than an absolute shortage. The EMS councils should coordinate the activities of the local Health Services Agencies (P.L. 93-641) and consultation from Community Mental Health Centers (P.L. 94-63) where they exist. He feels that no EMS system should be supported by public funds unless its plan includes a summary of available resources for handling a psychiatric emergency and a plan for coordinating these resources. Any publicity generated about a local EMS should include information about psychiatric services to help reduce the stigma associated with mental illness in the community and encourage patients to seek assistance in the acute phase of the illness. Huddleston recommends a centralized communication system both for deployment of psychiatric staff in emergencies and for referral of non-urgent psychiatric problems to appropriate community resources. Emergency mental status checklists should be available in emergency rooms and the quality of care provided patients with behavioral emergencies should be evaluated in the same manner as that for other categories of medical problems and should be reviewed by statewide and local peer review groups as well as EMS councils. Each Emergency Medical System should have a psychiatric emergency team composed of various categories of mental health professionals on call, available for consultation. A "case manager" from the team should be assigned for each emergency on a rotational basis and should be responsible for the development of a treatment plan. The case manager should be responsible for ongoing follow-up evaluation procedures.

Methodology for Implementation of a Comprehensive Psychiatric Emergency System

Because of continued resistance to mental illness as a legitimate medical problem, the local EMS will have to carefully plan for the provision of this component regardless of which approach is selected for implementation. Huddleston recommends that each system include a plan for (1) community stimulation, (2) comprehensive planning, (3) formalized operations procedures and (4) a review mechanism. It is only through attention to these issues that appropriate services will be rendered, financial support garnered, ongoing community involvement maintained, and continued training for professionals in the system made possible.

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BEHAVIORAL ASPECTS OF MEDICAL EMERGENCIES IN DISASTERS

C.J. Frederick, M.D.

In the Winter of 1974-75, severe winter storms and flooding off the coast of Nome, Alaska, created severe problems among the Alaskan native population. In addition to depression, hostility and paranoid reactions manifested themselves, requiring crisis intervention.

In 1973, Hurricane Fifi lashed the Honduras, took approximately 5,000 lives and rendered some 20,000 homeless. Upon learning that permanent evacuation of property and former sites would be necessary, it was reported that some 20 persons committed suicide, virtually overnight.

Expected and Unexpected Reactions

The news media descriptions of panic reactions and berserk behavior, ordinarily do not follow unless people are pinned into enclosed areas where fire is a problem. Responses of cohesiveness and a cooperative spirit to help one's fellow-man do not always develop, as might be expected. There are instances immediately following disaster where heroic actions are displayed by some persons, but this behavior quickly disappears. It is not unusual for persons under such conditions to become hostile toward friends and family, resentful of neighbors who have been spared personal heartache, and angry and suspicious of outside helping personnel. Moreover, the expectations that standard psychotherapy procedures will be useful, have not been borne out. Classical psychotherapy not only may be ineffective, but even inappropriate and deleterious. Reflective techniques emphasizing ego strength and lack of direction and guidance, contribute to frustration and promote further mental stress. Focused crisis intervention techniques of a directive nature are far more helpful when innovative elaboration is added.

In general, disaster victims are likely to show the following: signs of disorientation and lessened ability to function; psychosomatic disorders; fear of separation and loss; perceptual and cognitive dysfunctioning; sleep disturbances; depression reactions; and bereavement problems when death occurs.

Traditionally, much focus has been put upon attending to the physical needs of individuals during emergencies, including shelter provisions and the like, while until recently relatively little has been placed upon behavioral components in emergencies. It has been largely within the last couple of decades that a useful body of knowledge has been assembled for teaching purposes in the mental health crisis field. Knowledge regarding behavioral aspects of emergency situations has been developed largely from three spheres: catastrophic and natural disasters, wars, and suicidal behavior.

It will be helpful at the outset to distinguish between *crisis* and *emergency* situations in the mental health field. Any situation which affects the emotional or mental equilibrium of the individual to the extent that intervention should be given during the crisis in order to preclude possible damaging physical or psychological sequelae, constitutes a crisis. Crises may differ over time and vary from minutes to months. A crisis may enlarge or diminish and it may readily develop into an emergency, which necessitates more immediate attention. *Crisis* refers to a time interval in a sequence of events; whereas, *emergency* suggests a need for present action. In the extreme, one dimension is marked by self-destructive behavior. An *emergency* in behavioral and mental health work suggests an urgent, sudden and pressing need similar to an emergency in physical medicine. The etymological base of the work points to a raising-up or heightening of a condition. A quick change is implied, wherein the symptoms are intensified. Any emotional or mental disturbance requiring prompt attention so as to prevent either loss of life or injurious physical or psychological effects, constitutes a mental health emergency. With regard to time, an emergency may be arbitrarily defined as constituting a time period of less than a working day, or fewer than eight to twelve hours. Any therapeutic procedure which utilizes appropriate techniques in order to ameliorate the mental and emotional stress related to crisis, may be considered crisis counseling or intervention. By definition, a short-term and time-limited method is utilized. Any long-term procedure does not constitute crisis counseling, although it can be a suitable follow-up procedure in its own right.

Events Precipitating Disaster Reactions

Febeuary 9, 1971, an earthquake in San Fernando, California, took 67 lives. It created long lasting phobias and sleep disturbances among children, and anxiety reactions and family disturbances among adults. These problems continued in youngsters up to two years following the earthquake, particularly when crisis counseling was not made available.

February 26, 1972, a dam collapsed and flooded the surrounding valley in Buffalo Creek, West Virginia, killing 127 persons. This was followed by prolonged phobias, sleep disturbances and nightmares, diminished interest in interpersonal relationships, loss of libido, and decreased level of functioning among adults. Initial anxiety was followed by hostility and resentment. Difficulties in the management of money, caring for children, and responsibility for housework also were heightened as behavioral problems.

June 9, 1972, a falsh flood in Rapid City, South Dakota, took 237 lives and created disorientation, anxiety states, phobias and depression, particularly among adults.

April, 1974, a series of tornados in the midwest and south took 307 lives. In areas where schools were destroyed, problems among children were heightened, with an increase in truancy, delinquent behavior, and persistent sleep disturbances in younger age groups. Frustrations, marital discord, psychophysiological disturbances and depression became manifest in the adult population.

Role of ADAMHA/NIMH in Crisis Intervention and Disaster Assistance

Public Law 93-288, the Disaster Relief Act, gives statutory authority to the National Institute of Mental Health to manage disaster-related emotional and mental problems. This authority has been delegated from the Secretary of HUD, where financial support resides, to the Secretary of HEW and the Director of the NIMH, in order to carry out the mental health crisis aspects of this program. Regulations and guidelines have recently been published in the Federal Register to assist States, and regional and local agencies with the procedures necessary for implementing this joint effort of the Federal Disaster Assistance Administration and the National Institute of Mental Health.

Working regulations require an official declaration of a disaster in the affected State by the President, acting upon a request from the Governor or the State Coordinating Officer. An assessment should be supplied regarding the needs for supplemental mental health services to the population of the stricken area. The need should exceed the capabilities of established resources in local clinics and institutions. Basic information ought to cover the geographic area affected; the number of people who are apt to be receiving services; the kinds of emotional and mental health problems expected to be encountered; existing resources available for use; and probable time period for which mental health services will be required.

An Action Crisis Team can be made available to make the necessary assessment for implementing this program immediately. The survey group assesses, interviews, evaluates, and recommends appropriate action to provide relief. Thus, time consuming delays will not interfere with the rendering of such services when necessary. Federal and State support community mental health centers should have some capability for delivering services through their emergency mental health components. The disaster assistance program may coordinate its efforts with such an agency. Both Federal and local administrators must know when and how to expedite their forces. Specific disaster activity is integrated at Federal, State and local levels. Various professional disciplines should be in a position to mobilize and carry out their assignments in the most effective manner. Non-professional workers, who are trained and supervised, can be brought into action to supplement the program effort. Continuing follow-up activity is necessary, even when the acute phase is past.

Pre-Disaster Training

It is necessary to plan ahead and train a cadre of workers to be available to handle problems stemming from natural disasters prior to their occurrence. A need exists for the development of various types of preparedness programs in the realm of mental health activities. Educational projects for children and adults may be a part of this activity. Since fire-drills have long been a standard part of preparedness activities, there is every reason to believe that psychological first-aid and crisis intervention should become an integral part of a total preparedness effort. Training of family members in home settings, in keeping with their capabilities, should be a part of this program. The NIMH is entertaining ways of supporting needed research and training activities in order to render more effective service. Many studies are needed that will provide more definitive information concerning high-risk groups, susceptible geographic areas, cultural differences in reacting to stress, responses and mental health problems occurring in different types of disasters, magnitude and intensity of disaster, time of onset, and duration. Ongoing projects may supply some of this much needed information, but much more is essential for a truly effective program.

The NIMH has maintained a continuing interest in crisis intervention and emergency mental health since 1966. As new and different dimensions arise, with respect to research, training and service delivery, the NIMH intends to make every effort to keep abreast of the latest knowledge and materially assist in meeting the Nation's mental health needs.

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New Problems of Medical, Social and Legal Emergency Phenomena Affecting the EMS System

INTRODUCTION

Nathan Schnaper, M.D.

The EMS Systems Act of 1973 (P.L.-154) mandated fifteen specific procedural items necessary to develop and implement an emergency medical service. Included in the critical patient groups were psychiatric, drug overdose and alcohol abuse patients. These categories require the defining of issues, current experience and national awareness for the development of sound care and rehabilitation. Also essential to an effective system is the multidisciplined input of technical and professional individuals from private, academic and governmental areas. Program planning is the keystone. This includes evaluation of the process before, during and after.

Personnel, facilities, transportation and communications systems must be efficiently coordinated and function on a 24 hour basis. Access into the system is a prime concern, as is the training of health professionals and allied health professionals. Education of the lay public must be provided as to the system, how to gain access into the system and its service area.

A psychiatric emergency is any behavioral emergency that does not fit into a medical or surgical emergency, and is potentially life-threatening to the self or other, or is psychologically damaging. A psychiatric emergency can also be the product of a physical illness, injury or defect.

Today, we will turn our attention to the broader aspects of the psychiatric emergency as they relate to the EMS Systems and our society. With the improved awareness of problems of rape, child abuse, wife beating and personal violence of all kinds, the EMS System is increasingly involved in these crises.

Another area of concern is with the mentally retarded, the physically handicapped and sudden infant death. Each has their special problems and input into the EMS System.

Emergency systems are a real necessity and are becoming more involved in responding in a relevant way to social, emotional and legal considerations of these problems.

Our panel members come before us with reputations as authorities in their fields amply supported by impressive credentials. They will deliniate the problem in their respective area and offer us suggestions for solutions. We are fortunate and grateful for their willingness to contribute to our improved awareness.

PERSONAL VIOLENCE IN OUR SOCIETY

John R. Lion, M.D., F.A.P.A. and Nathan Schnaper, M.D., F.A.P.A.

The social threshold for the intervention of personal violence committed by persons is very high. Most individuals must get into actual legal trouble within a criminal justice system before they are noticed. Yet, ironically, entry into the Emergency Medical Services System is usually sudden, violent, and predicated on violence.

Children who demonstrate extremely disruptive physical behavior within a schoolroom situation receive the attention of school superiors, but the intervention itself usually consists of expulsion and no further action is taken. The child is perceived as having merely behaved poorly and is removed from the system in which he has so behaved. There are no formal programs in existence whereby attendance at some psychologically oriented course or treatment is a requisite for reintegration into the school system; an analogy would be a didactic course on safe driving which in many places is a mandatory part of reestablishing automobile licensure subsequent to revocation.

It is conceivable in looking at a school system with an eye toward prophylaxis that a child or adolescent who is indeed violent might be made to have psychological treatment as a condition for reentry into the school system. Perhaps one could even consider imposing psychological treatment with or without reentry into the school system, though such a coercive move might well be viewed as an infringement on civil liberties. Yet sadly, it is precisely those types of individuals ejected from the school system because of violence who ultimately get into some kind of trouble on the street resulting in an assault charge or other difficulty with aggressive behavior. In fact, in viewing the Antisocial Personality, it is tragic that the diagnosis can be made at the age of 12 and 13 largely on the basis of school performance and that deviant school behavior is one of the strongest predictors of this type of personality disorder. But any juvenile probation officer can tell you this anyway.

There is a certain hazard in the identification of young people as violence prone. In a recent LEAA sponsored research project, children in the Baltimore School System were given tests to determine whether or not they were "predelinquent." Our office was supportive of the American Civil Liberties Union which helped to abort this project because it was felt to be dangerous. It was dangerous because there is a high incidence of false positives in any attempt to find violent people. Whether one is looking at a police system, as we were asked to do for New York City where one percent of the 30 thousand New York City policemen are violent, or looking at school children, there is a distinct statistical danger of identifying too many people as violent. This is a risky venture which has severe stigmatizing potential.

The above considerations set aside, however, it is noteworthy from a phenomenologic point of view that an offender must be an offender before the system notices him. To some extent, this is understandable for our society often tends to look the other way with regard to violence. We tend to cherish violence and ignore epidemiologically ripe areas for social action. The networks and media are, as you will realize, overloaded with violence and we have been supremely negligent in taking action in this area for lack of scientific "evidence" casually linking such violence with crime.

Elsewhere, close to sixty thousand automobile fatalities a year occur in this country, and seventy percent of people entering the Maryland Institute for Emergency Medicine are from such automobile accidents. Thirty to fifty percent of these car fatalities involve alcohol, yet we are extremely lenient in labeling alcoholic drivers as risks for the highway. We do not conceptualize these drivers as "dangerous" or "violent" and we do very little to take them off the road. In comparison to Scandinavian countries where stringent requirements are necessary for driving and where licenses are suspended more readily, we tend to view driving as a privilege and a right and a necessity and it is, indeed, a necessity. To deprive someone of an automobile in this country is essentially to remove them from their place of work and their income since public transportation networks do not exist. We are then in a bind since we have a social system which does not allow for the removal of an automobile and we do not perceive the automobile as a weapon, something which it most definitely is. It is interesting in this regard to note that during the years 1973 and 1974, the reduction in speed limit, diminution in availability of gasoline, the fewer drivers on the road and fewer drivers driving fewer miles, all combined to lead to a reduction in deaths of 11 thousand people. (Less deaths, but unfortunately more injuries at less than 70 miles an hour.) Thus, covert social manipulation resulted in a drastic reduction of violence but people do not generally perceive this as a reduction in violence but something which merely happened as a result of impoverished natural resources. It is a reduction in violence and should be viewed as not only a reduction but a social manipulation which led to a reduction.

In this country, 55 percent of all homicides—and there are about 20 thousand homicides a year—involve handguns. Gun control in this country is extremely limited and basically meaningless. It is (and this is a pun) death to any politician to advocate gun control. This is certainly true in the South, and less true in the North but the phenomenon played a role in Maryland politics and indeed seems to play a role wherever any politician goes. The National Rifle Association has repeatedly said that guns do not kill and that people do, but it must be remembered that people who kill usually do happen to use guns to do so and guns are extremely lethal weapons with easy access and availability. That is, it does not take much to pull the trigger and a lot of people appear to pull the trigger when they are intoxicated in moments of stress. In an illuminating study in Texas, a psychiatrist reviewed 400 homicides and compared them with 1,600 aggravated assaults, with the finding that these two kinds of crimes occurred in the same census tracts of the city, during the same time of the day and night, among the same types of people, and in short were epidemiologically identical. The author concluded that the difference between death and assault seemed to lie in the availability of the gun. Yet it is necessary to realize that this study, the closest thing that we have, or can ever have with regard to demonstration of the dangers of guns, is not sufficient to outlaw guns. The outlawing of guns, like the institution of more stringent driving practices, is a social policy issue. Society plays a most crucial role in its handling of violence and can shape it, form it, or suppress it. In this country, we dealt with skyjackers literally overnight, by simple executive order. Now skyjacking is an interesting phenomenon. It resulted in enormous publicity, but it is questionable how much violence actually resulted from skyjackers themselves. Information from ALPA, the airline pilot association, indicates that skyjacking has been responsible for nine hundred deaths around the world. This is an inflated figure, and goes far back in time to the beginnings of skyjacking; it also includes airport massacres like the one during the Olympic games in Munich, Germany. What is clear about skyjacking is that it made intense infringements on commercial airlines and, most important of all, on the economics of the airlines. Under these pressures, we abolished it. The abolition cost the American people many millions of dollars a year and makes many impositions on personal freedoms by subjecting all of us to searches each day we fly. Yet we do not complain about being searched or having metal detectors placed around our bodies and the general reduction in skyjacking has come about largely through intense social pressure. This social pressure gives us an example of how powerful our culture can be when it wants to be, but society has yet to decide what it wants to do about other forms of violence.

The most ubiquitous and subtle shaping of violence occurs in the glamorous coverage that we give acts of violence each day when they occur. Assassins make the front page in blazing glory with full pictures, biographies, and interviews with the next-of-kin, witnesses, and neighbors. There is on the spot coverage with helicopters. One must realize that the only way that we can stop giving the covert message that violence makes news is to desensationalize it. This is a very touchy issue and infringes upon the borders of censorship but it is something we must deal with. To put the would-be assassins of President Ford on the front page of newspapers, *Time* magazine, and *Newsweek* is a disservice to the country if we wish to really reduce violence and make it something of negative value.

In looking at violence, we must look at the victim, for the victim is rarely naive; victims play a crucial role in homicide, for example, which occurs between people who know each other and can emotionally, as well as physically, wound each other. Domestic arguments are not benign. In New York City the second most dangerous place for a policeman to be — second only to armed robbery in progress —is in the midst of a family argument. (In Baltimore, three recent shoot-outs emanated from domestic quarrels.) The role of the victim has only recently received the scrutiny it deserves and is still far from being examined properly. Various groups have identified themselves with various titles such as battered wives and in so doing have put the burden of the conflict onto the assailant. While these groups may have enormous supportive value for individuals faced with impossible social situations, they also insidiously shift the focus from an examination of what is all too often a long and ongoing pathologic relationship. To be sure, a woman needs the help of a group to leave an abusive man. Equally important is an understanding of why she married him in the first place and whether or not the pattern will be repeated, for the pattern influences generations of children who see violence as a norm. What we do know about violence is that it is transmitted down in families. Abuse leads to abuse.

One cannot discuss trauma and violence without mentioning prisons, since the current recidivism rate of 65 percent attests to the fact that prisons in this country do no good and probably do harm and traumatize prisoners. Yet, more innovated programs both abroad and here (the Patuxent Institution, though controversial, is an example of a pioneering effort in our own state) have showed marked reductions in such recidivism, but at a price That price is indefinite and indeterminate sentencing. Society will have to decide, however, how it wishes to handle its aggressive offenders. If there is one social policy issue pertaining to violence, it is in the area of penology. Unfortunately, there is little scientific data to seek solace from. We simply will have to make some courageous decisions.

The issue of making courageous decisions is a fitting one to end this note on. The subject of this meeting, again, is trauma and trauma demands firm, assertive, and innovative intervention. Lives are saved by this process; other lives are lost, but speed and decisiveness are two crucial processes to repair the violence done a patient. Let us hope that we can infuse in our social system some of the sentiments so that we can, while maintaining a prudent outlook, tackle areas of intervention which may reduce violence on the streets and in the homes. The EMS System must assume a commanding role in responding to this charge if violence in our society is to be contained.

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A REPORT ON THE TASK FORCE TO STUDY A HAVEN FOR PHYSICALLY ABUSED PERSONS

Esther P. Gelman

Picture yourself, if you can, with a broken jaw, a black eye or with a painfully bruised arm and a sprained ankle. You have just been brutally attacked by someone you've loved and cherished. It's not the first time this has happened. You're determined it will be the last. You must fight back. Because you are no physical match for your opponent, you shout, "I'm going to the Police." The answer comes back, "Do that and I'll kill you."

Scenes like this occur with alarming frequency on weekends, holidays, and sometimes in between, in countless numbers of households across this nation. There is no definite profile of the abused or the abuser. The crime of assault and battery knows no social, geographic, economic, age or racial barrier. Statistics show that 95 percent of the cases are assault by husband on wife, and in more than 50 percent of the cases, it is believed that alcohol is the prime contributor.

Those of us here know that help is available to the alcoholic if he will take advantage of it. But what about those who continue drunken abuse and those abusers who are not drinkers? More importantly, what about the victims? Where do they go for help and what help is available.

The answer we are forced to face is: nowhere! While there are numerous counseling services available, without a protective shelter to which a victim can escape and without firm legal measures to deal with the abuser, the victim who attempts to call for help is laying his life on the line.

In an effort to determine needs and provide a solution to aid victims of adult abuse, the Montgomery County Council in February 1975 passed a resolution that established a Task Force to Study a Haven for Physically Abused Adults.

The 22-member Task Force included professionals in the fields of medicine, law, the ministry, social services, representatives of County government and dedicated and compassionate members from the Community. At least one member was a former victim. An important behind-the-scenes-advisor was a member of Al Anon. It was her earlier contact with the Councilwoman that had brought this crucial need to the Council's attention.

The Task Force promptly dug in, researching every available resource. An important aspect of its work involved a questionnaire mailed to victims. The answers were treated with the strictest confidentiality. The research was thorough, the results enlightening.

On November 1, 1975, the Task Force presented those results to the County Council. Its principal recommendation was that an emergency shelter be established in Montgomery County as quickly as possible.

Included in the 12-step recommendations were:

that County resources be utilized to the fullest extent possible and that the shelter offer excellent referral information on those services;

that the shelter be a place that has a non-institutional atmosphere, is physically secure and will include accommodations for sleeping and simple meals for adults, children and babies;

that the shelter make use of nearby hospital emergency rooms for injured clients;

that County Police be informed of the existence of the shelter and encouraged to transport abused clients to it as an alternative to remaining in danger, and

that every effort be made to provide liaison between shelter clients and agencies that can procure relocation housing where needed.

At this point I would like to highlight some statistics in the Report that led to the recommendations.

In 1974 the Montgomery County police responded to more than 4000 cases of "family trouble." *Three hundred of those cases* involved physical abuse. No statistics were kept on the number of people injured.

The head of the Criminal Division stated that those figures did not include affluent victims who fled to motels or hotels, or those who seek the aid of nearby families or close friends.

Calls of this nature are increasing at the rate of 10 percent a year. Police officers at the Police Training Academy presently receive 51 hours of Police Community relations training, which includes stress-situation problems. This training does not reach older officers.

A Friday-night victim must wait 3 days going through normal legal channels to file a charge with the States Attorney's Office, and is often by that time whipped and thoroughly discouraged. Where is the victim staying in the interim?

Police, Commissioners and the States Attorney spell out the consequences of filing a legal complaint: your husband may lose his job; if he goes to jail there will be no family support; and the children may be persecuted by friends and turn on the mother. An abused woman often senses the reluctance of that office to prosecute and will withdraw. The "Catch 22 situation" is that the State's Attorney may then say he dropped the case because the victim changed her mind and didn't want to prosecute.

Private attorneys are often equally discouraging and many are unable to take a case because the client lacks financial capability pay the fee. One attorney cited a judge's rule of thumb in deciding for the abused, such as evidence of abuse four times in 6 months, 6 times a year, etc.

One woman claimed that she shook her husband awake so that he wouldn't be late for work. He responded by smashing her face with a radio, splitting her lip and knocking out four teeth. The judge decided that the husband was provoked and that his response did not constitute assault.

Medical, law-enforcement and support service personnel have been known to ask, "what did you do to deserve it," or "what did the other guy look like?" Victims, in turn, often lie to medical people about the cause of injury.

Two major needs, then, are evident: immediate shelter for the abused, firm legal measures for her protection and to deal with the abuser. Counseling for both abuser and victim will play a major role in prevention of future conflicts and abuse, a preventative mechanism.

Possibly the hardest part to deal with will be getting a woman to not feel ashamed and guilty — as rape victims have been made to feel — for another person's crime. And I emphasize the word "crime." If the abuse if committed outside the home in the presence of witnesses, it might be considered a crime. If it takes place inside the home, it becomes something else. A husband's right. A right that goes back centuries to when women were chattel. And today, in this Bicentennial year, that condition still exists for many. And it is evidenced in the obvious mishandling of the victims and the lack of protective legislation on their behalf.

And now it's time to talk about money. If, in this final week of budgetary decisions by the Montgomery County Council, the recommendations of the Task Force should be legislated into being, the cost to the County will run approximately $50,000 for the first year. Some measure of Capital improvements will be necessary, but we anticipate the bulk of that amount will purchase services and provide a Master Social Worker to coordinate and counsel. As recommended in the Report, the Health Department will be responsible for overall management of the program.

If the Council does not provide the funds, we'll go for grants, both public and private. After all, humaneness demands it— and the price is right.

EMERGENCY MEDICAL SERVICE SYSTEMS FOR DEVELOPMENTALLY DISABLED

Stanley Meyers

Every hour of the day, somewhere in our communities, a handicapped person is born. At sometime during his/her developmental years, he/she will need emergency medical care. The more severely handicapped he/she may be, the greater likelihood of the need.

Currently, many of these individuals are residing in institutions for mentally retarded persons. They may not be mentally retarded. They may be cerebral palsied with normal intellect. They may be epileptic with normal intellect. But if you require residential care outside your own home, you're going to an institution for mentally retarded persons. Emergency medical services will be denied to you not out of malice (medical staff is home?), but out of ignorance, prejudice and rejection.

In every state of the union, there are publicly operated institutions housing a total of 250,000 mentally retarded, developmentally disabled persons. They are incarcerated in generally outmoded, understaffed facilities, located away from urban centers. They tend to house at least 500 persons, and will generally run from 1,000 to 2,000 disabled people.

There is a major effort underway today to return these persons to community residential settings. The populations will tend to be moderately, severely and profoundly handicapped. Not only will they be mentally retarded, but they also will tend to be physically or neurologically impaired. As a result of their institutionalization, their functional levels will be depressed, their medical needs neglected, and their dental needs ignored.

Mary was 30 years of age. She had been living in an institution for the mentally retarded in the Western Region of Pennsylvania. Mary was placed in a group home last year in a Southwestern Pennsylvania County. After living in the group home for approximately one year, Mary decided, against her caseworker's opinion, to move into her own apartment. She was working in a workshop for the handicapped, and between SSI and her salary, she was able to live on her own. One day, however, April 13, 1976, Mary came to the hospital and complained of numbness in her arms. The hospital emergency room gave her tranquilizers and sent her home because she was "nervous." Six days later, April 19, 1976, Mary returned to the hospital complaining she felt worse. This time the hospital admitted and treated her for "hysteria." Three days later, April 22, 1976, Mary died. There was no autopsy performed and the death certificate reads: "primary hysteria with secondary pulmonary embolism." Somehow the newspapers got the story and published a story which said Mary died of a broken heart because she was dumped into the community by the institution. The caseworker said, "I told her not to move into her apartment."

Mary walked into that hospital. She didn't need an ambulance. Which from what we read in the papers, seems to be the only planning for emergency services in some communities.

What responsibility do the leaders in emergency medical services have in planning to meet the needs of the handicapped? How can the newly evolving emergency medical services play a significant role in assisting those agents in our communities planning for the handicapped? When can we bring systems planning together for the benefit of the patient? The time is now!

All too often, we hear comments about the lack of knowledge one service system has about another. The excuse for not including a segment of one population in a community program is usually something like, "I didn't know about that." I submit we have an emergency in the planning for emergency medical services.

The EMSS Act defines an EMSS as ". . . one which provides for the arrangement of personnel, facilities, and equipment for the effective and coordinated delivery, in an appropriate geographical area, of health services under emergency conditions (occurring either as a result of the patient's condition, or of a natural disaster or similar condition."

From Publication #(HSA) 75-2003: "The EMSS Act requires that where plans are developed and systems established, expanded, and improved with funds under this Act, the recipients of funds must direct their efforts to the following components of a system: (1) the provision of manpower; (2) training of personnel; (3) communications; (4) transportation; (5) facilities; (6) critical care units; (7) use of public safety agencies; (8) consumer participation; (9) accessibility to care; (10) transfer of patient; (11) standard medical record keeping; (12) consumer information and education; (13) independent review and evaluation; (14) disaster linkage; (15) mutual aid agreements."

"Other grants will be available for the training of emergency medical technicians and for some research projects."

Although I am primarily concerned about the developmentally disabled and the mentally retarded persons, I must also call attention to the emergency mental health services required. After the 1971 flood disaster in Pennsylvania, no one has planned for the increased suicides that occurred in Wilkes-Barre until after the fact.

Interestingly, the EMSS calls for coordination with the areawide health planning agency. The area planning agency has in its guidelines, that psychiatric service representation can alternate yearly with veterinary medicine among others. The service system for the developmentally disabled, by the way, is not included in comprehensive health because it is covered by the Developmental Disabilities Act.

In three large institutions in Pennsylvania, with average daily census December 1975, of 1233, 1836 and 1344, the average death rate was 16.2, 25.1 and 22.3 respectfully. In comparable communities under 1,500, the average was 10.7. In communities with 1,500 to 2,000 the average was 12.6. Now it can be argued we have a weighted population in the institution. That's true, but if we had the time, I would present you with the unbelievable death certificate reports from our institutions. When I arrived in Pennsylvania three years ago, I was shocked to find on many death certificates from our institutional system that the cause of death was mental retardation!

During the latter part of the fiscal year 1975, we received an appropriation for staff in our mental retardation institutions. We used these funds to secure medical evaluations for our residents.

Nine State schools and three mental retardation units located in State mental hospitals participated in the Medical Assessment Project. Amost 14,000 examinations and evaluations were conducted by medical specialists. Five State schools utilized specialists in the medical aspects of physical handicaps (e.g., physical medicine, psychiatry and orthopedics), neurology and specialized laboratory tests and services of physical and/or occupational therapy consultants.

In State schools, for the most part, residents examined or evaluated by specialists were selected by staff, usually physicians, because of specific medical problems. In two of the MR units, apparently because of concern regarding the overall lack of medical services, the 75A funds were used to purchase physical examinations for the entire population of the unit.

Six thousand of the evaluations conducted resulted in recommendations for follow-up mainly by the State schools' own staff. Specific plans for follow-through were underdeveloped because of the speed with which the Medical Assessment Project had to be organized, and because of the lack of sufficient on-site medical staff to make effective follow-up likely.

Is this not an EMSS need as defined by the Act?

It was noted by several facilities that available staff or equipment were not able to routinely conduct such procedures as Pap smears or sophisticated laboratory tests. The Project afforded the means by which these procedures could be undertaken. Also mentioned were the contributions of specialists not readily available to facilities located in rural areas. Is this not an emergency as defined by the EMSS Act?

In some instances the facilities were very enthusiastic about the willingness of the consultant to share ideas with the staff. These favorable comments appeared particularly in cases where consultation was provided by medical schools. For example, in commenting on services provided by a pediatric consultant from Jefferson Medical College, Ebensburg commented, ". . . an excellent opportunity for staff to learn new techniques and plans of care, as the pediatrician encouraged the staff to ask questions and willingly explained procedures." Also particularly cited were consultants from Hershey Medical Center and Hahnemann Medical School.

Unfortunately, we also had to get medical teams from New York and Tennessee to go to two of our institutions, because our State medical schools; "couldn't go that far away to provide medical services."

Within three (3) months, the Commonwealth of Pennsylvania spent $1,689,471 on this medical assessment project. If we had been a part of the EMSS — could we have made better use of the funds over a long period of time? Could we have established an EMSS program for the State, thereby benefiting the patient, me and you? Do I need to continue to relate horror stories? Do we realize most developmentally disabled persons are in the community? Do we recognize that if we send an ambulance to pick up an emergency, we really have a person, family, friend, neighborhood, community, society emergency? Do we recognize we have not only a transportation emergency, but a fiscal, personnel, facility, intermediate and long-term personnel emergency? Do we recognize we have an emergency on top of an emergency if the individual or individuals involved are developmentally disabled. Because they are developmentally disabled, will they then even be treated as an emergency? Did Mary have to die on April 22, 1976, because she was retarded?

MANAGING AND OPERATING A CRISIS INTERVENTION AND FLIGHT AMBULANCE CENTER

Per Krueger, M.D.

The German Automobile Club, the ADAC, which has its headquarters in Munich, represents 4.4 million members and thus almost 10 percent of the population. The club is politically and financially independent and has its own administration.

The club's most important task is representing the interests of motorists and of course, in particular, rendering assistance to members.

In the course of the years, a smoothly functioning crisis intervention center was developed in Munich in which tourism experts and technicians work and which can be reached by anyone - not only members - around the clock.

The crisis intervention center is one part of the disaster staff. In order to ensure that this disaster staff remains flexible, it consists of only nine members, including tourism experts, technicians, lawyers, doctors and of course the press.

Any event involving a large number of motorists or tourists in distress is to be considered a disaster. ADAC arranged for relief measures, particularly in cases in which members or tourists who are part of groups served directed by the club are involved in serious accidents.

Emergency situations can necessitate the following kinds of aid: medical aid, technical aid, financial aid or assistance for persons without shelter, and legal aid.

How does this crisis intervention center work?

Whether or not a situation calls for relief measures is a decision which must be made from case to case. For this reason, it is important to obtain a general idea of the extent of the damage as rapidly as possible, using all available sources of information. If no information or only incomplete data can be obtained within a foreseeable period about the disaster which has occurred, experts are sent to the scene of the disaster.

After checking back with the crisis intervention center, these experts decide which measures should be taken.

What is most important is caring for injured persons and those who have fallen ill. This means emergency medical service. For this purpose, there are teams made up of an adequate number of surgeons, neurosurgeons, anaesthesists, etc. at two large clinics in Munich. The one clinic, at which I work, handles emergencies and disasters which occur beyond our borders and uses fixed wing planes for transportation. The other clinic, which handles emergencies and disasters in Germany, flies with helicopters. When emergencies arise, both clinics which are in close contact work together.

Since the automobile club operates on a national basis and is nevertheless politically independent, there is every possibility to cooperate closely and without friction with other organizations, particularly government agencies, for example the Ministry of Foreign Affairs or the SAR of the German Federal Armed Forces.

It is true that disasters which affect a large number of tourists - for example, the fire on the Helleanna ferry or the tornado in Northern Italy which destroyed an entire campsite - do not occur frequently, but when they do, they always come as a surprise.

One calculable risk is the 25,1 million German vacationists, 50 percent of whom spend their vacation abroad. Statistics show that 60 percent of them drive their own car. Since they all take to the road at the same time and roads in Europe are narrow, this results in traffic jams and pileups.

The majority of vacationists are not adequately prepared for their vacation abroad. All that interests them is the sun. They understand neither the foreign language nor the foreign mentality and have great difficulty with the climate to which they are unaccustomed. The results of long trips by car, coupled with physical and mental stress, are accidents and disorders which affect the heart and circulatory system.

Among the 163 patients we brought back in the past 13 months, there were 86 cases of internal diseases as compared with 77 trauma patients. The first group consists mainly of elderly patients. It is these patients in particular who cannot cope with the unfamiliar situation, and for mental and social reasons alone they must be repatriated.

Emergency medicine is still in the early stages in some southern and southeastern countries of Europe. In order to avoid long stays in the hospital, improve rehabilitation and prevent lethal consequences, we repatriate polytraumatized patients and those with skull and brain traumas as rapdily as possible.

After lengthy pilot tests, we started using Gates-Learjet 24,25 and 35 planes since April 1, 1975 and have been using them ever since. Only these planes have large enough door openings to allow taking a stretcher on board. The interior is large enough to make it possible to look after one patient, or with Type 35, two patients.

The medical equipment on board consists of an ECG monitor with defibrillator, a closed respirator with pulmotor, a suction pump, equipment for intubation, surgical instruments, one-way linen, infusion material and emergency medicine, etc.

The crew, consisting of a pilot and co-pilot with an airlines transports pilot license and instrument flight rating, and a medical attendant, must be familiar with emergency and aeromedicine. The doctor, who is usually a surgeon, is well trained in emergency medicine. This is indispensable as outside assistance cannot be expected during the flight. In special cases, for example in case of poisoning, specialists in the field in question are engaged.

Only the doctor decides, after previous checks with the doctors treating the patient, whether the patient should be brought back home and if so, by what means. Both the organization paying for the flight, in our case the ADAC, as well as the headquarters for the Lear jets must submit to these decisions. When setting up the flight plans, the pilot must first consult with the doctor.

Both the doctor and the planes must always be ready for operation. Since, as a rule, we only fly secondary transportation missions, there is always sufficient time for good preparation.

Because there are no financial interests behind this crisis intervention and ambulance flight center, it is possible to maintain good contact with national relief agencies. Thanks to the excellent cooperation with and support from the SAR of the Federal Air Force, we have connections with the rescue coordination centers in other countries, even those in the East Block. Only with the German Democratic Republic do we not have any contact whatsoever. It is not even possible for our ambulance planes to fly to West Berlin.

The experience of the past 13 months has shown that the path we have taken is a good one and that many people could be helped. In our opinion, the three most important points for optimum utilization of a crisis intervention center are: excellent training for staff members, mobility, and pleasure in and the desire to help others.

BEHAVIORAL CRISIS INTERVENTION AND DRUG ABUSE

Carl G. Leukefeld, D.S.W.

Although many Emergency Medical Systems do provide treatment for drug abuse emergencies, such treatment is most likely to be primarily medical treatment for overdoses or acute drug reactions. The purpose of this presentation is to suggest that Emergency Medical Service personnel should know about Crisis Intervention and develop referral mechanisms with community agencies for drug abuse treatment.

Crisis Intervention

The most common definition of crisis is an upset in a steady state (formulated by Gerald Kaplan at the Harvard School of Public Health, 1960). Cummings has defined crisis as "the impact" of an event that challenges the assumptive state and forces the individual to change his view of or readapt to the world, himself, or both."[1] Erickson in his writings, which are concerned with maturation and cultural influences on the lifecycle, regards crisis as inevitable in the development of an individual's identity.[2] As conceptualized, crisis is viewed as an emotional dysfunction which an individual experiences. Drug abuse treatment programs and rap centers regard situational problems (family, school, work) as crises. Such crises are frequently related to drug taking. Crisis intervention is defined as entering into the situation of an individual, family or group, to reduce the impact of psychological stress.[3]

The framework can be found is psychoanalytic personality theory; specifically, ego psychology which focuses on adjustment and conditions rather than understanding why something has occurred.

Crisis intervention is a straightforward approach for dealing with behavioral emergencies. In addition, there is substantial literature about psychological crises and their effects upon individuals and families which identify specific situations (i.e., drug and alcohol use, suicide, divorce, etc.) and specific process which can be used to deal with crises (i.e., focus on the here and now, limited goals, anxiety reduction, problem solving, therapeutic use of authority). Several assumptions rearding psychological crisis intervention have been proposed which lend themselves to this presentation[4]:

1) Crisis is not a pathological experience.

2) Crises are temporary and therefore self-limiting.

3) Each type of crisis pursues a course made up of typical identifiable stages.

4) An individual in crisis is especially amenable to help.

5) A small amount of assistance can make it possible for a person to surmount a crisis.

6) The weathering of a current crisis permits the individual to cope more efficiently with future crises.

The crucial distinction to make is that individuals in psychological crises are emotionally upset not psychologically or physiologically ill, although a physical illness or specific situation may trigger a crisis state. In other words, one is dealing with temporary periods of emotional stress. Intervention should focus on the individual's functioning, recognizing that individuals in psychological crises often ask for help directly to relieve their immediate problems. Intervention can take many forms depending upon the specific stress; the person intervening (intervener) has an opportunity to use his life experience to provide assistance. The intervener should focus on immediate events which precipitated the crisis and provide advice in a direct manner for problem solution. Thus, this method of intervention is not "long-term therapy," but the intervention which relieves immediate psychological stress. The intervener should take an active role in problem solution by identifying possible alternatives which will alleviate the stress and/or conflict. At times crisis intervention may involve only one encounter at the high point in an individual's psychological disruption. Drug abuse and mental health workers have used crisis intervention as a short term process (five or six interviews) to focus on limited goals.

Figure 1 is included as an attempt to pictorially display crises in the structural location of the person in society and culture (situation). The arrow indicates a personal breakthrough which impinges upon the individual. An input is too great and the individual cannot function. The arrow represents the situational factors, which are both societal and cultural, that penetrate the person (represented by the innermost circle) and cause the psychological crisis.

To illustrate how two similar situations could affect an individual differently, consider a man (person) driving his automobile who gets a flat tire while driving home from work (situation). He would change the tire or obtain assistance from someone to change the tire. His coping mechanisms would be actively incorporated into the situation. Now consider the same man (person) driving his automobile to the hospital with his wife, who is about to deliver their first child, and they get a

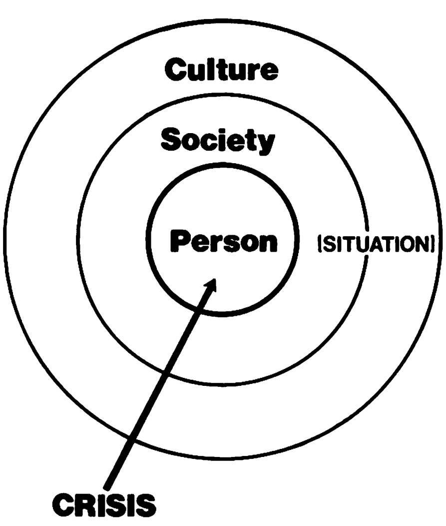

FIGURE 1

flat tire (situation). The high conflict of the situation would influence the personal stress and would probably cause a crisis situation. Resolution could take the form of driving with the tire regardless of destruction such an action would have on the tire or the automobile. This example illustrates how a crisis is related to the specific stress, person or persons and the situation. Whatever resolution crises take, interveners such as Emergency Medical Service System personnel can use crisis intervention principles to directly assist individuals cope with stressful situations.

Specific Suggestions for Intervention

The use of crisis intervention by Emergency Medical Services personnel can provide an approach for enhancing the functioning of not only drug abusers but other patients. The following recommendations should be considered, recognizing that this framework provides an approach rather than complete process, when dealing with an individual in a crisis state:

The interventive focus should be on the situation (the here and now).

The specific problem, threat or stress, must be identified. (Has the individual coped with this problem before?)

Focus on the problem, threat or stress.

Suggest and discuss alternatives for dealing with the problem, threat or stress.

Pay attention - make the individual in crisis feel understood.

Find out what resources (family, friends, clergy etc.) are available to provide support.

Identify immediate steps the individual will take and, if necessary, refer the individual to psychological crisis services.

Providing crisis and emergency services is only a starting point for patient care. For the drug abuser, his or her encounter with the emergency room for an overdose or drug reaction should be the commencement of comprehensive treatment which has historically not always transpired. Therefore, the second part of this presentation proposes several possible linkages which can increase relationships between Emergency Medical Services and drug treatment programs.

Referral Linkages

A mutual focus of both drug abuse treatment and rehabilitation programs and Emergency Medical Service Systems is on developing referral linkages in order to assure continuity of patient care. The National Institute on Drug Abuse has incorporated the development of linkages with hospitals for emergency services as part of the Institute's Federal Funding Criteria (Federal Register, 40:102: pp. 23062-23068, May 27, 1975). The Federal Funding Criteria are rules and regulations that apply to drug abuse treatment and rehabilitation programs that receive any Federal Funds. Specifically, each drug abuse treatment and rehabilitation program is required to develop a formalized agreement with a hospital for emergency medical services.

During the fiscal year 1975 the National Institute on Drug Abuse provided funds for 234 categorical grants and contracts for the treatment of drug abusers and narcotic addicts in 44 states not including formula grants. These programs provide services for: detoxification, residential treatment, methadone maintenance treatment and outpatient drug free treatment.

Within a compatible framework Emergency Medical Service Systems are to institute fifteen essential components. The fifteen essential components are Federal requirements which Emergency Medical Service Systems must provide to achieve coordinated services (Public Law 93-154. Emergency Medical Services Act of 1973). One of the fifteen components indicates that Emergency Medical Service Systems are to provide for the transfer of patients to facilities and programs which offer follow-up care and rehabilitation as is necessary to effect the maximum recovery of the patient. This follow-up care and rehabilitation includes not only physical care but also psychiatric care and vocational rehabilitation services to drug abusers and other patients with behavioral emergencies.

Developing such referrals becomes one of the critical factors in achieving an integrated process of patient care. Strengthening and formulating interaction between Emergency Medical Service Systems and drug abuse treatment services is an important ingredient since drug abusers are most likely to first contact emergency rooms for services.[5]

The exchange of information can benefit patients. As examples, Emergency Medical Service System providers should be aware of Public Law 92-255, Drug Abuse Office and Treatment Act of 1972, which prohibits hospitals which recieve Federal funds from refusing emergency medical care to drug abusers only because of their drug abuse, and confidentiality regulations which prohibit providers from disclosing the identity of drug abuse patients to law enforcement officials except in limited circumstances.[6]

Several specific linkages which can be developed between drug abuse treatment and rehabilitation programs and Emergency Medical Service Systems are identified below. These examples stress the importance of planned case management as an integral part of continuity of patient care.

Specific linkage mechanisms can range from formalized written agreements which identify areas of cooperation and affiliation to informal staff working agreements. However, formal agreements are preferable. Formal written agreements should include an identification of specific roles, functions and lead organization responsibilities. If informal agreements must be developed they should minimally include an explication of roles and functions.

Specific points which can be included as linkages in written agreements might include:

- The designation of individuals who can respond as case managers for individual patients and/or groups of patients.[7]
- Joint treatment team conferences to discuss patient care and to clarify referral problems and/or difficulties.
- Joint planning to clarify and strengthen policy and procedural difficulties.
- Mutual exchange of information such as newsletters which can clarify and increase communications.
- Regular or periodic meetings.
- Shared staff.
- Exchange of services, resources and/or funds.
- Identifying staff positions for telephone referral contacts.

This list is not intended to be exhaustive but, hopefully, suggest several specific areas that can be adopted for different geographic areas and/or communities. Written agreements comprise one method that can reduce impediments such as procedural obstacles and communication blocks.

Conclusions

This presentation suggests that Emergency Medical Service personnel should be knowledgeable about Crisis Intervention for drug abuse and other behavioral emergencies. Recent theorists suggest that crisis intervention is a straight forward approach for dealing with psychological crises. However, crisis intervention is only the commencement of the treatment process. Comprehensive treatment can only be realized by developing referral and coordination linkages that assure continuity of patient care which is a charge that both Emergency Medical Service Systems and drug abuse treatment and rehabilitation programs have been given. Several suggested linkages were proposed which attempt to highlight the need for joint planning and information exchange.

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SUDDEN INFANT DEATH SYNDROME: CURRENT STATUS — 1976

John P. Connelly, M.D.

The Sudden Infant Death Syndrome (SIDS) is the sudden and unexpected death of a healthy or minimally ill baby whose death remains unexplained after a complete autopsy. SIDS accounts for one third to one half of all postneonatal infant deaths. In the United States approximately 8,000 crib deaths occur annually. Cystic Fibrosis by contrast claims the lives of 300 to 600 babies annually.

The incidence of SIDS ranges from 2.3 to 3.95 deaths per thousand live births. (Table 1)

Babies born prematurely and/or of low birth weight, i.e. under 2,000 grams, have an eight fold increase in SIDS incidence. If a baby is a single full-term birth baby, the risk is 1.46 per 1,000 live births whereas the risk for twins is 3.8 and for triplets 8.3. Since twins and triplets are more likely to be premature and/or of low birth weight, this would be expected.

There is a significantly higher incidence of SIDS in black babies. In 1975, Chicago blacks accounted for 5.74 deaths per thousand live births and whites, 2.06. In California, the American Indians have the highest SIDS incidence at 5.9, well above Mexican-American incidence of 1.7. The risk of Californian Oriental babies is 0.5, well below the Caucasian incidence of 1.3. It is apparent all races are affected, but the American Indian and black babies are most vulnerable.

A universal phenomenon has been the increased incidence of SIDS in poor socioeconomic groups. A simultaneous observation can be made though; that is, that no socioeconomic group is exempt from the tragedy of SIDS.

Age, season of year and sleep all seem to have a relationship to SIDS. Babies are apparently protected from SIDS in the first four to six weeks of life. The most susceptible period is the second to fourth month of life. There is significant reduction in incidence from 6 to 12 months, and after 12 months SIDS happens but is rare.

The seasonal variation of SIDS is a constant feature with a clustering of deaths in November, December, February, March and April and a decreasing incidence in the summer months. The age and seasonal distributions coincide with the peak incidence of upper respiratory infections, particularly respiratory-syncytial-virus and bronchiolitis.

Most crib deaths are discovered in the early morning, and investigators conclude that the syndrome is related, in all likelihood, to protracted periods of deep sleep. Sleep physiology in infancy is a relatively uncharted sea. It is known that the metabolic processes are different during deep (rapid eye movement or REM) sleep. The long interrupted sleep when the "night feeding" is discontinued coincides with the peak age incidence of SIDS of 2 to 4 months. One can conjecture that prolonged fasting, altered cardiac rates and the rhythm and rate of respiration could be sufficiently altered to predispose the baby to crib death.

Current research has focused on prolonged periods of not breathing (apnea) during sleep. In 1972, Dr. Alfred Steinschneider of the Upstate Medical Center of the State University of New York observed apnea during sleep in five hospitalized infants who were either "near-misses," *i.e.*, those who stopped breathing but were discovered in time to be resuscitated — or siblings of SIDS victims. Two of the infants died suddenly in apneic episodes after discharge from the hospital. What constitutes dangerously long apnea is unknown but most investigators consider apnea of more than 15 to 20 second to be potentially hazardous. Correlation with sleep apnea and the epidemiological phenomena mentioned previously is being investigated in several other centers, such as the Massachusetts General Hospital, Columbia-Presbyterian Hospital in New York City, Loyola University Medical Center in Chicago and Stanford University School of Medicine in California.

Dr. Richard Naeye of the Milton S. Hershey Medical Center of Pennsylvania State University School of Medicine has made several important observations in crib death victims' tissues that resemble those who have suffered from chronically low oxygen concentrations in their blood. In comparing SIDS victims to normal controls, he found that in SIDS cases the walls of small arteries in the lungs were measurably thicker, that brown fat in the adrenals is present in relatively larger amounts than normal - a finding similar to children, for example, with cyanotic heart disease

TABLE 1: Incidence of SIDS

King County, Washington	2.3
Philadelphia	2.55
Cleveland	2.58
East Germany	2.6
Northern Ireland	2.8
Canada	3.0
Chicago	3.95

who have chronic oxygen deficit and finally, that the right heart of an affected infant is heavier than normal. He reasoned that the right heart must pump harder in a baby with oxygen poor circulation and the result would be thicker right heart walls. Dr. Marie Valdes-Dapena has confirmed the higher percentage of adrenal brown fat retention but does caution there is a tremendous range in normal and SIDS victims, making it impossible to use this as an absolute indicator of crib death.

A fascinating clinical correlation of SIDS victims' behavior and growth and development has been reported by Naeye and colleagues. They report that statistically SIDS victims had lower Apgar scores, required more resuscitation and were of lower birth weight. They were less active, had poorer muscle tone, a weak suck and an abnormal cry. Compared to SIDS victim siblings according to the parents, they had less intense reactions to environmental stimuli, were less active physically, were more breathless and exhausted during feeding and had more abnormal cries. These behavioral characteristics had a positive correlation with postmortem evidence of antecedent chronic hypoventilation and hypoxemia.

Emergency Medical Service personnel will be among the first contact personnel to a SIDS victim's family. They can help relieve the immediate guilt and anguish of the family or reinforce guilt that may have life-long implications. The first responsibility of the EMS personnel will be to recognize the possibility and probability of an infant being a SIDS victim if, for example, the baby was between one and twelve months of age, was otherwise healthy and found dead following sleep. Additionally, there will be a small amount of blood-tinged fluid in and around the nose and mouth, and where dependent blood has settled a bluish discoloration of the skin simulating bruise marks will appear.

The second responsibility of the EMS is to be aware of the severe psychological reactions to death by the parents who may be emotionally convinced they killed their baby. Questions at this time should be positive and not asked in such a manner as to reinforce the self-inflicted guilt of the parents. Questions to be avoided should include: Have you ever hit the baby? Did somebody drop the baby? Was the baby ill? Did the baby's brothers and sisters climb into bed with the baby? As with all other crises involving death, management depends on knowledge and prior awareness of the need to cope with survivors' emotional and psychological reactions.

On April 22, 1974, the President signed the Sudden Infant Death Syndrome Act (P.L. 93-270) which authorized the Secretary of Health, Education and Welfare to make grants for projects which include the collection, analysis, furnishing of information relating to the causes of the syndrome, and for the counseling of affected families. The law also authorized that public information and professional educational materials be developed and disseminated to health care providers, public safety officials and to the general public.

The Sudden Infant Death Syndrome program, administered by the Office for Maternal and Child Health in the Bureau of Community Health Services, Department of Health, Education and Welfare, has provided grant funds to 24 public and nonprofit groups who are implementing the information, counseling and educational programs across the Nation.

The objectives of the SIDS Regional Centers include: autopsies in all sudden, unexpected deaths of children up to one year of age; certification of SIDS on the death certificate; prompt notification of the parents about the cause of death, preferably within a 24 to 48 hour period; education programs for health care providers, public safety officials and the public; and counseling for families affected by a SIDS loss.

The services provided by these SIDS Regional Centers include: voluntary counseling to families affected by the syndrome through program physicians, nurses, social workers, and psychologists as well as by others in the community such as private physicians, religious leaders and voluntary organizations concerned about the impact of SIDS on the family survivors; education of health care provides, public safety officials and interested community members through articles, pamphlets and films about SIDS; and collection, analysis and furnishing of pertinent information from death investigations of all probable SIDS cases.

SIDS Regional Centers are located in Albuquerque, New Mexico; Baltimore, Maryland; Berkely, California; Boston; Massachusetts; Burlington, Vermont; Concord, New Hampshire; Detroit, Michigan; Houston, Texas; Jacksonville, Florida; Lincoln, Nebraska; Little Rock, Arkansas; Maywood, Illinois, Mobile, Alabama; Nashville, Tennessee; New Orleans, Louisiana; Omaha, Nebraska; Philadelphia, Pennsylvania; Providence, Rhode Island; Raleigh, North Carolina; Salt Lake City, Utah; Seattle, Washington; Spokane, Washington; Springfield, Illinois and St. Louis, Missouri.

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Research in EMS

EMERGENCY MEDICAL SERVICES ACTIVITIES IN THE NATIONAL CENTER FOR HEALTH SERVICES RESEARCH

Lawrence R. Rose, M.D.

Section 1205 of the Emergency Medical Services Systems Act of 1973 authorized the development of a research program as part of the larger effort to improve emergency care. It was felt that most of the critical problems in emergency care are related to our failure to use existing knowledge through properly planned, organized and managed health care systems. Harry Truman pointed out that "it's what we learn after we already know everything that really matters." Responsibility for this research program was assigned to the National Center for Health Services Research in the Health Resources Administration of the Department of Health, Education and Welfare.

Health services research is concerned with the organization, financing, administration, and other such aspects of health services. It is, in a sense, concerned with the *form* of health care wheras biomedical research focuses on the *content* of medicine.

A brief review of even a few of the terms used in the "EMS Act," the "Program Guidelines," and particularly in "The Evaluation Workbook," which is currently being distributed, will point out why the National Center considers EMS research a high priority activity. Communities are responsible for establishing and eventually funding EMS systems; therefore local policy-makers will have to determine whether the systems are acceptable. The meaning of such terms as "adequate," "emergency care," "appropriate training," or "regionalization of resources" will have to be defined by local as well as national standards.

The financial impact of categorizing hospitals is another matter of great concern. How can the safety of telephone screening procedures be assured? What would induce an urban EMS system to accept responsibility for rural and remote areas, and would such rural settings accept their assigned roles in regional systems? What kinds of equipment and communications capability might be considered desirable, but not essential, in a particular service area? How can EMS planning and management agencies work effectively with Health Systems Agencies?

Information about these and many similar problem areas has not been forthcoming from the large-scale EMS demonstration projects which were instituted prior to the passage of the EMS Systems Act. In fact, evaluation activities in these projects were far from ideal. The imprecision and insensitivity of the evaluative tools which were available for use in these studies is partially responsible for this result. It seems apparent that opportunities to ask questions and explore alternate strategies are far more available when Federal funding and assistance are provided than when individual communities are charged with providing services to their citizens. This is a major reason for the decision to focus EMS research on developing more valid and generalizable measurement methods.

Some of the concerns weighed in selecting particular points of emphasis in EMS research are:

Timeliness — is it likely that research results will still be needed when the studies are finished.

Opportunity — is a natural experiment available which makes it likely that studies done now would be more economical or more generalizable than if they were postponed.

Feasibility — is it likely that political, social, ethical, or technical problems would interfere with the studies or with implementation of the results.

Impact — is it likely that the studies would suggest policy options which could solve the problem being addressed.

Additional benefits — is it likely that useful side-effects will be associated with the studies, — such as research methods which could be applied in other areas, or greater public involvement in the issues and support for the results.

Other concerns about research targets include questions about whether appropriate methodologies are available or can be developed, whether qualified researchers are available, whether the required cooperation of various public and private interest groups can be obtained, and whether we can afford the costs of the studies in time and money.

With these concerns in mind, the National Center has designated a number of research targets and assembled them under four major headings:

Measures of performance, including such topics as the development of indices or urgency or severity applicable to all levels of illness, the design and testing of treatment protocols, and the designation and validation of tracer conditions.

System descriptions, which include, for example, the development and testing of systems models, patient record systems, cost-accounting methods, and utilization studies.

Policy issues, including political and organizational analyses of the effects of insurance programs, malpractice issues, and health planning bodies.

Techniques and devices, focusing on studies which can define the utility and effectiveness of new methods rather than merely their feasibility.

Studies to develop performance measures are of major importance to the EMS research program — half of the 44 studies, funded through $4.2 of the $8.2 million spent for EMS research thus far, are examining various ways of measuring the effectiveness of emergency care. The emphasis on such evaluative research is based on the belief that, although EMS systems can be organized, managed, and funded in various ways, it is necessary for system managers to be able to demonstrate that they are improving care and not merely spending money.

The National Center described these research priorities in a grant solicitation recently, an approach which was very successful in gaining the attention of investigators. Ninety three proposals have been received, requesting $10.6 million for the first year; this represents nearly half of all the health services research applications to be submitted to the National Center for peer review in June.

It seems obvious that research in EMS systems will be necessary as long as Federal policy encourages the establishment of categorical systems designed to provide "an arrangement of personnel, facilities and equipment for the effective and coordinated delivery, in an appropriate geographical area, of health care services under emergency conditions through the efforts of an entity which has the authority and the resources to provide effective administration of the system." The judgments which must be made concerning these terms imply the need for far more rigorous evaluative methods than are presently available. Even if such issues as malpractice, health insurance, accelerating health care costs, and the organization of complex multisite hospital systems were not facing us, the requirement that EMS systems be accountable and acceptable to their own community mandates better ways to examine policy options and evaluate system performance.

THE ABBREVIATED INJURY SCALE AND INJURY SEVERITY SCORE: NEW DEVELOPMENTS

Susan P. Baker, M.P.H.

A century ago, Sir Francis Galton wrote a paper called "Statistical Inquiries into the Efficacy of Prayer." He managed to cast substantial doubt on the efficacy of prayer — for example, by pointing to the short life span of many British kings for whom millions of people had prayed every Sunday.

More recently, David Boyd showed us a statistical analysis of death rates at three kinds of hospitals in Illinois. Trauma death rates were substantially higher in the regional trauma centers — about 7 percent, compared to 4 percent in the other hospitals — an observation that might well have led a skeptic like Sir Francis to question the efficacy of medical care at trauma centers.

All of us, of course, realize that these results would be expected when critically injured patients go to major trauma centers while ones with less serious injuries go to smaller hospitals. The problem is to determine whether patients with *similar* injuries fare better at major trauma centers than in the average hospital. To do that requires the ability to categorize patients on the basis of the severity of their injuries. Therefore I would like to briefly describe recent developments in two research tools for describing injury severity — the Abbreviated Injury Scale and the Injury Severity Score.

The Abbreviated Injury Scale (AIS) was developed to provide a numerical ranking for injuries sustained in highway crashes. First published in 1971, the AIS has recently been revised by a joint committee representing the American Association for Automotive Medicine, the American Medical Association, and the Society of Automotive Engineers.

Table 1 gives examples of chest injuries of various severity, with their corresponding AIS ratings. Prior to the 1976 revision, "fatal" scores of 6 to 9 were assigned whenever a person died within 24 hours of injury. As a result, a given injury would be coded "6" in a person who died within 24 hours, even though the same injury could be coded "4" for someone who survived that period. To correct this problem, the old "fatal" codes have been dropped, and each injury now is rated only on the basis of its severity. A new code 6 has been added, for assignment to *specified* injuries categorized as unsurvivable, given present medical capabilities — decapitation, for example, or a masively crushed skull.

A new code 9 has been added, for use whenever the severity of an injury cannot be determined. For example, if a person died before his injuries were diagnosed and was not autopsied, the severity of his internal injuries would be unknown, and should be coded "9".

The AIS is used to code individual injuries. The presence or absence of additional injuries, however, often determines whether or not someone dies. The Injury Severity Score (ISS), therefore, was developed to provide a numerical summary of the *overall* severity of injury. Ths ISS is determined by giving each injury an AIS rating, then added together the squares of the highest AIS rating for each of the three most severely injured body areas. The resulting sum (the ISS) correlates substantially better with mortality than does the AIS rating for the most severe injury. (An ISS is not computed for anyone with an AIS 6 injury; this helps to resolve the problem that an individual with a single overwhelming injury may have a lower score than someone with several injuries that, even collectively, are not necessarily fatal.)

The ISS was based on research using 2128 highway injury cases in Baltimore hospitals. Subsequently, John Bull applied it to 1333 hospital patients in Birmingham, England, and reported a correlation with mortality rates that was very similar to the Baltimore findings (Figure 1). He also found that the ISS correlated with degree of disability (Table 2) and length of hospital stay.

An interesting new use of the ISS, suggested by Bull, is to determine an LD_{50} - that is, the injury "dose" that is fatal to 50 percent of the people so injured. He reported that the LD_{50} was an ISS of 40 for ages 15-44, 29 for ages 44-64, and 20 for ages 65 and older - reflecting the fact that among older people it takes a much smaller "dose" of injury to result in death.

John Semmlow and Randall Cone used the Injury Severity Score in analyzing data from almost 9000 patients in the Illinois Trauma Registry, and found it to be a valid descriptor of injury severity. They found that the ISS correlates with length of hospitalization and with the likelihood of major surgical procedures. For scores below 40, mortality rates were similar to those for Baltimore and Birmingham. For higher scores, death rates in Illinois were lower, but the numbers were small and the difference not statistically significant.

For both vehicular trauma and all trauma, the numbers of patients decreased logarithmically (and similarly) with the ISS (Figure 2), suggesting to Semmlow and Cone that the ISS may be applicable to nonvehicular as well as vehicular trauma.

TABLE 1: Abbreviated Injury Scale: Examples of Codes for Chest Injuries

AIS Code	Injury Description
1	Muscle ache or chest wall stiffness
2	Simple rib or sternal fractures
3	Multiple rib fractures without respiratory embarrassment
4	Flail chest
5	Aortic laceration
6	Torso transection

TABLE 2: Injury Severity Score in Relation to Severity of Disability*

Disability	Number of Patients	Mean Injury Severity Score	Standard Error
Very Severe	5	32.4	±4.7
Severe	44	18.5	±1.6
Moderate	117	12.7	±0.6
Slight	98	10.1	±0.6
Nil	989	5.8	±0.6

*Data from Bull

This work was supported by the Insurance Institute for Highway Safety

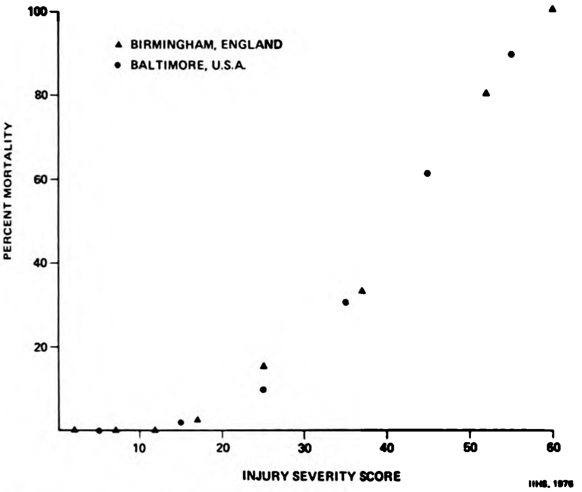

FIGURE 1: Relationship between mortality and Injury Severity Score for patients in Birmingham (ages 0-44) and Baltimore (ages 0-49). Grouped data; the ISS values plotted represent the averages for groups of patients. Individual scores can be as high as 75.

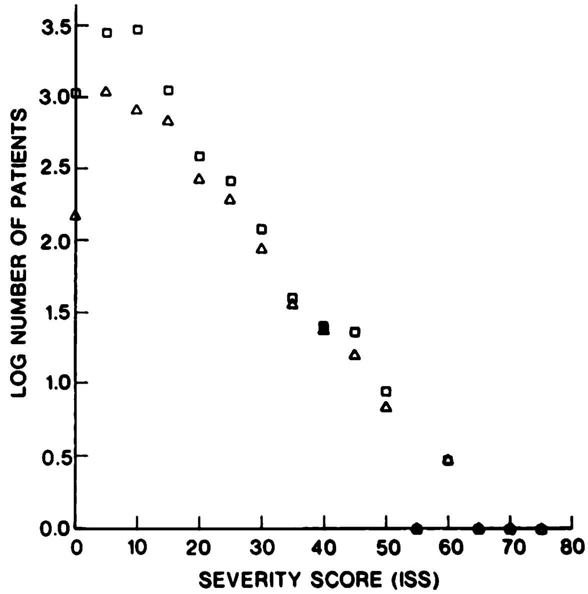

FIGURE 2: Relationship between number of patients (log scale) and Injury Severity Score, Illinois Trauma Registry data. Squares represent all trauma; triangles, vehicular trauma only.

The AIS and ISS are still in developmental stages. Their applicability to penetrating injuries, for example, has not been examined. Despite the encouraging reports described here, much work is needed in collecting, coding, and analysing injury data before its potential usefulness in EMS evaluation can realized.

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TREATMENT PROTOCOL FOR ACUTE MYOCARDIAL INFARCTION

Costas T. Lambrew, M.D.

The level of sophistication of the prehospital interventions necessary to treat acute myocardial infarction (AMI) and its complications will necessarily reflect the availability of mobile basic and advanced life support units, the time necessary for them to respond to the scene of the incident and the distance from the hospital. The mature clinical judgement of a physician is mandatory in treating such patients especially when transit times to hospital are prolonged. Therefore, medical control must be built into the system.

A treatment protocol is a critical element of medical control. In Nassau County, New York, a protocol based on the Standards for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiac Care (ECC) as published in the Journal of the American Medical Association in February of 1974 has been adopted by broad consensus of professionals and hospitals and become the regional standard for prehospital care. The protocol specifies drugs as well as dosages and the circumstances under which they are to be administered. The concentration and packaging of all drugs has been standardized. The protocol furthermore dictates what the paramedic may do independently and what interventions require a physician's order. Use of the protocol on a regional basis has led to standardization of training programs and skills performance requirements for paramedics, thereby facilitating training and providing a basis for meaningful evaluation of capability. Since multiple rescue units are involved, delivering patients to 15 different hospitals, standardization of drug dosage and form, as well as materials carried, has facilitated resupply of the units from each receiving hospital. The medical response to a given problem is defined by the protocol and therefore familiar to the paramedic and within the realm of his capability. Finally, the availability of a protocol, because of standardization of training and skills performance requirements for paramedics and standardization of intervention provides a firm basis for the evaluation of both process and outcome.

In Nassau County, ambulance services are provided by the Special Services Bureau of the Nassau County Police Department which operates 21 ambulances staffed by full time paid personnel trained to advanced life support capability, and 42 fire rescue units staffed by volunteers trained

TABLE 1: Vital Statistics - 1975: Nassau County (NY) EMSS

	Police Ambulance	Volunteer Fire Ambulance	Total
"911" Calls	21,612	20,045	360,223
Patients Transported			41,657
Patients Monitored - ECG Telemetry			14,420
I.V. Infusions	333	401	734
Defibrillations	119	181	300
Patients Medicated	146	294	440

to the same advance life support capability. Rotary aircraft operated by the Police Department also carry a paramedic. Each of the above rescue vehicles has a separate jurisdiction and response is coordinated by a central dispatch center. All communications between the scene of the incident or the vehicle enroute to hospital relating to patient care and requiring a response according to protocol are received by central base hospital console, staffed 24 hours a day, seven days a week by trained ambulance communicators with immediate access to a supervising physician. This patient communications network includes the capability for telemetry of the electrocardiogram. In 1975, a total of 41,657 patients were transported to the hospital. Of this total, 21,612 were transported by 21 police vehicles and 20,045 patients by the 42 fire rescue ambulances. It is obvious then that the frequency of exposure of volunteer rescue personnel to the need to practice their advanced care skills was significantly less than that of the full time police ambulance personnel. Nevertheless a preliminary analysis suggests that under identical standards as prescribed by the protocol, voluntary personnel were able to perform as effectively as full time paid personnel in rendering advanced life support (Table 1). However, a more detailed analysis of compliance to the protocol on the part of both of these groups is now in progress, as is an analysis of outcome of patients carried and treated.

There are certain components of any protocol for the treatment of acute myocardial infarction that are generic. These include patient assessment, cardiopulmonary resuscitation, stabilization of rhythm, relief of pain, maintenance of circulation, medical supervision and delivery of the patient to the appropriate emergency facility (Table 2). The specifics of implementation of each of these components will, however, differ from place to place, depending upon the level of training of rescue personnel, the availability of medical supervision, and the length of time needed to transport the patient to the nearest emergency department for stabilization and to continuing cardiac care.

TABLE 2: Generic Components of AMI Protocol Development

- Patient Assessment
- Cardiopulmonary Resuscitation
  - Airway Maintenance
    - Simple Adjuncts
    - Isolation of Trachea
    - Endotracheal Intubation
    - Esophageal Airway
  - Ventilation
    - Adjuncts
    - Ventilators
    - Oxygen
  - Circulation
    - Cardiac Compression
    - Defibrillation
    - Drugs
  - Stabilization of Rhythm
    - ECG Monitoring
    - Drug Administration
      - I.V. Infusion Lifeline
  - Relief of Pain
  - Maintenance of Circulation
    - Congestive Failure
    - Shock
  - Medical Supervision
    - Communications
    - Radio
    - Telemetry
  - Delivery To Appropriate Emergency Facility

EMS DELIVERY IN DISASTERS

Russell R. Dynes, Ph.D.

The Disaster Research Center (DRC) at The Ohio State University is conducting a systematic and comparative study of the delivery of emergency medical services (EMS) in large-scale and relatively sudden mass casualty producing situations in the United States. The objective of the research is to establish the nature and parameters of the conditions for, characteristics of, and consequences from the efforts to provide EMS in turbulent social environments such as natural and technological disasters and other catastrophic crisis situations with many victims. The core of the study involves intensive and extensive field work on community health care delivery systems in localities involved in disasters and similar events, as well as on systems likely to have to handle or at least to have to prepare to handle high potential mass casualty events.

Thus, the field work involves an examination in given localities of all components in the EMS complex of hospitals, ambulance services, fire-police and other victim transporting organizations present in a disaster area. Data are primarily obtained through in-depth, mostly open-ended interviews with key EMS officials as well as operational personnel at different levels of the EMS system or network, and through the collecting of documentary and statistical information on the receivers and providers of EMS services. Pre-disaster as well as trans- and some post-disaster data are obtained to the extent possible.

Field studies are conducted not only in actual and threatened disaster situations (such as tornadoes, floods, explosions, transportation crashes, etc.) but also at events with mass casualty potentials (such as during the Mardi Gras in New Orleans, the Kentucky Derby, etc.) as well as is some of the known, more high disaster prone localities in the United States (such as Los Angeles, Omaha, etc.).

So far, the study in its first 11 months has gone through the initial two phases.

Phase I has involved (besides the training of a field team and preparation of field instruments) four subtasks:

1) An examination of the relatively recent disaster-relevant EMS planning literature, whether so designated or not;

2) A very detailed, in-depth case study using previously

gathered data on the handling of hundreds of casualties in one major tornado disaster;

3) An intensive reanalysis of all previous hospital/medical area studies undertaken by DRC — this reanalysis involves hundreds of primary interviews and dozens of documents; and

4) The development of an overall theoretical framework for purposes of guiding the research and to allow for the drawing of practical implications.

Overall, this work covering about a four month period suggests the following.

Exceptions can be found, but the current disaster-relevant EMS literature is almost useless for planning purposes in connection with mass casualty situations; it is generally very limited and selective in coverage, has an administrative focus or bias, ignores many real operational problems, and rests in the main on impressions derived from single case ancedotal accounts.

The intensive case study does indicate that there are certain conditions that facilitate a fairly efficient and effective EMS handling of very large numbers of casualties. These conditions are not beyond a planning effort.

This point is supported by the DRC data reanalysis which further indicates that particular factors may contribute to a viable EMS disaster response, *e.g.*, preplanned interhospital links, understood relationships between ambulance services and police-fire departments, pre-disaster professional ties between key EMS system personnel, and clear organizational division of labor in processing victims, to mention but a few factors that appear to be important.

Partly as a result of the work done on the three just mentioned subtasks, DRS has been able to develop a framework that not only utilizes an open-systems model for looking at EMS but relates it also to a network or unit linkage model.

What has been discussed so far involves the already concluded Phase I of the work. Phase II, which has been underway for seven months, however, comes closer to the basic thrust of the study; it involves the conducting of pilot, exploratory and some actual comparative field studies. So far field work has been undertaken or is underway in 21 situations; 13 disaster-like incidents, five pre-disaster settings, and three potential high casualty producing events.

The following are some preliminary field work impressions from the field work, but to which exceptions can sometime be found in given cases.

1) Few localities and their health care systems have undertaken realistic and overall planning for handling large numbers of casualties; most assume the everyday EMS system can be extended to larger scale events even though there are qualitative as well as quantitative differences between disaster and everyday operations (*e.g.*, routine EMS operations are designed in the main to meet specialized problems such as cardiac cases, multiple trauma cases as in auto accidents, etc.) as well as the fact that daily EMS operations are seldom models of efficiency or effectiveness.

2) There is widespread lack of basic knowledge about the overall EMS system in almost all communities even within components of the EMS system itself; only a few officials even recognize this as a problem and even those are uncertain on how to go about diffusing greater knowledge.

3) Political considerations enter into all aspects of EMS planning and response even in disasters, with city/county and public/private splits almost universal, with little understanding by anyone that such process variables may be more important than input resource variables in affecting the development of disaster planning or disaster responses.

4) Almost without exception, lack of coordination among those providing EMS in disasters prevails even in situations where there has been considerable planning; this may be related to the tendency to think of coordination primarily in communication and transportation terms.

5) Poor inter- and intraorganizational communication appears to be almost as serious a problem as coordination of EMS in disasters, although seldom because of a lack of communication facilities per se; in fact, there is a failure to understand that some technological solutions may actual compound organizational problems.

6) By most relevant criteria, the extrication and transportation of disaster victims is generally very poorly handled and appears at times to contribute to additional medical damage; in part this stems from the general tendency of initial victims to be found and moved by non-medically trained personnel.

7) Meaningful triage is seldom attempted in actual disaster situations although some one-site treatment in preplanned situations indicate its value.

8) In certain situations, casualties are treated and admitted simply because they were persons involved in a disaster, and not because of the severity of injuries they have suffered; this lack of discrimination with respect to walking wounded is at the cost of attention to more critical care patients.

9) The frequent lack of implementation on an everyday basis of standardized patient record keeping, one of the 15 EMS components, makes it difficult for EMS personnel to observe the different EMS demands in a disaster situation.

10) In some instances, care being given to regular hospital patients falls below acceptable standards because of the attention given to providing EMS to disaster victims; few hospital disaster plans take this possibility into account.

11) Regular evaluation measures such as output measures, e.g., population mortality rates, do not lend themselves to disaster purposes; more relevant criteria need to be developed.

12) Few EMS systems have any institutionalized mechanisms for learning from disaster experiences, and at present there are also few ways for learning from the experiences of others.

Even the preliminary analysis and observations indicate that disaster related EMS planning is inadequate, that planners for these kinds of EMS activities have no body of systematic knowledge upon which to draw, and that EMS responses in disasters are only occasionally effective and seldom efficient. They also indicate that there are widespread misconceptions in the EMS area about human and organizational actions in disasters, that EMS system disaster experiences infrequently lead to learning, and that the existence of an EMS *system* is often a myth rather than a reality.

On the other hand, there are some positive factors at play that should not be ignored. Here and there in different EMS systems, key officials and operational personnel both recognize the major problems and are attempting innovative solutions. Some of the crucial variables impeding improvements are now also becoming clearer, for example, that disaster planning and response should be recognized as a certain kind of specialized problem, that disaster planning—one of the 15 EMS components—might lead to greater interaction among cooperating units so as to balance the conflict and competition that hospital categorization tends otherwise. to engender, etc. Finally, in the research so far conducted, the evidence is that most of the disaster related problems in the EMS area appear solvable by appropriate system and organizational planning, not requiring major financial expenditures, massive reorganization or the creation of a new technology.

Suggested Readings

Dynes, Russell: *Organized Behavior in Disaster*, 236 pp. Disaster Research Center, Columbus, Ohio, 1975.

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Basic Life Support Communications

TRAINING THE CAREER AND VOLUNTEER EMERGENCY MEDICAL TECHNICIAN

Lt. Willa K. Little, R.N.

There are several components of an effective emergency medical service. One of the most important is the training of the personnel who are actually going to deliver the service.

Training programs can be administered in two different ways. One way and the most common way is to send the people who are to be trained to the medical profession. These programs generally function well but also have some disadvantages. In many cases the medical people may be too busy to give the students their undivided attention. Also, once a person has received the initial training and certification there appears to be a lack of continuing education and in-service evaluation of performance.

Training can also be conducted by an in-house staff. The medical staff is employed by the agency responsible for delivering the emergency care. The medical staff is also responsible for the administration of the Emergency Medical Service as well as the training of both levels of EMT. An in-house staff can conduct an ongoing continuing education program and periodic performance evaluations of paramedical personnel. It is for these reasons that Montgomery County selected this approach. This is particularly important in a system utilizing career and volunteer personnel because volunteers may not be able to maintain skills due to less frequent duty assignments than a career person would normally have. An ongoing continuing education program and in-service evaluations will do much to alleviate the reservations that the medical profession may have when volunteers are utilized in a program of this type. One important point that must be stressed is that training and performance standards for career and volunteer personnel must be equal.

Volunteers have shown that they can perform well in administering prehospital care. Volunteers may have a higher degree of motivation; conversely some volunteers may take the training simply because it is available or because they assume it is the natural progression in training. It is for this reason that a candidate selection or screening system is necessary — not all persons are suited to the paramedic role. Another advantage that the in-house medical supervisors have is that it provides a closer relationship between training and performances. In other words those people that are providing training are also responsible for supervision and evaluation of actual performances. The end result is a system which allows for continuous training and education of personnel. Implementing a training program of this nature is not without problems. Much of the scheduling of classes and clinical experience must be done at the convenience of the volunteers. It requires considerable imagination and extra effort on the part of the instructors and definite flexibility in the schedule.

Many questions about training that existed in the first phase of emergency medical services have been answered. Yes, firefighters, police officers and ambulance personnel can be trained to administer sophisticated prehospital emergency care.

At the present we are wrestling with the questions of how far should these people be trained — just what medical procedures are necessary to be performed in the field. The Level II EMT training curriculum compiled by Dr. Nancy Caroline for the Department of Transportation includes many procedures as necessary for paramedical personnel to be able to perform and several procedures which are still left to the discretion of the administration of the particular programs.

Another question that we are trying to resolve is which agency should have the responsibility for providing the emergency medical service. Should it be in the fire service, the police department, the health department or the private ambulance companies? Another question is should it be delivered by career or volunteer personnel or a combination of the two? We are evaluating the types of systems in order to answer these questions.

What are our ultimate goals in training of emergency medical personnel. Ideally there should be paramedical programs in every community. At a minimum all persons called upon to deliver emergency care to the sick and injured must be trained to the basic EMT level.

Although an Advanced EMT program involves a different set of training needs and legal constraints, with a little imagination and extra effort volunteers and career personnel can perform well together in emergency medical services.

STATEWIDE EMS COMMUNICATIONS PLANNING

Gene A. Buzzi, B.S., M.S.

Introduction

This presentation provides an outline of Florida's Public Safety Telecommunications Planning with particular emphasis on Statewide EMS Communications. Please keep in mind that every state's telecommunication planning is a function of many variables such as enabling legislation, economic conditions, whether or not a state-level telecommunications organization exists, and if so, its size and capability.

As such, the methodology of each state's effort in this field will be unique. Therefore, this presentation in no way represents how this function should be performed, but how Florida's telecommunications planning and engineering operates in a specific environment.

Communications Division Organization

The Division of Communications was formed in 1969 by the Florida Legislature as a part of a broad state government reorganization act which consolidated over 200 state agencies into 26 major organizations. The Communications Division is one of seven operating divisions of the Department of General Services. The Department of General Services, in turn, is one of six departments responsible to the combined leadership of the Governor and the six elected Cabinet members.

At the present time, the engineering staff of the Division of Communications numbers 22 engineering personnel.

Telecommunications Legislation

As previously indicated, the legislation that established the Division of Communications was passed in 1969, and is referred to as the Governmental Reorganization Act. Insofar as Public Safety Communications legislation is concerned, the Regional Law Enforcement Communications Act was passed in 1972, the Emergency Medical Services Telecommunications Act was passed in 1973, and the 911 Emergency Telephone Act was passed in 1974. A Regional Fire Communications Act was introduced in the 1975 Legislative Session, but was not enacted, due primarily to the state's economic condition.

Law Enforcement Communications Legislation

This act directed the Division to formulate and implement a County and Municipal Law Enforcement Communications Plan, with publication of the Plan required within one year. The legislation authorized the Division to adopt any rules and regulations necessary for implementation, and required that any new or expanded law enforcement communications systems be approved by the Division of Communications.

911 Emergency Telephone Number Legislation

The Emergency Telephone Act established 9-1-1 as the emergency telephone number and requires statewide implementation, based upon a plan developed and implemented by the Division of Communications. Public agencies are required to obtain approval from the Division of Communications for all new or expanded 911 systems. Designated agencies are required to place an order with the telephone company within six months after Plan publication, and the telephone company is required to provide the system within 24 months of the order.

Proposed Fire Communications Legislation

Due primarily to economic conditions, the Statewide Fire Communications legislation has not been passed.

The proposed legislation is quite similar to the Emergency Medical Services and Law Enforcement Communications Acts.

Emergency Medical Services Telecommunications Legislation

In 1973, the Florida Legislature enacted two interrelated laws regarding statewide Emergency Medical Services.

First, the overall responsibility for Emergency Medical Services was vested in the Division of Health of the Department of Health and Rehabilitation Services, and secondly, the Emergency Medical Services Telecommunications Act was enacted to specifically address the communications component of this emergency health care program.

This act requires the Division of Communications to develop, coordinate and implement a statewide system of EMS Communications. All EMS entities (public and private) are required to comply with the Plan and to obtain Division of Communications approval for new or expanded EMS Communications Systems.

Approach To EMS Planning

Under this legislative authority, the Division of Communications has addressed the total statewide communications needs and requirements through the application of *systems philosophy* whereby the planning viewpoint encompasses the interrelationships which tie the subsystem parts into a total system and identifies those factors which act upon or are acted upon by the system. In other words, the program is approached from the statewide viewpoint, rather than treating the counties and cities as independent and unrelated.

Using this approach, a questionnaire was developed for use in surveying all public and private EMS agencies.

The survey questionnaire covered various topics involved in Emergency Medical Services, which were directed toward identifying the existing EMS framework. Of prime concern were the questions related to traffic flow and communications capability and therefore, definition of natural catchment areas.

Fifty-eight EMS Local Catchment Areas were defined following the evaluation of the survey data. The majority of these local catchment areas are defined by county boundaries, primarily because of the predominance of the county political/jurisdictional responsibility for providing Emergency Medical Services. These local catchment areas are individually presented in the Statewide Plan, along with corresponding tables describing the emergency medical service facilities.

Since the capabilities of all local catchment areas are not equal, a group of these areas will relate to one specific catchment area for its major emergencies. These major catchment areas have capabilities and expertise in specialized health care which other areas cannot normally afford or do not require consistently enough to justify. Fourteen of these facilities capable of handling major emergencies were identified by evaluation of the survey data, and the area that includes these specialized emergency health care services is described as a Major Catchment Area. The major catchment areas are thus comprised of grouping of local catchment areas.

These major catchment areas are individually presented in the Statewide Plan, along with corresponding tables describing the emergency medical service facilities.

The reduction of survey data in most cases clearly defined the local and major catchment areas. It also indicated that some local catchment areas referred to more than one major catchment area; that some major catchment areas extend beyond state boundaries; and on occasion, traffic occurs between two major catchment areas. Thus, the interrelationship among the various EMS systems were identified, and used as a basis to define the communications capabilities necessary to support the emergency health care delivery systems.

EMS Communications Planning

At the outset, it was decided to utilize the recently allocated Ultra High Frequency (UHF) channels to the greatest extent possible for the Statewide EMS Communications System, and retain the already-crowded Very High Frequency (VHF) channels for private ambulance dispatch, paging and point-to-point communications.

The basic EMS Communications System identified in the Statewide Plan requires three different categories of radio communications:

Category 1: Vehicle Coordination
- Dispatch and control of EMS vehicles
- Coordination of EMS personnel at the scene (optional)

Category 2: Medical Coordination
- Doctor/EMT talk and telemetry channel
- One-way paging for alerting and coordinating personnel

Category 3: Medical Resource Coordination
- Point-to-point radio communications between EMS facilities

A brief description of the frequencies utilized for these categories is as follows.

CATEGORY 1: VEHICLE COORDINATION

Dispatch and control of EMS vehicles is accomplished via the two UHF frequency pairs designated by the Federal Communications Commission (FCC). These are 462.950/467.950 MHz and 462.975/467.975 MHz.

For the optional scene coordination channel, it is recommended that portable radios be equipped with either 462.950 MHz or 462.975 MHz in the simplex mode (transit and receive on a single frequency).

CATEGORY 2: MEDICAL COORDINATION

The doctor/EMT talk and telemetry function is naturally performed on MED-1 through MED-8, the eight contigous UHF channels so designated by the FCC, which requires that all eight channels must be licensed in the mobile radios. However, base stations are only required to have three channel capability, or four channels if telemetry is used.

Based upon traffic loading survey data, the Plan geographically allocates dedicated channels to each catchment area to be used for this medical coordination function. This channel allocation provides maximum distance between co-channel users, and combined with the use of Continuous Tone Coded Squelch Systems (CTCSS), serves to minimize co-channel interference.

In rural counties with low traffic volume, these channels are also utilized for dispatching EMS vehicles in lieu of the dispatch channels previously described.

Finally, all base stations are equipped with the MED-8 channel for access by EMS vehicles which are out of their prime area as in the case of a long distance patient transfer.

For one-way paging, the four VHF low band and three VHF high band frequencies so designated by the FCC are recommended. All paging operations in the Special Emergency Radio Service must utilize these seven channels after January 1980.

CATEGORY 3: MEDICAL RESOURCE COORDINATION

For point-to-point communications between Emergency Medical Facilities, it was originally planned to utilize the MED-8 frequency of 463.175 MHz in the simplex mode. However, in actual use, this application requires a special base station with an extra receiver, it restricts the normal use of MED-8 and also causes nuisance interference to EMS facilities over a wide area. Therefore, it is presently recommended that this function be accomplished on the VHF frequencies of 155.340 MHz or 155.280 MHz, with the added feature of selective signalling so that communications is conducted only with the intended emergency facility.

Translation of Communications Requirements and System Design

The actual engineering design of each EMS system requires the development of detailed procurement specifications so that the system purchased will fulfill the operational requirements of the specific emergency medical service facility. This design beings with the translation of the medical operational requirements into technical specifications.

For example, if the operational requirement demands that the doctor have the capability to interrupt the EMT during ECG telemetry transmission from the EMS scene, this translates into the technical requirement for a full duplex field radio unit. Or, if the doctor requires simultaneous reception of patient ECG and EMT voice, this translates into the technical requirement for a field unit capable of multiplex transmission.

These translated requirements, together with the three basic categories of radio communication presented earlier, are thus combined to produce a working system that conforms to each user's unique operational requirements, and is compatible with EMS systems throughout the state.

Finally, in addition to this overall EMS *geographical* planning aspect, the EMS Communications Program is being integrated into the overall *functional* program of Public Safety Communications, which includes the Statewide Law Enforcement Communications Program and the Statewide 911 Emergency Telephone Program.

Thus the geographical, functional and operational objectives of EMS, Law Enforcement and 911 telecommunications are planned to be systematically integrated to maximize the shared use of communications resources and to provide the capability for intrasystem and intersystem coordination within the total Public Safety Communications environment.

DEVELOPMENT OF A STATEWIDE RURAL BASIC LIFE SUPPORT COMMUNICATIONS SYSTEM

John A. Wilkinson

Development of Emergency Medical Services and Emergency Medical Services Communications in Wyoming has followed the general national trend but until recently has lagged far behind most other states. The EMS system in Wyoming has evolved from the early day mortician-rural American doctor services to a fairly sophisticated blend of professional and volunteer programs offering the residents of the state adequate, if not fully developed, care in time of need. Ambulance development in the state has progressed from the horse and buggy era to the use of modern, well-equipped ambulances, most of which meet the Department of Transportation requirements and are staffed by trained and qualified ambulance attendants, including 81-hour trained Emergency Medical Technicians.

Communications for Emergency Medical Services within the state also has followed the general national trend. Initial communications developed were part of the law enforcement networks, mainly linking the ambulance to a central dispatcher in each community. This provided the ambulance attendant direct radio communications with county sheriffs, local police departments, the Wyoming State Highway Patrol and most fire departments. Communications from the ambulance to the hospital were generally provided by use of a telephone relay from the central dispatch center to the hospital. This type of communications often left much to be desired due to the tendency to misinterpret or incorrectly relay complex medical terminology.

Some limited range hospital to ambulance communications systems, were developed in the state prior to 1973. These mainly provided local coverage for a specific hospital and operated on the Emergency Medical frequencies of 155.340 or 155.280.

In order to understand the problems and the needs faced by Wyoming residents, a brief introduction to our state is in order. Located in the high plains area of the Rocky Mountain region, Wyoming is the nation's ninth largest state with a land area of 97, 904 square miles. It is the nation's least populated of the 48 contiguous states and 49th overall, with only Alaska having less than our 360,000 residents. About 400 physicians serve the state's residents.

Wyoming, which is composed of 23 counties, is served by 27 hospitals with one or more in each of 22 counties.

Cheyenne, the capital of the state, is the largest city with approximately 50,000 residents and is classified as urban. The majority of the population, approximately 60 percent, live in communities ranging from 2,500 to 50,000 residents.

The population density by county varies from .8 persons per square mile to 20.9 persons per square mile. The statewide average is a little under four persons per square mile.

Hospitals serving the state range from a ten bed facility to a 298 bed hospital. Of the state's 27 hospitals, only two have full time emergency department physicians with several others having physicians on duty in their emergency departments during specific periods of the day, usually from 6:00 P. M. to 6:00 A. M. The majority of the hospitals in the state have physicians on call, with the emergency department served by the charge nurse on duty.

In 1972, the membership of the Wyoming Hospital Research and Education Foundation directed the WHREF staff to investigate the development of a statewide Emergency Medical Services communications system or if sufficient funds were not available, to develop an appropriate model in one region of the state.

The WHREF staff first instituted a study of past Emergency Medical Services planning. Very little was found. The state did have an active division of Emergency Medical Services within the State Department of Health and Social Services, but this division was dedicated strictly to the purchase of ambulances with Department of Transportation funds and to the training of Emergency Medical Technicians. It was found that the State of Wyoming did not and still does not, have a Division of Communications.

Recognizing the lack of coordinated planning, the WHREF Board directed the staff to proceed with the development program and to include EMS Communications coordination.

A decision was made to attack the problem on the basis of needs of the area residents, capabilities of the health care providers in the state, to include facilities, and finances available.

A study of the needs of residents based on the meager information available indicated that trauma was by far the most pressing issue. Cardiac was a distant second. The high instance of trauma in Wyoming can be traced to the state's economic base. Included are such high risk occupations as farming, ranching, oil and gas production, mineral production and processing, outdoor recreation and tourism. This indicated to the staff that development of a basic emergency medical services communications system appeared to be a far more immediate need than that of a sophisticated biomedical telemetry system.

In studying the capabilities of health care providers, it was found that many problems existed. The major shortcoming was the deterioration of skills of health care providers, especially in the trauma area, due to a lack of continuing education.

The second problem identified was a high turnover rate. In one year, 600 of 700 state licensed LPNs changed addresses with the State of Wyoming.

Another problem was the maldistribution of physicians throughout the state. Of the state's 400 physicians, approximately 50 percent practice in the four major urban areas. This leaves only about 200 physicians distributed throughout the majority of the state.

A study of facilities in the area showed that while many of the smaller hospitals had well-equipped emergency rooms, many of the employees were not capable of utilizing the sophisticated equipment available. As noted previously only two hospitals in the state as yet have physicians serving around the clock in the emergency departments. This lack of trained personnel immediately available at the hospital also reinforced the decision to develop a basic life support communications system rather than a sophisticated advanced life support communications system.

Moving into the financing area, the staff found a large stumbling block. Funds in our underpopulated state simply were not available in sufficient quantity to develop even a basic life support communications system. Then, in April 1973, the Robert Wood Johnson Foundation announced a nationwide competitive program of grants for regional Emergency Medical Communications systems. A grant application was developed by the WHREF staff, with the assistance of the Colorado-Wyoming Regional Medical Program, and submitted. Following an on-site visit, the Northwest Wyoming Emergency Medical Services Communications System was one of 44 projects funded by the Robert Wood Johnson Foundation.

This initial development project was approved for the five county Big Horn Basin region located in Northwest Wyoming. The Big Horn Basin is aptly named. The Big Horn Mountains run from north to south on the eastern edge of the region with the Absoroka and Wind River Range running down the western edge of the area. These 13,000 foot plus mountains enclose a very rich region which was a natural working area for the project. The Big Horn Basin encompasses 23,600 square miles with a population of 69,000 people. It includes five counties, served eight hospitals and four medical clinics, two of which are operated by the Public Health Service on the Wind River Indian Reservation and serve the 3,900 members of the Arapahoe and Shoshone Nations. Operating in the area when the project started were 23 ambulances. These ambulance services are both private and public, ranging from volunteer to funeral home operated, but all are in some manner subsidized by county or city government. The equipment in most cases is modern, including many cardiac monitoring units which are capable of conversion to biomedical telemetry utilization in the future.

As a system development base, the five active and organized 911 centers located in either major communities in the area were incorporated into the project along with two rural single entry ring-down systems. Of the three remaining communities, two had already instituted development procedures for 911, leaving only one major community without this single entry system that we consider vital to a basic rural life support communications system. Following a meeting with the county commissioners and the city council in the remaining community, the local government officials initiated a request with Mountain Bell Telephone Company for development of 911. Thus, early in the model system development we had all major communities served by single entry 911 systems.

A call for volunteers to serve without compensation on area Emergency Medical Services Councils was greeted with enthusiasm. Almost overnight we had two active councils hard at work.

Since their inception, the councils have expanded their membership and both are presently broadening their scope of responsibility to include other areas of health care. Originally provider dominated, the councils are moving toward majority consumer membership in line with guidelines established for Health Service Agencies.

Along with our hard working council members, Wyoming's terrain came to our aid.

A preliminary decision during development of the great application had been to utilize a UHF/VHF crossband system with Ultra High Frequency communications from the hospital to selected mountaintop repeater sites for rebroadcast on 155.340 MHz to the ambulances. Additional study indicated that this wide area system would be required, but that a backup 150 MHz system also should be installed in each hospital to provide local area coverage in case of problems on our strategic mountains. The mountaintops selected dominate the area and provide almost complete coverage of every major road area in the region. In addition, they are situated so they provide interface with our norther neighbor Montana and allow for mountaintop to mountaintop interface with systems being developed, or yet to be developed, throughout the state.

To check the validity of the system design the staff traveled approximately 40,000 road miles in the region conducting actual communications checks utilizing the facilities of radio common carriers and private radio users in the area. This was done in good weather and bad to be sure that adequate communications would be provided for the area since most of our communities are 30 or more miles apart and weather variations are a major concern.

These studies were completed about the time the Federal Communications Commission came out with Dockett 19880 as amended revamping the Special Emergency Radio Service. Our preliminary plans had been to utilize one of the MED frequencies as a control frequency from hospital to mountaintop, giving us a future entry point into development of a UHF biomedical telemetry capable system. With the publication of Dockett 19880 as amended we moved from the MED frequencies into the joint use frequencies contained in section 89 101(p) of the Federal Communications Rules and Regulations.

There was no question of changing from the UHF/VHF crossband configuration to a UHF system due mainly to cost.

At the time of development, information available indicated that there 1.9 ambulance runs per day in the entire region. It was felt that this small activity did not require development of an alternate channel for the local systems and one was not implemented. Since that time, the 1.9 ambulance runs per day has grown to almost eight on the average and we are experiencing some interference problems since we utilize 155.340 MHz for both the local and wide area systems. To alleviate this interference, a separate local area frequency will be developed during the next six months.

One item that was questioned at the time of development was the use of Touch Tone encoding. This decision has proven to be correct during system operation. Use of Touch Tone has allowed "quiet" operation of the system with each hospital receiving only those transmissions intended for that particular hospital. In addition, Touch Tone provides a versatility needed for other system control functions such as mountaintop selection and intricate switching systems between the mountaintops. Only the hospitals and mountaintops are tone controlled. All mobile units operate on open squelch with priority scanning to insure that they receive all pertinent traffic.

Another portion of the system that has proved especially beneficial to the facilities and the personnel operating in the area has been the inclusion of a wide area paging system on 152.0075 MHz. Many of our hospitals are understaffed with one X-ray or lab technician on call 24-hours per day. Utilization of paging has freed these people from the telephone and allowed the hospital to have instant notification for these people, even if they are downtown shopping, on the golf course or on a nearby stream fishing.

Following development of the system plan, initial licensing and the obtaining of use permits for mountaintops located on U. S. Forest Service land, equipment specification were finalized. Contact with major vendors serving the area indicated that two, Motorola and General Electric, were interested in bidding on the system. Due to time problems and continually rising costs, the contract was not let for bid but individual negotiations were held with the two major vendors. Following these individual negotiations were held with the two major vendors. Following these individual negotiations, the contract was awarded to General Electric Corporation and installation was started. In September 1974, the system was put into partial operation. For the next six months, the system was "shaken down." As with any electronics equipment, there were individual equipment failures, but these were minor. The main problem faced by the staff was training.

Ambulance operators, who were used to radio operations proved to be fairly easy to train in use of the new equipment, including the Touch Tone encoding. Moving into the hospitals, none of which had previously had had radio communications, training proved to be more of a problem.

Individual training sessions were held at each hospital for all personnel who would be expected to utilize the equipment, including Registered Nurses, License Practical Nurses, nurses aids, ward clerks and other persons such as administrators and key supervisory personnel. The initial training sessions were followed by individual training sessions approximately three months later for personnel who had been identified in each hospital as prime radio operators. In the majority of instances, in the larger hospitals, these proved to be the ward clerks. In smaller hospitals, prime users varied from Registered Nurses to LPNs to aides.

Future training programs call for concentrated and in-depth training of two or three key persons in each hospital. By training these selected persons to be fully qualified operators, they in turn will be able to conduct continuing training programs and serve as training cadre for second and third generation users.

During the development of the Northwest Wyoming Emergency Medical Services Communications System, it was selected as one Robert Wood Johnson Foundation funded project to be evaluated by the Rand Corporation. An initial three month data gathering period was conducted prior to installation of the equipment. A second three month data gathering period, now that the equipment is in operation, is currently underway. Paralleling the Rand Corporation evaluation, the Wyoming Hospital Research and Education Foundation also is conducting an evaluation of the system, utilizing the ambulance trip report form and emergency department log originally developed by the Rand Corporation.

During the time of development of the Northwest Wyoming Emergency Medical Services Communications System, the WHREF staff also assisted in the development of a "local" system of VHF high band communications utilizing 155.340 in two other counties. In mid 1975 the WHREF began work with the State of Wyoming Emergency Medical Services Division to develop an HEW/EMS grant under Section 1203 of the Emergency Medical Services Act of 1974 for the state's six southeastern counties. The program was funded by DHEW in July 1975 with the WHREF serving as subcontractor to develop the communications system.

The DHEW approved State Plan calls for primary emergency medical services frequency for the state to be 155.340. This frequency will be utilized as the basic long range frequency under FCC Rules and Regulations allowing for UHF/VHF crossband repeaters. This system also allows for interface with adjacent states, with interstate coordination. Utilization of the VHF frequencies also provides for direct interface with other state agencies such as law enforcement, fire and emergency units. The Wyoming Highway Department is in the process of changing its highway patrol primary frequency band from low band VHF to high band VHF. This change is being followed by local law enforcement agencies and fire departments throughout the state.

Based on experience in the Northwest Wyoming EMS Communications System and to assure systematic development of EMS communications in the state as the population expands, the state has been divided into five local regions.

Under this plan ambulances operating in specific geographic areas will utilize frequencies different than 155.340 MHz but still authorized under FCC Rules and Regulations for EMS communication for local radio contact with their supporting hospitals.

One major area of concern has been centralized dispatch of ambulances. In Wyoming, at this time, we feel that this is impractical due to the lack of an effective statewide communications system. Therefore, ambulance dispatch is localized, usually county wide through use of a 24 hour manned 911 or other law enforcement center in major communities. As the EMS system develops, regional centers are being developed for coordination, mutual aid and disaster control. The eventual goal is a statewide centralized dispatch system similar to that in use in New Mexico.

As part of our program, we are stressing continued development of 911 or similar single entry emergency numbers. Currently 23 of Wyoming's 34 major telephone exchanges have 911 systems with three additional systems being developed. In addition, there are many small single entry systems in operation in more remote areas of the state. These range from ring-down circuits answered at the homes of combined emergency medical technician-volunteer firemen to a system in one community where the emergency calls come into a 24-hour a day truck stop operated by combined emergency medical technicians-volunteer firemen.

To provide the necessary type single entry centers within the state, three separate levels have been designated. These are local emergency centers, county emergency centers and regional CMEDCC centers. All but local centers will be interconnected with EMS radio, law enforcement radio and disaster coordination radio backed up by land line communications, either telephone or teletype. Each local center will be independently operated by county, city or volunteer agencies as appropriate. In addition, remote industrial users such as mines, mills, etc., may operate a local center designed to protect their workers. Each local center will be directly connected to a county 911 center by radio or telephone for additional assistance and control. Local centers will be required to provide a minimum of fire, rescue and ambulance service dispatch capability. This dispatch capability can be through a single 24 hour manned center or by utilization of a ring-down system to be approved by the State EMS office.

Each county center will be jointly operated by city and county agencies, usually the sheriff and police, and may include the fire department if appropriate. The county center will be responsible for an entire county or county region, depending upon population distribution and terrain, dispatch and control of law enforcement, fire, rescue, ambulance service and related disaster agencies. A county center may also serve a specific community.

Regional centers usually will be county center with the added responsibility of regional control and coordination in time of natural disaster or mass casualty situations. Regional centers must be connected to state agencies such as civil defense, National Guard, etc. Certain regional centers will be designated as interface centers with the additional responsibility of coordination with a specific adjacent state.

Wyoming has not yet achieved a complete statewide basic life support communications system, but we feel that we are moving towards our goal at a rapid pace with a definite plan to follow. At the present, we have one operational system serving five of Wyoming's 23 counties. A contract has been signed by the State of Wyoming with General

Electric, the successful bidder, to provide equipment for the six county DHEW funded Southeast Wyoming EMS Communications System. It is expected that this system will be on the air prior to the end of October. At this time, eleven of Wyoming's 23 counties will be served by a fully integrated Emergency Medical Services Communications System with two additional counties having local systems providing approximately 30 minute advance notice of arrival at the hospital of an ambulance serving the area. Thus, by October we hope to have reached a halfway point in our projected program to develop a comprehensive basic EMS Communications System for Wyoming. Continued development in the state's 12 additional counties will depend upon availability of funds, both federal, state and local, with a tentative completion of the entire state program set for 1979.

But, Wyoming is not standing still. Continual study and upgrading of the state plan will be conducted jointly by the State of Wyoming and the Wyoming Hospital Research and Education Foundation. Plans presently are being made for development of the Advanced Life Support training program. The communications system will be required with a view towards expansion into a full UHF system for specific areas.

In addition, studies are being conducted of the possibility of developing telemedicine systems to link some of our remote physician assistant manned clinics with area hospitals and we are studying the feasibility of interstate UHF biomedical telemetry with our more populated and medically sophisticated neighboring states.

Our primary goal is to provide the best possible patient care through use of modern technology on a planned basis.

BACKGROUND FOR MEDICAL RADIO SERVICE

L. R. Raish, B.S., J.D.

I would like to bring into focus for you some of the background of the medical radio service. In 1973 and 1974 actions were taken at the Federal Government level that serve as benchmarks for EMS communications—one by the Office of Telecommunications Policy (OTP) and the other by the Federal Communications Commission. Both of these actions were preceded by extensive study and deliberations.

Initial policy was set by the Administration in the area of Emergency Medical Services early in 1972 when the President made two statements on the subject:

In his State of the Union message to the Congress of January 20, 1972, the President said "We must develop new ways of organizing Emergency Medical Services and of providing care to accident victims. By improving communications, transportation, and the training of emergency personnel, we can save many thousands of lives which would otherwise be lost to accidents and sudden illnesses. Such improvement does not even require new scientific breakthrough; it only requires that we apply our present knowledge more effectively."

On March 2, 1972, in the President's health message to the Congress it was stated "*Emergency Medical Services:* by using new technologies to improve care systems and by using more and better trained people to run those systems, we can save the lives of many heart attack victims and many victims of auto accidents every year. The loss to the nation represented by these unnecessary deaths cannot be calculated. . ."

Paralleling the President's two statements was a groundswell of concern and interest in improving emergency medical services across the country. This had been prompted by the realization, among other things, that the Armed Forces had proved through its operations in Vietnam that the number of otherwise fatal combat casualties could be reduced substantially by prompt medical attention, and there was no reason why the same concepts could not be applied effectively to civilian life throughout our country, and that aerospace technology used in the manned space missions, with some adaptations, could make this a practical undertaking. The effectiveness of these concepts had been dramatically demonstrated by projects and programs such as those of Illinois Trauma Center, the Jacksonville, Florida; Houston, Texas; and San Francisco, California EMS systems, and the Military Assistance to Safety and Traffic (MAST) Program.

Concurrently there was an outpouring of activity among professional, lay, and governmental organizations toward upgrading emergency medical care. Technology and methodology for delivering high quality emergency medical care was developed for each element of EMS systems. All that was lacking was a means that would link the various elements of emergency medical care to provide optimum performance. That link has become recognized as telecommunications which, in fact, serves as the nervous system for the emergency medical service. This was followed by the recognition of the need for radio frequency allocations to facilitate system development. At this point, i.e., in April 1973, the Office of Telecommunications Policy stepped in and established a special Ad Hoc group to undertake a study and preparation of a report on Emergency Medical Service (EMS) communications. This group became known as "IRAC Ad Hoc 120." It was thus the Report of this group that was the forerunner of the FCC Report and Order of July 2, 1974.

It was found that there was hardly a government department or agency that is not involved in some aspect of EMS. DOT, HEW, the DOD, and the Veterans Administration have major, but not the only Federal Government, interest in EMS. Ad Hoc Group 120 included representatives from all of those agencies. In all we had something like 20 people participating in Ad Hoc 120 and believe it or not the group's effort resulted in a report that was published by the OTP in November, 1973.

In undertaking its work Ad Hoc Group 120 quickly recognized that the crucial matter to be observed is that telecommunications provides the means by which the various subsystems of a total EMS system are brought together in a coordinated fashion, and that it was telecommunications that systematically relates the many medical functions, ambulances, hospitals, and emergency departments that in many cases already existed. In developing telecommunications concepts responsive to the requirement for systematically relating various elements of EMS, the Ad Hoc group decided that any provisions made should be based on the following features:

That there must be compatibility among EMS systems along with operational arrangements for an interface with police, fire, and other emergency type services.

That EMS communications should be designed on a systems basis to serve natural catchment areas at the community level.

That coordination be managed from a centralized regional resource coordination communications center which could receive calls and be responsible for making an appropriate response of resources, acting under medical supervision, for such on-the-scene treatment.

That whatever system was adopted, it would have to take into account existing equipment inventories, while developing and implementing the eventual optimum EMS system for that particular area.

That UHF provides a greater flexibility and promise than does VHF so that encouragement for system development at UHF would be desirable.

That frequencies and systems developed should be interchangeable between Federal Government and non-Federal Government agencies so that mutual cooperation can be accomplished widely.

That EMS should be identified in the FCC Rules by a new and separate category in the Special Emergency Radio Service with radio frequencies designated exclusively for this purpose.

That systems concepts should be of sufficient flexibility to meet the unique needs of both urban and rural areas.

That medical paging should be based on providing service to the entire medical community (on the premise that a doctor would not be paged unless there was an emergency or some sort).

The report prepared by Ad Hoc 120 provides for an EMS communications plan adaptable to both urban and rural areas. Specifically it provided for:

Establishment on a national basis for common radio frequencies (39 in number) for use by EMS units at the scene of medical emergencies, wherever occurring.

Paging systems that would be used not only for EMS but also to contact members of the general medical community.

Dispatching and directing of ambulance operations, *e.g.*, instructions to drivers as to which hospital to go and traffic conditions enroute.

Communication networks for biomedical telemetry, medical data handling, and special voice circuits for exclusive use by doctors.

When I started I said there were two benchmarks for EMS communications. The Ad Hoc Group 120 report is one of them. The other is the Report and Order on EMS communications published by the FCC in July 1974.

The FCC Report and Order takes into account the features that came out of the Ad Hoc 120 study. The FCC did adopt rules establishing a separate medical services category in the Special Emergency Radio Service with rules and frequency complements of its own. No longer will EMS have to share, coordinate with, or be secondary to another type of mobile service. There is still a coordination requirement among EMS services but this is a precaution to assure that EMS systems serving adjacent areas do not disrupt the operations of each other—this is a simple matter compared to having to coordinate with all other emergency service operations in or adjacent to you.

The particular language with regard to EMS frequencies in the Commission's Report and order is important. The Commission said:

> Frequencies for use in Medical Services are shared by all licensees in an area. It is expected, therefore, that the most efficient and effective use of new frequencies being made available in the UHF bands will only result from user cooperation in the development of common systems involving the establishment of central centers for coordinated EMS operations under area-wide communications plans.

APPLICATION OF SYNCHRONOUS SATELLITE COMMUNICATIONS TECHNOLOGY IN EMS SYSTEMS

Cecil D. Burge, Ph.D.

Introduction

FCC regulations require that biomedical telemetry utilize the 460 MHz band. Voice communications may utilize the 155 MHz band for medical coordination and dispatch. The propagation characteristics of VHF (155 MHz) and UHF (460 MHz) bands are different. Atmospheric attenuation is higher in the UHF band; moreover, skip conditions sometimes enhance propagation in the VHF band. The result of these differences is that the grid of relay towers required for comprehensive UHF coverage in a given area must be finer than that required for comprehensive VHF coverage. This fact usually makes the provision of pervasive biomedical telemetry in rural EMS system prohibitively expensive.

A case in point which served as the impetus for the work described in this paper is the Southeast Mississippi Air Ambulance Service District (SEMAAD) EMSS in rural Southern Mississippi. The service area of this EMSS encompasses almost 4,000 square miles and 180,000 people. Almost two-thirds of the population resides in a purely rural area while some 60,000 people live in Hattiesburg, the services ares's only urban center. A large part of the 120,000 rural inhabitants live at distances in excess of 50 miles from the only Category II ER of the region at Forrest County General Hospital in Hattiesburg.

At the present time, the SEMAAD EMSS has comprehensive voice coverage over its 3,800 square mile service area. Two VHF channels (155.340 MHz for medical coordination and 155.325 MHz for dispatch) are now available. The original intent of the system design has been to implement comprehensive telemetry coverage; however, the cost has proven prohibitive. At the present time telemetry is being implemented in the Hattiesburg area.

As a result of the cost and coverage limitations of UHF terrestrial telemetry, the University of Southern Mississippi and NASA's National Space and Technology Laboratories (NSTL) with funding from several sources have conducted experiments involving the use of synchronous satellites that have demonstrated the potential application of these technologies in an EMS role. Specifically, two distinct approaches have been investigated. One involved the Geostationary Operation Environmental Satellite (GOES) and the second utilized the ATS-3 satellite. Both are an outgrowth of NASA/NSTL's involvement with the Department of Commerce's remote environmental monitoring programs and were funded in part by NASA's Office of Technology Utilization.

The GOES/DCS Program

Figure 1 shows the key elements in the GOES/DCS environmental monitoring technology. At the present time there are two GOES satellites, one located at 115°W longitude and the other at 75°W longitude. Both have roles other than

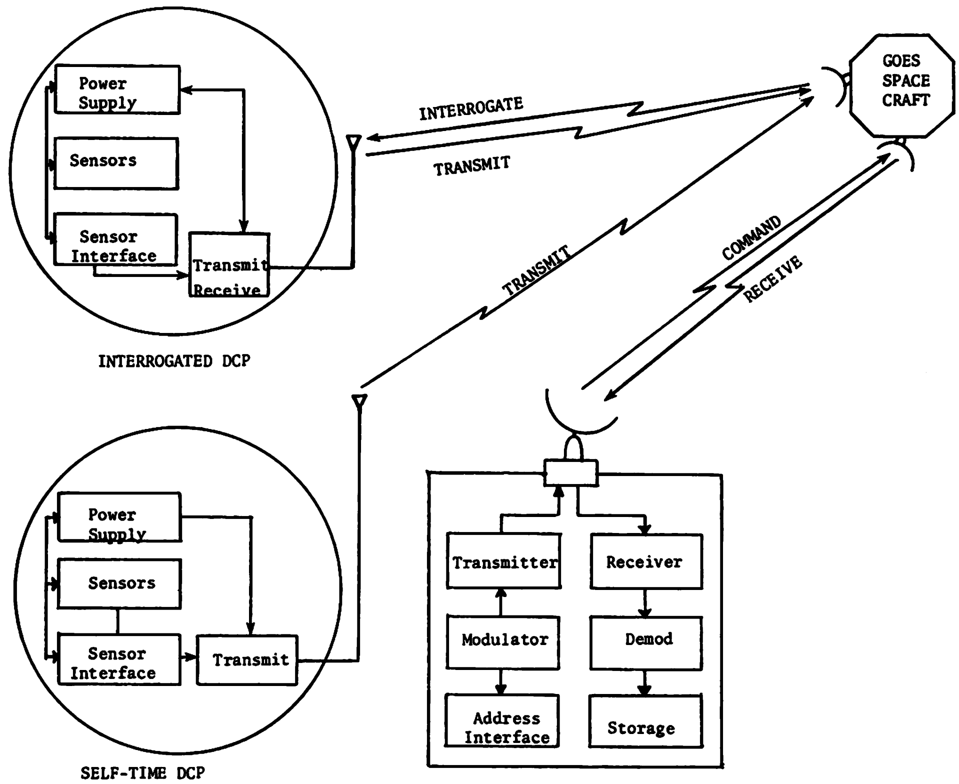

FIGURE 1: GOES-DCS Operation

environmental monitoring. Each has, however, a transponder designed for operation with self-contained Data Collection Platforms (DCP) that may be either for land or buoy placement with an antenna pointed toward the GOES stationary orbit position. Data messages from the DCP's are transmitted either automatically (the self-timed mode) or by an interrogation command relay from the single GOES Operation Control Center. A DCP message consists of a preamble, platform address, and then the data. To this extent they may be regarded as packet devices. The uplink is in the 401 MHz band and the downlink in the 1.7 GHz band. Data transmission is one way.

In its environmental application a DCP has a 5 watt transmitter working into a directional antenna at a data rate of 100 bits/second. DCPs contain the logic to acquire eight channels of either discrete or analog data. Two logic implementations are available—one using discrete TTL logic and another based on an Intel 4040 microprocessor. Packet sizes are variable up to a maximum of 384 bits. NSTL's contribution to the GOES Data Collection System is a low-cost, fixed antenna, ground receive station capable of sustaining unattended operation. This system design is currently available for GOES users and is now being acquired by the Corp of Engineers for flood control monitoring.

GOES Design Application to EMS Telemetry

As part of the NSTL/USM experiments a variant of the GOES environmental monitoring methodology was utilized to explore the feasibility of handling biomedical telemetry from a mobile medical vehicle through a synchronous satellite link. This has involved modification of a standard DCP to handle both a higher data transmission rate and longer messages as well as the design of an omni-directional antenna compatible with the 401 MHz QF transponder on GOES. The modified DCP (dubbed a Medical Data Transmitter—MDT) when coupled with a 40 watt amplifier and an omni-directional antenna has been successively demonstrated at a low data rate from a stationary vehicle and an EKG simulator. Figure 2 shows the salient components of the initial phase: low data rate with stationary vehicle. Figure 3 shows the salient components of subsequent phases now in process: moving ambulance to ER link at low and/or realtime data rate.

These experiments have been designed to meet technical objectives in minimum time and at minimal cost by utilizing the existing ground station at NSTL (70 miles from the hospital ER) as well as an unoptimized medical data transmitter. However, from a technical/medical standpoint the experiments to be concluded by July 1, 1976, should achieve three things:

Establish the design integrity of an experimental omni-directional antenna compatible with synchronous satellite communication from a moving vehicle.

Demonstrate the utility of the NSTL low-cost, fixed-antenna, ground receive station in this application setting.

Demonstrate the medical validity of digital data transmitted through a satellite system.

Although the technical gain yielded by such experiments is incremental, the knowledge gained concerning the application setting, the operational problems, the design of a functional system should be substantial.

Although the GOES experiments have addressed only an ambulance-to-ER telemetry link, an operational prototype using methodology of this type is not without merit. Figure 4 details two operational scenarios. Scenario 1, an EMS scenario, uses the satellite for telemetry while handling medical coordination over existing VHF voice channels. In this scenario, no existing hardware has to be modified or abandoned, hence telemetry appears as an "add-on" to in-

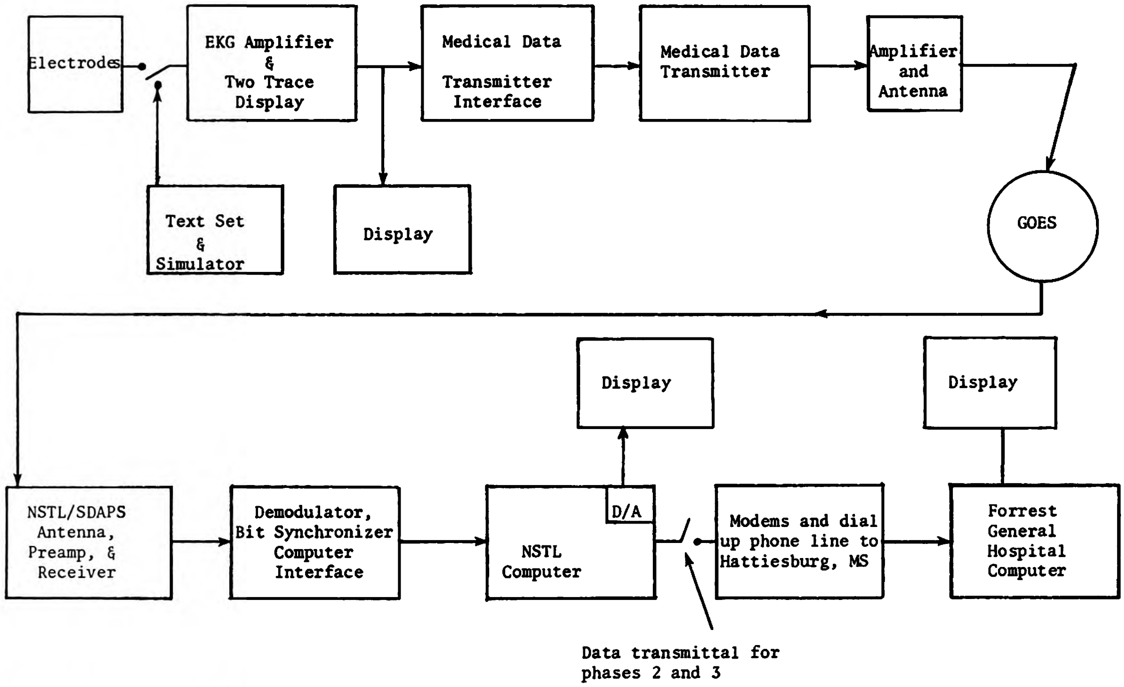

FIGURE 2: Salient Components of GOES Biomedical Telemetry Experiment

place VHF voice systems. Scenario 1 reflects the situation prevalent in many rural EMS service areas such as SEMAAD discussed previously. Scenario 2 depicts the use of this methodology in a remote cardiac monitoring setting. Since both applications can share the same ground receive station, the inclusion of the remote cardiac monitoring function appears to offer economic advantages.

The ATS-3 Experiment

An obvious disadvantage of the GOES-type methodology is the lack of a voice-over-satellite link. To investigate the technical difficulties associated with an ambulance-to-ER or ambulance-to-base station link using a synchronous satellite, the NASA/NSTL team performed an experiment using the ATS-3. The antenna, a two and one-half turn helix, two feet high and two and one-half feet across, produces a constant

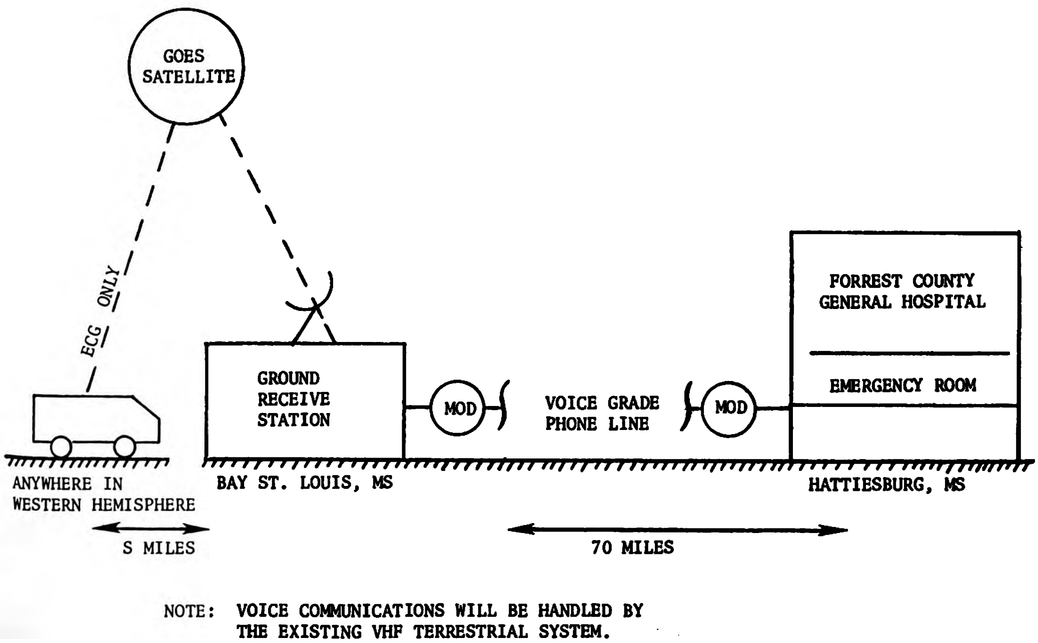

FIGURE 3: Ambulance-to-ER Telemetry Experiment Using GOES.

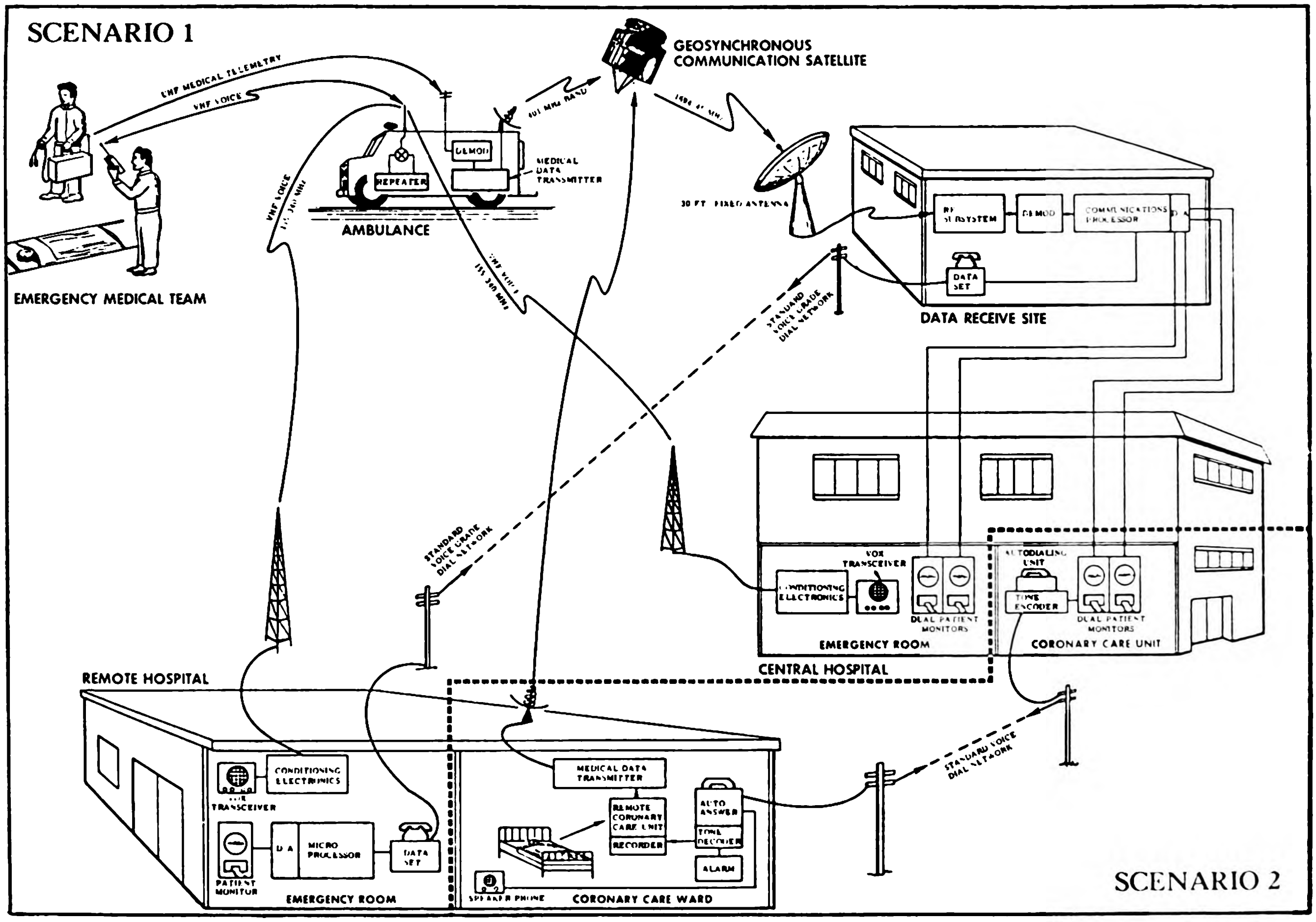

FIGURE 4: Salient Components of Two Operational Scenarios.

omnidirectional pattern. The angle to ATS-3 from the NASA site at Bay St. Louis, Mississippi, is roughly 47°.

For these experiemtns a full duplex VHF link in the 135-146 MHz bands) approximately 15 KHz wide was used. With this configuration, a SEMAAD ambulance was able to communicate from Bay St. Louis to base stations in Miami, Phoenix, and Schenectady. EMT's who experimented with the link reported great satisfaction and rate the satellite link much better than the SEMAAD terrestrial VHF system. Ambulance speed, direction, surrounding building, or forrest cover introduced no observable effects on the transmission process.

A logical follow-up on this experiment would be the inclusion of a telemetry channel and an investigation of its propagation characteristics from a moving vehicle. While this is currently being investigated, it must be borne in mind that the ATA-3 satellite is not operational (i.e. available 24 hours per day). GOES, although reserved strictly for environmental data by its owners (the Department of Commerce), is a fully operational system. Nevertheless, the different characteristics to the two systems aptly met the experiment requirements for voice and telemetry even though two satellites had to be utilized.

Conclusion

Over the past few months the NSTL/USM experimenters have demonstrated the technical feasibility and validity of biomedical data transmission over synchronous satellites. They have designed, built, and tested omnidirectional antennas compatible with existing UHF and VHF satellite transponders. Voice communication from a moving ambulance to base station has been successfully implemented on the ATS-3. Transmission of a simulated EKG from an ambulance to ground receive station over the GOES UHF transponder has been performed.

It is clear from these efforts that the development of an EMS Communications System based on synchronous satellites is technically and operationally feasible. However, the eventuation of such a system is dependent on a number of unresolved issues. Paramount among these is the debate between the use of telemetry with trained EMTs versus sole reliance on EMTs with advanced training. The resolution of this debate is fraught with many complicated medical and legal considerations. Beyond the medical/legal questions concerning telemetry lie the regulatory considerations on use of satellites for EMS communications.

The FCC's views on the eventual use of portions of the spectrum for land mobile communications are apparently still in flux. In the near term it is also apparent that no applicable commercial satellites exist for EMS communications. The 4, 6, 12, and 14 GHz bands now used by domestic communications satellites are not technically or economically attractive for land mobile applications.

To help answer some of these issues, the authors have proposed the establishment, demonstration, and evaluation of the technologies discussed here in a rural EMS environment. The work done to date is only an incremental step toward solution of a much larger problem: provide integrated, cost-effective communications for rural health care delivery systems.

Primary and Secondary EMS Transportation

THE ROLE OF THE U.S. DEPARTMENT OF TRANSPORTATION IN EMS SYSTEMS

Philip H. Bolger

In 1966, the Committee on Trauma and Committee on Shock, Division of Medical Sciences, National Academy of Sciences, National Research Council, reviewed the status of initial care and emergency medical services afforded to victims of accidental injury. Their findings were published in a paper entitled "Accidental Death and Disability: The Neglected Disease of Modern Society." The following are some of the conditions they found in 1966:

Few were adequately trained in the advanced techniques of cardiopulmonary resuscitation, childbirth, or other lifesaving measures, yet every ambulance and rescue squad attendant, policeman, firefighter, paramedical worker, and worker in high risk industry should be trained.

There were no generally accepted standards for the competence or training of ambulance attendants. Certification or licensure of attendants was a rarity. There was a need for a standard course of instruction and training aids.

Approximately 50 percent of the country's ambulance services were provided by 12,000 morticians, mainly because their vehicles could accommodate transportation on litters. But in most instances, as in the case of many privately owned ambulances, the vehicles were unsuitable for active care during transportation. No manufacturer produced from the assembly lines a vehicle that could be termed an ambulance. There were no acceptable standards for vehicle design.

Helicopter ambulances had not been adapted to civilian peacetime needs.

Ambulance medical equipment and supplies were incomplete.

With rare exceptions, ambulance radio installations provided communications only between dispatcher and drivers. There was a need for the assignment of discrete radiofrequency channels, to provide direct communications between the site of an accident, ambulances, hospital emergency departments, fire departments, traffic control officials and civil defense authorities.

In addition to these examples of the deplorable condition of the prehospital phase of emergency medical care in 1966, the study addressed the inadequacy of training programs for emergency department staffs; including physicians, nurses, and paramedics; the need for around-the-clock staffing by permanently assigned personnel; the implementation of recommendations provided by the Committee on Trauma of the American College of Surgeons on architectural design and equipment of emergency departments; the need for accreditation and categorization of emergency departments; and the need for road maps and road signs at appropriate locations, to designate routes to hospitals and emergency departments.

Public Law 89-564, the Highway Safety Act of 1966, was enacted on September 9, 1966, to provide for a coordinated national highway safety program through financial assistance to the states to accelerate highway safety programs. Funds made available under matching grant provisions of section 402 of the Act are apportioned to the states and are administered by the governor, through his representative for highway safety. There is no direct federal funding for political sub-divisions. Project application by a political subdivision must be made to the state for inclusion in the state program.

The Highway Safety Act of 1966, as amended, requires that states have a highway safety program developed in accordance with uniform standards promulgated by the Secretary of Transportation. One of these standards is Standard 11, "Emergency Medical Services." The purpose of the DOT(NHTSA) involvement in EMS is primarily for highway safety, but such a program involves a comprehensive EMS system. The approach has therefore been to design an EMS Highway Safety Program which assures the states the degree of flexibility necessary to upgrade their total EMS system to serve all medical emergencies. Demonstration projects and studies have been funded under the authority of section 403 of the Act. The results of these studies and Federal guidance have been provided to state and local emergency medical services coordinators through the administrators of the ten NHTSA regions. Tremendous progress has been made to correct the deplorable EMS conditions that existed in 1966, particularly in the pre-hospital phase.

We developed and published Highway Safety Program Manual, Volume 11, "Emergency Medical Services." This is the first comprehensive official document that has provided guidelines for state and local governments for planning, evaluating, and improving emergency medical services on a statewide basis.

The NHTSA issued a requirement that states develop a Comprehensive Emergency Medical Services Plan. We provided teams to conduct seminars and to provide on-site technical guidance. We were directly responsible for State Health Department assumption of the management of EMS programs. In 1966, only four states had an EMS staff. Today, all 50 States, Puerto Rico, and the District of Columbia have full-time staffs.

Experimental protocols were developed for eight demonstration projects. They were awarded to New York, Michigan, Arizona, California, Mississippi, Minnesota, Florida, and Nebraska. These projects addressed every element of the EMS system and its management, including extensive helicopter evacuation studies and telemetry. Approximately $3.5 million was expended. NHTSA provided the management and direction of these demonstrations and investigations.

We contracted for the first nationwide study of ambulance service economics. The report, "Economics of Emergency Ambulance Services," has had wide distribution and is used throughout the ambulance industry as the standard for rate setting, developing local services, inventory of services by type, identification of problems and need, State and local planning guidance and helicopter cost profiles.

The NHTSA recognized the need for ambulance design specifications and in cooperation with the National Academy of Sciences, produced the report, "Ambulance Design Criteria." At our request, these criteria were translated into Federal Specification KKK-A-1822 by the General Services

Administration. This is the standard of the industry. Manufacturers now produce ambulances in accordance with specific standards, built and equipped to provide emergency care at the scene and during transport. All ambulances procured under section 402 of the Highway Safety Act of 1966 and other Federal programs must conform to Federal specifications.

We designed and adopted the "Star of Life" symbol for the identification of emergency care vehicles, personnel, and services in the civilian sector. Application has been made to the Patent Commissioner to register this symbol under the cognizance of the NHTSA. International interest has been indicated.

The American College of Surgeons Committee on Trauma recommended a list of "Essential Equipment for an Ambulance." This has been adopted as the minimal standard.

Under contract, we developed a total basic training package for ambulance personnel that was responsible for establishing the new profession, "Emergency Medical Technician - Ambulance," and for a standard "Job Description." Forty-six states, Puerto Rico and the District of Columbia have adopted this program as the standard for the certification of ambulance personnel. It has also been adopted by all the military service. Four states have courses considered to be "equivalent" to the DOT program. Over 150,000 Emergency Ambulance Technicians have been trained using the DOT basic 81-hour course and the four equivalent state programs.

The "Basic Training Course for Emergency Medical Technician - Ambulance" lecture material has been used to provide video tape and 16 mm sound film programs. Through their use, training can be conducted in remote and rural areas where a physician is not always available for instruction. The complete 81-hour course is also available in a Spanish language translation.

The National Registry of Emergency Medical Technicians has as a requirement for registry, "Successful completion of an approved EMT training program (minimal DOT 81-hour or equivalent."

Twenty-four-hour ambulance service, with two trained Emergency Medical Technicians per ambulance, has been established as a national standard by the DOT.

NHTSA has also sponsored the preparation of a 480-hour, 16 module, Paramedic Course for Emergency Medical Technicians. It is being put in final format by the University of Pittsburgh, and should be available by July, 1976. Final preparation and course content has been closely monitored by a committee composed of a wide spectrum of emergency health care providers. The Department of Health, Education and Welfare is represented on the committee. This DOT course of instruction will greatly increase the life-saving capabilities of the Emergency Medical Technician.

Other widely accepted courses developed and available from the NHTSA include: Refresher Training Program for Emergency Medical Technician-Ambulance; Patient Handling Manual for Emergency Medical Technician-Ambulance; Dispatcher - Emergency Medical Technician; Emergency Medical Technician - Crash Victim Extrication Course; Crash Injury Management - for Traffic Law Enforcement Officers; and Emergency Medical Services Administrator, and an Emergency Vehicle Driver Training Course is under development.

The NHTSA provided financial support and stimulus for the first national conference on citizen access to EMS systems through a national emergency telephone number. "911" is now available in many areas and its use is rapidly expanding. Recent studies have been completed by the NHTSA to further assist citizen access and accident reporting through the use of citizens band radio. A CB Manual has been prepared and will soon be printed and distributed in a final edited form.

As an in-house effort, we developed manual "Guidelines for EMS Communications." This publication has enjoyed wide acceptance by the public and by other federal agencies as a national guideline. This activity resulted in gaining the interest of the Robert Wood Johnson Foundation, and its dedication of $15 million for EMS communications. The NHTSA was directly involved in the evaluation of community grant requests.

The NHTSA initiated awareness and concern for the necessity of EMS discrete frequency allocation. This was reflected in unprecedented action by the Office of Telecommunications Policy in defining EMS requirements for communications, and the Federal Communications Commission in providing a completely responsive frequency allocation structure (Docket 19880). The interface of public safety agencies and EMS providers is now facilitated by specific requirements for planning, including licensing and the criteria for funding eligibility under both DOT and DHEW EMS programs. A joint planning document and manual for EMS communications, initiated by NHTSA, has been developed to satisfy planning submission requirements by all federal agencies. Interface with public safety is required.

The DOT has two National Bicentennial Celebration Horizons Programs, one in Philadelphia, and one in the Washington, D.C. area. Medical Emergency Coordination Communication Assessment (MECCA) centers provide rapid response emergency medical services, using advanced electronic communications and computer technologies. The Philadelphia project will also evaluate the terrestrial use of LORAN-C for automatic vehicle tracking, as a model for wider use in crash detection location and resource management.

We have worked closely with the Department of Agriculture. The Farmers Home Administration loan program for community facilities has brought another Federal resource to bear on the Department of Transportation EMS upgrading effort. We have also participated in conferences and committees with other agencies to prevent unnecessary duplication of effort and expenditure of funds. These agencies include the Department of Health, Education and Welfare; the Department of Commerce, and the Law Enforcement Assistance Administration.

In 1969, we approached the Department of Defense with a proposal to use military helicopters and medical personnel to augment established EMS systems in the vicinity of inplace aeromedical and rescue helicopter units. The Military Assistance to Safety and Traffic (MAST) program evolved as a cooperative effort of the Departments of Transportation, Defense, and Health, Education and Welfare. The original concept of assistance to highway accident victims has been expanded to include response to all serious medical emergency incidents.

The MAST Interagency Executive Group, the federal policy making body, has been chaired by the Department of Transportation since the group was formed. The program has provided substantial inpetus to the development of EMS systems in the areas served, because of the requirement for the establishment of such a system prior to the implementation of MAST projects.

In the pursuit of program promotion and standard implementation and system development the Department has provided an extensive amount of guidance material and expressed itself in a number of significant policy statements. I will refer to two that may be of particular interest here. The first of these relates to rural community service and is stated as follows:

The quality of service rendered to the victim of an emergency must not be a variable, subject to negotiation from community to community. The guidelines that have been published are considered minimal and appropriate for all who render emergency care. It does not seem practical to make exceptions and deprive some of life-saving and life-sustaining care merely because they happen to live in a small community. Highway death rates in rural areas have exceeded those of the urban areas by 70 percent. Trauma centers and emergency rooms are of little value to the victim who has expired due to lack of proper care at the onset of the emergency or in transit to the facility. Quality of service rather than speed in transit is being emphasized.

The second of these expressed the Department's position relating to state EMS legislation as follows:

In view of widespread national deficiencies in emergency medical services, it seems incongrous to think of abrogating the basic provisions of State legislation or other forms of requirement or to evade enactment of legislation which sets out to ensure adequate emergency ambulance service for the sick and injured. The intent of the Highway Safety Act is to upgrade ambulance service nationwide by improving training, organization, and equipment. For example, DOT views licensing and certification as appropriate tools for a State to use to ensure that a desired level of competence is both achieved and maintained in this very significant field of human service and concern. The Department finds it difficult to believe that the seriously ill or injured person is interested only in rapid transit at a time when his life is ebbing away but could be sustained with proper care. There is a need to preclude avoidable death and permanent injury either at the scene, in transit or upon arrival at the hospital.

In conclusion, the main thrust of the DOT/EMS effort is in the prehospital Emergency Medical Care field. It strives to insure that through its administrative and funding efforts the best known resources—knowledge, techniques, and equipment—are being brought to bear on the victim of a medical emergency. The Department's ultimate objective in its prehospital EMS effort is to arrive at a point in time when it will no longer be appropriate to say that accidental death and disability is the neglected disease of modern society.

THE ECONOMICS OF EMS TRANSPORTATION

William F. Hamilton, Ph.D.

Current trends toward regionalization of emergency medical services pose important economic questions, including (1) What will it cost? and (2) How will it be financed? Inevitably, decisions to upgrade and restructure community EMS systems require difficult tradeoffs affecting the costs and financing of proposed improvements. The economic implications of such decisions have been examined as part of a two-year study of the costs and revenues associated with various approaches to EMS system development and operation. This paper presents a brief overview of the study followed by a summary of findings reflecting the costs and revenues associated with selected EMS transportation services.

An Overview

The EMS Economics Study has been based on in-depth analyses of costs, revenues, and other aspects of EMS activity in six selected "regional systems." The objectives of the study are to develop improved methods and data for assessing the economic impact of various approaches to EMS system development and operation now in use or under consideration. The sites chosen for the study represent a range of geographic, demographic, and EMS system characteristics. They include rural, suburban, and urban areas; private and public EMS system sponsorship; volunteer and salaried personnel; and a variety of EMS system structures. These sites and their EMS transportation services are described briefly below:

Philadelphia is a predominantly urban area of 129 square miles and a population of 2 million. EMS transportation services are provided by the city fire rescue and police services as well as a small number of private and volunteer ambulance services.

The *"Big Bend" Florida* region includes urban, suburban, and rural communities with a population of 220,000 in an area of 4500 square miles. The region combines six counties in northern Florida and one in Georgia. Nine ambulance organizations with a total of 20 vehicles provide EMS transportation in this region.

West Central Wisconsin is a predominantly rural region with a population of 320,000 in an area of 8,000 square miles. The region encompasses 10 counties and is served by 42 different ambulance services which operate a total of 68 vehicles.

Northwest Wyoming ranges from rural to remote wilderness areas in a five-county region consisting largely of mountainous terrain. This area is the largest of the sites studied with an area of 23,500 square miles; it also has the smallest population: 69,000. EMS transportation is provided by ten services operating a total of 21 ambulances.

The region around *Memphis, Tennessee* includes urban, suburban, and rural areas in six counties which span three states (Tennessee, Mississippi, Arkansas). The region has a population of 877,000 in an area of 3500 square miles. EMS transportation is provided by seven organizations which operate a total of 44 ambulance services.

Acadiana, Louisiana is a predominantly rural area covering nine parishes in an area of 7200 square miles and a population of 576,000. EMS transportation is provided through a single private organization which operates a coordinated regional transportation system.

EMS Subsystems

For the purposes of this study, the regional EMS system has been viewed as consisting of four functional components or subsystems: System Management (project administration, evaluation, public education, etc.), Transportation, Communications, and Medical Facilities. Because current financing and organization structures largely follow these functional lines, this breakdown simplifies and facilitates the data collection and economic analysis.

DATA TYPES AND SOURCES

A series of site visits provided detailed data on the wide range of regional and EMS system characteristics as a basis for comparative analysis. Data were collected in the following general categories:

Demographic Characteristics: population distribution, geographic features, income/age distribution, etc.

Service Organization/Patterns: numbers/size of ambulance services, service capabilities, training levels, organization structure, operating procedures, etc.

Capital/Operating Costs: equipment, installation, personnel, administration, etc.

Operating Revenues: users fees, subscriptions, donations, subsidies, etc.

Capital Financing: Federal government, local tax support, private foundations, etc.

These data were collected from a variety of sources in region, including provider accounting/service records, tax statements, city/county budget records, Medicare cost reports, and state records where appropriate (e.g., Highway Safety ambulance licensure records).

EMS Transportation Costs

The distribution of ambulance service costs varies widely among sites as shown in Table 1.

Much of the observed variation can be attributed to small rural services in the study group. The larger services typically experience costs in the range of $50-75 per run; similarly, personnel and administrative salaries in the larger services account for 60-75 percent of total costs; vehicle operating costs account for another 15-25 percent.

TABLE 1: EMS Transportation Costs

	Average	Range
Personnel Salaries & Benefits	73%	45% - 75%
Administration	9%	5.5% - 14%
Equipment, Materials & Maintenance	18%	11% - 25%
Depreciation	13%	9% - 17%
On-Going Training	.6%	.3% - 1%
Space Costs	.8%	.6% - 1%
Cost Per Capita	$2.20	$1.67 - $2.86
Cost Per Run	$52.80	$21.92 - $80.40

A number of other factors help to account for the variation in ambulance service costs. These are summarized in Table 2. Personnel costs account for the largest portion of ambulance service costs and can very significantly with the staffing arrangements (full-time, part-time, volunteer personnel). Administration costs vary with the organizational structure of the system and the nature of management activities (*e.g.*, evaluation, data processing, etc.). The costs of equipment, training, and space will largely depend on the type and sophistication of the services provided.

The burden of fixed costs and resulting impact of under-

TABLE 2: Factors Influencing Ambulance Service Costs

Cost Category	Influencing Factor	Relative Importance of Influence
	- number of runs	- Personnel expense per run, for salaried personnel, decreases as annual runs increase up to level of about 3000 runs per vehicle per year in urban areas, and 1000 runs per vehicle per year in rural areas. Personnel cost per run does not vary with number of runs for hourly paid volunteers.
Personnel Expense	- area wage/price level	- Salary rates in urban areas are typically 10% - 30% higher than in rural areas; personnel expense accounts for 70% of all expenses.
	- state standards for training	- Salary rates may increase 3% to 6% with higher training levels for some services.
	- type of ambulance organization	- Personnel expense is about 10% less with part-time personnel. Hospital ambulance services may save 10% to 80% by utilizi personnel for hospital duties when not on runs. Urban fire department personnel expense is 50% to 70% greater than for other types of services.
	- number of runs	- Vehicle operation & maintenance & maintenance expense increases linearly with number of runs; i.e., remains about the same or a cost per run basis.
Vehicle Operation & Maintenance Expense	- state standards for ambulances and equipment	- Operation & maintenance expense may be 20% higher for vehicles meeting standards.
	- number of runs	- Medical supplies expense increases linearly with number of runs made.
Medical Supplies Expense	- type of service provided	- Routine transporting services do not use sophisticated equipment while others must have oxygen, IV's, etc.
	- number of runs	- Vehicles are depreciated on a cost/run basis, but remains constant for run levels above 300-400 per year.
Vehicle Depreciation	- state standards for ambulances	- Vehicle depreciation may be 2 to 3 times greater with vehicles which meet standards.
Garage Expense	- type of ambulance organization (Commercial, Hospital, Volunteer, County/Municipal)	- Garage expense may account for 2% - 3% of total for commercial firms. For other types of organizations it is usually 0%.

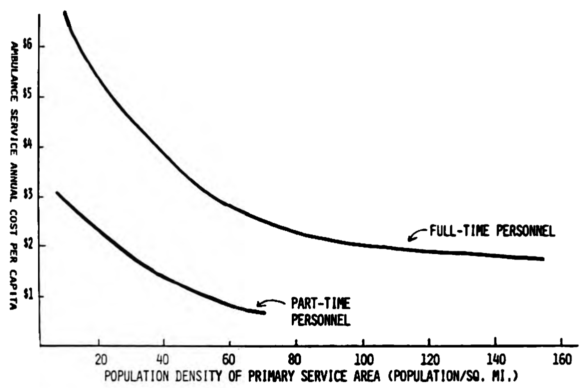

FIGURE 1: Ambulance Service Cost Per Capita vs. Service Area Population Density.

utilization are most apparent in the transportation component of the EMS system, especially in rural regions. Substantial fixed costs (those incurred regardless of the number of runs made) result in a high cost of maintaining an adequate ambulance response capability in sparsely populated areas. While regional coordination may offer potentially more efficient utilization of ambulance resources, per capita costs generally reflect a strong inverse relationship to population density in the primary service area when either full-time or part-time/volunteer personnel are employed. Figure 1 reflects data for ambulance organizations participating in regional systems for which primary service areas can be identified, suggesting that service area population density is a major determinant of the minimum per capita costs for EMS transportation achievable under regionalization.

Table 3: Typical Ambulance Service Charges

a. Base Charge ($ per run).

Base Charge	Frequency of Use (%) Urban Areas	Frequency of Use (%) Rural Areas
$15	0%	10%
$20	0%	10%
$25	20%	29%
$30	7%	14%
$35	27%	17%
$40	13%	6%
$45-$50	20%	6%
$60-$75	7%	6%
$100	6%	2%
	100%	100%

b. Mileage Charge ($ per one-way mile) for Rural Areas.

Mileage Charge	Frequency of Use (%)
$ .00	17%
$ .25-$ .40	13%
$ .50	20%
$ .60-$ .70	7%
$ .75-$ .80	13%
$1.00	25%
$1.50	5%
	100%

EMS Transportation Revenues

EMS transportation revenues typically derive from a combination of service charges, subscriptions, contributions, and subsidies. Service charges and subscriptions are the main sources of operating funds. Contributions and subsidies are more characteristic of municipal operations and are frequently restricted to capital expenditures such as new equipment purchases.

Ambulance services typically charge a base fee with additional mileage charges and charges for special services. In urban areas, a single fixed fee is quite common; rural ambulance services more frequently add a mileage charge. Base fees and mileage charges vary widely as illustrated in Table 3, but tend to be higher in urban areas than in rural areas. Differences in ambulance fee structures do not appear to be closely associated with service cost differentials. Among the ambulance services studied, total charges range from 70 percent below costs to more than 200 percent above costs of ambulance operation.

An average profile of service charges and collections based on the study sites is presented in Table 4.

Collection rates for many ambulance services are poor, ranging between 30 percent and 55 percent of charges. However, several ambulance companies have achieved collection rates above 80 percent (and, in one instance, as high as 95 percent) through the persistent pursuit of delinquent accounts and threats of legal action. Beyond the intensity of collection effort, collection rates seem to be influenced also by income level of the area and the assignment of insurance benefits. Most ambulance services do not accept assignment of a patient's insurance benefits because health insurance policies often pay ambulance fees only for specified cases, and some policies limit the amounts payable as well. There may also be long delays in preparing, processing, and payment. Thus, many ambulance services seek payment directly from patients, who must then request reimbursement from insurance companies. In so doing, of course, there is a trade-off between the uncertainty of payment by the individual and uncertainty of payment through the insurance carrier.

In most of the regions studied, local governments subsidized all or a portion of ambulance service operating costs. The methods for determining the amount of subsidies vary with some set in proportion to population served, some related to the number of runs actually made, and others established at an apparently arbitrary level. In many cases, once a subsidy precedent is established, local governmental units fail to monitor ambualnce operations or to audit financing records adequately. In a few instances, actual service costs were significantly below the annual subsidy provided by the local governments.

TABLE 4: Service Charges & Collections

	Average
Annual Cash Expenditures	$48,794
Total Charges	$30,790
Collections	$23,914
Subsidy	$ 8,141
Ratio of Charges to 1974 Cash Expenditure	96%
Ratio of Collections to Charges	68%
Ratio of Collections to 1974 Cash Expenditures	73%
Subsidy	43%

Third Party Financing

Approximately 80 percent of the United States population is covered by some form of health insurance through such third-party carriers as Blue Cross/Blue Shield, Medicare/Medicaid, commercial insurance companies, and private plans. The passage of a national health insurance program would be likely to increase this percentage still further. At present, many insurance policies do not provide coverage for ambulance services, and policies that do include ambulance benefits are typically limited in the nature and extent of coverage.

Common restrictions limit coverage to selected patient conditions, set maximum allowable costs for defined services, and/or restrict death benefits to hospital-based services. For example, 20 percent of the total population insured through Blue Cross plans across the nation are not covered for emergency transportation; and one-third of all those covered by Blue Cross are limited to reimbursement for accident-related injuries only (sudden illness excluded from emergency coverage). Some commercial policies provide benefits for EMS transportation services only if a patient is hospitalized following transportation. In some instances, treatment services rendered by emergency medical technicians and paramedics are also not covered.

As reflected in current third-party benefit structures, insurance benefits have not generally kept pace with changing concepts and developments in emergency medical services delivery. Coverage for the full range of emergent patient conditions requiring emergency transport is therefore often incomplete. In addition, benefit limits are often restrictive in kind or amount for expenses associated with necessary and appropriate prehospital activities. Until third party coverage is updated to reflect actual and necessary costs, their effect on EMS transportation service revenues will continue to be far less than on hospital emergency services.

Concluding Comments

The data and results presented above represent only a portion of the overall EMS Economics Study described in the first section. Continuing analyses are being conducted into various aspects of the selected regional EMS systems. Among the questions under active study are the following:

What are the appropriate sources of financial support for EMS management, transportation and communications? Should users of the services bear full costs, or should costs be borne, at least in part, by all people to whom the services are available?

What will be the impact of national health insurance, if enacted, on the financing of emergency health services? What features of a national health insurance program could best serve the needs of developing EMS systems?

Are there significant economies to be realized from tiered response systems? In what areas are such systems appropriate?

Those interested in these topics and other issues related to the economics of regional EMS systems are invited to write for a listing of reports issued by the project team. Several of these are included in the attached list of suggested readings.

Acknowledgements

The results report in this paper reflect the efforts of a number of members of the EMS Economics Project Team, especially R. E. Mittelstaedt and J. W. Thomas, who have contributed significantly to all phases of the research.

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AIRBORNE OXYOLOGY IN DENMARK

Knud Jessen, M.D., D.A.

The Hungarian cardiologist Aurel Gabor who recently and much too early in his life deceased after a traffic accident, realized many years ago the advantage of starting the treatment of emergency cases on the scene of an accident whether it concerns a coronary occlusion, a chest injury or a diabetic coma. The demands made on physicians, who, outside the protective walls of a hospital, have to carry out a qualified, life-saving treatment of all sorts of acute injuries and other emergency cases before and during transport are so tremendous, and such that a special education of these physicians is necessary. This is given at the universities in Hungary and again as a postgraduate course under the name of oxyology, describing very keen, hyperacute work in emergency medicine.

In Denmark there has not been too much interest among physicians in this speciality. But with the increasingly development of the Danish search and rescue service carried out by the helicopters of the Air Force to perform transportation of patients from the sea surrounding Denmark, from isolated areas and from smaller to bigger hospitals, we have had to consider these helicopters as types of mobile intensive care units, if the patients shall benefit to the widest extent from the lessons learned in the intensive care units in the hospitals.

The helicopter used in the Danish Air Force, the Sikorsky S-61, is very suitable for rescue tasks, because with its maximum speed of more than 250 km/hour it is able to be at the site of an accident in Denmark and the adjoining sea within a very short time. Furthermore it is very sturdy and to a large extent independent of weather conditions. Different sorts of navigational facilities ensure that it can operate day and night. The cabin gives amble space for patient observation and treatment, and the five-bladed rotors mean a minimum of turbulence, giving the flying profile of this patient-transport medium the best conditions for the patients, as it is mostly free from positive or negative accelerative forces. The design of the cabin with a stretcher surrounded by oxygen, suctions, ECG-apparatus with defibrillator, 12 volt outlet for incubators and respirators and a rich supply of medical equipment makes the search and rescue helicopter of today a sort of mobile intensive care unit.

The regulations of the Air Force state that transport has to be vital and that it cannot be done by any of the other organizations such as the salvage corps. These factors are normally considered to be fulfilled if the transport is urgent and the ordinary salvage corps is not able to manage the transport within a reasonable time because of weather, traffic or other conditions. Experience shows that helicopter assistance has been granted in about 97 percent of the cases in which assistance was requested.

Since the need for this supplement to the existing land- and air-ambulance service was recognized and brought into action, more than 600 missions with the helicopter as a mobile intensive care unit have been performed from 1972 to the end of March, 1976.

As the missions by their nature are considered to be very acute and the help to be carried out as quickly as possible, there has been some cases in which no injured persons were taken aboard. In the remaining approximately 400 cases the gravity of the condition demanded very close observation and very often intensive treatment before the patients were brought to a relevant department in a hospital.

This development gave rise to a request from the crew that it be supplemented by a physician in all cases in which there was a risk of patient transport. The problem then was to find the most appropriate physician for the task.

The medical work as oxyologist is normally best fulfilled by an anaesthetist, but as the physician also has to be on stand-by duty on the air-base as a crew-member and have a knowledge of helicopter-flying, so that he is best prepared to solve the problems during many different and difficult conditions, the conscripts from the Air Force were chosen to join the crew in case of a MICU mission.

But as the physicians doing conscript service are young and relatively inexperienced, special education in the field of oxyology is mandatory if they shall be able to serve the patients in the helicopters in the best way. Furthermore some situations demanded them to be well trained in catastrophe medicine, so that they — at the site of an accident — are qualified to fulfill a catastrophe-medical doctrine, which involves the following: 1) to ensure survival of the most severely injured, 2) to resuscitate and treat on the spot those victims who cannot tolerate transportation to a hospital without this primary treatment, and 3) to review the various categories of injured so that these may be transported in optimal condition to hospitals equipped with relevant special departments and also to arrange for appropriate distribution to the hospitals available.

Therefore, the training for this difficult and occasionally dangerous work has changed in character from year to year according to the increased demands made on the young military doctors. It begins when they enter the medical school of the Air Force. Physicians are chosen here with regard to their previous clinical experience, and they have usually worked for two years in surgery and medicine and often also in anesthesia.

The training in the medical school includes, apart from a course in medical military subjects and aviation medicine, an education in the most necessary fields of oxyology and

TABLE: The S-61 Helicopter Used as Mobile Intensive Care Unit: Categories of performed missions.

	1972-74	1975	until 31 MAR. 76	Total	%
SAR (no injured persons transported)	131	87	17	235	38.0
Trauma	73	42	13	128	21.0
Heart-Lung disease	50	10	8	68	11.0
Abdominal disease	39	17	3	59	10.0
Burns	26	12	-	38	6.0
Brain disease (non-traum.)	22	2	1	25	4.0
Poisoning (incl. metabolic disorders)	10	8	3	21	3.5
Obstetrics	9	8	2	19	3.0
Drowning/Hypothermia	12	2	1	15	2.5
Decompression Sickness	3	4	1	8	1.0
Total number	375	192	49	616	100.0

catastrophe-medicine, such as anaesthesiology, chest and abdominal traumatology, acute extremity surgery, injury of the central nervous system, and acute psychiatry. Furthermore lessons in drowning and hypothermia and in catastrophe organization are given. The education is very often given by teachers from the university hospitals, when the military physicians do not have the necessary expertize in some of these highly specialized fields.

The training also includes a few weeks basic teaching in navigation, radio procedures, air controlling and metereology, and some personal flight training. In the S-61 helicopter they practice hoisting operations from land, sea, and rubber boats, and they participate in simulated survival exercises. This training in flying and operational procedures is of a tremendous importance since the physicians are able to descend on a ship, and get an immediate impression of a patient and if necessary start the treatment before evacuation to the helicopter.

The helicopter can carry a patient in his own hospital bed, a method very often used for the transport of burn cases. Furthermore the rescue equipment includes single and double slings and a self-floating stretcher/basket combination for taking up the patients. These techniques are especially useful when moving patients from ships and other places, where a helicopter cannot land. Many trauma patients tolerate very well the sling technique, which has a great advantage, since it is a very smooth and easy way of hoisting the patient. On the other hand, the basket/stretcher developed by the squadron is easier to lower down to ships than the original stretcher, and it may quickly be changed on the spot from a basket to a stretcher which protects the patient during the hoisting very effectively.

Since January, 1972, there have been more than 600 missions in which a doctor joined the crew. In nearly 400 cases the helicopter had to act as a mobile intensive care unit, and the physician as an oxyologist, as all the patients needed very close observation, especially of the respiratory and circulatory systems, and treatment such as administration of IV drips, artificial respiration, correction of cardiac disorders and many surgical interventions.

Experience in this area has shown that there has been no special difficulty in the performance of this medical work within the helicopters. In special cases a doctor or a nurse from the transporting hospital also accompanies the patient, and this combination of a medical specialist with a thorough knowledge of the patient's condition and an Air Force physician with his knowledge of oxyology during helicopter-transport, has been very satisfactory. There has only been one case of death during transportation. It was a newborn, premature child with a severe respiratory distress syndrome, who died just before arrival at the University Hospital in Copenhagen. In other cases the patients were already dead from the onset for different reasons. Attempts at resuscitation in the helicopter have not been successful until now.

In most countries, centralization of acute receiving wards, with their elaborate medical equipment and highly skilled medical specialist services in large hospital complexes, has already been undertaken or will be in the near future, while smaller hospitals are or will be used for less acute service. But this evolution means consequently, that ambulance service has to be refurbished in such a way that all areas in a country can be served rapidly and effectively, and the patients benefit from the experiences learned in the intensive care units in the hospitals during the transport.

The use of this expensive, but efficient military apparatus as a mobile intensive care unit has shown, that with a helicopter whose cabin gives space for observation and treatment with proper equipment, as well as a specially trained crew, including an oxyologist, the Public Health Service has a supplementary means of patient transport, which is very effective, safe and easy on the patients.

THE AIR RESCUE SYSTEM IN THE FEDERAL REPUBLIC OF GERMANY

Gerhard Kugler

Improving the system of medical aid is not merely a question of quantity, but more so of the quality of the means of rescue. A decisive factor in the success of the treatment is ensuring optimum care of the emergency patient at the scene of the incident shortly after the injury has occurred. This has been the goal towards which the development of a dense air rescue service network has been directed since 1970 in the Federal Republic of Germany, for which ADAC laid the cornerstone with the first pilot tests. Standards for the organization of the air rescue service and the equipment of the rescue helicopter were established. According to these standards, not all helicopters are suitable for use in the rescue service. The most important criteria for deciding whether or not they qualify for use are, for example, turbine engines, because of their vibration level, and sufficient room for treatment in the cabin with stretchers placed side by side.

At present, there are 18 air rescue centers in the Federal Republic of Germany at which helicopters are stationed daily from 6:00 A.M. until sunset exclusively for rescue purposes. The helicopters are always stationed at large hospitals which supply doctors for all rescue flights. The helicopters can take off in a maximum of two minutes after the accident report has been received, and they fly within a radius of 50 to 70 km. They are directed by central rescue control centers.

Since 1970, the 11 rescue helicopters of the Disaster Relief Force which are administered by ADAC have flown 20,848 missions. All data relating to the missions were evaluated by ADAC by electronic data processing. By sharing the costs, expenses have been kept at a minimum. The Federal Ministry of the Interior bears investment costs, while ADAC pays administrative costs. Running costs are refunded by the health insurance institutions at a flat rate of DM 830,- per mission. ADAC has signed contracts to this effect with the health insurance institutions.

Increasing traffic density on the one hand, and the ever-increasing influence of technology on the entire environment on the other have not only led to a greater number of accidents, but also to a rise in the number of serious injuries. A well-functioning rescue service must aim at ensuring optimum care in the shortest possible time at the scene of the accident and at providing rapid transportation of the patient to the most suitable hospital for clinical treatment. In order to avoid secondary injury, it is important here to provide a maximum degree of transportation comfort.

The aim of the reform of the emergency rescue system in the Federal Republic of Germany which was launched a few years ago is to meet the hitherto unsatisfied demand which arose through the escalation of the number of accidents and to bring the performance level up to the current state of knowledge in emergency medicine. With new laws and an investment program as the basis, the aid network is to be made so dense that each patient can be reached within five to eight minutes by the rescue service.

An integral part of the project is the development of an air rescue system which supplements the ground rescue service. Air rescue is equally important for high density traffic areas where the rescue vehicles often get stuck in traffic jams and for outlying areas where hospitals are located more widely apart. The guidelines for rescue helicopter operations were laid down in extensive pilot tests in the Federal Republic in 1970/71 which were first financed by ADAC and later by the Federal Ministry of the Interior. In the process, concrete standards were developed which are today the basic rules for the use of helicopters in the rescue service. They comprise in the main the following concepts:

The air rescue service is not to be considered a separate institution, but an integral part of the overall rescue system.

Helicopters cannot replace a well-functioning ground rescue service, but instead are a most effective supplement to this service.

In order to ensure efficiency, the rescue helicopter operations must be managed by central rescue control centers which direct and coordinate all means of rescue in their respective area.

The medical equipment and fittings of the helicopter must be such that all kinds of emergency patients can be treated. Resuscitation apparatus should be portable since it is not always possible for the helicopter to land right beside the site of the emergency and the patient must be treated outside the helicopter.

The high costs involved necessitate optimum medical attention. This is ensured only by the constant presence of a doctor as a member of the crew in the helicopter. Along with the doctor, there must be a medical attendant on board.

The helicopter with its medical equipment must be ready for operation daily and must be available exclusively for rescue operations. Combining this function with other missions, for example of a military or commercial nature or for the police, is unwise.

Finally, the decision whether or not a helicopter should be used in a given case must not be made dependent on the question of cost, but should be flown even when the diagnosis is uncertain. This is because the alarm is, as a rule, given by laymen who cannot judge the seriousness of the patient's injuries.

The idea of using helicopters to rescue emergency patients is not new. Years ago, military SAR squadrons introduced rescue flights for civilian purposes. This was not done systematically however, and often was subject to bureaucratic procedures. Moreover, communication with the police was lacking since the helicopters did not have the appropriate radio equipment. Furthermore, it was difficult to get doctors for the helicopters. Time was lost with the result that the military's SAR helicopters were scarcely used for rescue missions. It thus became necessary to operate special rescue helicopters accompanied by doctors and to define their tasks clearly. These tasks are to be distinguished according to the following criteria:

1) Rapid transportation of the emergency doctor and medical attendant to the scene of the emergency to perform life-saving measures and make the emergency patient fit for transport.

2) Transportation of the emergency patient to a suitable hospital while keeping him fit for transport and avoiding further injuries (primary transportation).

3) Transportation of patients who have already received preliminary treatment from one hospital to another better suited for final treatment (secondary transportation)

4) Transportation of medicine, stored blood, organs for transplantation, or medical equipment.

5) Search flights, for example over lakes or in the mountains.

Until now, the transportation of patients were considered the most important function of the rescue helicopter. This concept has changed in the meantime. The decisive advantage of air rescue is the shortening of the interval in which no treatment is given and in ensuring treatment by a doctor at the scene of the emergency.

As a result of the first successful wide-scale test made by ADAC in 1970/71, there are 18 rescue helicopter stations at present, spread over the entire Federal Republic. Of these, 11 are managed by the federal Disaster Relief Force. Five were set up by the federal armed forces and two are operated by other organizations. By the end of 1977, seven more helicopter bases of the Disaster Relief Force will be established. At this time, the geographical coverage will be such that every citizen is guaranteed a better chance of rescue in case of emergency.

In general, rescue helicopters are stationed at large, well-equipped hospitals. This is necessary in order to ensure that specially qualified doctors can be taken on board at any time. They fly within a radius of 50 to 70 km and can be alerted by anyone daily from 6:00 A.M. to sunset. The time required for take-off is a maximum of two minutes after the call has been received. Each alarm is transmitted by radio over the rescue control center. The helicopters are equipped with multi-channel radios by means of which it is possible to communicate with the ambulance or police vehicles on the ground. According to Ministerial ordinances, all police stations are required to call the closest rescue helicopter via their control centre immediately upon receiving reports of accidents involving injured persons. It is not possible to judge a priori whether medical reasons necessitate a flight. Should it be established subsequently, either by the police or the rescue service at the scene of the accident, that the assistance of the doctor in the helicopter is not necessary, the helicopter can be radioed to return to the hospital at which it is normally stationed before it reaches the scene of the emergency. Otherwise, the ambulance must wait for the arrival of the rescue helicopter. The doctor on board the helicopter then decides on the means of transportation for the patient.

Not every helicopter is suited for rescue service. The helicopters we use are BO 105 helicopters which are manufactured by Messerschmitt-Bolkow-Blohm (MBB). This construction meets all demands which must be made on a rescue helicopter for technical and medical reasons: two turbine engines with sufficient margin of power; minimum vibration due to four blade rotor system (28 Hz); two stretchers next to each other with seat for doctor and attendant at the head of the stretcher; sufficient room for treatment during the flight; intubation and heart massage present no problems; low noise level inside and outside of helicopter; high elevation of main and tail rotors with small rotor diameter to ensure safe landings in very limited space; and little maintenance required.

The 11 rescue helicopters operated by the Disaster Relief Force have flown 20,848 rescue missions since the first helicopter was put into operation on November 1, 1971 by ADAX. 8,512 patients were transported and another 19,102 received medical treatment by a doctor at the scene of the emergency. A break-down of the different types of emergencies for which missions were flown shows the following percentages:

Traffic accidents	55.2%
Accidents at work	5.7%
Internal emergencies	8.7%
Secondary transportation	12.5%

In 41 percent of the flights, patients were transported. In 35 percent of the flights, doctors rendered first aid without transporting the patient in the helicopter. On the average, a rescue helicopter in a high density traffic area flies approximately 1,000 missions annually with a total flying time of 600 hours. The daily average number of flights is three, although the number of flights can reach a maximum of 10. The average distance to the scene of the emergency is around 30 km and approximately 8 minutes flying time. Short-distance flights thus make up the bulk of the missions flown. Because of the great strain on the helicopter, these flights make special demands on the technical reliability of the helicopters. In 10 to 15 percent of the rescue missions flown, lives were actually saved. So far, more than 2,000 people owe their lives to air rescue in the Federal Republic. Without this service, they would not have had a chance of surviving.

The helicopter is without doubt the most expensive means of rescue. Purchase costs alone for the BO 105 with the medical equipment amount in approximately DM 1,6 million. Thus financing presents the most difficult problem. In connection with this problem, all considerations should, however, be based on the principle that the rescue service is a public service. For this reason, investment costs for air rescue as well should be borne by the federal government. Another basic principle to be observed is that the patient should not be put to a financial disadvantage since only a few people would be in a position to bear the high cost of the flight. The health insurance institutions must assume the task of reimbursing their insured. This concept has been put into practice in the Federal Republic of Germany. It sprang from the awareness that due to the high costs, it is not possible to operate the air rescue service on a commercial basis. Without federal aid, the air rescue service could not have materialized.

The helicopters of the Disaster Relief Force were acquired by the Federal Ministry of the Interior for civil defence purposes. A price of DM 650,- per flight hour is charged for their use in the rescue service. This includes the costs for the pilot and maintenance. The Ministry pays the remaining portion of the costs per flight hour. At a rate of 600 flight hours per helicopter annually, total costs amount to DM 390,000. Additional costs for the doctor, medical attendant, accident insurance and medical equipment amount to approximately DM 190,000, thus making a total expense of DM 560,000 for 1,000 flights annually.

According to our experience, medical aid is rendered in 70 percent of the flights, the costs for which can be settled with the health insurance institutions so that DM 830,- must be charged for a flight in order to meet the costs. ADAC has signed contracts with all the health insurance institutions in the Federal Republic, fixing this charge.

If fewer missions are flown and this charge therefore does not cover the costs, the State or local government pay the deficit. In order to improve the economic situation, a financing pool is to be set up in the near future to help meet part of the deficit.

ADAC does not charge for the administrative work it does. Administrative costs in 1975 amounted to DM 1.3 million.

This system of dividing the financial burden between the Government and private institutions has made it possible to keep the cost of air rescue at a minimum.

However, it is not only financial necessity which has made air rescue a matter of teamwork. Where the crew is concerned, there are three main institutions which have coalesced: the hospital which supplies the doctors, the rescue organization which supplies the medical attendants, and the National Guard which supplies the pilots.

The role of ADAC has progressed beyond that which it had when pilot tests were being made, but it is not merely confined to administrative tasks. To this day, the Club has tirelessly promoted air rescue and both laid the groundwork and influenced the rapid progress made in this field. For example, ADAC financed, by means of a large-scale campaign for donations, a further helicopter. Apart from its routine obligation of handling the accounts for rescue missions flown, ADAC is also responsible for public relations activities, the goal of which is to popularize the rescue helicopter. For this reason, yellow stickers with the rescue helicopter's emergency telephone number were distributed to all motorists. The yellow helicopters which are called "Christoph" are thus by now firmly anchored in the public's consciousness.

MARYLAND'S MED-EVAC PROGRAM

R Adams Cowley, M.D.

As part of a comprehensive emergency medical services delivery system, a Med-Evac Helicopter system was developed in 1967 by the Maryland Institute for Emergency Medicine (MIEM), in cooperation with the Maryland State Police (MSP) Aviation Division. The system has been transporting patients to the MIEM Shock Trauma Center since 1970.

Background

After some preliminary trials with military helicopter transports, the Center approached the Maryland State Police to obtain helicopters to share between police work and patient transportation. In 1968, a Department of Transportation grant was awarded to develop the program. Bell 206B Jet Rangers with capacity for two litter patients in addition to the pilot and observer/medic were chosen. The helicopters were to be used mostly for police work, but Med-Evac transports were to have first priority. A large, all-weather heliport was built adjacent to the Center. The observer/medic completed the standard EMT-A 81-hour course and then took additional training at MIEM.

The Air Med-Evac system was the first element added to the clinical Shock Trauma Center. Later other specialty referral centers* were added to build an integrated, complete emergency medical services system for Maryland. The whole system has grown tremendously since 1970, and is now responsible for planning, developing, coordinating and evaluating all aspects of emergency medicine in Maryland.

*See Article "Facilities - The Maryland Experience" in this volume.

Med-Evac Operation

The Maryland State Police Med-Evac helicopter fleet has grown to 10: four two-litter Bell Jet Rangers, four three-litter Hueys, and two eight-litter Sikorskys. Three bases, geographically distributed across the state are now staffed 24-hours a day. In the near future, helicopters will be based at five more locations to assure complete coverage of the state.

The Med-Evac system is used for six major purposes: 1) direct pickup of patients with life-threatening injuries from the scene of an accident; 2) interhospital transfers for critical multiple trauma victims; 3) transfer of any patient whom a local physician deems an emergency needing care and equipment which are unavailable in his hospital; 4) transport of premature infants from outlying hospitals to the State Intensive Care Neonatal Program hospitals; 5) transport of medical personnel to the scene of the accident or to other hospitals for emergency care or evaluation; 6) transport of medical supplies, blood or blood components, and organs for transplantations.

Direct Pickup

Seventy percent of the Med-Evac transports come directly from the scene of an accident, usually a highway. Maryland's volunteer and paid ambulance and rescue squads cooperate with the State Police Med-Evac program to provide initial triage and facilitate rapid transportation to the appropriate care facility. The direct pickup at the scene of the accident involves the air Med-Evac helicopter by one of two methods. The helicopter crew, while on patrol, may see an accident or be alerted by monitoring emergency radio bands. In these instances, they would usually be the first paramedical assistance to arrive. Or a civilian or a highway patrolman may call the county central alarm for help, and the alarm dispatches an ambulance with a simultaneous request for helicopter support.

To coordinate the jurisdictional function and responsibilities at the scene of the accident, representatives from state police, local ambulance services, and physicians responsible for emergency health care delivery developed the following guidelines.

Whoever arrives first at the scene of the accident assesses the injury. If the injury is serious, he calls for both a helicopter and an ambulance. If the ambulance arrives first, the crew immediately administers first aid and resuscitation. If the injury is not life-threatening, the patient will be taken to the local hospital. If the injury is life-threatening, the ambulance crew will continue resuscitation at the scene until the helicopter arrives to transport the patient to the appropriate specialty referral center. If the helicopter notifies those at the scene that it cannot reach the scene in a reasonable time or that the mission is not logistically possible, the ambulance crew will proceed immediately with the patient to a local hospital. If the helicopter arrives at the scene first, the crew provides immediate first aid, resuscitation and injury assessment. If the victim does not require transport to a specialty referral center, they sustain the patient until the ambulance arrives for transport to the local hospital.

Mean response time for helicopters from call to pickup is 15 minutes. The helicopter crew spends no time at the scene stabilizing the patient, applying complex splints, G-suits, starting intravenous lines unless the victim is trapped in or under a vehicle. Instead, the medic/observer maintains the airway, administers oxygen, stops external bleeding with compression pads and practices cardiopulmonary resuscitation as needed. He is capable of inserting an esophageal obturator in comatose patients.

From most corners of the state, helicopters can reach the Baltimore centers within the critical "Golden Hour." (Research has shown that if patients reach definite care within one hour of a serious injury their chances for survival are much enhanced.) During this trip, the pilot contacts SYSCOM with the estimated time of arrival and the nature of the patient's injuries.

Interhospital Transfers

For interhospital transfers, a physician of an outlying hospital telephones SYSCOM at MIEM to request assistance. All patients accepted for admission come directly to the Shock Trauma Center emergency receiving area and do not pass through the hospital emergency room.

Those admitted are stabilized, diagnosed, and transferred directly to the 12-bed Shock Trauma Recovery Unit, to the operating room, or to the Intensive Care Unit for further assessment, management, and treatment. Those patients not requiring the Center's facilities (4%) are referred to appropriate areas elsewhere in the hospital (e.g., ICU, CCU) or to a general hospital bed.

Physician Emergency

When an emergency arises in the community and patient's survival is compromised because of inadequate facilities or a lack of specialized equipment, any physician may request assistance from the Shock Trauma Center by calling SYSCOM. Such patients qualify for air Med-Evac transportation unless the Shock Trauma and the referring physician indicate that an ambulance would be the more suitable mode of transportation.

Transport of Medical Personnel

Physicians may be taken to the scene of an accident where victims are trapped or pinned under a vehicle, or if the emergency rescue crews suspect that certain medical procedures are required at the scene. Neurosurgeons, anesthesiologists, and thoracic surgeons have been flown to outlying hospitals to help evaluate and treat patients when the hospital involved did not have the physician staff to prepare the critically injured patient for transport.

Transport of Medical Supplies

Rapid helicopter transportation is of great value to convey unstable and perishable medical supplies, such as blood or blood components, and organs for transplantation, when these are required by other hospitals for both emergency and elective procedures. This especially pertains to distances exceeding 50 miles.

Transport Patterns

Each year admissions to MIEM Shock Trauma Center have increased an average of 7.89 percent. For the last few fiscal years the admissions have been as follows: 1972, 615; 1973, 782; 1974, 872; 1975, 920; and 1976, 1105.

Eighty-two percent of the admissions are delivered by helicopter, 70 percent from the scene of an accident. Admissions are highest in summer months. For example, in June, 1976, there were 130 admissions compared with 73 in January, 1976. Saturday is the busiest day for admissions, with Sunday and Friday next. The largest number of admissions occur within several hours each side of midnight, with the fewest during morning hours. Sixty-five percent of MIEM patients are 17 to 35 years old; 76 percent are males. Sixty-six percent are admitted as a result of traffic accident, 10 percent because of assault.

In 1976, of those transported directly from the scene, 9.5 percent were discharged to home within 24 hours. The majority of this group had been intoxicated upon admission, which complicates the already difficult assessment and exclusion of head injury at the scene.

Survival

In 1976, of patients admitted directly from the scene, 6 percent were dead on arrival, either from a rupture of a heart chamber, thoracic aorta or vena cava; severe head injuries; or fracture dislocations of upper cervical vertebrae.

Of those arriving alive, 2.1 percent died in the admitting area from hemorrhage from major vessels or irreversible brain injury. Fifty-six percent underwent immediate, total repairative surgical procedures, during which 2.8 percent died. Uncontrollable hemorrhage accounted for all but three of these deaths.

Ninety-five percent of all patients who arrived alive survived to be admitted to the Critical Care Recovery Unit. Irreversible brain damage caused therapy to be discontinued within 24 hours for 2.1 percent. Of those surviving beyond 24 hours, 6.7 percent died in the unit within seven days, the majority due to brain death, the others due to sepsis.

Comparison of statistics for highway traffic accidents transported by Med-Evac helicopter from the scene to MIEM from 1972 to 1976 show improved survival rates. The percent discharged to home within 24 hours was cut in half: 19.2 percent in 1972 to 9.5 percent in 1976, reflecting improved triage at the scene. The number of patients dead on arrival decreased from 8.7 percent to 6.0 percent. The death rate in the admitting area fell from 5.3 percent to 2.1 percent and in the operating room from 6.3 to 2.8 percent. In the Critical Care Recovery Unit, the mortality of those who survived beyond the first 24 hours dropped from 8.0 to 6.7 percent. If the decreased early mortality can be attributed to more successful resuscitative and intraoperative care, more critically ill patients would be carried over to the Critical Care Recovery Unit, making these figures more impressive. Of all patients transported by Med-Evac, the percent surviving rose from 74.5 percent in 1972 to 82.1 percent in 1976, and of those who arrived alive from 81.6 percent to 87.4 percent.

Cost Effectiveness

The Med-Evac system remains cost-effective, because the helicopters are used for Med-Evac missions only ten percent of the total helicopter patrol time. The other 90 percent is used for routine police work: search and rescue for missing persons, aircraft and boats; criminal investigation support including search for escaped prisoners and persons fleeing crime scenes, general area searches for stolen cars and property that may be abandoned in rural, wooded, or isolated areas; surveillance and trailing of vehicles and persons suspected of involvement in criminal activity; aerial photography and area surveys in connection with murder, arson, etc.; route surveys and security; traffic control; security transports; support in disasters and civil disturbances and highway patrol. Med-Evac missions have first priority, however. By using this sharing system, the cost of each transport has been held down to $48 which is paid by the state. To keep the cost per transport down, the helicopters confine activities to an area which can be patrolled while maintaining an acceptable time-distance relationship with the specialty referral centers; are maintained on a full 24-hour alert and dispatched simultaneously with surface ambulance; and transport only patients with major life-threatening conditions to avoid competing with surface ambulances. To remain effective, helicopters maintain liaison and communications with state, county, and local police departments, ambulance units and treatment centers to assure maximum utilization and transport only to medical facilities which provide the necessary sophisticated level of treatment.

The Maryland Med-Evac Helicopter Program has thus proven that helicopters can be used successfully and efficiently to bring critically injured civilians to care. It has become an essential element in Maryland's integrated system of EMS care.

Suggested Readings

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HELICOPTER USAGE IN THE STATE OF ILLINOIS E.M.S. PROGRAM

Duane Moore

The State of Illinois is nearly 400 miles long, and its E.M.S. system is one of the most advanced in the country. This system encompasses areas which are highly urban, such as Chicago, to the remotest of rural reas in southern Illinois, with very poor highways.

Hospitals in the State of Illinois were categorized by law in 1972. Prior to this, categorization was on a voluntary basis. This categorization process was based upon the hospital's capabilities to respond to all types of medical emergencies. Following categorization, various hospitals were designated as local, area, or regional trauma centers. These hospitals are connected by a sophisticated communication system which utilizes both radio and dedicated telephone lines.

Transfers of critically injured or ill patients within the system are arranged through this communication system.

The difficulties of covering the entire state by three helicopters are obviously great, but we have managed to accomplish this to an extent much greater than we anticipated. The efficient usage of these three aircraft is insured by the system itself. Patients are usually transferred from a local trauma center or local hospital to a regional center. The decision to transfer the patient is made by the local family physician. The trauma coordinator is notified, details of the patient's condition are given to the local trauma coordinator. He in turn notifies the regional trauma center coordinator. These individuals then make the arrangements for a physician-to-physician conversation, whenever possible, by either radio or telephone. Again, pertinent information regarding the patient is exchanged, providing an educational experience, especially for the physician in a local trauma center or local hospital. Suggestions are made to prepare the patient for a safe transfer. The method of transportation is then decided upon. There are four modes of transportation available.

1) Conventional ground ambulances of a D.O.T. specified design.

2) An overland critical care van, which is an Intensive Care Unit on wheels, and contains all of the advanced life-support systems, such as respirators, defibrillator, monitors, suction apparatus that are necessary.

3) Fixed wing air ambulances.

4) Bell Jet Ranger helicopters.

The method is chosen by considering the following factors:

1) The patient's condition.

2) Time distance. This is dependent upon a number of factors such as weather, the type of highways, conditions of highways, traffic congestion, and the availability of vehicles.

When the "out of hospital time" is critical, the helicopter is the vehicle of choice. The State of Illinois Department of Transportation operates three Bell Jet Rangers. Space is at a minimum in these aircraft and the performance of any but the simplest of procedures in flight, is impossible. For this reason all potential patient problems must be anticipated and appropriate measures taken prior to loading them in the helicopter. Usually these problems are respiratory and cardiovascular in nature. Experience has taught us that we should have at least two large-bore intravenous lines and whenever the patient is unconscious or semi-conscious, they must also be intubated. Chest tubes, C.V.P. catheters are inserted when indicated before leaving the local trauma center.

We have utilized, in the helicopter, cardiac monitors, defibrillators, battery-powered suction apparatus, HLR-90 heart-lung resuscitators and respirators. Many of our transfers are also for high risk infants and the modified Ohio incubator is used for this purpose.

When the decision has been made by the physicians to transfer the patient by helicopter, the trauma coordinator notifies the helicopter pilot.

Arrangements are made to provide proper medical personnel to accompay the patient, generally a physician or nurse from the regional center accompanies the transfer.

Once the patient is on board the helicopter, constant radio communications are maintained with the Emergency Medical Services communication system. This enables proper medical staff to be waiting and ready at the regional trauma center when the aircraft lands. It also enables the medical personnel at the regional center to monitor and make adjustments in the patient's treatment while in the helicopter.

The State of Illinois presently has 77 certificated hospital heliports. Forty more are in the process of being certificated. Approximately 20 other areas are designated as emergency landing areas. When a designated heliport is unavailable, high school athletic fields are also used in conjunction with local or state police to provide the necessary safety precautions.

One of the unique features of this system is the establishment of priorities. Trauma is the number one priority. Should any state official or employee, including the governor, be on board, and a trauma transfer is indicated, the pilot proceeds to the hospital and the necessary procedures for the transfer are effected. The state official or employee is left at the hospital and the transfer is initiated. Other arrangements are made for the state employee's continued transportation.

We are presently working on an additional unique plan.

One of the corporations in Peoria is considering the purchase of a helicopter. The E.M.S. system was approached to be certain that the helicopter selected would be able to accommodate litter patients. This privately owned helicopter is to be operated as a backup for the three Jet Rangers owned by the State of Illinois, in Springfield. The same list of priorities would apply to this helicopter and its use would be requested through the State E.M.S. system.

We find this concept intriguing, especially if one considerd the number of privately owned helicopters in the United States. Many of these are operating in the midst of existing emergency medical services systems and the possibilities of interfacing these privately owned helicopters into a preexisting emergency medical service system provides endless possibilities for a greater utilization and a saving of patient's lives.

The Department of Transportation of the State of Illinois has some interesting concepts on spine boards. We would like to see 6,000 spine boards locally manufactured for the State of Illinois. This large number would assure every ambulance in the state an adequate supply. A simple rack would be placed in every hospital E.R. When a patient is brought to the E.R., spine boards would simply be exchanged. In other words, every patient would have his own spine board.

FIXED WING AIR TRANSPORT OF CRITICALLY ILL AND INJURED PATIENTS

Bruce A. Houtchens, M.D.

Introduction

A long distance transportation component of an emergency medical services system should, in its best sense, constitute a coordinated link between outlying community hospitals, and designated major medical center critical care units.[1] The ability to provide adequate care enroute is recognized as one of the key issues in transport of critically ill and injured patients.[2-14] These two concepts — coordinated link to designated critical care units, and ability to provide appropriate care enroute — will form the central theme of this discussion of chartered fixed wing air transport of critically ill and injured patients.

The Setting

The Intermountain West is a region where distances between major medical centers are great (Salt Lake City is 370 miles from Denver, 480 miles from Albuquerque, 500 miles from Phoenix, 640 miles from San Francisco, 660 miles from Portland, 730 miles from Seattle). Patterns of travel within this region are strongly influenced by natural obstacles (Continental Divide, Grand Canyon, Sierra Nevada), and limitations imposed by weather conditions. These same factors also influence patterns of medical referrals.

Salt Lake City has for many years been the major medical referral center for all of Utah and much of five sur-

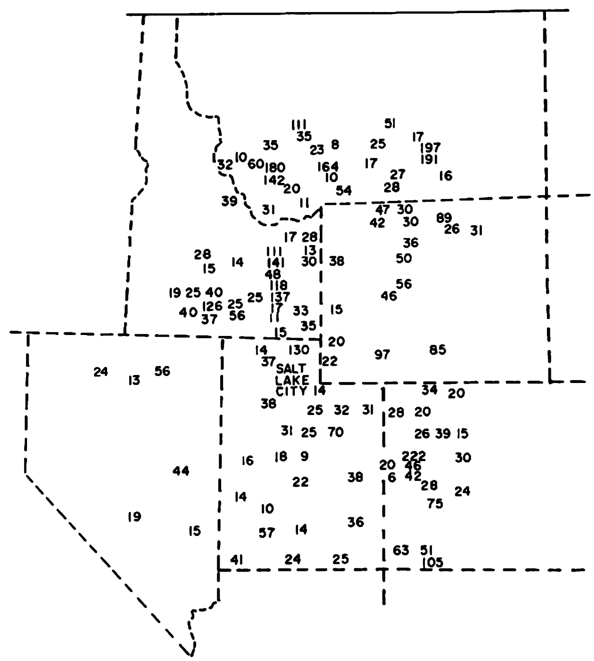

FIGURE 1: Outlying Community Hospitals of the Intermountain West: Bed Size (1974) and Location

rounding states. Figure 1 shows the locations and bed sizes of well over 100 outlying community hospitals in this six state region (exclusive of hospitals in the four county area adjacent to Salt Lake City, along the Wasatch Mountain "Front").

This vast region — a "radius of action" of about 400 miles; an area of about half a million square miles; with low population density — about three million, only three-quarters million of whom are found along the immediate Wasatch Mountain Front — is probably the largest contiguous region in the United States whose tertiary medical care needs are served by a single metropolitan area. This relationship of an enormous area, with diffused population, has long posed unique problems of retrieval of critically ill and injured patients to specialty care centers in the Salt Lake City area; and represents a setting ideally suited to development of a fixed wing air transport and retrieval system.

The Problem

To date, most outlying community ground ambulance services have been poorly equipped and poorly staffed; often operated by the local mortician.[15] Helicopters are rarely readily available in rural areas. Most fixed wing aircraft chartered to transport patients have no medical equipment at all (and no electrical system capable of sustaining operation of sophisticated life support equipment; are so cramped for space that even if equipment (and staff) were available, it would be difficult or impossible to provide patient care enroute; are only marginally safe to load (particularly over-the-wing); and are unpressurized.

Against this background, consider the dilemma of a rural physician who, limited by both his own training and facilities about him, may feel that a critically ill or injured patient will not survive at the community hospital yet also feels the patient will not survive a five-hour ground ambulance ride through the middle of the night with one nurse trying to keep an I.V. running — or a one- or two-hour unpressurized airplane ride with no monitoring or care enroute. If only from a standpoint of liability for the patient's condition during transfer (until arrival in care of a receiving physician) the doctor may be forced to manage the problem — albeit complicated — in the local hospital.

Systems of Transportation and Care Enroute

Ground ambulance capabilities in the Intermountain West are being upgraded, with federal aid through the 1973 Emergency Medical Services Systems Act. These improvements can be expected to result in an even greater number of critically ill and injured patients surviving to reach a *community* hospital; resulting in an even greater need for a coordinated link between rural hospitals and medical center critical care units.

This problem of *long distance* transport for transfer of critical patients to major medical centers will *not* so easily be solved. For complicated cases, it will usually be difficult (often impossible) to mobilize an appropriate transport team at the rural hospital site of origin. Cross-state/inter-state travel by (even a well equipped and staffed) ground ambulance will still involve too many hours; and for each such transport, the local community will be *without* the service of that vehicle and crew for *twice* that many hours!

Despite the dramatic decrease in combat mortality attributed to use of helicopters for rapid transport of battlefield casualties, helicopters have been — and are likely to remain — a minor component of the overall civilian medical transport picture. This is true for several reasons: Helicopters are relatively more costly to operate (per mile) than either ground vehicles or fixed wing aircraft, particularly when assigned in a standby mode. In most instances, high frequency of utilization is required to justify expense of assignment to the medical mission; such frequency is obviously more easily achieved in metropolitan areas. Yet with rapid expansion of EMT and paramedic training programs, and strategic placement of more and more well equipped and professionally manned ground vans in and around metropolitan areas, the role of the helicopter in medical transport may actually decrease in metropolitan areas.

There will, of course, continue to be some notable exceptions to this trend: Helicopter transport to the Maryland Institute for Emergency Medicine (from the Baltimore-Washington D.C. metropolitan area) benefits from immediate availability and priority use of the same aircraft in constant use by the Maryland State Police;[16] thus eliminating expense for standby of a "ready" aircraft. In those limited locations and situations for which MAST helicopter service is available, on short notice, and with appropriate recovery teams; use of these helicopters is a relatively cost effective critical care transport mechanism.

Where well equipped and staffed ground vehicles are not available, or not strategically placed, helicopter transport of critical patients can be time and cost effective to a range of about 150 miles (100 miles for piston powered machines). The helicopter is ideally suited to retrieval of ill and injured patients from remote mountain and lake recreation areas, and the ever-increasing scattered oil field and mining operation sites now so prevalent in the energy rich Intermountain West. Ironically, precisely the same reasons which make it unlikely that an emergency ground vehicle will be readily available in this setting (remoteness, sparseness of population), also make it unlikely that a helicopter (any helicopter - military, civil, commercial) will be immediately available.

The most effective military long range patient transport and

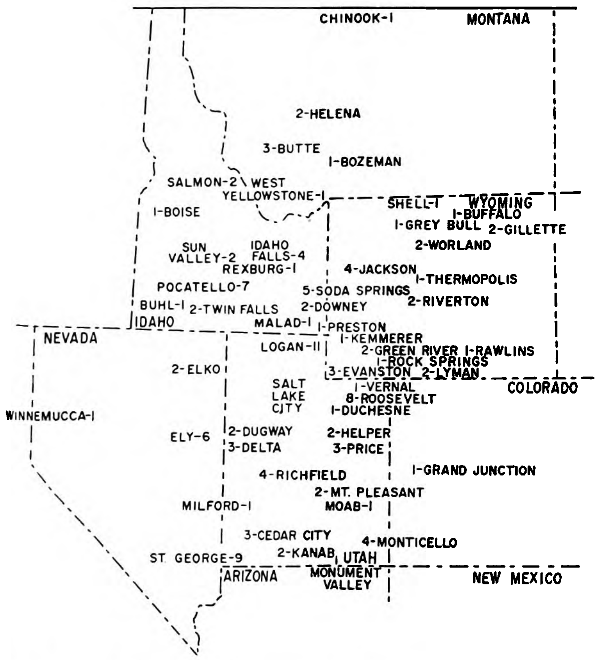

FIGURE 2: Points of Origin and Numbers of Infants Air-Transported to the Intermountain Newborn Intensive Care Unit - 1973

retrieval systems have employed fixed wing aircraft, with appropriately selected and trained onboard medical recovery teams.[2, 14, 17] A civilian prototype of this concept is in operation by a number of university hospital newborn intensive care nurseries around the country: Pediatric doctors and nurses, with transport isolette and other essential life support equipment, fly in chartered general aviation aircraft to outlying communities; to recover high risk infants, and provide monitoring and care enroute.

Currently in the Intermountain West, over 400 such flights are made annually by University of Utah Intermountain Newborn Intensive Care Unit teams under the direction of Dr. August Jung.[6] Figures 2 and 3 show the rapidly increasing frequency and wide distribution of these recovery missions.

Air transport and retrieval teams and intensive care equipment packs have also been organized by physician directors of the Intermountain Burn Unit and the trauma team at the University of Utah; and the Intermountain Respiratory Intensive Care Unit at the Latter Day Saints Hospital. On referral from outlying community hospital physicians in a 6 state region, adult patients are now being regularly recovered by air to these critical care units; flown in chartered all-weather twin engine fixed wing aircraft; with recovery teams composed of physicians and nurses derived from the critical care unit to which the patient is being referred.

Justification of Air Transport as a Link in the Critical Care System

In developing a sophisticated and expensive air transportation link to critical care units, several questions need to be asked:

SURVIVAL

First, has it been demonstrated that management of selected high risk patients, in designated critical care units, can significantly reduce mortality and morbidity associated with specific problems - in comparison to management in community hospitals and on general medical/surgical/pediatric wards?

The answer is decidedly yes: Management of acute myocardial infarction in coronary care units has reduced mortality by a factor of 2 to 3.[18-20] Management of acute respiratory failure in respiratory care units has reduced mortality by a factor of 5![21, 22] Management of neonates, with low birth weight, respiratory distress, and other systems failures, in neonatal intensive care units; has reduced mortality by a factor of 2 to 3; and significantly improved quality of survival.[23-28] Management of critically injured trauma patients in trauma units has reduced mortality by a factor of 2 to 3.[29-31] Management of severe burns in burn units has reduced mortality from specific causes by a factor of 3, and has reduced length of hospital stay by a factor of 2.[32-34]

Second, even if management in a critical care unit would benefit the most critically ill or injured patients, is there realistically enough time to effect a recovery of these highest risk patients?

Several studies suggest that, with respect to major trauma, there definitely is enough time: Up to 70 percent of trauma fatalities occur in rural areas.[35] A study by Brockert in 1970[36] showed that half of trauma fatalities in Utah occur after reaching a hospital; and over half of those reaching a hospital expire after hours or days. A study by Houtchens in 1974[37] showed that of trauma victims in the Intermountain West who expire in a rural community hospital, two-thirds survive for more than two hours after reaching the hospital, and one-third survive from six hours to one or more days before expiring.

CARE ENROUTE

Can adequate care really be provided in-flight aboard a twin engine (all weather) business-type charter aircraft?

The answer is definitely affirmative, if careful attention is

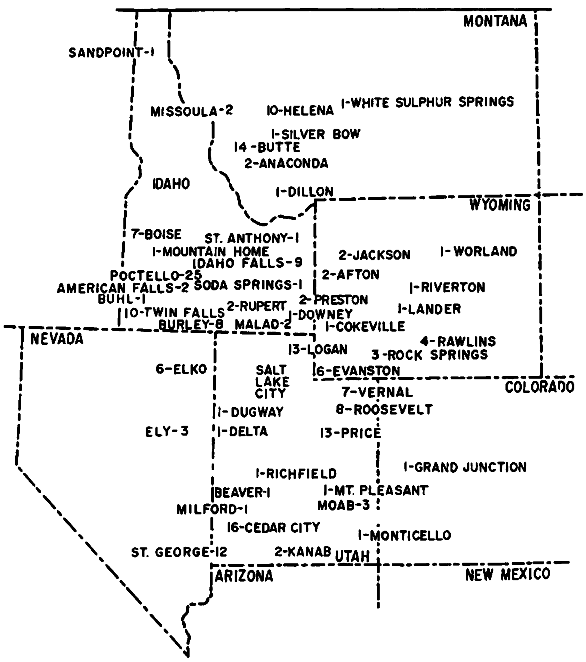

FIGURE 3: Points of Origin and Numbers of Infants Air-Transported to the Intermountain Newborn Intensive Care Unit - 1974

given to: selection of recovery teams, training of the teams, and selection and positioning of equipment, in order to create a useable flying intensive care environment. By using physicians and nurses derived from the same critical care unit to which the recovery is being made, it is assured that the team is medically as qualified as possible to handle the illness or injury to be encountered. By holding training sessions in classroom and aircraft, these teams are adapted to the somewhat unnatural environment of an aircraft cabin turned flying intensive care unit. By carefully selecting the needed intensive care equipment (and *de*selecting that which is not needed), appropriately packaging it for convenient access, and practicing in its use, it is possible to provide sophisticated monitoring and care in-flight.

COST

Can fixed wing air transport to these critical care units be accomplished in a cost effective and competitive manner when compared to ground transportation?

The answer again is decidedly affirmative: At $1.50 per mile (one way), plus "start-up" and "accessorial" fees, a typical 300 mile ground ambulance transport would cost $500-$550. At $1.00 per air mile (each way) plus transport team expenses, the same transport in a (pressurized, twin engine, all weather) fixed wing aircraft would be $650-$700. The air transport costs about a third again as much, but decreases the "road time" by four to five hours, and provides a critical care recovery team in attendance from community hospital bed to critical care unit.

A key issue is how to recover these transport expenses. Thorough investigation reveals that, when sending and receiving physicians assert that rapid transfer is essential as a life saving measure (i.e., for critical patients), almost all third party payment sources (public and private) will cover almost 100 percent of transport expenses. Despite this fact, collection rates achieved by air charter operators for patient transport have been as low as 30 percent. In Salt Lake City we have improved our collection rate to a steady 90 percent by having the receiving hospital do the billing for these same air transport expenses, as a component of critical care.

LIABILITY

Can a critical care air transport program, in a cost effective manner, assure coverage against potential medical malpractice situations?

Since recovery teams are derived from hospital critical care unit personnel, the housestaff physicians and nurses are fully covered under hospital malpractice insurances, provided they are declared to be in an "on-duty" status — and continue to be paid by the hospital — during a transport. Staff physicians are, of course, covered by their personal malpractice policies; and, as "captain of the ship" when they fly, are responsible for actions of other team members.

The physician directors of the critical care units are all intimately familiar with air transport procedures, having personally participated in a number of transports.They can critically evaluate indications and contraindications for air transport, thus reducing potential liability incurred when a "more knowledgeable" specialist "induces" a referring physician to effect air transport of a critical patient.

Summary

The Intermountain West represents an enormous geographic area with diffused population, posing unique problems of retrieval of critically ill and injured patients from outlying community hospitals to tertiary care medical centers. In studying the problem of long distance critical patient transport in this area, the record clearly indicates that:

Limited facilities and personnel in rural community hospitals are inadequate to successfully handle certain complicated critical disease and injury problems.

Chances of survival are distinctly increased when selected critical patients are managed in designated specialty care units.

Despite time-distance factors involved in long distance critical patient transport, if prompt referral is made, there still exists sufficient time to recover a majority of the highest risk patients.

Ground ambulance capabilities, though improving, will remain inadequate for long range critical patient transport.

Helicopters will continue to be rarely available in rural areas, and will remain time and cost ineffective at ranges beyond 150 miles.

In view of these facts, and in response to the problem, a group of critical care physicians in Salt Lake City have developed a comprehensive fixed wing long range air transport and retrieval system, to retrieve critically ill and injured patients — on referral from their community physicians — from outlying community hospitals to medical center critical care units.

The operation is directed by physicians who are also directors of critical care units; who themselves receive air transported critical patient referrals from physicians throughout the region; who can evaluate indications and contraindications for air transport; and who can define and train appropriate flight recovery team personnel for specific kinds of patient problems.

In developing this system, primary attention has been given to insuring the ability to provide adequate care enroute. This is accomplished by creating a flying intensive care environment, and deriving the recovery team from (the receiving) critical care unit personnel. Careful attention has also been given to making the system cost effective and financially solvent, and to insuring adequate liability coverage.

Functioning as a coordinated link between outlying rural community hospitals and medical center critical care units, it is anticipated that this critical care air transport and retrieval system can effect a distinct decrease in mortality and morbidity from critical illness and injury, on a regional basis.

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THE U. S. COAST GUARD'S ROLE IN THE TRANSPORTATION OF MEDICAL CASES

David E. Ciancaglini

The U. S. Coast Guard has specific statutory authority and responsibility for developing, establishing, maintaining and operating Search and Rescue (SAR) facilities; for rendering aid to distressed persons and property, both military and civilian, on, over and under the high seas and waters subject to the jurisdiction of the U. S.; and may render aid to persons and protect/save property at any time and at any place at which Coast Guard facilities and personnel are available and can be effectively utilized. It is this authority that charges the U. S. Coast Guard with the responsibility of participating in the EMS program.

The Coast Guard, as the world's largest SAR organization, maintains a wide variety of SAR facilities. Our resources include cutters, boats, aircraft — fixed wing and rotary wing, and numerous stations throughout the U. S. and its territories. Its operations are supported by an extensive communications network of coastal radio stations, specialized landline circuits and numerous communications centers. To understand how the Coast Guard assists persons in distress, one must be aware of the initial communicative actions that are taken, the resources we have available and finally, how these resources and our personnel are used to everyone's best advantage.

First and foremost, our Rescue Centers and Search and Rescue (SAR) stations are manned 24 hours a day and thereby offer an immediate response capability in our areas of responsibility, the maritime region subject to the jurisdiction of the United States. For those cases where military assistance is required for a Medical Evacuation (MEDEVAC) originating on land, our District Commanders are authorized and also, encouraged to enter into Emergency Medical Services Agreements with state, county and local officials. However, when Coast Guard facilities are provided, it should be understood that it will be performed on an "operations permitting" basis; requests will be limited to serious cases in which the use of the Coast Guard facilities appears to be the most feasible means of providing the required assistance and the competition with private ambulance services, including air ambulances will be avoided; and there should be an understanding that should an aircraft be dispatched in response to air emergency medical request, that the pilot will be the final judge of the feasibility of carrying out the mission and will be responsible for discontinuing it if, in his opinion, it cannot be accomplished safely.

How does the Coast Guard prosecute a call for assistance? Basically, these calls are normally received via a telephone call by either our District Rescue Coordination Centers or a SAR station or else, by a radio call on standard distress frequencies (2182KHZ, 156.80MHZ, etc.) to the nearest SAR stations. Now, assuming the call is received by a SAR station and concerns a MEDEVAC, information concerning the patients problem, his present condition, age, nationality, etc. is ascertained while our personnel are preparing to launch their aircraft and/or vessel. The information received is relayed to the nearest Public Health Service Medical Officer via the cognizant District Rescue Coordination Center controller who, after receiving the medical officer's recommendation, decides whether or not the MEDEVAC should be performed - in most cases, the situation is such that this decision is almost instantaneous.

Within minutes after receiving the initial call of distress, the aircarft and/or vessel launches to rendezvous with the vessel requesting assistance. In most instances, a Search and Rescue crewman who possesses basic knowledge in First Aid procedures performs as the rescuer and attendant for the patient. If the condition of the patient is serious, every attempt is made to transport a medical officer to the scene; if he isn't available, either an EMT trained SAR crewman or a corpsman is used. After the helicopter arrives on scene, the SAR aircrewman will use a rescue basket to hoist the patient from the vessel if the person is ambulatory - if the person isn't ambulatory, a metal litter will be utilized.

When the condition of the patient is serious, every effort will be taken to transport him directly to the hospital. When not serious, the patient will normally be taken to either a Coast Guard Air Station or SAR Station for further transportation to the hospital. If the MEDEVAC is performed by a Coast Guard vessel, the patient will be taken to the nearest safe harbor and then transported directly to the hospital via other means.

As you can well imagine, the degree of medical treatment that we can administer to the patient while he's in our care depends primarily upon the condition of the patient, the experience level of the Coast Guard attendant and the type medical equipment and medications with which he has to work. In this regard, except for the specialized equipment and medications carried by our Medical Officers, our SAR crewmen use the Standard Military First Aid Kit which contains very basic equipment.

How many cases does the Coast Guard handle during a year? Most recent statistics indicate 1685 cases. To some of you, this figure may not be too impressive. However, you must realize that the mariner community is small when compared to the number of persons who inhabit our larger cities, and the environment in which we must perform these type missions is quite different than that encountered when driving a vehicle from one location on land to another. A MEDEVAC conducted during a cold wintry night when either instrument, turbulence and/or icing conditions are encountered by our aircraft or heavy seas, low visibility and ice conditions are encountered by our vessels is not an uncommon occurrence.

Of the 1685 MEDEVACS performed, 46 percent were conducted by our aircraft and 31 percent by 4 different types of boats ranging in length from 30 feet to 44 feet. The remaining cases were handled by a multitude of different type resources. A total of 342 lives were saved, 98 lives were lost at a time either prior to when Coast Guard assistance arrived on scene, while enroute to a medical facility or after arrival at the medical facility, and 1433 persons were otherwise assisted. Our primary responsibility is to transport the patient and our secondary one is to provide enroute first aid treatment to the patient at a level commensurate with the training our SAR crewman has received — the minimum being a basic First Aid Course with the maximum of an EMT trained person.

The Emergency Medical Service benefits that can be realized as the Coast Guard endeavors to upgrade its personnel and equipment for the purpose of primarily meeting its operational commitments are the purchase of new fixed and rotary wing aircraft and also, vessels capable of providing a faster mode of transportation and carrying more personnel and equipment; the qualification of a greater number of personnel as Emergency Medical Technicians, the making of our medical kits more standardized and sophisticated as our personnel become better trained to use them, and the hosting of a conference to determine exactly what the hypothermia problem is and how to protect for and treat it. This conference would be attended by the world's foremost authorities in the field of hypothermia. Presently, we are evaluating different methods of treating persons who have experienced the effects of hypothermia — one of which is a heated oxygen treatment device.

The Role of Foundations and Associations in Emergency Medical Services

FIRE FIGHTERS AND EMS

Roswell L. Atwood, Ph.D.

The subject EMS Systems Development is necessarily broad in scope and, quite properly, has to focus attention upon medical and scientific subjects. At the same time, it is essential that some consideration be given to the individuals who are to perform the services. It is generally the feeling that fire fighters are these individuals. There are several reasons for this view, chief among them the face that fire fighters are men who have an unusual concern for others. The nature of their work calls for a selfless dedication to other people. Indeed, this spirit of dedication is a pincipal cause of the enormous injury and death rates among fire fighters.

I shall discuss some viewpoints representative of the attitudes of many fire fighters toward their participation in EMS. There are many communities in which fire fighters are the crew for emergency medical vehicles and in which they provide these services. There is little doubt that many more communities will have such programs and assign them to fire departments. There are certain considerations which need to be made when a community is contemplating such a program. Let us look briefly at some of these considerations.

Safety

The safety of fire fighters should be a matter of high priority in any community. It is not only a matter of humane feeling but also a financial obligation that is incurred when fire fighters are injured or killed in line of duty. If fire fighters are to have the added responsibility of responding to emergency medical situations, careful attention should be given to the overall manning of the fire department. If EMS is to be added to the responsibilities of a fire department without a comparable increase in the manning of that department, the emergency vehicles of all types within that department will be further undermanned with additional hazards, not only for the fire fighters but for the population of that city.

Many fire departments are already grossly undermanned.

Pieces of equipment are being sent in response to fire alarms manned by two or three fire fighters instead of the minimum of five who should be on the equipment. If, in addition to the present dangerous conditions, more fire fighters are to be taken from the fire suppression activities, then it is obvious that the lives and property of the people in that community will be substantially endangered. It is equally obvious that such practices add substantially to the hazards of the fire fighting occupation.

Training

Another concern of fire fighters which should also receive the most careful consideration is the adequacy and continuity of the medical training provided. This training should include the actual handling of patient emergencies under the close supervision of physicians. In some cities the emergency crew goes into a hospital and spends a month or so under instruction during which they witness treatment of all categories including surgery. Usually the local medical society provides instructors and the full cooperation of such a society is essential to the success of this kind of program.

Not only must the emergency care training be extensive but it should also be continuing. As new methods are developed, these have to be imparted to the medical service personnel.

Communication

It has been the general experience that, as soon as it has become known that emergency medical services are available, a constantly increasing number of calls result. This means that a city planning to start this kind of service should be prepared to expand the scope of the program as need indicates.

One of the prerequisites for an efficient EMS is a careful analysis of the dispatch system with particular attention as to the capability of the dispatchers to handle adequately the greatly increased number of dispatches that will be required. As to the proportion of emergency medical calls to fire alarm calls, it has been the experience in some cities that as many as 65 percent of all dispatches were medically related.

The emergency vehicle has to be equipped with radio and electronic devices to assure instant communication between crew members and the medical doctor who has charge of that response.

Vehicle

The vehicle used for emergency medical service should be not only a traveling emergency room, adequately supplied with those essentials determined by the medical profession to be requisite to the needs of patients, but there should be protective gear for the fire fighters who are riding the vehicle. Vehicular accidents happen when the emergency crew is responding and fire fighters have been seriously injured because of lack of restraining devices for their protection.

Fire Fighters Symposia on the Health and Hazards of the Fire Service

Beginning in 1971, and at intervals of approximately two years, the International Association of Fire Fighters (IAFF) has sponsored three symposia on the health and hazards of the fire service. Many fire department physicians have participated in these sessions and, at each, there have been panel reports which were subsequently published in Proceedings. These have been widely distributed throughout the United States.

The Panel on Emergency Care, at the 1973 Symposium, including the following as representing the views of most of the individuals who had presented testimony at the panel hearing. Because these views are derived from a nationally represented group of fire fighters, I shall now list them.

1) An increased opportunity to serve the public and save lives.

2) An improved level of emergency care delivered to fire fighters or civilians injured at the scene of the fire and including care at the hospitals.

3) Upgrading of the fire fighters' public image.

4) A broadening of the professional skills of fire fighters.

There were some negative views expressed which included:

1) Requests for personnel to assume EMS duties without the addition of new personnel.

2) Assumption of these duties without adequate training.

3) Failure of the administrative or legislative part of the city government to support financially these additional programs.

4) Failure to provide incentive pay to fire fighters who are assigned to EMS.

5) Failure on the part of employers to assure adequate manning of the EMS units.

6) Failure on the part of employers to insure legal protection for its paramedics.

7) Failure to maintain proper safety and maintenance standards on the emergency care apparatus and equipment.

When a city is contemplating having EMS as part of the fire department assignment, it is essential that there should be a willingness to approach the budgetary authorities with increased requirements necessary if EMS is to be provided.

Because of the present thrust of government into the practice of medicine, some physicians are concerned that the involvement of local government could represent another layer of interference between the physician and his patient. Some doctors are concerned about more demands on their time, which, of course, would be necessary to train emergency technicians. Another Symposium Panel Report offered four recommendations:

1) An effort should be made to contact appropriate elements of the insurance industry so as to obtain credit for emergency care capability within a departmental rating. In other words, priority for human life versus property damage.

2) Formation of a standing committee on emergency care in the International Association of Fire Fighters.

3) Formation of a clearinghouse for films, documents, resource information, and guidelines to assist departments in developing new systems.

4) The preparation of a brochure or pamphlet suitable for distribution by the IAFF to local government fire chiefs, citizen groups, etc., explaining EMS and the role of the fire service in developing and supporting these proposals.

Summary

As future development of emergency medical service expands, and it no doubt will, it is important for city authorities to keep in mind certain things. Among them, we have noted the significance of manning of all of the emergency equipment within that department. It is a mistake, which might well become a catastrophic one, for EMS to be added to the responsibilities assigned to fire fighters, without increasing the total manning of the department.

It is a prime obligation of any community to make available the best of safety equipment, an adequate and continuing safety training program and responsible and safety-conscious supervision for fire fighters in all of their work.

This obligation certainly includes fire fighters who are assigned to EMS. The emergency vehicles should be equipped with safety devices to protect fire fighters while riding in the vehicle.

Communications systems must be thoroughly analyzed as to their capacity for substantially increased volumes of emergency medical requests. The city is responsible for the installation of adequate electronic and radio devices to assure instant exchange of communication with medical authority.

Adequate budgetary provision must be made to support emergency medical service.

The employer has an obligation to insure legal protection for personnel assigned to EMS. This is, admittedly, a brief and somewhat sketchy presentation of some of the basic concerns of fire fighters with regard to emergency medical service. The point being made is simply that of the vital requirement that those who are going to be the actual workers in the first care of medical emergency victims must receive the full consideration to which they are entitled.

NATIONAL SAFETY COUNCIL

James R. Grisham

The National Safety Council is a nongovernmental, non-profit, public service organization dedicated to safety education and the development and implementation of accident countermeasure programs which reach every segment of American life. Organized in 1913 and chartered by Congress in 1953, the council has for more than 60 years served as a center of the voluntary safety movement in the nation.

Council concern with emergency medical services began in the early 1950s when this emerging service was defined as transportation of the injured. A chronological outline of the council's activities in service to improved emergency medical services in the past 20 years, leading to our current service activities, include the following programs and service activities:

1957

On October 20, 1957, the National Safety Council joined with officials of two surgical groups, the American College of Surgeons and the American Association for the Surgery of Trauma in what was termed the joint action program. It was the major premise of these separate organizations that the problems of accident prevention and post-accident trauma were interlocking. The joint action program established a number of program development goals, many of which were later adopted by organizations more capable of implementing program concepts envisioned by the joint action program. The program goals in which the joint action program demonstrated direct action include: promotion of a model ambulance ordinance; standards for emergency ambulance service; promotion of essential equipment for ambulances; promotion of flammable fabric information; highway safety programs in emergency medical services; and Surgeons' Award for Distinguished Service to Safety.

The program goals in which the joint action program demonstrated indirect program action and support included: studies for improved eyesight, medical services training, training medical technicians, prophalaxis against tetanus, new files and visuals covering certain types of injuries, national registry for ambulance technicians, program services for the aged, affects of alcohol as a cause of injury, develop text for the transportation of the injured, use and promotion of seat belts and passive restraints, emergency identification system, medical advisory boards, Good Samaritan laws.

Of the various program objectives established by the joint action program, let me expand for just a moment on two of them - the Surgeon's Award for Distinguished Service to Safety and the development of a Model Ordinance or State Statute Regulating Ambulance Service. The Surgeon's Award for Distinguished Service to Safety was inaugurated in 1960, and, since then, some 15 surgeons in the United States have been honored for their service to safety. The 1976 award will be presented in October of this year in Chicago. The Model Ordinance or State Statute Regulating Ambulance Service was prepared to assist state and local jurisdictions in the preparation of ambulance ordinances and statutes. More than 2,000 copies of the model ordinance have been distributed since 1963 when the document was officially adopted by the Traffic Conference of the National Safety Council.

1960 - 1966

Beginning in about 1960, the National Safety Council added an EMS emphasis to an existing program called the Annual Traffic Inventory. This program begain in 1932 and provided local jurisdictions with an analysis of their traffic safety program including traffic accident experience, traffic engineering, police traffic supervision, traffic courts, school traffic safety education, public safety education and organization for traffic safety. In the year 1960, a new section was added to this inventory program called Transportation of the Injured in which an analysis was made of the jurisdiction's emergency transportation services, equipment and personnel. This program continued until 1965 when a new department in the council was developed around the emerging Highway Safety Act of 1966. Prior to 1966, over 1200 cities and all 50 states participated in the inventory program each year.

1966 - 1976

During the ten-year period of 1966 to 1976, the National Safety Council has conducted a number of program services in support of emergency medical services, centering primarily around traffic safety. These include:

HIGHWAY SAFETY PROGRAM ANALYSIS

The Highway Safety Program Analysis is similar in format to the Annual Traffic Inventory mentioned previously. The basic difference is in the criteria used to evaluate program activity and in the expanded format of the highway safety program analysis. Since the inception of the Highway Safety Act of 1966 and its revision in 1973, the criteria used for the analysis is primarily that which is promulgated in the 18 highway safety program standards. Included as a primary section of each highway safety program analysis is a section on emergency medical services. To date, more than 900 regions, counties and cities in over 30 states have benefited from this analysis.

In Illinois, we conducted an analysis in 1974 of 157 cities with populations in excess of 10,000 persons; also 9 selected counties, 6 regions and concluded with a state summary.

COMPREHENSIVE TRAFFIC SAFETY PROGRAM DEVELOPMENT

The National Safety Council has conducted Comprehensive Traffic Safety Program Development for several major cities including Long Beach, California; Portland, Oregon and Chicago, Illinois. With the exception of Chicago, these comprehensive program development include a complete analysis of emergency medical service with master plans for program administration. In each comprehensive program development, a team goes to the local jurisdiction and gathers current status information by interviewing all officials with traffic safety responsibility. This information is then analyzed and program recommendations for coordination of traffic safety program plans are developed. The comprehensive program in Portland was conducted under the auspices of the Portland Traffic Safety Commission. In this plan are our recommendation and systems design for EMS in Portland, Oregon which features a combining of city and county government resources in providing emergency medical services to the city and metropolitan area.

COMPLETE EMS SYSTEMS DESIGN FOR ELIZABETH, NEW JERSEY

Under the auspices of the Hospital and Health Planning Council of Metropolitan New Jersey, the National Safety Council evaluated the EMS needs of Elizabeth, New Jersey and developed a complete systems design for the administration of EMS in that city which has been implemented and is now in operation.

DEVELOPMENT OF STATEWIDE EMS RULES AND REGULATIONS

Under the auspices of the Indiana Regional Medical Program, the National Safety Council assisted Indiana in the development of its Official Rules and Regulations for Operation and Administration of Emergency Medical Services. Owing to Dr. Otis M. Bowin, Governor of Indiana and the progressive leadership of the Indiana Emergency Medical Services Commission, these rules and regulations will go into effect in the year 1978, making Indiana one of the leaders in providing minimal standards for ambulance service operations at the state level.

ASSISTANCE TO STATES

Assistance has been provided to states in the development of their annual work programs, comprehensive traffic safety programs, state emergency medical services program plan development and improvement. Each of these mandatory documents contained sections pertaining to emergency medical services.

The publication of EMS-related materials by the National Safety Council goes back several years. The National Safety Council is the world's largest safety organization and as such, is the third leading mail order facility in the city of Chicago, in the number of postal items mailed each day. In the past years, the Council has distributed over 5 million copies of the *Pocket Emergency Handbook* and *A Pocket Guide to First-Aid*.

Publication activities also include *A Guide for Operation of Ambulance Fleets*, numerous published articles in our magazine's, *Traffic Safety*, *Family Safety* and *National Safety News*. These publications have a combined circulation of 1.7 million copies. Additionally, several EMS-related technical information sheets are published annually.

INDIAN HIGHWAY SAFETY NEEDS STUDY

This represents one of the more recent studies conducted by the National Safety Council relating to 257 Indian reservations in the United States. The study included the projected status of emergency medical services needs and the projected cost to improve these services and fund operations for the next 10-year period.

In addition to the program services just outlined, the National Safety Council has one of the largest safety libraries in the United States. Two features of the safety library relating to emergency medical services is a computerized coordinate index of reference materials which provides the title of the article, name of the author and the date. The other library feature relating to emergency medical services is an abstract service that provides a synopsis of journal articles pertaining to EMS. Information from these library services are available by writing, phoning or visiting the National Safety Council in Chicago.

The current thrust of the National Safety Council in the area of emergency medical services is to provide program services in areas that support national program emphasis and that provide services where service gaps are known to exist. A careful evaluation is being conducted now by the council to identify all national program emphasis and service gap areas. While these program service outlines are in their formative stages at this time, the National Safety Council will continue its tradition of supporting all national program efforts which strengthen EMS program services throughout the nation as conducted by the U. S. Department of Health, Education and Welfare, U. S. Department of Transportation, General Services Administration and the Health Resources Administration, and state and local agencies.

It is in the development of public support that the National Safety Council finds a continuing opportunity to contribute to improved emergency medical services through its national membership. The council membership includes 16,500 members, representing industrial corporations, labor unions, civic, service and religious groups. Seventy-nine state and local chapters, 28 affiliate safety organizations and 163 local safety organizations provide a nation-wide network to disseminate programs and provide support for implementing national and local EMS program service goals.

A STORY OF GROWTH

Arlene Carsten

I have an exciting story to share with you — a story of growth! In 1972 EMS legislation was passed which created five pilot demonstration projects aimed at establishing an integrated system for delivering emergency services.

The San Diego area was one of the five funded projects, and the only one to include $41,000 seed money over a three-year period of time for the establishment of a Burn Center.

The sprouting of seeds depends on many different factors. These seeds found good soil in the community based Board of the newly formed Institute for Burn Medicine, and nine months after they were planted (which seems to me to be a suitable gestation period) a six bed ICU for burns was open and operating.

In those nine months more than $70,000 of contributions, mostly in one and five dollar denominations were collected from the community to make this vitally needed emergency medical resource possible.

These seeds had produced a health sapling with an extensive root system in the community. Now, three years later, those six ICU beds have an additional eight intermediate care beds operating adjacent to them. A Skin Bank and Clinical Support Laboratory have also been added to the Center's capabilities — totally through community involvement and support!

The community involvement was vital in more than one way. *First:* If the most elaborate and extensive capability for treating burns was suddenly and miraculously made available back in 1972 without the kind of community involvement that occurred in our region — very few people in the community would have known what benefits it offered or how to find and use its life saving services. Other hospitals and private physicians in the community might not have immediately initiated transfers of severely burned patients.

Second: Once the community was involved and "invested" in supporting its Burn Center, it began to see more clearly some of the senseless *causes* of these injuries and the need for working to *prevent* them.

The Institute for Burn Medicine, governed by its community based Board of Directors, initiated a strong public education program which continually told about the Burn Center and its capabilities as well as how its services could be accessed, and also focused on burn prevention and fire safety. Its volunteer speakers bureau had businessmen, housewives, firefighters, toastmasters and former burn patients bring their message to tens of thousands of people in our community on a face to face basis each year.

The Institute began to sponsor major national conferences in this subject area, and discovered that in other communities throughout this country there were other groups who were also working in the area of fire and burn prevention — but that there was no mechanism available to enable sharing of ideas or educational programs. Cross fertilization was seen as a positive step forward not only by those in San Diego, but in New York, Massachusetts, New Jersey, Ohio, Oregon, Arizona, Virginia, Maryland and elsewhere.

In March of 1975 a meeting of representatives of thoses interests from around the country took place, and the National Burn Federation was born.

Its goals:

To identify community-based fire safety and burn prevention programs.

To enhance and support the educational programs of individual members.

To aid in establishing community programs in areas that have none.

To assist in general with programs and efforts of members.

To develop material for national use by members.

To conduct nationwide publicity on the availability of and access to burn treatment and fire safety and burn prevention programs.

To exchange ideas.

To disseminate and share relevant information on statistics, techniques and problems.

Thus far the National Burn Federation has initiated a hospital survey in order to locate areas of our country in which specialized burn care is available as well as whether there are community groups supporting the work of the medical professionals. Staffing patterns have also been requested from those hospitals surveyed so that community groups working with Burn Centers can have a better understanding of the level of staffing utilized in different areas of the country and possibly even put this information to good use in convincing the administration of their local hospital to upgrade the staffing for burn patients in their community.

Sources for educational materials have also been identified by the National Burn Federation and in fact some materials have even been produced with the Federation's help to aid local community organizations in better educating the public to the need for burn prevention.

We at the Institute belong to only one of many member organizations in the National Burn Federation. The seeds of a great forest exist in this country. Those seeds are being enriched as we share the common ground which gives us diverse capabilities for reaching our citizenry. Those seeds are being enriched by community groups working hand in hand with medical professionals in this important area of EMS. Those seeds are being enriched through the reality of the National Burn Federation.

The development of a national, comprehensive, effective EMS system is still in its infancy. As it grows, it must include a partnership with the people it serves, or else it will exist in a vacuum.

THE AMERICAN TRAUMA SOCIETY

Thomas S. Morse, M.D.

Surgeons know that trauma is a major health problem. Many wonder why their efforts have made so little progress toward its solution. One reason may be that professional and lay groups concerned with trauma have not successfully pooled their efforts through a voluntary health agency like the American Cancer Society or the American Heart Association. In 1968 the American Trauma Society, a voluntary health agency, was established to do for trauma what these two highly successful agencies do for cancer and heart disease.

Trauma is the leading cause of death from ages 1 to 37 years. Accidental injuries kill more than one hundred thousand, temporarily disable over ten million, and permanently impair over four hundred thousand American citizens a year. It is estimated that more than two million victims of accidental injury are hospitalized annually in the United States, occupying some sixty-five thousand hospital beds for twenty-two million bed days. This exceeds the number of bed days required for all heart patients and is more than four times greater than that required for all cancer patients. Trauma kills thousands of children and young adults who would otherwise be expected to live long and productive lives, whereas those afflicted with malignancy, heart disease, and stroke usually die late in life.

Physicians and surgeons have not sat idly by while the toll of accidents has mounted through the years. For over thirty years the annual meeting of the American Association for the Surgery of Trauma has provided a forum for the exchange of clinical and scientific information on the care of trauma victims. The Journal of Trauma, a monthly publication devoted exclusively to the accident problem, is in its thirteenth year. The Americal College of Surgeons has a Trauma Committee in each of the fifty states and in a few large metropolitan areas as well. The American Academy of Orthopaedic Surgeons has had a long history of vigorous activity in the field of trauma. Accident prevention committees of the American Medical Association and American Academy of Pediatrics are by no menas new. More recently the American Burn Association, the University Association for Emergency Medical Services, the American College of Emergency Physicians, and the Society for Critical Care Medicine have been added to the list of concerned professional organizations.

Despite the activities of all of these professional organizations the public remains insensitive to the magnitude of the problem of accidental death and disability, and the average citizen does not see clearly how he can do anything bout it. In years past, the same was true for heart disease and cancer.

Through the efforts of two very successful voluntary health agencies heart disease and cancer have become household words and nearly everyone knows how to contribute time, energy, skills, or money to the American Heart Association or to the American Cancer Society. The essence of these agencies is mutual respect and cooperation between members of the medical and dental professions and enormous numbers of lay people working together to achieve common goals. These goals include prevention, early detection and treatment, public education and service, professional education, and research. The importance of medical leadership and specialized medical knowledge has never been challenged in either agency, but the damaging effects of secrecy and mystique have been clearly recognized.

Physicians found that if they took time to explain and interpret their medical knowledge to laymen, these laymen could achieve objectives which the medical profession could not. Even if every doctor in the country were to abandon all other responsibilities and devote his full energy to the conquest of a single disease, physicians working alone could not hope to accomplish the monumental tasks of public service, education, and fund raising which are essential to success. There are only three hundred eleven thousand physicians in active practice in the entire United States. The American Heart Association and the American Cancer Society each claim over two million volunteers. Through their efforts the public has been awakened to the problems of heart disease and cancer. The average citizen has been informed about prevention, early detection, and the benefits of early treatment. He has been given a means by which he can help himself and by which he can satisfy his inherent desire to help his fellow man. His response has been generous. In the year 1975 the two vast armies of volunteers raised nearly one hundred sixty *million* dollars.

Since these voluntary health agencies came into being the outlook for victims of heart disease and cancer has greatly improved. When the American Cancer Society was in its infancy, fewer than one cancer victim in five could expect a five-year survival. Now this expectancy is one in three. One and half million Americans are alive and apparently free of cancer five years after diagnosis and initial treatment! The record in heart disease is no less impressive. Rheumatic fever has been conquered, hypertension tamed, open-heart surgery, valve replacement, and coronary care units developed — all with significant support from the American Heart Association! Both agencies stress the rehabilitative aspects of care, so that not only are there more survivors, but the quality of life which they survive to enjoy is improved.

On May 11, 1967, a group of concerned surgeons made the decision to establish a voluntary health agency for trauma. With the endorsement of the American College of Surgeons, the American Medical Association for the Surgery of Trauma, the National Safety Council, the American Medical Association, and the American Academy of Orthopaedic Surgeons, the American Trauma Society was incorporated in the State of Delaware on June 27, 1968. Early financing came from small grants from the sponsoring agencies and from founding membership dues.

Today the American Trauma Society has divisions in thirty-two states. Each division is developing units in counties or groups of contiguous counties. The National Headquarters is in Chicago at 875 N. Michigan Avenue. Here the Executive Director, L. Nicholas Lotz, and his staff are developing programs in four major areas. Most important for the immediate future is public information and education. The average citizen must be made aware of the problem of trauma and shown what can be done about it. The second area is professional and paraprofessional education. Fellowships and Trauma Professorships fall in this category. The third area is community services. The American Trauma Society could not hope to undertake the tremendous financial burden of paying for the care of individual trauma victims; it can, however, help to finance community needs such as communications equipment, ambulances, and the like. It can also sponsor rehabilitation programs for disabled trauma victims. The fourth major area is research. Research has become the biggest single budget item for the American Cancer Society and the American Heart Association. It is in sponsoring research that these agencies have made some of their most valuable contributions. Research is badly needed in many areas of trauma, particularly in finding ways to motivate people toward safer patterns of living. The day will come when the research activities of the American Trauma Society are among its most important functions, but for now the research program is in an early planning phase.

Those who have worked closely with the Society may feel discouraged by the apparent snail's pace which has characterized its infancy. Actually, its progress has been relatively rapid compared to the early days of the American Heart Association or the American Cancer Society. Officials of both agencies have been extraordinarily helpful in providing information, advice, and cooperation. In one sense the American Trauma Society poses a threat to them since it will be competing with them for health dollars. On the other hand, there are many areas of potential cooperation, such as the development of community emergency medical services which will serve the needs of heart disease and cancer as well as those of trauma.

Much remains to be learned through research in trauma, but much knowledge is currently available for dissemination and immediate application to prevent accidents and to reduce the toll of death and injury. More is known today about accident prevention than about the prevention of either heart disease or cancer. In industries where this information has been applied intelligently and conscientiously the accident rate has been cut by about 50 percent. Only an aroused public which feels effectively involved can get the drunk driver off the road, achieve the mandatory use of seat belts, and bring effective pressure to bear on the unsafe driver whose speeding and other hazardous behavior is responsible for the majority of traffic deaths. The same aroused concern can achieve similar reductions in accidents at home, at work, and at play.

The lessons of the American Cancer Society and the American Heart Association are clear. Concerned surgeons can accomplish far more by pooling their efforts with those of lay groups than by continuing on their separate ways.

The average citizen has inherent desires to help himself, to protect his family, and to help others. To satisfy these needs, enormous numbers of people respond to education with a generous outpouring of time, talents, and money to support education, research, and service. What these two agencies are doing for heart disease and cancer, the American Trauma Society can do for accidental death and disability, the neglected disease of modern society.

THE MEDIC ALERT FOUNDATION, INTERNATIONAL

Luther L. Terry, M.D.

Medic Alert, a unique emergency medical identification system, is currently observing its 20th anniversary. It began in 1956 to protect a single person — a young girl whose allergy to tetanus antitoxin was so severe she nearly died from a sensitivity test of that drug.

Today, there are approximately 635,000 individuals in the U.S. who are protected by Medic Alert. Membership growth is running about 1,500 each week. Internationally, there are about 950,000 members of Medic Alert who belong to 14 affiliate organizations on four continents. Included are Great Britain and Republic of Ireland, Canada, South Africa and Australia.

We are setting a goal of 100 percent increase in the U.S. membership by 1980. And in the international area, we plan to add at least two new countries per year, thereby increasing international membership by more than 100 percent by 1980.

Now, you ask, what is Medic Alert? It is unique in this world today — the original and world's largest system of emergency medical identification that is nonprofit, charitable, and tax exempt. The Foundation has been built on the firm belief of our Board of Directors that one internationally recognized symbol will best protect all people with hidden medical problems. That is what Medic Alert does so well — protects individuals with any medical problem or condition that cannot be easily seen or recognized. Allergy to penicillin, diabetes, heart conditions, taking anticoagulants, wearing contact lenses, and epilepsy are the leading reasons for membership, although there are more than 200 common reasons for an individual joining.

Tragic or even fatal mistakes can be made in emergency medical treatment unless the special problem of the person is known. Medic Alert is, therefore, an extension of the good health care each of us desires for those we serve.

When an individual is unconscious or cannot communicate his medical problem in an emergency, Medic Alert speaks for him, *loudly*.

Each Medic Alert member wears a metallic alerting device in the form of a bracelet or necklace. It bears the insignia of the medical profession and the words "Medic Alert" in red. Designed to attract attention, the emblem is recognized by emergency personnel the world over. On the reverse side of the emblem is engraved the medical problem or problems of the wearer together with his membership number and the telephone number of the Foundation's Emergency Answering Service. Emergency personnel can call this number around the clock, from any world location, collect, and receive in seconds all the personal and medical information on a member that could help save his life.

Each member also receives an annual wallet card carrying additional personal and medical information to that on the emblem. The member also receives a computer printout of his entire emergency record each year so that it can be verified. Although this is an annual reminder for the member to bring his record up to date if need be, he can change or update his record at any time and as often as is needed. Incidentally, each card is dated so that emergency personnel always know they are working with information not more than a year old.

Proof that the Medic Alert system works is seen in the fact that in a recent 12-month period, over 2,000 individuals wrote saying Medic Alert had contributed to the saving of their lives.

For the total system of protection, there is a one-time, lifetime basic membership fee of $7.00. That is what it costs to install and maintain a membership for life because the fee goes totally toward underwriting the cost of the direct service to the member.

In order to conduct its educational programs, the Foundation relies on contributions, gifts, and bequests.

These educational programs are conducted by volunteers working as individuals or as groups which include a wide variety of civic, service and fraternal organizations that conduct ongoing Medic Alert programs in their local communities. These groups include medical auxiliaries, Lions and Rotary clubs, business organizations, B'Nai B'rith groups and approximately 300 local Life Underwriters Associations. In Cincinnati, there is an ongoing Medic Alert program conducted by the Dental Society. In San Francisco, the Pharmaceutical Society has involved all its members. In Manhattan Beach, California, firemen and paramedics conduct a program. And in San Diego, the Medical Society has teamed up with the life underwriters to develop an outstanding program. Police in New York City are heavily involved in supporting Medic Alert. And, in one West Virginia County, the rescue team has assumed Medic Alert responsibility.

Medic Alert's programs, educational in nature, are in two parts:

First is the professional education program where the volunteer organization works with emergency personnel to educate them to search for the Medic Alert emblem and to take immediate and appropriate follow-up action upon identifying the emblem. This program is directed to hospital emergency room personnel, paramedics, ambulance drivers, police, firemen, rescue personnel, etc.

The general education program is directed toward bringing to the attention of the general public the availability of this lifesaving service. In this program, persons with hidden medical problems become aware of the Foundation's emergency medical identification service.

The key to the general education program is distribution of the informational Medic Alert folder "This Could Save Your Life" which also contains an application form for membership. Contained in an attractive stand-up canister, the folders are displayed primarily in waiting rooms of doctors, on pharmacy counters, and at several locations in hospitals. Today, roughly 31 percent of all new Medic Alert members learned of the Foundation from their hospital. About 13 percent were introduced to Medic Alert by their physicians, and another 8 percent received their applications from their pharmacist. Also making considerable contributions are paramedics and rescue personnel, police, fire fighters, health departments, clinics, as well as school and industrial medical organizations.

A key factor in our professional education program is the many endorsements of national and international organizations, each providing invaluable assistance. This august group includes the American College of Physicians, American Academy of Allergy, National Sheriffs' Association, International Association of Fire Chiefs, International Association of Police Chiefs, the International Rescue and First Aid Association and the National Association of Life Underwriters.

Recently, endorsement by the American Hospital Association has brought additional endorsements from practically every one of the state and metropolitan hospital associations with the result that upwards of 1800 hospitals have implemented in-hospital programs of distributing Foundation literature.

You can thus note that these endorsements are essential to the Foundation's reaching the massive membership of the medical and emergency professions which, in turn, provide such vital support in helping the Foundation achieve its commitment of service.

Of the more than 7 million copies of Foundation literature printed last year in support of our various public information and education programs, a significant amount was associated with the 35,000 letters we mailed under our professional education program . These were communications to sheriffs, pharmacists, hospital administrators and physicians.

As an adjunct to the mail program, the Foundation maintained exhibits at 15 major nationa conventions and at numerous state and local professional meetings. Again, the purpose then, as it is today, was to deliver the message to Medic Alert.

Members of the medical and emergency professions recognize clearly the lifesaving protection that Medic Alert provides individuals with hidden medical problems. As Chairman, one of my major objectives is to accelerate even further our work in this area everywhere to help fulfill the Foundation's commitment of bringing its system of protection to every individual who needs it.

EMERGENCY MEDICAL PROBLEMS CONFRONTING THE UNITED MINE WORKERS OF AMERICA

Lorin E. Kerr, M.D.

Most people realize that coal mining is the most dangerous occupation in the world. But few really understand the staggering number of men who have been killed and maimed in the nation's coal mines. In this century alone, over 100,000 men have met their death crushed by fallen rock, smothered or scorched in an underground fire, or crushed by mine machinery gone out of control. Over 2.5 million miners have been injured in the mines during the same period. While the figures for 1975 are incomplete 151 miners were killed at work, and during the first nine months of the year, 14,098 more men suffered job-related injuries.

Equally important but never publicized is the death on the job each year of more than one hundred miners from illnesses such as stroke or heart disease. Illness occurring on the job often forces miners to stop work and some need immediate removal from the mine.

The huge disasters claim the headliners, but more miners ill or injured on the job die in ones and twos, their death scarcely meriting a story in coalfield newpapers. Even less known is the fact that many ill or injured miners die enroute to the surface or on the way to the nearest hospital because of inadequate medical attention. A miner ill or injured far underground might wait for as long as twelve hours before eventually receiving qualified medical treatment.

The development and expansion of Emergency Medical Service programs throughout the nation's coalfields would assist materially in the resolution of these problems. Crucial to ultimate success, however, is the ready availability of adequately trained personnel. The only answer is to train coal miners themselves to provide emergency life-sustaining services to each other whenever tragedy strikes. At present, virtually no coal miners have training beyond the most basic first aid techniques. As a result, men who could escape serious permanent disability are in fact disabled for life, or worse die simply because the care they needed quickly, on-the-spot, was not there. Moreover, the acute shortage of all health personnel including physicians in coal mining communities makes it essential that miners be prepared to help the sick and injured in the communities where they and their families live.

Over 175,000 men work in the nation's mines today. And that number is growing rapidly as an energy starved nation turns to coal as its staple source of power. The United Mine Workers of America is cooperating with Federal and state agencies in eleven coal mining states in an effort to initiate EMT programs which will ultimately assure that a trained coal miner-EMT will be available on every shift at every mine. The UMWA urgently recommends the expansion of this program. Surely that is not too much to provide the coal miners of this nation in return for the risks they take eight hours every day to provide this nation with the energy it so desperately needs.

AS WE MOVE AHEAD

Eugene C. Wood, B.S., M.S.

There was a time in this nation's history when the hospital served only what we might loosely classify as "emergency patients"—patients on the very brink of life and death. The hospital was viewed as a place of last resort where victims of illness, accident and injury came to die. They came, that is, if they knew the hospital existed. They came, if they could get there without dying on the journey. They came, if the hospital or doctor could be contacted. They came, *if*...

Today, the role of the hospital in American health care has changed dramatically, but the hospital continues to play a major role in the provision of emergency medical care services. Unfortunately, effectively carrying out that role is still dependent on some of those "ifs" I just mentioned.

It is difficult to begin talking about hospital involvement—either individually or through the American Hospital Association—in the delivery of EMS without first defining our goal. The challenge, whether we are talking about a rural or urban setting, is to concentrate a sufficient volume of services of specific kinds into single systems so that the staff and equipment can be assembled to provide prompt and adequate care in sudden, life-threatening situations. That, of course, is a big order, and it cannot reasonably be tackled in its aggregate form.

This means that we must devote our attention to each of the different elements which comprise the EMS problem. These include resource identification and planned development, financing, transportation, communication, and not to be forgotten, public education. If we look carefully at each of these components and at trends in emergency medical care provision, it becomes clear that the hospital, and the American Hospital Association, should be actively involved in seeking workable solutions. Traditionally, the hospital has played a major role in providing emergency care, and the AHA represents more than 7,000 hospitals.

In 1974, the last year for which complete figures are on hand, hospitals reported a total of more than 71 million emergency outpatient visits; nearly 25 million of them took place in hospitals with fewer than 199 beds. Significantly, it is these smaller, rural hospitals—which comprise over half of the total number of hospitals in this country—which have some of the most pressing difficulties in implementing effective EMS systems. It is in these same hospitals that the problems of supporting and adequately staffing a fully-equipped emergency department are most obvious. The problems of sparse money and manpower resources, great distances between major medical centers, and a population too sparse to support all of the full range of emergency services in each institution leave the unwarranted impression that patients in these areas must just "learn to make do."

This is, however, certainly not the case, whether we are talking about emergency care in the small, rural hospital, the suburban hospital, or the large urban ghetto hospital. What *is* true is that *hospitals* are learning to "do." Independently, on community and area-wide bases, and through the AHA, hospitals are learning to overcome some of the problems of public education, transportation, communication, and resource development and utilization. This is essential if we are to provide effective emergency medical care.

At the national level, AHA has been actively involved in identifying and defining some of the component problems. More importantly, we have developed liaisons with groups such as the American Medical Association, The Department of HEW, the U. S. Nuclear Regulatory Commission, the Emergency Department of Nurses' Association, the American College of Emergency Physicians, and the Emergency Care Research Institute in order to identify particular problems and point out areas for leadership and concentration of effort in solving them.

The Association has supplemented its seven major EMS-related publications and guideline statements with area and regional institutes and workshops on management improvement and cost containment in providing emergency medical care, and on disaster planning and disaster preparedness as well. We also established an Advisory Panel on Emergency Radio Communications and an Advisory Panel on Signposting which were involved in the evolution of model systems and coordination of Federal Highway Administration emergency efforts.

Earlier this year, AHA testified in support of proposed amendments to the Emergency Medical Services Systems Act of 1973 before both House and Senate committees. We endorsed the proposals "in the interest of extending authorizations for and making technical improvements in a law that holds the promise of a national coordinated effort to reduce the number of deaths in the U.S. attributable each year to accidents and medical emergencies." Indeed, this is the operating philosophy behind all of the Association's EMS activities.

We are now working closely with state hospitals associations in their development and implementation of EMS plans. Because an adequate data base is necessary if we are to devise workable models for solutions to some of the problems which have been identified, AHA is developing data on emergency department quality assurance standards, hospital disaster plans, hospital evacuation plans, and ambulatory care group management. This is the beginning of a national information repository. From here, the AHA can draw the information necessary to carry out its role as spokesman in tracking, commenting on, and helping to implement regulations and legislation relating to EMS.

While all of this activity is going on at the national and state levels, ultimate solutions to EMS problems must be found within the constraints of particular community situations. The emphasis is on developing the necessary range of emergency treatment levels or specialties among all hospitals within a given service area which can be reached quickly by available transportation. While every hospital must be able to provide basic first-aid and stabilization level care, we have begun to identify the specialized emergency capabilities of each hospital. This "categorization" is the first step toward making full use of the area emergency services and resources. Then, with the use of modern communication and transportation facilities, we can get the patient to the level of care he needs without wasting precious time in intermediate stops along the way. Hospitals, their medical and professional staffs, and state and area associations are actively involved in devising the locally appropriate categorization systems.

Hospitals are also finding appropriate and innovative ways of dealing with the problems of communications and transportation of emergency patients. In some communities, they have encouraged police and fire departments to establish a central emergency communications system such as the 911 network. Seven years ago, the emergency medical care personnel in Tulsa, Oklahoma instituted an integrated radio network which have every ambulance and hospital the capability to transmit and receive emergency information on a common frequency. Since emergency medical care is so closely related to travel time to the nearest hospital equipped to handle the problem, this system also has helped improve EM care in surrounding rural communities. It has been augmented by emergency medical technician training, so the patients can now receive first-aid and stabilization treatment on route to the emergency department.

In Mt. Vernon, Ohio one hospital has experimented with the use of city-trained teams to staff emergency vehicles. The vehicles themselves are purchased by the city and leased to the hospital for $1.00 per year.

Two Colorado medical centers are in the process of establishing a 24-hour emergency room in a rural area 35 minutes away. It will be staffed by critical care nurses and linked to the medical centers' back-up and support facilities by biomedical telemetry and telecommunications. Out in California, a small, rural community hospital operates its emergency room in cooperation with a major university medical center located 180 miles away. The medical center's second- and third-year surgery residents staff the hospital's emergency department and the medical center's helicopter evacuation service is used to transport critical patients. As a result, this 36-bed hospital in a rural vacation area has routine access to university-quality medical care.

In each of these instances, hospitals have become involved in working to solve the interrelated problems of providing emergency and trauma care in areas where the resources are not always readily on hand. In each case, individual hospitals or hospital groups have taken the initiative in overcoming particular problems of distance, and shortage of trained manpower. AHA, through its Committee on Community Emergency Health Services, has assisted hospitals in identifying EMS problems and in developing workable solutions within each community's particular resources and suited to each one's particular needs.

Our nation's emergency medical care system still suffers from a lack of disciplined coordination, but we have come a long way in our abilities to provide various kinds of care and to deal with the remaining problems. Today, in our nation's bicentennial year, trauma care may no longer be the "neglected disease" it has been in the past, but I think it is one which we are only beginning to manage effectively. We have come a long way in improving our abilities to deal with life-and-death situations, but we have by no means come as far as we either could or should. In conclusion, I will leave you with a few lines from AHA's manual on *Emergency Services:* "That there is nationwide concern about improving the quality of emergency care is apparent. That we *know* better than we *do* is clear. Progress would seem to depend on the will to join forces and apply the knowledge we have."

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Disaster and Civil Emergency Response Systems

INTRODUCTION

John W. McConnell

We all know an emergency occurs somewhere every minute of the day. We also know it can take place where we live, or work, or happen to be. Some emergencies begin and end with one person or, at most, a small number of people. Others involve large numbers of people and entire communities. Some are even called "disasters." I recognize words such as "emergency," "small," "large," and "disasters" are relative: What might be "small" in a big city setting might be "large" in a rural area, and the term "disaster" has different meaning for different people.

An emergency may be defined as a situation where immediate action is required. The possibility of one occuring may be anticipated so that plans are made to deal with it, or it might be unforeseen and dealt with on an off-the-cuff, reactive basis. What makes it different from other situations is the time element; in an emergency, the time for action is now. If the taking of action can be postponed without affecting the outcome, the situation might be serious or even critical, and still not be an emergency.

In this context, a medical emergency requires immediate action of a medical nature. It can take a variety of forms and magnitudes, ranging from the routine cardiac arrest or trauma incident to multiple or mass casualty incidents which occur during a major emergency in which a number of services—polices, fire, rescue, communications, as well as medical—are involved.

Emergencies can be categorized in a variety of ways. There are routine day-to-day kinds of emergencies as opposed to out-of-the-ordinary, infrequent kinds. They can also be categorized in terms of predictability, possible effect on the community, the amount of warning time available, etc. This workshop is about out-of-the-ordinary, infrequent kinds of emergencies, and the EMS aspects of such emergencies. More specifically, it will be on the subject of disasters and plans for dealing with them.

As I said earlier, the word "disaster" is relative—a man dies and that is a disaster to his family. Even here, however, the definition provided in Webster's Third International Dictionary applies: a sudden, calamatous event producing damage, loss (of life and property), and distress.

The disasters to be considered in this workshop include natural phenomenon such as tornatoes, hurricanes, floods, earthquakes, and volcanic eruptions, plus man-caused emergencies in connection with nuclear power or terrorist activities. But regardless of the kind of disaster, I think it is generally agreed community plans and arrangements for responding to any major emergency or disaster will involve the same basic systems of personnel and resources. What will vary with the individual disaster are the ways the personnel and resources are used.

I believe more attention is being given these days to disaster planning, particularly by local governments, because it is both good sense and good politics. For one thing, there is the population explosion. Because there are more people, the effects of a major disaster on the population of a community today usually are greater than would have been the case 25 or 30 years ago. For another, technology has created new hazards such as wide bodied jets and nuclear power. Finally, our society has become increasingly complex and interdependent. Fifty years ago, for example, the average farmer would not have been affected by a power failure whereas today the cows might not be milked!

Civil emergency and disaster planning should have four objectives. First, to the greatest extent possible, it should identify the emergencies and disasters that might occur in the community, and the problems that could result. Second, it should establish the requirements for operational communications because, in these situations, communications are the glue that holds things together. Third, it should identify the resources needed for disaster operations - manpower, equipment, etc. - and indicate which are already available because of meeting day-to-day needs, and which are surplus in terms of day-to-day operations but essential for operations in a disaster situation. Finally, it should assign responsibilities because, if this isn't done, the result is planning for the sake of planning and nothing happens.

Disaster planning by a local government therefore begins with an analysis of the hazards the community might face. A list of hazards may include weather phenomena, and other natural hazards such as earthquakes, volcanoes, or tsunamis. It should also take the possibility of man-created hazards into account, such as industrial fires or explosions, transportation accidents that could produce mass casualties, energy accidents, nuclear emergencies, etc. The hazard analysis should cover questions such as frequency of occurrence, specific geographical areas and numbers of people at risk, and the degree to which prediction and warning are possible. Based on this analysis, the planning then should consider preventive, mitigating, or ameliorating actions that might be taken before, during, and after the actual emergency or disaster.

Two observations about disaster planning at the local level. First, it is being done in some places on a regional basis. The Puget Sound Council of Governments in Washington State, and the Association of Bay Area Governments around San Francisco are two which immediately come to mind.

Second, these two regional organizations and some 1000 local governments have been helped in their disaster response planning by the Defense Civil Preparedness Agency through the provision of On-Site Assistance. This has been a major effort by DCPA to assist local governments improve their operational capability for coping with the effects of a nuclear attack by increasing their capabilities for dealing with natural disasters and other peacetime emergencies. It involves Federal, State and local representatives working together on-site. It starts with a hazard analysis, and includes an assessment of existing operational capability plus the development of an action plan which all three levels of government agree to use to correct or improve the situation.

From a DCPA point of view, On-Site Assistance has two objectives: The first is to help a local government meet its responsibilities for the public safety and welfare, by improving its capability for directing and coordinating the operations of emergency services in the community during a major emergency. The second is to accomplish this at reasonable and manageable cost.

Planning for operational coordination in a major disaster situation almost always requires dealing with the two major differences between day-to-day EMS operations and EMS operations in a major disaster situation. The first involves the case load. The basic EMS system usually is designed to deal with the day-to-day emergency, the one-or-two casualties-at-a-time kind of problem. There is nothing wrong with this approach: most police and fire departments also function on the basis of dealing with the here-and-now, day-to-day emergency.

A major disaster, however, normally presents a series of problems of larger dimensions. One such problem is that the medical case load usually is beyond the normal capacity of the EMS system. There can be exceptions: A tornado, for example, or a hurricane, may result in heavy property damage and even loss of life, but not provide a case load problem. And it is important to be precise here. Most references to death and casualties in the context of a natural disaster—Hurricane Agnes, for example—are cumulative, and not limited to one place. We speak of over 110 deaths caused by Agnes—but these occurred over an eleven-state area, not in one place all at once.

What we are talking about is an unusual case load at one place all at once. But if that were the only difference between day-to-day EMS and EMS in a major emergency, the solution would be to get more doctors, more nurses, more EMTs, more ambulances, more hospital beds, more medicines. That is part of the solution but, if I may say so, it is a lesser part.

This brings me to the second major difference between day-to-day EMS, and EMS in a major disaster situation. It is operational in nature—so let me make some observations about the operational environment in the day-to-day situation.

First, I think each emergency service — police, fire, medical, etc. — normally deals with its own emergencies on a unilateral basis. By that, I mean they use their own command structures, their own guidelines, and I might add, function very effectively without interfering with one another. In these circumstances, it is not necessary for a mayor (or city manager or county commissioner) to get into the day-to-day operations of an individual emergency service unless something goes wrong. Second, I think that in the day-to-day situation, the other services make a major effort to assist the emergency medical service because that service is more involved in life-and-death emergencies on a daily basis than the others.

The difference between the operational environment in the day-to-day situation as opposed to the major emergency situation is not just the imposition of an unusual case load. An even bigger difference is that the case load problem frequently arises when the other emergency services can't assist the medical service because they are unilaterally involved in their individual operations—the police with traffic control and security, the fire-fighters with fighting fire, the search and rescue people searching and rescuing and so on.

However, even though each service is working unilaterally to accomplish its primary mission, all of the services must work together because the public safety and welfare is involved, and that makes it a government concern. In this kind of situation, the government should be implementing its emergency plans, and acting in a coordinating capacity by relating the operations of the individual emergency services to one another so that they will work effectively together in a situation when the day-to-day cooperative procedures may not be enough.

That's what government is all about: It must have the capability of stepping in and performing this coordinating function. Moreover, when the emergency is so big that this coordinating function becomes important, the chief executive usually gets involved.

I've already said he or she does not have to be involved in the day-to-day operations of the individual emergency services. But when the emergency becomes larger than life, when it really affects the community, he or she has to become involved. And the voters eventually indicate on Election Day their satisfaction or dissatisfaction with the way things were handled.

The kinds of EMS questions that must be considered by a government when it is planning for the conduct of coordinated operations during a major emergency are similar to those EMS planners have to consider in developing component 14 of an EMS project application: This is the component that requires a plan whereby an EMS system would deal with "mass casualties, natural disasters, and national emergencies."

Operationally speaking, I believe there are three identifiable phases in a mass or multiple casualty situation: The first is the "on-the-scene" phase where rescue, first-aid, and the possible need for triage are the primary medical considerations. These, in turn, interface with other public safety considerations, such as fire fighting, security and traffic control, search, the possible need for saving life by evacuating people, etc. The second is the transportation phase of getting a casualty from the disaster scene to a hospital, and the third is the hospital phase.

The interface between the EMS and other public safety considerations is shown by questions which, in my jugment, should be asked by a government whenever a plan for coordinated emergency operations is being developed. The answers, of course, will vary from community to community, because as I said at the beginning of these remarks, what might be a small problem in a big city setting where there are all kinds of medical resources, might be big in an area where they count their resources by one's — one hospital, one operating room - or none's — no burn unit, no helicopters.

But no matter what the answers are, I think the questions apply everywhere. These are the kinds I have in mind:

In a major disaster situation, how do the hospitals know when and where there is a mass casualty emergency? Who has the responsibility for telling them? Are there special arrangements needed for inter-hospital communications during such an emergency?

I think you all know the Joint Commission on the Accreditation of Hospitals requires every accredited hospital to have a disaster plan. But are the disaster plans for one hospital coordinated with those of other hospitals in the area, and with the emergency operations plans of the government services such as the police and fire departments? Are the hospital disaster plans tested and exercised realistically?

What are the arrangements for rescue, first-aid, triage, and ambulance dispatch at the disaster scene? Are there agreed arrangements and procedures as to roles and responsibilities for fire, police, medical, civil defense at the disaster scene, as far as overall direction and coordination are concerned? And, believe me, this is important, because if there is a major emergency and the arrangements haven't been worked out beforehand, the chances are there will be bickering instead of effective rescue and relief.

Are there enough resources locally available to deal with the expanded case load resulting from a mass or multiple casualty emergency in the community? There are many other questions but I think you see what I mean.

In conclusion, I want to make three points about disaster planning in general, and disaster planning for EMS in particular. First, all disaster planning should be made on the basis of what is most likely to happen but be flexible enough to deal with disasters not specifically covered in the plan. It should involve the identification and definition of anticipated problems and the projection of possible solutions on the basis of the resources most likely to be made available. Some planning can prevent certain events from happening but, in the vast majority of cases, plans merely provide the system or procedures for making pragmatic decisions that result in appropriate actions being taken to deal with a specific specific situation. This is particularly true in the case of natural disasters. Thus, disaster plans can help to indicate the range of problems that will occur and establish the basic mechanism or system for solving these problems.

In this sense, planning reduces uncertainty but it usually does not prevent a situation from happening. It is, in fact, very unwise to assume that everything can be planned for, that the unknowns of a disaster situation can be totally predicted ahead of time, and that because certain things can be correctly anticipated, it will be possible to prevent them. Planning is no substitute for common sense, but good planning makes it easier to use common sense.

Second, what I just said about disaster planning in general is just as applicable to the medical aspects of such planning. Moreover, I think disaster planning for EMS will not be very effective if it is done in isolation; for maximum effectiveness, it should be accomplished in the context of the disaster and emergency response planning for the entire community.

Third, except for metro areas like New York and Los Angeles — where the EMS disaster response systems are involved in real life multiple casualty incidents on a fairly frequent basis — the EMS disaster response system of any community — metro or rural — will be as good — or as bad — as its last test or exercise. My advice is to make those tests and exercises tough and realistic, because they may mean the difference between those who survive and those who die if there is a major emergency situation in your community.

HURRICANES, FLOODS, AND TORNADOES

Richard E. Hallgren, Ph.D.

The United States has more natural disasters than any other country. While other nations might be plagued by more of a particular phenomena, we can claim, with no satisfaction whatsoever, that we have the greatest variety.

Hurricanes, floods, and tornadoes alone are causing about $2.3 billion damage annually in the United States. They have killed more than 27,000 people in the past 50 years and injured hundreds of thousands.

And when you group tornadoes, hurricanes, and floods together, there's not a place in the United States that's immune from the fury of these storms. We're vulnerable everywhere.

Let's take a look at some statistics. Tornadoes have struck in every state at one time or another although they're most prevalent in about half of the U.S. In the last five years, more than 4,000 tornadoes caused about $4 billion damage, killed about 700, and injured about 15,000. The incredible tornado outbreak of April 3-4, 1974, saw 148 tornadoes gouge paths throughout 13 states east of the Mississippi River over a 16-hour period. When it was over, more than 300 people were dead. Injuries totalled about 6,000 and that violent episode caused half of a billion dollars in property damage.

We must not forget lightning. Lightning usually kills only one or two people at a time so we don't hear about it as a big threat. Yet, lightning kills more people than tornadoes, hurricanes, or floods.

No area of the U.S. is completely free from the threat of floods. River floods and, particularly the deadly flash flood, drive some 75,000 Americans from their homes each year. About 90 people are killed and more than $250 million worth of property is damaged or destroyed in an average year. In the last five years, the American Red Cross reported about 20,000 injuries.

Flash floods and river floods attributed to Hurricane Agnes in 1972, resulted in 122 lives lost and $3.5 billion in damage. The flash flood that devastated Rapid City, South Dakota, in that same year killed more than 230.

The worst natural disaster in the history of the United States came as the result of a hurricane which struck Galveston, Texas, in 1900. Six thousand people lost their lives—a greater toll than the battle deaths recorded in the Spanish-American War two years earlier. In 1893, a great storm surge drowned more than 1,000 people in Charleston, South Carolina. In October of that year, nearly 2,000 perished on the Gulf Coast.

In 1935, 400 Floridians died in the infamous Labor Day hurricane. Camille in 1969 caused about $1.5 billion property damage and took more than 250 lives as the vicious storm smashed into Mississippi, Louisiana, Alabama, and then caused severe flash floods in Virginia and West Virginia.

Statistics alone cannot tell the whole story of the suffering and personal losses brought about by these dreadful storms.

A growing population in urban areas along the hurricane-vulnerable coastline and through unchecked flood plain development has increased the potential for large disasters across the Nation. The spectre of great loss of life, injuries, and destruction looms on the horizon.

Let's look at our hurricane vulnerability. Over a 10-year period from 1960 to 1970, there was a 43 percent increase in people living along beachfront subdivisions. There are now about 37 million people living along the Gulf and Atlantic Coasts. More than 28 million of them have absolutely no firsthand experience with a hurricane of any kind.

The decade of the '40s was characterized by major hurricanes over the State of Florida. In the '50s, they affected the east coast. The decade of the '60s and so far in the '70s, we have seen major hurricanes along the Gulf. These trends in statistics are real. We know that there will be a shift again. But there is no predictability of when it will change or for how long.

But when the present "cycle" changes—and it will—are the people psychologically ready to take approrpiate life-saving actions? Are the communities prepared? If history gives us a clue, the answer is probably "no." Most communities get ready only after tragic first-hand experiences.

We estimate than 80 to 90 percent of the nearly 20,000 urban and rural communities in America are basically unprepared to cope with *major*, natural disasters. And yet, we have had tremendously gartifying examples in the past few years where preparedness did pay off. The April 3-4 tornado outbreak of 1974 took an inordinate number of lives. But the loss of life would have been in the thousands if it were not for the remarkable job of warning the public and if it weren't for viable community disaster plans.

Just last year, Hurrican Eloise struck the coastline between Fort Walton Beach and Panama City, Florida with winds exceeding 120 mph and a storm surge of more than 16 feet of sea level. Property loss was estimated at $200 million. An almost total evacuation of residents had taken place in an orderly fashion. Only two people died—both from heart attacks. Preparedness plans and an aware citizenry responded to the very adequate warnings.

Also in 1975, the single most destructive tornado in history roared into the southwest corner of Omaha, Nebraska, at 4:29 p.m. on May 6. City officials estimate that 31,000 people lived or worked in the 2000 block area that caught the full fury of the storm. Only three people lost their lives. Early warnings sounded by Civil Defense sirens and broadcasts by radio and TV were credited with saving hundreds of lives.

The saving of lives reflects improved forecasts and warnings, better communications to disseminate them and better public understanding of the dangers involved.

Every tornado, flash flood, or hurricane incident emphasizes the need for fast and complete dissemination of forecasts and warnings, improved community preparedness planning, and a responsive public.

In the Weather Service, we're making it top priority to develop an ability to deliver warnings of severe weather within a few minutes to all people in danger. We're accenting multiple delivery systems.

One of the most effective methods for getting forecasts and warnings out to the public is NOAA Weather Radio—a growing network of continuously broadcasting weather radio stations. We have more than 100 nationwide. By 1980, the network is expected to total well over 300 stations capable of serving about 90 percent of the U.S. population with alerts to fast-breaking weather events.

When severe weather threatens, forecasters interrupt the routine broadcasts and substitute storm warnings, taped or live. They also activate specially designed "warning alarm" receivers which have been left in a muted but electronically active state. The activating mechanism is a high-pitched tone or pair of tones that sound inside the receiver when the forecaster presses a button. In some receivers, this triggers a siren which alerts the listener to turn up the volume; it others, it automatically brings the receiver up to full volume so that the forecaster's voice is heard, delivering the warning.

Such warning alarm receivers are especially valuable for schools, hospitals, nursing homes, factories and other places where large numbers of people are congregated who are unable to monitor weather broadcasts themselves. They also are the best means for public-safety agencies and news-media offices to get warnings of severe weather from Weather Service offices with the absolute minimum of dealy.

We encourage rebroadcast of the watches and warnings by commercial radio, television, and cable TV.

We are not in competition with the public mass media. In fact, we're absolutely impotent without them. Radio and television will always be the number one way in which to reach the greatest number of people in the shortest period of time. Together with the FCC and DCPA, we're working toward an improved and expanded version of the nationwide Emergency Broadcast System (EBS) designed for dissemination of short-fused natural disaster warnings as well as attack warnings.

We rely heavily on the NOAA Weather Wire Service to deliver hard-copy of our watches, warnings, and other vital weather information directly to news outlets as well as other civil preparedness and law enforcement agencies.

We need to use every available dissemination method and communications means to satisfy the public's need for critical weather information. We use amateur radio networks and other agencies' communications as well as our own.

The Defense Civil Preparedness Agency has provided service on the National Warning System (NAWAS) to about 235 National Weather Service offices across the Nation. This is an invaluable hot-line that permits us to receive and disseminate critical reports in seconds. NAWAS was instrumental in the mass evacuations of tens of thousands as Eloise approached the Gulf states. It has been used effectively in countless tornado and flash flood episodes as well.

We talked earlier about success stories where all the links in the warning chain were strong and hundreds of lives were spared. I asked my staff to get me some verification figures on severe weather watches and warnings. They found that in the first three months of 1976, the average lead time between the beginning of the watch and the actual occurrence of a tornado was a little more than two hours. Twelve of 17 killer tornadoes occurred in valid watch areas; 14 of the 17 were covered by either a tornado or severe thunderstorm warning. The average warning lead time for these 14 tornadoes was 30 minutes. We're proud of that kind of performance. But here's something none of us can be proud of: *More than three-quarters of the fatalities were in the warned areas*.

In the case of hurricanes and river floods, we have the gift of time that we don't have in the deadly, short-fuse tornado or flash flood. Twelve thousand people fled the rampaging Souris River in Minot, North Dkota, in late April of this year. Thepeople in Minot were believers. This was the sixth time that Minot was faced with major flooding since 1969.

We feel it's virtually impossible for a hurricane to hit the U.S. coast unannounced. We have three lines of defense: early detection by weather satellites; probes by reconnaissance planes; and protection from a dense network of high-powered weather radars from Maine to Brownsville, Texas.

We're constantly getting better. We're developing new and better forecast techniques and employing new science and technology to the forecast and warning problem. But, it won't be worth much if we don't improve our ability to quickly deliver the warnings to those threatened by the storms. And if we solve that problem, we're still nowhere if we don't improve public response to those warnings.

There's really no reason for loss of life from tornadoes, hurricanes, and floods if preparedness plans are developed and exercised if people react properly and positively to warnings and advice.

An effective warning system is a series of links. If one link is weak, the chain of effective action is broken.

We must plan and act together—all organizations at every level of government—to strengthen the warning system and insure the correct preparedness posture in the United States.

PREDICTION OF NATURAL DISASTERS: THE EXAMPLE SET BY LAVA EMERGENCIES

Joseph Sperrazza, Dr. Engr. and Benjamin Cummings, Ph.D.

Natural disasters are a source of suddenly developed demands for massive emergency medical services. Because there are so many geographical locations in which these demands may occur, prior warning becomes a vital issue in resource allocation over time and location. Prediction of the exact time, location, and magnitude of any disaster are subjects of some form of research effort for the purpose of prediction and prevention. One example of natural prediction that has a history of success is the prediction of volcanic eruptions. Active research in prediction volcanic eruptions is continuing in the Soviet Union, Japan, the United States and Italy. Particular success in prediction of lava flow eruptions has been demonstrated in Hawaii. The summit eruption of Mauna Loa in July of 1975 and its previous northeast flank eruption in the 1940's were accurately predicted. The capacity to predict this kind of emergency drastically changes the threat to population by making protective measures possible.

The threat spectrum for both victims and EMS teams includes cinder inundation, projectile inundation, high temperature (~1000°C) projectiles and lava, high temperature gases (~500°C), dense poison gas as well as the associated effects of earthquake and, in coastal areas, tidal waves.

A classic example of volcanic disaster was the Martinique eruption in the late nineteenth century where the reported major casualties were in the tens of thousands of people.

Threat characteristics for representative volcano emergencies are discussed, in the context of the prognostication of disasters. Details of past experience are used to show the time and physical environments in which EMS will have to function.

Possibly the worst natural disaster in recorded history was an earthquake in the Shensi Province of China on January 23, 1556. It was reported to have killed 830,000 Chinese. By comparison with this huge loss of life, volcano disasters tend to be modest. The most disastrous volcanic event appears to have been the explosion of the island volcano Santorini in the Aegean Sea. The explosion took place about 1470 B.C. and was probably responsible for the destruction of the Minoan culture on the Isle of Crete 80 miles away. The means of destruction was a Tsunami (tidal wave) 165 feet high. On August 27, 1883 the volcanic island of Krakatoa in the strait of Sundra between Java and Sumatra exploded. The explosion could have been heard over an area of 1½ million square miles. Projectiles were thrown in the air to a height of 34 miles. The Tsunami generated affected areas over 3000 miles away, and in the process wiped out 163 villages killing more than 36,000 people. The energy released was equivalent 1.3 billion tons of TNT. If that energy had been directed at populated areas as efficiently as was the Hiroshima bomb, there would have been 5.8 billion casualties.

This is not an isolated event. On April 5, 1815 Mount Tamboro on the Island of Sumbawa, Indonesia erupted with a pressure of 46.5 million pounds per square inch. It disgorged a volume of 36.4 cubic miles of lava. (The Santorini eruption had yielded only about 15 cubic miles and the Krakatoa eruption only about 4 cubic miles of lava.) Mount Pelee on the island of Martinique in the West Indies produced an incandescent avalanche in 1902 which roared down the mountainside at a speed of 100 miles per hour and in a matter of minutes destroyed the city of St. Pierre and its 30,000 inhabitants.

In case you find these events geographically distant, note that a *single* prehistory lava flow covered an area of 20,000 square miles near the Grand Coulee in Washington. And the Columbia Plateau of the Northwestern United States is covered with 100,000 cubic miles of lava. If you assume that there are few volcanos to affect mankind, then you should know that there are 455 known active volcanos above the ocean and an additional 80 submarine active volcanos. They are spread from 85°10' North (submarine sea Mount Ostenso 346 miles from the north pole) to 77°35' South at Mount Erebus. The most northerly of the volcanos above water is Beeren Berg at 71°05' North. The largest concentration of active volcanos is in Indonesia where there are 77. But within the continental United States Mount Baker in Washington State is active as are numerous volcanos in the Hawaiian Islands.

Types of volcanic eruptions vary widely, depending largely on the viscosity of the lava as it rises to the surface. The first type is known as a lava flood. Typically, these are massive flows covering large areas to a depth of 50 or 100 feet (the flow near Grand Coulee contained 74 cubic miles). The only lava flood of historic times was in Southern Iceland in 1783 when three cubic miles of lava were given forth as a lava flood.

The second type is the typical Hawaiian eruption characterized by low viscousity (no explosions, flat cones) and low volume compared with lava floods (the largest single Hawaiian flow is about one tenth of a cubic mile).

The third type is known as Strombolian (after the island of Stromboli near Italy). These are characterized by explosive eruptions with many volcanic bombs, and ash blanketing the countryside. To Americans the best known example was in 1943 when a cinder cone grew out of a Mexican cornfield. Within five days the cinder cone was 300 feet high. The cinder cone grew to 1200 feet in altitude and the eruption continued for nine years. This is the mechanism that lead to Mount Fuji, Mount Vesuvius and Mount Shasta.

The fourth type is the volcanian eruption in which the crater is torn apart by violent explosions which hurl angular fragments great distances. The volcano typically gives forth a dark and dense cloud of ash-laden gas rising several miles above the cone.

The fifth type is the Peleean eruptions. There is visually an explosive outbreak followed by the formation of a dome over the vent. Subsequently very viscous lava is squeezed up and fractures the dome creating spine-like structures in the central part of the volcano. It is this type of eruption that gives rise to the glowing cloud of dust and gas which was so dramatic in Martinique.

The sixth and most violent eruption type is the Plinian eruption. It is named for Pliny the elder, killed while studying an eruption of Mount Vesuvius in 79 A.D. Tambora and Krakatoa were events of this type. These eruptions typically follow long dormant periods which makes warning unlikely.

The seventh and least recognized type of eruption is volcanic mud flows. Typical volcanic mud flows are caused by rains following a volcanic eruption. The loose material on the cone due to the eruption becomes mixed with rain forming an extremely mobile mud slide which may travel at 50 or 60 miles per hour.

Thus far we have characterized what volcanic eruptions are but not how to identify the threat which leads to a requirement for emergency medical services. Volcanic eruptions produce earthquakes, tsunami, projectiles, poisonous gas, airborne cinder and ash, molten lava (at about 1000°C), incandescent gas/dust slurries, mud slides, spectators and to various extents, warnings. By analogy to known past events and the type of trauma that have been produced we may make up a table of trauma types and eruption types that may be expected. Six types of trauma have been considered (see Table 1): burns, projectile wound, wounds encountered in being knocked about by blast or flood, poison gases, direct blast damage and respiratory damage due to inhalation of fine lava dust.

Burns may occur directly from radiation or contact with molten lava, or as after effects of lava, earthquake of tsunami causing uncontrolled fires.

TABLE 1: Trauma Types and Associated Criteria

TRAUMA TYPE	CRITERION
Burns	
1st Degree	Radiant exposure 2 or more CAL/CM²
2nd Degree	Radiant exposure 4 or more CAL/CM²
3rd Degree	Contact burns or gaseous exposure
Projectile Wounds	
Lacerations	0.1 gram 235 ft/sec
Serious Injury	1.1 gram 430 ft/sec
Fatal Injury	10 grams 355 ft/sec to 10 lbs 20 ft/sec
Body Motion	
Fractures (Bone)	Displace 10-20 ft/sec
Fatal Injuries	Displace more than 20 ft/sec
Poison Gases	Exposure to volcanic gases in isolated low-lying regions where stagnant air occurs
Blast	
Hemorrhage	15 PSI long duration
Organ Rupture	18 PSI long duration
Lung Edeme	20 PSI long duration
Embolic Obstruction	26 PSI long duration
Respiratory Damage	Inhalation of volcanic ash in its finely divided state (~2–20 microns)

Similarly, projectile wounds may be directly due to volcanic bombardment or the product of earthquake, tsunami or fires, etc.

Body motion wounds will be caused directly by blast and earthquake and indirectly by tsunami.

Blast damage will be a direct effect. Generally, blast damage is a function of both pressure level and total impulse applied. But, in the case of long duration loads ($\Delta T > 500$ msec) only pressure is needed to characterize the damage level.

Respiratory damage is known to occur when small particles are inhaled. It is unlikely that particles in the 2 to 20 micron size range will be encountered and will constitute both short term and long term health problems.

We have projected probably trauma occurrences for the seven types and six types of trauma discussed (see Table 2). Projections were based on limited documentation (news articles, reports of eyewitnesses, anthropological data) rather than hospital records. Where no data was present we have tried to make analogies with unnatural disaster — namely warfare. The projections show that in the first four and seventh types of volcanic eruption; warning, planning, stockpiling and preparation for a rapid expansion of local emergency medical services probably has merit. However, in the catastrophes type five and six eruptions, only evacuation upon warning is a rational policy.

We have been dealing in abstractions. Let us go to a real case: the city of Hilo, Hawaii. This city and harbor are currently valued at almost two billion dollars. We believe that this city is currently facing a major volcano emergency. This is the prediction of volcanologists of the U.S. Geological Survey.

The U.S. Geological Survey maintains an Hawaiian Volcano Observatory. They measure and monitor the activity of Hawaiian volcanos in terms of bulging and tilting of the volcano surface, earthquakes (down to the smallest measurable) both in magnitude and location and venting of gas and lava. Time histories of these parameters give geologist and volcanologists the capacity to predict time frame and location of expected eruptions. What they cannot predict is magnitude of lava flow, earthquake or tsunami that will accompany the eruption. At this time the Hawaiian Volcano Muana Loa has been predicted to erupt from its northeast flank in the near future (within the next 24 months). Previous predictions for the same volcano have been accurate both as to time and location.

Most Hawaiian eruptions are viewed by local citizens as religious events and are treated almost like a spectator sport. People get out their cameras and go to the eruption in great masses, and most of the time this is a safe practice. But eruptions in the northeast flank of Muana Loa spill their lava toward the city and harbor of Hilo with its thirty to forty thousand residents. The distance from the predicted vent to Hilo is about 40 kilometers. At typical lava flow rates, that gives a comfortable period of days before the lava flow can reach Hilo. But since the entire island was formed by lava flow, the existence of Hilo is proof of the capacity of lava to reach that area.

Historical times have recorded several near miss threats to Hilo: In 1852 a flow of 140,000,000 cubic yards; in 1855 a flow of 150,000,000 cubic yards; in 1881 a flow of 300,000,000 cubic yards; and again in 1942 a flow of 100,000,000 cubic yards almost reached the city of Hilo.

The source of these flows throw up a cinder cone of a hundred or more feet in height. The fountain may in some cases shoot one or two hundred meters into the air in forming the spatter cone. The side of the cone will cave in at some time and

TABLE 2: Trauma Types as a Function of Volcanic Eruption Type

TRAUMA TYPE	ERUPTION TYPE I	II	III	IV	V	VI	VII
Burns							
1st Degree	F	F	F	F	VF	VF	S
2nd Degree	S	F	F	F	VF	VF	S
3rd Degree	S	S	S	F	VF	VF	S
Projectile Wounds							
Lacerations	-	S	F	VF	VF	VF	S
Serious Injury	-	S	S	VF	F	VF	S
Fatal Injury	-	-	S	F	F	VF	S
Body Motion							
Fractures (Bone)	-	S	S	S	S	VF	S
Fatal Injuries	-	S	S	S	S	VF	S
Poison Gases	F	F	F	S	S	-	-
Blast							
Hemorrhage	-	S	S	F	VF	VF	S
Organ Rupture	-	S	S	S	VF	VF	S
Lung Edema	-	S	S	S	F	F	S
Embolic Obstruction	-	S	S	S	F	F	S
Respiratory Damage	-	S	F	F	F	F	VF
		Hawaiian			Glowing Cloud	Krakatoa	

CODE:
S = Seldom
F = Frequent
VF = Very Frequent

the lava lake will be free to start its trip down toward Hilo. The flow will probably form an enclosed tube and flow most of the way to Hilo in a self-generated, perfectly isolated underground tube, emerging again only near the end of its travel.

One of the reasons that the lava flows of hundreds of millions of cubic yards fail to reach Hilo is because the tubes have structural failures.

One way of avoiding the need for emergency medical services in the predicted eruption of Muana Loa would be to bomb the lava tubes and block the flow. This may not work. Another means of avoiding the medical emergency might be to build barriers to control the flow. But if these measures are not effective, then some of you had better be ready to provide emergency medical services in Hilo, Hawaii.

THE DEVELOPMENT AND URBANIZATION OF AN EMERGENCY MEDICAL CARE SYSTEM AND ITS APPLICATION TO NATURAL DISASTER

Marvin A. Wayne, M.D.

Bellingham and Whatcom County, located in the far northwest corner of the continental U.S. truely represents the land from sea to ski. The city and county comprise an area of 2,500 square miles with Bellingham Bay and the San Juan Islands to the west, the Cascade Mountains, including 10,700 ft. Mt. Baker to the east, the international border with Canada to the north, and Skagit County to the south. The 100,000+ population is located primarily in Bellingham (45,000) and along the Interstate 5 corridor running north to the Canadian border. This unique geographic location makes it a very desirable locale for tourish influx from the more densely populated areas of Vancouver B.C. to the north and Seattle to the south. This influx occurs the year round but peaks with a two-fold population increase during the summer months. The region is also a popular retirement area with a disproprotionate number of older residents.

Commerce is primarily agricultural, logging, fishing and a few industrial corporations such as Georgia-Pacific, Intalco Aluminum, and Atlantic Richfield and Mobile Oil Refineries.

Climate, a very important factor, shows a large annual rainfall at the lower elevations and heavy snows in the mountains. These climatic conditions, combined with the low lying Nooksack River Basin make flooding, an infrequent, yet potentially serious threat, during heavy river run-off periods.

Because of these unusual geographic, environmental and population factors, the development of a comprehensive Emergency Medical Services System presents a significant challenge. Integrating this system to function on a daily basis, as well as in disaster situations becomes seemingly impossible.

But, the achievement of these goals has occurred through both an evolutionary and revolutionary process. The story of this evolution and revolution may give needed insight to help other regions accomplish seemingly impossible tasks.

Four years ago medical care in Whatcom County consisted of two hospitals, one of a religious order, the other a community hospital. A full-time, physician staffed emergency department had recently been organized at the community hospital and was just beginning to be accepted by the public and the medical community. Prehospital care consisted of one private ambulance company using substandard equipment and inadequately trained personnel. Only a handful of the counties 19 volunteer fire districts had attempted to integrate and coordinate services and few had adequately trained personnel to deliver emergency medical care. The sheriffs department and state police were only beginning to see the need for proper first aid training and neither local government not the average citizen had shown interest in improving the situation.

A revolution was about to occur with the organization of a country-wide, open, Emergency Medical Services Council. This council made up of concerned individuals from both medical care providers and consumers provided a forum where goals could be set and action taken to implement these goals. Motivation was generated among some of the providers of emergency services to upgrade their skill level. To accomplish this a community Emergency Medical Technicians program was established through the community college. Early attendants in the EMT program included members of the Bellingham and County Fire Departments, Sheriffs Department, State Police and interested citizens. From its humble beginning, the program has graduated over 350 certified EMTs, and recertified many of the original graduates. Today all members of the state police, most members of the sheriff's department, Bellingham and Whatcom County Fire Departments and local safety engineers are EMT certified.

Next the council sought to establish an enlightened public. Through a public information program, demand began to be heard to upgrade, by legislative action, the ambulance service. By passing an ambulance regulatory ordinance, the city and county caused an inadequate private ambulance firm to cease to exist. Following the demise of the private firm, city and county ambulance care was assumed by EMT trained members of the Bellingham Fire Department. From early borrowed vehicles, the service has grown and now uses the most modern fully equipped modular vehicles. However, limited resources required ingenuity to provide the most efficient and rapid service throughout the city and county. To accomplish this efficiently, and maximize limited resources, a tiered call system was achieved. County calls are jointly responded to by the Bellingham Fire Department and volunteer units in the county. City calls are responded to by the closest engine company as well as by the ambulance units. By using this method, medical response times average four minutes in the city and eight minutes in 60 percent of the populated county.

It soon became evident that higher skill level of prehospital emergency medical care was not only needed but could be supported by our city and county. People were suffering death and disability here that had been alleviated elsewhere by using paramedics. Therefore a full scale 1500 hour paramedic program was initiated. All but the internship phase was taught locally and now nine paramedics are on duty with the Bellingham Fire Department and eight more are in training. Along with the increased skills, the most advanced equipment such as cardiac monitor defibrillators, MAST suits, and training aids were obtained through donations by local industrial firms such Intalco Aluminum and Georgia-Pacific Corporation and service organizations such as Lions and Rotary Clubs. By using these sources of funding not only was adequate equipment obtainable but the community became more involved with the program. Of course, basic funding for the entire system came from city, county, and federal revenue.

The logarithmic progression of events has continued with the employment of a physician director of Emergency Medical Services to not only direct the paramedic program but to upgrade and integrate all aspects of emergency medical care delivery. Within this responsibility, goals such as central dispatch for all emergency services, organization of uncommitted EMTs as disaster aids, and continuing education programs have been or are being implemented. One unique idea within this system is using EMT disaster aids to respond along with our disaster triage vehicle to treat simple "band-aid" type injuries in the field to prevent overloading the medical care system.

What of the average citizen? Though we try to provide skill training through EMT and American Red Cross first aid courses only small numbers are reached. The need for a full community cardiopulmonary resuscitation program was evident. Using federal funding along with local corporate donations, a community CPR program has been established with a goal of training 20 percent or more of the citizens between the ages of 12 and 60 in this basic life support technique. Although the program only recently began, public response has been excellent and early dividends in lives saved has already occurred.

With the development of the comprehensive Emergency Medical Services Program outlined, the real test of its effectiveness would require application in time of disaster.

Last fall heavy rains and rising temperatures resulted in excess water runoff with the subsequent flooding of large areas of the Nooksack River Basin. Rural homes, farmland, animals and recreational subdivisions were hardest hit. Our system was activated with central organizing from the Civil Defense Emergency Operating Center. Although significant flooding lasted several weeks, through the coordinated and combined efforts of the sheriffs department, Mountain Rescue, the Army Corps of Engineers, the American Red Cross and our Emergency Medical Services System, not one human life was lost. This system proved itself capable of handling a natural disaster.

With 10,700 foot Mt. Baker, one of the only remaining active volcanos in the continental U.S., located in our county we may again have to prove the efficiency of our system. Mt. Baker has shown increased steam venting over the past one to one and a half years and potential eruption is a possibility. If eruption occurs no populated area will fall directly in its path but slow flowing lava striking Baker Lake will flood much of the surrounding land. Early warning will come via scientific instruments on the mountain and via a C.B. and ham radio emergency network established in our county. With warning of an eruption mobilization will take place and again we hope to prove the systems efficiency and effectiveness.

What has happened in our county thus far only represents the birth of a system. Constant growth and updating will be required if we are to meet future challenges, whatever they may be. We are not unique to have this system, but it does require perseverance, public desire and silling leaders if such a system is going to be developed. Although I give the impression our system developed without opposition, obviously this was not the case. Many individuals were opposed to both the financial outlay and a public run ambulance system. Each effort of opposition was met with an open factual appraisal pf what this program could achieve. Further, my answer to individuals who fought our system and would deny the ability to develop a similar one elsewhere is to place yourself on the receiving end of the care structure, for if I may misquote 'Pogo' "We have met the so called other guy and he may very well be us."

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Whatcom County - State of Washington Emergency Services Disaster Plan.

V I P MEDICAL COVERAGE

John W. Otten, M.D.

We want to make it very clear that in no way should our remarks be interpreted as implying that our plan was officially accepted by the White House staff as an ideal method of providing the President with the optimum, temporary medical coverage.

The plan we suggested to the members of the White House staff, incorporated various functioning components of the State of Illinois Emergency Medical Services System.

These components were: 1) A sophisticated communication system, 2) A mobile Intensive Care Unit and, 3) State of Illinois Department of Transportation helicopters.

The utilization and deployment of these components were under the complete control of the staff providing security for the President. Initially, we met with a member of the advance party of the Presidential staff. We familiarized these people with our systems approach to the critically injured.

St. Francis Hospital of Peoria is a regional trauma center, serving 17 counties. These 17 counties are interconnected by a sophisticated communication system utilizing both radio and telephone.

The second component utilized was the Overland Critical Care Van. This is an intensive care unit on wheels whose primary function is the transportation of patients from one hospital to another. We modified this vehicle and converted it into a mobile emergency room by simply èxchanging some of the equipment on board. This unit was of particular interest to members of the Presidential party.

The third component was the State of Illinois Department of Transportation (Jet Ranger) helicopter. These also are equipped with a radio system which permits communication between the various components of the Emergency Medical Service system, as well as the Illinois State Police. The Department of Transportation helicopter pilots are completely familiar with the Emergency Medical Service System of the State of Illinois, in which they have participated for 5 years.

In the event of a catastrophic incident, experienced pilots, totally familiar with the area, personnel involved, and the communication system, are essential to an efficient, effective operation.

Two Bell Jet Rangers were available and three pilots were assigned to the Peoria area. One of the pilots was assigned to the Communication Center at St. Francis Hospital, to assist in the communications, should the need arise.

The following organizational plan utilizing these components was implemented in Peoria: One Department of Transportation helicopter was on standby at the heliport of St. Francis Hospital. The second helicopter was airborne, whenever requested by the White House staff.

Prior to Air Force I landing at the Peoria airport, the helicopter was in the air. In addition to the pilot, a member of the Secret Service staff, equipped with a radio on their frequency was on board. An Illinois State trooper and a Peoria police officer were also on board with the appropriate radio equipment.

Prior to the landing of Air Force I at the peoria airport, the helicopter flew over the approach route to the Peoria airport, which the President's plane was scheduled to take. After the President deplaned from Air Force I, the helicopter checked the ground route to be taken by the Presidential caravan. This route was from the Peoria airport to the Dirksen Memorial Library in Pekin, Illinois. Upon the arrival of the limousine at the library, the aircraft landed in a pre-selected spot, away from the scene of activities, but was in constant radio communication. Immediately prior to the President's departure, the helicopter was again airborne and surveyed the caravan route from Pekin, Illinois to Peoria, Illinois, a distance of approximately 12 miles. Once Mr. Ford was inside his hotel, the helicopter landed at the St. Francis heliport, and again remained in radio contact with all agencies. When the President departed from the downtown hotel to Air Force I, the helicopter again checked the ground route.

The Overland Critical Care Van, equipped as a mobile intensive care unit, was in position in Pekin, Illinois, by the time Air Force I touched down. The van was inspected by the Secret Service and security clearance was again given to the medical personnel. A member of the Presidential staff, equipped with a radio, was assigned to the Critical Care Van. The medical personnel were briefed as to their role, should an emergency arise.

In the event of an emergency, security would be of the utmost importance. The van would be under the command of the Presidential medical staff and the regularly assigned driver would be replaced by a Secret Service driver. The medical personnel on board would assist the President's medical staff, in whatever way they requested. Primary and secondary hospitals were designated for treatment.

During the address by the President, frequent radio checks were made between all units, as well as minute-to-minute instructions to various units involved. When Mr. Ford returned to the limousine, the Overland Critical Care Van was assigned a position toward the end of the Presidential caravan. Upon arrival at the hotel, the van was positioned in an appropriate location, previously selected by the Presidential security and medical staff.

Upon the limousine's departure from the downtown hotel, the Overland Critical Care Van and the medical personnel were released. An ambulance, however, was stationed at midpoint between the hotel and the airport.

During this entire time period, the Communication Center monitored all frequencies, except that of the Secret Service. A direct telephone line, however, had been installed in the Communication Center to the Secret Service switchboard temporarily located in Peoria.

Immediately prior to the President's arrival in the area, a radio request was made to all units to limit the radio traffic to essential transmissions only. Trained radio operators, totally familiar with medical radio transmissions, were on duty at all times, as well as the Department of Transportation helicopter pilot assigned to the Communication Center. Fortunately, none of these precautionary steps were called upon.

Again, we would like to emphasize that this entire operation was planned and carried out by the White House staff. The components of the Emergency Medical Service System of the State of Illinois, and the medical personnel served in a standby capacity, should they be needed. It is interesting, however, to observe how a pre-existing sophisticated systems approach to the care of the critically ill and injured, could be interfaced with the unique systems approach necessary for the protection of the President of the United States.

Evaluation of EMS Systems

EMS EVALUATION: CRITERIA FOR STANDARDS AND RESEARCH DESIGNS

Geoffrey Gibson, Ph.D

Introduction

Since Webster's defines "evaluation" as meaning "to judge or determine the worth or quality of something," EMS evaluation may be specified as "the objective determination of the value or effectiveness (usually including costs, accessibility and quality) of emergency medical services by comparing what is observed to a predetermined set of standards." There are two aspects of note about this definition. First, evaluation involves more than mere observation or description of *what is* interspersed with arbitrary and unsystematic editorial comments. In brief, evaluation is description plus standards. Second, the definition emphasizes the importance of standards or evaluative criteria.

This approach is somewhat in contrast to the definition of and requirements for EMS evaluation as indicated in DHEW's Program Guidelines for the Emergency Medical Services Systems Act of 1973 (P.L. 93-154) which state that:

> Each EMS system must provide for periodic, comprehensive, and independent review and evaluation of the extent and quality of an emergency health care services provided in the system.s service area. . . Each grant recipient. . . is required to submit as part of the final performance report, an independent review and evaluation of the regional EMS system. It is intended that such review and evaluation be periodic and comprehensive so that changes in emergency health care can be determined.

The DHEW' term "independent review and evaluation" means that an agency or person other than the grantee will submit an evaluation report on the basis of reviewing material (collected either by the EMS system or its independent evaluator) which consists at least of the following:

A description of the EMS resources, capability and performance measures at the start of the period being evaluated.

A description of the interventions brought about during the period to include clinical and EMS component elements.

A description of the EMS resources, capability and performance measures at the end of the period being evaluated.

The description of the achievements of performance measures of the EMS system referred to above. There should be at a minimum an analysis of 14 days performance throughout the year. The 14 days should be a modified random sample chosen so that there is at least one day for each month and two replication of each day of the week. Total numbers of calls for ambulance service and of emergency department patient visits should also be reported.

The report should include a description of the system's resources, capability and performance and also analytical tables to reflect inventory changes, component activity and patient care services.

Clinical output or impact evaluations of death and disability should include those clinical patient groups that have been specifically addressed in the operations application and include samples of the major categories. General patient population studies as well as specific patient groups analysis will have local and national relevance.

There are several interesting characteristics of this DHEW requirement that separate it from the normal meaning given to the term "evaluation." Clearly, the major focus in the passage is on description and the associated assumption that one can evaluate merely by describing the state of affairs at different points in time. In general, this is an incorrect belief since description (even at several points in time) can only produce statements about change and not normative statements about improvements or effectiveness. For an observed change to be regarded normatively as an improvement or a worsening requires the application of a norm, that is, a standard. The only implied standards contained in the passage already quoted are that interventions are better than no intervention, that increasing resources are better than stable resources (*i.e.*, that four ambulances are better than one ambulance, etc.), and in general doing something is better than doing nothing. While these normative standards may be programmatically appealing to a government agency monitoring compliance with its own requirements, they do not per se constitute EMS evaluation nor even useful management data for EMS system s to assess the effectiveness or improvement of observed program changes.

EMS evaluative norms, as with all program standards, may refer to input, process or outcome criteria. Input standards refer to the presence within the EMS system of certain resources specified by expert groups as necessary. Ambulances should have 54 inches head room, and EMS system should have a burn center, there should be a 911 single access number, etc. Input standards are readily available, precisely defined, and easily and cheaply measureable. They have, by reason of long rather than valid usage, achieved wide currency and a certain credibility. They have certain disadvantages. Many of them were generated by an arbitrary process with no documentation as to the degree of agreement among the experts establishing the standard, nor documentation as to the relationship between compliance with the resource standard and improved patient outcome. They are probably not conceptually or methodologically valid indicators of an effective or even a good EMS system. The process whereby most input measures have been generated are no less arbitrary because of the eminent personages and organizations bestowing their imprimatur on them. It is all the more regretable that many of these resource standards have been subsequently reified and set in concrete and not subject to critical scholarly scrutiny. Many input standards are incorporated within and therefore mandated by federal and state laws as well as local ordinances. Input standards assume (with little or no testing of the assumption) that if a resource item is available it will be utilized, and if utilized it will improve the patient's clinical course. In addition, if an EMS system is evaluated by means of input criteria, inevitably improvements will be defined tautologically as the acquisition of additional resources while the appealing and less costly possibility that improvements can result from better useage of existing resources will remain unexamined.

Process standards refer to the utilization of resources and the appropriateness of that utilization. Thus, emergency departments are characterized by patient waiting time, ambulance systems by response time, and entire EMS systems by, for instance, the proportion of patients in need of a resource who actually received it. Process standards are quite expensive and time consuming to collect since they require data not just on the existence of a resource but patient utilization of it. Particular attention is required by the sampling/representativeness issues raised in selecting sample time periods for study. While process standards are programatically specific in their focus in particular aspects of the EMS system in contrast to certain outcome measures that are aggregate indicators of the entire system, they make an often untested assumption that compliance with a process measure is highly correlated with an improved clinical course. Similarly, process standards are based on the conception of appropriate utilization, a construct which is exceedingly hard to operationalize and about which to secure consensual acceptance. Why is 10 minutes seen as an appropriate ambulance response time in urban areas? Why not 15 minutes? or five minutes? What is the evidentiary basis for believing that trauma patients should go to trauma centers: or that a centrally dispatched ambulance system produces better outcome than a multiple-dispatch situation? As with input standards, process criteria suffer from a lack of clinical specificity. The proper configuration of resources varies in part by the type of clinical emergency as does the appropriateness of utilization. Yet available input and process standards are, for the most part, not condition-specific. Thus, the importance of a surgeon as a resource in an emergency department or the acceptability of a 10 minutes ambulance response varies greatly according to whether it is the clinical needs of an exsanguinating trauma patient or of a burns patient that are being considered. They do have major advantages: they allow for local as well as federal determination of standards and they are somewhat more useful than either input or outcome standards for identifying in programmatically constructive ways what is wrong and what needs to be changed.

Outcome standards refer to a change in the health care status of a patient or population that is attributable to a change in the EMS system. It is important to note outcome evaluation is more than merely measuring health status at some point subsequent to the patient's encounter with the EMS system. Instead, it is being able to attribute a known and measurable change in outcome to the independent effect of the variable quality of EMS by controlling for ane excluding all other influences on outcome. This, of course, calls for an ability (not presently available for all diagnostic groups) to measure independently and partial out all exogenous factors impacting on outcome. These factors include environmental variables (speed limits, automotive and highway safety design, etc.) patient characteristics (age, comorbidity, prior health status, etc.) and most importantly the severity of the patients illness or injury. While outcome measures are, of course, ultimately the most importwnt test of effectiveness, there are grave difficulties associated with their use. They are expensive to collect and hazardous to interpret. Non-fatal outcomes are not easily conceptualized and even less easily operationalized and measured, while fatal outcomes are often insensitive to program changes. There is the added conceptual problem that, since the EMS system is not so much a single input-process-outcome sequence but rather a sequential set of such patterns where the outcome of one EMS subsystem (ambulance) is the input to another (emergency department), it is difficult to think of the entire system as having a single outcome that is attributable to the overarching system. Because of this, outcome evaluation runs the danger of not being able to specify causality with any precision in the sense of identifying the particular subsystem interaction responsible for the outcome. As a result, outcome evaluation may be programmatically confusing and even destructive and abrasive in its consequences.

Minimal Characteristics for EMS Evaluative Standards

Given the importance of evaluative standards against which we measure our descriptive observations of emergency medical services, it is clear that the standards to be used should meet certain minimal characteristics and equally clear that present EMS evaluative practices do not meet all or even most of these characteristics, as suggested in this paper. First, the standard should be precisely defined and therefore measurable. It is insufficient to say, as the DHEW program guidelines do, that a hospital emergency department or a critical care unit should have an "adequate number of appropriate persinnel" without defining the terms "adequate" or "appropriate." On the other hand, the DHEW specifications that an adequate response time for an ambulance system is one in which "95 percent of cases are responded to within 10 minutes in urban areas and 30 minutes in rural areas" is precise and measurable. Nebulous standards are not only problematic methodologically but can lead to programmatically destructive reactions. Second, the standards should represent an expert consensus, systematically arrived at, on a preferred or "ideal" state of affairs. Thus, the program evaluator should avoid imposing his or her own standard upon an evaluative design or even a standard arbitrarily arrived at or plucked out of the extant literature unless it has been generated by an appropriate set of experts by means of a process which indicate a high degree of agreement between the experts on that standard. Ex cathedra pronouncements by single individuals, however eminent, should not be regarded as acceptable standards until there has been consentual validation. The definition and representativeness of the standard-generating experts is also noteworthy as is the documentation of reliability (or repeatability) of the experts in agreeing to that standard.

Third, the evaluative standard should refer to compliance with a variable that has been shown to have a direct and close relationship to beneficial patient health outcome. Unfortunately, several norms presently used as standards do not meet this characteristic. Minimal equipment lists for emergency departments and ambulances, recommended design characteristics of ambulance vehicles, and even specialized regional and/or critical care facilities continue to lack adequate documentation of their relationship to health status outcomes, however superficially attractive they may seem in terms of their precision, measurability, and presumptive correlation with outcome. Fourth, the standard should be programmatically relevant and responsive so that a finding that an EMS system does not comply with it is useable and constructive data on which program changes can be made. Fifth, the standards should be sufficient in number and diverse in range that they constitute a comprehensive and representative evaluation of the EMS system under review. Many evaluative standards suffer from the same deficiency that EMS tracer studies do: that is, the assumption that what is true for one standard or tracer is true of all by extension rather than by actual measurement. Sixth, the standards need also to be such that they can be used diagnostically as well as evaluatively. That is, the standards should be useable for needs assessment to tell an EMS system (prior to program intervention) what needs to be done and to serve as a baseline set of measures as well as being used subsequently and evaluatively to determine what changes have resulted from which program intervention.

Seventh, evaluative standards for EMS should also be locally credible, acceptable and responsive in the sense that they represent criteria local providers, administrators, planners, consumers, and elected officials are willing to accept as a credible test of their system's effectiveness. This also implies that criteria cannot entirely be federal or national in their origin and that the standards must be developed in conjunction with local providers and not imposed by the evaluator in isolation. It is very important that the evaluator see his/her role as a facilitator to enable a community to see whether its expectations are being met and not as a program expert applying his/her own standards.

Eight, and finally with regard to standards, EMS criteria should be as concerned with the appropriateness of system non-use as with that of system use. Thus, while there has been concern with characterizing emergency department and ambulance utilization as clinically justified or not, there has been scant attention to unmet need and its life threatening consequences.

Minimal Characteristics for EMS Evaluative Research Designs

Clearly, the standards must be applied to what is observed in such a way that they result in precise statements about what resulted from what type of system intervention. Though this sounds simple it is in fact an enormously complex requirement and calls for research designs with at least before and after measures and control vs. experimental group comparisons. Research design is an area in which EMS evaluation is particularly weak and there is an unwarranted reliance on statistical manipulation to adjust after the fact for design deficiencies. Problems at present include measurement only after intervention and therefore a lack of pre- and post-states, and the absence of any control groups which are similar in every respect to the EMS system under study except that it lacks the intervention in question. As a result it is quite likely that EMS evaluation to date has seriously overestimated the impact of EMS intervention. This happens because EMS improvements result from several factors in addition to EMS system intervention (lowered speed limits, increasing citizen sophistication, national EMS publicity, etc.) and without a comparison between an experimental group (with system intervention) and a control group (without intervention) it is quite impossible to determine what part (if any) of the observed changes are attributable to EMS intervention. A further deficiency in EMS evaluation research design is that we are to date mainly examining total package effect rather than the disaggregated efffects of single discrete EMS interventions. Thus, we know more about the net impact of $3 million being invested over three years in up to 20 overlapping interventions than we do about $50,000 invested in a single intervention. In a time of finite resources with a shift from federal largesse to local scrutiny, as well as for the sake of program feedback, what we need to know and what is elusive at present is not what $3 million and 20 interventions brings but rather whether $50,000 spent on public education will reduce treatment delays from onset to treatment more than will $50,000 spent on ambulance radios.

There are similar design flaws of note. EMS evaluation design often attaches little importance to population-based statements of change and instead prefer to deal with user-based measures. An important requirement of EMS evaluation is that it prove or disprove effectiveness on the basis of such population-based changes as mortality or morbidity rates for the entire population being served and not just the system users. A similar deficiency is shared by several patient registry data systems or rather the use to which they are put. Because trauma, or neonatal, or burns patient registries only document those patients seen within trauma centers, neonatal centers, or burns centers, they do not constitute an acceptable basis for statements about the effectiveness of such centers, because, of course, they lack a proper control group and inclusive case coverage.

In summary, research designs for EMS evaluation should meet the following characteristics. First, there should be pre- and post-intervention measurement and comparison. Second, a control group should be selected for comparison with the experimental group under study. Third, the designs should allow statements about the relative effectiveness of single interventions rather than overall total package effects. Fourth, population based statements about changes resulting from EMS intervention should be provided. Fifth, research designs should control for exogenous influences on the impact measures so that rigorous statements can be made about the association between EMS changes and improved health outcomes.

In conclusion, the case, of course, can be made that none of these minimal characteristics for EMS standards or research design are either practical or desirable and that the public and government are quire appropriately willing to accept the effectiveness of EMS on faith and without further proof. This may well be the situation at present and without doubt the relative ease of the legislative passage of the EMSS Act of 1973 and the continuing legislation of 1976 suggests that it is. Ironically, such a point of view argues not so much for less evaluation and of a lower rigor as for no evaluation at all. Evaluation is, of course, important enough as an exercise in scholarship and accountability to be either worth doing well or not doing at all.

THE EPIDEMIOLOGY OF THE ILLINOIS TRAUMA SYSTEM PATIENT

Lynne C. Sheaff, M.P.H. and David R. Boyd, M.D.C.M.

Introduction

One of the major problems in providing improved care for the injured patient is the lack of a well-defined system of care for the critically injured. Patients are ordinarily taken to the nearest hospital, not necessarily the one best equipped and staffed to treat them. Many of these patients are later transferred to more appropriate facilities with considerable discomfort, disability and even death resulting from these unnecessary movements. A major barrier to improving trauma care is the lack of cumulative knowledge and experience in the complex management of severely injured trauma patients. The general inadequacy of the present medical record system further compounds this problem.

In response to this obvious deficiency and at the suggestion of the National Research Council, a computerized Trauma Registry has been developed at the trauma unit of the Cook County Hospital, the Department of Surgery of the Abraham Lincoln School of Medicine, the Research Resources Center of the University of Illinois at the Medical Center, and the Illinois Department of Public Health.

The Trauma Registry has been developed to serve the following objectives:

To provide clinical summaries of diagnostic and therapeutic methods,

2) To establish a data source for developing at-risk factors for accidental events,

3) To define the variables on which patient morbidity and mortality depend,

4) To determine logistical and manpower requirements for a given community's trauma needs, and

5) To provide continuous monitoring of project planning for the care of the critically injured.

This report presents a summary of the 26,271 cases admitted to the Illinois Trauma System between July 1, 1971 and June 30, 1973.

Epidemiologic Characteristics

WHO

More often than not, the Illinois Trauma System patient was a Caucasian male resident of Illinois in his teens or twenties. Of the patients treated by the Illinois Trauma System 97 percent were Illinois residents.

The majority of the Trauma System patients in all regions were males (Table I). Metropolitan Chicago had the highest proportion of male patients (71 percent) and the region around Springfield had the lowest (55 percent). Statewide, 62 percent of the Trauma System patients were male. This, compared with the 1970 census (49 percent males in Illinois), indicates a substantially higher proportion of male Trauma System patients than would be expected if the sexes were equally prone to entry into the Trauma System.

The age distribution of the Trauma System patients differs significantly from the 1970 age distribution of the population. Age groups 20-29 and 70+ are over-represented among trauma patients (Figure I).

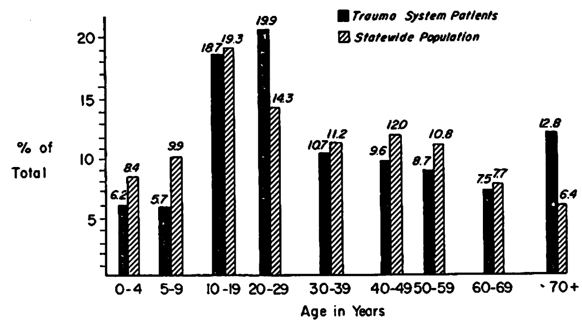
WHERE

The home was the most common location of injury in all regions. Streets were the second most common place of injury in three regions; highways were the second most common place of injury in four regions.

HOW

Table II depicts the four major mechanisms of injury: vehi-

Figure I. Age Distribution Comparison: Trauma System Patients and Statewide Population*



*Based on 1970 Census of Population

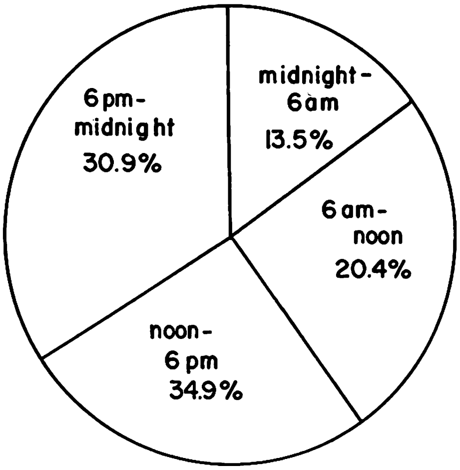
TABLE I TRAUMA SYSTEM PATIENTS: SEX DISTRIBUTION

	N	%
MALE	16,309	62
FEMALE	9,962	38
TOTAL	26,271	100

TABLE II TRAUMA SYSTEM PATIENTS: SELECTED MECHANISMS OF INJURY

	N	%
VEHICULAR		
AUTO DRIVER	3,338	42
AUTO PASSENGER	2,411	30
INDUSTRIAL/FARM		
INDUSTRIAL	1,862	85
FARM	334	15
HOME/RECREATION		
HOME FALLS	6,589	57
RECREATION FALLS	2,117	18
VIOLENCE		
ASSAULT	1,551	36
GUNSHOT	1,259	29

Figure II Admission Time



cular, industrial and farm, home and recreational, and violence. Within each major group, the two most common subgroups are presented. In considering vehicular trauma alone, 42 percent of the 3,338 patients were automobile drivers and 30 percent were automobile passengers. Eighty-five percent of the industrial/farm patients were injured in an industrial accident; 15 percent were involved in a farm accident. Among home/recreation accidents, falls predominated (57 percent at home, 18 percent during recreation of play). Assault with fists or instrument was the most frequent violent mechanism of injury, with gunshot wounds the next in order.

WHEN

The distribution of admission time for the total Trauma System is depcited in Figure II. The plurality of admissions occurred between noon and 6 p.m. This distribution is representative of the pattern followed in all regions except metropolitan Chicago. There, the plurality of admissions occurred between 6 p.m. and midnight. The difference in the midnight to 6 p.m. period is most striking, accounting for 20 percent of the admissions in metropolitan Chicago and only 10 percent of the admissions in other regions.

Males were particularly prominent as trauma victims due to industrial/farm and violent accidents. Man and women were involved in home/recreational accidents in proportion to their population (Figure III).

There is considerable difference in age distribution of trauma

Figure III Mechanism of Injury by Sex

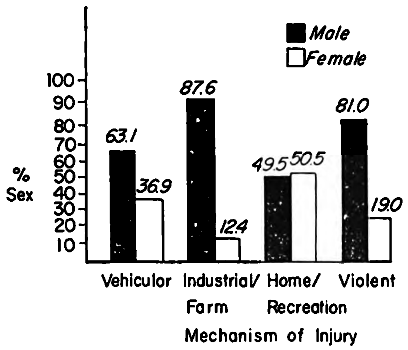
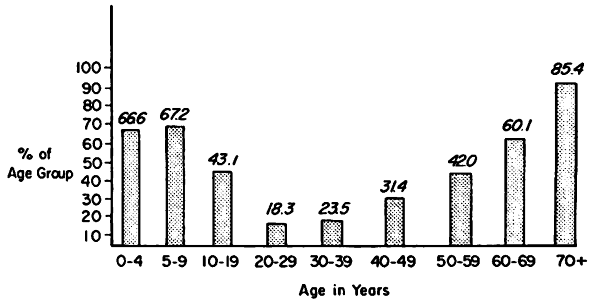


Figure IV Home/Recreational Injuries by Age Groups



patients by mechanism of injury. Almost half (49 percent) of those involved in vehicular accidents were between 10 and 29 years of age. Industrial/farm accidents were a more important factor in the age groups 20-59, the working years. Home/recreational accidents (Figure IV) involved a larger proportion of persons under 4 and over 70 years of age than would be expected by chance. Injuries due to violence were more often seen in persons in their twenties and thirties; the pre-teen ages and, to a lesser extent, ages 50 and over were less often injured from violence.

System Performance

Direct admission to a Trauma Center predominated in all regions. Transfers from other hospitals accounted for 21 percent of the trauma patients in metropolitan Chicago and for 5-6 percent of the patients in all other regions. Patient transfer becomes more common as the level of the Trauma Center goes from Local to Areawide to Regional. The proportion of patients who enter the Trauma Center by transfer is 2.4, 4.2 and 18.6 percent, respectively, for Local, Areawide and Regional Trauma Centers (Figure V).

Private cars (43 percent) and ambulances (33 percent) are the most frequent modes of initial transit throughout most of the state. Police transit remains an important mode in metropolitan Chicago, accounting for 25 percent of the initial modes of transit in that region.

Overall, 63 percent of the Trauma System patients were transported 10 miles or less to the first hospital. This number varied from 39 percent to 70 percent. Less than one percent of the trauma patients were transported more than 40 miles for initial care.

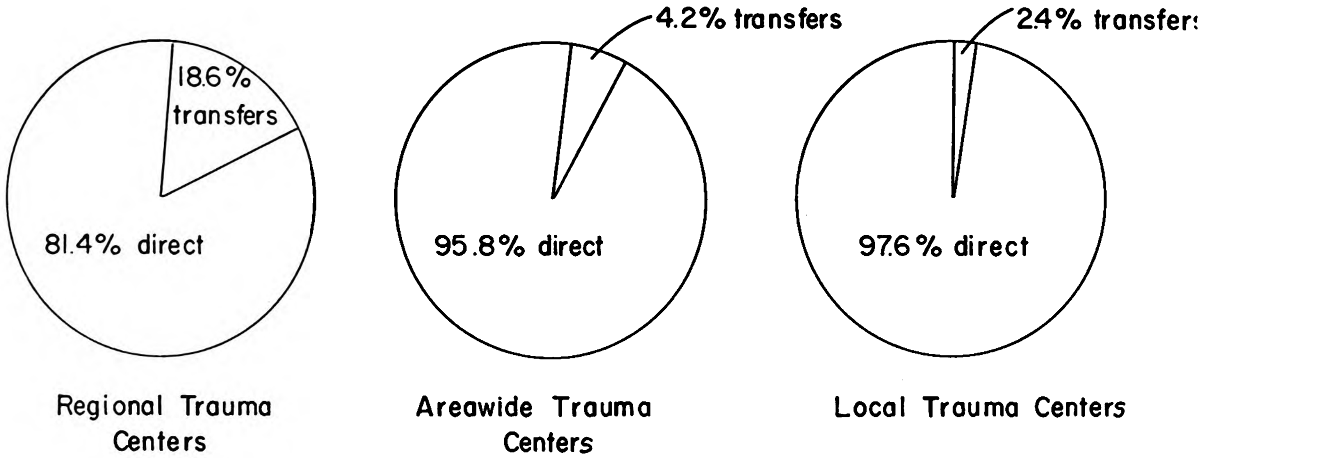
The median time from injury to initial care was 31 minutes (for patients for whom this value was known). It varied from 26 to 46 minutes. Ninety-eight percent of the distances in the two highly urban areas (St. Louis and Chicago) were 20 miles or less, and the median time to initial care was between 32 and 35 minutes; in comparison, 88 percent of the distances in Region 5 (a highly rural area) were within 20 miles and the median time was 28 minutes. This shorter median time from injury to initial care in this rural area is not explained by this study. The following possible explanations may be postulated:

1) Less crowded streets and highways in the rural region;

2) More severe automobile accidents, therefore less delay on the patient's part in seeking access in rural areas.

Fractures and open wounds were the most common abnormal conditions observed in trauma patients on arrival at the Trauma Center (Table III). Regional Centers handled more patients with abnormal conditions, except fractures, than Areawide or Local Centers. Since more than one abnormal condi-

Figure V Entry Method by Type of Trauma Center



tion may be reported per patient, the total number of abnormal conditions exceeds the number of patients; therefore, the total of the percentages of abnormal conditions is greater than 100 percent.

Twenty-six percent of the Trauma System patients had surgery performed (Figuure VI). The range among regions was 11 percent. Surgery was more common in industrial/farm and home/recreational accidents. Twenty-four percent of the victims of violence and 20 percent of the vehicular received surgery.

In treating trauma patients, physicians most frequently functioned as would an emergency room physician (72 percent of the cases). Additionally, physicians functioned as orthopedic surgeons (44 percent of the cases), neurosurgeons (20 percent of the cases) and eye-ear-nose and throat specialists (10 percent of the cases). In all of the above cases, the physician's actual training is not taken into consideration, merely the role assumed in treating the patient. The average number of consultations per case was 2.6.

The median length of hospital stay was slightly longer (4

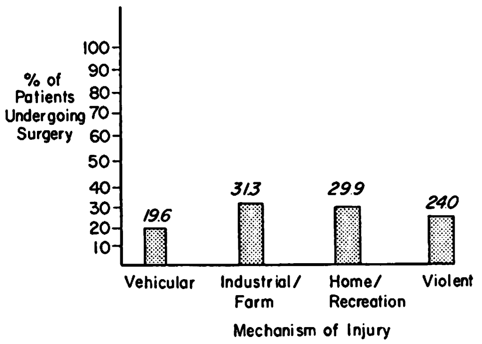
TABLE III TRAUMA SYSTEM PATIENTS:

ABNORMAL CONDITION ON ARRIVAL BY TYPE OF CENTER

ABNORMAL CONDITION ON ARRIVAL*	TYPE OF CENTER			
	REGIONAL	AREAWIDE	LOCAL	TOTAL
	%	%	%	%
FRACTURES	49	50	49	49
OPEN WOUNDS	47	49	34	44
COMA	15	17	9	14
SHOCK	11	6	10	10
CARDIAC	11	5	8	8
VENTILATION	5	4	5	5
HEMORRHAGE	3	3	3	3
AIRWAY	2	2	2	2
TOTAL PATIENTS	11,202	7,814	7,255	26,271

*MORE THAN ONE ABNORMAL CONDITION MAY BE REPORTED PER PATIENT.

Figure VI Mechanism of Injury by Surgery Performed



to 5 days) in the Regional Centers than in the Areawide or Local Centers (2 to 3 days).

Patient Outcome

Survival rates were not affected by the type of center in which the Trauma System patient was treated. Ninety-seven percent of all Trauma System patients survived (Table IV).

Males and females had equal survival rates (Table V). Survival declined slightly, but significantly, as age increased. Ninety-eight percent of the patients under 60 years of age survived, while only 92 percent of those under 70 and older survived. There was also a difference in mortality by mechanism of injury, with industrial/farm victims surviving most often (99 percent of the time). Vehicular accident victims survived 96 percent of the time (Table VI). Death prior to arrival at the Trauma Center was most frequently found among vehicular accident victims (1.5 percent).

Two percent (n = 588) of all Trauma System patients developed complications within the first 24 hours of hospital admission. Central nervous system complications were most frequent (36 percent), followed by pulmonary (19 percent) and circulatory (17 percent) complications (Table VII). Only 36 percent of patients with acute complications survived.

The Value of Registries

Registries, such as the Trauma Registry, serve an important role in evaluating the internal functioning of health care systems. We have seen from the preceeding data that registries can delineate inventory, process and outcome data for large numbers of patients. Thus, changes for better or for worse within an existing system can be documented and trends spotted or confirmed. Comparisons of, for example, mortality can be made with other systems and with national figures. Detailed clinical data on study cases can be accumulated for later analysis; registries provide an ideal data base for the development of clinical standards and for the comparison of various treatments over time.

The primary limitation of registry data is that they deal only with system patients. Inferences or deductions about incidence of trauma in the general population cannot be drawn.

Other limitations of registry data are:

1) Fairly long period of time required to accumulate sufficient cases for analysis;

2) In attempting to provide an overview of the problem, enough detail for clinical studies is often missing.

Of course, all other evaluation methods and tools have their inherent drawbacks and limitations:

1) Household surveys are a very expensive way to determine incidence of a condition in a population; they are dependent on memories and clinical confirmation of cases is usually not available;

2) Summaries from local health departments often underreport cases;

3) Hospital discharge summaries deal only with hospitalized patients and, like registries, cannot lead to the generation of incidence data;

4) Experimental and quasi-experimental designs are of a one-shot nature and do not yield long-term results.

Clearly, the ideal evaluation tool has not yet been developed. Several alternatives exist. Program planners and evaluators must be cognizant of the advantages and disadvantages of each tool and choose the one most suitable for the evaluation task at hand.

TABLE IV — TRAUMA SYSTEM PATIENTS: SURVIVAL BY TYPE OF CENTER

SURVIVAL	TYPE OF CENTER							
	REGIONAL		AREAWIDE		LOCAL		TOTAL	
	N	%	N	%	N	%	N	%
SURVIVOR	10,797	96	7,635	98	7,034	97	25,466	97
NON-SURVIVOR	405	4	179	2	221	3	805	3
TOTAL	11,202	100	7,814	100	7,255	100	26,271	100

TABLE V

TRAUMA SYSTEM PATIENTS:

SEX BY SURVIVAL

SEX	SURVIVAL					
	SURVIVOR		NON-SURVIVOR		TOTAL	
	N	%	N	%	N	%
MALE	15,792	97	517	3	16,309	100
FEMALE	9,674	97	288	3	9,962	100
TOTAL	25,466	97	805	3	26,271	100

TABLE VI

TRAUMA SYSTEM PATIENTS:

MECHANISM BY SURVIVAL

	SURVIVOR		NON-SURVIVOR	
	N	%	N	%
VEHICULAR	7,601	96	350	4
INDUSTRIAL/FARM	2,170	99	26	1
HOME/RECREATION	11,346	97	308	3
VIOLENCE	4,239	97	119	3
OTHER	110	96	2	4
TOTAL	25,466	97	805	3

TABLE VII TRAUMA SYSTEM PATIENTS: FREQUENCY OF ACUTE COMPLICATIONS

	N	%
CENTRAL NERVOUS SYSTEM	210	35.7
PULMONARY	111	18.9
CIRCULATORY	98	16.7
HEMORRHAGE	54	9.2
BACTERIAL	31	5.3
METABOLIC	22	3.7
RENAL	3	0.5
OTHER	59	10.0
TOTAL	588	100.0

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THE INCIDENCE OF PREHOSPITAL LIFE-THREATENING ARRHYTHMIAS IN TRANSPORTED PATIENTS WITH ISCHEMIC HEART DISEASE

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Introduction

The use of ambulance telemetry as a strategy to reduce both mortality from ischemic heart related sudden death (S. D.) and the prehospital myocardial infarction (MI case fatality rate is predicated on there being a high incidence of life-threatening arrhythmias during the initial period following the acute event which are reversible with prompt, appropriate medical management by trained ambulance personnel.) Projected cost benefit analysis indicates that ambulances with electrocardiogram (ECC) monitor equipment and specially trained staff might reduce the MI case fatality rate between 0.4 percent and 16 percent, with the "best guess" being a 4 percent reduction at a cost of $3,600 per life saved.

Retrospective autopsy series and the 15 to 25 percent success rate of defibrillation of the *subset* of the S.D. population found in ventricular fibrillation (VF) suggest that VF is probably the modus of death for the majority of S.D. patients. The 25 percent success rate in Seattle is coupled with the unique circumstance of having 90,000 citizens trained in cardiopulmonary resuscitation. The frequently cited high incidence of arrhythmias in the early post MI period is derived from the inpatient experience of coronary care units (CCU) and selected outpatient populations such as those who are transported by mobile coronary care units following physician sucreening by phone or in person.

However, the actual incidence of reversible life-threatening arrhythmias in S.D. and MI patients who survive long enough to use an existing, efficient municipal ambulance service

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without a physician intermediary in an unselected general populace is unknown.

This study, based on the experience of a pilot program of ambulance telemetry on two municipal ambulances, was designed to examine the incidence of arrhythmias in patients with ischemic heart disease (S.D. and MI) during ambulance transport in a general population, with appropriate controls for patient delay in seeking medical assistance.

Methods

The first 22 months' experience (January, 1973 - October, 1974) of two telemetrized ambulances in southeast Baltimore County was examined in a community trial. Ninety percent of all patients transported were taken to one of two hospitals, a municipal hospital and a community hospital, both of which participated in the study. The two-way radio and ECG write-out equipment is located in the University-affiliated municipal hospital where the housestaff provides ECG interpretation and medical support for ambulance crews.

These ambulances were staffed principally by 18 Cardiac Rescue Technicians (CRTs) who were trained in a 90 hour advanced cardiac course and were certified by examination by the State Medical Board. These CRTs had been certified previously as Emergency Medical Technicians - Ambulance (EMT-A) under Department of Trnasportation regulations. The staff received in-hospital training in each of these skills and their performance was monitored by two cardiologists in weekly review sessions. Due to restrictions on the use of emergency wave bands, the Federal Communications Commission (FCC) permitted 20-second ECG bursts every minute enroute except in cases where the ambulance staff noted any significant rhythm disturbances in the ensuing 40-second intervals on the monitor unit in the ambulance. The average time en route was 12 minutes, so that approximately 12 to 14 20-second ECG strips per patient were available for analysis in this study. The average response time to a call seeking medical assistance was four minutes.

For each of the 778 patients with ECGs transmitted during this period, the ambulance and hospital medical records and ECGs of transported patients were analyzed and each patient or next of kin was interviewed by means of a three-month telephone follow up. Patients found to be pulseless, apneic, and with a straightline ECG were excluded from the analysis.

Results

During the first 22 months' experience, there were 7,654 patients transported and the CRTs elected to transmit ECGs of 778 patients using guidelines for patient selection set forth in their training. Some form of acute cardiovascular disease was present in 398 patients of which 179 had either acute MI or acute ischemic heart disease. These 179 patients are the study population under discussion.

Fifty-eight of these 179 patients (32 percent) had potentially life-threatening arrhytmias including bradyarrhythmias, PVCs (>4/min), ventricular tachycardia, ventricular fibrillation, and slow idioventricular rhythms. Bradycardia less than 40 beats per minute, multifocal PVCs, "R on T" PVCs, ventricular tachycardia, and ventricular fibrillation were absolute indications for therapy. Intervention was necessary for 22 patients (12 percent).

In Table 1, the incidence of arrhythmias en route is compared to the Belfast experience. Twenty-seven (15 percent) had ventricular tachycardia/fibrillation including ten patients with slow idoventricular rhythms, 19 patients (11 percent) had more than four PVCs per minute and 12 patients (7 percent) had sinus bradycardia. The incidence of potentially life-threatening arrhythmias in the 113 patients with MI was not significantly different from that in patients with acute myocardial ischemia without MI.

TABLE 1: Incidence of Arrhythmias in the Telemetered Population

	Baltimore		Belfast
	Study Group	MIs	
	(N=179)	(N=113)	(N=284)
Normal Sinus Rhythm	56 (31%)	28 (25%)	51 (18%)
Sinus Tachycardia	47 (26%)	27 (24%)	62 (22%)**
Supraventricular Arrhythmias	28 (16%)	17 (15%)	37 (8%)
PVCs (>4/Minute)	19 (11%)*	13 (12%)*	163 (57%)
Ventricular Tach/Fib	27 (15%)	25 (22%)	141 (50%)
Sinus Bradycardia	12 (7%)	11 (10%)	125 (44%)
Conduction Defects	7 (4%)	2 (2%)	28 (10%)

* Excluding patients with ventricular tach/fib

** Derived from subsequent studies

Percentages total more than 100% due to multiple arrhythmias per patient.

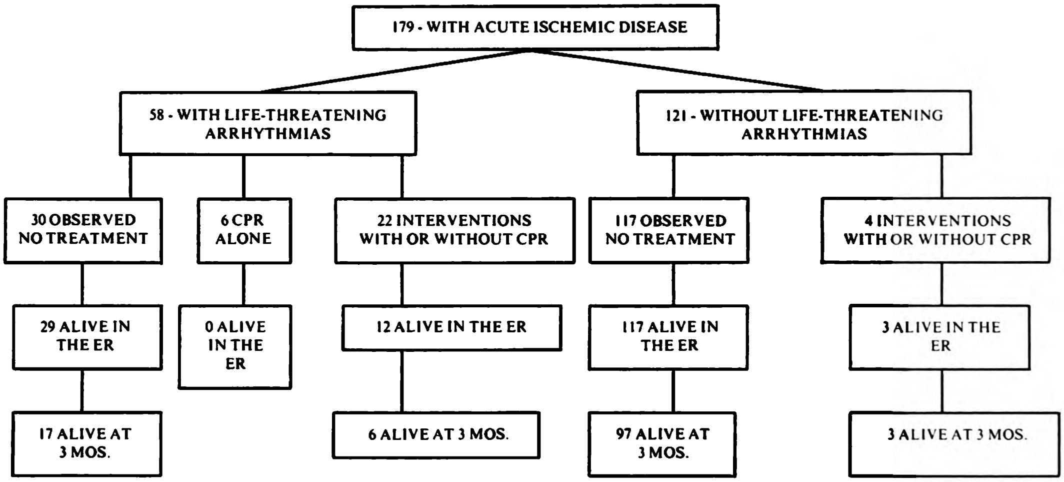
Twenty-six drug/defibrillation interventions were undertaken by the ambulance staff with radio confirmation of arrhythmias and advice of the Baltimore City Hospitals' housestaff. Four of these interventions were for patients with arrhythmias other than bradycardia or ventricular ectopy. Four of 15 defibrillations were initially successful with two survivors at three months. There were seven sruvivors at three months of the 11 patients given drugs alone (Figure 1). The number of interventions is somewhat lower than it might have been because the crews were not licensed to intervene except for CPR during the first six months of the program, *i.e.*, with the first 42 patients of whom 11 had potentially treatable arrhythmias. The incidence of arrhythmias in each time period was equivalent.

Survivorship data revealed that 41 of the 179 patients (23 percent) died during hospitalization. Eighteen of these deaths occurred in the Emergency Room where continued resuscitation was unsuccessful. An additional 15 patients expired in the three months following discharge and a total of 61 (34 percent) were dead at one year.

The clinical characteristics of this study population were typical of patients with MI. (Table 2) Of the 179 patients with acute ischemic events, 113 had acute MIs using standard criteria. Sixty-six had acute ischemic events in the absence of unequivocal evidence for an infarct. Of the 113 MI patients, 55 percent were Killip I and II, 45 percent were Killip III and IV. Sixty-five percent of the infarctions were anterior/lateral and 35 percent were inferior/posterior, 75 percent were transmural and 25 percent were subendocardial. The 73 percent incidence of ventricular ectopic arrhythmias and the 20 percent bradyarrhythmias seen in these patients while in the hospital were comparable to the reports from other CCUs.

Of note among the demographic characteristics were the high percentage of females (40 percent) and the virtual absence of non-whites. The mean and median age of the population at 62.5 and 63 respectively, may be somewhat higher than other reports because patients over 70 years were not

FIGURE I



systematically excluded. Twenty-six percent of the study population were between the ages of 70 and 79 and 6.5 percent were 80 or older. The 44 percent incidence of a documented previous MI is higher than that usually cited.

Since the incidence of arrhythmias is inversely related to the interval from the time of onset of symptoms to the time of call for assistance, this interval was determined from three sources: the ambulance record, the hospital record, and a patient interview. In the event of discrepancies, the longest time was used. Once notified, the ambulances' response time averaged four minutes and ECG's were transmitted within eight minutes. Half of the patients sought help within the first 30 minutes of the onset of symptoms and 72 percent within two hours.

Ten months after the ambulance telemetry program began, a six month study of those patients who did *not* have ECGs transmitted was undertaken. During these six months, 1,928 patients were transported and the CRTs elected to transmit the ECG s of 182 patients, 47 of whom (26 percent) had acute myocardial ischemic events. Review of the remaining 1,746 records by two cardiologists revealed that an additional 113 patients should have had ECGs transmitted. Twenty-four (21 percent of the group) had acute myocardial ischemic events. The remaining 89 patients had serious trauma, altered mental status, and/or respiratory distress. An analysis of these non-transmitted patients is reported elsewhere.

TABLE 2: Clinical Characteristics of Study Population

Study Population	179	
Acute Myocardial Infarction	113	(66%)
Acute Ischemic Events	66	(34%)
Age		
Range	28 - 91	
Mean	62.5	
Median	63	
History of Prior Myocardial Infarction		
Yes	78	(44%)
No	101	(56%)
Killip Classification (Admission)		
I and II	62	(55%)
III and IV	51	(45%)
Location of Myocardial Infarction		
Anterior/Lateral	73	(65%)
Inferior/Posterior	40	(35%)
Type of Myocardial Infarction		
Transmural	85	(75%)
Subendocardial	28	(25%)

Discussion

In this study population, the incidence of potential life-threatening arrhythmias in patients with acute ischemic heart disease is low as compared to reports from many centers, despite the face that the patients were seen early in their course. Reversibility of those life-threatening arrhythmias, ventricular fibrillation in particular, was infrequent.

Variability in demographic characteristics may explain some of these differences. There was a low proportion of non-white (4 percent) a relatively high proportion of females (40 percent), and patients more than 70 years old were not excluded. The effect of these variables on the incidence of arrhythmias or response time to symptoms is unknown. The clinical characteristics of the population, however, were typical in the distribution of site of infarct, type of infarct, presenting Killip classification, and initial blood pressure. The incidence of in-hospital arrhythmias was similar to the reports from many monitored units indicating that the patients were not uniquely resistant to the development of post-infarction arrhythmias. Their proportion of previous MIs (44 percent) and the in-hospital case fatality rate of 13 percent, excluding patients unable to be resuscitated in the Emergency Room, also supports the contention that their underlying status and acute clinical problems were not unusually benign.

The relatively high proportion of previous MIs as compared to Belfast (20 to 25 percent) may explain the lower incidence of arrhythmias in this population, expecially with respect to bradycardia which can be more effectively treated than the other life-threatening arrhythmias. The Belfast group has demonstrated that in patients with a first infarct in the inferior/posterior distribution, the incidence of bradycardia is over 80 percent. Patients with second infarcts in that distribution had a much lower incidence of bradydeed, bradycardia with first infarcts in an inferior/posterior location was frequent though the absolute number was small. The relationship of ventricular arrhythmias and previous infarction has not been clarified.

There are logistical differences among reporting centers which may explain some of the differences. In Belfast, initial ECG s are taken at the scene before moving the patient and therapeutic interventions are begun there by the physician and nurse working with the ambulance staff. In this study, the initial ECG and interventions were done on the ambulance. In fact, the Belfast patients are not moved to the ambulance until they are hemodynamically stabilized. The Belfast group has demonstrated that the movement per se of patients from their beds to the ambulance increases heart rates in a significant proportion of patients. Bradycardias which respond to movement alone are of dubious hemodynamic significance. Heroin is used extensively in Europe as an analgesic for the infarct patients and has a well-known bardycardic effect. Neither heroin nor morphine was used by the Baltimore ambulance staff. In some centers, continuous monitoring from bedside to hospital may be as long as two to three hours due to therapeutic interventions in the home. In Baltimore, FCC regulations mandated that only 20 second strips be sent out of every minute en route (average 8 to 12 minutes). It is possible that occasional PVCs and borderline bradycardia may have been missed on the monitor scope and not recorded. However, it is doubtful that ventricular fibrillation or ventricular tachycardia with their hemodynamic consequences, or more than transient borderline bradycardia, was missed by the ambulance staff who had no responsibilities other than the observation and treatment of a single patient en route.

Selection bias provides another explanation for the differences between these data and the data from MCCUs such as in Belfast. In Belfast, patients have been screened and selected for telemetry by physicians. The Baltimore patients are essentially self-referred and the lay ambulance staff uses rather broad guidelines for the selection of patients for telemetry. Little is reported about patients who are transported for whom ECGs are inappropriately not transmitted. Therefore, the relative contribution of this false negative group to the differential incidence of arrhythmias can not be assessed. In this study, the incidence of arrhythmias was somewhat reduced on the basis of those patients with ischemic heart disease whose ECGs were inappropriately not transmitted. Likewise, the outcomes from intervention may have been slightly reduced because the first group of 11 patients with treatable arrhythmias was not treated because the ambulance staff had not been certified.

Still another explanation may be that since the case fatality figures tend to be similar to the in-hospital case fatality rate (excluding patients unable to be resuscitated in the Emergency Room) plus early post discharge case fatality rate, this ambulance telemetry program may be reaching that group of patients who would ordinarily reach the hospital alive under traditional systems. The corollary is that the telemetry program is not reaching the "sudden death" group among whom the incidence of life-threatening arrhythmias is assumed to be very high.

It should be noted that other centers with different selection mechanisms which tightly control for diagnosis, delay in seeking medical assistance, and appropriate denominators have found a similarly low incidence of arrhythmias. The specific incidence of ventricular arrhythmias in Baltimore is in the same range which has been reported from Montgomery County, Maryland. The San Pedro, California group reports a low incidence of life-threatening arrhythmias in patients within the first hour of MI. Likewise, the Brighton, England group, which uses trained lay ambulance personnel, has found a relatively low incidence of life-threatening arrhythmias en route on those vehicles.

The incidence of potentially life threatening arrhythmias in this study is substantially lower than that reported from many centers actively involved in telemetry. Demographic, clinical, and logistical differences provide only a partial explanation of these results. The patients' time delay, the absence of public training in cardiopulmonary resuscitation, and the mechanics by which a patient enters the ambulance system seem to be the critical factors in explaining these differences. The low incidence of pontentially life-threatening arrhythmias in this unselected general population who seek medical assistance early in their course raises serious questions about the efficacy of ambulance telemetry under existing municipal systems.

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AN APPROACH TO CATEGORIZATION OF INJURY

Howard R. Champion, M.D., F.R.C.S., William J. Sacco, Ph.D., D. Sue Hannan, B.S.N., and R A. Cowley, M.D.

Although the quality of emergency health care delivery is currently attracting significant research activity, there are but a few urgent or life threatening disease processes sufficiently characterized to allow for their standardization within a system of evaluation. Without controlling for the spectrum of disease that constitutes an "emergency," objective evaluation of the systems for delivering such care is likely to be both futile and erroneous.

Injured patients are but a proportion of those requiring emergency treatment but account for over 50 percent of the average emergency room population, 40 billion dollars per year in total cost, and the majority of deaths under the age of 37 years. Unlike cardiovascular disease and cancer, medical facilities and expertise exist to reduce the mortality and morbidity from traumatic injury. Their maximum effective use is dependent on their efficient integration into the total system of emergency health care delivery. The means of achieving this objective are the subject of conflicting opinion not infrequently supported by data of dubious relevance often serving only to highlight methodological inadequacies. Not until a methodology is developed for characterizing and thus controlling for the pathophysiology of injury will objective evaluation of the systems of care be possible.

This report presents the interim results of collaborative effort between surgeons at the Maryland Institute for Emergency Medicine and the U.S. Army Biomedical Laboratory towards an objective characterization of the trauma victim. On the basis of a state of the art appraisal of the clinical presentation and response to injury, sophisticated pattern recognition techniques have been used to compute the degree of derangement from normal that exists in a patient at the time of initial evaluation and thereafter. The degree of derangement has been related to and tested against the outcome measure of probability of survival.

Previous attempts to characterize injury have relied heavily on the arbitrary assignment of "scores" to denote severity, either with or without the benefit of consensus expert opinion. Concentration on but single or superficial aspects of the pathophysiology has resulted in failure of the score to characterize the complexity that constitutes the human response to injury. Thus, a score that identifies an isolated splenic rupture will under no circumstance accurately account for the spectrum of this injury that can result on one hand in death within 30 minutes and on the other hand may go undetected with minimal ill effect for weeks. Yet, simple remedial isolated splenic rupture accounts for a significant number of patients who, surviving the emergency delivery system, die as a result of inadequate or inappropriate in-hospital care.

An attempt has been made to comprehensively characterize injury. This communication is to provide other workers, aquainted with our fragmentary reporting to date, with an overview of the cohesive nature of our approach and of the potential implications.

I. Methodological Approach

A number of indices have been developed to characterize aspects of the anatomical and physiological pathology of injury. Each index is a component of a developing system towards a comprehensive characterization and has been independently evaluated against the outcome measure of patient survival.

Identification of the components of the human response to injury required simplified though strict adherence to basic pathophysiological tenents.

II. Pathophysiology

Trauma, of whatever etiology, results in a fixed amount of anatomical disruption which, once inflicted, does not alter with time. Immediate responses at organ, cellular, and subcellular levels occur, which vary with the severity of the initial insult, pre-existing disease processes, and time. These attempts to maintain the integrity of the total organism define the degree and capabilities of the individualized response. Events resulting from the initial disruption such as bleeding, increased oxygen requirement, and cellular swelling continue with time, to impose on the homeostatic capabilities. Diminution of local blood supply results in an additional insult at the cellular and intracellular level to the vital organs.

With the exception of massive brain damage, instantaneous death from anatomical disruption rarely occurs. Death results from cellular failure within certain vital organs such as the brain, heart, lungs, stemming from the metabolic deficiencies that center on hypoxia and hypotension. Such processes are forestalled within the range of homeostatic adaptability by successful treatment. Complete return to normal cellular function may ensue with attention to transfusion, oxygenation, and perfusion. Not infrequently, successful resuscitation from severe injury is followed by a variety of organ failure syndromes, each with formidable mortality rates, and each an exhibition of cellular subfunction that resulted from the metabolic derangements occurring between injury and effective therapy. Thus, failure to attain physiological and biochemical function within a reasonable range of normal can result in early or acute death within minutes or hours of injury, or death some weeks or months later from later hypoxic effects to brain, kidney, lung, or other organs.

On the basis of this approach to the pathophysiology of injury a number of indices have been developed using objective statistical methods on real patient data (Table). As a group these indices reflect the initial steps towards a comprehensive characterization of injury founded on clinical and statistical principles.

III. Data Base

For a four year period data were collected on approximately 3000 trauma victims admitted to the Maryland Institute for Emergency Medicine. Subsets of these data were used to develop the indices which were then tested in a prospective manner with regard to accuracy of prediction of outcome and misclassification rates. Each index was developed from commonly acquired data used in the management of the patient thus not imposing new technologies or methods on the clinical scenario.

IV. Outcome Measure

Four outcome measures are available as yardsticks for severity scores; death, disability, cost of disability and socioeconomic cost. The latter three require variable matrices and the development of operational definitions to be of value. Many injuries that are likely to result in death have relatively little associated disability and many injuries that rarely result in death (e.g. musculo-skeletal) commonly involve significant functional disablement. Our patient population predominantly involved the more critical spectrum of patients and thus death as the outcome measure was the most applicable and the most acceptable.

V. General Statistical Methodology

Once medical evaluation and therapeutic intervention commences, data accumulate on each patient which in total characterize the course of the patient. Acquired for the purpose of medical management, they describe a multidimensional

TABLE: Relationship of indices to functional aspects of pathophysiology of injury

Triage	Triage Index
Blunt Anatomical Index Penetrating Anatomical Index	Anatomical Insult
Acute Trauma Index	Physiological- Biochemical Response

RESUSCITATION

CNS Failure	—	CNS Index
Respiratory Failure	—	Respiratory Index
Renal Failure	—	Renal Index
Cardiovascular Failure	—	CVS Index
Hepatic Failure	—	Hepatic Index
Sepsis	—	Sepsis Index
General Metabolic Status	—	CHOP Index

space within which an individual patient exists at any point in time and also provide a track or trail which described the in-hospital changes that led to the death or discharge, with or without disability. The vector of all possible measurements on a patient, some of which are unattainable, can be used to conceptualize the state of the patient. Utilizing a finite number of measurements, the patient state can be compared to the state of the normal person, and can be used to calculate a measure of derangement. This measure of derangement was correlated statistically with a probability of death within certain confidence limits. As data accumulate with use of a developed index, the probabilities of movement from good to poor prognosis regions were computed:

The approach to the development of objective indices has been to take large numbers of variables and, by applying a wide variety of multivariate analyses and pattern recognition techniques to define those variables which best characterize the patient state. Each index was developed by testing combinations of the variables for predictive power. Preference was given to variables which were frequently and easily acquired during routine patient management.

Within this general approach slightly differing methodologies have been used to develop each index (for details see Suggested Reading List).

VI. Examples of Results

1) CHARACTERIZATION OF ACUTE INJURY

The Blunt Anatomical Index and Acute Trauma Index describe numerically the patient state prior to therapy. The blunt anatomical index was derived from 6856 injuries in 2135 patients. The widely used H-ICDA coding system can be used directly to assign a probability of survival to the patient, with an expected misclassification rate of about 10 percent. The Acute Trauma Index is an attempt to provide a measure of the metabolic and physiological derangement existing just prior to treatment, and thus, for identical anatomical injuries, to differentiate between a patient who arrives in good condition shortly after injury and one who arrives in extremis some hours later. On the basis of a single pretreatment blood sample and blood pressure measurement an Euclidean distance is simply computed and provides a probability of survival. Used in conjunction, these two indices have an 8 percent expected misclassification rate in predicting patient outcome.

2) RESPIRATORY INDEX

The florid syndrome of post-traumatic respiratory dysfunction has an associated mortality of over 50 percent. Based on the three variables most commonly requested by physicians evaluating such problems the respiratory index has been shown to correlate well with patient outcome and, on initial testing to provide more precise and accurate definition of patient state than a physician. It can be used to define prognosis, track patient state and to influence therapy to maintain the patient in a good prognosis region.

3) RENAL INDEX

The 80 percent mortality associated with post-traumatic renal failure enabled our characterization of renal function as the Renal Index to clearly define the level of function associated with good prognosis. Composed of normalized values of the blood urea nitrogen, serum creatinine, and urine volume, the index can be calculated from a simple table. When compared with the three component variables the index provides earlier warning of movement in the direction of a poor prognosis region. From another institution the use of early and frequent hemodialysis in trauma victims has been shown to reduce the mortality from this process. The mean levels of the variables attained by this therapy confirm the existance of the good prognosis region defined by the renal index and this the validity of the methodology.

VII. Discussion

Provided the methodology is sound an objective characterization of injury will escape many of the pitfalls associated with scoring systems based on arbitrary assignment of numbers and presumed equivalence of severity. Such systems have been applied in medicine in the past and have a life span dictated by state of the art diagnostic and therapeutic capabilities. Medical history provides many examples of arbitrary scoring systems that were totally dismantled as a result of a single diagnostic innovation.

In addition to providing a means of communication and objective characterization of patient sets, the results to date indicate that the indices that have been developed may have an integral value in their ability to define patient state. Accepted in mathematics, but perhaps dimly perceived in medicine is the fact that more information is available in even small sets of measurements than can be appreciated without proper analysis.

A physician operates within a functional space. Diagnosis and treatment result from a complex decision tree wherein variables are assigned certain weights. The indices may thus function as an extension of this functional space by providing information not readily apparent from their component variables. Clinically apparent and measurable this extension can be termed the information gain (see Lancet ii. 1974). An area of great potential significance will be in the characterization of the patient by the Triage Index.

This index is being developed to allow non-instrumental objective evaluation of an injured victim by first responders, such as EMT-A's or a triage nurse at the emergency room. Detailed anatomical and biochemical data are not available for this evaluation. Once evaluated for reliability and predictive capability, a correlation between the triage index and the combined probability of survival afforded by the anatomical and acute trauma indices, will be a major step in comprehensive characterization of acute trauma. As with the other indices, the least to be expected is an objective means of communication, but the information gain inherent in this index will be of value in effecting triage. Thus, if the triage index is found to predict outcome at a level of accuracy somewhere between that of a nurse and a physician, this capability is automatically transferred to the EMT at the site of an accident. Effective communication would then be provided between all parties and improved therapy may be affected.

The inherent value of these objective indices is available not only to the therapeutic interventionist but also to those evaluating care. By its very nature the use of a system to score severity or characterize injury will depend on the degree of resolution that is afforded in its application to a particular patient population. Given the total spectrum of injury, it is unlikely that a single scoring system will have sufficient resolution to be applied with equal value to both minor and major injuries. The use of an index or score must be considered in terms of both the population under study and the degree of resolution to be expected by application of a given index to that population. Thus, an index with an outcome measure of death will provide little insight into quality of care in a patient population with an a priori probability of survival of 98 percent. The 20 patients that die per 1000 studied would not significantly affect the evaluation irrespective of their severity and could not provide a valid basis for judgement.

Before evaluation of trauma care can be undertaken injury requires characterization. Before any system of characterization or scoring is applied to injury the scoring system itself must be described in terms of the patient population under scrutiny. Towards this end a method of describing any index has been developed with the acronym PER.

Where

P = a priori probability of survival of patient population to be studied.

E = misclassification rate associated with a random decision rule.

R = expected misclassification rate for application of the index to this patient population.

The Random Decision Rule (RDR) predicts survival for a patient if a random number, r, chosen from a uniform distribution of numbers on the unit interval is less than or equal to P; if r is greater than P, the RDR predicts death. The expected survival rate associated with the RDR is P, and the expected misclassification rate, E, is 2P(1-P). This latter quantity is obtained as follows:

E = probability that $r \leq P$ and the patients dies + probability that $r > P$ and the patient lives

$= P(1-P) + (1-P)P$

$= 2P(1-P)$.

To determine R, one needs P(I) which is the probability density function for the occurrence of values of the index I, P(S:I) which is the survival probability as a function of I, together with a decision rule which predicts survival if $P(S:I) \geq 0.5$ and predicts death otherwise. R is computed by

$$R = \int_A P(I)\,P(S:I)\,dI + \int_B P(I)[1-P(S:I)]dI$$

$A = [I:P(S:I) < 0.5]$

$B = [I:P(S:I) \geq 0.5]$

The quantity E – R which we call Information Gain is a measure of the prognostic value of an index applied to a patient group.

The Renal Index can be used as an example to clarify the concept. In our total patient population P = 79 percent, E = 33 percent, R = 15 percent. Thus, applied to the total population with an a priori probability of survival of 79 percent the information gain of the index (33-15) = 18. By using an operational definition to define the patient group as those with a renal index greater than 2, PER = (24,36,19) with an information gain of 17. However, a Renal Index of 1 or greater will define a population with P = 48 percent, E = 50 percent, R = 24 percent and an information gain of 26. The patient population most likely to benefit from clinical use of the index is the latter group.

Thus from a single patient population three subsets are available for comparison with another center where a different therapeutic regime is evoked. From this other center a population may be precisely defined for comparison of therapies. Similarly PER and the indices may be used to evaluate populations of injury defined by operational definitions for the purpose of accurate comparison of system or therapy. In spite of its simplicity, PER addresses the use of indices or scoring systems on disparate patient populations for the purpose of comparing injury severity and quality of care.

Summary

A brief overview has been given of a cohesive approach to characterization of inkury through a system of interrelatable indices each of which described a distinct aspect of the pathophysiology of injury. An index descriptor, PER is identified to aid in the comparative valuation and use of any index.

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EMERGENCY SERVICES IN CANADA

David L. Martin, M.B.A., F.A.C.H.A.

In order to set the scene for this presentation, I should briefly establish its perspective. Referring to Table 1, while the physician to population ratio in this country is relatively good, the population density is very sparce, being about one-tenth that of the United States and one-fiftieth of that in Europe. Referring to Table 2, the distance to travel in this country is one of the highest, higher than the United States, and several times higher than that of Great Britain or Germany. I would submit that while alcohol consumptions contributed to accidents, the accidental death per 100,000 population is affected not only by inadequate drivers or poor emergency response systems, but probably in greater proportion on the rather hazardous road conditions in this country much of the year. I might say that, with the inception of

TABLE 1: Population and Physician Density 1972

	Pop/Km²	Phys/ 10,000 Pop
World	28	8.2
Africa	12	1.4
Asia	78	2.9
Europe	95	15.3
Oceana	2	10.4
U.S.S.R.	11	24.6
America	13	10.8
of which U.S.A.	22.3	16.1
Canada	2.2	15.0

Source: W.H.O. Annual Report, 1973

seat belt legislation in one major province, we expect to see significant decreases in this ratio.

Referring to Table 3, we see that, while the physician to population ratio is roughly equivalent to most other Western European or North American countries, the distances to be covered by physicians in this country are vast in comparison, and illustrate graphically our problems in transporting patients to medical care, as compared for instance to the Federal Republic of Germany. Table 4 illustrates that even within the country there significant variations in population density. In provinces which are approximately three times the size of the Federal Republic of Germany, Table 5 illustrates that the distances to be travelled to reach a physician is much higher, and in our most inaccessible areas, Yukon and the Northwest Territories, the comparisons become almost ridiculous. I should point out that, while the physician per 100,000 population appears relatively low in the Territories and in three of the provinces, in four cases out of five there is no medical school there and therefore a significantly lower number of interns, residents, teaching and medical research staff.

The second area of perspective that I would like to emphasize concerns the past development of research activities in this country. Briefly, with the exception of the activities of the Working Group on Ambulance Services which completed its report in 1972, until 1973 there had been no national study on Emergency Services. Such studies as existed were generally either subsidiary to more major projects (the best example being the Ransford study in British Columbia, which formed part of the background for the Foulkes Report on Health and Social Security for British Columbians). In other cases, emergency services studies have been restricted to local perspectives, the best example being the surveys undertaken over the period of five years in the Greater Vancouver area in British Columbia.

I should, however, say that, at the same time that the National study to which I will refer took place, the province of Ontario launched a provincial study, and a local study took place in the Kingston area, under the aegis of the faculty of Queen's University and of the General Hospital in Belleville, Ontario. When the field survey activities for the studies were under way, all three levels, national, provincial and local, combined to gather their data on one series of survey visits, and thus avoided redundent and duplicated survey efforts.

While a number of other local and sometimes academic efforts were started, in most cases their perspectives were either extremely limited, due to the lack of funds, or the studies failed to materialize and produce benefits. There were, however, a number of studies in local areas sponsored under the aegis of the Department of Transport to study the occurrence and aftercare of automobile accidents. The data, to the knowledge of this researcher, was never published and was used primarily as information for the development of the Department of Transport policies.

The third point in perspective concerns what was felt to be the state of the art in this country. Mr. Steve Sieverts, in September 1973, indicated that studies by emergency

TABLE 2: International Comparison: Population Density and Road Accident History, 1973

	Pop/Km²	Road Kilo /Person	Acc Death /100,000
US.A.	22.3	0.029	45.1
England and Wales	324.5		
Scotland	66.1	0.006	32.6
Northern Ireland	109.5		
Fed. Rep. Germany	248.1	0.007	48.8
France	94.5	0.015	66.0
Sweden	18.1	0.012	41.2
Canada	2.2	0.038	50.8

Source: International Road Federation, Washington, D.C.

TABLE 3: International Comparison: Physician Density, 1973

	Phys/ 10,000 Pop	Km²/Phys
U.S.A.	16.1	27.8
England and Wales	12.7	2.4
Scotland	12.4	7.4
Northern Ireland	15.6	9.7
Fed. Rep. Germany	17.8	2.3
France	13.9	7.6
Sweden	13.9	39.9
Canada	15.0	304.4

Source: W.H.O. Annual Report 1973

TABLE 4: Interprovincial Comparison, Population Density, 1973

	Area Km²	Pop/Km²
Canada	9,976,139	2.19
Newfoundland	432,736	1.21
P.E.I.	6,051	18.45
Nova Scotia	58,863	13.40
New Brunswick	788,559	8.08
Quebec	1,648,158	3.66
Ontario	1,143,127	6.74
Manitoba	695,437	1.42
Saskatchewan	697,377	1.33
Alberta	707,309	2.30
B.C.	1,014,770	2.15
Yukon	573,738	0.03
Northwest Territories	3,615,450	0.01
For Comparison		
U.S.	9,363,123	22.3
F.D.R.	248,577	248.1
World		28

Source: Canada Year Book, 1974

TABLE 5: Interprovincial Comparison, Physician Density, 1973

	Phys/ 10,000 Pop	Km²/Phys
Canada	15.7	289
Newfoundland	9.4	859
P.E.I.	9.2	58
Nova Scotia	14.3	513
New Brunswick	10.1	120
Quebec	15.9	170
Ontario	16.9	86
Manitoba	15.8	442
Saskatchewan	12.5	612
Alberta	14.6	289
B.C.	16.8	264
Yukon	8.0	35,859
Northwest Territories	8.4	116,627
For Comparison		
U.S.	16.1	28
F.D.R.	17.8	2
World	8.2	43.6

Source: Canada Year Book, 1974

medical services planning councils produced recommendations which could be predicted with total certainty. These are listed in Table 6. As a result, it was felt that what was needed at this point was not original research, spiced with occasional stints of "ambulance chasing," but rather a survey of what existed in the country compared to the then known standards for emergency services developed in the many documents available at the time. Examples included the American College of Surgeons' and the American Hospital Association's manuals on emergency department planning, and so on.

However, because of the different situations between this country and those countries wherein many of these publications existed, (as I have indicated earlier), it was decided that the survey should encompass not only an accreditation style evaluation of the existing system (or non-system), but also an opinion survey of the persons involved in the delivery of emergency services as to their problems, and particularly as to the applicability of the standards proposed. In other words, it was felt that it was essential to talk to all who were involved in the fox-holes and trenches of emergency care systems in Canada to develop an appreciation of the problems as they perceived them before relevant standards could be developed.

The fourth and final perspective concerned the development of standards for special care units in hospitals in Canada. For a number of years, at the request of all provinces, a Working Group on Special Care Units had studied the requirements for and of special care units in hospitals, and had to 1973 dealt with a number of such units. (Table 7) The provincial health authorities unanimously indicated that emergency units in general hospitals also were to be considered high on their lists of priorities for such standards. Therefore, the study which I will outline was done at the expressed request of all provinces, with provincial collaboration, and under the aegis of the joint Federal-Provincial Advisory Committee on Health Insurance and its subcommittees. While its minimum objectives were to establish guidelines for minimum standards for the planning, organization, and operation of emergency units in general hospitals, by unanimous agreement the study was expanded to consider all aspects of the emergency services system, both within and outside hospitals.

The study itself took place in three phases. In the first, the standard literature survey was done and the subjects for study delineated. The second phase consisted of a questionnaire sent to all active general hospitals who had been or were expected to be involved in the delivery of emergency services then or in the forseeable future. The questionnaire was primarily of the direct response by tick-off method, and contains 19 questions covering administration, triage, medical and nursing coverage, related units in hospitals, the range of services covered in the emergency unit, related services such as ambulance services and general family medicine clinics and the research, statistics, and other studies kept or performed by the hospital. A response rate of 92 percent of the hospitals with emergency units was achieved. These hospitals in turn represented 98 percent of the emergency visits reported by hospitals in 1973. The results helped to paint a graphic pciture of the response capability in the emergency services system in this country, and provide the data for the selection of hospitals for the site visit stage which followed.

The final phase consisted of site visits by a multidisciplinary team consisting in each case of a physician, a hospital administrator, a nurse, and a hospital architect. In all, four physicians, four nurses, two hospital administration consultants and two consultant architects were involved in the visits. Each used a basic questionnaire format to initiate a semi-directed

TABLE 6: Probable Recommendations of Emergency Medical Services Planning Councils

- minimum standards for ambulances and attendants
- the reorganization of emergency departments
- segregating emergent and non-emergent conditions
- the categorization of emergency departments
- the establishment of an area wide emergency communication systems

Source: Keynote address by Mr. Steven Sieverts to the Institute on the Hospital Emergency Department, Challenge and Change, American Hospital Association, Boston, Massachusetts, September, 1973.

TABLE 7: Special Care Units in Hospitals for which Guidelines for Minimum Standards in the Planning, Organization, and Operation have been Developed.

- intensive care unit
- coronary care unit
- burn unit
- perinatal intensive care unit
- cardiac surgery
- dialysis unit
- total parenteral nutrition
- physical rehabilitation medicine unit
- nuclear medicine
- respiratory technology service unit
- patient hostel unit
- day surgery unit
- diabetic day care unit
- narcotic addiction treatment unit

Source: Federal-Provincial Working Group on Special Care Units in Hospitals, Ottawa, Canada, 1975.

TABLE 8: Areas for which Recommended Guidelines have been Established for Emergency Medical Systems

- Provincial and Regional Emergency Services Councils
- Ambulance Services
- Physician and Nursing Education
- Poison control system
- Signs
- Notification and Communication
- Prevention and First Aid
- Definitions and Statistical records
- Definitions of Programs
- Categorization of Emergency Unit Capability
- Coordination and Communications
- Medical Charting and Auditing

Source: "Emergency Services in Canada", Department of National Health and Welfare, Ottawa, Canada, August 1975.

TABLE 9: Areas for which Recommended Standards have been Established for Hospital Emergency Units

- Administrative Policies, Procedures and Controls
- Staff Establishment and Coverage
- Training and Qualification
- Relationships with Specific Supporting Departments and Services
- Space Allocation
- Equipment
- Relationships with Other Departments
- Recommended Distribution of Emergency Units

Source: "Emergency Services in Canada" Department of National Health and Welfare, Ottawa, Canada, August 1975.

interview with their counterparts in each hospital visited, including the hospital administrator, the medical head of emergency unit, the chief of staff, the nurse in charge of the emergency unit, and frequently other such persons as the president of the medical staff, the director of outpatient services, the director of nursing, and so on. In addition, frequently outside persons involved in emergency services were interviewed, including ambulance operators, emergency health service coordinators, funeral directors who operated ambulance services, university faculty dedicated or particularly concerned with emergency services systems, and so on. Following these visits, the members prepared what was to be the final four volumes of the Emergency Services in Canada report, representing from their four separate perspectives the state of the art of emergency services in Canada and recommendations to improve the system.

The final result of this effort was the development of a statement of guidelines for minimum standards in the planning, organization and operation of emergency services, particularly hospital emergency units in this country. This included, first, recommendations on a number of areas related to Emergency Medical Systems generally. (Table 8) For the emergency units themselves, the areas are outlined in Table 9.

Since that time, further activities have gone on to extend, on the basis of the report and of its field documents, our understanding of the facilities requirements in emergency units. These have been compiled into a document entitled "Design Considerations for Emergency Units" which was completed by the Health Facilities Design group, Health Programs Branch of the Federal Department of National Health and Welfare.

Further studies are being undertaken into such areas as nursing staffing requirements, the costs of emergency services, the detailed space, mechanical and electrical requirements, the application of the concepts of mobile intensive care unit and telemetry to this country, and related subjects. At the same time, efforts are being made to develop national standards for ambulance service designation and equipment, and, within the provinces, efforts are being taken to study the impact of this report and its recommendations, particularly in light of the present constraints on finances for health care in this country.

The report has probably served as something of a watershed for the efforts of agencies outside of the federal and provincial governments. A number of these, including the Canadian Medical Association, Royal College of Physician and Surgeons of Canada, the College of Family Practitioners of Canada, and the Canadian Council on Hospital Accreditation have used the report as at least one of the bases for their own deliberations and studies.

The final results have been most gratifying. Based on our experience, we would consider that any country in the position that existed in this country three years ago would do well to go through the same steps of surveying their response systems, and above all talking to the persons immediately involved in them. With that as a base, further research activities can be undertaken which best fit their own country's individual requirements.

Facilities Integration for Medical Services

EMERGENCY MEDICAL SERVICES SYSTEMS DEVELOPMENT: A NATIONAL INITIATIVE

David R. Boyd M.D.C.M.

Introduction

Considerable improvements are now being made in the delivery of emergency medical care, with major advances the result of the development of a "systems approach" and the integration of standardized vehicles, communications and medical equipment, training programs, emergency facilities, and critical care unit capabilities. Advanced in on-site care by physician agents (Emergency Medical Technicians-Ambulance and Paramedics) in radio telecommunications with medical professionals have been shown to be effective in improving patient care for a wide variety of emergency, critically ill, and injured patient categories, especially those suffering from acute myocardial infarction and major trauma. Pioneering programs [1] in Miami, FL (Nagel); Nassau County, NY (Lam-

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brew); Charlottesville, VA (Crampton); Seattle, WA (Cobb); and Illinois (Boyd) have illustrated the necessary systems design, treatment protocols, technical adaptations, facilities orientation, and organizational structure that are required for successful program development.

It is now quite apparent that significant improvements in emergency and critical care of all types of emergency patients can be realized if a sound integration of all of the essential components of an EMS system are logically structured and directed towards delivering ideal care to "real" ***patients in need***. Heretofore, some debate has existed as to which component, or subsystem, is the most important. However, current consensus is that only a comprehensive EMS program, logically planned and staged, will develop and mature so that all patients in need will receive the most appropriate care in the prehospital, hospital, interhospital, critical care, and rehabilitative phases. An EMS system must then develop a sound sequence of comprehensive program activities on a regional basis if the needs of all potentially emergent patients are to be properly anticipated and receive aequate response.

The Emergency Medical Services Systems Act of 1973

The passage of the Emergency Medical Services Systems (EMSS) Act of 1973 (P.L. 93-154) by Congress [2] has provided the mechanism and funds for communities to develop regional emergency medical services delivery systems across the nation. With the passage of the EMSS Act, the Congress mandated that the emergency medical care programs funded with Federal dollars must address, plan, and implement a "systems approach" for the provision of emergency response and medical care. In the EMSS Act, some fifteen component requirements have been identified to assist system planners, coordinators, and operators in their attempts to establish comprehensive, areawide and regional EMS programs. These components are listed below.

1) The provision of manpower.
2) Training of personnel.
3) Communications.
4) Transportation.
5) Facilities.
6) Critical care units.
7) Use of public safety agencies.
8) Consumer participation.
9) Accessibility to care.
10) Transfer of patients.
11) Standard medical record keeping.
12) Consumer information and education.
13) Independent review and evaluation.
14) Disaster linkage.
15) Mutual aid agreements.

The Division of Emergency Medical Services (DEMS), Department of Health, Education, and Welfare (HEW), the established Federal lead agency, has developed Program Guidelines in which under chapter III,[3] "Special Program Guidance," the clinical significance of the systems approach in developing an EMS system is described. While an EMS system must respond to all declared emergency calls within its appropriate geographic region (including the nonemergency 80 percent, the truly emergent 15 percent, and the critical cases—5 percent), there has been a special identification of those well identified critical patient groups which demand a competent system for survival. It is to the survival of these critical patients (trauma, burns, acute cardiac, high risk and premature infants, poisonings, psychiatric, drug, and alcohol overdose) that a "system" conceptualization and initial system efforts must be directed in order to insure the development of a sound, medically competent, and comprehensive EMS system.

Emergency Medical Care Issues

The central theme and intent of the EMSS Act is to develop systems of emergency medical care that would significantly decrease current death and disability rates. The goal of the national EMS program is to initiate regional planning and integration of the fifteen mandatory components so as to provide the essential and appropriate EMS emergency and critical care services for all emergency patients.

The current EMS patient problem is compounded by the 65 million citizens who enter the system each year. At least 80 percent of these patients cannot be considered "true medical emergencies." Another 15 percent are real emergencies which require urgent care (i.e., minor trauma, infectious diseases, and other acute general medical and surgical problems). The remaining 5 percent are the critically ill and injured patients. This last group was not salvageable only a few years ago, but today, these lives can be saved if initial, definitive, and rehabilitative care is given in time and the patient is moved through the regional system and provided essential medical care.

Specific planning of regional EMS response to these particular critical care categories assumes that in time all critical medical emergencies will receive better care, and will benefit from sound regional EMS systems planning and operations.

Likewise, certain local occupational and/or recreational hazards must also be addressed with a goal toward prevention. These special target patient groups provide each regional system with an opportunity to develop evaluation criteria for systems performance and patient outcomes (distribution and survival).

EMS Systems Development

Each regional emergency medical service plan must include a description of the general and specific protocols for the emergent and nonemergent patients in its delivery system. It must also include a detailed explanation of care and triage patterns for critical groups by identifying the patient treatment needs as well as the involvement of the systems operational components (vehicles, telecommunications, manpower, facilities). These care patterns will depend upon the clinical patient demands, the sophistication of the transportation capability, the level of care during transportation, the communications coordination, the delivery to a categorized general hospital or designated critical care facility, and the migration into the rehabilitation phase. These patient care programs must be established with appropriate backup relationships by written arrangements among the various provider elements in order to insure a sound and competent regional EMS system.

When an individual becomes seriously ill or injured it is manifested in a specific way. Patients have accidents. They have heart attacks. They are burned. They have problems at birth. They are poisoned with alcohol, drugs, or other toxicants. They have emotional disturbances resulting in varying degrees of psychiatric instability. The planners of EMS systems must consider the general patient population and these easily identifiable and significant critical patient groups that exist within the geographic regional area. An indepth knowledge of the demography, epidemiology, and clinical requirements associated with these critical patient groups is mandatory to effective EMS planning and operations.

In many circumstances the initial patient access, response, and transportation considerations are general in nature until the severity of the patient's (diagnostic-specific) problem becomes clarified. As soon as this clarification develops, a rather specific patient treatment and triage plan must be activated to include the prehospital, hospital, interhospital phases, as well as the specialty care unit and later the specific rehabilitation services necessary for each illness and injury.

It is now a fairly well accepted position across the country that initial and definitive medical care for each of the target patient groups can be improved, and most of these patients can be salvaged by an effective EMS system. The design of an EMS system will need to include certain organizational and operational changes. There must also be additional adaptations of treatment in the prehospital, hospital, and interhospital phases with proper modification of existing and new technology that will enable paraprofessional, and professionals to successfully manage and treat all emergent problems at the scene and during movement through the system whether they occur in urban, metropolitan, rural, or wilderness areas[4].

The development of an EMS system usually starts with an initial upgrading of existing resources and then progresses through periods of increasing sophistication. That is, following the establishment of a basic life support (BLS) system within the region, there usually is a logical progression to the advanced life support (ALS) system due to the increasing capabilities of the EMS region.

Basic Life Support System

A BLS system includes all of the fifteen components. However, certain ones are more critical, at least early on. BLS services can be effectively provided by the integration of nationally accepted minimal standards for ambulance personnel (e.g., Emergency Medical Technician-Ambulance, EMT-A[5], ambulances of the Department of Transportation (DOT) specification[6], two-way voice medical communications (VHF or UHF band)[7], and standard equipment as recommended by the American College of Surgeons[8]. Effective placement of these vehicles, staffed by two EMT-A's, can provide emergency medical care with patient stabilization, airway clearance, hemorrhage control, shock management with MAST trousers[9], initial wound care, and fracture stabilization. Under medical control (physician directed), specific noninterventive treatment in which the EMT-A's have been previously trained can be applied. The transportation subsystem must be developed in the context of a sound hospital/critical care unit categorization program. The categorization of the facilities[10,11] (hospital emergency department, critical care unit, and rehabilitation center)[12] is a major aspect of any program and is critical in the initial development of a BLS system. It gives identification and direction to all mobile, communications, transportation, and manpower elements at even the basic level, and makes possible the sound conceptualization of a delivery system for all emergency patients, while also providing a standard for clinical impact and EMS process evaluation. Most communities have begun their EMS systems in this manner, causing a considerable increase in public awareness of the need for improved EMS.

Advanced Life Support System

Most urban communities, and now even[13] some rural regions, have progressed to an ALS system. This involved a much more sophisticated level of EMS systems planning and operations with highly skilled field personnel, EMT-Paramedics, trained to successfully identify and aggressively treat life-threatening emergencies (shock, cardiorespiratory failure, and cardiac dysrhythmias) at the scene and enroute to the hospital. At the ALS level, mobile units are equipped with appropriate intravenous fluids, drugs, and usually with some form of bioelectrical communications (telemetry). This enables paramedics with proper physician backup to perform expert diagnosis, treatment, and triage of critical patients. The need for a sound categorization of facilities during the BLS period is quite obvious due to the requirements for a medical communications control facility, and standardized treatment and regionwide triage protocols that ensure a progressive and continued enhancement of critical care for patients from the field to initial care facilities and on to the definitive advanced care facility, as is appropriate for each individual case and locale.

The components of an ALS system are as outlined here. ALS is the more sophisticated and logical progression of BLS, in which extensively trained EMT-Paramedics can provide true resuscitation (CPR) and specific interventive measures (e.g., endotracheal or esophagogastric intubation), intravenous therapy, specific cardiac dysrhythmia detection, and control with drugs and electrocountershock. These life savings techniques administered by EMT-Paramedics are always undertaken, except in rare circumstances, under the direct control of a physician or physician-surrogate in contact by voice and EKG telemetry. Most urban and many metropolitan communities (over 50,000 population) have initiated these ALS prehospital mobile intensive care unit (MICU) programs and have realized a major impact on the trauma, cardiac, and other critical patients. In many parts of the country, this increased capability of critical care will need to be developed not only in the central metropolitan areas, but also, with a further extension of satellite critical care units, in outlying community hospitals. This restructuring and resource development approach will affect primary and secondary transportation, communications, and EMS manpower, all of which must be upgraded to meet this advanced level of care, particularly in the prehospital and interhospital phases of development. While most of the activity in the ALS system is currently in the metropolitan areas, an appreciation of the need for ALS and critical care services for the rural and outlying areas is now developing. A national goal will be to realize these essential emergency and critical care services for the rural emergency patient at the scene and during the long transportation periods to distant appropriate treatment facilities.

It is these health care aspects that must be stressed in EMS planning and operations with detailed narratives of what the emergency care situation is, how the proposed EMS system will respond to an emergency patient in a certain locale, and how the patient will be evaluated, treated, and transported to an appropriate hospital or critical care unit.

Regionalization of Emergency Medical Services

A regional EMS system is one that is geographically described by existing natural patient care flow patterns. It must be large enough in size and population to provide definitive care services to the majority of general emergency and critical patients. Where highly sophisticated medical resources are not available within the region, arrangements must be made for obtaining these patient care services in an adjoining region. Various counties and cities will need to be grouped together. Therefore, the region will tend to be much larger than previously considered by independent local governmental operations. Identifying the regional EMS delivery area, with its critical patient origin and distribution patterns, is the essential issue in defining regional boundaries.

The regional EMS operational and organizing unit must attempt to pull together the EMS services within the entire medical-geographic area. The planning and evaluation process must be based upon sound clinical considerations with state, local, and interjurisdictional relationships being maintained. In these EMS regions the provider elements within the appropriate goegraphical area will need to work together to solve mutual problems. An EMS Council should be developed with advisory input into these regional EMS programs and encouraged to maintain contact with other local, regional, and state health and public safety authorities. The EMS region must be contiguous with the adjoinging regions. Regional planners must recognize that population in the fringe areas of a region may need to develop dual plans and allow for intercommunications with adjoinging regional EMS plans and operations. A coordination mechanism also must be developed between intrastate and interstate regions.

The EMS system must be integrated through an appropriate regional organization so that the total EMS resources can be effectively utilized to meet the needs of the geographical area. The financial resources of the region must be sufficient and mobilized to develop and sustain the EMS system operation. The EMS system must be interfaced with the total health care delivery system for the region. The EMS system resources must be linked to local disaster organizations in order to respond to sporadic high intensity needs of a natural disaster within the regional service area and adjoining service areas.

Emergency Medical Services System Components

The EMSS Act of 1973 requires that plans developed and systems established, expanded, and improved with funds under this Act, address the following components.

1) Manpower—An adequate number of health professionals, allied health professionals, and other health personnel, including ambulance personnel, with appropriate training and experience.

This means sufficient numbers of all types of personnel to provide EMS on a 24-h a day basis, 7 days a week, within the service area of the system.

The EMS system must emphasize recruitment of veterans of the Armed Forces with military training and experience in health care fields and of appropriate public safety personnel in such areas. The major manpower elements to be considered are as follows:

- First Responders—fire, police, and other public safety elements;
- Communicators—EMS/Resources Dispatcher;
- Emergency Medical Technician—Ambulance (EMT-A);
- Emergency Medical Technician—Paramedic (EMT-Paramedic);
- Registered Nurses—Emergency Department;
- Registered Nurses—Critical Care Units;
- Physician—Emergency;
- Physician-Specialty (medical, surgical, pediatric, psychiatry);
- EMS Systems Medical Director;
- EMS Systems Administrator;
- EMS Systems Coordinators.

2) Training—The provision of appropriate training (including clinical training) and continuing education programs which a) are coordinated with other programs in the system's service area which provide similar training and education and b) emphasize recuitment and necessary training of veterans of the Armed Forces with military training and experience in health care fields, and of appropriate public safety personnel including: police, firemen, lifeguards, park rangers, and other public employees charged with maintaining the public safety.

3) Communications—Provisions for linking the personnel, facilities, and equipment of the system by a central communications system so that requests for emergency health care services will be handled by a communications facility which a) utilizes emergency telephonic screening, b) utilizes or will utilize the universal emergency telephone number 911, and c) will have direct communication connections and interconnections with the personnel, facilities, and equipment of the system and with other appropriate emergency medical services systems.

The EMS communications system should include a command and control center which is responsible for establishing those communications channels and allocating those public resources essential to the most effective and efficient EMS management of the immediate problem. The center should have the necessary equipment and facilities to permit immediate interchange of information essential for the system's resource management and control. The essentials of such a command and control center are that a) all requests for system response are directed to the center; b) all system response is directed from the center; and c) all system liaison with other public safety and emergency response systems is coordinated from the center.

The EMS communications system must address access, allocation of resources, management (central dispatch), and medical control for BLS and ALS.

In most states a physician must assume legal responsibility for all care rendered in an emergency at the scene of an incident and enroute to the hospital. Such supervision may take one of several forms depending upon resources available and the configuration of the system in a particular area. In most states, BLS measures are considered to represent emergency first aid and do not require strict medical supervision although a physician remains responsible for the training and actions of nurses and emergency medical technicians rendering such care. When ALS is required, physician supervision becomes mandatory. In most systems, medical supervision is provided through the availability of voice communications between a physician and emergency medical technician in the field. The communications may rely solely on a telephonic link from the scene of the incident to the physician, but usually involves radio communications or a combination of radio and telephone linkages between the EMT in the field and the physician. Although it is generally agreed that medical supervision may best be given by a physician located in a hospital, it is often not practical to do so, especially in rural areas where frequency of utilization of the emergency rescue service is low, and inhospital physicians on a 24-h a day basis are not available. In such areas, the EMT must be patched to the physician, via dedicated phone lines, in the major hospital within the region.

In most urban areas, medical supervision is provided through a central base hospital resource. It is emphasized here that it is quite impractical in terms of available frequencies and from the standpoint of expense to have every hospital in an urban area providing medical supervision to ambulances bringing patients to each of these hospitals. Most importantly, personnel at each of the receiving hospitals cannot be expected to be familiar with the radio equipment and communications procedure with resultant communications failures. Furthermore, where multiple users are sharing a frequency, information may become interchanged which may lead to errors in diagnosis and treatment. Therefore, for urban areas it is imperative that medical supervision be regionalized and confined to one base hospital communications center as appropriate to the needs of the area.

Telemetry of biological signals, primarily of the electrocardiogram (EKG) has been found to be a useful adjunct to voice communications especially in the treatment of the acute cardiac emergency. The absolute need for telemetry of the EKG will vary from system to system, again, depending upon the level of training of available rescue personnel and the frequency of exposure of such personnel to the need to monitor the EKG. In programs which use volunteer rescue personnel, telemetry becomes a more important adjunct than in programs utilizing highly trained full time EMT's with a high frequency of exposure.

Treatment protocols for each major emergency are an important aspect of medical supervision. They provide a basis for the training of all EMT's and afford the opportunity for standardization of training programs on a regional basis, establish a medical legal standard of care for the patient with an emergent problem and, through a standardized approach to the patient, facilitate cooperation between rescue personnel in approaching a given problem and allow for meaningful evaluation of training efforts and patient outcome. Such protocols can be simple or complex as required by the patient type and will be influenced by such factors as the level of training of available rescue personnel and the length of transport time to the nearest appropriate medical facility. These treatment protocols must be approved by a consensus of area physicians, based on available national standards and implemented on a regional basis.

The supervising medical resource facility must be responsible for notification of the other receiving associate hospital so that it will be aware of the problem and what has already been done in order to expeditiously assume responsibility for the care of the patient immediately upon arrival. Furthermore, this communications resource facility should be responsible for decisions that relate to transportation triage of a patient to a special care unit in accordance with previously developed patient transfer guidelines and agreements. It should have the capability of hospital-to-hospital communications for the purpose of determining Emergency Department capability and bed availability information which is necessary in effective coordination of patient disposition. There must of course be a linkage between this regional resource facility and the responsible unit for dispatching all emergency vehicles.

The communications element should include the following.

Access providing public interface system to emergency resource system:

- 911.
- Alternative single access number.

Resource management function:

- Central Dispatch.
- Coordination of EMS and other public services.

Medical Control:

- Medical communications to hospital for triage, diagnosis, and treatment.

Hospital to Mobile Unit:

- Basic voice.
- Basic voice/advanced biomedical telemetry.

Hospital to Hospital Unit:

- Basic voice.
- Relayed biomedical telemetry.

4) *Transportation*—This component shall include an adequate number of necessary ground, air, and water vehicles and other transportation facilities properly equipped to meet the transportation and EMS characteristics of the system area. Such vehicles and facilities must meet appropriate standards relating to locations, design, performance, and equipment; and the operators and other personnel for such vehicles and facilities must meet appropriate training and experience requirements.

The elements of transportation should include the following.

Ground—Basic Life Support Elements:

- Ambulance vehicles meeting DOT/GSA specifications and including equipment recommended by the American College of Surgeons, HEW/DOT.
- Radio communications providing two-way voice for vehicle control and for medical control and consultation.
- At least two EMT-A's on each ambulance.
- Locations permitting (for 95 percent of all calls) a maximum of a 10 min response time in metropolitan areas.
- Locations permitting (for 95 percent of all calls) a maximum of a 30 min response time in rural areas.

Ground—Advanced Life Support Elements:

- All elements of a ground Basic Life Support component, plus personnel trained to the EMS-Paramedic level must address specific clinical items in medical service plan.
- Extra communications to provide advanced biomedical telemetry.
- Extra equipment for critical care procedures.

Air:

- Helicopters
  —Primary response-unique use depending on geographic constraints.
  —Secondary response, 30-150 mi transport radius.
- Fixed Wing
  —Greater response for 150 mi transport radius.
- Water
  —Special geographical considerations.
- Snow Mobile
  —Special geographical considerations.

5) *Facilities*—This component shall include an adequate number of easily accessible emergency medical service facilities which are collectively capable of providing service on a continuous (24h a day, 7 days a week) basis, which have appropriate standards relating to capacity, location, personnel, and equipment, and which are coordinated with other health care facilities of the system.

Categorization of the emergency capabilities of hospitals is an[14] established EMS systems concept[16]. Since the mid-1960's there has been considerable discussion about the need for the categorization of the general and specialty hospital emergency care capabilities on a regionalized basis. Medical professionals and organizations and interested health agencies have recognized and supported the need for adoption and implementation of EMS facility categorization. Unfortunately, little positive action has taken place in many states at the regional and local levels to implement programs that integrate the principles of established national categorization guidelines and that assess the individual hospitals' general and special care resources and potentials to effect sound regional EMS system development.

The concept of categorization of all emergency care facilities originates from the realization that emergency patients have varying magnitudes of injury and illness and that all hospitals have varying capabilities with which to provide adequate initial and/or definitive care. It is also realized that a categorization program must address the needs of all emergency medical patients and, therefore, deal with the growing numbers of nonemergent (primary care), truly emergent, and critically ill and injured patients. Effective categorization must involve all of the emergency receiving facilities and ascertain both the general (HORIZONTAL) and specialty (VERTICAL) care capability for all emergency patients. Categorization efforts should utilize the principles of established National Guidelines and in addition develop statewide criteria for implementation on a regional basis (CIRCULAR).

Categorization has relevance in urban, suburban, rural, and wilderness areas. The categorization concept will have additional significant effects on the utilization of EMS manpower and other EMS resources by eliminating duplication, providing additional data and information for improving EMS systems development, and should help check the spiraling costs of improved medical care. The basic purpose of categorization is to identify the readiness and capability of each hospital within a region to receive, diagnose, and treat all emergency patients, especially those with serious or critical injuries or illnesses, in an adequate and expeditious manner. Ambulance personnel, law enforcement and public safety officers, and the public must be knowledgeable of the designations of the hospitals within the region in order for the system to operate effectively and selectively utilize the appropriate hospital to which critically ill or injured patients are to be transported for treatment.

Elements for facilities consideration include the following.

- Regional categorization with accepted state or national criteria with at least one Category II hospital providing 24-h physician coverage in the emergency department in each EMS region.
- Regional EMS advisory groups to plan and carry out the categorization plan. These groups should include hospital administrators, physicians, nurses, other providers, and health system planners.
- Regional plans for mutual agreement of categories, use of critical care units, systems linkages (transfer agreements), and resource sharing.

6) Critical Care Units—This component requires providing access (including appropriate transportation) to specialized number and variety necessary to meet the demands of the service area. If there were no such capabilities in the EMS region, then the system must provide access to such capabilities in neighboring regions.

Specialized critical medical care units should include trauma intensive care centers/units, burn centers/units, spinal cord centers, poison control and alcohol detoxification centers, coronary care units, high risk infant units, drug overdose and psychiatric centers, and others as appropriate.

A twofold issue here is the availability of critical care service units within the EMS region or in neighboring regions. Specialty care services should provide an adequate number of beds in the region or access to critical care units in neighboring areas. An operational plan for utilization of critical care units should be developed, including trained personnel, equipment and transportation, triage and interhospital treatment protocols. The EMS system should include the development of professional advisory groups (trauma, burn, cardiac, etc.) to work with EMS programs to insure that these critical services are being appropriately utilized and interrelate across political boundaries.

7) Public Safety Agencies—Provisions must be made for effective utilization of appropriate personnel, facilities, and equipment of each public safety agency in the area.

"Effective utilization" means the integration of public safety agencies into standard EMS and disaster operating procedures of the regional system. It also includes the shared use of personnel and equipment, such as helicopters and rescue boats, appropriate for medical emergencies.

Public Safety agency personnel are most frequently the first responders to an emergency patient. The EMS system must therefore work with these agencies to ensure the use of special equipment, proper training of staff, linked communications, and the development of cooperative operating procedures.

8) Consumer Participation—The EMS system must make provisions in its system management that persons residing in the area and having no professional training or experience may participate in the policy making for the system.

While there is no federally required percentage of consumer participation in EMS planning or advisory organizations, reasonable consumer representation should be provided. One approach would be to involve the committee of the advisory council of the local planning Agency which has consumer representation.

9) Accessibility to Care—The EMS system must provide necessary emergency services to all patients without prior inquiry as to the ability of the patient to pay.

The EMS system must not require evidence of the ability to pay prior to care for the services of ambulance, hospital, or critical care units. The system should provide the means to monitor for restrictive measures that may eliminate any person or group of people from equal quality of services within the region.

10) Transfer of Patients—The EMS system shall provide for transfer of patients to facilities which offer definitive follow-up care and rehabilitation as is necessary to effect the maximum recovery of the patient.

The transfer agreement is necessary to facilitate communication and cooperation of key professional providers (physicians) within the system. Actual letters that describe the transfer requirements for the critical target patients are essential contracts of regional EMS development. They not only open the radial lines of communications between the physician in the outlying area with a patient problem beyond his capability to the center physician with the necessary resources, but they also will establish the manner and mechanism by which critical patients will be initially treated and retransported through the system. Only through this transfer agreement method will physicians at varying care capability levels come together and decide mutually on treatment, triage, educational, and evaluation protocols.

In urban areas, areawide prehospital treatment and triage protocols will have to be established by councils of key professional providers for the various specialty patient groups. These programs will necessarily "bypass" the nearest hospital as special critical cases are identified.

11) Standardized Patient Recordkeeping—Each EMS regional system shall provide for a standardized patient recordkeeping system which covers the treatment of the patient from initial entry into the system through his discharge from it, and shall be consistent with patient records used in follow-up care and rehabilitation of the patient[17].

The minimal patient records necessary for the EMS system are the dispatcher records, the ambulance records, the emergency department, and critical care records. In order to fulfill requirements of evaluation and reports to Congress, certain information must be available to be derived from these records.

- Patient identification information: the records must be designed so that the dispatcher record, ambulance record, and emergency department record on each patient can be compared for evaluation and management purposes.
- Patient access information: How did the patient access the system (arrive at emergency department)?
- Timing of ambulance services: response time, time at scene, and travel time to hospital.

- Patient condition: at scene, upon arrival in emergency department, and critical care unit.
- Patient treatment: at scene, during transport, in hospital.
- Patient diagnostic and treatment services: at emergency department, in hospital, and critical care unit.
- Disposition of patient: discharged, referred for outpatient care, referred to another hospital, admitted, died.
- Condition of patient: at discharge from emergency department, in hospital, and critical care unit.

12) Public Information and Education—The EMS system shall provide programs of public education and information for all people in the area so they know about the system, how to access it, how to use it properly, and how to pay for it. Successful systems operation depends not only upon the organizers, but also the participants. Continued support, particularly in the arena of competition for dollars, requires community commitment. To secure that commitment, the EMS system must keep its public informed. Programs should stress the general dissemination of information regarding appropriate methods of medical self-help and first-aid and the availability of CPR training programs, and other preventive oriented resources.

13) Independent Review and Evaluation—Each EMS system must provide for a) periodic, comprehensive, and independent review and evaluation of the extent and quality of the emergency health care services provided in the system's service area and b) submission to the Secretary of the reports of each such review and evaluation.

It is intended that such review and evaluation be periodic and comprehensive so that changes in emergency health care can be determined. The evaluation should be conducted by a qualified organization other than the grantee project personnel.

There is no intention to require sophisticated and expensive research oriented evaluation from funds granted under Sections 1203 and 1204. What is required is that persons not associated with the project conduct a review and evaluation of the extent and quality of the services provided. As a minimum the reviewer should have available:

- a description of the EMS resources, capability and performance measures at the start of the period being evaluated;
- a description of the interventions brought about during the period to include both clinical and EMS components;
- a description of the EMS resources, capability, and performance measures of the period being evaluated;
- clinical output or impact evaluations of death and disability should include the clinical patient target groups.

14) Disaster Linkage—The EMS system must have a plan to assure that the system will be capable of providing emergency medical services in the system's service area during mass casualties, natural disasters, or national emergencies.

The EMS system is not the regional health disaster organization. It is the emergency medical program that will work with other agencies during a disaster to provide emergency medical care. The EMS system must have links to the local, regional, and state disaster plans, and participate in exercises to test disaster plans at least biannually.

15) Mutual Aid Agreements—Each EMS system must provide for the establishment of appropriate arrangements with EMS systems or similar entities serving neighboring areas for the provision of emergency medical services on a reciprocal basis where access to such services would be more appropriate and effective in terms of the services available, time, and distance.

Arrangement among EMS regional systems and similar entities serving neighboring areas must be written agreements, signed by individuals authorized to act for the respective parties with respect to such agreements, and reviewed and reevaluated at least once a year. Such agreements should cover the exchange of service coverage, communication linkages, licensure and certification, and reimbursement.

EMS Systems Management

National experience with public and private funds has demonstrated that a few strategic factors are paramount to successful operations and management of an EMS system effort. The following elements must be addressed in order to develop and maintain an integrated total EMS system.

- Action Plan for EMSS Area—A comprehensive and detailed and progressive plan must be created for establishment, operation, and expansion of the EMS system.
- Lead Agency—A lead agency must be identified as the responsible operations unit for the EMS system including grants management control and operations coordination of the involved community and regional organizations and resources.
- Financial Support—Appropriate means of financial support for initial and continued EMS operations must be considered. Such financial support may be derived from various Federal programs, state and local funds, general revenue sharing funds, third party payments, and direct payments from patients.

The intent of the EMSS Act is to fund EMS projects on a multigovernmental and multicommunity basis. At the present time there are a few regions in the country where an "ideal" appropriate regional health authority exists. Such an organization or special health consortium must be developed usually with reliance on the established state health office (or major Metropolitan Health Agency) with its established management and regulatory capability for successful program initiation and support.

EMS Legislation

The Emergency Medical Services Systems Act of 1973 called for "a study to determine the legal barriers to effective delivery of medical care under emergency conditions,"[18]. The report of the Committee on Interstate and Foreign Commerce of the House of Representatives (H.R. Rep. No. 601, 93rd Cong., 1st Sess. 19 (1973)) stated that "legal barriers include situations where existing state laws prevent appropriate emergency services as well as situations where the absence of needed legislation fails to encourage and require such services." The report described some of the legal barriers which were included in testimony before the Committee, including: restrictive licensing laws, absence of laws requiring ambulance personnel to have adequate training, absence of laws requiring adequate design and equipment for ambulances, and inadequacies of state "Good Samaritan" laws.

The study revealed that the absence of enabling legislation at the state level rather than the presence of specific legislation provisions which preclude delivery of service, represent the major "legal barriers" to the development of regional systems of emergency medical care. Because of this, state legislatures should enact comprehensive laws to create and control the many components of the areawide emergency medical services system. State legislation should address the following areas:

- Definition of an areawide EMS system.
- Creation of a state governmental unit to plan, develop, and coordinate EMS activities in the state, emphasizing areawide systems with intersystem cooperation and including interstate cooperation.

- Ambulance services, including licensing of ambulances and ambulance services; standards for vehicle design, equipment for medical care and for communication; and personnel.
- Personnel, including definition of categories of personnel involved in EMS, training, and certification requirements, and explicit definitions of which services the various categories are authorized to perform under specific circumstances.
- Emergency medical facilities, including a requirement for participation in areawide systems and a requirement for systemwide categorization of hospitals by the level of care they can provide.
- "Good Samaritan" legislation.
- Responsibility for providing care, including responsibility of the general public, health professionals, ambulance services, and hospital emergency facilities.
- Financial responsibility for care, defining who is responsible for paying for care provided.

National program efforts will focus on how to assist state legislatures in implementing such legislation that will encourage the development of regional EMS systems. The EMS system will be enhanced and placed on more solid foundations by the enactment of adequate EMS legislation by state legislatures.

EMS System Evaluation

At this time it is impossible to determine how many lives are being saved and the amount that disability is being reduced because of EMS systems. To date, evaluation of the emergency medical care programs have been geared toward the survey approach, resources documentation, and data on subsystems (e.g., transportation, training, etc.). Essential data must be obtained to evaluate the clinical effectiveness of regional EMS systems. There must be developed new methodologies for "tracking" and evaluating emergency medical care for specific patient groups, e.g., trauma, burns, etc., within the system. These analyses will allow programmatic decisions as to the appropriateness of utilization of facilities, personnel, equipment, clinical treatment, and cost effectiveness.

The following should be the basic ingredients for the development of an evaluation stragety. It is appreciated that at present the "state of the art" of systems evaluation is rather primitive across the country. This is consistent with the relative development stage of most EMS systems at this time. As EMS projects grapple with the multiple components and organizational changes, they must also comprehend the basic precepts of evaluation methodology [19].

The following are basic to an evaluation strategy.

a) Development of a descriptive narrative of the organization's operational components, and "clinical systems" design and implementation. A key evaluation task for each program will be that of the narrative description of the relative systems changes implemented and perceived as the EMS system develops. This essential evaluation component cannot be overlooked and is essential for subsequent steps b), c), and d), described below.

b) Structural analysis and resource development. In this area one must describe some of the key implementation aspects (radio-installed, ambulances placed, etc.) that are well identified phonemena of an EMS program. These will be necessary in the area of organization and management, at least the six clinical tracer and impact groups, and at least one parameter for each of the fifteen components.

This inventory assessment will describe these key structural phenomena and provide some guidance as to the quality of extensions were also approved during fiscal year 1975 for 18 regions that were awarded grants in fiscal year 1974: 17 under Section 1203 and 1 under Section 1204.

Fiscal Year 1976

Fifty two grants covering 63 regions and serving a population of 44,100,000 were awarded in the amount of $29,115,300.

Section of Act	Number of Grants	Number of Regions	Dollar Amount	Population Served
1203[1]	41	51	$21 836 475	35 700 000
1204	11	12	7 278 825	8 400 000
Total	52	63	$29 115 300	44 100 000

Because of constraints in the current Act, no new regions will be planned or new systems will begin operations during fiscal year 1976.

Training

Section 776 of the Act provided funds for training during fiscal year 1974 only. Under this section, 76 grants and 2 contracts were awarded in the amount of $6,666,869. These awards provided training for 36,350 individuals:

Discipline	Number of Trainees
EMT (Basic and Advanced)	25 000
Emergency Department Nurses	4000
Emergency Department Physicians	1200
EMS Administrators/Coordinators	150
Other	6000
Total	36 350

Under other authorities, the Health Resources Administration continued to fund applications for EMS training during fiscal year 1975. They awarded 9 grants in the amount of $813 191 under Section 772, health professions special grants and contracts, and 39 grants in the amount of $4 432 492 under Section 792, grants to improve the quality of training for allied health professions.

Research

In fiscal year 1974, five grants and 14 contracts were awarded in the amount of $3,311,000 under Section 1205. In fiscal year 1975, 14 grants and four contracts were awarded in the amount of $4,444,474 under Section 1205. These awards supported research in the four major categories described in Section 1205 (a).

Category	Dollar Amount
I. Medical Techniques	$1 022 766
II. Methods	3 657 995
III. Devices	2 181 326
IV. Delivery	892 476
Total	$7 754 474

Discussion

The time has come in this country when a strong positive force must coordinate all of the excellent, well developed medical resources and available technology to impact upon and improve patient care services for all emergency patients. The EMS problem was identified in 1966 by the National Research Council in "Accidental Death and Disability: the

[1]Funding limited to second year awards under Section 1203, and first and second year awards under Section 1204.

Neglected Disease of Modern Society,"[20] and is now an accepted soluble nationwide medical problem.

The heretofore frequently isolated islands of excellence have often been separated by areas of confusion and fragmentation, there are many communities where emergency care is poor because of disarray, even disrepair, in terms of providing a system of emergency care, especially in the rural, the wilderness, and inner city areas. Previous local, state, and Federal initiatives have addressed single components or those parts of a system that seemed to represent the most acute and obvious need at the time. It is now apparent that a system must include all of the 15 components and is no more effective than its weakest links. Further development of one or two of the chosen strong links will not make the chain stronger and will not create a better system of care for the critically ill or injured victim. The "nonsystems" approach has been due to a combination of local ignorance, provincial prerogative, and lack of guidance by the Federal Government. The passage of the EMSS Act of 1973 now provides an opportunity to establish health priorities for emergency medical care at the local, regional, state, and national levels of our society, and to foster the development of a comprehensive and sound EMS systems approach that will affect all communities, especially the rural, the economically depressed, and the medically underserved areas.

Organizational Responsibilities

It is now quite obvious that an EMS system must incorporate a certain well identified and credible organizational unit to coordinate all of the various provider, community, and governmental interests. This unit must be the focal point for ensuring the system's integration from a systems access, a first responder's identification[1], communications coordination. While no individual organization has the responsibility for all of these components, the operations unit must coordinate these many activities of the EMS system and must represent the professionally and publicly supported EMS Services Council for policy development, advice, grievances, and resources utilization.

Critique of Emergency and Critical Care Delivery

It is now well recognized that patients are still being lost unnecessarily because of systems failure, not simply because of neglect of injuries or severity of medical problems. Prior to current trends in management, many emergency cases were, more or less justifiably, treated conservatively because of the attitude that they were too "sick" to get well. Now that well established techniques of resuscitation and emergency medicine and surgery have been disseminated, an extremely aggressive approach in prehospital and hospital care phases is being shown to salvage lives. This sophisticated, aggressive, and coordinated approach to emergency care is not without significant cost and demands in terms of emergency medical services resources, especially manpower. Only by a consolidation of experience, personnel, vast medical resources, operating rooms, intensive care, X-ray, blood banks, etc., on a regional basis can such a program be developed and supported by the civilian community.

The concept of adequate emergency medical care requires an organizational responsibility which provides sound planning for the prehospital and hospital critical care services; and must engender community and region wide patient triage with well established, practical, and refined medical care plans that involve the care at the scene during transportation, in hospitals, and critical care phases of patient services. The whole aggressive systems approach must be without weaknesses or gaps, and continually needs to be reassessed and evaluated to assure optimal operations.

Federal Involvement in EMS Development

A large body of representatives from the many interested professional medical and health groups appeared in Washington in 1971, and testified at the Congressional Hearings on the Emergency Medical Services Systems Development Act of 1972, unanimously supporting the critical need for improvement of care of emergency patients. They also indicated that such care should and would be improved by the systems approach. Much of this testimony was given by witnesses from organizations who stated that they were convinced that the following pertains. "An environment now exists in the nation for the development of comprehensive total emergency medical services systems on a regional and statewide basis. The lack of provision for emergency illness, accidental death, and disability can no longer be classified as an insoluble health problem, as medical expertise and technology are available in this country which can easily be applied to this previously neglected situation." The essence of the opinions and precepts stated by those interested in the national EMS problem was that the "neglected disease of modern society" could now be effectively handled by efficient utilization of expert care principles and by organizing and improving, in each community across the nation, the existing and developing EMS resources and care capabilities. It was obvious that Federal direction would be an essential catalyst for a national EMS systems development program.

This organized systems approach to the care of emergency victims has been proven already in some areas. It has also been proven that by such a systems approach, a more effective return on the current and future investments of Federal dollars can be anticipated.

EMS As A Component Of The Total Health Care Delivery System

The coordination of established medical services and public safety efforts brings the emergency medical care program to an interface with community service activities heretofore outside the scope of established medical practice. Community involvement by a wide spectrum of the public, private, and governmental entities gives an emergency medical service system a new dimension to health care that has not previously been a major consideration in American medical practice. An additional result of the regional EMS system effort will be the demonstration of how other essential nonemergent health services and programs might be stylized similar to EMS on a geographic and service demand basis. Some experience already suggests that programs such as blood, organ transplantation, and rehabilitation services as well as quality assurance programs might be enhanced by regional systems models.

The national EMS system effort will improve the quality of care for the critically injured and ill citizens across the country. Due to its unique characteristics, emergency medical care provides a rare opportunity for experience in many other phases of health care delivery. It is anticipated that the "ripple effect" in the EMS effort may extend beyond the limits of acute care phases to many functional component areas.

The success of any EMS system is dependent upon the wisdom of its leadership and appropriate integration of resources, operations management, and financial planning into an effective program. The major task of the Division of Emergency Medical Services is to provide current and timely technical assistance and guidance by communicating results of lessons learned from established and ongoing operational EMS projects.

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CATEGORIZATION OF HOSPITAL EMERGENCY SERVICE CAPABILITIES

Oscar P. Hampton, Jr., M.D., F.A.C.S.

Categorization of hospital emergency services is the designation of the *relative capabilities and state of preparedness* of hospitals in a community, region or state, to provide essential treatment to the seriously injured or ill. Categorization *is not* a classification of hospitals. Many fine hospitals for patients with elective or nonemergent conditions do not purport to have excellent emergency services—all to the good as categorization envisions some hospitals not offering them as the community does not need them.

Categorization has concerned some of us since the concept of categorization of hospital emergency departments (ED) only was proposed in 1966 in Accidental Death and Disability: The Neglected Disease of Modern Society (AD&D), a publication of the National Academy of Sciences-National Research Council. Thereafter, a few interested surgeons, particularly the Committee on Trauma of the American College of Surgeons (ACS), gave intensive consideration to categorization. All concerned, including those who developed AD&D, then agreed that the entire hospital emergency service capabilities should be categorized, the ED being only one important criterion. Services furnished *within* the hospital are vital to the quality of its ED services. Crucial in-hospital services include not only radiological and laboratory services but the skills, expertise and *availability* of essential personnel, particularly those of the medical staff.

Purposes of Categorization

Improved care of all emergent patients is the prime objective. Emergency ambulance personnel, ambulance dispatchers, physicians, law enforcement officers, and the citizens of a community may know which institution and its medical staff are best *qualified* and *prepared* for life saving emergency services. Patients can be routed accordingly, even though it means by-passing other hospitals known to be less capable and less prepared for emergency patients. The concept is negated that the severely injured and the seriously ill should always be taken to the closest hospital, a concept all-too-prevalent today. For patients with life threatening conditions, the selection of the hospital with the best qualified and prepared emergency service may determine the outcome—life or death.

Categorization identifies the parts to be played by each hospital and its staff in the community emergency medical service (EMS) system. It permits all involved to learn more about that system and medical staffs and administrators often are jarred from all-too-prevalent complacency. They learn just where their institutions are proficient but, of more importance, just where they are deficient. Such information should lead to improved preparedness and capabilities, if for no other reason, in the hope of achieving a rating in a higher category.

Surveys and studies of the emergency service capabilities of the hospitals in a community, region or state, as a first step toward categorization, provide essential information for State, Areawide or Local Comprehensive Health Planning Agencies on which, in part, they can base any future recommendations. Categorization also permits highway departments to place directional signs indicating the location of hospitals with the most capable emergency services.

Another potential and important dividend of categorization is the closing of the ED in selected hospitals. In communities with many hospitals, usually two or more are located close together and really available to the same group of emergent (and nonemergent) patients. A single well prepared and staffed ED probably could provide all of the needed emergency services. The other hospitals could close their EDs, thereby conserving manpower and money. Excess staff from closed EDs could augment that of the ED remaining open. Current Standards of the Joint Commission on Accreditation of Hospitals (JCAH) permit accreditation without an ED provided a recognized community plan approves.

Progress Since Categorization was Proposed

Soon after categorization was proposed in 1966, several medical organizations, principally surgical, and some individual physicians, principally surgeons, grasped the significance of the idea promptly and, in varying degrees, have advocated categorization in their volunteer efforts to promote improved community EMS systems. The majority of these physicians are faculty members associated with sophisticated university medical centers likely to rate the highest category. They need many seriously injured and seriously ill for teaching purposes and stand to see their teaching needs fulfilled by implementation of categorization.

Few, if any, hospital administrators have endorsed realistic categorization that might achieve its objectives. Many administrators and physicians connected with hospitals likely to merit less than a superior and perhaps an inferior rating, appear afraid of the idea and some have spoken disparagingly of it. Presumably, they fear loss of trauma and acutely ill patients (and income) to other physicians and hospitals in a higher category. Moreover, everyone naturally wants everything about his hospital to be rated first class and no one likes the idea of a significant reduction in patient load (and income). In fact, potential loss of income by practicing physicians and by a hospital appears to be the only disadvantage of categorization.

Many physicians and hospital administrators seem to ignore categorization and feel that it will go away, somewhat as many physicians hope that Professional Standard Review Organizations (PSRO) will go away. Actually categorization is now the law of the land as it is a requirement of the EMS Systems Act of 1973 (Public Law 93-154). However, many hospital staffs and administrators need indoctrination in its concept and to be shown its advantages.

Interestingly, the American Hospital Association's "Emergency Service . . . . .", published in 1972, stated "The impossibility of providing comprehensive emergency service in all hospitals . . . . . . is another reality that cannot be ignored." It goes on to say that what has been proposed is "concentration of emergency care in a few well-staffed emergency departments in hospitals equipped to deliver care of the highest quality." These statements imply some acceptance of categorization.

In May of 1969, ACS and the American Academy of Orthopaedic Surgeons held a conference on EMS systems at the Airlie House in Warrenton, Virginia; the 50 conferees were selected because of their expertise in all facets of EMS. This conference endorsed the concept of categorization and recommended that the Commission on Emergency Medical Services of the AMA sponsor a conference of knowledgeable individuals to develop standards and guidelines for its implementation. The conferees at this conference in 1971 represented each medical and surgical specialty concerned with the care of emergent patients in hospitals. Prior to the conference, several groups had produced their own guidelines for categorization. These included the Committee on EMS of NAS-NRC, the Committee on Trauma of ACS, the Committee on Acute Medicine of the American Society of Anesthesiologists and the American Academy of Pediatrics. These sets of guidelines served as "straw-men" for the conferees as they developed designations for four categories of hospitals emergency service capabilities and guidelines to distinguish between them. The conference proceedings were published by the AMA and have become known as the "AMA Guidelines."

Designations for the categories are: I Comprehensive Emergency Service, II Major Emergency Service, III General Emergency Service, and IV Basic Emergency Service. Guidelines common to all categories are:

ED Accessible - To ground or air transportation.

Hospital Records - Old records promptly available in ED.

Poison Control - Advisory service in-house or ready access to one.

Continuing Education - For all emergency care personnel, professional and non-professional. Periodic reviews with ambulance personnel.

Audit and Review - Regularly on ED Services - Mortality and Morbidity reviews.

Emergency Care References - Posters on tetanus, burns, etc. and treatment manual in ED.

Communications - Two-way radio between ambulances, dispatchers, etc.

Mass Casualty Preparedness - Rehearsed plan; and access to supplemental supplies.

Responsibility to Public - Treatment without delay pending financial arrangements.

The Scopes of Capabilities and some Distinguishing Features of each are as follows:

CATEGORY I - COMPREHENSIVE EMERGENCY SERVICE

Hospital is fully equipped, prepared, and staffed to provide prompt, complete and advanced medical care for emergencies in patients of all ages including those requiring the most complex and specialized procedures.

Distinguishing Features

Physician(s) in at least third post-doctoral year in ED and specialists (including radiologist) concerned with life-threatening conditions in hospital at all hours. Medical staff specialists available on short notice.

Blood storage facilities with all types in ED.

OR ready almost instantaneously; personnel including anesthesiologist in hospital at all hours; cardiac by-pass capability on short notice.

Separate surgical (trauma), cardiac and burn ICUs.

Renal and peritoneal dialysis capabilities.

Helicopter landing pad nearby.

Psychiatric Facilities - in ED for acutely disturbed patients from any cause and a predetermined plan for follow-up including, if necessary, transfer to specialized facilities.

Laboratory Service - Comprehensive for all sophisticated tests needed in care of seriously injured or ill by qualified technicians in-house at all hours.

Radiological Services - in both radiological department and in or adjacent to the ED; all sophisticated services including angiography and other contrast studies in the radiological department. Qualified technicians and radiology specialist physicians in hospital at all hours.

Post-Operative Recovery Room - in or adjacent to the OR staffed with specially trained personnel at all times when needed for P.O. emergency patients.

CATEGORY II - MAJOR EMERGENCY SERVICE

Hospital is equipped, prepared, and staffed in all medical and surgical specialties to render resuscitation and life-support for patients of all ages. It supplies definitive care for all except the occasional patient who requires follow-through care in very specialized units. Transfer may be necessary and shall be under prior agreement with other hospitals.

Distinguishing Features

Physician(s) in at least second post-doctoral year in ED and in the hospital (including radiologist) at all hours capable of rendering services of all specialties concerned with life-threatening conditions. Medical staff specialists available on short notice.

Blood storage facilities with all types in ED.

OR ready within a few minutes; personnel including anesthesiologist or nurse anesthetist in hospital at all hours.

Separate surgical (trauma) and cardiac ICUs. Access to Burn ICU by prearrangement.

Psychiatric Facilities - Same as for Comprehensive.

Laboratory Services - Same as for Comprehensive.

Radiological Services - Same as for Comprehensive except radiologist in-house not required.

Post-Operative Recovery Room - Same as for Comprehensive.

CATEGORY III - GENERAL EMERGENCY SERVICE

Hospital is equipped, prepared, and staffed in the medical and surgical specialties necessary to render resuscitative and life-support care of persons critically ill or injured of all ages. The availability of supplementary specialty services shall be prearranged with non-staff specialists. Transfer of patients for specialty care shall be by prior agreement with other hospitals.

Distinguishing Features

Physician(s) in at least second post-doctoral year in hospital at all hours available immediately for ED.

Blood storage facilities with all types in hospital.

O.R. ready within a reasonable time; personnel including anesthesiologist or nurse anesthetist on call from within or outside hospital.

Combined surgical (trauma) and cardiac ICU.

Access to Burn ICU by prearrangement.

Psychiatric Facilities - not specified.

Laboratory Services - Same as for Comprehensive but technician only on call from inside or outside hospital.

Radiological Services - In radiology department only. Technician on-call from inside or outside hospital.

Post-Operative Recovery Room - Same as for Comprehensive but for daytime use only.

CATEGORY IV - BASIC EMERGENCY SERVICE

Hospital is equipped, prepared, and adequately staffed ro render emergency resuscitative and life-support care for patients for all ages. Transfer when necessary shall be under prior agreement with other hospitals.

Distinguishing Features

Physician(s) on call and available from outside hospital at all hours for ED or in hospital services.

Access to blood bank and maintains a donor list.

OR ready without prolonged delay; personnel including nurse anesthetist on call from outside hospital.

Psychiatric Facilities - Not specified.

Laboratory Services - Same as for General.

Radiological Services - Same as for General.

Post-Operative Recovery Room - Not specified.

Criticisms of AMA Guidelines

A number of criticisms have been registered; some are valid and some invalid.

Valid criticisms include the following:

1) Requirements for Categories I and II of multiple Intensive Care Units for adults, children and infants including newborns, are unrealistic for some communities and regions where all children and infants with emergency conditions are directed to childrens' hospitals, and all neonates to specialized newborn services.

2) Requirements of a blood bank in the hospital for Categories I and II are unrealistic because in many large communities blood is supplied to all hospitals by an American Red Cross or a non-profit community blood bank.

3) Packed cells are not mentioned yet they are being used increasingly and advantageously in patients in hemorrhagic shock.

4) Helicopter landing pads should not be a firm requirement for Category I.

5) Requirements for Category II are too demanding and approximate those for Category I. The only significant differences are that cardiopulmonary bypass capability and the helicopter landing pad are not required.

6) Physician staffing requirements should be more demanding for Category III. The same physician should not take ED and in-hospital emergency calls. Moreover, mere intern staffing for the hospital or the ED is inadequate.

Invalid criticisms are as follows:

1) Only large university teaching hospitals with a full complement of residents can possibly meet the ED and in-hospital staffing requirements for Category I. The criticism is invalid as such hospitals probably are the only ones having the necessary physicians in-hospital. For optimal timing of treatment for life-threatening conditions, available capable physicians are crucial both in the ED and in/hospital.

2) Blood storage facilities in or adjacent to the ED are not worthwhile. The criticism is invalid for hospitals which receive many critically injured because uncrossmatched low-titer O or type specific blood (RH-negative in females) occasionally may be a life saving measure in a dying, bled-out patient. ED storage makes blood immediately available.

3) A cardiopulmonary by-pass capability on short notice is unnecessary for Category I. The criticism is invalid because such a capability is necessary if lives of some patients are to be saved from cardiac and great vessel injuries.

Over and above the valid and invalid criticisms, some of which were just discussed, the AMA Guidelines are based on the concept that categorization of hospital emergency capabilities should be determined by each institution's capacity to deal with the broad spectrum of emergent conditions which bring patients to hospitals. The all-embracing scope of such requirements, by virtue of their magnitude, probably has been a deterrent to realistic practicable categorization and its use in EMS systems in many localities. A given hospital which should rate a Category I designation for acute cardiac care but only a Category III for trauma and pediatric care for example, would undoubtedly receive the latter designation under the AMA Guidelines.

Therefore, a more selective categorization of hospital emergency services is likely to be advantageous. This selective approach will reflect more precisely each institution's resources for the provision of emergency care of patients in one or more of several critical care areas, *e.g.*, trauma with its subcategories of burns, spinal cord injuries and head injuries, cardiac, neonatal pediatric, psychiatric and acute medical. This categorization scheme, termed "horizontal categorization" by some, affords appropriate recognition of each hospital's capabilities in one or more specific critical care areas. Regardless of the names or numbers given to several categories, however the crucial ingredients are physician knowledge, skill and *availability*, sophisticated often expensive equipment and skilled technicians to operate it.

In summary, the AMA Guidelines for Categorization of Hospital Emergency Services, while in need of some revision which was anticipated when they were developed have served to stimulate categorization activities in many localities and states. They are the most comprehensive guidelines now available. Practically every effort at categorization throughout the United States has utilized them as a stanting point. However, no group has implemented them verbatim.

The so-called horizontal categorization appears to be the way of the future. This system will identify the hospital or hospitals best prepared to receive and treat patients having one of the several conditions requiring "critical care." Certainly this system should ameliorate opposition, justified or unjustified, by medical staffs and hospital administrations to the concept of categorization of hospital emergency services.

Categorization of hospital emergency service capabilities is coming, either voluntarily or by governmental imposition. Governmental imposition of categorization of emergency services is not a mere threat. Under a contract with the Regional Medical Programs Service, JCAH had developed for the Secretary, DHEW "criteria for identification of hospitals capable of providing the most advanced techniques and methods for the diagnosis and treatment of heart disease, cancer, stroke and end-stage kidney disease." Categorization of hospital emergency services is now one of the requirements for federal funding under Public Law 93-154 on Emergency Medical Service Systems, which implies a threat of governmental imposition, if necessary.

The merits of categorization of hospital emergency service capabilities transcend all petty objections in the best interest of the care of emergent patients. It is hoped that the private sector promptly will implement categorization and avoid governmental imposition.

THE HOSPITAL POSITION IN CATEGORIZATION

Duane T. Houtz, B.S., M.H.A.

Hospitals are being categorized, not always as a result of their own initiative, nor to their own liking, but toward the best interest of the patient and of the community. The concept is working, although slower than some would like or may have envisioned. On a national basis it is comparable to working on a giant picture puzzle. Most of the outside framework is in place, and the inside picture is beginning to take form; however, many pieces still need to be put together.

Why do I say the system is working? Many hospitals are beginning to work together to benefit their communities as a whole. Historically, some hospitals and physicians have been concerned only about caring for "their" individual patients rather than caring for all of the patients in their community. The accident victim was not "their concern" unless he was in their emergency room, and, even then, some rejected the patient on the basis of: "no money;" "we do not treat that type of patient;" "the patient's physician is not on this staff." Categorization is changing these attitudes.

The system is working because hospitals and medical staffs are beginning to accept the fact that we cannot be all things to all people. We are learning that no one institution can be the best in everything. The demands are too great, the distances too far, and it is impossible to be appropriately staffed or equipped for everything. Our goal is changing from competing aginst each other, to complementing each other.

The public is now beginning to appreciate our concern for delivering the patient to the appropriate facility. On the television program, "Emergency", on May 8th this problem was dramatically portrayed. The patient's daughter wanted the ambulance to travel 25 minutes farther than the designated hospital, where it was unknown whether the patient's physician or any physician was available. The emergency team (Gage and DeSoto) advised against the extra travel time because of the serious condition of the patient, and because the vehicle would be unavailable to the community for an extra 50 minutes. The impact of this program on public awareness is significant, when we estimate that 10 or more million people were watching. Categorization will benefit from this illustration of the facilities selection process.

As each piece of the puzzle is fitted into place, the whole picture of categorization develops. The improvement of each phase in the emergency medical services system is beneficial to the development of all the components. For example, better trained emergency physicians and other emergency personnel are demanding a more responsive delivery system. In turn, better communications facilitate the improved dispatch of patients. The concept of categorization will be realized only to the extent of the development of all the elements of E.M.S. system.

Categorization is working because it is being accepted as a useful concept in differentiating among the specialized capabilities of our institutions. This specialization is an outgrowth of the trend in medicine. As pediatrics develops the field of neonatology, we see the growth of high risk nurseries, the specialty trained nurses, and all of the specific equipment that supports these units - including the transport vehicles that go out from the institutions to bring the infants to the units. Internal medicine has delved into cardiology with the resultant coronary care units, cardiac nurse specialists, coronary care vans, and all the electronic support equipment. The same is true for other specialties within medicine and it has the same ramifications for our institutions. The classification process is required to identify individual capabilities and to help integrate specialized facilities back into a complete system to benefit the patient in need.

Each year the concept is finding new advocates in administrators, many of whom were initially reluctant to participate in categorization. When we see something working to the benefit of other communities we lose our fears. Some resistance was because they were not the one initiating the system, rather it was being imposed by those physicians who worked in the facilities, and who could see the benefits.

We can understand some of the concerns of many administrators, if we recognize that what they want is:

1) To provide good patient care and to have satisfied patients.
2) To meet community needs.
3) To please medical staffs, boards, and employees.
4) To be financially solvent.

What they do not want is:

1) To give bad care.
2) To lose money.
3) To be sued.
4) To suffer from poor public relations.

I feel the major concern of administrators has been financially both direct and indirect. The underutilization of emergency facilities and, more important, hospital beds poses severe economic problems for hospitals to solve. In addition, treating emergency patients who are unable to meet the institutions' financial requirements, creates a burden for both the hospitals and their medical staffs. Administrators are also sensitive to pressures from their boards and medical staffs.

It is difficult for an administrator to accurately determine the real impact of an emergency patient on his total financial operation. The income and expenses derived from increased inpatient census, additional laboratory and x-ray procedures, along with other indirect income and expenses are difficult to identify and understand. The administrator is apprehensive because there remains a great deal of controversy as to the economic impact of changing the emergency patient load of his hospital, and he is fiscally accountable.

Categorization is working, although hospital acceptance and implementation has been slow in some areas. We must realize that it is easier to change concepts than it is to change facilities and organizations. The brick and mortar of hospitals is costly and difficult to relocate because they are linked together by existing massive highway networks, and relationships are hard to modify because they are built on many complicated organizational and medical staff ties.

Still I am encouraged. As we come closer to finishing this picture puzzle, the remaining pieces fall into place more rapidly. I believe that we *are* doing a better job of matching the needs of the patient with the capabilities of the institution.

VERTICAL PROFILING OF CRITICAL CARE FACILITIES AND CRITICAL PATIENTS

Jay Kranz, M.D. F.A.C.S.

Problem

Critically ill or injured patients are not regularly delivered to the proper critical care facility.

Cause

There are really two causes which can be helped by the program described and a third which is related to consumer education. The first is the increasing number of people involved in the care of the critically ill and injured patient and the increasing number and complexity of hospital facilities available to help these people care for these patients. All of these people do not know about all of these facilities and have no reliable way of finding out. The facilities have had an understandable reluctance to describe their capabilities for fear they would suffer from a loss of patient volume or incur medical-legal exposure of even greater degree.

The second problem is due to the wide spectrum of technical backgrounds of those interdependent poeple who compose the EMS System. These different groups do not always understand the technical jargon of the other groups that are used to describe the patient's condition, his care requirements or the services offered by the facilities.

The third problem arises because our freedom of choice of care allows the patient to override the judgement of EMS personnel in the choice of facilities.

Purpose

The purpose of the Washington Vertical Profiling Program is to identify and list the critical care facilities in the state, profiled in a three level hierarchy for each critical care area. This profiling is primarily related to patient care capability and is expressed in a nomenclature that is understood and accepted by planners, administrators, communicators, providers and ever-present critics.

Strategy

The "marketing" of any categorization scheme must be done against a general resistance to change, a fear of external control, a genuine concern for the economic viability of both overbuilt facilities and rural, "underbuilt" hospitals, and a well taken view that systematization does not guarantee improved patient care. The first step was to develop profiling material on a vertical plan which allowed hospitals to describe their facilities in terms of General Trauma (including Emergency Department), Burns, Head and Spinal Injury, Cardiac, Respiratory, Neonatal, Overdose- Poison-Control-Alcohol, and Behavioral Emergencies. These last two categories have been allowed to wait until profiling material is better developed in order to sell the less controversial package. The second step was to develop actual profiling criteria for three levels of patient care. These criteria generally described; *Level 1* as a facility able to care for those kind of patient problems generally managed by a general physician in a general hospital setting, *Level 2* as a facility able to care for those kinds of patient problems generally managed by a specialist in a special care unit, and *Level 3* as those facilities able to deliver care to those patients who required the highest current "state of the art." The "Catch 22" inserted by those of us who have been manipulated by experts, appears to have successfully widened the space between Level 2 and Level 3 by requiring those facilities who choose to classify themselves as Level 3 to also accept consultative and training responsibilities for Level 1 and 2 services in their areas as well as supply trained transfer personnel when requested.

The actual criteria were then developed by individuals or groups whose expertise was generally accepted. The criteria were planned to be revised annually. These criteria dealt very well with patient care issues but required some editing to be acceptable to all groups, and to fit the mechanics of the profiling program.

The program called for self-profiling with signed statements by the hospital administrator and appropriate Chiefs of Service as well as the hospital Chief of Staff. This seemed preferable to either mailed questionnaires or inspection visits which had continually failed to indicate the competance of personnel or the day-by-day capability of any service. In order to avoid any gross errors in self-assessment, the signed self-profiling statements were to be approved by the local EMS Councils. Any criteria statements that seemed to deal with quality of care were reluctantly omitted because of conflicts with PSRO activities, and the statements were then listed in a "check list" format at the request of hospital authorities. Finally, transfer agreement statements were included for each service so that both categorization and transfer birds could be stoned in a single toss. The completed drafts were then returned to the expert committees for final approval.

The Selling of the Profile — 1976

The nature of the Washington EMS Program requires consensus in all major activities as a preferable alternative to legislation. As a consequence, the profiling program had to be approved by all state level provider organizations and widely circulated to field providers for review and comment. Several major problems and their answers deserve special comment as they will probably recur from state to state.

HOW SHOULD A SERVICE PROFILE ITSELF WHEN IT FALLS BETWEEN LEVELS?

"The profile designation for a given service considers three kinds of information; physical facilities, training of personnel and administrative commitment. When facilities and/or training falls between two levels, the administrative commitment will decide whether the lower level should be selected, noting additional resources, or the higher level designated, noting correctable deficiencies, and mechanism and date of correction."

WON'T THIS PROFILING MATERIAL CAUSE ADDITIONAL MEDICAL-LEGAL EXPOSURE?

The data collected in the profiling program is already a matter or public record, and the patient care guidelines generally consistent with accepted practices published by national specialty organizations. The medical legal effect is actually to give the medical providers information which is already known (often better known) by the community of plaintiff's attorneys. Furthermore, Dr. James Page, whose doctorate is in law, continually stresses his opinion that it will be many years before a significant body of legal opinion is collected. Consequently EMS planners and providers should go ahead and provide the best kind of care that they can supply and not worry about further legal predictions.

WILL THIS PROGRAM INCREASE THE PATIENT LOAD AT LEVEL 3 EMERGENCY DEPTS.?

Profiling material is for the use of providers. Consumer information should be disseminated through other parts of the program. Patient care guidelines refer to definitive treatment and may or may not be appropriate for the determination of the initial disposition of the patient. The initial disposition of the critically ill or injured patient is often a complex medical decision which must consider the patient's problems, his doctor, his wishes, the capability of the EMTs and their equipment, the location and capability as well as the state of readiness of emergency departments in the area and the weather. The local EMS Councils should adopt written plans to cover this decision for most types of patient problems in most locations with appropriate concern for facility capability. These plans must fit local circumstances, but the following guidelines should be considered:

1) The EMT should have a minimum responsibility in making the *medical* decision regarding choice of emergency department.

2) A physician experienced in emergency medical care or his delegate should be contacted as soon as possible after the incident to guide the choice of initial emergency department disposition.

TABLE: Section of Profiling Material Related to Emergency Department — General Trauma

Level 1

1. 24-hour assigned (designated) nursing personnel capable of immediate diagnosis and treatment of life threatening arrythmias, respiratory insufficiency and shock.
2. Skill capability of emergency department personnel as defined in WAC 248-18-285.
3. Physician supervision as defined in WAC 248-18-285.
4. General surgeons and orthopedists (board qualified) available.
5. Written policies and procedures as required by WAC 248-18-285.
6. Usual diagnostic x-ray and laboratory facilities.
7. Intensive care unit.
8. Capable of providing care to patients with closed, uncomplicated fractures, soft tissue injuries or moderate severity with controlled bleeding, chest injuries not producing respiratory distress, and blunt abdominal trauma not showing evidence of internal bleeding or perforated viscous. (The immediate availability of a staff member who is a board qualified specialist may extend to treatment capability of this service in single system injuries within his usual practice activities.)

Level 2

1. Service supervised by a physician experienced in the care of the critically ill and injured patients.
2. Emergency department staffed 24 hours by experienced physicians capable of advanced life support skills as defined by JAMA supplement February 8, 1974, p. 852-860.
3. Usual surgical specialties represented on "on-call" roster including general surgeons particularly versed in trauma care, orthopedist, urologists, and neurosurgeon.
4. Physician coverage for in-patients present or readily available.
5. Nursing staff initially trained in emergency care, and on-going, in-service training program for E.D. staff.
6. Diagnostic services should include capability to measure blood gases, pulmonary artery pressure, and do immediate angiography, and nuclear scanning procedures.
7. Formal arrangements with a blood bank for the delivery of large volumes of blood and 0 negative cells.
8. ICU supervised by a physician experience in the management of critically ill.
9. Respiratory care service supervised by a physician skilled in the management of chest problems.
10. Capability to treat patients with combined system injury, complicated fractures, uncontrolled hemorrhage, unstable chest injuries with respiratory distress, penetrating abdominal wounds and blunt abdominal wounds with evidence of bleeding or perforated viscous, and severe maxillofacial injuries.

Level 3

1. Chief of service trained and experienced in trauma care.
2. Level 2 trained personnel, equipment and services.
3. Cardio-pulmonary bypass capability within two hours.
4. Operating suites available within 30 minutes.
5. Administrative commitment to supply training and consultative needs of Level 1 and 2 services, and trained personnel to assist in transfer from other facilities as needed.
6. Capability to care for patients as described for Level 2 services and all trauma victims which may be referred from Level 1 and 2 services.

3) The actual state of readiness of the potential receiving ED should be verified by the transporting unit.

4) There must be provision for a "grievance committee" to hear complaints regarding individual hospital dispositions. Any circumstance in which patient care issues were thought to be subordinated to other considerations must be investigated critically and dealt with vigorously.

WHAT WILL THIS PROFILING PROGRAM DO FOR MY HOSPITAL?

"This program, which described all critical care facilities in a common language according to their care capabilities, will cause more appropriate utilization of all critical care facilities. While all of the experienced providers in a community know all about the capabilities of all the facilities in all the hospitals (in fact they seem to know very little), there are lots of new men in the community including the ED physicians who will find this information very useful in patient care. Furthermore, the transfer agreements, signed by all units insures that receiving units will accept your patients and return them as soon as possible."

State Legislation

Hospital licensing regulations relating to emergency services were revised and contain several items significant to critical care profiling. These regulations (WAC 248-18-285) allow a hospital to choose not to operate an emergency department, but to have a "crash-cart" available for "in-house" emergencies. Those hospitals who do operate an emergency department, however, are required to have a nurse in the hospital at all times who is capable of managing life threatening cardiac arrythmias, acute respiratory insufficiency, shock, and to record a baseline neurologic examination. They are required to have identifiable physician supervision, and a series of written policies and procedures regarding levels of responsibility, transfers, records, etc. Hospitals who have only the "crash-cart" capability are simply designated "Basic," and not further profiled.

Summary

In order to assure that the critical victim is regularly delivered to the proper critical care facility, the State of Washington EMS Program has implemented a vertical profiling program that described critical care facilities in a three-level hierarchy for each of six care catagories: Emergency Department—General Trauma, Head and Spinal Injuries, Burns, Cardiac, Respiratory, and Perinatal. A compatible nomenclature that generically describes clinical conditions of critical patients is included so that "Level 2 patients with Head or Spinal Injuries" are related to Level 2 Head and Spinal Injury critical care units. A transfer agreement associates each self-profiling statement for each service as well.

Strategies for developing and marketing the program are described along with a few recurring questions and apparently acceptable answers.

INTEGRATION OF WILDERNESS FACILITIES INTO URBAN PROGRAMS

James C. McShane, Dr.H., M.P.H.

A recognition and understanding of the divergence between Wilderness and Urban EMS Systems is paramount to the provision of alternatives for a systems approach to emergency care delivery and thereby nurture the integration of distinctly different facility capabilities.

The genesis of our wilderness institutions was historically based upon settlement patterns by our forefathers in areas of agriculture, mining, and commerce. Clinics arose out of the need to provide communities a capability for the care of disease states (both chronic and acute) in geographic areas of near to total isolation and which was compounded by immense geographic expanses and varying topographic barriers. Many rural/wilderness communities have had over time a decrease in population for a variety of reasons (played out mines, altered commerce patterns and migration to the urban sprawl). Today, wilderness patterns by their own nature compromise health resources available to communities by limited numbers of appropriate and skilled professionals, paraprofessionals and support providers; equipment allocations; and economic resources.

In contradistinction, urban programs are marked by a plethora of resources—a hallmark of the current duplication and fragmentation of emergency services. Such duplication is compounded further and perpetuated by what may be termed vested interest and institutional chauvinism. Despite these mild criticisms, urban communities provide centers for secondary and tertiary care, sophisticated reconstructive and rehabilitative services, center of specialized training and education, and modalities of specialized transport. (Table 1)

It is this contrast between the maldistribution of emergency care personnel, facilities, equipment levels and economic constraints that mandate a need for the integration and sharing of urban resources with our wilderness counterpart. Aside from the issue of resource maldistribution required for the care of the sick and injured, the wilderness concept distorts the temporal relationship (nearness to care) essential for positive outcomes in patient management. Examples may include urban response times of three to six minutes in contrast to wilderness response times of 30 to 60 minutes, excluding time required for access and alert of the response mode. This latter may be in the magnitude of several hours.

The urban plethora of resources must be channeled to pro-

TABLE 1: Wilderness-Urban Resource Contrast—An Example

Characteristic	Wilderness Region	Urban Area
Population	200	1,300,000
Hospitals	clinic	23
24 hr. E.D. centers	-0-	16
% physician specialists	-0-	86
Ambulance services	1	43
Average annual ambulance runs	8	54,000
Primary service care area	square miles	square miles
Specialty centers	-0-	Poison, Neonate, Burn, Cardiac, Neurotrauma, Trauma, Behavioral

vide an optimal balance of resource availability to wilderness progress on both a timely and quality basis. Major components to be considered include: the manpower pool, training modalities, transportation capabilities, communications, facilities, transfer agreements and medical management protocols.

In order to successfully integrate the wilderness facility into urban/metropolitan programs, an adequate number of appropriately trained and skilled personnel is paramount. Such includes not only the traditional physician and nursing component of the facility but also a predictable level of trained field allied health and first responder members. Consideration of the facility staff includes appropriate training of the physician and nurse in emergency medical care. It is to be noted, however, that in the vast majority of wilderness communities physicians are either not present (most common) or general practitioners with limited expertise in the management of the critically ill and trauma patient. This deficiency may also be present with the nursing population.

The most significant resource available to the wilderness facility is the institution's own staff. Specifically, it is crucial that training levels of staff personnel be optimized in the techniques for management of the emergency medical patient. In order to accomplish this upgrade of training and the subsequent development of skill judgement and performance, four significant training modalities can be identified:

In-service and ongoing training This modality best serves the wilderness facility if provided on a "team" approach to include physicians, nurses and paraprofessionals of both inhouse and field service. Approaches to in-service training should be directed toward the review and critique of EMS patient records, training in new techniques for the management of patients, and practice sessions on emergency care procedures. In addition, training programs should be implemented to provide not only the above enumerated personnel but also the first responders and community members in cardiopulmonary resuscitation programs.

Urban facilities The second modality for training of staff members requires wilderness personnel to seek and enroll in emergency care programs provided in either urban college or medical center settings. Traditionally, a wide range of training programs have been available to physicians, nurses and allied health personnel to expand and upgrade their skills in emergency care. Programs may be structured as practitioner courses, workshops, seminars, symposia, or academic degree programs. Of major consideration in the provision of sending wilderness candidates to urban programs is mileage and per diem, significant staffing coverage problems of the wilderness facility in the temporary absence of the candidate, and in the case of long term training programs, the life style of wilderness staff member family units may be severely disrupted. Considerations should be given and alternatives provided if this training modality is to be of benefit to the community.

Urban programs to wilderness areas This concept has received increasing support and commitment in the field of emergency care over recent years. In particular it best serves the training program of short duration (one to five days) by presentng to wilderness regions a team of educators from urban medical centers with expertise in the management of critically ill and trauma patients. Training programs include not only the emergency medical technician but also programs for nurses and physicians. Specifically, in Colorado a two-day workshop has been developed by the University Medical Center for rural physicians in which a team of physicians spend 16 hours in presenting a didactic and practical experience to rural physicians. In addition, surgical residents are sent as team members to provide coverage of the wilderness facility while the local physician attends the two day program.

Rotation This fourth modality is based upon a rotational system in which professionals and paraprofessionals of wilderness facilities arrange rotational programs to urban settings with professional counterparts. The mechanism affords staff members an opportunity to work and train in centers of high patient volume and at the same time not deplete the staffing pattern of the wilderness facility since a professional or allied health member of the urban institution would rotate to the wilderness facility. This modality provides two major benefits; first, it maintains appropriate medical coverage of the wilderness facility and second, rotation provides the urban staff member with an insight into daily issues which arise in the parctice of primary care in these remote facilities. These programs should in the long run provide both urban and wilderness personnel an appreciation of resources and issues confronting and available in each medical setting of the service care area.

Development of a preplanned and appropriate transportation service for the transfer of the critically and injured patient to urban centers is essential for the integration of these divergent areas. Consideration must be given to both surface and air (rotor, fixed wing) vehicles in addition to vehicle structure (*e.g.*, four wheel drive, weight, height clearance), medical and extrication equipment, communication capability and trained EMTs. Emphasis should be placed upon developing a "core" of EMTs to be designated as primary technicians to be alerted when transportation is required either for the initial response or transfer of patients to escalating centers of care. It is not uncommon to find in a volunteer service a list of 20 to 30 squad members, however, development of a "core" of four to eight well-trained EMT's should be realized in order to provide a predictable and skilled service.

Utilization of air vehicles has become increasingly more popular with a greater emphasis placed upon the helicopter as it becomes an extension of the urban emergency department for critical patients. It must be pointed out, however, that inappropriate utilization of the helicopter (*e.g.*, routine transfers, minor injuries and ailments) has in some rural/wilderness areas been a detriment to the planning of a total EMS System as communities rely upon the helicopter for all "emergency" events and fail to recognize the need for developing a total systems approach for the delivery of emergency care by not being knowledgeable of limitations of helicopter missions (inclimate weather, availability of rotor aircraft, and patient conditions which would be contraindicated for air flight).

Essential for the integration of wilderness facilities with urban programs is the development and implementation of a medically controlled communication network. Such a system must include not only the traditional two-way direct voice modalities between field operations (ambulance, rescue squad, public safety agencies) and the wilderness facility but also communications linkages between the facility and the regional 24-hour primary receiving unit (trauma center). Linkages must provide direct two-way voice capabilities and not be compromised in response capability by having communications directed through an intermediate party. The network must integrate direct voice communication to higher centers of escalating care (neurotrauma, poison, burn, neonate) for consultation. Future networks may include provisions for closed circuit television monitoring between wilderness facilities and urban primary receiving units and telemetric modalities for physiologic data. It is to be stressed that the communication network established between the two divergent regions must provide for strong medical control, review and audit of appropriateness of communication direction and in-service education as to equipment utilization.

In order to provide quality and predictable emergency care to the people of the wilderness regions, facilities must be staffed and equipped to provide basic life support (resuscitation and stabilization) of the critically ill and injured victim. Management of the cardiac and trauma patient by skilled staff members who can initiate such treatment in the temporary absence of a physician is mandatory.

The significance of establishing patient transfer agreements between wilderness and urban facilities cannot be overemphasized. A special note must be given that the agreement between institutions is not a "mandate to send patients" but rather "a commitment" on behalf of the escalating institution to accept patients from the wilderness regions for secondary and tertiary management. It is essential that such transfer agreements are signed by both administrators as well as the presidents of the medical staff of *each* institution. To further enhance the referral of patients to secondary and tertiary centers, it is incumbent that more than one agreement for each of the designated clinical categories be initiated in order to provide maximum referral and consultation capabilities for the prudent disposition of the primary patient. Agreements are to be initiated with secondary and tertiary centers of known quality and not just to satisfy a system's requirement of a paper exercise. In addition to the transfer agreement, management protocols in each of the clinical categories must be developed and implemented for field and facility programs. Protocols are to be written and integrated into ongoing training and education of field crews and facility staff. Protocols and transfer agreements should be periodically reviewed for appropriateness to the ever-changing dynamics of the EMS System. Initially, these management protocols will be no doubt primitive in nature but in time will become sophisticated and well defined as management patterns become established and reinforced by patient referral.

In summary, this paper deals with the major components which are required to provide an integrative mechanism between our vast wilderness regions and their emergency capabilities with those programs which offer secondary, tertiary and rehabilitative services of the urban EMS program. Specifically, discussion is made of the requirements in training, transportation, communications, facilities, transfer agreements and critical management protocols. A short discussion of each component provides in some detail the specific sub-component or programmatic activity pertinent to the integration of wilderness and urban programs.

THE MEDICAL CENTER AS A LEADER IN FACILITIES INTEGRATION

Earle W. Wilkins, Jr., M. D.

In academic medical circles it has become customary to define the function of the teaching hospital in analogy to the three-legged stool, deriving its stability from equal weights on research, teaching and patient care. The decades from 1950 to 1970 have highlighted a tipping of this delicate balance by lengthening the emphasis on research. The availability of federally funded grants was the principal stimulus to this imbalance, an example of the power of the federal government in its control of the money.

The present era, conveniently labeled the decade of the Bicentennial, may someday be recalled as the time of restoration of balance. Inflation calls for economy of expenditures. The consumer insists upon appropriate service for tax money directed to the health budget. The medical center seeks credibility. The occasion is ripe for the medical center to assume its leadership in the fashioning of a functional emergency services system. This time the power of federal government, in controlling the dollar, is being directed in the provision of accountable service to the public.

Where We Have Been

In the building of a system it makes eminently good sense to identify the strengths of an area and to utilize these strengths as the foundation of the effort. The metropolitan areas, where medical centers are traditionally located, usually have an abundance of facilities. Boston is a typical example with three medical schools and some seventeen teaching hospitals. Boston also typifies the situation of "where we have been" prior to the interest in improved emergency services provided by the Trauma Committee of the American College of Surgeons, the American Academy of Orthopedic Surgeons, and the American College of Emergency Physicians and prior to the passage on 16 November 1973 of Public Law 93-154, the Emergency Medical Services System Act.

Prior to 1974 the attitude of the medical community, at least as far as the centers were concerned, was that hospital emergency responsibility began at the door to the emergency ward. The initial precious minutes of managing an emergency illness or accident was the responsibility of someone else. There was no effort to collaborate in the provision of needed health services. Duplication of facilities, or omission of essential services, were fact. Eight hospitals provided the potential for treatment of cardiac surgical emergencies; only one met the established requirements for a burn center. The poison information service was in disarray. Individual hospital efforts were vigorous and competitive, but there was a vacuum of cooperation and a high degree of inefficiency of enterprise. There was no system; indeed the word was not known.

It is only fair to recount the early rumblings of collaboration before the EMSS Act of 1973. The teaching hospitals of the three medical schools had formed the Conference of Boston Teaching Hospitals. The directors of the five neonatal units in the city had been meeting informally to consider their mutual problems and concerns. There was a Boston Emergency Services Committee which worked primarily on disaster planning.

Where We Are Now

In just two years remarkable progress has been achieved in the integration of facilities. The Office of Emergency Services in the Commonwealth's Department of Public Health approached the single strong element in the Boston situation, the Conference of Teaching Hospitals, and from this contact came the Hospital Emergency Services Committee, the group which has produced the actual integration of the individual hospital facilities.

It is paramount to understand the necessary ingredients, both to appreciate the Boston effort and to make use of the lessons elsewhere. First, there must be a convener. (In Boston, the OEMS.) Someone has to start the ball rolling, to provide the spark, to promote interest. Second, there must be a carrot. (In Boston this was the possible availability of federal funds for training, hardware for communications, and salaries. The need for improved image and credibility of hospitals enhanced the appetite for the carrot.) Third, there must be a leader. (An individual who embrances interest, stature, enterprise and responsibility.) Finally, there must be workers. (Persons who understand the needs and the plan—including physicians, nurses, administrators and para-medics *plus* a full-time, hard working project director.) It is, after all, people who make any effort work.

The mechanics are important and an accounting of the actual steps in the evolution of the system as it stands in May 1976, just two months short of the Bicentennial, is necessary.

1) The working committee must accept its challenge and responsibility with a willingness to meet regularly and work hard, not only in representing their institutions but reporting back substantive actions and progress. They must become acquainted, develop mutual confidence and understanding, and agree on a plan to help achieve the goal, a system which provides improved emergency care to those who need it.

2) Care capability of the available hospital facilities comes next. This means analysis of capability of emergency wards and back-up critical care units, by questionnaire developed via a state advisory physicians committee. The capability of a hospital emergency ward may be limited to stabilization only, in which case this partial capability must be recognized and publicly stated. Facilities with no emergency capability in any emergency category should not be allowed to treat or be presented with such problems. Vertical categorization of facilities is a prime axiom of the process.

3) Site visits are an important element of the plan, needed not only for verification of self-analyzed care capability reports but also to provide the familiarity of personnel and mutual respect and understanding which facilitates committee function. These visits are conducted by combinations of physicians, nurses and administrators from other teaching facilities.

4) Development of the point-of-entry plan evolves sequentially from the preceding two steps. This is a printed, and published, vertical categorization of individual facilities listing capabilities in the seven critical groups of injuries or illnesses; trauma, acute medical/cardiac, poison/overdosage/alcoholism, neonatal, pediatric, psychiatric and burns. The coding for each institution in each category is: 1 = stabilize, admit and provide definitive care, 2 = stabilize only and transfer, or 3 = no capability. Approval of the plan by the parent organization (the COBTH) is mandatory.

5) Incorporation of the point-of-entry plan in the operational function of the communication coordinating center for the city was accomplished with computer assistance. Supervision of this function by an employee of the COBTH stationed in the center helps ensure responsibility for the system and essential medical direction and accountability.

6) The final element in the integration of facilities is the development of agreements among all cooperating hospitals in the development of treatment protocols and transfer agreements which permit smooth shifting of patients to critical care units where beds are available.

Where We Hope To Be

The achievement of an integrated series of critical care facilities under the medical center seems certain. As the bulwark resource for the complicated problems in an area, this would then become the focal point, the crucial hub, for the entire state, or even regional system.

The ultimate requisite for linking all facilities and for operational direction of the entire system is the communications potential. When completed, this UHF network would provide, via the computerized communications coordinating center, the following: 1) two-way voice conversation between any two points in the system—from hospital to field unit, 2) medical advice to the ambulance technician, 3) critical care bed census to aid dispatch to the appropriate facility, and 4) data accumulation for monitoring of system efficiency and effectiveness.

In the Boston area "where we hope to be" must include improved vehicular transportation capability and advanced life-support technician paramedic training, essential for minimizing loss of precious time.

The potential pitfalls to be assiduously avoided are loss of incentive in the withdrawal of federal support, the allocation of too much leadership responsibility in too few individuals, and undue financial burden on the medical center hospitals as the result of geographic concentration of the costly critically ill.

SPECIALTY CONSULTATION FOR EMERGENCY MEDICAL SERVICES

Sol Edelstein, M.D.

The ideal emergency medical service (EMS) system would guarantee every citizen access to the best available care for his or her particular emergent disease. Such care should not be dependent on when or where the patient happens to enter the system. Recent advances in the training of ambulance personnel, development of portable medical equipment, vehicle design and communications technology have allowed for the delivery of sophisticated emergency medical care in the prehospital setting. These prehospital services are in a large part, dependent upon qualified physicians giving medical direction to trained paramedics both at the scene and enroute to medical facilities. Patient care is then dependent upon which facility the patient is transported to and which health professionals are present upon the patient's arrival. The accessibility of consultation by physician specialists to doctors and nurses who staff the emergency department and critical care units may help solve the enigma of providing timely and definitive care to patients in institutions where appropriate specialists are unavailable.

An increasing number of paramedics are being trained to render both basic and advanced life support. It is our firm conviction that physicians charged with giving medical command to paramedics should themselves be experts in emergency and critical care. Further, these physicians should have knowledge of prehospital care protocols, paramedic capabilities, field conditions and the feasibility of medical intervention under such conditions. Such physicians who provide command practice a very unique kind of medicine and should be considered specialists in the delivery of prehospital care.

In any of the six identified emergent disease categories there are clinical situations which occur, though relatively infrequent, that warrant physician specialty consultation. Examples of such include: the patient who has ingested, inhaled, or absorbed a highly toxic substance; the chronic hemodialysis patient who develops severe cardiac or nervous system disorders; the acute psychiatric patient who may be presenting a danger to himself or others. One can easily see where the availability of consultation by toxicologists, nephrologists, and psychiatrists could be crucial in limiting subsequent morbidity and mortality. This consultation can be directed to paramedics in the field or preferably to the physician giving medical command who in turn directs paramedics in appropriate actions. The above system is feasible today because paramedics are becoming more proficient and are capable of delivering very specialized care. Once the patient is stabilized, he may be transported to the closest hospital, or if his condition will allow, to the nearest appropriate facility.

The overwhelming majority of hospitals do not have house staffs, let alone in house medical specialists, to assist emergency department physicians who must diagnose and treat a myriad of clinical problems every day and more importantly, every night. The evening hours often find large metropolitan hospitals vacated of their practicing specialists and the institution is left with only one physician to cover the emergency department as well as the "house." Furthermore, in urban areas, this physician may be a moonlighter from the local medical center who is totally incapable of dealing with truly emergent and life-threatening problems. In rural areas, there is a good chance that the evening hours may find the local hospital void of any physician. The emergency department and the critical care unit may be covered by nurses who *may* or *may not* be trained in basic and advanced life support. Thus, one of the challenges that faces the EMS system is the development of a mechanism to minimize the deficiencies of hospitals who must provide immediate treatment for critically ill patients. A feasible solution to this challenge consists of the following two steps. The first being, staffing emergency departments and critical care areas by nurses, and where possible, physicians trained to provide basic and advanced life support. Second, would be the provision of accessability to *reliable*, specialty consultation. Such consultation might be used to aid in confirming or differentiating a diagnosis. It might result in the emergency physician instituting special procedures or treatment modalities. It may be used to determine the desirability of transferring a patient to a regional center, and, in some cases, may be used to determine the suitability of donor organs for transplantation patients.

In Pennsylvania we have seen numerous instances where specialty consultation by phone resulted in decreased morbidity and mortality. In one case, consultation by a neurosurgeon to a *trained* emergency department doctor in a rural hospital resulted in that doctor drilling a burr hole in an eleven year old child to relieve an acute life threatening subdural hematoma. The patient's condition stabilized and he was then transfered to the regional medical center for further treatment. The patient was discharged a few weeks later with no permanent neurological defects. This emergency doctor had never performed this procedure on a patient but did so after consultation. The neurosurgeon felt that immediate treatment was necessary and even a small delay might result in the patient's death. In another case, phone consultation resulted in a critical care physician actually going to an outlying hospital to help stabilize and then transfer a young postpartum patient with adult respiratory distress syndrome to the regional center. This patient required sophisticated ventilation techniques enroute to sustain vital functions. She left the hospital without permanent disability. These are concrete examples that clearly demonstrate the benefits of consultation. The need is to make such consultations accessible and realistic.

The Emergency Medical Services Operation Center is a project of the University Health Center of Pittsburgh. The Health Center is a consortium of the University Health Professional schools and six major hospitals. These are three major adult medical/surgical facilities, a pediatric hospital, an obstetrical hospital with an active neonatal unit and an acute psychiatric facility. There are residency programs in all major specialities and fellowships in most subspecialities including a unique training program in critical care medicine. A National Poison Control Center also emanates out of the University Health Center of Pittsburgh.

The EMSCO intends to utilize the resources of the Health Center through the use of communications networks to help improve the emergency medical service system of the region. The functions of EMSOC include providing medical command for ambulance services engaged in the provision of advanced life support in the metropolitan Pittsburgh area. This command is given by third year postgraduate house officers either from the departments of surgery or medicine who are on rotation in the emergency department. Before they are permitted to take on this responsibility they are given training in the provision of prehospital care and they must follow established, written medical protocols. A staff physician from the Critical Care Medicine Department, who has experience in emergency and critical care, is always available for consultation. The EMSOC can also link the medical command physician with specialty physicians in the Health Center. Expert consultation is available to the paramedics through the commanding physician. We are currently in the process of developing a mechanism whereby this same specialty consultation is readily available to aid professionals in all sixty acute care hospitals in the region. Thus, a physician or nurse seeking such consultation would merely contact the central EMSOC to gain access to specialty consultation. In this manner we believe we will provide appropriate specialty consultation for the entire EMS system for all of Southwestern Pennsylvania.

In summary, it is our belief that availability of specialty consultation for both pre-hospital and hospital setting enhances the provision of emergency medical services. Such consultation is dependent on the other components of the EMSS being operational, such as communications, transportation, etc. Further its successful integration of specialty consultation is vitally dependent upon having competent, well-trained health professionals including paramedics, nurses and physicians. In Southwestern Pennsylvania the EMSOC is utilizing the resources of the University Health Center of Pittsburgh, a regional health facility, to provide both medical command to paramedics and specialty consultation for health professionals throughout the region. It is hoped that the efficient utilization of available health manpower will improve the total EMS system for over the 3.2 million of this area.

CRITERIA AND STANDARDS FOR PLANNING FOR SPECIALIZED BURN AND TRAUMA SERVICES

Judith L. Wagner, Ph.D., Elliott R. Pickar, M.A., and Donald S. Trunkey, M.D.

Introduction

As part of its mission to provide improved health planning technology and technical assistance to health planning agencies, the Bureau of Health Planning and Resources Development (BHP&RD) of DHEW has sponsored the development of a series of monographs to assist Health Systems Agencies (HSAs) and State Health Planning and Development Agencies (SHPDAs) in planning for and reviewing proposals for health services in a number of categories.

The monographs present suggested criteria and standards for specific health services which can assist HSAs and SHPDAs in conducting project reviews of proposed capital expenditures pursuant to certificate of need laws mandated by the National Health Planning and Resources Development Act (P.L. 93-641). They also include descriptions of planning approaches for determining the need and/or demand for the services under study. These planning approaches serve a dual purpose: as inputs to an important set of project review criteria and as methods to support health systems plan (HSP) development.

Two specific health services covered under the study reported on here were specialized burn and trauma services. Because the focus of certificate of need review is upon expensive capital expenditures made by health care institutions, the study concentrated on projects to develop burn units or centers (the addition of bed capacity) and projects to establish or expand specialized trauma services. Criteria for planning for care capabilities at lower levels of specialization, while extremely important to total EMSS planning, were not developed as a part of the project.

History of Certificate of Need Review

Health planning agencies have been involved in reviewing proposed capital expenditures or changes in health services since 1964, when New York State enacted the first certificate of need law. This law was followed in the ensuing year by a large number of states whose concerns were for the uncontrolled expenditure by hospitals and institutions on bed capacity and capital equipment. Certificate of need laws have by and large attempted to control these expenditures by tying licensure or reimbursement to the issuance of a certificate prior to construction or purchase of a capital nature.

In 1972, the role of health planning agencies was strengthened by the Social Security Amendments of 1972 (P.L. 92-603). These amendments added Section 1122 to the Social Security Act. It provided that health care facilities and HMO's would not be reimbursed by Medicare, Medicaid, or the Maternal and Child Health programs for depreciation, interest or return on equity capital relating to capital expenditures that were determined by designated planning agencies in the individual states (usually the comprehensive health planning agency) to be inconsistent with standards, criteria or plans developed by the state agencies. This important provision related health financing to health planning in a major way and has since been reflected in almost all major proposals for national health insurance through a series of devices intended to insure that national health insurance does not pay for costly services which the planning process determines are unneeded.

P. L. 93-641 has consolidated and strengthened the mandate for review of proposed capital expenditures by health planning agencies. This Act established a system of health systems agencies (HSAs) and State Health Planning and Development Agencies (SHPDAs) with a broad mandate to plan and review health services within their jurisdictions. Specifically, each SHPDA must administer a state certificate of need program which applies to new institutional health services proposed to be offered or developed within the state. This certificate of need program must meet certain requirements specified in regulations and must be enacted before the end of the first regular state legislative session following the development of regulations. Proposed regulations require that the state certificate of need program provide sanctions such as denial or revocation of a license to operate, civil or criminal penalties or injunctive relief to assume that only those new institutional health services which are found to be needed shall be offered or developed.

In addition to administering a state certificate of need program, the SHPDA must also act as the designated planning agency for review and approval of proposed capital expenditures under Section 1122. Furthermore, Section 1513(f) of P.L. 93-641 requires the HSA to review and approve the health resources use of federal funds in the health service area allocated under the Public Health Service Act and certain other health related acts.

Each of these review and comment or approval functions requires the appropriate agency (HSA or SHPDA) to apply criteria developed and published in accordance with procedures specified in regulations. The broad criteria which must be considered are outlined in Section 1532(c) of the Act. The law explicitly states that the review criteria used by HSAs or SHPDAs "may vary according to the purposes for which a particular review is being conducted or the type of health service being reviewed."[4] The purpose of the monographs developed in this study were to provide detailed criteria within the broad criteria required by law which are relevant to the review of proposed burn and trauma projects. The criteria for specialized burn or trauma services are intended to be used as a basis for decisions about whether a particular hospital should be allowed to establish or expand its burn or trauma treatment capability.

Categories of Criteria

The broad categories of criteria specified in P.L. 93-641 include the following considerations: the relationship of the proposed health services to the applicable HSP and AIP; their relationship to the long range development of the parent institution; the need for such services; the availability of alternative methods of providing such services; the relationship of the services to the existing health care system; the availability of resources for the provision of the services and

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the availability of alternative uses of such resources; the special needs and circumstances of regional referral centers; and the costs, methods, and impacts on the costs of providing health services by the project applicants of any construction project.

These general areas formed the basis for the development of criteria and standards for review of project applications for burn and trauma services. The first step in the development of these criteria was to specify criteria categories which would cover all aspects of service delivery and resource allocation in the two health services which should be included under these broad categories. The set of working categories that was developed are the following: need/demand; relationship to existing system; accessibility; community participation or endorsement; provision of services; coordination of services; patient review and program evaluation; patient records; volume of services; financial management and organization; educational activities; accreditation; medical personnel; other health personnel; administrative personnel; facilities; equipment; capital costs; financial position; program efficiency; and patient and family rights.

One or more criteria were developed in each of these areas for each of the services. Criteria were developed by a combination of a literature search and a panel of experts composed of experienced clinicians, planners, and financial administrators. Criteria were included only if they were considered important for the review of the burn or trauma services.

Highlights of Criteria for Burn and Trauma Services

The criteria that were included in this monograph covered a variety of different areas related to burn and trauma services. The specific criteria included in each of the two criteria sets addressed the particular needs of each health service. Therefore, for the most part, the criteria specified for burn services differed from those specified for trauma services. Some examples of the criteria included in each set follow.

CRITERIA FOR BURN SERVICES

The following represent some of the system-oriented criteria to be used in reviewing applications for burn services:

Existence of Unmet Need for Burn Beds at Proposed Level of Specialization The number of burn beds proposed shall not exceed the unmet need for beds in the facility's service area.

Existence of Appropriate Referral Patterns Referral arrangements reflecting cooperation among all health care providers to assure the proper distribution of patients among specialized and non-specialized services should be developed and demonstrated in the project application.

Maintenance of Burn Registry Plans for collecting and maintaining a registry of all burned patients should be developed. The proposed burn facility should contribute to an areawide or regional registry if one exists. If none exists, it should consider initiating one.

Availability of Consulting Specialists Physician specialists often required as consultants to burned patients should be available on an as needed basis. Such physicians include: opthalmologists, orthopedic surgeons, otolaryngologists, pathologists, pediatricians, psychiatrists, and urologists.

CRITERIA FOR TRAUMA SERVICES

The following are specific criteria which were developed for review of specialized trauma service applications. These few criteria were chosen from the total set of trauma criteria that were developed as part of the project for the purpose of illustrating the nature of the concerns which review and comment should address.

Relationship to Existing System The impacts of the proposed trauma service on the existing EMS system and the impacts of the available EMS resources on the proposed trauma service should be carefully considered.

Relationship of the Area Emergency Transportation System to the Trauma Service An important factor affecting accessibility of a trauma service to the public is the availability of the emergency transportation system. The trauma service must be consistent with this resource.

Communication between Trauma Service and Emergency Transportation Vehicles Communication equipment for in-hospital coordination and for direct two-way communication between the trauma service, emergency vehicles, public safety agencies, dispatchers, and other hospitals is required in the trauma service.

Existence of a Qualified Trauma Team The trauma team should include board certified or eligible physicians in the following specialties: general surgery, orthopedic surgery, neurosurgery, and anesthesiology.

CRITERIA AND STANDARDS AND FACILITY CATEGORIZATION

A major initiative of the federal EMSS program has been the categorization of existing emergency care capabilities in order to establish a coordinated system of patient placement and transfer. Categorization of facilities according to their general EMSS capabilities (horizontal categorization) and according to their capabilities to deliver care within each of the seven emergent conditions (vertical categorization) has been attempted by a number of EMSS grantee agencies using a variety of horizontal and vertical categorization criteria developed by groups throughout the country. The vertical categorization criteria for burn and trauma services have attempted to differentiate among successive levels of care capability on the basis of the availability of personnel, equipment, and ancillary services.

These categorization systems are directly related to the planning criteria developed under this study, and, indeed, some categorization criteria systems were used as background for criteria development in this project. The need for consistency between criteria used for categorizing existing facilities and criteria for approving new or expanded facilities is obvious. Because expenditures for a new or expanded facility should be approved only if the services are actually needed, the HSA must be able to assess the degree to which services at the proposed level of care are already being provided in the community. Furthermore, if categorization of existing facilities uncovers serious gaps in care capabilities to specific target groups, then the need for expansion or establishment of new facilities is identified. Consequently, the planning criteria for manpower facilities, and ancillary services were developed to be consistent with the best vertical categorization systems existing at the present time. (Because a single, universally accepted, set of vertical categorization criteria has not been developed, perfect consistency could not be obtained.) However, the planning criteria specified in these categories focused on the highest levels of care, since these were the vertical categories of care for which expensive capital expenditures are most likely to be proposed. In the case of burn treatment services this meant focusing on criteria for facilities meeting the burn unit definitions of Stone and Boswick;[8] for trauma services our criteria focused upon the criteria for "optimal care" as proposed in draft guidelines under development by the ACS Committee on Trauma.[1]

Determining the Need for Burn and Trauma Services

Part of the study involved the identification and evaluation of existing methods for determining the need for burn and trauma services, and the development, where, necessary, or new approaches for needs assessment.

NEEDS ASSESSMENT FOR BURN SERVICES

The planning approach for burn services calls for the determination of the number of specialized inpatient beds required in a planning area. Inpatient beds served as the proxy measure for all resources required in the delivery of specialized burn services. Determination of burn bed requirements is, essentially, a three step process: 1) estimate the total number of admissions to specialized burn facilities expected to occur in the area during a particular time interval (preferably one year); 2) translate the number of expected admissions to the number of beds which are sufficient to meet the bed requirements of this number of admissions; and 3) determine the difference between the estimated bed requirements determined in the second step and the actual number of beds already available. Methods for accomplishing each of the three steps were selected for the study. For the second step, the translation of an admission flow into bed requirements, three alternative methods were presented, the first based upon the Feller and Crane formulation;[2] the second and third on stochastic models of burn arrivals and service.[3,7]

NEEDS ASSESSMENT FOR TRAUMA SERVICES

Any method to determine the need for trauma services must meet certain conditions. The first and most important condition is that the methodology address the basic tradeoff in health planning—cost vs. quality. In this case, quality is reflected in the time accessibility of victims to a facility capable of providing the appropriate level of care. High accessibility transport capability, and hence, high costs of providing that level of accessibility.

The second major requirement of the method is that it determines the need for facilities with specific, well defined care capabilities. Ideally, the method should identify an appropriate heirarchy of trauma care capability of emergency facilities which corresponds to distinct levels of severity encountered in trauma victims.

The third requirement is that the methodology for determining the need for trauma services must be capable of integration with plans for other components of the EMS system. The appropriateness of a particular configuration of trauma facilities in a region depends largely on the nature of other components of the system. The methodology developed for planning trauma services should be equally valid for a region with helicopter or air evacuation services as it is in a region with only the most conventional forms of emergency transportation.

The methodology suggested in the trauma monograph meets these conditions. It determines the minimum number (and locations) of trauma facilities in a network region which are necessary to provide a specified level of time accessibility to a given target population. The method uses time to reach the facility as a proxy measure for quality and the number of facilities as a proxy measure for costs. Therefore, minimizing the number of facilities subject to constraints on the time required to reach a trauma facility from any possible location in the area will give an optimal solution to the problem. It should be noted that this approach can be used for all levels or categories of trauma facilities (on a vertical categorization scheme).

The method for solving the problem as stated above is provided in the monograph for trauma services. It applies a mathematical integer programming technique that was suggested originally by Toregas and ReVelle[9] for solving this class of facility location problems.

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The Role of Federal Organizations in EMS

THE INTERAGENCY COMMITTEE ON EMERGENCY MEDICAL SERVICES

Robert van Hoek, M.D.

The Emergency Medical Services Systems Act of 1973 (P. L. 93-154) provided statutory authority for the establishment of an Interagency Committee on Emergency Medical Services. The function of this Committee is to provide for coordination and information exchange among Federal programs involved in EMS and to advise the Secretary of HEW on the conduct and administration of the activities authorized under the EMSS Act.

The Committee is composed of five public members appointed by the President and representatives from 23 Federal departments and agencies. The Committee has formed four work groups to assist in the detailed work. The Work Groups are for: (1) communications, (2) transportation, (3) manpower and training, and education, and (4) finance and administration. The Work Groups are chaired by a member of the parent Committee and include representatives from each of the departments and agencies.

In the late 1960's there was a great deal of professional advice given to states and local communities to form Emergency Medical Service Councils. These councils were to assist states and local communities in developing their EMS plans and to provide continuation of advice and consultation during implementation and operational phases. It was appreciated at that time that the EMS problem is not just a health problem. It requires the added participation of many scientific, engineering and medical interests, if the total system's approach is to be used.

In 1972, when the Presidential Initiative on EMS was undertaken, it was immediately appreciated that there was no Federal EMS Council. At that time we organized an Interdepartmental Committee on EMS to begin to talk about many of the issues of standards, funding and the exchange of technical information. This Committee was reestablished by the statutory authority of the EMSS Act in 1973. Since that time, the Committee has met five times.

In establishing the Interagency Committee on Emergency Medical Services, a major decision had to be made as to whether this Committee would be composed of individuals representing the senior policy level of each of the major federal agencies. After reviewing many of the topics to be discussed, and in view of the requirement that the Committee meet at least four times a year, the decision was made that the Federal representatives would be from the senior technical staff so that prompt and timely discussion could develop on many of the programmatic issues which are currently open for improved coordination and information exchange. It was also recognized that senior programmatic representation would lead to appropriate staffing and presentation of policy issues developed by the Committee for subsequent presentation to the Department Secretaries.

Before discussing accomplishments of the Committee, I would mention that the Committee has gone through the initial period of adjustment. There is now good and open discussion about interdepartmental problems and issues among the representatives that make up the Committee. A great deal of the apprehension and guarded speculation with regard to the purpose and activities of individual representatives of the Committee have been addressed and no longer exist.

The Committee activities during its formal sessions have involved both an educational process about the multiple activities of the Federal Government in the field of EMS, and substantive discussion of numerous problems of coordination and standards. The Committee has completed or has in process the following activities:

1) The Federal Resources Guide for Emergency Medical Services has been completed. This Guide lists 64 Federal programs that provide funds, services, or technical assistance to States and communities. This Guide will be available to all of the participants of this Workshop and represents an up-to-date listing of individual programs, their scope of activity, type of assistance, funding cycles, and the office to contact for additional information.

2) Within the next 30 days, it is anticipated that the curriculum for the Emergency Medical Technician-Paramedic (EMT-Paramedic) will be completed. This is a contract effort which was initiated by the Department of Transportation with the University of Pittsburgh. The Interagency Committee became involved just as the contract with the University of Pittsburgh was being finalized. The Committee recommended to DOT that the selection and technical review of the curriculum be made by a cognizant group of Federal and non-Federal technical experts. As a result of the significant progress that has been made, a modular curriculum for EMT-Paramedic has been completed and is in the process of final review by the review committee. Then, the National Registry for Emergency Medical Technicians, the National Academy of Science, EMS Subcommittee, the Department of Transportation. Highway Safety Program for Standard 11, and the HEW Bureau of Health Manpower and Divison of Emergency Medical Services, will endorse this single program. This endorsement will then be presented to the Interagency Committee for formal recognition as the Federal curriculum. It is anticipated that this curriculum will be supported by HEW, DOT, Appalachia, LEAA and the other agencies that fund training of Emergency Medical Technicians.

3) The Committee has initiated a study by the Transportation Work Group to develop a standard for the patient compartment of air ambulances. The Department of Transportation is working with HEW and other organizations on that standard.

4) The Committee is in the final phase of reviewing a document on Planning an EMS Communications Subsystem. A subsequent document on EMS Communications Operations is also under development by the Communications Work Group.

5) The Committee has listened to a report by the Food and Drug Administration on Poison Control Centers. The HEW, EMS Program and the Poison Control Program have agreed to staff a reexamination of how EMS and the Poison Control Program can be better coordinated.

6) The Committee has also requested that the Finance and Administration Work Group work more closely with the emergency Health System Agency Program (P.L. 93-641) to coordinate EMS planning and operational activities with the HSA organizations.

It is anticipated that during the extension of the EMSS Act one or more reports will be required of the Interagency Committee to improve Federal coordination.

In summary, as Chairman of the Interagency Committee on Emergency Medical Services for the past year, I think that this Committee has been productive in meeting its chartered mission of providing exchange of information and coordination among Federal programs. A great deal of additional work needs to be done, and the Committee and its membership have set the proper ground work to undertake these future problems.

A STRATEGY FOR MORE RESPONSIVE FEDERAL COORDINATION IN EMS

General D.G. Penterman (Ret.)

I would like to present one of the great problems facing the public safety operational structure of our state and local governments today.

In the opinion of many, and I believe you will agree, it is of immediate and grave concern because it effects the day-to-day working patterns of every segment of our public and the agencies they support or represent.

Nowhere is the urgency for *coordinated action* more pronounced than in the development of emergency capability to respond to the public needs under life threatening or physical harm conditions. I, of course, am referring to Emergency Medical Services.

Senator Cranston, in delivering his supporting comments for the extension of the Emergency Medical Services Act of 1973, before the Senate Committee on Labor and Public Welfare this year, expressed his concern with these remarks which I believe are truly stage setters for the task we face today.

I quote from Senator Alan Cranston's remarks of January 23, 1976:

> The complexities of coordinating the many resources and governmental units required to provide the broad range of care and services needed to meet the medical emergencies of a community are a major deterrent to the development of a system. Convincing the medical facilities in an area of the importance of accepting categorization even though it may mean they must share specialized resources with other facilities—is not an easy task. And the desire of units of local government to be totally independent of other jurisdictions in caring for the immediate medical needs of their residents, though certainly understandable, is another enormous barrier.
>
> However, for comprehensive emergency medical services to be provided and to be accessible and affordable, all the elements within a goegraphical area must be brought together, and must work together, in a system to serve everyone equally in that area.
>
> I believe the only way we will develop emergency medical systems capable of providing the services communities need is through the use of front-end federal grants to serve as an incentive to the elements within a community to come together and pool their resources to develop a comprehensive emergency medical services system. That system is the goal of the Emergency Services Systems Act.

Since the publishing of the National Academy of Sciences Report in 1966, "Accidental Death and Disability, The Neglected Disease of Modern Society", state and local governments and medical agencies have made significant progress in the development of Emergency Medical Services (EMS Systems and the supporting element centralized/coordinated Communication Systems.

Encouraged by the interest, direction and limited funding from some federal agencies and philanthropic foundations the past three years have seen strong growth in awareness and public demand for action. During this same time period, continually surfacing during meetings at all levels of government, have been two primary questions:

1) Who is really responsible to establish, fund, operate and maintain an EMS regional system serving multiple political jurisdictions and,

2) How can Federal-State-Local funds, now being expended by the many multiple disciplines of government, be effectively coordinated to design and support an EMS Regional System?

It is the latter question, coordination of direction and funding, this paper will address.

We must without delay establish the mechanism for putting order into the expensive, chaotic clutter of federal programs which are currently overlapping and duplicating.

Mr. Gregory J. Ahart, of the U.S. General Accounting Office, testifying before the Senate subcommittee on Health and Public Welfare on the extension of the EMS Act of 1973, on January 23rd of this year, put it this way:

> Federal funding for emergency medical services (EMS) has been provided to local communities on a fragmented basis. Eleven Federal programs, primarily in the Department of Transportation (DOT) and the Department of Health, Education, and Welfare (HEW), provided funding of over $122 million between 1966 and 1973 for various EMS components, such as ambulances, communications equipment, and training of attendants. In addition, several other Federal programs have indirectly supported EMS components. However, the Federal programs had not been coordinated for development of comprehensive regional EMS systems.

Local progress is being impeded and effectively arrested by the confusion of Federal guidance, primarily differences in home, highway, recreational and disaster programs. Separate programs going their own way attempting to create a Medical System to serve one need when a common system of high quality and effectiveness would be more economical and certainly less confusing to the public it is intended to serve.

Technical design is not a problem. Technology is far ahead of the system organization. Modern telecommunications can bring the distant assistance—near and now—can make a village of the world—can make a village of any region or area we choose to organize.

Studies and analysis have revealed that extensive medical programs and response systems, with supporting telecommunication capability are now in existence. The logical step is to encompass these existing capabilities into a centralized/coordinated EMS System and develop a cost-share formula acceptable to all concerned (especially the Federal accounting office). Existing federal programs must not only produce guidelines in funding to allow such cost-sharing but must establish multi-agency staff arrangements to encourage and remove the roadblocks to the implementation of joint-agency support plans and operational systems. (The present Federal Act encouraging multi-agency grants is plainly not working.)

Experience in separate pilot projects conducted by HEW, DOT, State and local governments indicate that certain distinct collateral advantages accrue to those regions/communities that engage in coordinated public safety, security and emergency services planning:

Improving capability to deal with public emergencies regardless of degree, magnitude or location.

Improved coordination in all government operations.

Economics resulting from improved use of existing resources.

A reliable information base for decisions by governing or responsible bodies on budgeting and coordinating systems and methods used by the several agencies.

The National strategy must be a program acceptable to all agencies, compatible with and serving their responsibilities, while developing a medical response capability based on the fundamental precepts of 1) planning and preparing for the most effective use of existing resources; 2) development of linkages, operational guidelines, and additional means to assure effective coordination and 3) simplified public access to emergency medical care and prompt assistance.

A primary purpose of this paper is to outline a strategy for improved federal coordination of the more than 60 federal programs of numerous departments and agencies which can and do provide guidance to state and local governments for perfecting EMS Systems.

In providing this stragety you will readily note that elements of the entire system are defined with a suggested method for identifying lead agency assignments. It is not the intent of this paper to leave the impression that the agencies so identified herein are to be exclusive or final. Rather it is intended to provide a format for systematically looking to agency capabilities and responsibilities as pertain to EMS System element development. It is my belief that the agency assign-

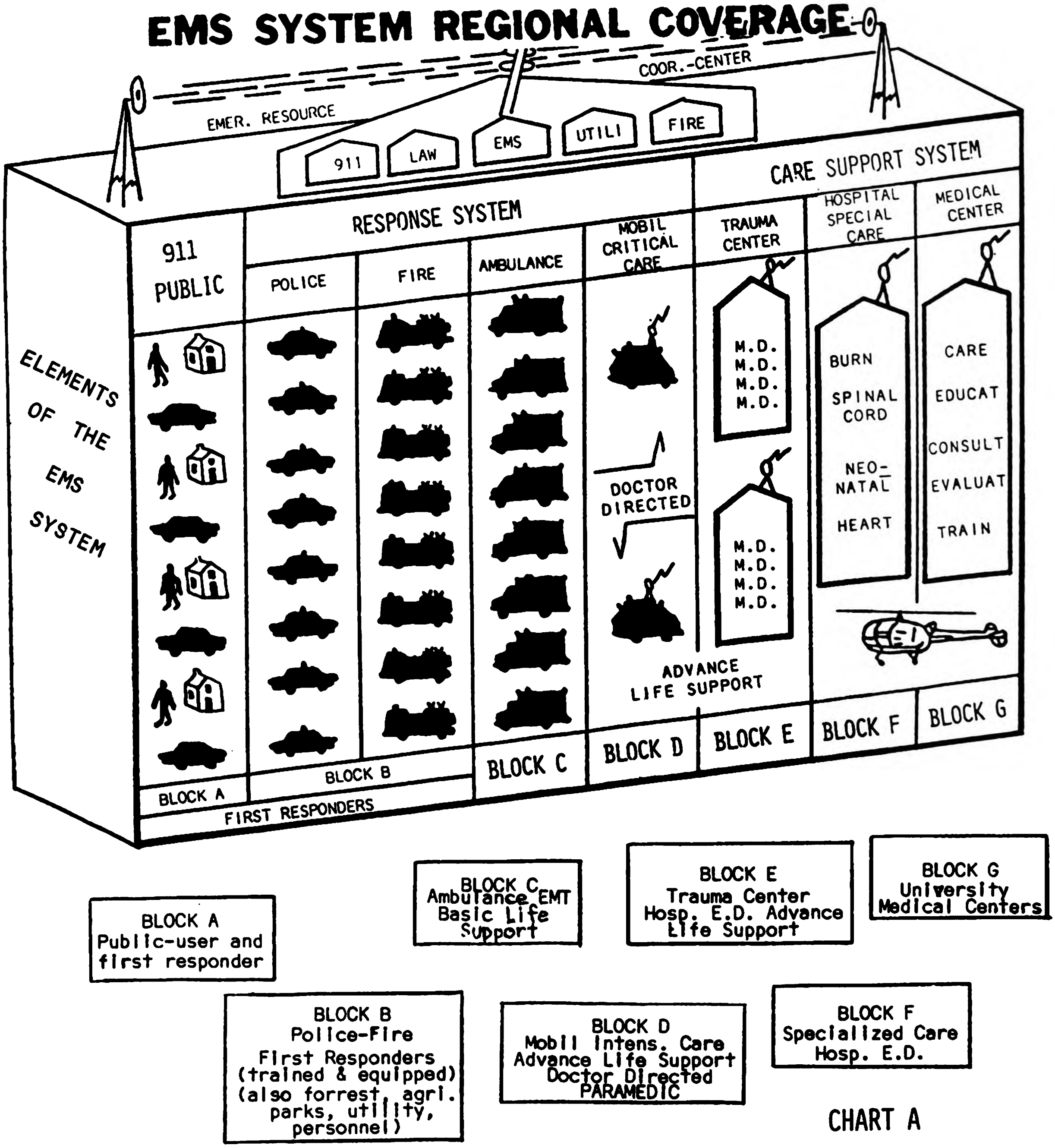


CHART A

ment remains as an urgent task for the Inter-Agency Committee on EMS—as defined in the EMS Act of 1973. This approach, assigned agency responsibility in a template, is also intended to underscore all of the elements of a complex, multi-agency supported system. In attempting to present a complete picture of an EMS System in a short period I recognize that I am running the risk of undertreatment of some really important points as we attempt to focus on the objectives for a National Strategy.

Suggested National Strategy Objectives

The Federal objectives should be to establish a coordinated system of Regional Emergency Services for each state (Emergency Resource Management Program.) To achieve these broad objectives, there are two subobjectives:

1) Coordinated guidelines (all Federal Agencies) for defined standards for operations, equipment and training.

2) The development of a capability for state level direc-

tion and coordination of multi-agency emergency resource systems, by projecting uniform operational procedures, guidance and standards for community (region or area) development. Making mutual aid arrangements which assure prompt emergency assistance to people at home, work or play, on the streets, highways, or recreational areas.

To establish "effective operational capability" states must develop a programs consistent with federal guidelines, which contain the following elements:

1) A clearly recognized authority to make decisions that are promptly provided under the full variety of public emergency circumstances.

2) An organization appropriate to the complexity of the great variety of emergency responsibilities that have to be performed.

3) Appropriate coordinated systems, procedures, standards and data to insure economic and efficient management and utilization of emergency services resources in the public interest.

Eight Specific Recommendations For Improving Emergency Service Systems

The progressive improvement of medical emergency service systems will be fully effective only if each government and governmental agency is able to respond to its proper responsibilities through contributed planning to a total system which develops "coordinated team action" utilizing highly professional and competent services. The first requirement, therefore, is to establish the organizational framework under which total system planning can be accomplished.

#1 - RECOMMENDATION - DHEW should, without delay, through the interagency committee for EMS, publish coordinated guidance and direction to the Federal Regional Offices, States and local EMS organizations. Such guidance shall clarify and direct the coordination of Federal funding and technical assistance as now available. (Chart B)

At present, development and operation of Emergency Systems has been left to the individual agencies within each level of government and to various components of the departments.

Mr. Ahart of G.A.O. stated it this way, in his recent report on January 23, 1976, to the subcommittee of the U.S. Senate:

> Various federal agencies administer programs which relate to one or more aspects of EMS System development. Coordination among these agencies is limited. Therefore, applicants for development assistance may not be receiving the full range of Federal assistance available.
>
> The EMS Act provides for HEW to take the lead role in promoting coordination of system development efforts with Federal funds. It provides for HEW to establish an interagency Committee on EMS. The Committee is responsible for promoting the exchange of information necessary to maintain a coordinated and effective development program. The act further provides for HEW to consider the funding available to applicants from other Federal programs in making grants under the act.
>
> At the time of our field work, the Committee had issued no coordination guidance or direction to the Federal regional offices. Consequently, Federal regional personnel and potential grantees are left to their own devices to identify and coordinate the use of Federal funds for EMS. As pointed out by one grantee, lack of awareness of other programs might have caused them to miss other funding sources.
>
> In addition to the EMS grantees, other organizations in some regions received funds for EMS activities from several Federal funding sources. Use of Federal funds by many of these organizations was not controlled by or coordinated with the designated EMS system management entity and may impede rather than stimulate regional development.

Existing systems vary in capability and staff interest for responding to the varying kinds of requests for emergency assistance. These system variations and differences lead to procurement of incompatible equipment, produce incompatiable data, fail to make effective use of existing communications networks and generally neglect the information needs of officials having government-wide responsibilities.

Today's complex public service problems usually require the coordinated action of several departments and agencies in order to work out acceptable solutions and provide the effective flow of emergency services—properly coordinated. The public should not be left to sort out the details of emergency help required or on who's responsible for the piece of ground they're standing, in order to solicit help.

#2 - RECOMMENDATION - The Federal government should encourage the creation of an Emergency Services Action Council in state, regional and local governments, thereby providing a means by which all agencies may supply representative views and provide collective thought towards a common coordinated Emergency Services Response System which the public fully understands. (Chart B)

Although persons, responsible for the operation of the various emergency service and public safety agencies, recognize the urgent need for planning and testing teamwork, many are frustrated in their efforts to obtain useful consultation for coordination of plans or the development of operating procedures which would provide action interface and equipment compatibility with other services.

Existing state and local safety councils could be substantially strengthened if they could tie accident and safety education to a program of quality service promptly responding "when safety fails." These state and local safety councils might well provide the channel for promoting public education and understanding of the community emergency resources response system. Even dial for advice can prelude an emergency from developing.

In most cases, the federal funds provided to separate programs preclude or discourage multi-function thinking for use of dollars. A prime example—a helicopter procured from DOT (Transportation) funds for highway services cannot legally be used for law enforcement. States and local governments are advised that separate LEAA Funds are available to procure a duplicating, expensive piece of equipment. (Idle time and cost effectiveness problems become readily evident to local officials.) In other words, separate function federal programs insist on separate procurement or separate staffs so that the auduit trail for expenditures remains clear. Problems of cost effectiveness, to maintain and operate equipment and utlize staffs, is "passed off" as a state or local problem.

#3 - RECOMMENDATION - That the Interagency Committee serve as a focal point for the establishment of standards for training EMS staffs, equipment procurement and operational procedures obtained from the results of multi- or single-agency program studies.

Many communities, organizations or individuals throughout the nation are striving to improve emergency medical care, recognizing that a wider Medical Emergency Care System is needed. Research action funded by many federal agencies is prevelant. We must recognize these research efforts to be a matter of national concern. There are goals to be established

JURISDICTIONAL COORDINATION STRUCTURE

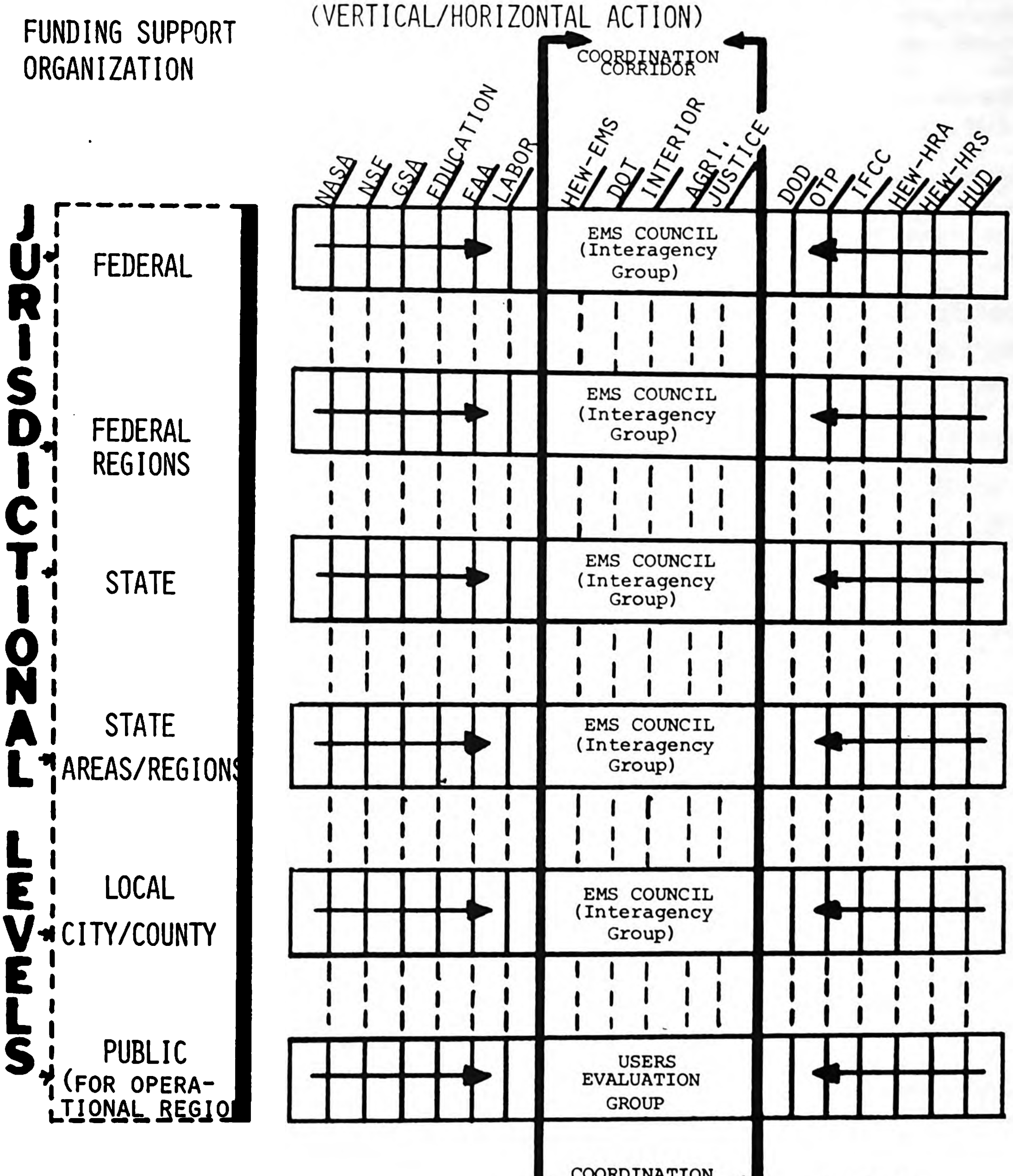


CHART B

and attained and problems to be solved; however, some planned uniformity should be maintained. There should be a provision for exchange of information and ideas when developing a system of this magnitude and importance.

Although the federal government is currently involved in many medical programs, none of these programs afford sufficient guidance to the states for the establishment of coordinated emergency medical care. If the emergency care system is to be effective and efficient, there must be some uniformity in standards. Standards must be developed for communication systems, for training, for licensure and for medical equipment in ambulances and hospitals as they relate to emergency care.

In order to improve efficiency of operations in terms of speed and accuracy, there is a definite need to establish a common language that can readily be understood by all personnel associated with handling and processing emergency life saving actions. There is a requirement for clear and concise communications systems and codes between ambulance attendants, professional medical personnel, law enforcement personnel, telephone/radio communications personnel and other emergency vehicle operator personnel. A common glossary of terms is essential and should be incorporated in all training programs.

#4 - RECOMMENDATION - the Federal government should recommend that responsibility for the planning and coordination of emergency medical programs be fixed at the Chief Executive level of the state. The National Governors Conferences should be encouraged to establish a Committee for EMS.

The need for coordinated action through a central agency becomes unmistakably clear when one examines pilot studies and national reports all containing broad, real world experience with extensive backup data. Over 500,000 Americans die each year of accident injuries and heart attacks and over half of them are dying prior to reaching a hospital. Contributing factors to this condition are many and varied. However, one of the most prominent and probably most contributing to loss of life is conflicting instructions for public access, between action agencies or the lack of fingertip access to resources available (skills and machines). "Today—who is really responsible for operating an EMS Life-Saving System?" The slow action of local officials in community planning can be attributed primarily to lack of overall guidance from a central agency. Also, it is evident that, although a number of state agencies have resources which should be utilized in the development of a coordinated system of emergency medical services, they tend to work independently unless central guidance exists and insists.

#5 - RECOMMENDATION - the Federal agencies should insure that all EMS research projects have a federal multiagency research supervision team established to select, observe and monitor the project as it progresses.

Research for improvement in methods for providing the standards and specifications data for the procurement of equipment, facilities, and services must continue. There is a strong need. Technology, properly handled, is effective economical and essential.

During the period of project research interest is normally high; many untested, partially completed exploratory findings are carried away and even known to be started through costly piece-meal development because public interest is aroused. (*i.e.*, citizen band radio usage—DOT Federal project 1968-69. Yet the "hello" end of the Motorist Aid Communications Network has not been developed). Central Federal Agency guidance and coordination of available technical assistance program areas is lacking.

#6 - RECOMMENDATION - That action be taken to standardize equipment used in conjunction with emergency medical care within all emergency service functions (ambulances, police, fire, wreckers, rescue, mobile/critical/care units, etc.)

Benefits that would be derived from utilizing standard equipment are far-reaching. It would speed up procurement time and reduce equipment costs. It would simplify maintenance. It would simplify and reduce training for equipment operators, allow interchangeability between services. (Equipment could range from backboards to portable radios.) Finally, it would assist in the development of uniform or standard operating procedures.

#7 - RECOMMENDATION - That the elements of the "Total EMS System" as subsystems be allocated to specific agencies of government for development responsibility. (Chart C).

The presently fragments, uncoordinated, separate services cannot be effectively pulled together into a workable total system until specific agency responsibilities are clearly defined, either as supporting or lead agency responsibilities. The following suggestions are not intended to be firm or complete. This printed "task identification" is only intended to provoke thought for final decision by the Interagency Committee.

Possible Sub-division of Element Responsibility (As Lead Agency), might be:

A. Total System Coordination:
  1) Development - HEW/EMS - (With DOT- and LEAA Close Coordination)
  2) Coordinated Training Exercises
     DOD - (Defense Preparedness)
     DOT - (Highways)
     Agricultural - (Farms-Forests)
     Interior - (Parks)

B. Public Access - Sub-System - (As a National Emergency Reporting System):
  1) Common Emergency Telephone Number (911)
     LEAA Program - Development
     HEW Education Departments - Public Education
  2) Use of Mobile Radio on Highway for Motorist Aid (Includes Citizen Band Radio)
     DOT - System Development
  3) Mobile Radio in Use by Agencies
     Agriculture - Farms-Forestry
     Interior - Park Services
     REA - Electrical Utilities

C. Central-Coordinated Communications - An Operational Sub-System Serving a Community, Region or Area:
  1) Facility and Communication System - DOD (Civil Preparedness) and FCC
     Utilizing Existing Federal Civil Defense Guides as Possible Base:
       Part E - Chapter 3 - Emergency Communications
       Part E - Chapter 2 - Emergency Operations Centers
       Part E - Chapter 9 - Law Enforcement During CD Emergencies
  2) Public Access by Common Emergency Telephone Number (911) - Developed Nationwide - HEW - EMS
  3) Add-On-Automated Surveillance and Reporting Heart, Cancer, Stroke Patients - HEW - HSA
  4) Add-On-Automatic 911 Caller Location Identification - LEAA
  5) Add-On-Drug/Poison Information Center - HEW
  6) Add-On-Hazardous Commercial Chemical - Information Center - HEW - HSA

D. Response Vehicles - Sub-System:
  1) Ambulance (Basic Life Support Level) - With On - Board Equipment, Including Communications
     Base Vehicle - DOT
     Personnel - Training and Standards - DOT
  2) Mobile Critical Care Units - (Advanced Life Support Level - Physician Directed) - Vehicle, On Board Equipment, Personnel Training, Etc. - HEW - EMS
  3) Police Units - LEAA (EMS Service, Training & Equipment)
  4) Wrecker Services - DOT (EMS Service Training & and Equipment)
  5) Fire Units - DOT (EMS Service Training and Equipment)

CHART C

EMERGENCY FUNCTION AND AGENCY ASSIGNMENTS BY EMS SYSTEM ELEMENTS

BLOCK	EMS FUNCTION / AGENCY	HEW								DEFENSE									
		EMS	HRA	HSA	DOT	Justice Dept. LEAA	AGRICULTURE	INTERIOR	HUD	DCPA	ARMY NG	LABOR	GSA	FAA	FCC	Education HEW			
A	PUBLIC - (911) -	P			S	S	S	S	S										
A	(1) EMS System Information	P			S	S	S	S	S				S			S			
A	(2) Medical Education	P			S	S	S	S	S				S			S			
A	(3) Research	P			S	S	S	S	S			S				P			
B	FIRST RESPONDERS																		
B	(1) Police	S				P													
B	(2) Fire	S				P	S	S	S										
B	(3) Utilities	S						P											
B	(4) Parks	S						P											
B	(5) County Agr. Agents	S			S		P	S											
B	(6) Forest Service	S			S		S	P											
B	(7) Research	S			S	S	S	S				P	S			S			
C	AMBULANCE																		
C	Equipment	S			P		S	S											
C	Staffing	S			P		S	S				S							
C	Communications	S			P		S	S				S							
C	Research	S			P		S	S											
D	MOBIL CRITICAL CARE UNIT (Air and Ground)																		
D	Vehicle	P			P														
D	Staff	P			S							S							
D	Equipment	P			S														
D	Research	P			S														

Continued on next chart

6) Specialty Care Centers (Trauma, Neo-Nat, Burn, Etc.) - HEW - EMS
7) Hospitals, Emergency Departments, Doctors, Nurses - HEW
8) Sheriff Units - LEAA
9) Helicopter (Multiple Purpose Vehicles - Priority to Ambulance Use) - DOT (Properly EMS Equipped and Staff Trained)

E. Specialty Care Facilities - Sub-System:
Hospital or Emergency Aid Stations - HEW
3) Police Units - LEAA (EMS Service, Training & Equipment)
4) Wrecker Services - DOT (EMS Service Training and Equipment)
5) Fire Units - DOT (EMS Service Training and Equipment)

CHART C-continued

		HEW								DEFENSE						
		EMS	HRA	HSA	DOT	Justice Dept. LEAA	AGRICULTURE	INTERIOR	HUD	DCPA	ARMY NG	LABOR	GSA	FAA	FCC	Education HEW
E	EMER. DEPT. HOSPITALS TRAUMA CENTERS	P			S		S			S						
E	Facility	P			S		S			S						
E	Staff	P			S		S			S		S				
E	Equipment	P			S		S			S						
E	Research	P			S		S			S						
F	HOSPITAL-SPECIALITY CARE															
F	Facility	P			S		S			S						
F	Staff	P			S		S			S		S				
F	Equipment	P			S		S			S						
F	Research	P			S		S			S						
G	MEDICAL CENTER UNIVERSITY															
G	Facility	P			S		S			S						
G	Staff	P			S		S			S		S				
G	Equipment	P.			S		S			S						
G	Research	P			S		S			S	P					
H	CENTRAL COMMUNICATIONS	P			P	P				P	S					
H	Facility	S			S	S				P	S					
H	Staff	S			S	P				P	S	S				
H	EQuipment	S			S	S				P	S					
H	Technical assistance				S	P				S	P					
I	OPERATIONAL MANAGEMENT															
I	Office	P														
I	Staff	P														

P - PRIMARY RESPONSIBILITY - S - SUPPORT RESPONSIBILITY

NOTE - The above chart is not intended to be all inclusive or totally representative of local or state government. However, in general, agency functions will indicate a common flow to identify responsibility.

EMERGENCY FUNCTION AND AGENCY ASSIGNMENTS

BY EMS SYSTEM ELEMENTS

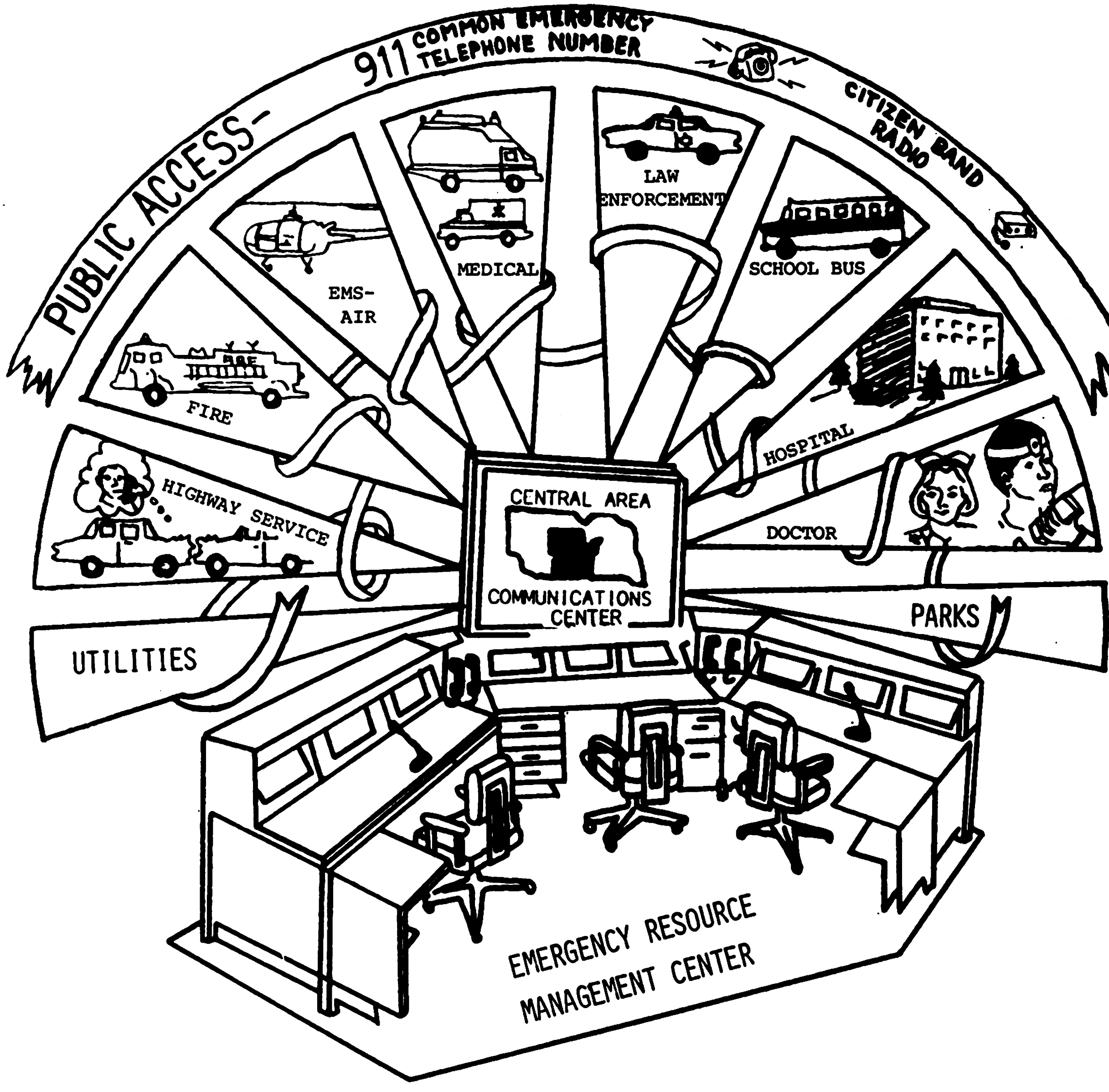
#8 - RECOMMENDATION - Because of the essential nature of telecommunications to the effective EMS system, it is recommended that a separate entity (task group) be established under the state council (Recommendation #2) to deal with statewide communication system development. (Chart D)

The very vital link, to effecting prompt service, teamwork and mutual aid is communications. The need is for the many separate service systems to be coordinated into a total use system, which will create the capability of "mobile unit cross-talk" and "radio/telephone cross-patch", thereby, serving the "on-road or in-field task forces" of multiple services responding to vast variety of incidents.

Today's telecommunication technology is not the problem ...... the lack of organization to effectively use existing technology is!!! Bottlenecks to acquire and use available "service cross-talk-or sensor/paper technology" are pri-

CONSOLIDATED/COORDINATED COMMUNICATION CENTER

WITH IDEAS FOR COST-SHARE % START-UP ESTIMATES



COST-SHARING FORMULA

FIRE	-10-15%	DOCTORS	-5%
EMS-AIR	-5%	HOSPITALS	-5%
AMBULANCE	-15-20%	UTILITIES	-5%
LAW ENFORCEMENT	-40-50%	PARKS	-5%
HIGHWAY SERVICE	-20-30%	FORRESTRY	-5%
SCHOOL BUS	-5%	CIVIL DEFENSE	-20%-30%

CHART D

marily behavioral, not technical or economical. This includes the capability of direct connections between the calling public (911) and the On-Road Service Units or the Emergency Physician. (Doctors can make house calls.)

Cost-sharing and consolidation of federal agency programs and funding assistance for this effort become extremely important. Substantial savings can occur.

In this regard, the resolution passed by the Midwestern Governors' Conference on July 3, 1968, reflects the urgency:

BE IT FURTHER RESOLVED that the federal government be encouraged to (1) consolidate the multitude of separate agency programs which are now providing piecemeal assistance in the development of state communications system, (2) reorganize such programs into a cost share-system approach which will meet federal and state requirements in a systematized, economical manner,

COORDINATED PLANNING

COMMUNITY/REGIONAL

GEOGRAPHY-POPULATION BASIS

EMS SYSTEM FORMULA

SQUARE MILES ↓ / POPULATION →	100 TO 10,000	10,000 TO 50,000	50,000 TO 100,000	100,000 TO 500,000	500,000 TO 1 MIL	1 MIL TO 2 MIL
1 TO 5			1-C	2-D	5-D 2-E	8-D 4-E
5 TO 10		1-C	2-C	2-D	5-D 2-E	8-D 4-E
10 TO 20	1-C	1-C	2-C	2-D	5-D 2-E	9-D 4-E
20 TO 50	1-C	1-C	2-C	2-D	5-D 3-E	9-D 5-E
50 TO 100	2-C	2-C	1-C 1-D	3-D	6-D 3-E	9-D 5-E
100 TO 500	2-C	2-C	1-C 1-D	3-D	6-D 3-E	10-D 6-E;1-F
500 TO 1000	2-C	3-C	2-C 1-D	3-D 1-E	7-D 4-E	11-D 6-E;1-F
1000 TO 1500	3-C	1-C 1-D	2-C 2-D;1-E	4-D 1-E	8-D 4-E	11-D 6-E;1-F
1500 TO	4-C 1-E	1-D 1-E	1-E	1-E	5-E	1-F 1-G

BLOCK A
Public-user and first responder

BLOCK B
Police-Fire
First Responders
(trained & equipped)
(also forrest, agri. parks, utility, personnel)

BLOCK C
Ambulance EMT
Basic Life Support

BLOCK D
Mobil Intens. Care
Advance Life Support
Doctor Directed
PARAMEDIC

BLOCK E
Trauma Center
Hosp. E.D. Advance Life Support

BLOCK F
Specialized Care
Hosp. E.D.

BLOCK G
University
Medical Centers

CHART E

FOOT NOTES:
Blocks "C"-"D" etc. refer to graphic chart A Displaying total EMS system elements.
(i.e.- 1C means one ambulance, Block C capability, etc.)

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and (3) develop new programs and procedures that will permit maximum possible date-to-day usage of communications systems that are designed to meet total federal-state-local emergency needs; . . .

Though some very limited movement for encouraging state consolidation of communications is being displayed at regional levels of federal government, no central directed instructions are apparent. As examples, serious duplications of funding in facility construction, hardward and planning for emergency services systems can be found in the following federal directions or actions now providing for separate service development:

Public Law 89.564 - Highway Safety Act of 1966
Public Law 90.351 - Safe Streets and Crime Act of 1969
Public Law 93.154 - EMS Act 1973
Public Law 91.606 - Natural Disaster Act 1971

Federal Civil Defense Guides:

Part E - Chapter 3 - Emergency Communications

Part E - Chapter 2 - Emergency Operations Center

Part E - Chapter 9 - Law Enforcement Under CD Emergencies

Proposed Funding for Emergency Telephone Number 911.

HEW - Public Health Services Memorandum - 70-77-E, Dec. 2, 1970, Emergency Communications

HEW - Public Health Services - Planning Community Health Resources for Disaster

Transportation - Highway Research Circular #155 - March 1974 - HRB

The message we have intended to leave is two-fold:

First - Great duplication of funding and effort exists. Present expenditures are actually excessive for a new, full quality, nationwide, Emergency Medical Service which would be physician directed.

Second - A bold new cooperative program is needed. Requiring a new aggressive partnership in science, technology and cooperation which brings together the Federal Agencies, private enterprise, state, regional and local governments, supported by our Universities and Research Centers.

In conclusion, let me list some of the pressing needs to which we, in service to the public, are always challenged:

1) Ready or not — the time is NOW. We're paying a high price in lives and dollars for failing to solve the lack of cooperation problem.

2) Must our incentive for action be brought about by more and greater tragedies created by lack of resource coordination? (Just read after action reports on national or local emergencies)

3) Following an accident, time is a killer. Today's operations cannot succeed without prompt cooperation. "TEAMWORK"

4) Modern communications can bring distant professional assistance near and now. Systems can be installed for less than we are now paying.

5) Coordination of existing Federal/State expenditures for EMS is not only feasible, but highly desirable for reasons of economy and utilization of staff and plant capability - definite savings will result.

6) A convenient effective mechanism for resource coordination will have a healthy and substantial influence towards modernizing present methods and procedures for accomplishing all EMS tasks.

7) It can be expected that a convenient, efficient EMS System will influence health care delivery of every community or region.

THE STRATEGY FOR MORE RESPONSIVE EMS COORDINATION AMONG FEDERAL PROGRAMS

Sherman Lazrus

My remarks will be limited to the relation of the Department of Defense to certain aspects of EMS systems within the Continental United States. Specifically, I would like to briefly comment on DOD involvement in the MAST Program, civil preparedness, and local EMS programs.

The Military Assistance to Safety and Traffic (MAST) Program was initiated in 1970 as a cooperative effort by the Department of Defense, Department of Transportation, and Department of Health, Education and Welfare. The MAST Program is designed to supplement existing EMS systems by providing military helicopters configured as air ambulances, crew members, medical equipment and supplies for response to civilian medical emergencies. The helicopters are maintained in a state of readiness to respond quickly when requested by law enforcement officers, physicians, or other responsible persons such as public safety officials at the scene of an emergency. Overall policies of this program are developed jointly by an interagency group at the Federal level. Local MAST operations and coordination are the responsibility of the local MAST Coordinating Committee, composed of individuals representing the providers of EMS in the geographic area. From a beginning of five test sites in 1970 the program has gradually expanded to 23 operational sites at present. As of 12 April 1976, 7396 patients had been transported in 7035 missions.

It is important to be aware of one of the unique features of this coordinated EMS program. Military resources available for participation in MAST are limited to existing air ambulance units. The civilian community provides communication support and, through the civilian MAST coordinator, directs the non-military aspects of the project on a day-today basis. Experience to date has demonstrated that the concept of using military helicopters and paramedical personnel in an air ambulance role to respond to civilian medical emergencies is entirely feasible from both the military and civilian viewpoint.

The Federal Civil Defense Act of 1950, as amended, authorizes and establishes a national civil defense program, and makes it a joint responsibility of the Federal Government, on the one hand, and the states and their individual jurisdictions on the other. The Defense Civil Preparedness Agency (DCPA), the latest of a number of Federal agencies responsible for this program, was established within the the Department of Defense in 1972. It is responsible for developing a national program, and providing preparedness assistance and guidance to help state and local governments achieve disaster preparedness. DCPA thus has a role relating to the EMS Systems Act of 1973. Specifically, it relates to requirement 14 of the Act which calls for a linkage between everyday EMS capability and community disaster response capability.

DCPA works with several Federal agencies on different aspects of national civil preparedness; for example, development of emergency communications systems are coordinated with FCC. It works with State and local governments to maintain and improve their readiness to cope with major emergencies. A central objective of the program is to develop a coordinated and effective capability to protect lives and property in the event of disaster. All significant hazards are included in this readiness concern, ranging from localized peacetime emergencies to the national threat of nuclear attack.

The scope of DCPA activities covers a wide range of programs related to civil defense and natural disaster preparedness. It includes arrangements for warning the public, the provision of communications in Emergency Operating Centers used by State and local governments, radiological detection and protection, a national shelter system and development of damage assessment systems. As you can see, it covers a spectrum of emergency needs and involves a variety of Federal agencies. At the State, and even more, at the local level, planning varies from one area to another according to the size of the place involved, the hazards being planned for, and other factors. Certain basic elements must be included in emergency operations planning at the local level. All of these have the objective of enhancing the ability of a State or local government to meet its responsibilities for providing for public safety and welfare in major emergencies. This is best accomplished through the coordinated operations of all emergency services in the community.

A third area of Department of Defense involvement in EMS systems occurs at the local level where DOD medical treatment facilities relate to the community on a day-to-day basis. In recent years a need to upgrade DOD hospital based emergency medical services has been recognized. Many hospitals have designated a full or part-time Chief of Emergency Medical Services. Within the hospital he has supervised the training of Emergency Medical Technicians, developed and conducted continuing education programs for all emergency care personnel, and coordinated construction and equipment improvements within the emergency rooms. Categorization of hospital EMS capability has been used to assist in planning staffing needs and evaluating the hospital's relation to local emergency medical care support plans. DOD hospital representation on community EMS committees has been encouraged to facilitate useful ongoing dialogue between the military and civilian personnel engaged in EMS activities. Understanding and coordination between these personnel have been appreciated as important factors in achieving an effective ongoing area EMS operations and in forming a sound basis for integrated response to large scale community emergency situations. EMS Communications improvements have included upgrading of hospital-ambulance capability and in many cases have allowed for an interface between local military and civilian medical facilities.

FEDERAL EMS MANDATE

Robert van Hoek, M.D.

The mandate to improve the emergency medical services (EMS) is not new. It is an accumulation of professional, scientific and legislative actions that have been taking place over a period of several years requesting the Federal Government to move in a direct and forthright manner to assist States and communities to improve that portion of the total health care delivery system which is concerned with emergency health care.

In 1966, the Mollihan Report pointed out the need to improve the delivery of health care to victims of automobile accidents and other accidental causes of injury and death.

In 1966, the National Academy of Sciences, National Research Council, made recommendations to address the increasing number of deaths due to accidental injury. The National Academy of Sciences recommended that several conferences be conducted on emergency medical services, that a national organization be initiated for the study of trauma, that there be an approved organization of community EMS councils and that a national council on accident prevention be formulated. The Academy also recommended a National Institute of Trauma.

In 1965, the data indicated that 52 million accidental injuries killed approximately 108 thousand citizens, temporarily disabling over 10 million individuals, and permanently impaired 400,000 citizens at an approximate cost of $18 billion dollars.

In 1971, the Bethesda Conference on Emergency Health Services was held, at which time many of the statistics were made available as to the fragmented, understaffed, under equipped and under trained resources that were available to provide EMS at the State and community level. The fragmented Federal effort was also discussed and recognized at that time. The Conference, in an official communication, urged the President to commit renewed Federal resources to improve this deteriorating health situation.

In March 1972, the National Academy of Sciences, National Research Council, issued a study entitled, "Roles and Resources of Federal Agencies in Support of EMS." This document reported the involvement of the many Federal agencies involved in EMS and the need to impro.. ~ederal guidance and direction for the establishment of standards, provision of leadership and improved coordination of the multiple Federal programs involved in EMS.

These have been the significant actions and events leading up to the current EMS Program.

In January 1972, the President included in his State of the Union message an acknowledgement of the EMS problem and directed that a demonstration effort be undertaken to prove the systems approach to the delivery of emergency medical services.

In November 1973, the Congress enacted the Emergency Medical Services Systems Act to provide funds for planning, establishment and initial operations, and improvement and expansion of emergency medical services, together with the establishment of an Interagency Committee on Emergency Medical Services and a charge to improve information exchange and coordination among Federal agencies.

The Congress, in reporting out the EMSS Act, stated that it did not intend to create new grant authority which was duplicative of existing authorities. The basic purpose of the new EMS legislation was to encourage and provide incentives to the appropriate units of government to inventory their resoucres for providing comprehensive emergency medical services, to identify gaps in such services and to seek remedies for such deficiencies through better coordination and utilization of existing resources. The statute provides for the development of new components essential to achieve an integrated and comprehensive EMS regional system. Support of these objectives should be sought not only through the authority created by the EMSS Act, but also through other Federal authorities which provide funds, technical assistance, and services to provide emergency medical care at the community level.

Thus, the mandate to improve the delivery of EMS is clear. It is clear from the Congressional intent and the work of others prior to this Act that we are speaking about the delivery of comprehensiv~ care, encompassing not only those activities of hospitals and ambulances, but all of the components spelled out in the EMSS Act. There is a further mandate to improve Governmental coordination during the exercise of this process and such coordination will result not only in the delivery of care, but also an improved usage of available resources at the Federal, State, and local levels. Thus, an EMS system may serve as a further demonstration of the systems approach for other portions of the total health care delivery system.

During the three years of the EMSS Act, a great deal has been done by the Federal establishment, State governments, local communities and individual citizens. The problem is solvable, the resources are available, and a good beginning has been made. However, two thirds of our country still needs to improve its regional system of EMS care and delivery. Thus, our mandate for the future is also clear. We must work together to continue to reduce needless death and disability.

THE POTENTIAL FOR INTEGRATING THE NEW EMERGENCY MEDICAL SERVICES GRANT PROGRAM WITH U.S. DEPARTMENT OF AGRICULTURE PROGRAMS

Marvin E. Konyha, Ph.D.

Introduction

Several U.S. Department of Agriculture (USDA) agencies administer programs which make resources or assistance available to communities which are preparing plans for implementation, or are already implementing, emergency medical services (EMS) systems. However, it should be clearly noted that the USDA does not administer health programs, per se. The Department of Health, Education and Welfare (HEW) is the agency responsible for administering Federal health programs.

The Department of Agriculture does administer several specific rural development programs, and many of the Department's more general programs also make a major contribution to rural development. We recognize that an essential component of successful rural development is the establishment and maintenance of an adequate health care delivery system. We endeavor to utilize USDA programs and resources to enhance the development of rural health care systems. Thus, we have a keen interest and concern for the implementation of adequate EMS systems throughout rural America.

Rather than just emphasizing USDA programs with a "health" component or relationship, I will focus attention on the needs and potential for coordinating or integrating the EMS grant program with these USDA programs and resources. Because of the way these programs are administered, they are presented here on an agency by agency basis.

Farmers Home Administration

Two basic rural development programs of the Farmers Home Administration (FmHA) have much potential for contributing to rural EMS systems, the Essential Community Facilities Loans program and the Business and Industrial Development Loans program, sections 104 and 118 respectively of the Rural Development Act. Briefly, the details of these programs are:

Essential Community Facility Loans (10.423)* - Communities under 10,000 population may apply for these loans for virtually any type of community facilities deemed essential by the local people. Experience to date indicate that local officials have placed health and health related facilities very high on their priority lists, as about 70 percent of total loan funds under this program have been used for health and health related facilities - hospitals, health clinics, nursing homes, fire and rescue (EMS), and public safety.

Business and Industrial Development Loans (10.422) - Public, private, or cooperative organizations (profit or non-profit) in areas outside cities of 50,000 population are eligible for these loans. The purpose of the program is to improve the economic and environmental climate in rural communities.

Although not extensively utilized in the health area, this program does have the potential for assisting in the development of health facilities and businesses, including those which tie in closely with EMS systems.

Extension Service

The Extension Service is the educational arm of the Department of Agriculture. Through the Cooperative Extension Service, which is based in every land-grant university in the country, Extension personnel are located in virtually every U.S. county. Extension activities are organized around four broad program areas - agriculture and natural resources, home economics, community resource development (CRD), and 4-H youth work. Basic Extension functions which may be closely related to and integrated with rural EMS systems are as follows:

Information and Education - Cooperative Extension organized homemaker clubs and 4-H youth clubs are ready made vehicles for disseminating information and education about EMS systems and local EMS needs in rural areas. Extension CRD personnel work with a broad cross section of citizens and local officials in public affairs education programs. Health services and EMS needs can be the focus of these educational programs. One example of this, and materials developed for it, is in Indiana. Purdue University CRD specialists have produced "A Study of EMS in Indiana" describing resources available, and the companion, how-to-do-it pamphlet, "If Your County Wants Better Emergency Medical Services."

CRD Organizational Assistance - Local or area level CRD personnel can assist in bringing community people together to organize an EMS system. Extension often functions as the neutral forum for bringing together competing or conflicting community groups and helping them reach a consensus.

CRD Technical Assistance - When requested to do so by the community, Extension CRD personnel often provide assistance in interpreting program guidelines and in making application for assistance to state and Federal agencies.

Two specific EMS systems components, as described in the EMS Guidelines, have the potential for very close linkages with the Cooperative Extension Service, the consumer participation and consumer information and education components.

Rural Electrification Administration

The major function of the Rural Electrification Administration (REA) is the insuring of loans to rural electric and telephone cooperatives. While these cooperatives are not USDA agencies, they do work very closely with REA and are always very concerned for and involved with developmental activities in their respective communities. These activities often include the development of health facilities, including EMS systems. The REA does have one specific, communication function which might be of service in establishing EMS systems.

REA Telephone Engineers - Each state has an REA telephone engineer assigned to it. Depending on the current work load, these engineers represent a potential source of technical

*Numbers in parentheses beside each item heading refer to sections of the *Catalogue of Federal Domestic Assistance* which provides detailed information.

assistance to local communities in the communications aspects of EMS systems.

Rural Electric and Telephone Cooperatives - These electric cooperatives number over 950 serving about 12 million families in nearly 90 percent of all rural U.S. counties. Rural telephone cooperatives also number over 950, serving communities under 1,500 population which are often those most in need of improved emergency medical services.

Both types of cooperatives can play major leadership roles in organizing rural EMS systems because of their concern for the overall development of the areas they serve. Through Coop newletters and information inserts with regular billing statements, additional information and leadership can be provided. Finally, it may be possible for rural EMS systems to utilize cooperative office facilities and their shops for EMS vehicle maintenance and repair.

Rural Development Service

The Rural Development Service (RDS) has responsibility for the coordination of national rural development activities. State and local coordination activities are designed to assist local officials to better utilize the programs and services of government agencies and commissions and to help them secure needed resources for the development of locally determined plans and priorities. RDS has initiated the only one-stop service for information and assistance concerning rural development resources, including health resources, in the Federal government. This service is provided by program specialists who give assistance and counseling on Federal grant and loan programs.

Research

Two separate research agencies should be mentioned. The *Economic Research Service* (ERS) of USDA conducts a considerable amount of rural development research. More attention has been given recently to rural health, and specifically EMS, research needs. To assist local officials in decision-making, a study of the "Economics of Rural Ambulance Service in the Great Plains" was recently conducted (see USDA, ERS Agricultural Economics Report No. 308). A companion piece to the "Economics" study is the Oklahoma State University Extension Facts No. 800, "Estimating Receipts and Costs for an Ambulance Operation."

The *Cooperative State Research Service* (CSRS) funds research through each of the land-grant university agricultural experiment stations. Land-grant university researchers are uniquely situated to conduct rural EMS research under Sections 1202 and 1205 of the EMS Act.

United States Forest Service

The U.S. Forest Service provides medical self-help and first air training for volunteer rescue squads in National Forest areas. Search and rescue operations and ski ranger patrols are also conducted within the National Forests. The Forest Service has an extensive radio communications network which may need to be integrated into an EMS communications system.

Each State Forestry Department also cooperates closely with the Forest Service. They administer the Rural Community Fire Protection program which provides grants up to 50 percent for organizing, training, and equipping rural fire departments. This program may contain specific emergency rescue service components and, therefore, has potential for significant integration with rural EMS systems.

Rural Development Committees

One final USDA rural development entity should be mentioned. Each state has a USDA Rural Development Committee composed of USDA agencies in the state and, frequently, several agencies of the state government. These committees provide an excellent focal point for all USDA rural development efforts, and they sometimes have rural health task forces to direct agency efforts more specifically into the health area.

FOREST SERVICE AND RURAL HEALTH

James R. Abbott and Paul Madden

The Forest Service has no direct legislated or programed role in rural health, although it does get involved indirectly in a number of ways, as follows:

1) Rendering aid (emergency medical treatment) in emergency situations where the agency primarily responsible for rendering such aid is unable to arrive with sufficient speed to provide the necessary assistance. The exact language of the Forest Service position is:

> Inside the National Forests, the Forest Service recognizes its public duty to render assistance in cases involving persons seriously ill, injured, or who die inside the National Forest, to the nearest place where the sick or injured person or where the body may be transferred to interested parties or local authorities.
>
> Section 3 of the Act of May 27, 1930 (16 U.S.C. 575, authorizes the payment of necessary expenses to effectuate this policy. This authorization is limited to those cases where the person's condition necessitates prompt removal to a place where medical attention and care are available, and the situation can be met only through action by the Forest Service. The authorization does not contemplate expenditures from F.S. funds in ordinary cases of illness, etc., of persons who at the time are inside the National Forest. In the event of minor accidents, particularly where there appears to be no immediate danger to life or health, incidental help and information or advice may be given by the F.S., but usually the person(s) involved, if able, should make their own arrangements for relief, medical attention, or repair. Usually relatives, friends, local authorities, and other interested persons or agencies cooperate voluntarily in defraying necessary expenses.

2) Title IV of the Rural Development Act of 1972 is the Rural Community Fire Protection Section. It authorizes and directs the Secretary of Agriculture to provide financial, technical, and other assistance to State Foresters or other appropriate officials in cooperative efforts to organize, train, and equip local forces in fire prevention and suppression. Under the authority granted in this legislation the Forest Service does help develop skills in Emergency Medical Treatment in local rural fire organizations, etc.

The F.S. mission involves work in remote locations often far removed from professional medical services of any kind. Probably the more serious problem occurs in wildland fire situations in which thousands of people can be mobilized for suppression efforts. The safety and care of these people requires adequate emergency treatment expertise on site for immediate treatment and transportation to medical facilities. Special portable 500 man first-aid stations are available for use in these situations.

When possible, contracts are arranged with commerical emergency medical treatment firms which provide for that service at the fire area. Where commercial services are not available, Forest Service employees fill the need. These people are certified through various State programs and the National Registry of Emergency Medical Technicians.

There are currently an estimated 400 F.S. employees certified in this program. Many serve on local rescue and ambulance crews on a volunteer basis in this capacity.

In summary, the F.S. does not have a direct legislated or programed role in rural health, but does get involved through care of F.S. personnel on the job, especially fire-fighting, in remote areas.

EMS WHERE YOU WORK

Leonard Burchman

A new respect for Emergency Medical Services has begun in America. And with this new"EMS Era," a whole host of new problems, new issues, new solutions have emerged.

From all over America, our diverse geographic regions report innovative EMS programs saving countless lives. We're proud, justly so, when we are identified with an EMS "pilot" group which is credited in unraveling incredibly complex radio telemetry systems or trauma nursing problems.

But there is another side of the coin that only the families of employees injured and mained at the worksite see. No amount of rhetoric is defensible. My colleagues from our prestigious Bureau of Labor Statistics tell me that we EMS professionals have a long way to go before we can rest comfortably. For example, in 1974, there were 5,915,800 work related injuries and illnesses on the job. In 1973 the count was 6,078,700. This covered all private sector jobs, including agriculture, mining, railroad, except self-employed and domestic service workers. The percentage drop in the injury rate from 1973 to 1974 is minuscule. What is important here is that one out of every 10 workers were injured or contracted a work related illness. In 1973 (the latest report date) 5,700 workers died as a result of injuries or illnesses suffered on the job. No matter how you slice it, that's totally unacceptable and something must be done now to markedly drop the injury, illness and fatality rates. The big question, how?

Medical costs today, at the worksite or at home, are skyrocketing. People are concerned. They know that lives cannot be saved by a quick "fix." People have a right to expect the very best where their lives are concerned. They want topline equipment used by the best professionals available. This costs money, lots of it. With tight fiscal constraints on governmental and corporate budgets, where's the money going to come from?

CETA, the Department of Labor's Comprehensive Employment and Training program may provide a very modest answer to at least the paraprofessional training aspects of local EMS systems. CETA is a tool that can be very useful to the EMS system, because it is locally administered and funded. It has close ties to your mayor's office, your county executive's office, and your governor's office. The four-plus billions of dollars that have been allocated this fiscal year to these governmental units by the Department of Labor are being used to train jobless persons and place them mainly in private industry as well as in public service employment. The cornerstone of CETA is Title I which provides classroom training and on-the-job training programs for mostly economically disadvantaged and jobless persons. The cities, counties, and States, as prime sponsors of local CETA programs, obtain proposals from every imaginable type of private firms, semi-public and public agencies and organizations to conduct training programs, either on the job, in classrooms, or combinations of both.

Among the thousands of subcontracts and grants that have been executed by the 431 prime sponsors have been scores of funded training projects with public and private hospitals and other health care institutions this year. The exact numbers and places are not available for a full count, since the prime sponsors operate independent programs with the Federal funds allotted to them. Many have used public service employment allocations under Titles II and VI to place jobless persons in health facilities operated by the cities, counties, and States.

The main point I want to make is that training funds *are* available from the manpower agencies in local areas to fund worthwhile programs. And, EMS certainly is a worthwhile program that can and should be supported. What is required is that directors of an EMS operation work up a proposal for training needed personnel and submit the proposal to the prime sponsor in the locality. It is best to have a proposal ready well before the start of any fiscal year so that the prime sponsor, if it accepts the proposal, may include the plan and earmark the necessary funds for the operating year. This means that a proposal for the next fiscal year, which starts October 1, 1976, should be proferred no later than June 1 or earlier.

The national office of the Employment and Training Administration in the Labor Department has just executed a special program funded for $480,000 to train 240 jobless residents of the Washington, D. C., areas as nurses and health care technicians. No, this contract was not executed by a prime sponsor, which would have been Washington, D.C., and the mayor's manpower office. It was worked out by the ETA's national contracting office to serve as a model for other areas and organizations to emulate. The program is jointly sponsored by The George Washington University and Marymount College of Virginia. It will provide 32 months of schooling and on-the-job training in four occupations for which there is a shortage of trained workers in the D. C. area. The occupations are: biomedical engineering technician, medical and health care institutions safety technician, automated medical information systems technician, and registered nurse.

The student-workers will participate in alternating four-month periods of work and study. They will be employed in hospitals, nursing homes, and other medical and health institutions, under both public and private auspices. GW will provide instruction in the technician courses and Marymount, the nurse program.

So, you see, CETA has definite possibilities for the kind of work we are talking about.

American workers and employers alike know that somehow a competent, professionally operative EMS system can be installed within quick reach of their worksite. They expect us, EMS professionals and lay groups alike, to develop such a program. We are being called on to make "hard" decisions, despite ever shrinking budgets and nagging shortages of paraprofessional man and woman power. We are trying to deal with today's EMS priorities while paying yesterday's bills. Productivity—squeezing the fat out of our EMS systems is called for. If a life is worth saving, then we will do just that.

THE ROLE OF THE COAST GUARD COMMUNICATIONS SYSTEM IN EMS

Cdr M. E. Gilbert, B.S., B.S.E.E., M.S.E.E.

Background

One of the earliest and most traditional functions of the United States Coast Guard is Search and Rescue (SAR). The SAR program objective, stated simply, is to minimize loss of life, injury and property damage by rendering aid to persons and property in distress on, over and under the high seas and waters under the jurisdiction of the United States. In carrying out this objective, the Coast Guard utilizes a network of rescue facilities, including cutters, boats, aircraft and shore stations. Their primary mission is to locate and assist persons and property in distress. The successful accomplishment of this objective is dependent on numerous factors including, in particular, the timeliness of distress notification and the accuracy of information relative to location of the distress incident.

Coast Guard Communications

In order to expedite receipt of distress alerts by radio, selected Coast Guard facilities guard internationally recognized radio distress frequencies (2182 kHz, 500 kHz, 156.8 MHz). Calls for assistance received over these channels are passed directly to Rescue Coordination Centers for coordinating of the search and rescue phases of the operation.

The Coast Guard is responsible for Search and Rescue incidents occurring in the Maritime Region. To carry out this responsibility, the Coast Guard has established long-range radio stations at Boston, Portsmouth, Va., Miami, San Juan, New Orleans, Long Beach, San Francisco, Ketchikan, Kodiak, Adak, Guam and Honolulu. These stations are primarily responsible for communications with merchant vessels. They provide information pertaining to weather, aids-to-navigation failures, receive position information for relay to AMVER—a system designed to keep track of participating merchant vessels for SAR purposes—and receive distress information. Should a merchant vessel on the high seas have need for medical information, they can request it through these Coast Guard radio stations. The Coast Guard can then obtain the necessary information from the Public Health Service and relay it to the requesting vessel. Should the on-scene assistance of a doctor be required, the Coast Guard can request information from the AMVER computer, and locate the vessel closest to the distress with a doctor aboard. If the distressed unit is close enough to shore for helicopter evacuation of the patient, should that be necessary, the Coast Guard has helicopters strategically located along its coasts with ranges up to several hundred miles offshore.

For assistance to smaller boats closer to shore, the Coast Guard monitors 156.8 MHz, the VHF-FM maritime mobile distress, safety and calling frequency. This is accomplished at over 200 remote monitoring sites. By carefully locating these sites, the Coast Guard has designed a system with coverage out to at least 20 nautical miles offshore. This coverage includes the entire coast of the continental United States, including the Great Lakes, Puerto Rico, Hawaii and portions of the Alaskan coast. The information received from these remote monitors is relayed to over fifty central SAR facilities called groups. The group commanders are responsible for dispatching the appropriate SAR forces from those under his command or providing medical information, should that be needed.

Coast Guard EMT Training

There are generally no medical personnel, such as a doctor or corpsman, attached to the crews of coastal SAR stations' boats. Medical personnel are generally available at larger Coast Guard bases and air stations however.

Medical personnel in the Thirteenth Coast Guard District have been training personnel at life boat stations and air stations located in the States of Washington and Oregon with approximately 80 hours of Emergency Medical Technician training. With this training, non-medical Coast Guard personnel called to assist will be better trained to handle, on a first aid basis, medical emergencies occurring on SAR cases.

An experimental program recently instituted at Coast Guard Air Station Los Angeles incorporates a capability of transmitting electrocardiographs directly to at least a half-a-dozen hospitals in the Los Angeles area. When the air station has information that a medical emergency evacuation is required, they notify the Los Angeles paramedics, located two minutes from the air station, allowing the paramedics to arrive before the helicopter can become airborne. Using a biophone and datascope, carried by the paramedics, the paramedics are in direct voice and data communications with doctors. This allows the paramedics to administer life saving drugs, on the doctor's advice, before the patient arrives at the hospital.

The partnership between paramedics, EMT trained Coast Guard personnel and Coast Guard operating forces can only increase in emphasis and importance. This partnership will only further strengthen the traditional, primary Coast Guard responsibility of saving lives and otherwise assisting those in distress.

GOVERNMENT EMS COMMUNICATIONS PROGRAMS

L.R. Raish, B.S., J.D.

During the 1968-1972 time period, the realization that Emergency Medical (EMS) could save lives of many accident and heart attack victims stimulated an outpouring of activity among professional, lay, and governmental organizations. Technology and methodology for delivering high quality emergency and affordable EMS telecommunications to link those elements, i.e., ambulances, hospitals, and the various medical functions became apparent. Needed was recognition and the establishment of an EMS Radio Service on a national basis, utilizing its own allocated radio frequencies.

During 1973 and 1974, actions were taken on three fronts at the Federal Government level in Washington with regard to EMS communications. These were:

First, during 1973, the Office of Telecommunications Policy (OTP) undertook an extensive review of the telecommunications aspects of EMS. This review culminated in a report providing policy and planning guidance for establishing an EMS telecommunications system adaptable to both urban and rural areas. The establishment on a national basis of a common radio frequency plan for priority use by EMS units at the scene of medical emergencies was an essential part of that report.

Second, the FCC, through its Docket 19880, invited comments on the OTP report with the result that in July 1974, it published changes to its Rules to provide for an up-dated licensing and regulatory structure as well as radio frequencies to accommodate the growing requirements for emergency medical radio communications.

Third, in November 1973, the Congress enacted the "Emergency Medical Services System Act of 1973" (PL 93-154) that, among other things, required that "An emergency medical services system shall . . . . . join the personnel, facilities, and equipment of the system by a central communications system so that requests for emergency health care services will be handled by a communication facility which (I) utilizes emergency medical telephonic screening, (II) utilizes, or within such period as the Secretary prescribes, will utilize the universal emergency telephone number 911, and (III) will have direct communication connections and interconnections with the personnel, facilities, and equipment of the system and with other appropriate emergency medical services systems."

The Act of 1973 also established an Interagency Committee on Emergency Medical Services to pull together the various Federal Government interest involved in EMS. Four Work Groups were established by the Interagency Committee, and one of them is the EMS Communications Interagency Work Group. The Communications Work Group is chaired by a Senior official of the OTP, and is made up of representatives of eleven of the Government Agencies directly involved in EMS.

Note is taken that the purpose of this Workshop is to discuss resources available for EMS at the Federal level. Since communications is one of the subsystems of an EMS system, such would ordinarily be funded as part of the overall EMS operation, rather than as a separate entity. Another purpose of this Workshop is to discuss strategies for improving EMS coordination, including, of course, communications. It is this latter that the EMS Communications Interagency Work Group is doing in a substantial way.

Communications by its nature requires EMS interests to work together. Lack of cooperation at the local level can lead to chaos. However, we all know that the local level interests frequently have ties to Federal Government programs controlled from Washington. Hence it is important that there be teamwork at the Federal level to facilitate the local cooperation that is so important. This means such things as OTP and the FCC cooperating to establish EMS communications policy as well as Rules for the licensing of operations. It also means teamwork to establish EMS Communications policy guidance and operations source documents.

The EMS Communications Interagency Work Group is producing *two documents* in response to requirements for EMS telecommunications, namely:

a) A "Guidelines for Developing an EMS Communications Plan" is undergoing final coordination in Washington right now, and should be published in booklet form in the next two or three months. The Plan as written provides guidelines to States, their political subdivisions or to any other planning agency for their preparation of EMS communications plans. It sets forth suggested format and content of an EMS Communication Plan, as well as Goals and Objectives to be attained, EMS Communications Systems functional requirements to be met, and identifies systems elements, e.g., radiopages, mobile radios, mobile relays, biomedical equipment, etc.

b) Still in first draft stage is a second document entitled "Manual for Communications Operations." It will be another five or six months before this Manual gets approved and published, but you should know it is on the way. The availability of a Manual is important because there is a conspicious special requirement for highly reliable EMS communications in a mobile situation. This requirement has existed from the inception of emergency health care and has become more complex and apparent with the improvement in medical care facilities and training of emergency care specialists. The ambulance attendant has become an integral part of the medical team for providing treatment as well as transport. The movements of emergency rescue vehicles and the effort of physicians, nurses, and technicians must be coordinated, beginning as soon as the emergency is recognized, and becoming critical when the victim has been reached by members of the emergency team. Since public safety and emergency response agencies are often involved in responding to medical emergencies, means for their effective coordination is essential. The Manual provides a common basis for doing this throughout the United States.

EMS Communications is being watched by Federal Government authorities because there are always needs for improvement. A recent statement by the General Accounting Office indicates their finding that "most regional management entities are not proposing central communications systems which would include a central command and control center through which all system resources will be controlled. Several are proposing to establish a communications system which will link together all system resources and other public safety agencies. Although this is an advance, system access, dispatch, and resource control will remain a local function and responsibility, resulting in the benefits of central communications not being fully realized."

I would like to conclude with the observation and expectation that the program we are working on in Washington will result, before long, in the full benefits of EMS communications being realized.

Special Rescue Operations Under Difficult Environmental Conditions

MOUNTAIN MEDICAL PROBLEMS

L. K. Buchanan

It is 2:00 in the morning. It is raining — mixed with snow, temperature is 32°, gusty wind blowing moisture in all directions. The first six-man team has reached the patient on a granite ridge 9,100 feet above sea level and almost a vertical mile above the valley floor. The patient's climbing party had left him dry and reasonably warm in a tent on the ledge which stopped his fall. He has a fractured pelvis, probable internal injuries and is in shock.

He fell 80 feet while descending the mountain Sunday afternoon, but due to distance, his party did not get back to the road end until late Monday to ask for help. They did not mention the tent — only that he was in a sleeping bag. By then the ceiling was 6000 feet and the weather was getting worse. An Army helicopter had time to transport three six-man teams from the road to just below 6000 feet before darkness and storm stopped the flying. As the Mountain Rescue teams went up the steep rock and snow slopes they were getting wet. Visibility was less than 50 feet and only the team leaders had any idea of the route to the top where they expected to find the cold and badly injured climber. The others were busy finding hand and footholds.

At about 10:00 p.m. the first team made contact and advised the others that the patient was stable and dry. At that point all team members bivouacked for the rest of the night rather than start moving the patient in the dark. They were sitting on ledges, under big slabs of granite, and in the case of three — under a tent stretched over a couple of small boulders.

At 2:00 a.m. most of the rescue party heard the rumble of a desk sized block of granite sliding about 20 feet to crush the tent. Those who didn't hear it, certainly heard the scream of the man with the dislocated hip and fractured lower leg.

The rescue party now had a total of three litter cases (two of them cold and damp) to evacuate down 60 degree ice slopes alternating with steep rock and short vertical pitches.

This is what Mountain Rescue personnel mean when they discuss patient care in the *wilderness*. In this case we would have about 24 hours of work to get the first patient to road end. This would best be done in the daylight due to the technical nature of the terrain. First a lift to the ridge top from where he was resting and then the lowering down the smooth icy wall to the normal climbing route — then 5000 vertical feet to the valley — the shortest, least technical way out.

In this situation with three casualties it would take nearly three times the manpower. Sophisticated equipment is of very little use in this terrain. With everything carried on the backs of the climbers who are already carrying about 40 pounds of personal gear each, the basic requirements are skill, knowledge, and highly trained personnel to manage the few pieces of needed equipment.

To those thinking in terms of injuries these are not life-threatening. To those thinking in terms of patient care, there are several problems: time required to transport; internal bleeding; keeping the patient warm and dry in a hostile environment; and control of shock while constantly moving the patient over rough terrain.

There are 46 Mountain Rescue units scattered throughout the mountainous areas of the U.S. and Canada. In this country the organized Mountain Rescue units date from the late 30s; the national association from 1950. Originally organized to help fellow mountain climbers; in many areas they were the only group able to handle *wilderness* injuries and the severe weather that was often part of the problem. There are only 2500 members in these units, but they are highly skilled in their specialty. Each team must meet minimum standards of ability and equipment before it is recognized by the national organization and allowed to wear the Mountain Rescue Patch. The communications problem was recognized and solved back in the 1950s with all units licensed to operate on 155.160. Operations are often multi-unit — crossing county, state and even national boundaries.

The personnel of Mountain Rescue are all volunteers. Many are also Ski Patrollers. All have basic first aid, many are EMT-A qualified but very few have additional medical training. We find that it is easier to train a climber in rescue techniques and EMT than to make a climber of a doctor or nurse.

Only those who enjoy climbing do it regularly. It is a way of life — the lawn gets straggly, the roses go unpruned, and the house probably needs some paint. Unless a person climbs regularly, he or she is usually not in the physical condition necessary to sustain a concentrated push to a high altitude.

The call comes at midnight. Avalanche on Mt. St. Helens. At least five persons missing. The storm is pretty bad, even for March. Twenty minutes to get your gear, four hours driving. On the mountain howling wind and constant snow. All you can see is the person in front of you.

The clothing and equipment used on that trip is almost the same as for an expedition to Mt. Everest. The weather was actually worse in the state of Washington than on a mission to the Alaska Range near Fairbanks a month or two earlier in the winter.

There are other missions: elk hunter shot, severe shock, blood loss, bad weather, night; two hikers unconscious from hypothermia above timberline, winds now at 70 knots, snowing; two injured, two dead in a lightplane crash high in the mountains, freezing rain and snow; three climbers last seen tumbling down a glacier at a high rate of speed, the word gets out at dark; high winds.

The people are available to do the rescue. They will and do take the training to enable them to care for the patient as best they can. How much training should they have?

For most of them earning a living prevents participation in daytime training classes. EMT-A classes can be taken in the evening so this is normally the highest level of training achieved. To maintain proficiency many of them work as volunteers in hospital Emergency Departments on a regular schedule — 5 to 10 hours a week. Some do get advanced training on the job in these situations but are legally unable to use it in field situations.

Because of the sporadic need for the Mountain Rescue team, paid professional medical or paramedical personnel are seldom involved in the field operations. They are ready at the hospital or the road end, but how much care does the patient need before he gets there? How far into the real wilderness should the benefits of the emergency medical system reach? There are volunteers ready and able to take the training and do the work if they can help the patient in the field.

WINTER EMERGENCY CARE

Gary Bunce

The winter season, with its ice and snow means different things to different people. For many, it is that miserable time of year when even getting around presents problems. But for over three million Americans, winter means "ski season" from some of the most populated places to some of the most remote. On the well groomed slopes of any of the over 200 developed ski areas that handle 12,000 to 15,000 skiers per day, on trails that wind their way through the nations woodlands, or on wide open mountainsides, people take to the snow.

Unfortunately, sometimes they get hurt.

In 1938, the National Ski Patrol System, commonly known as the NSPS, was organized to provide emergency care and transportation to those who are injured while skiing. The NSPS serves the skiing public without charge throughout the United States and at Military recreation areas throughout the world. (There are only seven states without skiing, but we're working on South Dakota.)

The minimum entrance requirements consist of either the 81-hour EMT course or the American Red Cross Advanced First Aid and Emergency Care.

Once accepted on a patrol, a candidate must complete the NSPS Winter First Aid course on the specialized equipment and procedures necessitated by the environmental and terrain conditions in which patrollers work. This course concentrates instruction on frostbite, hypothermia, and problems created by altitude (some ski areas operate at over 12,000 feet.)

It is amazing how many, otherwise intelligent, people have little or no knowledge of the incipient danger of the combination of cold, wind and wetness. Skiers dress for fashion, not for the environmental conditions they are out in. Stretch ski pants, gloves, little or no head covering—very chic—but also very dangerous to those few, (approximately 6 per 10,000 skier days) who do get injured and end up laying on the snow. It is even worse for the cross-country skier that goes out without sufficient back-up equipment, clothing and supplies. Not only is he unprepared for the cold and dampness, but he may be a long way from help.

Our training program deals not only with recognition and treatment, but with prevention. Prevention of not only cold injury, but also skiing injuries.

Once the initial first aid training is completed, the candidate learns and is tested on, the handling of the toboggans used to evacuate injured skiers. Techniques in handling the sleds in deep powder snow, over ice, and down steep, moguled slopes must be accomplished. They also learn how to improvise a toboggan while out on a ski tour.

There are some who recommend the use of snowmobiles for moving the sleds over the snow. While this can work, there are some real dangers. First, the exhaust on the snowmobile must be modified to extend up in the air over the trailing sled, rather than down on the ground where the patient lies in the constant flow of carbon monoxide. Secondly, the method of attachment of sled to snowmobile must be carefully developed. Twisting motions of the vehicle should not be directly transferred to the sled. Thirdly, there needs to be a person on skis acting as a "tailman," especially if there are traverses or turns on steep slopes.

After learning the basics, the patroller is taught how to evacuate skiers from a stalled chairlift, gondola or tramway. While this rescue technique is simple, it requires specialized equipment and procedures. The NSPS has produced a lift evacuation manual, available from the national office in Denver, that goes into considerable detail as to these procedures. For example, to protect the rope from wear while running over a cable, we use a device called a "line saver," a twist in the rope is used to make up for friction loss, and the wear is far less than with direct rope contact with the cable.

A normal hip belay is not recommended because with the slippery footing of a snow or ice covered trail, the belayer's stance can be lost, even with the use of ice creepers or crampons, and these must be modified to fit on ski boots. But with proper form and determination, a patroller will have no difficulty.

Gondolas and trams present a slightly different problem. They are so high from the ground that you have to get up to them. One method utilizes a specially designed body harness with two clips. The patroller climbs up and out on the tower and clips onto the cable, swings over and is then lowered down the cable to the gondola. Once on the car, they climb down, open the door, crawl in and lower the occupants to the ground. Finally, they decend themselves.

In some parts of the country during the winter months, there is a frequent danger of avalanches. Because of this danger, patrollers are trained in avalanche hazards recognition. They may have to determine when an area or particular slope should be closed to skiers. They learn to measure and record the snowfall accumulations using snowstakes placed in an area protected from the wind. They also learn to test the resistance of the various layers of snow with a "ram penetrometer." Detailed studies are conducted on the make-up of the snow pack by digging snowpits and by taking temperatures and density samples at varying depths.

Patrollers are also taught avalanche control procedures, including the use of artillery and explosives. Explosives may be used to remove dangerous cornices, wind-blown overhands that may fall and trigger a slide below, or to check the stability of avalanche prone slopes prior to their being opened for the skiing public.

NSPS conducts both nationwide and regional avalanche training programs in conjunction with the United States Forest Service. Patrollers working with explosives are licensed by the appropriate state agency in the states in which they work.

But avalanche control is an inexact science and sometimes, without warning, down one comes—taking its toll. Although danger areas are carefully posted, some people ignore the warnings and venture beyond. Patrollers are taught avalanche search and rescue procedures, and sometimes the training pays off. But, time is a key factor. Probe poles, shovels and other rescue gear are stored at appropriate locations. All available manpower may be pressed into service. The patrol must maintain strict discipline to search the avalanche debris effectively. Practice probing can be done under ideal conditions, but the real thing seldom is. The storm may still be raging, and there may be danger of further avalanches. Unfortunately, some who ignore the warnings of the patrol, can't be found in time.

In response to the increase in nordic and cross-country skiers traveling away from developed ski areas and in people enjoying winter camping, the NSPS has developed Nordic patrols and instituted a "ski mountaineering" training program which concentrates on wilderness search and rescue, improvision and personal survival, such as proper clothing, map and compass and emergency shelter construction. The emergency care training offered in this course is referred to as second aid since it provides knowledge and skills that might be used in the "back woods", but not in normal patrolling. Because of their training, patrollers are often called upon to assist other rescue groups and winter search parties.

To maintain their level of training, members of the NSPS must go through a fall refresher course of at least 12 hours each year in first aid and other patrol skills.

The National Ski Patrol is not just a winter rescue and emergency care group. More and more of our emphasis is being put on ski safety. In addition to marking trails, patrollers constantly observe the equipment at the area for potential problems. They encourage preseason physical conditioning, the use of proper equipment, and are conducting a nationwide binding release check program to make the skiing public aware of potential problems with their bindings. We're finding that over 85 percent of all release bindings are improperly adjusted, or simply don't work) due to improper adjustment and/or mounting.

NSPS is not just active on the hill. In addition to having membership on a number of nationwide ski safety committees, we publish our own training manuals as well as the "Journal of Winter Emergency Care," available to anyone on subscription through the national office in Denver. Patrollers speak to various groups on ski safety, avalanche hazards and first aid.

We are, however, not without our problems and I'd like to present two of them.

1) Should the emergency care training given special rescue teams be specialized or general? Many of our patrollers question the need for them to learn emergency childbirth and radiation hazards to function on the ski slopes.

2) How can we deal with the variations between state laws? We have thousands of patrollers who receive training in one state and then patrol in two or three other states. This problem will become more acute as we get into advanced care.

I would like to close by saying that the NSPS is also trying to improve the image of skiing. Contrary to all cartoons, it is *not* a dangerous sport! According to a recent study, basketball has an injury rate almost three times that of skiing. Ranked roughly equal to or slightly more dangerous than skiiing were baseball, fishing, and ice skating.

Come skiing. You'll enjoy it.

How Media Theory Fits the Practicality of Developing Public Information and Education in EMS Systems

OUR AUDIENCE — "THE PEOPLE"

Kenneth M. Webb

Basically, I am going to talk about public education, communication with people and, last but not least, how people are motivated. I am going to start with the premise that EMS is one of the most neglected segments of our health care system—*particularly*—prehospital emergency care!! Having said that, I know I have laid myself open to challenge and I will accept the challenge, but hope to proceed to demonstrate the problem and, more importantly, discuss how we can help improve the situation. To illustrate the premise, I have lifted an analogous situation from a recent AMA journal — an editorial by the famous Dr. Irvine H. Page of the Cleveland Clinic. It is an editorial entitled, "Hypertension — A Strange Case of Neglect." In summary, Dr. Page talks of the discovery of hypertension, the discovery of therapeutic agents to treat it, and the many successful public education programs for identifying the millions of people that have hypertension, but don't know they have it.

Dr. Page then said, and I quote, "But there are advantages to the current enthusiasm for hypertension, despite the obvious dangers. It is important that everyone wake up to the need for public education. People must learn to help themselves—a long neglected need that we have not communicated to our patients. In terms of economics this is the crux of preventive medicine. Such is the history of hypertension as seen through the eyes of one who has seen it all. The pattern is worth studying, because hypertension will not be the last disease of major importance that made its way on its own, to be widely recognized only after major scientific and medical achievements had been consumated. It will be richly rewarding to inquire what will be the next 'Strange Case of Neglect'."

Well, if my friend Dr. Page were in this room today, I would tell him we have found another strange case of neglect—prehospital emergency care!

Isn't it strange that in this age of plentiful hospitals, with expertly trained personnel, sophisticated electronic equipment and miracle drugs, that we too often fail to get a patient to a hospital in time to take advantage of its life saving capabilities?

Isn't this stranger than ever when we consider the fact that this phase of medical care is one of the least expensive and ever stranger yet when it has been demonstrated to the public that the people are willing and able to do it themselves—if someone will guide them.

Well then, how can we help these willing and able people?

First, we have to communicate with them! This means we have to tell it to them like it is, using plain concise language and better yet—show them what the problem is and how and why they should solve the problems.

Now this brings me to the first of three points I would like to make on effective communications—effective communications meaning those that result in a desired action.

Point number one: Practice what you preach.

It is a fundamental law of human behavior that when anyone *hears* something, and then sees something that does not agree with what he heard, he will always believe what he has *seen.*

For instance, and at the risk of being critical, can we ask people to act expeditously when we procrastinate over such things; for example if CPR training — whether to thump or not, or whether or not to teach the public the Heimlich maneuver. If time is important, and I think we all realize it is, in saving lives, we must set the example — practice what we preach.

Point two in effective communications is one we often forget: Give human dignity a chance.

What is it most of us hate about so many of the T.V. commercials. I believe it is that they simply impinge upon our dignity by denigrating not only our intelligence but even our common sense; *e.g.*, Alka Seltzer's plop-plop-fizz-fizz or Hayley's I'm M-o.k. You know, when you put those in juxtaposition, it's hard to tell the antacid from the laxative.

Let my try to bring the concept of human dignity a little closer to the theme or our gathering here this week.

I have personal friends who are active, front-line basic EMTs. When I engage these very dedicated people in conversations about their EMT activities, they invariably get around to discussing the failures — the DOAs. In other words, those lives that were lost are foremost in their memories.

Why is this? I believe the answer is that in all too many cases — *not all* — but too many, we have not given their human dignities a chance! After all, these are intelligent dedicated people. They know there are other things they could have done to help save a life, but their dignities were not satisfied because the system doesn't allow them to do more without the proper training and equipment. Well now, there can be absolutely no argument about the need for proper training and equipment, but there is something sorely lacking in a system that provides awareness, but fails to provide the tools and adequate know how to allow them to do more in preserving life.

I sometimes think the reason we fail in the area of prehospital emergency care is that some feel that if we upgrade the necessary number of E.M.T.'s they will compete for emergency room jobs, displace nurses, hospital technicians, and even try to play doctor.

I say to you this is absolutely absurd. EMTs do not want to compete with anyone to save lives. They want to be equipped to be able to cooperate in saving lives. They want to be a part of the team. They want to pull their own weight. With the possible exception of the next of kin, EMT's hate DOAs more than anyone. And, isn't it ironical that all too often the DOA is a friend or a neighbor. How demoralizing can a situation become?

In discussing this situation, we should all realize that there is no person, regardless of station in life, who doesn't realize that he or she has a superior, whether it be here on earth or somewhere in the spiritual. This, oversimplified, means everyone knows he has a boss and, therefore, can accept a subordinate condition and still maintain a sense of self respect. What they *cannot* accept is a subservient condition, because subserviency denies them adequate satisfaction of their psychological needs. We need to watch closely for this latter because it is not at all uncommon for the person placed in a subservient position, to rebel!

I sincerely believe we need to educate the public that EMTs can be given adequate training and the equipment in order for them to play their very important role in the very important task of saving lives.

Just before leaving this, you may have noticed that I emphasized adequate and proper EMT training. I did this purposely because I believe we are impinging on our basic EMTs dignity if we try and impose on them an additional 500 to 600 hours of training. This is particularly true of volunteers and, anyway, the record shows this much extra training is not necessary.

The third point about communications that motivate comes in the form of a *most* important question and that is — What's in it for me?

There is no reaction in the whole scope of human behavior more common than the attitude represented by the simple question, "What's in it for me?"

Why does a mother dash into a burning building to save her child? Is it because she is brave? Is it because she wishes to sacrifice her life? No. It is because she could not live with herself in the future if she did anything else. Such conduct can be called "instinctive," but it is fundamentally selfish.

A rich man gives large sums of money or a poor man gives small sums of money to a good cause. Is it because they are generous? Probably not. It is because they each need the feeling that comes to them through giving, more than they need the money. This conduct may be selfish but it is completely wholesome and, therefore, acceptable.

"What's in it for me?" Each of us is more interested, and rightly so, in himself than he is in his neighbors, his employer, or his boss. For this reason, the most effective approach to any person, when a change in his behavior is desired, is to *show* him or her how the change will benefit him or her.

In summary then, I would like to tell you that public education — communication — is no easy task. It is challenging and, last but not least, most gratifying when you know you are a part of effecting a change for the better. We have discussed today that in order to communicate effectively:

1) We must practice what we preach.

2) We must give human dignity a chance.

3) We have to show and tell our audience — people — what's in it for them.

I leave this simple formula with one last amplification and that is, no single thing will motivate everyone. If we want someone to do something, we have to keep it simple and, most importantly, present it in terms of their needs, their hopes, their wants, their aspirations and, yes, even their dreams.

In closing I would like to demonstrate a motivating communication. I am going to quote *very briefly* from the sound track of the ACT Foundation film, "A Life in Your Hands."

Burt Lancaster is speaking—"CPR—life or death. It's that simple. The difference could be you."

"Wouldn't you like to be able to save that life, if you have a life in your hands?"

Now I ask you, isn't that a motivating communication?

It's simple.

It doesn't insult your dignity by saying or implying you are stupid if you can't save a life.

It doesn't order you to save a life. It simple says you can and that's all that matters.

It leaves no doubt as to "What's in it for me?" It simply says life or death and regardless of which part you are destined to play, the difference could be *you*. If this life or death matter is selfish, I'm all for more selfish people. But I know that all of you would like to help people be able to save that life, if they have a life in their hands. You have proven that by your past activities as well as being here today. Just in case you weary in your pursuit of public education or motivating people, allow me to quote from history. Calvin Coolidge said, "Nothing in the world can take the place of persistence. Talent will not; nothing is more common than unsuccessful men with talent. Genius will not; unrewarded genius is almost a proverb. Education will not; the world is full of educated derelicts. Persistence and determination alone are omnipotent. The slogan 'Press on,' has solved and always will solve the problems of the human race."

EMS, PEOPLE, AND PRINT

Irving J. Cohen

We're here today to help you become more effective propagandists for emergency medical services programs. Our premise is that if EMS in this country is to advance much beyond where it is now, we are going to have to build public support on a continuing basis and the place to begin our campaign is at the local level.

Our task is not just to finance the purchase of another piece of hardware but rather to dramatize the need for and importance of comprehensive EMS programs. The way to get people interested in any cause is to show clearly how they stand to gain from its advancement—in other words, you have to tell people what's in it for them. In EMS there's no group better qualified to do this than you, the people who are actually providing emergency medical care out on the street, in ambulances, or in hospitals.

All media of communication should, of course, be used in this effort but I am going to limit my suggestions to those utilizing the printed word. Let me begin by calling attention very briefly to some of its unique advantages. First, print alone yields something that can be used not only to convey new information but to serve as a permanent, inexpensive, personal reference. Information in print can be tailored specifically to the broad range of educational and socioeconomic levels of the people who need and use EMS. Finally, language barriers can be overcome easily.

Now, what are some specific things we can do to help people who need emergency assistance and also get them to help us when we ask them to support EMS programs?

As I have suggested, if you're going to get people to back you, they have to be persuaded that what you propose is going to make a difference in their lives. It's much more difficult to get people stirred up when you beat the drum for solutions to problems they don't identify with. A good way to arouse interest in EMS is by making people think about what will happen to *them* or *their families* if they suddenly get hurt or very sick where they live, work, or go to school. One of the first things you can do, therefore, is find out through a survey what people actually understand about the EMS system in their community and how to enter it, about what an emergency is and is *not*, and about what to do for themselves or others until help arrives or they can get to help.

In formulating such a survey I urge you to keep it all very simple. Don't ask complicated questions. If you have a 911 system, or some other emergency number, see whether people know it. If they do, see if they know when to use it. Find out what the word "emergency" means to people of various ages and walks of life. Do people know what to do for a heart-attack victim or a trauma victim until help arrives? Do they know when to wait for help and when to go directly to the hospital emergency room?

After you have tallied the results of your survey and determined what they mean, you are in a position to begin informing educating people to overcome specific deficiencies in their knowledge and in the emergency care available in *their* town, school, factory, or office building.

You can use the printed word in a number of ways to inform, teach and thereby win friends for EMS. If you find that people don't know how to send for help or where to go for it, you can easily and inexpensively prepare flyers that spell it out. You can make up labels that can be attached to the telephone, a kitchen cabinet, or the glove compartment of a car. You can make bumper stickers that give the emergency phone number. You can prepare brochures that explain the differences between life-threatening emergencies and everything else, that show and tell in very simple terms how to support life and protect an emergency patient until he gets assistance from trained EMS people. Distribute these materials to homes, stores, schools, factories, and offices. You can ask you local utility and telephone companies to include them with their bills as a public service. You can get your local newspaper to publish this information as a service to their readers. The editors of local civic and service club publications, as well as school and college newspapers, would also be receptive to such articles, perhaps even as a series.

Converting ordinary citizens from disinterested observers to doers in emergencies is a very effective method of winning active backers of EMS. The way to do so is to give them reasons to learn emergency-care skills and then help them acquire those skills. By working with local units of the Red Cross, American Heart Association, and the American Trauma Society you can bring together those who want training and those who can provide it. People who know how to protect and help a trauma victim or do CPR on someone felled by a heart attack will know what you're talking about and be on your side when you try to get your city or state to install two-way radios in every ambulance. A little knowledge can be a powerful thing in converting passive allies to active advocates.

You can use the people who are already involved in your local EMS, as well as interested citizens and civic groups who want to get involved, to help you conduct surveys and to distribute informational materials.

With the cooperation of interested professionals, point-by-point assessments could be made of the quality and availability of care and services at every point in your EMS system. Then publish the results and compare your system to one in a similar community that has a better system. When people are made aware of their town's EMS deficiencies, they're likely to get mad enough to demand improvements.

Examine the emergency capabilities of rescue squads, emergency rooms or departments, and local hospitals themselves. It would not be amiss to look into the training and equipment of ambulance crews and their vehicles, the geographic distribution of rescue squads and hospitals with basic and specialized emergency care facilities. It would be valuable—for physicians as well as laymen—to know the emergency capabilities of local ERs and the laboratory, radiologic, and specialized medical and surgical backup that is available. At different times of the day and night, how long would it take to get some stat blood chemistries, a cervical spine series, a neurosurgeon? Where deficiencies are found they should be brought to the attention, first, of the professionals most directly concerned and in a position to improve the situation. The public can and should be brought into it when its pressure can help produce the desired changes.

You have to start people thinking in very personal terms about their EMS systems and you have to ask tough questions. If your wife or teenage child was in a really bad auto accident, would the first person at the scene be likely to know how to get help? Would he know how to keep the victim alive while waiting for the ambulance? How long would that be? If your child were pinned in the wreckage, would your rescue squad have the training and equipment to get him out? What kind of help would he receive en route to the hospital? Would the ambulance crew be able to radio ahead to the hospital and describe your child's injuries so that the doctors and nurses would be ready to begin treating him effectively the moment the ambulance arrived?

By asking tough questions and then making people aware of what can be done, you are creating the climate for constructive change. If you can get editorial writers to ask these questions in their newspapers, you will create powerful pressure for constructive changes.

The hoped-for by-product of the information you publish, giving emergency telephone numbers, information about self-help, the location of emergency facilities, comparisons with other EMS systems, is a change in the attitude of government bodies toward emergency care services. Here, too, printed statements can make people aware of the short shrift EMS receives at most levels of government. Town councils usually make sure there's enough money to pay for police and fire protection but would they even *think* of allocating as much money for emergency health services?

I can visualize some very powerful flyers, advertisements, and editorials that point out how much is spent to protect property and how little to protect people stricken by sudden injury or illness. The discrepancy is ironic because a house that burns down or a car that's stolen can usually be replaced without any real loss; not so, a person who dies of a heart attack or is disabled after an injury because he couldn't get effective emergency care when and where he needed it. I can see dramatic posters and billboards, strategically placed all over town or even a state, that urge citizens to demand "equal time" for emergency health service. You can use print media very well to persuade government bodies to regard emergency medical services in the same light as police and fire protection and to give them the same kind of support.

As we all know, good EMS of necessity is a team endeavor. Through effective use of the printed word, in conjunction with other media, we can bring together those who need help and those who give help and that's a team that will be unbeatable.

EMERGENCY MEDICAL SERVICES FILMS

Stanley Zeitlin

Use films to *motivate* in a public education program: Films inform and entertain. The thing films do best, however, is motivate. People usually can't remember all the facts they see in a film. Images fly by quickly, the brain is brought forward and back, the eye jumps from detail to detail, split screens and optical effects dazzle us. The net result is an *impression*, an attitude.

Motivating your community by using films is one step in the sequence of public education. Often it's the initial step that gets everything underway and whets peoples appetites to learn more and/or get involved in the whole EMS system.

My organization works with hundreds of thousands of audiences each year. Most of them tell us the ways they were impressed by the film they saw. Their minds were changed; a spirited discussion was started; they said they would take local action; some even reported they'd buy a product they saw displayed in a film.

Keep in mind the tremendous difference in *training* films and public information *motivation* films. Training films are used within specific courses as motion picture illustrations. Motivation films are designed to get people to . . . well, perhaps take that course. Indeed we'll soon see such an example of a motivation film on CPR.

Who would want to see/films in your community? Those of you who have worked with audio-visual media know the answer—practically everyone. The beauty of it is that practically everyone belongs to an organized group that is reachable through just one person. Here are some audience categories who borrow films from us, and who would be just as happy to get them from you:

Adults meeting professionally—in Kiwanis, Rotary, Lions clubs, etc.

Adults meeting socially—women's clubs, American Legion and Veterans of Foreign Wars posts, Knights of Columbus chapters, Elks, Moose.

Adults meeting at work—in employee lunch-hour programs at large plants and offices, at special programs set up by plant personnel managers.

Mass audiences—through telecasts on local television stations.

Schools—at the college level: in teacher education at the high school level and younger: through physical education and health education classes.

Government and health agencies—local hospital public education programs; public and private health clinics; public libraries.

Every one of the audience categories cited above has or have access to a 16 mm sound projector. Some are using video cassettes, others prefer filmstrips—but everyone has a standard 16 mm projector at his or her disposal.

Where do you get films that can be shown under your auspices? There are many sources of *free-loan* films where you pay no rental fee whatsoever, only the return postage.

The nation's pharmaceutical companies, for example, maintain extensive libraries of free-loan films. You can borrow films from comparies such as WEST GLEN. There are about a half-dozen companies like ours that lend films. (You might ask how we get paid. Simple. Our fees are paid by our corporate and non-profit clients for whom we distribute their films as public service.)

Government agencies are also sources of fine free-loan films.

Check your local public library for "The Educator's Guide to Free Films," published by the Educators Progress Service of Randolph, Wisconsin. Of course, you're more than welcome to contact me for any help we might be.

How can you have an inexpensive film made that's localized just for your community?

Films have a reputation for being expensive to produce. I might spend hours talking on the *value* of a film, rather than its mere cost. However, if you feel a local film producer's proposed budget is more than your own budget can stand, you might try these sources for having a film made at rock-bottom cost:

Local college—many colleges are offering film courses; you might prevail on a film professor to have his class make a film on EMS that can then be turned over to you.

Local TV Station—you might be able to interest a local TV public affairs manager to do a film on the EMS situation and opportunities in your area. Then your cost is likely to be only for prints of the film.

Channel the motivation of your audience into action. Because films motivate so well, you have a very real opportunity to get viewers to take action quickly.

One way to do this is by supplying printed materials to accompany the film showing. The brochure, "How do you know if you're having a heart attack" is based on the American Heart Association's *Heart Signals*, and is provided free to every viewer of "A Life On The Line"—about EMS—and "A Life In Your Hands"—about CPR. Both films are made available through WEST GLEN on free loan on behalf of the ACT Foundation.

Indeed, ACT provides other materials with the film. Audiences get a Leaders's Discussion Guide that is an actual blueprint for audiences to follow to get involved in EMS and CPR. They get a poster to promote attendance, and they get a press release to send to local media for further publicity.

Do films *really* work?

That's the real test. Can you document success with films? Yes, and one way we do it is to get audience reaction in writing. These are Audience Reports received within the last two months, for the two ACT Foundation films:

"Everyone really enjoyed this film many of them were not aware that this kind of car was available," Program Chairman, Knights of Columbus, Mobile, Ala.

"The film is very effective. In the Los Angeles area we have five paramedic teams already. However, the film gave people a better understanding of how emergencies are handled," Ambulance Driver, UCLA, West Los Angeles, Calif.

"Excellent as a motivational device when speaking to civic, special and fraternal organizations," CPR Training Coordinator, Oregon Heart Association, Portland.

"The film was excellent and provided the exact effect we were trying to elicit from the group. The group was made up of community members," Administer, Ambulance Care, Misericordia Hospital, Bronx, N.Y.

"The audience was amazed by the simple way to save a life by the use of the CPR method. I signed up 28 recruits to take this course," Chairman, Sudden Death, Knights of Columbus, Maple Shade, N.J.

"Many of the people who saw the film wanted to know when they could get me to come teach a class on CPR Basic Life Support," Instructor, American Red Cross, Mobile, Ala.

"The audience was very receptive to the film and it motivated at least 100 people to take the CPR course offered by the American National Red Cross," Ambulance Driver, UCLA, West Los Angeles, Calif.

"An excellent film for stimulating interest in CPR. When plans are formalized for offering a course in CPR, we may request the film for a noontime showing in our auditorium," Safety Coordinator, Bell Laboratories, Holmoel, N.J.

64% VOTED "YES" FOR EMS TAX LEVY

Donald W. Therens

I will briefly describe to you the area of Northern Ohio where our EMS system has been developed.

There are five small towns just west of the City of Cleveland. They are "bedroom" communities, typical suburban residents, very little manufacturing with an area wide total population of approximately 175,000 people.

Each of these 5 cities have a full paid Fire Department, all separately funded and controlled. These Fire Departments have historically been involved in ambulance work, as there were no other agencies available to handle these activities. We in the fire service also believe this to be a natural place for an EMS system when there is an established fire service.

Two area hospitals that are also involved, Lakewood, a city hospital and Fairview General Hospital, a private, but full service hospital.

Over the past three years with new technology available, two of these cities contacted a hospital, and with the help of the American Heart Association, started a pilot program of Cardiac Care with the City of North Olmsted and Fairview General Hospital, and the City of Rocky River with cooperation from Lakewood Hospital, began a program. Both of these community fire services began with no additional manpower or budgetary assistance from the municipal governments. The training was supplied by the hospitals, and the fire services supplied manpower and ambulance equipment. As these systems grew and prospered in their life saving techniques, reports began filtering back to the neighboring communities. Citizens began to ask us, do we have the same capabilities as Rock River or North Olmsted.

In Fairview Park we stood on the sidelines for many months watching these systems prosper, we also wanted this service for our community, but felt with the minimum manpower available for fire protection, we could not justify an additional service without cutting deeply into the firefighting force. We had to find a way to get some additional people into the fire department, to increase the total staff and get some additional funds for purchase of telementry equipment, defibrillator and other related equipment.

We were fortunate in one very costly area. We had purchased two modular type rescue squads, that could function as "Cardiac Care Units," one unit purchased in 1971 and the second in 1974. These units are matched to the final detail, and both have capability for cardiac care.

I began a campaign to upgrade the fire service manpower with a goal of implementing Cardiac Care for Fairview Park. There were several steps to be taken, the first being to convince my boss, the Mayor, that I really needed additional people and funds to start a program. The Mayor, although in favor of the concept, knew of no city funds available for this purpose. We would be required to generate additional taxation from the citizens.

The next step we used was to form a "Citizens Cardiac Care Committee." I personally at the time thought the Mayor was wasting time - foot dragging - but it turned out to be most beneficial as the months of work unfolded. This was a "loaded" committee with physicians, nurses, ex-councilmen, church groups, Golden Agers, hospital administrators, PTAs, League of Women Voters and service club representatives.

This group of concerned citizens picked up the ball and carried it to the City Council, who immediately accepted the recommendations of the committee. Their first recommendation was to begin this Cardiac Care Service as soon as possible, second, utilize the local fire department personnel and equipment and third, add additional manpower to the fire service by placing a 1 Mill Levy on the November General Election. This levy would generate approximately $100,000 to hire 6 more firefighters, pay their salaries, and the training equipment for a paramedic program, to include all members of the department.

This One Mill was very important to us in the fire department. We did not want it muddled by any other additional tax for sewers, policemen, garbage trucks or any other general operational uses by the City. We knew if it stood alone on the ballot we could have a chance at convincing the taxpayers of our needs. The people would thereby choose, for or against, an additional life saving service. For the next four months, our work was cut out for us. We had to educate the public. How were we to convince the taxpayers to pay more taxes? Our first tool was to have open house at the station with coffee and cookies donated by the firefighters.

All across this country of ours, citizens were fighting against additional tax. Inflation has carved out our paychecks to the bare bone, everyone is looking for ways to cut unnecessary expenses, and here we come asking for more.

We felt the best approach was to tell the people like it was, honest, nothing deceptive, no mumbo jumbo—"give us the opportunity to save lives with a Cardiac Care Program."

We called on a local public relations firm and told them our problem. They suggested a printed brochure tailored to our needs. It was very costly, but we wanted the best approach possible. We ordered 15,000 brochures at a cost of $4,800 (about 32c each). Now tax money cannot be used for this purpose. We would have to collect money from donations. As a full paid fire department we had never been exposed to asking for donations or holding bazaars, ox-roasts or turkey raffles. The members of the department went out into our business community to raise the funds. Our local Chevrolet dealer kicked off our drive with a $500 check.

Boy, were we enthused - There's nothing to this fund raising, we'll have our money in a week or two - NOT TRUE. The businessmen did support us, but it was a buck here and there, a no answer here and there, and an assortment of 5 - 10 - 15 dollar donations. We had to go further, to pay the expenses for the brochures. We next wrote a letter to every doctor and dentist who either resided or had an office in Fairview Park. Again we did not get 100 percent support, but we gathered enough funds to pay off our bills.

In the meantime, I had a visit from Mr. Paul Meyer, a resident of our neighboring town of Rocky River, who is featured on the front of our brochure. He wanted to help, to tell his story, and witness the fact that he was alive and well due to the prompt and effective care of the Rocky River Paramedic Team. What a beautiful opportunity to educate the public, a living victim of a heart attack—saved by a program we were trying to sell—the magic words—"they saved my life." From that day on, Paul and I were sweating his survival to election day. We had many laughs over it. (Could you imagine Paul having another attack, fatal—before election? What would we have done with all those brochures?) Incidentally, as I stand here today - Paul is alive and well.

During the four months of public education before the election, there were several things I felt were also important to our campaign.

The ACT Foundation, for one, supplied films, a most useful tool on the lecture circuit. They supplied ideas, technology, pamphlets and literature. We literally forced our way into every club, group and organization in the city to show our film tell our story and pass out pamphlets and brochures. We begged, yes begged for their support and their vote on November 4.

On one weekend in last September, we literally moved the fire house to our local shopping mall. Our large equipment was placed outside, and various demonstrations were given hourly. This brought the people to us. On the inside we set up display tables of paramedic gear, showed films constantly, and also invited nurses to assist us at a blood pressure station. The people reacted to these activities very well.

This was the beginning of our mutual love affair with the media people. All three local TV stations gave extensive time to our project (at least once per week for the next month). We felt this was extraordinary coverage because we are in a metropolitan area of 2 million, and we represented only a very small slice of this pie. Our local suburban editors were also very thoughtful. All it took was one personal visit to their office and they responded with many, many articles regarding the West Shore Paramedic Service. That's the name of the game - keep your project in the public eye - as much as possible.

I can recall a couple of incidents that will show the type of support we received.

The Altar & Rosary Society at the local Catholic Church have historically at their October meeting, a demonstration by several vendors on Christmas decoration ideas - it was the highlight of the year for these women. Last October, there was no show, or shall I say no Christmas decoration show. They instead chose to have the Fire Department come and explain the need for the 1 Mill Levy. Can you imagine 400 women coming in the door, looking for Christmas decorating ideas and finding NONE, only the Fire Department to ask for more tax dollars. I suppose some of those gals didn't vote for our levy as retaliation, but I know for sure very few votes we lost.

On another occasion, the Baptist minister asked his entire congregation from the pulpit, to stay after the service and hear what the Fire Department had to say. That Sunday morning, we spoke with approximately 300 of the 400 Baptists who attended the service. Believe me these things can get you pretty pumped up with enthusiasn.

I cannot possibly tell every story I encountered while on the lecture circuit, but the motto we used was "We'll talk to anybody - anywhere - anytime."

I met one evening with a women's social group - supposedly 15 or 20 women to attend—only three showed up. We still gave them the full program, the same as if they were 300 strong. Those three women in turn spent the week before election canvassing their neighborhoods for votes—and this showed up on the election. Their wards and precincts voted 80 percent affirmative for the levy. Eight out of 10—what a job they did for us.

Another incident, about the middle of October, a citizen came to me in the Fire Station. He said that he read our sign out in front of the Fire Station about how many more days left to vote for Cardiac Care. The firefighters had placed two 4 x 8 sheets of plywood out in front and reduced the number each day until election day.

This gentlemen asked if he could help. He identified himself as a telephone company supervisor. He had researched the company files and found 125 telephone company employees residing in Fairview who wanted to go door to door to every resident to explain the levy to their neighbors.

At this stage, I was awestricken—here were people coming to us—volunteering time and effort to get a tax passed. Two weeks later those telephone people did go out, and talked with practically every resident in our city.

This was not the end of citizen involvement. The Boy Scouts and Girl Scouts wanted to help also. We decided they could distribute our brochures on that Saturday before election, which the Girl Scouts had stamped with the issue number on it, all 15,000 brochures. The Scout Leaders gathered their troops on that Saturday morning, came to the Fire Station en mass—about 150 of them—picked up brochures and 3 hours and 60 miles of streets later had accomplished the task. There was not one single complaint of walking on lawns or discourteous activities. I will never forget these young people for their tremendous enthusiasm and support for this project.

I think the biggest complaint I received during this period before the election was people stated that they were approached 7, 8 and 9 times about "Vote for the Levy."

I failed to mention earlier, the the City of Bay Village had also tailored a program after ours to get additional tax money to hire and equip the Fire Department for "Paramedics." These two communities had the ***only levies*** that passed on election day in the entire greater Cleveland Area. Even many renewal school issues were soundly defeated. A new school levy in Bay Village did not pass. This is proof to me, the citizens want this service and will support it.

The laws in the State of Ohio, kind of worked against us, preventing a clear and concise message on the ballot, we were not permitted to state "Paramedic Cardiac Care" on the ballot. The law states for operating levies—it cannot be earmarked for special projects. This was another reason I believe when the final election results were in we only had 64 percent affirmative. I believe our people were confused how it was worded on the ballot, and I encourage everyone, when you have an issue to place before people, find a method to clearly identify it on the ballot.

We have hired our six new firefighters and are presently engaged in the final steps of training. Our equipment was purchased from Telecare Inc. of Houston, Texas, which has been delivered. We hope to be fully operational by June 15.

There is something unique about this system in Northern Ohio that I should mention. All the equipment is different. Rocky River is using a Motorola CORE radio system. Westlake and North Olmsted are using Biocom equipment. Bay Village and Fairview Park are using Telecare. The two hospitals are also different. Lakewood with Motorola and Fairview General with Biocom - and it is all working together. There are problems, plenty - procedures - authority - directions - priorities. But with the cooperation from hospital administrators, physicians and nurses, city administrators and above all the taxpayers—I believe anyone in this great country could also build a good EMS/Paramedic Care Program for their community.

OUTREACH OF A COMMUNITY HOSPITAL

William Michael Tomlinson, B.S., M.P.A.

Introduction

This paper will attempt to outline briefly the problem of patient and community health education from a community hospital's point of view. Initially discussed will be the need for such education; the second part of the paper will deal with specific examples of what one hospital is doing in this area besides its normal role of providing patient care.

The Need

In the past, and today, hospitals have tried to educate the populations they serve in matters concerning health and disease prevention in addition to providing the more commonly thought of direct patient care. The hospital is the most commonly found organization that has the varied knowledge and expertise to be able to accomplish these goals. To place these responsibilities elsewhere would require the creation of additional levels of bureaucracy.

Not too many years ago few hospitals had patient education departments, for this area was assumed to be the sole province of the physician. With the coming of the concerned consumer, the informed consent requirements and Public Law 93-641 which lists as one of its ten priorities patient education, and the PSRO legislation, more hospitals are now establishing these services.

The logic behind this effort is simple: We must, in this country, find cheaper and better ways of having a healthier population. The old saying that "an ounce of prevention is worth a pound of cure" still holds true. We cannot go on spending money for inpatient services as we have in the past. In 1975, $118.5 billion went for health care and it is projected that, at the same rate of growth in 1980, we will spend $220 billion. The health care segment of the Gross National Product has gone from 5.9 percent in 1966 to 8.3 percent last year towards an estimated 9 percent in 1980. The well is running dry.

How are hospitals to finance these health education and disease prevention programs? It is unreasonable to expect that each and every hospital will arrive at such a novel or untried program that it might seek grant monies. No. Rather these monies must come from routine operations. Fortunately, the third-party payers, in most cases, will reimburse for patient education as a part of routine patient care. Charlotte Crenson, Senior Director of Comsumer Affairs of the Blue Cross Associations, has stated that "Blue Cross has traditionally absorbed health education costs incidential to the average hospital's routine patient care procedures." Further, the costs of such programs are not really major capital expenditures. With a projector, some tape recorders and possibly a closed circuit television system, and by using current staff plus volunteers (a major untapped resource in the area of community health education) much can be accomplished.

Paoli Memorial Hospital

Paoli Memorial Hospital is located near Philadelphia in an upper middle class area known as the Main Line. It services a population of approximately 190,000 people. There is a great deal of community interest in the hospital as evidenced by the more than 700 active volunteers who work at the hospital. These individuals serve as an important part of the hospital's outreach programs. Many of the programs listed below are joint efforts of the employees, doctors and volunteers or, in some cases, are run totally by the volunteers.

The hospital's goal should be, through education and preventative medicine, to put itself out of business. Realizing that such a goal is unobtainable and yet desiring to reach as far towards this goal as possible, Paoli Memorial Hospital has undertaken to educate its community in the hope that the citizens will not need its services, will need them less frequently, or when they do need the hospital, will arrive at the point of initial definitive care in the best condition possible.

Historically, the hospital's efforts were solely in the area of inpatient education with programs conducted by physicians, nurses, dieticians and others at the "bedside." While maintaining these efforts, new approaches have been made to reach the nonpatient and the expatient. The following is a partial listing of programs currently being sponsored by Paoli Memorial Hospital:

Educational Programs

The traditional Inservice Training Department has been expanded from covering just the Nursing Department to covering all hospital employees and recently some of the programs have been offered to our volunteers, auxilians and other interested citizen groups. Courses such as Cardiopulmonary Resuscitation are run each month for these groups. Industrial and school nurses have been invited to attend, at no expense.

Paoli Memorial Hospital has established a relationship with a local college and now offers its employees college-level courses taught at the hospital in the early evening. Currently, over 40 employees are enrolled in both this program and other advanced educational courses with some financial assistance available through our tuition refund program.

Seminars of general interest have been held for various groups. Rape prevention, the National Geographic MAN THE AMAZING MACHINE and other subjects have been offered. Other programs are in the formative stages.

Outside of the hospital, the hospital has and will take its CPR course to local industries, PTAs, etc. Complete with video tape (the result of a public television show the hospital did on CPR), Resusi-Anne and Resusi-Baby, and instructors, this program takes about two hours to put on. We have developed what we call our "traveling road show" in an effort to stimulate industrial interest in health education. A presentation is made to business leaders, either individually or in groups, explaining to them what their community hospital has to offer. Besides the typical hospital services, these businessmen are informed that we offer Health Maintenance Examinations, more commonly known as executive physicals (we may soon move into providing full health services for all of their employees); the availability of the above-mentioned CPR course; training for their health nurse and other health personnel; the possibility of our developing special skills or tests in the event that their manufacturing process requires such; and advice on the best types of health insurance for their employees.

Other educational programs are conducted by our volunteers and auxilians. Currently our auxilians are becoming involved in the Medic-Alert bracelet program. This is a bracelet which a person should wear if he has some allergy or unusual medical problem. The volunteers also sponsor a program called *Hello Hospital* which is aimed at familiarizing young children with what they will encounter should they have to be admitted to the hospital. Run entirely by the volunteers, a film is taken to local elementary schools and shown. The volunteer also has dolls that have been sutured and bandaged, O.R. gowns and masks, and casts which the children may play with in the hope that by doing this, some of their fears may be alleviated. Started only 6 months ago, the program has been seen by over 2,500 children.

Paoli Memorial Hospital also uses the Speakers' Bureau approach to inform our community as to what their hospital has to offer. Speakers have been provided for PTAs, service clubs and other groups. The Hospital and Medical Staff have also sponsored community seminars on medical programs of common interest with subjects ranging from Heart Attack to Adolescence to Poisons.

Orientations

We, as a new hospital (only 8 years old) feel that there may be residents of our community who are not familiar with us. For this reason, about annually, we hold an Open House for the community or other interested groups such as ambulance personnel, fire and police and their families. A few months ago, we held such an affair complete with tours and a buffet dinner for more than 250 people. In a few weeks, yet another Open House will be held for the community to show them our recently completed building project. To all Open Houses, employees and their families are invited, for we feel that our families should know where we work and what we do.

Orientation takes other forms at Paoli Mmeorial. Our service area has many families who are frequently transferred for business reasons. To familiarize these new people with what the hospital has to offer, we follow the real estate transaction listings in the local newspapers and send an introductory letter explaining what services we offer and where we are located. We also indicate in the letter that, in the event they need to establish contact with physicians, we would be happy to make recommendations. We have also developed a brochure for the groups known as the Welcome Wagon and the Greeters who visit new residents. This "throw away" has a map indicating hospital location, lists our services and the fact that there is a fully-equipped Emergency Department with 24-hour physician coverage.

Yet another type of orientation is the Career Elective Program we have set up with several local high schools for their students. These students, who are tentatively interested in pursuing careers in the various medical fields come to the hospital for discussions about and observation of their specific fields of interest. Each year we are "sold out" for this program.

A final orientation program is for new drug salesmen which is run by the hospital in conjunction with a major drug firm located near the hospital. We instruct the salesmen in how to and how not to approach the sale of drugs to both physicians and hospitals. Hopefully, some of our fellow hospitals will garner the benefits of these sessions.

Emergency Services

Our Emergency Department is probably one of the best in the area. Through a number of fortuitous circumstances, we have been able to develop a service which is of such caliber that the Philadelphia medical schools rotate residents through it at little expense to the hospital.

Paoli Memorial was the first hospital in our two-county area to sponsor and conduct Emergency Medical Technician training programs. While other hospitals in our area have now joined in this effort, we still participate and are used as the measure. EMTs currently volunteer in our Emergency Department for practical experience. Our hospital personnel are called on constantly to aid local ambulance squads in the selection of equipment and recently, when a growing township decided to inaugurate an ambulance service, we were asked to serve as consultants for their entire program.

We, about a year ago, developed a telephonic electrocardiogram program with a device known as a cardiobeeper. This compact instrument (twice the size of a pack of cigarettes) is used for patients with Pacemakers and is also carried by several local ambulance squads so that they may get a tracing at the scene if a telephone is available. This device is currently being introduced to local industry and their nurses, so that they may have the same capability.

I have saved the Bicentennial efforts for the last. We are the nearest hospital to Valley Forge Park. Studies indicate that on an average day this summer, about 30,000 tourists will try to visit the Park. These studies also indicate that about 45 people will need some sort of medical care and of the 45, some 2 to 5 will need admission to a hospital. The road system in the Park is not naturally designed for our purposes and so we have, besides putting a ground ambulance in the Park with 2 EMTs manning it, constructed a helipad at the hospital in the event that someone needs to be air evacuated to us. Radio systems tying together the hospital, the local police, the Park police and the ambulance are in operation. The hospital has further volunteered to provide training in first aid to Park personnel. Because there will be many foreign visitors this summer, we have canvassed our employees and volunteers to determine how many different languages we speak. At the current moment we can converse in 18 different languages including Tonga.

We have also borrowed from our brochure for newcomers and developed another "throw away" map for tourists visiting our area. This map, as the other does, indicates the fastest routes to the hospital and will be distributed by local motels, police and Valley Forge Park.

Expenses

Total expenditures for these programs have not exceeded $10,000 for equipment, and if all the part-time hours of various employees were added, might equal at most, two full-time equivalents. All of the ideas and programs listed above are naturally in addition to the inpatient education programs we and other hospitals run.

One final area I would like to mention is our food. Most patients cannot judge medical care, but they can judge cheerful, friendly spirits (which we have and work hard to maintain) and the food they receive. While these may not fall in the area of "outreach" or "community education" they are still a matter of great concern to us. We have, through the use of high grade frozen foods, been able to institute for any patient (with physician permission) a gourmet diet. We do charge extra for it, but our charges are reasonable. Where else can you get filet of sole or Beef Wellington with wine and crepes for dessert for $2.50 per patient and $5.00 for a guest?

Our best ways of having credibility in our community are through our expatients and our employees. If our efforts help to set this frame of mind in the patient and the well citizen, causing them to listen to our messages, then we have accomplished part of what we have set out to do.

EMS RESPONSE SYSTEMS TEACHING THE GENERAL PUBLIC IN ITALY

Prof. Dr. Rosa D'Andrea

The so called "pathology of the development" which increased in the last years and which shows its peculiar manifestations especially in the increasing of the accidents, in the stress conditions caused by the fast pace of modern life, and in the degeneration of environmental conditions justifies the present interest in the health emergency situations and in the study of the most suitable actions to decrease the loss of human lives.

The review of lethal pathology of the last 20 years in Italy, clearly shows the change which took place. The pathological causes which presented the most noteworthy variations are the ischemic heart diseases with a 461 percent increase in death rate, and traffic accidents with a 91 percent increase. To a prevailing chronic-degenerative pathology was added another type of pathology, caused by traffic accidents, and also work accidents, which reached the figure of over one and a half million per year.

The incidence of accidents is very high even among children. In fact in the age group between three and fourteen years the main cause of death is accidents. For infant pathology, the neonatal emergency adds a considerable contribution to perinatal death rate which in Italy is about 29 percent.

It is known that for early intensive assistance for health emergency cases it is mandatory that education of the public be given a high priority.

What the public must necessarily know: 1) the alarm system to be used, 2) the operation of the assistance system, and, 3) the life danger status of the patient.

In Italy there is a standardized alarm system; the 113 phone number managed by the Police Force which provides ambulances or first aid mobile units or information to hospitals and physicians. In exceptional cases the service of the Army helicopters and the cooperation of the Air Force SAR/Air Assistance Service may be also requested. The Air Force Assistance Service is being strengthened by the employment of the new helicopter "H H - 3 F" and by the establishment of new bases throughout the national territory.

This alarm system has been made known through every means of propaganda and through all the information media. It may be safely said that the phone number "113" for all its meaning and importance is well known by all the population which uses it with high civic spirit and sense of responsibility.

Italy has 1,163 hospitals with 363,203 beds for a population of 54 million. For each hospital it is mandatory to provide a continuous first aid service equipped with all necessary facilities for emergencies.

The emergency assistance outside the health organization of the hospital is still carried out mainly by the "municipal doctor" until at least the new law on the National Health Service which forsees the establishment of the Local Health Units is approved. The "municipal doctor" is one of Italy's more characteristic and historically well established institutions of our country where the "Medico Condotto" (Medicus conductus) is obliged to live in the area of his assignment and to be always available to act in time.

Italy has 89,995 municipality physicians who serve as screens before the hospital organization is called into action. The public generally contacts these doctors without fear and with full satisfaction while some prejudices against hospitals exist especially in socially and economically depressed areas. Many hospitals, which by law should promote for education in health and hygiene for the patient and his family, are actively seeking a direct contact with the public by implementing programs for health education of the patient and his family especially for patients suffering from coronary disease, for the handicapped and for those with artificial kidneys.

In consideration of the considerable increase of traffic accidents and the consequent necessity to teach people from childhood a correct behavior on the roads, the road education will be introduced in all schools, including first aid and identification of the basic cases of health emergency.

As today periodical campaigns on road education are launched in Italian schools with the aid of a special organization such as the School Park of Traffic, which is located in Rome and is the only one existing in Europe. Other campaigns are generally addressed to the public through the mass media (press, radio, TV). The Youth Section of the Italian Red Cross and other humanitarian organizations are holding courses for teachers and students to become rescuers through the teaching of first aid techniques and distribution of various health material (pamphlets and first aid carrying cases). These courses are well attended and are generally successful.

THE EMT — AN UNTAPPED PUBLIC INFORMATION RESOURCE

Janet L. Schwettman

In 1776 there were approximately 250 physicians in America. Today, two hundred years later, there are only 370,000 practicing physicians in this country.

In comparison, in the short span of five years since the recognized evolvement of the Emergency Medical Technician, over 170,000 EMTs have been certified with hundreds more applications being processed . . . a remarkable vocation explosion. Fifteen thousand EMTs are registered in the State of Illinois alone and we don't even have an ambulance law requiring such certification.

The following major plus developments have occurred in medicine in the past five years:

1) The increasing focus on preventive medicine rather than the traditional reactionary response to episodic and chronic illness or injury.

2) The EMI - a fantastic machine that scans the body and presents a precise diagnostic profile, eliminating the need for an enormous amount of invasive surgery.

3) The linear accelerator - developed at Stanford, it is capable of differentiating between cancerous and noncancerous cells and destroying only those which are diseased.

4) Computerization of diagnostic techniques making for immediate and accurate assessment of a patient's condition and programming the most optimum treatment on a minute by minute basis. It's Nick the Greek in an IBM 370!

5) The Emergency Medical Technician—the EMT is not a machine, theory, idea or program. There are times when we planners tend to forget that he is a trained INDIVIDUAL in a large and growing body of men and women with enormous impact potential.

He's been asked to wear many hats and his current and projected responsibilities are expanding beyond on-scene patient care, his initial charge.

Let us differentiate here between Emergency Medical Service *Education* and *Information*. Education deals with the teaching and acquiring of *skills*. Information relates to making the public aware of the various facets of EMS—for example, when to call for an ambulance. Too often these terms are used interchangeably.

EMTs are becoming involved in a wide range of teaching, from CPR classes for the public to instructing physicians in prehospital emergency skills. There's no better educator than an EMT who can teach. He's been there. No ivory tower lesson plans for him! He's worked the streets and can translate the text with the flavor and practicality of the real world.

Now we're suggesting that the EMT act as an information funnel—an important task, for the best prehospital care system in the world is of little value if the public doesn't know about it and learn how to access it. A case in point: A fifty-year old women who had lived in a community that had been running MIC units for several years refused to call for help because she felt "embarrassed" and "thought the chest pain would go away." An hour after the onset of cardiac symptoms the call was made. She did not survive the trip to the hospital.

Because of this and similar incidents, Public Safety Officers Foundation (PSOF) has developed a unique brochure designed to aid victims of illness and injuries in overcoming the psychological blocks often inherent in quickly initiating an ambulance call. The pocket-sized "Patient Assessment" brochure also lists the thirteen life threatening conditions and symptoms of each. Presented in language the layman will easily understand, the brochure is being distributed by EMTs as a public information handout. This is only one of the mechanisms which can be used to forge strength into the weakest link in the chain of events in medical emergencies, *i.e.*, lack of public information. *Casual communications can cause casualties.*

Expanded Role

Besides being the nation's most important new health care provider, the EMT usually has another vocation and he touches our lives not only when ambulance service is sought, but when the drain is clogged, a house needs painting or any of the myriad services his other career provides. As you are aware, most ambulance service in this country is provided by Fire Departments whose personnel works 24 hours on, 48 off or on a volunteer on-call basis.

It is precisely because of his multiple role in society that the EMT can be a highly effective source of EMS information to the general public. His interacting with the community occurs in three different ways aside from his EMT involvement: as a business person, as a community oriented citizen, and as a private individual.

He is a unique and valuable combination in his whole personage.

A tested tenet for establishing EMS systems is "Build on Existing Resources". Well, the EMT *exists* and is a tremendous resource on which to build public information and education programs. Currently EMTs are teaching basic CPR, First Aid courses, and EMT I and II classes. PSOF is also utilizing the EMT as an organizer/instructor of the Foundation's Emergency Medical Procedures (EMP) program whereby industrial plants and office buildings are "CPR Secured" by training employees and setting up an EMP protocol.

On the information side of the activities log, the EMT is a refreshing and enthusiastic public speaker who tells it like it is. He's a welcome relief at the monthly meetings of the Garden Club of Yam, Utah, for he has an exciting message to impart that holds his audience's attention like a typical club lecture on "A Peek Into the Troubled World of a Philodendrum" never could.

His "other career" contacts are another excellent opportunity to move the message as he interacts with his business clientele. The EMT can also be importantly involved in those special EMS occasions such as Health Fairs, Paramedic Day, etc. The list could go on and on for its focal point is the EMT himself. Enthusiastic and action oriented, his movements through life make him a natural for educating and informing.

Most importantly, he is trusted and LOVED by the populace. The honeymoon is not over for the EMT and at this stage of the profession he wrestles with less self interest than any other provider of health care.

Suggested Guidelines

Planning a communities' public information program is a customized procedure. For, just like a ladies' lingerie it must be designed to cover various shapes, sizes and problem areas. However, here are a few suggestions that can be useful wherever you live:

1) Use imagination . . . we're rutted . . . the terms Public Information and Education are dull in themselves, but the mechanisms used can be bright and beautifully effective. For example, Senior Citizens in a condominium in Buffalo Grove, Illinois, held a Paramedic Gala, charged five dollars a drink and raised $7,000 in one night for ambulance equipment while at the same time making the public aware of the MIC program's operational aspects.

2) Don't assume anyone knows anything about emergency medical services. Spell it out in a simplistic fashion like the old Dick and Jane readers.

3) Do *continuously* program your public information efforts. The transcient nature of today's world makes this mandatory. It's an unnecessary tragedy for a new resident to die or suffer needlessly when he moves into an area that has effective EMS of which he is unaware. Take-A-Welcome-Wagon-Hostess-to-Lunch is a workable idea that can result in an EMS handout being part of her kit when introducing community services to a newly arrived citizen.

4) *Momentum-ize* your information timetable. Block out your goals, strategy and mechanisms and see that milestones

are established and met. Once lost, momentum is as hard to retrieve as a hubcap on a freeway.

It has been our experience that community EMS information must be built with the EMT as the cornerstone for maximum lasting effectiveness. While media and the printed word are highly important, nothing replaces or impacts in as lasting and effective a manner as repeated person-to-person contact. The Emergency Medical Technician is an

E-xtraordinary
M-eaningful
T-ransmitter

His pioneering footprints are tracks for coming generations of EMTs to follow. Let us call upon his innate ability and willingness to interact with his fellow man to further improve the nation's Emergency Medical Services.

Suggested Reading

EMS Public Awareness Manual, Chicago Hospital Council, 840 N. Lake Shore Drive, Chicago, IL, 60611

Ingalls Today, (Spring, 1975 issue), Ingalls Memorial Hospital, One Ingalls Drive, Harvey, IL, 60426 (Contact: Janet Laible, Director of Public Relations)

Saving Lives with Emergency Coronary Care, Act Foundation, 350 Grove, Somerset, N.J. 08876 Chapter 8, p. 51)57

Emergency Medical Service Legislation

CURRENT STATUS OF EMS LAW AND POLICY

James O. Page, J.D.

Although a substantial body of case law related to the provision of inhospital emergency care has issued from litigation over many years, the development of statutory law related to EMS is a relatively new area of public policy. Largely inspired by federal initiatives, nearly all States have enacted one or more legislative proposals related to emergency medical care or transportation since 1966.

The most active period of EMS-related statutory activity appears to have been between the years 1971 and 1975. Although a few of the states have created comprehensive legal structures for development of EMS systems, many others have merely enacted statutes which require and provide for licensing and regulation of ambulance services, vehicles and personnel. Most State EMS legislation since 1973 has tended to establish State EMS Advisory Councils. It appears that only three States have provided for categorization of emergency facilities in their statutes.

Examination of the various State EMS legislation discloses great diversity in approach, structure and extent. The relative newness of EMS (in a systems context) has deprived most states of legislative information or sophistication in determination of statutory need. In some cases, the need for political compromise has resulted in piecemeal approaches to EMS legislation as a first step toward future and more comprehensive legal structures.

The EMSS Act of 1973 required the Department of HEW to study any legal barriers to the effective delivery of medical care under emergency circumstances. Pursuant to this requirement, a study was conducted under contract and a report to Congress, based on that study, was developed and submitted. In the report to Congress, it was stated, "Much of the State legislation reviewed was very recent and a number of States were in the process of changing their legislation as the study was being done." It was further stated that "State legislation for EMS is a dynamic area."

In the interim period, informal interviews with a number of EMS officials, as well as written communications, confirm that State legislation for EMS continues to be a dynamic area. Legislation introduced in many States since July, 1973 discloses a continuation of the diversity in approach, structure and extent. Also evident is a nearly universal delegation of rule-making authority to a State agency, board or commission with EMS interest or responsibility.

The dynamics of EMS legislation are frequently reported in terms of political conflict and controversy over the intent, language and extent of such legislative measures. It has also become apparent that such State legislation is being created and debated in the absence of any scientific analysis of value or impact of State EMS law as an instrument of change.

The continuing dynamics of this area of policy development have made obsolete the contract study made earlier on behalf of HEW. That study was largely devoted to potential legal barriers to provision of care at State borders. The study also revealed that *absence* of enabling legislation at the State levels, rather than *presence* of laws which preclude delivery of service, represented the major legal barriers to development of areawide systems of emergency medical care.

The current programmatic emphasis of the federal Division of EMS is in keeping with the Act's requirement that an EMS system provide access (including appropriate transportation) to specialized critical medical care units in the system's service area. HEW has encouraged development of mechanisms to create and facilitate such a component in all systems currently receiving grant funding. A principal element in such emphasis is the device of the transfer agreement.

As reported at last February's National Symposium of Rural/Wilderness Emergency Medical Services, there is great concern among grantees for the potential legal impact of such patient transfer agreements. It is also clear that the States have not yet seen the need to reassess and reassign legal responsibility for patient transfers. Thus, the old and obsolete case law doctrines remain generally intact. Those doctrines would hold that transfers should not be made unless the patient is capable of withstanding the transfer. They would hold the transferring physician and hospital generally liable for the patient's well-being until such time as the patient is safely received by the second hospital.

It is clear that such case law could easily feed legal anxiety and thus blunt a most important element of the national program. Reassignment of legal responsibility would appear to be within the power and province of State legislatures. This may well be an untouched area of statutory law which needs serious consideration.

According to health agency officials contacted in all 50 States, legislative proposals related to EMS have been introduced in at least 46 States since July, 1973. The informants also report that EMS laws have been enforced by criminal action or other legal means in only eight States.

Currently, there is no apparent measurement as to the efficacy of State EMS laws for improvement and/or mainteannce of EMS standards and performance. It is not known whether the existence of an EMS law encourages the desired change or improvement without the need for enforcement action. There has been no analysis of comparative circumstances in those cases where criminal or other legal means have been used for enforcement of EMS laws.

As mentioned, State EMS legislation introduced and/or enacted since 1973 has included nearly universal delegation of rule-making authority to a State agency, board or commission with EMS interest or responsibility. However, contact with State EMS officials discloses that less than half of such agencies, boards or commissions have accomplished the task of developing the rules or regulations called for by such laws.

It is apparent that the mere passage of EMS legislation cannot be measured as a significant achievement if a rules structure authorized and commanded by such legislation does not materialize. It is also apparent that the diversity of approach found in EMS laws is being replicated in the creation or rules, regulations and guidelines for EMS development, implementation and regulation.

The tendency toward State agency delegation also focuses on two other significant issues: reputation of the State agency to which authority is delegated, and the process by which the legislation is introduced and enacted. A distinctive contrast is presented by the esperiences of Michigan and California.

Michigan's approach to comprehensive EMS legislation was highly participative. The first draft of the legislation was sent to 800 interested parties throughout the State for review and comments. Competent staff was provided for working with interested parties in achieving consensus. Hearings were held which included some educational content for legislators. Apparently, the Michigan Department of Public Health was seen as a trusted recipient of delegated authority.

By contrast, California's EMS community was recently thrown into turmoil as the so-called Beilenson Bill was unveiled. Coming as a surprise to most local EMS activists, the Bill seeks to give California a comprehensive legal structure for EMS. But is also seeks to place primary authority for rulemaking and regulation in the California Department of Health. Generally speaking, that Department does not enjoy the respect and trust of the EMS community. The Beilenson Bill was immediately the center of adversary politics. The adversary political process is likely to produce something less than an intelligent and workable body of law.

Good samaritan laws are another area of activity and interest in the EMS field. Apparently commencing with an undocumented 1963 Readers' Digest, legislative activity has occurred in nearly all the States to produce a legal device which is intended to provide a degree of protection for a variety of citizens, paraprofessionals, and professionals in the provision of prehospital emergency care.

Diversity of approach is widespread in this area of lawmaking also. This diversity is to be found in the varying categories and identities of those entitled to the purported protections. It is found in the variety of conditions which are prerequisites to operation of these laws. And it is found in the limiting conditions which seek to describe the mental condition and relative skill with which the emergency functions are performed.

Despite the clutter of good samaritan laws, there is no evidence of litigation history to justify their creation. In fact, to our knowledge, there has been only one case in which a good samaritan law was used as a defense in a case involving provision of emergency care. In that California case, dismissed just a year ago, one of California's good samaritan laws was successfully utilized to free paramedic personnel from responsibility for alleged negligence in the treatment of a child.

Those paramedics were part of a phenomena which has swept the nation in the last nine years. Starting with a few pioneering programs of advanced prehospital care in 1967, the use of non-physicians to perform definitive prehospital care now occurs in at least 45 States. California is believed to be the first State to have developed a statutory authorization scheme for such activities. Interestingly, California's new Beilenson Bill seeks to do away with that law, known as "Wedworth-Townsend Act," and replace it with an undefined rules structure.

Twenty-five States are believed to have commenced their paramedic programs without any form of statutory or other legal means of authorization. Currently, eleven States are believed to be allowing the function of such programs without any form of legal authorization or statute. Among the other States, a variety of approaches have been taken to provide some form of authority.

The trend of legal development for advanced prehospital care programs appears to be toward delegated rule-making authority. In such cases, the State legislature usually adopts a vague provision which acknowledges a defined class of allied health practitioners and authorizes a regulatory agency or body to adopt a training program and rules and regulations for functioning of such personnel. At least 15 different job titles have thus far been adopted by law for paramedic personnel. Most laws which would delegate rule-making authority for paramedics have not been followed by development of a rules structure. In many cases, an approved training program has not been created or adopted.

In those cases where laws, rules and regulations do exist, diversity is again evident. Distinctions in training, certification, regulations, authorized functions, communications and telemetry requirements, ventilation techniques, drug and solution lists, preconditions for administration, reporting, program evaluation, continuing education, and recertification of personnel are most notable in comparing these materials.

Litigation experience with advanced prehospital care programs has been investigated nationally during the past year. That investigation has revealed such litigation in only two States and has disclosed no serious legal threat to the concept at present.

However, it has been generally determined that development and refinement of advanced prehospital care programs is currently retarded by legislative, administrative and medical anxiety over the potential for liability. This would appear to suggest a need for continued research and inquiry in this area of EMS activity. It would appear to disclose a need for reliable and accurate information concerning the dimensions of the liability problem, if any, and a sharing of that information with those agencies and individuals who currently lack an appropriate response to uninformed contentions of legal hazards.

Linked with any discussion of EMS law and liability hazards must be some reference to liability insurance. At present, the entire topic of liability insurance in the health care field seems to lack any opportunity for informational measurement. The issue is dealt with, and premiums purchased, on a local basis without any definable relationship between experience, hazard, availability of coverage and cost of premiums. It is compounded by many legislative efforts to create reactionary patchwork solutions. Liability insurance is one area of EMS law and policy which currently defies any rational assessment.

Clearly, all areas of EMS law and policy cry out for a national base of reliable and up-to-date information. As the national program moves on to more advanced and sophisticated elements of system development, there is a possibility that work already done will be unraveled in the political arena. The resources of State EMS agencies are currently distracted by growing numbers of legislative initiatives, both positive and negative. As subsequent presentations will indicate, EMS law and policy is a major issue in our nationwide effort to improve emergency health care services.

LONG-TERM REGIONAL ORGANIZATION OF EMS

James O. Page, J.D.

On January 23rd, 1976, Mr. Gregory J. Ahart, representing the U.S. General Accounting Office, issued a statement on the EMS Systems Act of 1973 to a Subcommittee on Health of the U.S. Senate. The statement was prepared following a GAO review of the activities of 12 EMS grantees who received federal support for either planning, establishing, or expanding EMS systems in their geographical areas. The statement was an attempt to provide the Senate Subcommittee with insight into what the GAO sees as progress and problems being experienced in developing regional EMS systems.

In describing problems perceived by the GAO, Mr. Ahart referred to difficulties in establishing and operating systems on a regional basis. He further stated that problems being experienced by the regional management entities will become more critical when federal funding, as called for in the Act, stops.

In attempting to analyze this perception of organizational problems, we should first attempt to make certain that we are all discussing the same issue from a mutually understood viewpoint. What is a system?

We have all read the law and the implementing guidelines. We have seen the definitions of an EMS system. But, given the substance and implications of the GAO report, there may be some conflict between what the Congress intended, how HEW interpreted the Act, what the grantee implementers see as a system, and what the GAO currently envisions.

The GAO states that the act and implementing guidelines provide for bringing together existing resources into a regional system operated directly or indirectly by a single management entity. *Operated* by? A single *management* entity? What does the GAO visualize when they refer to a single management entity which directly or indirectly operates a regional EMS system? How direct? How indirect?

Much of a practicing lawyer's time can be spent in analyzing statutes. Application of a law to specific factual circumstances nearly always raises questions of statutory intent. What did the lawmakers intend when they composed the language of the law?

Unfortunately, we have neither the time nor the forum to adequately investigate the precise intent of the Congress in passage of the EMSS act of 1973. Perhaps an alternative is to view, in general terms, the end results the Congress was seeking. That is, improved emergency health care services.

The GAO report acknowledges that, with the aid of Federal funds authorized under the Act, communities throughout the country have been able to upgrade their EMS resources. But the report continues by identifying certain "problems." Our question is whether those alleged "problems" are truly relevant to the Congressional goal of improved emergency health care services.

For example, the GAO contends that regional management entities are having difficulty identifying firm sources of permanent financing of "administrative" and "operating" costs that are initially borne by Federal grant funds. In addition, it is contended, these regional management entities have little control over the level of emergency medical services being provided by local governments and EMS providers.

The validity of the GAO report must be questioned when it is noted that "operating costs" are identified as monies being used to purchase central communications lines or towers, equipment, etc. It is our impression that those are implementation monies—capital funds which are intended to upgrade EMS resources, create higher public and industry expectations, and eventually create such community reliance on the system and its hardware that local governments will find it politically necessary to continue operation and growth of the system after a departure of federal monies.

If we can distinguish "operating" costs from "administrative" costs, we should then be able to look at future financing ***needs*** before decrying the apparent absence of identified funding sources. What administrative costs will be necessary in a typical region at the conclusion of the five years of federal funding?

We suspect that the GAO has visualized a bureaucratized and institutionalized agency which would organize, reorganize, control, manage, fund and operate all the services that fall within EMS in a region. At the very least, such a profile would superimpose a strong regional management entity over local governments and local services. Obviously, such an EMS bureaucracy would be expensive and would require firm and long-term sources of finance.

But is such a superagency necessary to accomplish the Congressional goal of improved emergency health services? There is not much evidence to indicate that large, all-inclusive bodies or agencies are a desirable path to improved service of any variety. Nonetheless, there may be regions currently funded under the Act where such a structure is deemed an appropriate goal. If so, long-term administrative costs can be viewed as a funding ***need*** for which firm ***sources*** of financial support should be developed during the period of federal funding.

However, the general thrust of the GAO report is to question the entire national program for the inability of several grantees to line up long-term funding ***sources*** for which there may be no ***need***.

The current political climate in America is heavily stacked against creation of new levels of government—EMS or otherwise. Against this background, the GAO report criticizes the coordinating and advisory role assumed by most of the grantees. This criticism fails to recognize that local governments and service providers will only reluctantly and begrudgingly allow themselves to be coordinated and advised. Efforts by some new and uninvited agency to manage and control local EMS resources will be met by reactions ranging from fury to total disregard.

The report states that because of their responsibility for, and financial interest in, the provision of emergency health services, local governments and EMS providers are reluctant to relinquish management and operational control of their resources to the system's designated management entity. The GAO identifies this as a "problem." We see it more as a problem of form than of substance.

Did the Congress truly look for revolutionary transfers of management and operational control to hundreds of grantee agencies? Once again, we must revert to the basic Congressional goal of improved emergency health care services. Can those services be improved without such a transfer of management and operational control?

In response to this question, we have once again reviewed the list of fifteen basic requirements for an EMS system. With regard to each of the requirements, we have asked, "Can it be satisfied by a coordinating and advisory body or will it need a region-wide, unified EMS management and control agency?" We are convinced that in most cases, the general goals of the Congress can be met without force-fitting another unwanted governmental or quasi-governmental administrative entity into the already strained fabric of the health care system.

But this conviction relies heavily on the personal skills and credibility of the current grantees as they work with the federal resources which are temporarily available.

The GAO report includes capsule reports of episodic incidents of difficulty and failure experienced by certain of the grantees who were site-visited. In one case, for example, it is noted that a local referendum to support operating costs of advanced life support teams had ended in defeat. In another case, it was reported that a demonstration project in its final year of federal funding has failed to secure local government commitments to continue a regional telephone communication system, data collection, and system management. In still another case, the report pointed to one project's inability to reduce the excessive number of ambulance vehicles serving the region.

In its report to Congress, the GAO should have balanced these episodic incidents with a realistic view of the environment. First, let us recall that the federal money has now been working for EMS system development less than two years. Many of the projects have moved from the planning to implementation stages only during the last year. There has been no public outcry for reorganization, development and improvement of EMS resources. Most local government elected officials had never heard of EMS, much less Public Law 93-154, until the arrival of a health planner supported by something called a "1202" grant. At the same time, they have been confronted by the economic outfall of a severe recession.

The GAO should attempt to recognize that public policy is usually the result of political forces. Political forces often represent community demands and consensus. Most communities have yet to achieve consensus on EMS as a priority public service issue. In very few communities has there been any noticeable public demand for creation of a regional EMS system. Until public demand presents a strong consensus to political representatives within the community, there will be no public policy sufficient to bring about basic change in management and control of local EMS.

Even where public policy would allow creation of an EMS superagency, we wonder whether such an agency would serve the long-range needs of people in the region, or the general goals of the Congress. The nation's experience has shown that the security and comfort of a big, deeply-entrenched bureaucracy frequently leads to passive and insensitive response to changing needs. There is something to be said for the built-in competitiveness of the multiple service providers operating in most of the EMS regions—even if they do have too many ambulances and they are painted different colors.

Returning to our basic proposition, we feel that in most regions the list of fifteen basic requirements can be met without the imposition of a new level of management authority and control. We must presume then that the GAO, or the Congress, or both, have missed the mark in speculating on the size, shape, function and effect of the regional EMS system at the terminus of federal funding.

As stated, the more practical profile of a long-term EMS system will be determined largely by the personal skills and credibility of the current grantees. Such qualities, if appropriately and persistently applied, can produce a higher degree of consensus for improved emergency health care services. If skillfully managed—manipulated, if you will—such a consensus can be converted to public policy. That public policy can reflect a local government commitment to long-term improvement and operational support for emergency health care services.

At best, this process is inexact and time-consuming. It will usually involve setbacks—such as an occasional loss of a referendum election. It may produce only a tenuous coalition of service providers, each reluctantly consenting to policy changes which involve infringements to territory, authority and role. Most likely , it will be difficult for a federal accounting agency to comprehend and appreciate during brief site visits. But, given the current public policy environment, it may be the best configuration we can hope to achieve.

The heart of the regional EMS system may well be its advisory board—the EMS Council or Committee. In many areas, it is likely to be the organizational and management remnant of the five-year sequence of federal funding. In many areas, it is likely to reside within the Health Systems Agency.

What sort of legacy will the EMS Council or Committee have to build on at the conclusion of federal funding? Once again, that depends on the personal skills and credibility of those currently engaged as grantees. Hopefully, there will be a higher degree of consensus for improved emergency health care services throughout the region. Hopefully, that consensus will have produced public policy which reflects local government commitments to long-term improvement and operational support.

There are still volunteer rescue services that see EMS as little more than extrication. There are still physicians who lack the skills of basic life support. There are still city managers who see EMS as a contract for ambulance service. There are still fire chiefs whose perceptions of EMS are limited to some ill-defined paramedic concept. There are hospital administrators who still see categorization as a threat. And critical patients all over America are still being delivered to the wrong hospitals. These are the issues with which we must deal while we have the benefit of federal resources. They are issues of perception. They are issues which must take precedence over concern for size, shape and power of a management structure which would inherit the system and its problems.

Capable and credible grantees should be working to change viewpoints. They should be using every mind-bending tool at their disposal to lead the volunteers, the physicians, the city managers, the fire chiefs, the hospital administrators and others out of their self-limited images.

An improved understanding of EMS as a system is likely to produce the desired public policy commitments from local government. Long-term organization and management of those commitments is likely to rest with an EMS Council or Committee. But we must recognize the independent nature of most Americans. Plainly, they don't want to be managed or organized.

Given the reality, what mechansim can be employed to assure long-term clout of the residual structure, the EMS Council or Committee? The federal funding effort provides capital funds for building some of the mechanical elements of the system - radio communications systems, for example. Those mechanical elements provide a service which most personalities within the system will see as desirable and necessary.

In essence, if the EMS Council or Committee is to serve as the long-range management entity, it must provide some form of commonly-needed and mutually-appreciated service. Consultation, advice and coordination won't suffice. People don't want consultation or advice. They don't want to be coordinated. They certainly don't want to be managed or controlled. Thus, if the long-range management entity is to be at all successful, it must possess some form of lure which will establish its position, validate its existence, and compensate for unpopular policy decisions it may formulate.

The Act was never intended to be a hardware giveaway program. Nonetheless, it is providing millions of dollars for hardware acquisition. That hardware is currently being dispensed by the grantees. That hardware can be committed to a regional service function that can serve as long-term glue for the system, that can provide the residual EMS Council or Committee with substance beyond consultation and advice, and can lure all the personalities within the system into seeing that entity as the system's focal point.

An excellent example of this principle can be found in one of our midwestern states. There, a regional government organization has become an EMS focal point by designing and installing a regional communications system. It provides radio equipment to municipalities and service providers who are willing to accept certain policy prerogatives. The regional organization has never been overly popular with local governments in the region. But it has proven that old animosities can be quickly buried for the price of a free radio for an ambulance. The regional organization retains title to the equipment and thus can exercise the option of repossession in cases where regional system policy is not respected.

Two matters are important in analyzing this example. First, the regional government organization has not asserted itself as an EMS superagency - it is not a provider of direct services. Secondly, it has taken several years to achieve a status of recognition within its local political environment.

As EMS grantees, we should be challenging the contentions of the GAO report, but we should also be looking seriously to the future of those systems we are attempting to build. What will happen to them after our federal trough runs dry?

It is obvious that the GAO vision of a single management entity will not be satisfied in most areas of the nation. But it is also obvious that we have a unique opportunity to use current federal resources to build a focal point for long-term management of a less ominous nature. We should set the stage for our EMS Councils and Committees to inherit the management role with a reasonable chance for success. As stated, that role must involve something more than just making the rules.

During the current year, our efforts have been largely directed to the needs of the critical patient, particularly that patient who must be transferred to a critical medical care facility. In the past, most such transfers have been poorly handled, if at all. Too often, critical patients are transferred for the wrong reasons to the wrong facility by people who have little capacity for critical care in vehicles designed for transporting the dead.

In reaction to this collection of EMS wrongs we should be building critical patient transfer systems. Through use of the federally-funded hardware, and a systems analysis approach to critical patients transfers, we should be creating a managed methodology for moving critical patients to appropriate facilities. And we should be placing long-term control of this useful and needed service in the entity which is likely to survive the end of federal funding—in most cases, the EMS Council or Committee.

We have found that physicians want a more intelligent method for transferring their critical patients to distant facilities. We have found that administrators are disturbed by the dangers in the current arrangements. We have found that ambulance personnel are aggrieved by their lack of preparation and guidance in their role as transporters of critical patients. We have found EMS Councils and Committees wondering about their role at the end of project funding. This combination of doubts presents the opportunity to place long-term management of a needed system in an entity which needs visibility, identity and a meaningful task.

The GAO persistently views current grantees as regional management entities. It might be more appropriate to view them as regional EMS catalysts. These catalyzing agents can identify untouched service needs within their region. They can utilize federally-funded staff expertise and hardware in designing long-term systematic responses to those needs. They can design those systematic functions around long-term control by the residual EMS Councils and Committees. And in most cases, there will be satisfaction of the Congressional goal of improved emergency health care services.

The topic of this session is EMS legislation. We note that the GAO has met with Senate Subcommittee staff to discuss several possible changes in the legislation which they feel may help overcome the problems they allude to. That is a frightening revelation, given the GAO's demonstrated failure to understand the realities of community organization in general, and EMS in particular.

It is somewhat appropriate that this topic is under discussion at a Bicentennial Conference. This setting provides us with a reminder of those rebellious and cantankerous qualities which led to the formation of this nation. They are still out there - after 200 years. And they will not be dissolved by a sprinkling of federal money. They will not passively allow the creation of EMS superagencies for regional management and control of their resources and efforts. And they will not be affected by any redesigned legislation which might seek to circumvent their independence.

A SURVEY OF STATE EMERGENCY MEDICAL SERVICES LEGISLATION

J. William Thomas

Introduction

Funds recently granted in accordance with DHEW's emergency medical services program have assisted many communities in planning and developing EMS systems consistent with the generally accepted concepts embodied in the EMSS

Act of 1973. Other federal government initiatives, particularly Standard 11 programs under the National Highway Safety Act of 1966, have also been instrumental in upgrading local emergency medical services resources. However, to achieve uniformly high quality EMS systems on a wide scale, such federal efforts must be complemented by strong state-level activities.

Accordingly, many states in recent years have passed legislation intended to:

1) Encourage local EMS providers to meet vehicle, equipment, and personnel training standards, and to participate in regionally coordinated systems; and

2) Remove legal and financial barriers to the utilization of new approaches to the delivery of emergency medical care.

Although DHEW commissioned a review of state EMS legislation in 1974, much legislative progress has been achieved since the study was completed. Thus, to provide a more up-to-date assessment of the status of state EMS-related legislation, a mail questionnaire was recently sent to the directors of each state's emergency medical services program. Between January and April 1976, replies were received from 90% of the states, and the data presented below is based upon these responses.

Minimum Standards For EMS Providers

The primary focus of legislation in the area of emergency medical services has been the mandating of minimum standards for EMS providers. Specific requirements may be included in legislation directly, or, alternatively, an agency of the state government may be empowered through legislation to develop and implement the standards . Within any requirement category, the strictness of legislated standards varies considerably from state to state. For example, among states with minimum training standards for ambulance personnel, some require advanced first aid, some require at least one emergency medical technician (EMT) on each run, and some require at least two EMTs. Less strict standards are often imposed on an interim basis in order to guarantee a minimum level of service quality over the short term, while recognizing that more stringent requirements can be enacted later. Another approach employed commonly is to enact standards but to delay their formal implementation. When standards are phased in over a two to five year period, providers may avoid the financial losses that would be incurred if non-conforming equipment had to be replaced before the end of its useable life. Thus, for example, ambulance vehicle standards established in 1975 might not formally take effect until 1978 in order to allow providers to acquire conforming vehicles during routine replacements. Following the same motivation, some states have enacted standards which apply only to new purchases, with previously owned equipment being exempted from compliance with the standards.

In several states, the State Division of Emergency Medical Services or other appropriate agencies have developed standard which local EMS providers are encouraged to meet, but which have not been formally mandated. The use of informal standards may reflect the political difficulties associated with achieving legislative enactment. In some cases, however, a conscious decision has been made to keep standards on an informal basis in order to avoid undermining the strong sense of voluntary participation felt to be prevalent among EMS providers. It is reasoned, in these states, that if all providers willingly subscribe to the standards, it is preferable not to legislatively force compliance.

Figures 1 through 8 show the current status of state standards for ambulance vehicles and equipment, for ambulance

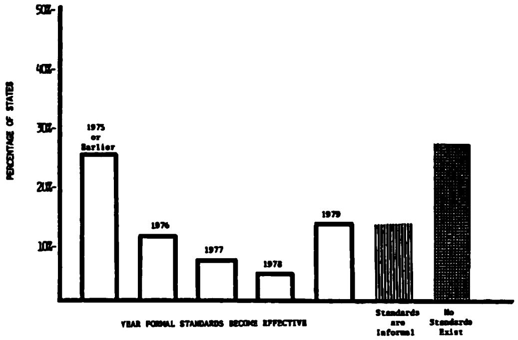


FIGURE 1: STATUS OF AMBULANCE VEHICLE STANDARDS

and hospital emergency department radio-communications, and for ambulance personnel training. Each of these figures is discussed below.

AMBULANCE VEHICLE AND EQUIPMENT STANDARDS

Figures 1 and 2 show the prevalence of minimum standards for ambulance vehicles and equipment, respectively. Prior to and including 1976, 36 percent of the states had imposed minimum standards for vehicles, while 45 percent required that ambulances carry a specified minimum set of equipment (such as that recommended by the American College of Surgeons). Such state-mandated standards are often less stringent than DOT KKK-A-1822 specifications, which must be met by all vehicles purchased with the aid of National Highway Safety Act grants, EMSS Act grants, or other federal funds.

Of the states which have formally enacted vehicle standards, over 60 percent exempt one or more classes or providers. For example, three states exempt volunteer ambulance services from the minimum standards, four exempt federal government vehicles, four exempt private company vehicles which serve only company employees, and three states exempt all non-commercial ambulances.

RADIOCOMMUNICATIONS STANDARDS

State requirements for two-way, mobile radios for ambulances are shown in Figure 3. Among states where no ambulance radio standards exist (49 percent of the total), several

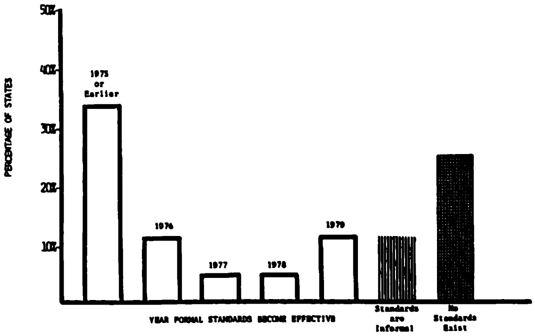


FIGURE 2: STATUS OF AMBULANCE EQUIPMENT STANDARDS

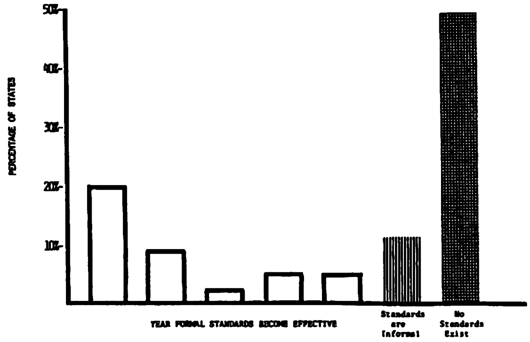


FIGURE 3: STATUS OF MOBILE RADIO REQUIREMENTS

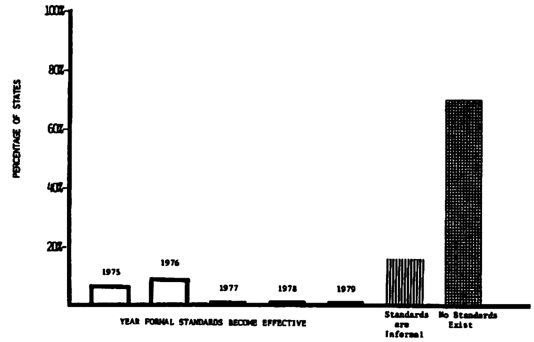


FIGURE 4: HOSPITAL EMERGENCY DEPARTMENT RADIO REQUIREMENTS

feel that such requirements are unnecessary since all, or nearly all, ambulances are already equipped with mobiles.

Less than 16 percent of the states currently have formal standards for hospital radio-communications, although an additional 16 percent informally require that hospitals be equipped to communicate with ambulances. Several states with no standards in this area feel that requirements are not necessary since nearly all of their hospitals are already radio-equipped.

AMBULANCE PERSONNEL TRAINING STANDARDS

Figures 5 through 8 indicate the current status of state requirements for ambulance attendant initial training, periodic recertification, and refresher training. As shown in Figure 5, 31 percent of the states now require that at least one EMT be present on every ambulance run, and 13 percent require two EMT's on each run.

To help correct for the problem of skills attrition, most (51 percent) states either require that ambulance attendants undergo periodic retesting and recertification, or they mandate that a specified number of retraining hours must be completed every several (e.g., 24) months. Only 18% of the states require both periodic recertification and retraining for ambulance attendents. See Figure 6.

Figure 7 shows that among the states which require periodic recertification, (43 percent of the total), the most common recertification periods are 24 months and 36 months. These intervals are also common for retraining, as indicated in Figure 8 where requirements for instructional hours are shown in relation to the specified periods between refresher training courses. Figure 8 demonstrates that there is little standardization of ambulance attendant retraining requirements, whether for EMTs or for personnel with advanced first aid training. Required instructional hours range from 8 to nearly 60, while three states demand that refresher training be completed every 12 months; nine states, every 24 months; and six states, every 36 months.

Eliminating Barriers to EMS System Development

In order to provide advanced life support services, EMT-Paramedics must be allowed to administer drugs, start IVs, and perform other prespecified emergency procedures on patients in the field. However, the laws of many states consider such procedures to lie within the realm of medical practice, with only licensed physicians and nurses permitted to perform them. To eliminate this barrier to the development of advanced emergency medical services systems, 49 percent of the states have amended their medical practice laws to allow paramedics to perform such procedures under standing orders of a physician. An additional 29 percent currently have ammendments to medical practice laws under consideration, and amendments are judged to be unnecessary in 4 percent of the states.

Fear of legal liability claims is a factor sometimes cited as hindering the provision of emergency medical services. In response to this concern, 49 states have in recent years enacted good samaritan (GS) legislation to protect persons who

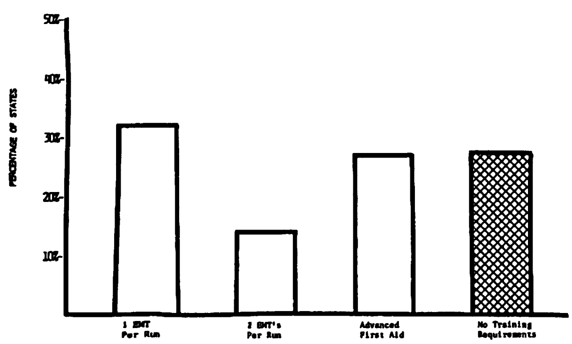


FIGURE 5: STATUS OF AMBULANCE PERSONNEL TRAINING REQUIREMENTS—CURRENT

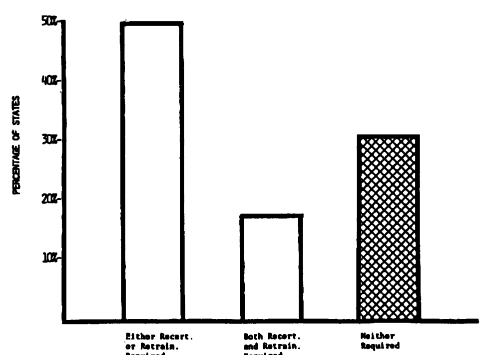


FIGURE 6: STATUS OF STATE REQUIREMENTS FOR PERIODIC RECERTIFICATION (TESTING) AND RETRAINING OF AMBULANCE PERSONNEL

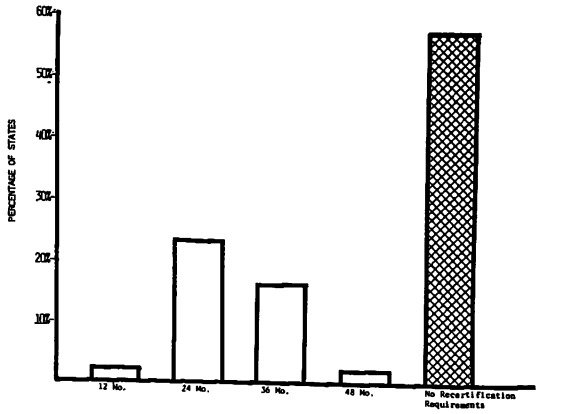


FIGURE 7: PERIODS BETWEEN REQUIRED RECERTIFICATIONS OF AMBULANCE PERSONNEL

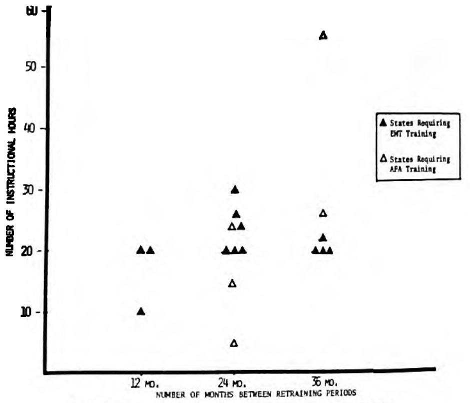


FIGURE 8: REQUIREMENTS FOR PERIODIC RETRAINING OF AMBULANCE PERSONNEL

offer assistance at accidents. In the GS laws of 44 percent of the states, both EMTs and physicians are covered explicitly, while the laws of another 20 percent cover either one or the other of these medical professionals. In at least nine states, GS protection is extended to the nurses and physicians who radio orders from a hospital to ambulance personnel at the accident scene. GS laws often include limitations, such as in cases of gross negligence, and it is difficult to assess generally the protection they provide.

Another barrier to the development of high quality EMS systems is a financial one. In many cases, federal or other categories of grant funds are available to assist with system start-up costs. However, financing the ongoing operation of the improved system, once the start-up funds expire, may prove difficult. Addressing this issue, 47 percent of the states now allow communities to assess special taxes for supporting emergency medical services. Eight states (Georgia, Idaho, Indiana, Kentucky, Mississippi, Missouri, North Dakota, and Texas), by providing for multi-county EMS tax regions, enable regional EMS systems to develop coherent financing strategies, free of the interjurisdictional constraints which normally complicate EMS planning.

Conclusion

Within the past two to five years, activities supporting the improvement of emergency medical services have been directed at a number of fronts. Complementing local efforts and the national efforts of DHEW and DOT, state governments are now developing their own broad EMS programs. Enacting legislation which encourages the upgrading of resources through imposition of minimum standards and which eliminates existing barriers to improved services is usually viewed as a necessary step to achieving state EMS goals. Only 7 percent of the states have no legislation in any of the areas reviewed in the previous sections. In comparison, over 60 percent of the states have passed legislation in more than half of these areas. Increasingly, state EMS legislation is designed as a comprehensive package which covers many specific areas, such as those described above, and which also provides for strong program management state-level agencies.

MODEL LEGISLATION: PRELIMINARY CONSIDERATIONS

Kevin M. McIntyre, M.D., J.D.

It has been pointed out by many a pundit that a man who does not know where he is, very likely does not know where he is going. This observation can be applied to the relationship between many EMS systems and model legislation: If you're not sure where your EMS system is, then you may not know where it will be in six months or a year. I understand that this is the situation with many systems, by virtue of their newness in an uncharted area. A comprehensive approach to model legislation may, and perhaps should, anticipate where an EMS system is likely to be at any number of points in the future. The theme of my remarks, therefore, will be that model legislation should be approached with studied restraint, with the hope that a package as well-conceived as the Michigan Act can be passed. Surely legislative correction of certain types of impediments to EMS implementation may be helpful at any level of maturity of an EMS system. But an effective EMS system cannot be put on track by legislation alone and problems can be created by legislation which is untimely or ill throughout as to its long range consequences. With this background I would like to offer for your consideration one opinion and two proposals on the subject of model legislation. These thoughts were developed in discussion with the director and staff members of our EMS office in Massachusetts and so reflect the attitudes of a developing EMS operation, within the limits of my ability to express their very realistic perceptions.

The opinion, which may on its face seem heretical at this panel on model legislation, is that model legislation, as critical as it may be to full implementation of an EMS system, is a two-edged sword and that legislative changes should follow, or progress in concert with, the forward movement of the EMS system. Legislative changes, for the most part, should not attempt to fashion a mold by which the growth and progress of evolving EMS systems are controlled; rather, legislative changes ought to be flexible so as to be maximally supportive of the needs of the maturing EMS system. Since the needs of the evolving system change with growth and progress, an attempt to anticipate those needs with a legislative master plan may ultimately be counterproductive.

Of the two proposals, the first is that deliberation on the subject of model EMS legislation should begin with an evaluation of the preparedness of the concerned parties.

The second proposal is that, given a series of issues that may be approached by model legislation, a priority be attached to each of the issues. Possibly, somewhere there is an ideal model legislation package. But in a less than ideal world, it is naive to think that always and everywhere the ideal package will either be offered or accepted by the legislature. Therefore, while an "ideal" package may be drafted, that part of the package which has a realistic possibility of acceptance perhaps should be identified. In addition, those elements which constitute the minimal acceptable legislative actions should be identified. In essence, this proposal suggests that priorities be assigned to the elements of model legislation, in anticipation of a need for compromise at a later date. These may differ from state to state, from region to region.

The first proposal, that the level of preparedness for model legislation be evaluated, requires, as I suggested, the evaluation of the preparedness of each of the individuals, agencies or groups which may either facilitate, hinder or block the passage of model legislation. These elements include at least the following: the local, county and/or state legislative bodies; the local, county or state executive branch; the public; and last but not least, the EMS system itself.

How might one go about an evaluation of these elements? Evaluation of the level of preparedness for model legislation of the EMS system itself seems the logical beginning. At the onset, it would be helpful perhaps to define the level of completeness of the EMS system in question. If the system is relatively new and young—which often means the system may not yet know where it is, let alone where it is going—perhaps the wise decision would be to defer action on a comprehensive model legislation plan until a later date, when relationships are better understood, better defined—for better or for worse. Clearly recognizable, high priority issues, may need to be approached even at an early stage. A more mature system, which has earned public and legislative acceptance, which knows where it is and where it wants to go, is more likely to benefit from model legislation. A more mature system perhaps has learned to appreciate the complexities of issues of legislative change. For example, with regard to the civil service laws, what impact will the extra training taken by EMTs have on their civil service benefits? Do they, or should they, get additional "points" for the additional training? Perhaps even more importantly, the more mature system speaks more authoritatively, commands more respect, is better able to resist politically motivated challenge when its representatives request amendment of the Medical Practice Acts or provisions for limited immunity or indemnification of governmentally employed EMS providers.

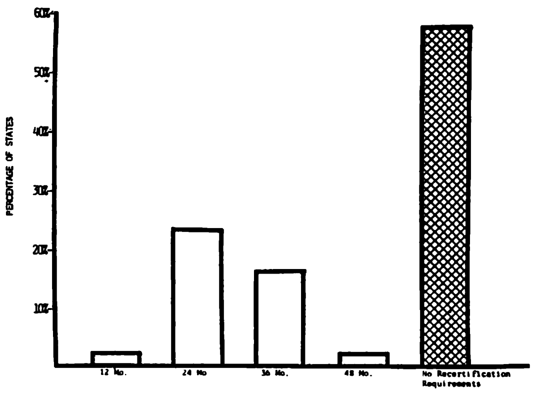
Of critical importance to the EMS system directors is the question of where the system will be in five years. How will the transition be made from federal funding to other sources? To what extent may the best progress of the EMS system be sacrificed to the personal need to perpetuate the bureaucracy, should the lead agency be faced with a phase-out as part of the transition to local or regional support? The human stress and conflict created by a circumstance in which the achievement of a goal is met not with a reward but with a form of punishment is well known. How will this color the crucial issue of the ultimate future of lead EMS agencies and the behavioral aspects of individuals in those agencies? Ultimately, the issues of accountability and cost-effectiveness must be faced. A new funding agency eventually, or as condition of coming on board in the first place, will want to see evidences of accomplishment which justify their dollar cost—absent which there may not be continuing economic support. And the movement in the direction of increasing demands for accountability is clear. These two issues are of great importance for the future of EMS systems.

An evaluation of the readiness of the responsible legislative body is integral to a well-planned approach to model legislation. If the legislature in general—or the leadership in particular—is not receptive to the idea of legislative change to facilitate EMS, it may be important to ask why. If the lack of receptivity is due to a lack of knowledge or misinformation—what might be referred to as "uninformed resistance"—the next reasonable step may be an educational campaign. If the legislature is aware and informed about EMS, but not receptive—a posture which may be referred to as one of "informed resistance"—the problem may be much harder to overcome. Perhaps the executive branch may be persuaded to lend support. Perhaps public pressure can be effectively mobilized. It could clearly be of great benefit to identify a champion in the legislature, one who will aggressively and persuasively carry the argument to his or her colleagues. Once the legislature—or rather the appropriate individuals within the legislative body—have opened a dialogue, it may be useful to consider a mechanism by which any legislative proposal which could adversely affect EMS—would be considered jointly by EMS advocates and the appropriate legislative committee.

An approach to the evaluation of the executive branch may reasonably parallel that of the legislative branch. An evaluation of the preparedness and receptivity of the public at large, to model legislation to facilitate EMS, on the other hand, may require a different approach. A reasonably reliable estimate of the level of public knowledge, acceptance and support for EMS may be the first important step. If public knowledge is low, an educational effort may be necessary. If knowledge is good and acceptance and support are low, one must look critically at the EMS system. In Massachusetts, the coincidental occurrence of ambulance tragedies due to a lack of training and ambulance requirements may have gone a long way toward persuading the legislature to accept an ambulance law which they had previously rejected a number of times. While some may claim this is waving of a bloody shirt, the public insistence on upgrading of standards was effective in pursuading the legislature. Of course, the public can sometimes be the best educator of legislators and other elected or political officials.

One inescapable question that will remain when most of the others are finding answers is: who is going to support the program in an ongoing way? Will it be the state, regional, county, or city government? Will it be private, or private and public? Will a foundation provide partial support for a limited period? I am sure you are all familiar with Sutton's Law—named for Willie Sutton the famous bank-robber who was once asked why he was in fact a bank robber. His reply was that he robbed banks because that is where the money is. In terms of funding of EMS systems, it may be a good rule. On the other hand, along with funding goes the issue of control. To what extent will local prerogatives—and with them quality and cost control—be compromised by a centralized funding source, such as a state. This subject is far too complex to get into here—but it is far too important to dismiss.

I think I will stop in the midst of this active dialogue which not only discusses desirability of certain approaches to model legislation but the need and desirability of model legislation at all—it would be presumptuous to offer an approach to model legislation.



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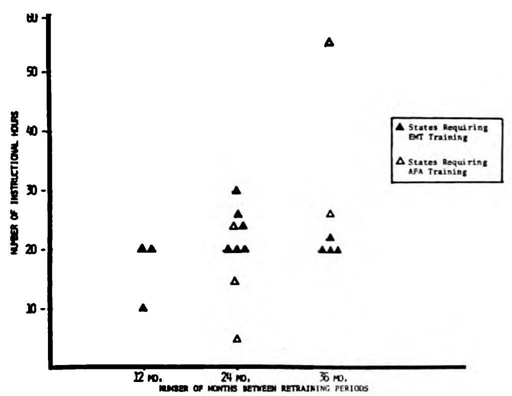

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Of the two proposals, the first is that deliberation on the subject of model EMS legislation should begin with an evaluation of the preparedness of the concerned parties.

The second proposal is that, given a series of issues that may be approached by model legislation, a priority be attached to each of the issues. Possibly, somewhere there is an ideal model legislation package. But in a less than ideal world, it is naive to think that always and everywhere the ideal package will either be offered or accepted by the legislature. Therefore, while an "ideal" package may be drafted, that part of the package which has a realistic possibility of acceptance perhaps should be identified. In addition, those elements which constitute the minimal acceptable legislative actions should be identified. In essence, this proposal suggests that priorities be assigned to the elements of model legislation, in anticipation of a need for compromise at a later date. These may differ from state to state, from region to region.

The first proposal, that the level of preparedness for model legislation be evaluated, requires, as I suggested, the evaluation of the preparedness of each of the individuals, agencies or groups which may either facilitate, hinder or block the passage of model legislation. These elements include at least the following: the local, county and/or state legislative bodies; the local, county or state executive branch; the public; and last but not least, the EMS system itself.

How might one go about an evaluation of these elements? Evaluation of the level of preparedness for model legislation of the EMS system itself seems the logical beginning. At the onset, it would be helpful perhaps to define the level of completeness of the EMS system in question. If the system is relatively new and young—which often means the system may not yet know where it is, let alone where it is going—perhaps the wise decision would be to defer action on a comprehensive model legislation plan until a later date, when relationships are better understood, better defined—for better or for worse. Clearly recognizable, high priority issues, may need to be approached even at an early stage. A more mature system, which has earned public and legislative acceptance, which knows where it is and where it wants to go, is more likely to benefit from model legislation. A more mature system perhaps has learned to appreciate the complexities of issues of legislative change. For example, with regard to the civil service laws, what impact will the extra training taken by EMTs have on their civil service benefits? Do they, or should they, get additional "points" for the additional training? Perhaps even more importantly, the more mature system speaks more authoritatively, commands more respect, is better able to resist politically motivated challenge when its representatives request amendment of the Medical Practice Acts or provisions for limited immunity or indemnification of governmentally employed EMS providers.

Of critical importance to the EMS system directors is the question of where the system will be in five years. How will the transition be made from federal funding to other sources? To what extent may the best progress of the EMS system be sacrificed to the personal need to perpetuate the bureaucracy, should the lead agency be faced with a phase-out as part of the transition to local or regional support? The human stress and conflict created by a circumstance in which the achievement of a goal is met not with a reward but with a form of punishment is well known. How will this color the crucial issue of the ultimate future of lead EMS agencies and the behavioral aspects of individuals in those agencies? Ultimately, the issues of accountability and cost-effectiveness must be faced. A new funding agency eventually, or as condition of coming on board in the first place, will want to see evidences of accomplishment which justify their dollar cost—absent which there may not be continuing economic support. And the movement in the direction of increasing demands for accountability is clear. These two issues are of great importance for the future of EMS systems.

An evaluation of the readiness of the responsible legislative body is integral to a well-planned approach to model legislation. If the legislature in general—or the leadership in particular—is not receptive to the idea of legislative change to facilitate EMS, it may be important to ask why. If the lack of receptivity is due to a lack of knowledge or misinformation—what might be referred to as "uninformed resistance"—the next reasonable step may be an educational campaign. If the legislature is aware and informed about EMS, but not receptive—a posture which may be referred to as one of "informed resistance"—the problem may be much harder to overcome. Perhaps the executive branch may be persuaded to lend support. Perhaps public pressure can be effectively mobilized. It could clearly be of great benefit to identify a champion in the legislature, one who will aggressively and persuasively carry the argument to his or her colleagues. Once the legislature—or rather the appropriate individuals within the legislative body—have opened a dialogue, it may be useful to consider a mechanism by which any legislative proposal which could adversely affect EMS—would be considered jointly by EMS advocates and the appropriate legislative committee.

An approach to the evaluation of the executive branch may reasonably parallel that of the legislative branch. An evaluation of the preparedness and receptivity of the public at large, to model legislation to facilitate EMS, on the other hand, may require a different approach. A reasonably reliable estimate of the level of public knowledge, acceptance and support for EMS may be the first important step. If public knowledge is low, an educational effort may be necessary. If knowledge is good and acceptance and support are low, one must look critically at the EMS system. In Massachusetts, the coincidental occurrence of ambulance tragedies due to a lack of training and ambulance requirements may have gone a long way toward persuading the legislature to accept an ambulance law which they had previously rejected a number of times. While some may claim this is waving of a bloody shirt, the public insistence on upgrading of standards was effective in pursuading the legislature. Of course, the public can sometimes be the best educator of legislators and other elected or political officials.

One inescapable question that will remain when most of the others are finding answers is: who is going to support the program in an ongoing way? Will it be the state, regional, county, or city government? Will it be private, or private and public? Will a foundation provide partial support for a limited period? I am sure you are all familiar with Sutton's Law—named for Willie Sutton the famous bank-robber who was once asked why he was in fact a bank robber. His reply was that he robbed banks because that is where the money is. In terms of funding of EMS systems, it may be a good rule. On the other hand, along with funding goes the issue of control. To what extent will local prerogatives—and with them quality and cost control—be compromised by a centralized funding source, such as a state. This subject is far too complex to get into here—but it is far too important to dismiss.

I think I will stop in the midst of this active dialogue which not only discusses desirability of certain approaches to model legislation but the need and desirability of model legislation at all—it would be presumptuous to offer an approach to model legislation.

STATE LEGISLATION — THE MICHIGAN EXPERIENCE

Gordon T. Rude, M.S., M.P.H.

For the past 18 months, at the direction of the Senate and House Health committee chairmen, I have been the senior staff person working on a package of three EMS bills which would establish new standards for EMS providers, as well as, a statewide system for EMS planning. During this time, I have come to believe that EMS has the potential to demonstrate that an organized health care delivery system can be developed. The foundation of such a system lies in the development of sound public policy at the state level. Without strong state legislation the long-range objectives of EMS development in this country will not be achieved.

The first two bills to be reviewed deal with the establishment of standards and the regulatory aspects of the EMS legislation. One of the intents of the federal EMS program is to demonstrate that with adequate standards and a workable planning mechanism, an effective regional EMS system can be established. While some achievements in the development of Emergency Medical Services in communities would no doubt remain, in most instances, the withdrawal of federal dollars would result in a loss in standards development and programs. The purpose of this legislative initiative in Michigan has been to insure that these standards are maintained.

Senate Bill 985 is a bill that proposes to license ambulance operations. It requires that ambulance operations reveal all critical aspects of their operation; including ownership and management; availability of vehicles; equipment; staffing; advertising; and other information necessary to understand and regulate the operation. It requires that each ambulance operation accept primary responsibility for a geographical area, but does *not* establish a certificate of need mechanism. It grandfathers in all existing vehicles, until such time as they are replaced. They must be replaced with vehicles that meet the standards of the Department of Transportation. We calculate that in four years approximately 85 to 90 per cent of all the vehicles in the State will be replaced. It requires all EMS vehicles be properly equipped with the American College of Surgeons equipment list serving as a minimum standard. The bill also requires that upon enactment at least one licensed attendant will ride in the patient compartment during patient transport. By 1979 one licensed EMT will ride in the patient compartment and by 1980 two EMTs will be present on each run with one EMT in the patient compartment during transport. Senate Bill 985 also permits local units of government to contract with ambulance operations using local general revenue funds or funds derived from a special assessment for ambulance services.

The bill is 12 pages in length, comprehensive in detail, and leaves little flexibility in the promulgation of rules by the Administrative Agency, Department of Public Health.

Senate Bill 986 is also administered by the State Health Department as a bill that licenses and regulates EMS personnel. It establishes three levels of licensure:

1) Advanced emergency medical technicians who have completed a special course of study which has been approved by the Department, and who have passed a written and practical examination.

2) Emergency medical technicians who have completed a course of training approved by the Department. It is the 81 hour course based on the Department of Transportation standards. EMTs must have passed a written and practical examination. The bill also allows for the establishment of equivalencies to cover armed forces trained paramedics and nurses.

3) Attendants who have completed the 56 hour advanced first aid course prescribed by the American Red Cross.

Senate Bill 986 certifies communications personnel, and emergency medical technician instructor-coordinators, who have completed a Department-approved course and passed an examination. The bill also approved all training courses. It relicenses and recertifies all EMS personnel licensed or certified in the bill, every two years when they have completed ongoing education programs and passed appropriate exams.

Senate Bill 986 limits liability of emergency medical personnel, when they perform in good faith, when their performance is consistent with their training, when the life of the patient is in danger, and when the services are rendered outside the hospital.

The bill grandfathers all attendants holding a current license for two years, all persons who have emergency medical technician training for two years, provided they take the exam when it is available, and all advanced emergency medical technicians for two years, provided they have completed an approved course of study and they take the exam when it is available.

Authority for patient management is vested with the individual who has the most emergency medical care training. Management of the scene of a medical emergency is vested with appropriate public safety agencies.

As you can see both of these bills were constructed to; raise standards for vehicles, equipment, and personnel and establish a mechanism for continued upgrading of standards as new innovations in vehicles, equipment and training evolve. This will be achieved by adopting the hardware standards of DOT and ACS by requiring continuing education and relicensure examinations; and by centralizing the regulatory responsibility in a single agency. All of these objectives are to be achieved over time in order not to disrupt current delivery patterns for emergency medical services, and to allow the planning mechanism adequate time to prepare for changes in service delivery patterns.

In regards to standard setting, I would like to make an observation about the federal and state roles. The Department of Transportation though its allocation of dollars for vehicles and equipment, and HEW with its allocation of funds for planning and implementation activities have established ad hoc minimum standard for vehicles, equipment and personnel. They have filled a "policy vacuum" by raising standards through the allocation of dollars. While one must acknowledge the advancements that have been made, as a result, we must also be acutely aware of the inherent dangers in such a situation. The establishment of standards must be a matter of uniform public policy formulation and not a matter of accountability for earmarked federal grant dollars. In Michigan 99 vehicles have been funded in the last three years and we have over 800 vehicles delivering services. What about the other 700? Only half of the planning regions have 1202 or 1203 grants, who is concerned with personnel standards in other regions? I would submit to you that we should not let the largess of the federal government delute the state initiative in establishing uniform standards. In addition to the demonstration, it is the responsibility of the grantees to assure that standards will be maintained long after federal dollars are no longer available.

Adequate vehicles, equipment and personnel are the primary building blocks of EMS. But the best standards in the world are absolutely useless unless they can be put together in a system. This brings us to the proposed EMS planning bill, Senate Bill 987.

If one reads the General Accounting Office's January, 1976 report to the Senate Subcommittee on Health, you get the feeling that there is a call for the establishment of a regional level of government to plan and implement emergency medical services. They point to a number of problems including, lack of a regional management entity, lack of regional control over financing, lack of regional control over operations including transportation, facilities and communications, and lack of standard medical record-keeping and patient outcome evaluation. I believe that the clarification of responsibility and establishment of accountability, at the local, regional, and state levels of government can correct many of the problems pointed out in the General Accounting report.

The EMS planning legislation (S.B. 987) is an attempt to establish the responsibility for the development of EMS in Michigan.

The proposed legislation places the responsibility for the development of a statewide EMS plan in the Department of Public Health. It requires the Department to incorporate all regional and local plans into a single state plan. Duties prescribed by the Department of Public Health are:

- to inventory EMS resources with the state
- to review and evaluate regional plans
- to develop and administer a statewide data collection system
- to evaluate the availability and quality of emergency medical care
- to develop a program of public information
- to review and comment on all grant and contract applications on EMS
- to develop a statewide communications network for E.M.S.
- to provide for the annual categorization of emergency facilities and services through the designated health planning agencies

The bill establishes a statewide advisory committee, composed of consumers and providers, having responsibility for the approval of the state plan, and advisory responsibility in key policy areas. These committee members are appointed by the governor with the advice and consent of the Senate and are members of the regional EMS advisory bodies.

The designated regional health planning agencies are named as the regional planning and coordinating agencies for EMS. These agencies, under the direction of an EMS coordinator, are responsible for developing and submitting to the Department of Public Health a regional plan for emergency medical services. Responsibility for local planning can be delegated to local organizations. In the event a region is unwilling or unable to perform the planning function, the State is authorized to do EMS planning for that region.

The bill establishes a regional EMS advisory committee composed of consumers and providers appointed by the designated regional health planning agency. This committee has approval power over the regional EMS plan, and over regional priorities and policies of EMS.

The planning mechanism that is proposed in the bill is consistent with P.L. 93-641 (The National Health Planning and Resource Development Act). It enables the regions to continue their planning activities through the HSAs, but assures that there will be consistency in the planning format, data collection, patient records, evaluation mechanisms regarding quality and availability of care, hospital categorization, communications, development and other issues essential in an EMS system. While Senate Bill 987 does enable the regions to carry out their planning responsibility, and in fact mandates the form that planning will take, the State Department of Health does become the agency that is accountable for assuring that EMS planning is achieved on a statewide basis. Without such authority, the development of a state EMS plan is impossible. Without regional compatibility, data basis differ from one region to another. In addition, there is no way to accurately evaluate progress, or lack thereof, in the development of an EMS system. Furthermore, separate and unrelated plan development by the regions, make it impossible to coordinate regional activities and coordination is essential, if there is to be a sharing of facilities, and other resources. For instance, the development of transfer agreements, mutual aid agreement, and a statewide communications network would be difficult to secure or develop if coordination authority of a single state agency did not exist. And of course, circular categorization and the resultant facilities development becomes nearly impossible without the state planning authority.

The GAOs problems with the national EMS program is, the lack of a regional management entity and the control over operations and financing. We believe, to a large extent, that these problems are resolved through the establishment of state legislation. When the State EMS planning act is fully implemented each region will submit an annual plan which will be based upon reliable data that is compatible from region to region.

Ambulance operation coverage can be plotted on a map, since they must declare a primary service area for which they are responsible. The prehospital communications system is mandated as a condition of ambulance operation licensure according to a statewide communications plan. Emergency facilities will be categorized, and a medical record-keeping system will be standardized with the Department having the authority to evaluate the quality and availability of emergency medical services. Both the regional planning body and the state will have review and comment on the proposed EMS expenditures. The act therefore, will allow for an adequate gathering of data and will mandate the establishment of priorities in order that recommendations for the expenditure of funds may be made, and mechanisms for a systematic evaluation system will be in place.

It is important to make two points regarding Michigan's planning act that all states should take into account when developing comprehensive EMS legislation. First, although the state health department has been given both the regulatory and planning responsibilities; it has not been empowered to independently develop a statewide EMS system. The establishment of an advisory body that has the ultimate authority to reject the state EMS plan holds considerable power over the Health Department. It forces the bureaucracy to be much more participatory than it would normally be. In addition, inherent in the legislation are certain performance standards that must be achieved. The development of a plan, statewide data collection system, a communications system, the categorization of hospitals, and many other highly visible activities must be achieved to implement the legislation. It will be very clear to the legislature, who control appropriations and the governor who is administratively responsible for the Department, if there is a lack of performance in this area.

Secondly, the regional planning agencies are also exposed. Once the evaluation mechanisms are in place that will show how well patients were cared for, or not cared for, and how well the system operates, it will be relatively easy to evaluate whether or not the regional agencies are doing their job. That evaluation will be as clear to the people the agency is supposed to serve as it will be to HEW.

Generally, we believe the legislation is supportive of HEW's efforts to improve EMS through grants for planning and implementation of basic and advanced life support systems. In fact, the legislation was designed with that objective in mind. However, HEW has been perceived by the grantees as an agency that is concerned with the disbursement of dollars rather than an agency that is responsible for establishing adequate standards. The regional grantees have been so preoccupied with the pursuit of dollars in compliance with the federal act that they have lost sight of the actual objective of the program. HEW on the other hand has supported this "paper chase" by responding to the pressures put upon them by others including Congress. For instance, when the GAO report came out in January, it pointed out that few regional management entities had neogitated patient transfer agreements. In February, grantees were urged to secure such agreements even before some of the grantees had completed their categorization process. The development of a systematic planning mechanism at the state level will tend to limit the flexibility of HEW. Also, it will stimulate the regions to plan to implement the purpose of achieving planning objectives rather than the procurement of Federal dollars.

I would like to conclude with a few words about the legislative process. It is fitting that this meeting is around the Bicentennial theme. In Michigan, we have tried to open the legislative process to the people to whom this government belongs. The committee chairmen chose not to rely on the lobbyists and the administration to develop the legislation. Instead, our staff charge was to get a concensus about what our state EMS system should be from the consumers and providers of services and to deliver a product that represented sound health policy.

We have listened to the Medical Society, Michigan Emergency Service Health Council, the UAW, and other powerful state organizations. But we have also listened to the volunteer ambulance attendant in the Upper Peninsula, who couldn't get EMT training, the second and third level government bureaucrat who really does know what is going on in the field, the private ambulance operator who is being driven out of business because of the manipulations of the local planning agency, and many more. We believe we have a statewide concensus on this legislation even though we have only tacit support from some of the traditional self interest groups such as the Hospital Association and the State Medical Society.

Perhaps we have annoyed the traditional capitol lobbying corps. But we have convinced quite a few Michiganders that they can have an impact on the policies formulated by their government. We have also convinced a few legislators that conducting the public's business in an open forum is the best way to develop quality legislation. I would like to close by making a few recommendations to HEW:

1) We need to know precisely the impact of state legislation or the lack thereof, on the development of EMS systems throughout the country. If it is a critical an issue as I have proposed, and if there is as little attention being given to it as it appears, then long-range objectives in EMS will not be achieved. I would like to recommend that HEW through the 1205 grant mechanism support such research projects.

2) We need to define and categorize the critical elements in EMS that must be addressed by state legislatures if we are to achieve long-term objectives. We must also define strategy options that different legislatures can utilize as they wrestle with complex problems. Strategies such as "grandfathering," "floating standards," "limited liability," and others have resulted in successful legislation initiatives. Such a definition will require EMS and legislative expert to join together and I would recommend that HEW support that effort.

3) Finally, once we have defined what is legislatively prescribed and we know what options and strategies are available, we need to inform EMS leadership around the states on how to proceed. Conferences with legislative leaders and EMS leadership, a handbook on how to relate to state legislatures, are examples of two tools that could be developed to promote the EMS cause.

Airport Disaster and the Community Disaster/EMS Response System

AIRPORT/COMMUNITY MASS CASUALTY PLANNING

Oliver C. Hood, M.D.

The Federal Aviation Administration is an agency within the Department of Transportation whose reason for existence is to insure the highest degree of safety that is possible in the operation of air transportation. Air transportation involves many forms of vehicles, from very large jet aircraft transporting hundreds of people or tons of cargo to very small aircraft containing one person. One factor that is common to all air transportation vehicles is that each one departs from a site on this earth and each one eventually stops at a site on this earth. The FAA has the charter to advise and to regulate the air transportation system operators to promote and insure safety of individuals and the public in general, both on the ground and in the air. Although the FAA is concerned and involved in a very wide range of aviation activities, the focus for this presentation is the FAA concern and responsibility for the operation of airports.

Airports vary from the very large and very busy with 24 hours a day operation, to small ones with very infrequent landings and take-offs. Our subject at this time relates to FAA responsibility in establishing rules governing the certification and operation of airports serving air carriers that hold certificates of public convenience and necessity issued by the Civil Aeronautics Board and that operate aircraft into these airports.

Prior to the passage of the Airport and Airway Development Act of 1970, there were very few mandatory safety standards that airports were required to meet. This act empowered the FAA Administrator to issue Airport Operating Certificates to airports serving those air carriers who were certificated by the Civil Aeronautics Board, and to establish minimum safety standards for the operation of these specific airports.

There are some 12,000 land airports in operation subject to Federal rules and regulations. Approximately 500 airports serve CAB certified air carriers who use large aircraft and fly on a scheduled basis. Another 400 airports serve certified air carriers who fly unscheduled flights and those scheduled or unscheduled small aircraft operations. These latter 400 airports operate with a "limited certification" and it is the original 500 airports that are our primary concern.

Federal Aviation Regulation Part 139 entitled, "Certification and Operations: Land Airports Serving CAB-Certificated Air Carriers," was most recently published in December 1974. It addressed a wide range of areas concerning airport operations, from pavement, to lighting, fire and rescue, etc. Included is a section, Part 139.55 entitled, "Emergency Plan." This regulation specifically states that no person may operate a land airport serving any CAB-certificated air carrier operating aircraft into that airport, in any State of the United States, the District of Columbia, or any territory or possession of the United States, without or in violation of an airport operating certificate for that airport, or in violation of the applicable provisions of this Part or the approved airport operations manual or airport operations specifications for that airport. Further, each applicant for an airport operating certificate, and each certificate holder for, or operator of, a certificated airport shall allow the Administrator to make any inspection or test to determine its compliance with the Federal Aviation Act of 1958, the Federal Aviation Regulations, the certificate, the approved airport operations manual or airport operations specifications, and the eligibility of the certificate holder to continue to hold its certificate.

FAA airport certification authority began in July 1972, and by September 1972 inspections were well underway. In the early stages it was obvious that in some instances an airport manager would be unable to comply exactly to the new requirements for reasons beyond his control. It was not felt to be in the public interest to arbitrarily close airports where there was clear evidence of full effort being made to comply with standards not previously in being. A good example is that of fire fighting equipment. Subsequent to the certification requirements being established, some 420 separate fire fighting units, of all sizes and types, were ordered by the nation's airports. This involved some $20 million in 50/50 matching grants between FAA and the airports. Fire equipment manufacturers were not prepared to respond to such a sudden order and to date a few airports have yet to receive their final unit.

In this case, FAA inspectors would require that the airport manager show what temporary alternatives he had instituted to insure that fire fighting capability was available in the direction of the requirements of the new standards. In those few cases certification was granted in order to continue service to the public while airports sought to improve their resources.

Today, there are 29 inspectors who work out of the eleven FAA regions, and there are six inspectors assigned to Washington Headquarters. This small force has been able to physically inspect all 500 original airports more than once, and to inspect or monitor the second group of 400 "limited certification" airports. Between September 1972 and May 21, 1973, approximately 257 were inspected. The rest were spot checked and monitored. From May, 1963, to May, 1974, all were physically inspected at least once. Since May, 1974, all have been inspected more than once.

The regulations require that an applicant for the issue of an airport operating certificate under this subpart is entitled to a certificate if it serves or is expected to serve scheduled air carrier users; and the administrator, after investigation, finds that the applicant is properly and adequately equipped and able to conduct a safe operation in accordance with this Part, and has approved the airport operations manual submitted with and incorporated in the application.

Deviations from the regulations were provided for in those instances when certificate holders could deviate if conditions required the transportation of persons or supplies for the protection of life or property. A report of such deviation must be submitted to the local region.

A sampling of the items addressed in the current regulations include: marking and lighting of runways; fire fighting and rescue equipment; handling of hazardous materials; traffic and wind direction indicators; self-inspection programs; and many others. One item that is of interest at this time is the one listed as "Emergency Plan." The lead paragraph states:

a. The applicant for an airport operating certificate must show that it has an emergency plan that insures prompt response to all emergencies and other unusual conditions in order to minimize the possibility and extent of personal and property damage to the airport. The plan must be sufficiently detailed to provide adequate guidance to all concerned.

b. The emergency plan must provide for the following:

(1) Instructions for response to -

(i) Aircraft incidents and accidents;

(ii) Bomb incident procedures including designated parking areas for the aircraft involved;

(iii) Structural fires;

(iv) Natural disasters;

(v) Sabotage and other unlawful interference with operations; and

(vi) Radiological incidents or nuclear attack.

(2) Medical services.

(3) Crowd control.

(4) Removal of disabled aicarft.

(5) Emergency alarm systems.

(6) Mutual assistance with other local safety and security agencies.

(7) A description of control tower functions relating to emergency actions.

c. The applicant must show that before applying it has coordinated its emergency plan with law enforcement and fire fighting and rescue agencies, medical resources, the principal tenants at the airport, and other interested persons.

d. The applicant must show that all airport personnel having duties and responsibilities under its emergency plan are familiar with their assignments and properly trained.

It should be noted that the use of only the words "Medical Services" was intentional although, obviously, there could be 500 different interpretations by the airport managers concerned as to what this meant. We recognized this obviously unacceptable possibility; however, we also recognize that there are literally 500 sets of circumstances concerning these airports. A bureaucratic decision to publish a "pass-fail" list of standards and requirements for medical services at each of the 500 airports could have literally closed the air industry.

There is an obvious need for guidance and direction for airport managers toward developing practical medical plans for the occasion when a disaster situation must be faced. To this end, the FAA has prepared a draft of a Notice of Proposed Rule Making which was published in the Federal Register on April 1, 1976. This rule will require airport managers to show that they have established coordinated plans with their local jurisdictions including rescue, fire, police, hospitals, etc., and that the joint plan is to be exercised periodically.

The law providing Federal funds for airport assistance (Airport and Airway Development Acceleration) expired in June 1975. Currently, there are seven bills before Congress to continue this effort. One is sponsored by the FAA and would provide money to the separate States for three years.

There are four separate situations in which an airport manager and/or airlines may become involved in reacting to a medical problem. One, a passenger in flight may suffer a medical problem, minor or major, with this problem being literally delivered to the airport where the aircraft lands. Two, passengers and visitors at airport terminals may be injured or exhibit symptoms of medical problems while in the terminal. Three, a major accident may occur on the airport involving either passengers on an aircraft, or persons on the airport; or both. And, fourth, an aircraft, large or small, may have an accident off-airport, but in the immediate vicinity of the airport. A single seat aircraft crashing on takeoff into an off-airport hamburger stand is as disastrous as a 747 with a collapsed gear on the runway, if not more. In prior years, passengers on board aircraft that crashed were either dead or could walk away. The new wide-cabin aricraft now make it very likely that serious accidents may produce many who survive, but may be seriously injured and require rapid medical care to remain alive.

The regulatory role of the FAA is to provide the United States citizens who fly or are affected by the flying industry the highest possible degree of safety.

THE PILOT'S VIEW OF THE DISASTER RESPONSE

John X. Stefanki

The Air Line Pilots Association has been in the forefront of airport disaster planning for many years.

It was back on May 1, 1971, that the first full scale simulated aircraft disaster drill was held at the Oakland International Airport under the direction of Dr. Wayne Chesboro and with the help of ALPA.

On May 1, 1974, all air carrier airports were required to have a written disaster plan under Federal Air Regulation, Part 139. Nothing in the regulation stated that the airport disaster plan should be tested. A disaster plan that has not been tested is no disaster plan at all. The ALPA Fire and Rescue Committee advocates ***annual*** full scale airport/community disaster drills to ensure viable disaster plans in the local community.

The second full scale disaster drill was held at the San Francisco International Airport on October 31, 1972. This was the first time that an actual air carrier aircraft was used as a prop, a United Air Lines DC-8, which added authenticity and realism to the exercise. This drill was recommended to the airport authorities following an ill-fated landing accident by a Pan American B-747. Some of the events that transpired indicated some weakness in the plan.

Today, San Francisco has a 24 hour Medical Clinic, a Building 1000, where a command post, communications and other disaster vehicles and medical supplies are stored. Disaster drills are held on a regular basis.

A mutual aid plan with two counties is in operation, taking into consideration fire, police, medical civil defense, communication and coordination.

Airport disaster drills have been held at the John F. Kennedy Airport under the direction of Dr. Leon Star, the originator of the Airport Medical Clinic. He has utilized the Mobile Inflatable Tent Unit which serves as protection in inclement weather and can be used as a command post, triage area, hospital or morgue.

The Paris Air Authority has a colored inflatable 10 bed hospital which is available at the three Paris airports.

The Denver Stapelton Airport has had regular drills and also has a medical clinic. Denver is unique in that it has the only civilian based paramedic helicopter operation as an integral part of their disaster plan. The helicopter used in a French "Allouette," a vehicle made for mountain flying.

The Allouette was to transport 12 seriously injured passengers in the Continental 727 windshear accident at Denver on August 8, 1975, to the St. Anthony's Hospital helipad.

On March 26, 1976, a gondola fell from a Vail, Colorado, ski lift and three people were killed and nine injured, four critically. The "Flight for Life" Allouette transported the nine injured from Vail to St. Anthony's Hospital. This is a fine example of complementary airport/community disaster planning.

It is strongly recommended that airport/community disaster plans include a wide range of local helicopter organizations, i.e., military (Army, Navy, Coast Guard), police and fire departments. This will ensure transportation when terrain, floods, earthquakes, distance create ground transportation problems.

Survival in a disaster is directly related to time, to seconds. The inhalation of cyanide gas and carbon monoxide can kill or immobilize a person in approximately 55 seconds. A new aircraft manufacturer has to demonstrate that the aircraft can be evacuated, fully loaded, in 90 seconds with one half the exits inoperable for certification.

The airport fire equipment has to be able to respond in 3 minutes to the farthest runway but only one half the distance to the farthest point of the runway. It can be ascertained that the time spans have much to be desired. A more viable fire prevention system has to be devised to hold off fire ignition.

Fire preventive engineering indicates that fire retardant upholstery and materials would be of great help. The aircraft should be designed with automatic fuel shut off valves, break away fuel lines and impact resistant fuel cells. The Army Air Corps UH-1 has implemented these changes. In a period from April 1970 to April 1974 not a single life was lost to fire in 776 accidents. Surprisingly, 101 lives have been lost to fire trauma in other helicopters not equipped with the above changes.

Conculsion

1) FAR Part 139 be amended to require an annual, not a periodical, simulated aircraft disaster drill for certification. (These drills can be held in conjunction with hospitals holding their six month certification drill.)

2) Airports be required to have a medical clinic or a paramedic unit where 3,000 persons are employed or when 2 million passengers fly through the airport.

3) All air carrier airports be required to have a designated medical officer responsible for medical care, transportation and supplies.

4) Greater dissemination of medical data pertaining to treatment of injured and non-injured passengers involved in trauma situations.

5) All air carrier airports appoint an official photographer responsible to take accident photographs at the site.

6) Further expansion of helipads at hospitals. Where helipads are not practical, designated adjacent areas such as parking lots, parks, football fields, etc. should be included.

THE FLIGHT ATTENDANT AS A FIRST RESPONDER

Linda Cote Crowley

This U.S.A. Bicentennial year marks the progress of what was developed 200 years ago into the mobil stage as it is known today. Through trial and error, every effort is made to move forward in order to improve and to meet future needs in the field of safe airline travel. Fortunately, excellent safety records exist across the nation, permitting time for each airport community to develop a prepared program for the unwelcomed airport/harbor disaster. Something must be done soon—through a well-planned and tested approach.

The airport community consists largely of professional personnel who are specially trained to service a high density population—the traveling public. An excursion into the network of the area's emergency services often reveals shortcomings in the essential safeguards so often taken for granted in one's own profession. Is the airport and the surrounding physical environment ready to cope with a major airport/harbor disaster? For example, is there adequate and quick helicopter and water rescue service standing by for an inadvertent landing in shallow or bay water in order to evacuate critically injured people? Are there enough qualified medical teams and equipment available on sudden notice to administer first aid and to treat passengers with burns and broken bones? Will the supply of ambulances respond immediately to the crash sight and deliver passengers to hospitals without delay? Can the nearby medical units absorb the influx of emergency cases without exhausting supplies, space, and staff? For future reference, will the airport manager take charge and have a detailed report of the procedures taken at the airport/harbor disaster in order to review, upgrade, or correct any parts in the plan?

There is no exaggeration of the real danger of an airport/harbor disaster. The tragedy lies in the shortsightedness of a plan which is inoperative when used because it has not been previously tested. Confusion leads to chaos leading to lost time and lives. Can anyone explain why injured passengers lay bleeding next to a crippled aircraft at a major American airport for hours while all of modern technology stands helplessly by because an official in charge has not given an order or is unwilling to be responsible for actions taken?

The task at hand for a flight crew in a planned or unplanned emergency begins inflight. A safe landing is imminent, as the pilots control the troubled aircraft to the best of their ability. In the cabin, the flight attendants make every second count toward their efforts to safely secure all passengers and luggage, to brief the passengers for the landing, and to assign responsible passengers to the exits, the unaccompanied children, the elderly, and the incapacitated.

Flight attendants react to an emergency in the manner in which they are trained initially and through their annual recurrent seminar. During a crisis, flight attendants make it their duty to calm the passengers, and to provide authoritative directions for rapid evacuation of the aircraft. In the name of safety, they are determined to lead the passengers away from the endangered site.

Once the injured aircraft is grounded, the heroic activities of the flight crew are limited. The pilots and flight attendants seriously require fast and efficient assistance in the evacuation of the passengers. Flight attendants have a basic knowledge of first aid, but not to the extent of the experience of an emergency medical team, which is able to treat serious injuries. Flight attendants have a limited supply of first aid kits on board the aircraft, and they have no auxiliary medical equipment. Flight attendants can operate the emergency water and carbon dioxide equipment stored on board, but they are not trained firefighters, and their supply is of short duration. Within the time frame of the emergency, flight attendants experience great pressure and tension as they execute their duties. However, there is a great need for the Emergency Medical Services to relieve this stress by carrying on the treatment and delivery of the passengers to well-equipped medical units.

On the ground technical crews involved with Emergency Medical Services need to assure that the Systems Development during an airport/harbor disaster will function accurately and efficiently. A Mass Casualty Planning Program may be organized under the following phases:

1) Sizing up the effects of the disaster on the ground; 2) Immediate identification with the flight crew on board the aircraft; 3) Communication with the flight crew to learn of the need for specific equipment in evacuating the aircraft; 4) Adopting an effective procedure in the assistance of evacuating passengers from the aircraft; 5) An awareness of who is in charge of the disaster proceedings on the ground in case of extra reinforcement, or crowd control. 6) A mock timed drill simulating realistic evacuation conditions involving speedy assistance of passengers away from the site, adequate procurement of medical equipment, immediate administering of first aid to traumatic and injured passengers, and delivery of the injured to hospitals in the least amount of time.

I. Sizing up the effects of the disaster.

The airport certification standards of Section 139.55(a) of the Federal Aviation Regulations" . . . provides that the applicant for an airport operating certificate must show that it has an emergency plan that insures prompt response to all emergencies and other unusual conditions to minimize the possibility and extent of personal and property damage on the airport."[1]

This regulation requires the emergency plan to be detailed in order to provide overall guidance of the procedures outlined. However, there is a drawback. This regulation does not require that the plane be tested and evaluated on any basis—whether annually, periodically, through simulated disaster exercises, or after any accident or emergency in order to update or correct any problem areas.

The Federal Aviation Administration is considering amending Part 139 of the FAR's as recommended by the National Transportation Safety Board. This proposal, no. A-75-1, if adopted, will make the FAR more specific and will require the preceding necessary information. In addition, the emergency plan will need to specify facilities, agencies, and personnel providing transportation and medical services for the maximum number of persons carried on board the largest air carrier served by its airport. Each applicant and operator will be required to plan for crowd control and for the participation of all parties involved in the department and implementation of its emergency plan.

The maintenance of detailed, timed records is essential in order to record accurate information at the time of an accident. First and second-hand reports may not be complete. The airport manager, Emergency Medical Services, fire department, or any agency in need of information in regard to an accident should send their request to the National Transportation Safety Board for accident reports published.

Of the 500 carrier airports in the United States, as few as 15 actually have tested disaster plans in full-scale exercises. Some of the reasons for this low participation are as follows:

Money—some airports resist spending the often large amounts of money in order to mount a full-scale exercise.

Record—many airport officials view a nearly perfect accident record, and are not in a hurry to play games with fake crashes.

Emergency—the fear of an actual disaster is sometimes used as an excuse by government agencies for not taking part in mock exercises due to the large number of people involved.

Equipment—aircraft donations by the airlines are rare, and when it occurs, are incognito. The reluctance is due to adverse publicity when information taken out of context may damage the identity and perspective of the airline helping out.

Responsibility—the reluctance of the airport manager is due to adverse publicity when information taken out of context may hide the bona fide intentions of the airport community.[2]

II. Immediate identification with the flight crew on board the aircraft.

Locating members of the flight crew is not an easy task but more than likely they would be in the vicinity of an open exit. It is important for ground personnel to contact the flight attendant and to display some means of identification of one's position. In this modern day, the possibility of a troubled plane from a foreign country landing at a U.S. airport would face confusion as a result of a language barrier. The same holds true when the shoe is on the other foot. This year, in an aircraft accident of a U.S. carrier under investigation in a foreign country, a language barrier became evident. The passengers did not understand that they should evacuate the aircraft immediately, and remain away from the disaster site. It was difficult to get them out because the passengers would repeatedly crawl back into the aircraft for luggage. One man continued to come back and climb aboard the aicarft, and each time the flight attendant kicked him off. The flight attendant could not identify him by his clothing as a uniform, as often is the case in a foreign country, and he made no attempts to signal or to show any form of identification. The man turned out to be a fireman.

In one accident during December 1972, a quick check by the fire department of the exterior of the aicarft discovered a cry in the forward compartment which was jammed. A flight attendant was blocking the door by the jumpseat. There was a crack on the right forward compartment behind the cockpit where the firemen entered to dig the flight attendant out. It took twenty minutes to chop a hold big enough for the escape while hoses were on the fire, keeping it away from the rescue scene.

Some exits may appear blocked or jammed because the flight attendant may have been unable to open them. Firemen or rescue personnel should ask the flight attendant how to operate the exits. Perhaps the added strength may be just the ticket to free the exit for use.

III. Communication with the flight crew to learn of the need for specific equipment in evacuating the aircraft.

Ground crews may not know how to open aircraft exits from the outside.

The use of a "cherry-picker" has helped in opening the doors from the outside.

If the doors do not open within a short period of time, it is possible that decompression did not occur and the cabin pressure has not been released. An ax should be used to break the windows in order to release the pressure.

Depending on the attitude of the aircraft on the ground, some exits may be operational, but not fit for use unless the situation is altered.

A regular jet aircraft sits at the height of approximately ten feet from the ground in a perfect position. If this aircraft were at an angle, the slides to some of the door exits would have difficulty in reaching the ground adequately. In an airplane accident, after the aircraft landed within a few minutes, it settled on its tail. Of the 11 exits, only the two aft exits were usable because all the other slides were inoperable at that point.

Portable high staircases may be helpful in making use of another exit in the case of planes setting in an abnormal position.

Knowing how to operate the stairs may make an exit usable if the slides do not deploy. In one airplane accident, the plane blew a tire, setting the plane lower on one side. One of the chutes did not work, and the flight attendant who barely survived from falling out of the jumpseat harness, ended up using the stairs. Some aircraft stairs can be triggered to unlock and may then be manually pulled out.

When the flight attendant opens the slides, do not bring any equipment too close—it could block the slides from opening, or as the slide deploys, it could knock out anyone nearby.

Ask the flight attendant where the location of the emergency equipment is, if it has not already been deployed. Use those first aid kits, blankets, and oxygen. In accidents where there is smoke, that extra portable oxygen may be helpful to aid some of the ailing passengers, especially in cases where the fixed oxygen drop-out mask did not work.

Perhaps some portable illuminated markers for a command post or triage area could be set up and a crowd control squad would aid in getting passengers away from the aircraft, especially in a smoke filled accident. During one accident, one of the flight attendants was criticized for returning to the aircraft to secure blankets and medical supplies because the aircraft was still in danger.[3]

Orders for special equipment for handicapped, disabled, or unaccompanied passengers are helpful if the passenger list was obtained ahead of time.

In a special study of the "Inflight Safety of Passengers and Flight Attendants" made by the N.T.S.B., it was found that it was difficult to obtain information at the time of an accident in sufficient detail as to indicate any special passenger problems.[4]

Check with the flight attendant about any special cases. Frequently, one must go to the local FAA office in order to obtain the information. There is a need to have information consolidated and made available.

The airport manager should have on hand a diagram of the emergency exits location of the injured aircraft. What one views externally may have different perspective inside the cabin. Flight attendant seats are located near the emergency exits and may block them.

In September 1964, the FAA conducted a study of "Human

Factors of Emergency Evacuation" and found of emergency exit locations that flight attendant seats are located adjacent to primary emergency exits which cannot be opened unless the flight attendant seat is unoccupied and retracted. Often, upon opening of primary exits, flight attendant seats jam against slide covers, thus preventing the door from fully opening until the seat is secured against the wall in stowed position. (Any plug type door must rotate inward before it can be operated outward to an open position).

Primary exits which are located in galley areas and near emergency equipment (i.e., life rafts) and coat closets are often blocked in an emergency situation because items and contents of these areas become dislodged, thus hindering operational and use of emergency exits.

Coat closet and storage compartment contents have dislodged (often violently) during turbulence and deceleration forces severely hamper the flight attendant's ability to function expeditiously and properly in an emergency situation.

IV. Adopting an effective procedure in assistance with evacuating passengers from the aircraft.

Usually the FAA Tower Control activates the primary emergency lines to alert officials. This "crash net line" usually includes four key stations—the police, the airport manager, the city or country ambulance squad, and Civil Defense. The airline personnel are notified as well.

In a recent article on an aircraft accident in January of this year, the engine on a 747 jet with 224 passengers on board was on fire and made an emergency landing in Honolulu. The FAA Tower Control notified the State Ramp Tower Control of the incident, and they ". . . called only the police, company personnel, and the small private medical clinic at the airport. The city ambulance service, Oahu Civil Defense, and other agencies were not alerted . . . ."[5] It was reported that State Control Tower felt that because there was only an engine fire and that no one was hurt, the emergency was not a major disaster.

Whether or not an accident is termed a disaster, any emergency plan must have clear and concise procedures to be followed when evacuating large numbers of people.

In this same Honolulu accident, disaster procedures require the airport supervisor on duty to set up a triage site near the aircraft and using a bullhorn, direct uninjured persons to a safe holding area for transporting. However, airport supervisors have no bullhorn. A policeman reported that no triage area was set up. Thirteen people were injured during evacuation, receiving various slide burns and sprains. The other passengers apparently were uninjured. There was no medical treatment at the scene. The fire chief did not request use of the ambulance, which stood by a nearby taxi way. One ambulance, which was called from the private airport clinic, waited at its office at the terminal gate. "All passengers—injured and apparently uninjured—walked across the field to the terminal. . . As a result, firemen, the crew, and two airport policemen took responsibility for guiding the 224 passengers into a grassy runway area about 100 yards from the burning craft."[5]

Portable equipment designed to effectively assist during the evacuation process is a godsend. For example, San Francisco International Airport is well-prepared for a major disaster. Airport Safety Officer Jim O'Malley "created Building 1,000—a warehouse loaded with all the equipment necessary to handle an airplane crash. Converted cargo carts donated by airlines are stacked with everything from litters and backboards to medical supplies and a complete command post—communications center. All the gear is standing ready to be towed."[2]

V. An awareness of who is in charge of the disaster proceedings on the ground in case of immediate extra reinforcement, or crowd control.

Making mere assumptions of what should be done during a disaster robs critical and timely actions for its proceedings.

There is the problem of getting the people away from the aircraft. If officials are short people power, use military personnel and security guards.

Ground crews may or may not see things as the flight crew in the aircraft may. For instance, the flight attendant might consider the captain in command even when on the ground. Following this chain of command, in a Honolulu accident a flight attendant initiated evacuation in the forward cabin section and the Captain tried to stop the evacuation. Meanwhile, ground personnel crew witnessed the aircraft becoming enflamed, and yelled at the flight attendant to get the people off.

A Bradford, Pennsylvania, air crash on Christmas Eve of 1968 occurred only two and a half miles from the airport, "but it took more than an hour to locate the crash, three hours before the first doctor reported to the scene, and 6 hours before the last casualty was removed from the aircraft. . . . The crash scene was chaotic. People who first arrived at the scene refused to take charge because of jurisdictional problems." ("Disaster Preparedness," p. 15). It is obvious that the disaster plan did not work. One month later a second crash occurred, and with the experience of the first crash, the disaster plan operated more efficiently.

In contrast, a jet lost power in Denver and made an emergency landing. Within an hour, all of the injured were in the hospital. This efficiency came as the result of the disaster exercise plan which was tested and simulated just three weeks previously.

The airport manager is the catalyst of the airport community to ensure a totally organized and successful operation of the disaster plan.

VI. A mock timed drill team simulating realistic evacuation conditions involving speedy assistance of the passengers away from the site, adequate procurement of medical equipment, immediate administering of first aid to traumatic and injured passengers, and immediate delivery of the injured to hospitals.

Disaster plans must be developed in conjunction with the Civil Defense agencies in the total airport community or choas will result. One fine example is the result of ALPA's Rescue and Fire Committee which worked with the Civil Defense to have a 200-bed packaged hospital at major airports. Baltimore-Washington International Airport was the first to do so.

In conclusion, it is obvious that preparedness and disaster planning is the vital life-saving device in the airport community.

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AIR CARRIER VIEW OF DISASTER RESPONSE

Edwin W. Abbott

As viewed by the airlines, disaster at an airport, whether it's large or small, whether it's serving international or national flights, can develop in many different forms. Some of these disasters could be directly involved with an aircraft accident while others may be only indirectly related, or not related at all, such as natural disasters, sabotage to include bomb explosion, structural fires, shoot outs, etc.

Let's briefly consider first those disasters which may develop as a result of an aircraft accident and some precautionary measures that have been taken in which the airlines have been deeply involved. As we are all aware, prior to the advent of the jumbo or wide-bodied jet aircraft, the total passengers carried per aircraft was far less and the requirements for fire and rescue facilities and capabilities were not as demanding. Today, with these sized aircraft now well embedded in the air transportation scene, it has become necessary to expand the types of requirements in order to insure that an adequate, well-trained force is always available and equipment is always in a state of preparedness, ready to move on a moment's notice. Aircraft accidents can be placed in several packages, those on the airport, those near the airport, and those with or without any prior notification. In every case, all aspects must be considered.

As some of you may recall, the Federal Aviation Administration, after many months of coordination with and assistance from the airlines and other segments of industry, promulgated Federal Aviation Regulation Part 139 in 1972, a regulation which was initially directed towards airports serving only large aircraft (above 12,500 pounds) but has since been expanded to include all airports serving all regularly scheduled aircraft that are certificated by the Civil Aeronautics Board. Part 139 clearly spelled out the procedures and means that were to be adopted by the airport in order to continue to conduct safe operations. These rules not only addressed pavement areas, but also listed airport emergency plans, handling and storage of hazardous articles and materials, as well as the airport fire fighting and rescue equipment requirements. It was especially in their area of fire and rescue equipment that requirements were reviewed most stringently, changed where applicable, and adopted. The amount of equipment at any airport was specified in accordance with the size and frequency of aircraft being served. Additional regulation was also directed towards the maximum amount of time that the emergency vehicles had in which to respond to the scene of the accident on the airport proper.

An excerpt from Part 139.49 of FAR Part 139 reads:

(e) The applicant must show by a demonstration run that —

(1) At least one fire fighting and rescue vehicle required by the applicable Index can reach the midpoint of the farthest runway serving air carrier users from its assigned post ***within 3 minutes from the time of alarm*** to the time of initial agent application.

(2) At least one other fire fighting and rescue vehicle required by the applicable Index can reach the midpoint of the farthest runway serving air carrier users from its assigned post ***within 4 minutes from the time of alarm*** to the time of initial agent application, and

(3) All other fire fighting and rescue vehicles required by the applicable Index can reach the midpoint of the farthest runway serving air carrier users from their assigned posts 4-1/2 minutes from the time of alarm to the time of initial agent application."

Also, terms such as "***Respond***" meaning that the fire trucks will be prepositioned at runway positions as required and "***Standby***" meaning that the airport fire trucks will be manned and maintained in a ready status, were defined and then became a part of the Regulation. In addition, FAA, again in coordination with the airlines and other segments of the industry, developed and promulgated Advisory Circular 150/5200-17 entitled, "Emergency Plan," a publication to be used in conjunction with Part 139. This Advisory Circular includes a section on aircraft incidents and accidents that, based on experience, outlines conditions most likely to occur to aircraft and passengers which will require response or standby of fire trucks and/or ambulance rescue equipment. These conditions relate to all types of situations that could occur aboard the aircraft from passengers' personal injuries to the type of arrangements to be made for identification and securing of the accident site as well as handling public announcements through the media.

Beyond the domestic scene and in the international field, the United States, through its membership to the International Civil Aviation Organization, including airline representation, has worked closely with representatives of this 132 member body to provide higher and more up-to-date standards in the field of fire and rescue.

In the nonrelated aircraft category, the area of natural disasters (such as tornados, hurricanes, earthquakes, floods, and tidal waves), sabotage, structural fires, shoot outs, and hazardous cargo accidents, there is also the potential threat that perhaps hundreds or more people will be killed or injured. Proper precautions need to be taken and airport disaster plans that have been written, exercised, and critiqued beforehand are to be utilized. Although these forms of disaster may not be aircraft or airline operations related, the airlines, nevertheless, recognized the future possibilities of such occurrences and have worked closely with the FAA in various areas. One area was that of handling and storage of hazardous cargo, which the FAA has addressed in the Airport Certification Rule. Under Part 139.51 of the Rule it is stated:

(a) The applicant for an airport operating certificate must show that, as the cargo handling agent, it has adequate controls and procedures listed herein to protect property and persons on the airport during the handling and storing of hazardous articles and materials that are, or are intended to be, aircraft cargo while they are on the airport. These articles and materials include flammable liquids and solids, corrosive liquids, compressed gases, and magnetized or radioactive materials. The following controls and procedures are required:

(1) Designate personnel to receive and handle hazardous articles and materials

(2) Assurance from the shipper that the cargo can be handled safely, including any special handling procedures required for safety

(3) Provision of special areas for storage while on the airport.

This particular section also requires that an applicant for an airport operating certificate must also show that it (or its tenant) has trained personnel and procedures for safely storing, dispensing, and otherwise handling fuel, lubricants, and oxygen on the airport.

In addition to working with the FAA in developing the hazardous material regulation, the airlines also deal with the problem through the Air Traffic Conference (ATC), a division of the Air Transport Association. Civil Aeronautics Board (CAB) Order 76-3-136 issued on March 22 of this year, an agreement which establishes a permanent restricted Articles Board within the Air Traffic Conference.

The stated objective of the agreement is to make a permanent part of ATC, an entity which is staffed by employees of the airlines who have expertise in the handling, transportation of, and rule pertaining to hazardous materials. Thus the Articles Board is to assure safe transportation through the establishment and maintenance of standards to be adopted by carriers for on-line and interline transportation of hazardous materials.

In support of the agreement ATC points out that for years a group of experts from different fields has been serving on what was known as a Restricted Articles Policy Advisory Board (Advisory Board). Working together with shippers, government agencies, and the International Air Transport Association, the Advisory Board has determined proper packaging for hazardous materials. In addition, after consideration of Government regulations, it has made recommendations as to tariff language for the Restricted Articles Tariff No. 6-D CAB No. 82, which deals with the carriage of hazardous materials. ATC further states that there is and will always be a need for an established and knowledgeable group to keep up to date and recommend the necessary safety precautions on air shipping of potentially hazardous materials. Membership on the Articles Board represents a variety of airline expertise in the fields of safety, engineering, chemistry, and cargo handling.

Within the Air Transport Association, there is also a task force that works with the airlines, known as the ATA Specification No. 300 Task Force. All manner and forms of packaging are addressed in a specification for which they are responsible, "Specification for Packaging of Airline Supplies," from common packaging up to and including packaging of hazardous materials supplied to airline customers are outlined and are materials defined and regulated in Federal documents. They include: 1) explosives, 2) flammable liquids and solids, 3) oxidizing materials, 4) corrosives, 5) compressed gases, 6) poisons, 7) etiologic agents, 8) radioactive materials, 9) irritants, and 10) combustible liquids.

For packages containing any of these materials, magnetized materials or compounds thereof, the ATA Spec. 300 lists documents to be consulted and points out that hazardous materials should be labeled in compliance with these documents.

There are also other areas in which the airlines have taken action to formulate guidelines for disaster control at an airport similar to those for hazardous materials, such guidelines being generally based on Federal Aviation Regulations and local regulations.

In the event of a major aircraft accident, good planning, as we have specified before, is a must. The National Transportation Safety Board is in charge at the scene of the accident, and the airport physician is placed on the human factors team. If a large airline is involved and has a medical department, their doctors are usually dispatched to the scene for rapid positive identification of crew and passengers. Assuming that a particular accident is categorized as a major accident due to the type and number of passengers killed or injured, then, in the airlines' view, the overall effort should be coordinated and controlled through a central disaster unit for the community involved. Too many disaster planners associate disaster with fatal aircraft accidents. Airport disaster planning is only one facet of community disaster planning but should include the following considerations:

1) An important aspect in airport disasters is highway traffic control. It seems that an airport aircraft crash is a signal for morbid curiosity seekers to head for the airport. Preplanning of this type of traffic control is, therefore, all important.

2) Communications means established through helicopter (police or armed forces) facilities for evacuation of injured should be the primary means for evacuation if at all possible.

3) Practice sessions should be held to keep the plan current.

4) When fatalities are involved, a temporary morgue, such as the Fire Department garage, is considered desirable.

5) Dependent upon the size of aircraft utilizing the airport, facilities for 100 fatalities appears to be reasonable.

6) Civil Defense casualty vehicles and supplies seem adequate for airport field casualty stations. The local Medical Society, Civil Defense, or disaster type teams should be provided the opportunity to conduct a "dry" or "practice" run at periodical intervals.

Relating to another aspect of airport disaster planning, we cannot help but reflect on some airport emergency plans that have been written thus far but do not include data on hospital services and medical supplies needed to actually treat the victims of an aircraft accident or any major catastrophe for that matter. We feel that an effort should be made to incorporate into those plans, which do not already have it, data on available hospital and medical services.

Finally, and most important, is the thought concerning equal sharing by the airlines, airport, and the community in a Community/Airport Disaster Plan. As some of you may not be aware, the requirements for emergency services, facilities, equipment, and training have to be unique and specialized when concerned with aircraft and the operations of the aircraft. Techniques and procedures standard in combating fires and conducting rescue operations in a community disaster that is non-aircraft related vary considerably from those employed when an aircraft is involved. Some even visualize the two types of situations as being "worlds apart." Equipment and training in rescue operations associated with aircraft becomes extremely costly, especially from the standpoint of annual funding for recurrent training as well as the financial outlay for sophisticated equipment. Additionally, at those airports where medical departments are located, and this is generally only at the larger airports, the purpose of the medical department is for preventive, not therapeutic, type medicine. Therefore, in the final analysis, there does not appear to be adequate justification whereby the airlines should be included as equal participants in a Community-Airport Disaster Plan to the extent of becoming involved with sharing overall additional costs of training, equipment, and services, plus any other costs which may arise. Such participation would only tend to have a significant impact on the economic regulated airline industry. However, it should be emphasized that the airlines have been and will continue to be willing to cooperate, to the extent feasible, with equipment and services, in any community effort to meet an unforeseen disaster situation.

We hope the foregoing has been of some assistance in pointing out some of the past efforts that have been taken by the airline industry as well as some of our current concerns and thoughts associated with disaster response planning at the airport. For the immediate future, as in the past, we anticipate current airport disaster plans to be reviewed and updated. We are also anticipating some proposed changed by the FAA to Part 139, which as in the past years, will undergo review by the airline industry as well as other public segments.

Suggested Readings

Air Transport Association Specification No. 300, "Specification for Packaging of Airline Supplies," Chapter 6 (pp. 1-2).

Federal Aviation Regulations - Part 139, "Certification and Operations - Land Airports Serving CAB Certified Air Carriers."

FAA Advisory Circular AC 150/5200-17, "Emergency Plan," Appendix 1 (pp. 1-2).

EMS SYSTEM RESPONSE IN AIRPORT DISASTERS

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An airport disaster is classically thought of in terms of that sequence of events following a commercial airplane crash which results in multiple personal injuries and multiple fatalities. It strains the best-laid plans, the best equipped facilities and the most organized services. It is an event which we all fear, and an event which millions of dollars are spent to prevent. There has been, because of our concerns and the money spent, a considerable reduction in the number of airplane crashes and of the number of injuries and fatalities. However, it is an ever present threat for which we must continue to plan, continue to drill for, and continue to discuss because we have not and will not in the near future reach that millennium in which no crashes occur.

We have looked at the airport disaster from the point of view of the flight attendant, the pilot, the air carrier, the airport and the community, especially their disaster planning officials. There is one more group of people whose viewpoint needs to be heard—that is, the patients!

It is my view that the average American, traveling commercially, does not view himself impartially in the mass disaster situation in which the primary concern is the saving of as many lives as possible. The patient is concerned primarily with himself and his problems. His reactions to the disaster are totally personal. He views everyone's response in terms of the assistance that they may provide to help him survive and to help him return to a normal life. In the light of these considerations, the parameters of our thinking regarding disasters must be related primarily to those considerations of the patient wnd those actions which will save the patient's life, minimize his disability, and return him to as normal a life as possible.

Furthermore, these concerns become operative when any life-threatening problem occurs. A life-threatening problem, whether it is in the form of an acute severe illness, such as a heart attack, or an injury in a plane crash, is the most severe emergency the patient faces. This emergency can occur in the air, in the air terminal and on the airport grounds. To the patient and, indeed to all patients, the life threatening event is a disaster! It makes little difference to him whether he is alone or with 500 other patients.

It is the patient disaster that the EMS system must address. The EMS system must be able to respond to the need of any patient with a life-threatening illness or injury. Ordinarily the response to a single patient is considered part of the ordinary day-to-day operations of any well functioning Emergency Medical Services System. It is the needs and requirements of the simultaneous occurrence of these kinds of problems to three, four, or five hundred patients that we are addressing today. However, we should never forget the one patient and the fact that his problem is a disaster as well. I feel that the real test of an EMS system is its ability to respond to the single patient and his needs. For, if we can respond to that patient, we surely, when marshalling the resources to handle a major disaster, will have a system that has been tested repeatedly and modified until it has become successful. In the major disaster situation with multiple patients this system then should prove its mettle and should succeed for the majority of patients in a crash.

Let's look at two things. Let's look first at a system that can respond for the one patient with an acute heart attack and the sudden cessation of effective cardiopulmonary function. If we can save that patient, we are, indeed, ready to save many, many others. Then let's look at how we should function in a major crash.

But let's make it hard to save the patient. The patient should have a heart attack in the air and should have a sudden ventricular fibrillation. How do we help that patient? Today, I think an effective EMS system should be able to save a significant percentage of these people. But it requires training, capability and organization.

In the air, the person best trained to meet the sudden patient emergency is the flight attendant. The flight attendant should be able to recognize the sudden severe problem and should be able to promptly and effectively initiate cardiopulmonary resuscitation. When effective CPR occurs, the patient has another 30 minutes before definitive therapy aimed at correcting acidosis and ventricular fibrillation must be initiated. In that time, the plane can land and a life support team can have been assembled and be ready to assume the responsibility for the continuing care of that patient. This coordinated activity requires effective communications, a responsive EMS system, and capable personnel.

When the cardiac arrest occurs on the ground, the patient has the same needs. They are: early detection, prompt initiation of effective cardio-pulmonary resuscitation, and early definitive care. On the ground, the airport personnel must be able to provide this early care and be in immediate communication with the EMS system. The EMS system must immediately respond with a life support team, which today should be paramedics acting in coordination with the emergency nurses and emergency physicians in the hospital facility. The paramedics should be able to provide both initial care and early definitive care under the guidance of standard procedures and under the direction of the emergency care team at the hospital.

Today, however, I think this happens only by accident, and not as a preplanned effort by all involved. In order to make air travel safe for the individual whose heart suddenly stops, we must effectively initiate the EMS system I have outlined at the principal airports across the country.

Let's next look at the airplane crash. It is not usually the commercial airliner. It is most often a small plane, and it is not always on the airport grounds. In fact, it is most usually away from the airport and, oftentimes, when the plane is out of radio communication. But, frequently, the airport control tower or the approach control center knows of the event, knows where the event occurred, and is in the best position to alert the public safety agencies in the EMS system. The biggest problem, because of multijurisdictional concerns, is who to alert, how to alert them, and then be assured the response will be immediate, and that required by the victims of the crash. The great need then is for the airport control tower or the approach control center to be in immediate communication with an area wide EMS system whose communications agency is able to notify the proper public safety agencies, the appropriate ambulance and rescue services, and the hospital facility most likely to be inundated with the patients.

Finally, let's consider the EMS system response requirements in a major plane crash. In order to facilitate resource deployment, the EMS systems communications agency needs to know as accurately as possible the location of the crash and especially the possible number of casualties, priorities must often be set regarding initial transportation. These decisions are medical in nature and require the presence of the most capable medical triage personnel available. The provisions must also be made for the initial care of the injured who are waiting transportation. This is especially important to those with minor injuries who must necessarily wait a number of hours prior to definitive care. It provides for them the reassurance that their injury was at least recognized, that the crisis was controlled, and that the life threat is over. Provisions must also be made to subsequently examine the uninjured and to also provide a temporary morgue for the dead. Thus, it can be seen that the management of the scene of the crash requires the best planning that the airport, airline, and EMS system personnel can provide.

Equally important is the resource deployment at the hospitals and the selection of the hospital to which the patient is sent. It makes little sense to send a patient with a major neurologic problem to a hospital with no neurosurgeon. It is as great an error to overload a hospital emergency facility when other capable facilities and personnel exist. Thus, patient transportation decisions must be made with full knowledge of the resources available to handle the casualties on an immediate basis.

As I see it then, the role of the EMS system in response to an airport disaster is to be able to alert the proper public safety agencies, to manage the resource deployment of the ambulances and rescue services, medical triage personnel and the hospital facilities and their medical capabilities in a coordinated manner that best serves the need of the patient. These requirements dictate that we all sit down and draw up agreements to participate on a rational basis in the further development of our system of emergency care.

AIRPORT DISASTER EXERCISE PLANNING

Dennis W. Evans

Medical emergencies in the airport/community environment occur daily. Though these emergencies are routine, they reinforce the interagency, multijurisdiction interface required for delivery of emergency medical care. Medical assistance for a sick passenger, transportation of an injured worker from the airport to an appropriate medical facility—these medical emergencies usually progress smoothly. Such occurrences as multiple-injury automobile accidents and brush fires in the vicinity of the airport present an infrequent but important reinforcement of each agency's capabilities and responsibilities in an emergency situation.

Against these rather uncomplicated operations must be contrasted the extraordinary occurrence. In a mass casualty situation, when the total medical resources of the community and the airport are entangled in a fluid, sometimes even chaotic situation, normal lines of communication are overtaxed, areas of responsibility are unclear, and inter-agency coordination is difficult. A mass casualty occurrence does not require the same response on a larger scale, as a routine emergency; the enormity of the emergency creates unique problems which become apparent only when confronted on a large scale. The major means of identifying these special problems is through the conduct of a full-scale, mass casualty exercise.

There are as many types of exercises as there are actual medical disasters. Not all exercises need to be full-scale and have total participation to achieve valuable benefits. Limited exercises produce specific, *limited* outcomes. The decision-making process can be evaluated through a command post exercise. Casualty transportation systems can be tested on a limited scale without involving a large number of casualty actors or vehicles. Determining the availability of supplies and personnel at any particular moment can be established by a synchronized request of status reports from key agencies. In each of these instances, the specific outcome reflects the nature of the exercise. Regardless of the scale, a demonstration should not be confused with a disaster exercise. Revelry should not be confused with a maneuver. The successful display of manpower and equipment without the learning process does not meet the criteria of an exercise.

The full-scale medical disaster exercise affords the greatest opportunity to identify and assess aspects of a mass casualty situation which cannot be separated and individually tested. If you will, the whole is greater than the sum of its parts. To put it most simply, the disaster exercise tests the framework which connects the various elements that will operate in a real disaster. Since a disaster exercise requires the services of a myriad number of agencies, their ability to work together in a fluid situation must be tested, assessed, evaluated, and honed to the nearest point of perfection possible. A "medical" disaster exercise, with the emphasis on the delivery of emergency care, imposes certain minimum levels of agency involvement which cannot be tested individually in a limited exercise or in anything other than a situation which brings everything together at one time.

Development of the Disaster Plan

The most important phase of planning for the exercise is the development of a well-coordinated and comprehensive medical disaster plan. The plan, which ultimately will be tested in the exercise, must have the input of all involved agencies, and their awareness of the importance of the plan. Conducting an exercise based on an incomplete plan is an exercise in unreality. The essential contributors to the plan should include:

1) *The Airport Management* - which is uniquely aware of thd special problems and procedures involved in an aircraft-related mass casualty situation.

2) *The FAA Control Tower* - which has responsibility for providing guidance to aircraft and specific procedures for handling many different kinds of aircraft emergencies.

3) *Major Air Carriers* - who have a responsibility to the passengers to assure the availability of medical resources in the event of an emergency.

4) *Airport and Community Fire/Rescue Services* - the total fire/rescue capabilities of the community may be required in an aircraft-related mass casualty occurrence.

5) *The Existing Emergency Medical System* - from initial triage and transportation through definitive care facilities. This network exists on a day-to-day basis and stands to benefit greatly from conduct of the exercise.

6) *Enforcement Agencies* - access to the emergency site, crowd control, security, etc. mandate an active role for enforcement agencies.

7) *Medical Examiners* - with the likelihood fatalities, the medical examiner's input for specific requirements and procedures is very important.

8) *Red Cross & Civil Defence* - if these agencies can mobilize fast enough to bring their unique service to bear on the emergency, they should play an active part in emergency plan development.

9) *Supportive Agencies* - such as clergy, U.S. Customs, U.S. Mail Service, etc. who may or may not be called upon to render services in an actual emergency.

Assessment of Resources

Before the actual plan can be drafted, several key tasks must be undertaken to assure that the disaster plan realistically reflects the community's total resources and makes the most effective utilization of resource and manpower.

1) With the assistance of state and local medical societies, an Advisory/Steering Committee should be established to provide overall medical guidance to the plan and to establish treatment and transportation philosophies and guidelines.

2) Available medical resources, manpower and material should be inventoried, keeping in mind the response time, availability of manpower and the accessibility and appropriateness of the medical supplies. For example, a complete field hospital stored at the airport may be of little worth if it takes 24 hours to set up, or the available manpower consists of volunteer first-aid workers.

3) Examine existing communication linkages from emergency site through hospitals and vice versa, to identify major communication gaps.

4) Develop a rough manpower and medical supply needs analysis based on the largest aircraft routinely utilizing the airport.

5) Review the existing emergency plans of all involved agencies to identify duplications, inconsistencies and gaps.

With the above information in hand, development of the Emergency Plan itself can begin.

1) The Medical Advisory/Steering Committee must establish the overall framework of the care to be delivered, including the establishment of procedures which are unique to the special problems of aircraft-related mass casualty situations. The determination of who should triage and the level of medical care to be delivered at the scene should be determined by the medical committee.

2) Participating agencies can be separated into essentially four areas according to the services they provide: Fire/Rescue Services, Emergency Medical Services, Enforcement Agencies, and Support Agencies. Although integrally related, each area must be intracoordinated and procedures within each activity area defined in accordance with the overall plan.

3) Resolve conflicts in duties, responsibilities and procedures and formalize mutual-aid agreements.

4) Establish clear-cut notification procedures and priorities.

5) Obtain formal concurrence for the plan and train all personnel involved in new procedures, etc.

Planning The Exercise

By involving the agencies who will be asked to participate in the exercise, in the Disaster Plan development, the bulk of the network building for participation in the exercise is complete. The following major steps outline the specific planning procedures for the exercise:

1) It is of ultimate importance to establish the objectives for conducting the exercise. If the overall goal is a complete test of the emergency plan, the specific objectives within each of the four major agency areas of involvement (Fire/Rescue Services, Emergency Medical Services, Enforcement and Support) should also be established.

2) Establish the parameters of participation by all agencies involved to ascertain if the objectives can be met with limited participation. Most agencies will continue to be on call during the exercise for actual emergencies and will be unable to commit 100% response.

3) Determine the availability and extent of expendable supplies.

4) Develop a breakdown on the kinds of injuries to be handled in the exercise. This listing should be feasible and designed to reflect the overall exercise objective.

5) Selection of volunteer casualties is very important. Unless the exercise is meant only to test the transportation system with no attempt to train emergency medical personnel in triage and treatment, casualties should be able to accurately portray the symptoms of their injuries. This may require using mature volunteers who either have medical knowledge of their own or who receive thorough briefings on the best way to portray their injuries. Casualty make-up (moulage) is also very important to give medical personnel an opportunity to exercise judgmental skills.

6) Determine casualty transportation limitation. If neighboring hospitals choose to participate in the exercise, in conjunction with their certification requirement, adequate arrangements must be made for the transport of sufficient numbers of casualties to the hospitals for their purposes. If military units participate in the exercise, no civilian volunteer casualties may be transported in military vehicles.

7) Selection and preparation of the emergency site should take into account access and egress as well as operational problems which may be encountered with active portions of the air operation areas. Fire/Rescue equipment must have ample area for set-up, as well as sufficient up-wind area for casualty collection and command post operations. If helicopter evacuation of casualties is part of the exercise, a safe landing area must be planned for. Special props to simulate realism, observing areas, a first-aid station for actual medical problems and comfort facilities must also be provided at the site.

8) Due to increased awareness in the importance of airport/community disaster exercises, special provisions must be made for members of the press and official observers to afford access and an opportunity to learn from the exercise without becoming a factor in the actual exercise. This requires

special briefings, identification and procedures specifically for them.

Evaluation

The major concern of all agencies involved in a mass casualty situation is the victim. The first and ultimate test of success or failure is both the *efficiency* and *appropriateness* of emergency medical care delivered to each casualty, from the incident site to definitive care. The appropriateness of the care delivered to a casualty with a fractured femur, for example, can be determined by following from initial triage to the hospital. By whom and at what time was the fracture immobilized? What priorities evolved in the transportation of the casualty to the hospital? The airport community has been slow to grasp the importance of an *orderly* and *controlled* entry into the emergency medical system. Rapid transport of all casualties regardless of the nature of the injuries may be attractive to some, but irreparable damage may be inflicted by hasty, careless mishandling at the emergency site. The speed with which casualties can be removed from the emergency site is ***not*** an indication of the appropriateness of the medical care delivered.

The second criterion for evaluating a mass casualty exercise is the effectiveness with which emergency medical resources are employed at the site. Were there delays in getting manpower and resources to the emergency site? Of even greater importance is the deployment and utilization of the various skills of medical manpower at the scene. It would be inappropriate, for example, for physicians to be involved in providing low priority first-aid treatment in the field if critically injured are in need of care in the casualty collection area. As the medical community responds, the reassessment and redeployment of medical manpower can be objectively evaluated.

Conclusion

The conduct of an airport/community disaster exercise can be a very significant learning experience for the entire community and of particular benefit to the emergency medical system. The experience gained greatly enhances the response, efficiency and effectiveness of all agencies who would become involved in the event of an actual airport/community mass casualty occurrence.

TRACK II
TRAUMATOLOGY

SECTION I

Trauma Management Introduction

INTRODUCTION

Sam F. Seeley, M.D.

The five general sessions on basic and general considerations of trauma management, and the twelve workshops on special problems of trauma management constitute one of the most ambitious of symposia of this decade on traumatology.

This session is devoted to identification of fundamental elements of the emergency medical services system necessary to comprehensive care of the victim of trauma. Panelists will highlight the importance of organization of a complete EMS system, facilities, manpower, resuscitation and transportation, and research, with a special emphasis on requirements to minimize mortality and morbidity following trauma.

REGIONALIZATION OF TRAUMA PATIENT CARE

David R. Boyd, M.D.C.M.

Introduction

The development of regional systems for trauma and emergency medical services (EMS) is an exciting proposition. Over the last century the United States has developed the models and set the standards for military field casualty care and evacuation. These progressive improvements were initiated after the medical care and evacuation disaster experienced by the Union Army of the Potomac at Bull Run on July 21, 1861.[1] From this chaotic awakening, a series of reorganizations of the army surgeons, medical corps, ambulances, and hospitals was undertaken. During the Civil War, major changes in administration, professional personnel, transportation, hospitals, sanitation, and medical records established patterns that have been continually refined and improved and, in large part, have been responsible for the improvements in military field casualty survival now realized in modern times.

Stimulated by pressing demands of war surgery and coupled with parallel advances in medical care over the last century, an almost unbelievable level of performance has been realized in the recent Vietnam experience. Advances in field resuscitation, efficiency of transportation, and energetic treatment of military casualties have proved to be major factors in the progressive decrease in death rates of battle casualties reaching medical facilities: from 8 percent in World War I to 4.5 percent in World War II to 2.5 percent in Korea and to less than 2 percent in Vietnam.[2] The integration of rapid evacuation of the critically injured directly to adequately staffed and equipped advanced treatment units has shown that a highly perfected and well-operating trauma system can save lives in the civilian peacetime community as has been repeatedly demonstrated in previous military conflicts.[3,4]

While there are considerable differences between the civilian peacetime community and a battlefield, many principles for an areawide trauma system design for accident patient care are transferable and can be successfully implemented into statewide and regional programs for the comprehensive care of the injured. In fact, it is most surprising that more of the medical lessons learned on the battlefield over the past century have not been implemented in civilian day-to-day accident care.

Only a relatively few individuals, hospitals, universities, and communities have taken a special interest in the critically injured trauma patient. In 1966, Cook County Hospital in Chicago established the first trauma unit, and the University of Maryland in Baltimore extended its ongoing research interest in shock patients to a multidisciplinary investigation of severe trauma victims. At the same time, the National Institute of General Medical Sciences of the National Institutes of Health began to support research programs aimed at the study of injuries and the need for improved treatment and rehabilitation methods, and launched a comprehensive attack on this problem through a program of clinical and basic research activities. As of January 1973, the Institute was supporting eight trauma research centers at Columbia Presbyterian Medical Center, New York; Albany Medical Center, Albany, New York; Cincinnati General Hospital, Cincinnati; University of Texas Southwestern Medical College, Dallas; E. J. Meyer Memorial Hospital, Buffalo, New York; University Hospital, Boston University Medical Center, Boston; University of Mississippi School of Medicine, Jackson; and San Francisco General Hospital, University of California, San Francisco. Research areas studied included energy metabolism, infection, burns, low flow states, acid-base and hormonal imbalance, pathophysiology of drowning, computer assessment of the injured, wound healing, and lost defense mechanisms.[5] These initial special efforts were necessarily limited in scope and benefited relatively few trauma patients. They did not address the key issues of initial treatment at the accident site nor the evacuation to designated care centers, so well described in our medical war history.

The ineffective nonsystems and inadequate attention and support for the trauma patient that still exist in most of this country were well documented in the crucial white paper published by the National Academy of Sciences/National Research Council.[6] This publication presented the problem and set forth a series of recommendations for improvement. A strong case was made for the development of a system of trauma patient care, and a series of subsystem components essential to the success of an overall effective effort was outlined. This timely document made specific recommendations for improvements in accident prevention, emergency first aid and medical care, ambulance services, emergency medical communications, use of air evacuation by helicopter, upgrading and categorization of emergency departments, and expansion of the role of hospital intensive care units.

Also, recommendations were made for the development of trauma registries:[7-9]

> Establishment of trauma registries in selected hospitals as a mechanism for the continuing description of the natural history of the various forms of injuries.
>
> Subsequent consideration of establishment of a national computerized central registry.
>
> Studies on the feasibility of designating selected injuries to be incorporated with reportable diseases under Public Health Service control.*

Special attention was given to the need for hospital trauma committees, studies on convalescence, disability and rehabilitation, medical-legal considerations, disaster preparedness, and increased federal and voluntary support for research in shock, trauma, and related areas with a goal of complete autopsy study of accident victims.

This document, its authors, and other interested professionals stimulated the passage of the National Highway Safety Act in 1966, which called for the improvement of emergency medical services and provided implementation guidelines as they pertained to highway-related accidents.[10] These and other concerted efforts furthered the enactment of the Emergency Medical Services Systems Act of 1973,[11] which authorizes the planning, initiation, and expansion of EMS systems in areawide and regional designs.

Regionalization of Trauma Care

The terms "regional" and "areawide" have great implications for the trauma victim, as his injuries usually occur away from readily available emergency medical care. Trauma and other emergency medical patients have other negative time factors that significantly affect the availability and adequacy of necessary care. Therefore, pressing time-distance relationships must be considered in any trauma-EMS system design. A third important dimension to this time-distance ratio to be considered is medical competence and capability. Every regional system for trauma patient care will be necessarily modified to account for the existing geography, time-transportation factors, and the maximum health care delivery

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potential within the area. All efforts to upgrade professional and paraprofessional personnel, improve equipment and facilities, and, most important, the integration of these "soft" and "hard" components must satisfy the needs of trauma patients with demanding medical-surgical problems and be consistent with regional and areawide limitations.

Therefore, in designing regional trauma-EMS systems, it is emphasized that focusing on one component or subsystem will not be as effective as an overall and comprehensive view of the sequence of events as they affect the course and final outcome of the critically ill and injured, including care at the accident site, during transportation, and on to definitive treatment and rehabilitation.

The Illinois statewide trauma program[3,4,12] has shown that the regionalization of expert care, which was previously available only in the university centers, can now be effectively and efficiently delivered throughout the state, especially in rural areas. The initial success of the program has provided the groundwork for the development of a total emergency medical service (EMS) system in Illinois.[13,14] This program was facilitated by a special message on health care in 1971, when the then governor of Illinois, Richard B. Ogilvie, discussed the future development of some 45 trauma centers for the care of the critically injured patient to be designated in hospitals throughout the state,[15] and became the first component of a total emergency medical service program now being developed on a controlled and systematic implementation schedule.

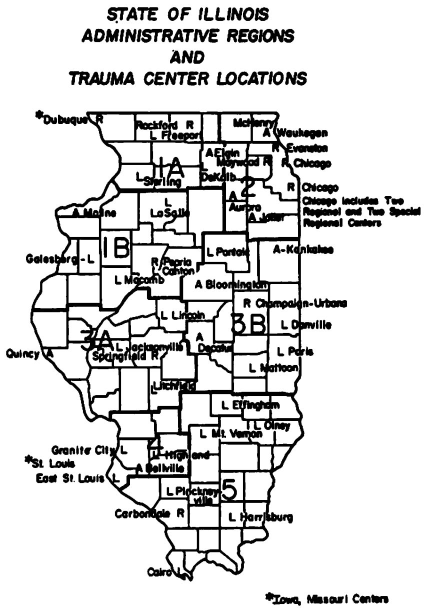

FIGURE 1: State of Illinois, administrative regions with present configuration of trauma center locations: local (L), areawide (A), and regional (R).

The Illinois Trauma Care Plan

The critically injured trauma victim is an easily identifiable patient with complex care requirements that demand a sound clinical and geographically designed systems approach to the provision of emergency medical care. The Illinois system for trauma care integrates the following essential components: hospital (trauma center) categorization and designation, communications, transportation, training and education of professionals and the public, and program evaluation. These essential subsystems have been integrated into a comprehensive unit that supports improved patient care and furthers development of regional designs for other health care programs. Some controversy may have existed as to which of these subsystems was to be the most important. In Illinois the initial decision was to proceed along the lines of categorization and designation of emergency care hospital facilities (trauma centers) for the critically injured patient and implement other essential subsystems as appropriate and feasible.

The designation of one trauma center in each major and strategic geographic health service district area was achieved only after determination by the local health planning agencies in cooperation with medical societies, public officials, professional health organizations, and representatives of the professional and administration staffs of area hospitals involved. Local medical consumer groups were included in these decisions to gain maximum community support. Trauma centers have been established in existing general hospitals utilizing and upgrading resources already available (Figure 1). The success of the trauma program has been due, in large part, to the medical leadership of area physicians and surgeons who appreciated the need for a trauma system in their own communities.

In addition to this initial designation of a trauma center, all interested area hospitals, professionals, allied health personnel, and community leaders subsequently began the task of integrating other subsystems into a comprehensive trauma system and subsequently a total emergency medical care system.

This effort stimulated the development of areawide emergency medical service councils. Because of the trauma program initiative, every Illinois hospital has self-categorized its capability for comprehensive emergency medical care as of July 1, 1973 into one of 40 operating areawide trauma-EMS plans.[16]

Each trauma-EMS planning area relates to an emergency medical service council and is responsible for continued planning and coordination of all trauma-EMS activities for its area and region. These EMS councils relate to the local comprehensive health planning agency and involve a specified geographic and medical service area. The council is made up of EMS providers and consumers and is an umbrella advisory group over more specific EMS subcommittees with activities directed to categorization, communications, transportation, professional and paraprofessional training, public education, and evaluation. The areawide hospital emergency "categorization" committee is now mandatory under Illinois law (P.A. 76–1858[17]), and is responsible for development of hospital categorization and the further development of trauma-EMS plans. It is made up of all member hospitals in each of the 40 areawide EMS plans.

The Illinois Trauma Care System

A basic premise of the Illinois statewide program is the extension of the intensive care concept for the treatment of trauma to provide a wider distribution of essential life-saving services by involving and upgrading strategically located hospitals as trauma centers across the state. Trauma patients admitted to these special trauma care centers are observed until all life-threatening problems are resolved. The basic life-saving resuscitation function can be performed in any well-staffed and equipped local trauma center, where expert personnel are always available. After a patient is resuscitated, he may receive surgical care at that local facility, or, if necessary, be sent to an areawide or regional trauma center for more complex posttraumatic treatment. The primary physician in charge at a center initiates patient transfers, and the trauma center network (state involvement) provides him with the necessary backup support.

ECHELONS OF CARE

The trauma center concept utilizes small community hospitals as well as the large medical centers. The care available at the local, areawide, and regional levels is shown diagrammatically in Figure 2. The requirements for hospitals to be included in a specific care category are as follows:

Local Trauma Center

At local trauma centers, basic resuscitation and life support are performed by skilled medical and allied health personnel. These emergency resources are becoming more available in rural center hospitals as emergency departments provide physician coverage 24 hours a day. In these local centers a nurse is on duty and an emergency physician is available at all times to provide initial care for the critically injured patient.

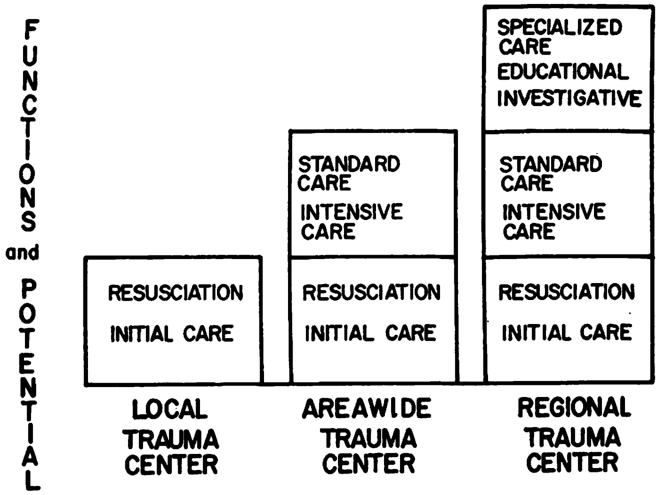

FIGURE 2: Basic echelon trauma care capabilities of trauma center hospitals.

At the inception of the trauma program, a hospital designated as a local trauma center did not always have a physician physically present in the hospital. However, this requirement has been fulfilled within a reasonable time period and as the statewide hospital emergency categorization program was completed.

To expect highly specialized care at the local center is unfair to both the patient and the physician. Emphasis here is on resuscitation prior to transfer and efficient evacuation to an advanced trauma facility when necessary. In Illinois the helicopter and fixed wing air ambulances have been most useful in these situations.

The 19 local trauma centers now in existence are distributed in rural regions so that each covers a specified 50-mile area. This distribution is now being studied to evaluate whether the centers can provide an adequate response time for the safe transportation and successful initial care of the critically injured.

Areawide Trauma Center

Major trauma centers, both areawide and regional, are required to provide 24-hour staffing by highly competent medical and allied health personnel who are able to perform resuscitative and definitive care for all injured patients. They are required to maintain operating rooms, intensive care units, laboratory services, blood banks, resuscitative equipment, and x-ray facilities (including arteriography). The designated trauma director of these centers (usually a practicing general surgeon) must be experienced in the initial care, triage, and priority determinations for victims of severe trauma. Specialty consultants are available and on call at all times. Areawide trauma centers have been established across the state in general community hospitals (500 beds) in communities with populations over 50,000 (Fig. 1).

Regional Trauma Center

The regional trauma centers are located in communities with established and developing university health education complexes. They provide sophisticated treatment and educational support and coordination for the statewide program, and are models for the areawide and local trauma centers in their regions. They are hubs for professional education and paraprofessional training, regional transportation networks, communications systems, data control, and epidemiologic and clinical study efforts. Not all critically injured patients are taken to these centers, because in most cases they can be adequately handled at the areawide or local trauma centers. Backup support and resources for medical, technologic, epidemiologic, administrative, and educational activities for the region are centered in these regional trauma centers and their respective university health education complexes.

The designation of one institution as a regional trauma center must not be misconstrued as detrimental to other hospitals in that community or region. The emergency department of this center functions as the continually accessible point of entry into the trauma emergency care system for the most critically injured patient. After initial resuscitation and definitive treatment, the patient can be transferred to any other hospital within the area.

The distribution of regional trauma centers in Illinois is now providing stimulation for improved care in all regions of the state. Not every regional center has all of the resources to manage every unique trauma care. Special patients, such as those requiring hyperbaric oxygen therapy, radiation detoxification, spinal cord injury care, or special burn problems, demand expensive and sophisticated equipment and personnel, and can be effectively transported to "special" regional centers within Illinois or in neighboring states.

Special Regional Centers

The Illinois trauma system has worked toward the identification and support of specialty care units across the state. Patients with unique problems are selectively transported to these units as rapidly and efficiently as possible.[18] At present three special statewide regional centers have been integrated into the Illinois system: the Midwest Regional Spinal Cord Injury Center, the Children's Memorial Hospital Trauma Center (both of Northwestern University), and the Central Nervous System Trauma Study Center (University of Chicago). Underway is a statewide effort for the establishment of burn intensive care units in Chicago (Cook County Hospital and Children's Memorial Hospital), Evanston, Maywood, Rockford, Rock Island-Moline, Peoria, Springfield, Champaign-Urbana, and St. Louis, Missouri. The 35-bed burn center at Cook County Hospital is a special referral and training center for the entire statewide burn network.

By focusing on the care of the most critical trauma patients in well-identified designated centers, other patient and program benefits have been realized and more are anticipated. The Illinois kidney transplant program is now being interfaced with the trauma centers, and with it a more effective professional and public education effort has been possible. This effort has been productive in a marked increase in the number of harvested and successful renal transplants from trauma patients in Illinois. Surgeons at regional centers are developing the skills for organ removal, preservation, and transportation to Chicago, where active transplantation programs are now ongoing.

The Illinois total volunteer blood, perinatal, and acute cardiac care programs now being planned will develop along these regional lines and will utilize many of the available resources of the established trauma-EMS program.

The Triage System

Each trauma center, regardless of its care potential level, must provide comprehensive resuscitation, initial evaluation, and full stabilization of all critically injured patients. A patient is stabilized when all injuries that constitute immediate threats to life have been recognized and treated supportively. All local trauma centers are capable of stabilizing the patient, diagnosing the majority of injuries, and treating almost all locomotor injuries and the majority of less complex visceral injuries.

All centers utilize the concept of successive triage, in which the basic functions of the local center are performed while the definitive care requirements relative to the care potential of that individual center are assessed. When definitive care is required beyond the capabilities of the trauma center, and such care can safely be delayed for a short time, the patient is evacuated to an appropriate center. Thus costly, highly specialized, and infrequently used care facilities need only be available at a few special centers in the state. The primary physician in the local center determines the need for, authorizes, and initiates any such transfer; the statewide trauma program merely supports this physician in effecting a safe transfer to an appropriate advanced center.

A Comparison of Two Regional Trauma Centers

The following is a comparison of two dissimilar regional trauma centers: Cook County Hospital, Chicago[19] and St. Johns Hospital, Springfield.[20]

COOK COUNTY HOSPITAL REGIONAL TRAUMA CENTER

Since the beginning of the trauma unit in March 1966 at Cook County Hospital, annually some 5,000 to 7,000 patients have been managed in part or totally by this pioneer trauma care facility. The lessons learned in the organization and operation of this unit have been invaluable in subsequent organizational and therapeutic endeavors across Illinois. Of paramount importance throughout has been the concept of the team approach in patient care, teaching, and research.

Development of a Model Trauma Unit

Because of the demands on this hospital as a major health resource for the inner-city population of Chicago, the hospital's staff organized a care system for the management of all hospitalized trauma victims. This center was the nation's first trauma unit (21 beds) which provided the centralization of all available hospital resources for optimal, comprehensive resuscitation, initial evaluation, and operative care. The capital outlay for establishing this unit and mobilizing the available sophisticated equipment was minimal. Its success can be attributed primarily to its organized approach to the delivery of critical health services utilizing the medical expertise of this teaching hospital.

Several important principles were involved in this approach:

1. Immediate identification of the injured patient and provision for transport to the trauma care area.
2. Triage of all hospitalized trauma victims in a specified location by a single team of experienced surgeons.
3. Resuscitation and comprehensive initial evaluation in a fully staffed and equipped area of the trauma unit.
4. Utilization of a team approach to the individual patient with a general surgeon functioning as the team coordinator.
5. Upgrading the level of training of the trauma team coordinator to that of a senior experienced trauma surgeon.
6. Establishment of a specified intensive care area dedicated to the needs of the critically injured patient.
7. Specially trained nurses and other health professionals developed to staff the unit, with continuing education for these personnel.
8. Consolidation of all related hospital resources for the injured patient in this central treatment location.
9. Establishment of a priority system in the hospital's x-ray department and blood bank, in which trauma patients are given appropriately high consideration at any time of the day or night, and providing necessary emergency laboratory services immediately available in the unit itself.
10. Development of a unit operations and clinical management assessment tool: the trauma registry.

Functions of a Full-Service Center

Patient Care. The Cook County Hospital Trauma Unit typifies the improvement in patient care that results from an organized approach to the provision of all available medical services. Over 45,000 injured individuals have been examined and treated in this facility with an extremely low mortality rate (under 2 percent). This centralized initial evaluation has greatly reduced the problems of inadequate resuscitation and missed injuries resulting from an incomplete initial evaluation, low index of suspicion, and failure to observe the patient for an adequate time.

Teaching and Manpower Development. Care of the injured patient is grounded in the basic sciences as well as in fundamental principles of clinical care. A trauma care center provides an excellent environment in which instruction in basic principles and care of the critically injured may be provided. Invaluable learning experiences are available for nurses and house staff, including daily bedside care of the injured patient and development of the technical skills required for comprehensive resuscitation.

Research. Clinical and applied basic science research, previously difficult to conduct in this area, have been greatly facilitated by the establishment of the trauma unit. The natural history of certain injuries and their need for intensive care provide the opportunity for basic and clinical investigation. Several major contributions to the improved level of patient care have been generated from this unit by a variety of researchers, and include major metabolic[21,22] and hemodynamic[23,24] changes in shock and trauma, analysis of the clinical management of many visceral injuries,[25,26] and the first trauma registry.[7-9]

ST. JOHNS HOSPITAL REGIONAL TRAUMA CENTER

St. Johns Hospital is in Springfield, a community of approximately 100,000. This hospital was designated to serve as the regional trauma center for region 3A (Fig. 1) and has traditionally served as a referral center for the surrounding area. Two large hospitals, St. Johns and Memorial, provide approximately 1,300 beds into which the 200 physicians in Sangamon County admit their patients.

The initiation of the statewide trauma program provided a framework and a catalyst for developing new programs in the Springfield area. In this area, as in others across the state, the designation of a community hospital as a trauma center necessitated a critical evaluation of the varying potentials of two or more hospitals. The internal planning for the trauma center at St. Johns Hospital required the participation of a mixed committee of administrative, nursing, and medical staffs. A trauma coordinator,[27] appointed by the Illinois Division of Emergency Medical Services and Highway Safety, provided full-time organizational and administrative support in this effort.

A general surgeon with special interest in emergency and trauma medicine was named program director for the trauma center. Twelve board-certified general surgeons serve as a trauma care panel. Appropriate call lists for trauma surgeons and subspecialists have been implemented to effect prompt and accurate multi-disciplinary care. The trauma center at St. Johns Hospital is staffed with full-time emergency physicians who assume the responsibility for declaring an injured patient a trauma patient. This initiates a call for the trauma team and activates a special protocol that includes alerting proper specialists and hospital care units and laboratory and x-ray departments. When called, the trauma surgeon reports immediately to the trauma center, where he functions as the triage physician throughout the care of the patient.

The trauma surgeon accepts the total responsibility for patient care throughout resuscitation, diagnosis, and initial management. Then, when it is apparent that his services are no longer required, he announces, in writing, his withdrawal from the case. At this time, another appropriate physician assumes full responsibility for patient care.

Two of the largest cubicles within the emergency department at St. Johns Hospital are now set up as the trauma admitting and resuscitation area. These rooms are fully equipped with necessary resuscitative and diagnostic equipment. Patients enter the trauma unit for initial diagnosis and stabilization and may then be transferred to the intensive care unit or operating room, as appropriate.

The trauma program has provoked a lively interest among the trauma panel surgeons in developing training programs for themselves and other members of the trauma team. Specialized training sessions for emergency and intensive care nursing staffs have been in continuous operation since the inception of the trauma program. Training programs for emergency medical technicians have also been developed. Regular clinical conferences on morbidity and mortality of trauma patients have provided discussions on techniques of current trauma management for trauma center physicians.

Initially there was concern that the trauma center in Springfield might prove so attractive to the public that the flow of emergency department patients between the two hospitals would be substantially altered. The volume of patients utilizing emergency services in each hospital was studied and an increase in emergency visits was observed in both hospital emergency departments. However, there is no evidence to suggest that the trauma center has had any effect in changing the pattern of routine emergency department admissions.[20] There has been a steady and significant increase in the number of critical patients from the entire region (3A, 18 counties) to the St. Johns regional trauma center.

Simultaneously with the development of the trauma center, the Southern Illinous University School of Medicine was established in Springfield. It is anticipated that the trauma center will serve as an important educational resource for medical students and residents who will further contribute to the improved care of injured patients in the region.

New Health Specialists For Trauma Patient Care[28]

In the Illinois trauma care system, experienced personnel in trauma patient care are now being developed. The development, reorientation, and integration of trauma care specialists into an active trauma care system provide the personnel with greater experience with trauma patients and better opportunity to achieve professional growth while guarding against the inevitable "skill decay" that occurs where trauma care is an underutilized and underchallenged medical specialty.

The following new trauma and emergency medical services specialists have been developed in the Illinois trauma care system: emergency medical technician-ambulance (EMT–A), advanced emergency medical technician, trauma nurse specialist, trauma-emergency medical services coordinator, emergency department physician, trauma-emergency medical services fellow, and trauma surgeon.

THE EMERGENCY MEDICAL TECHNICIAN–AMBULANCE (EMT–A)

The emergency medical technician-ambulance (EMT–A) is an allied health worker highly trained to provide expert medical care to victims of injuries and medical emergencies. The development of this new allied health specialist is necessary for a total systems approach to the problem of improving emergency medical care at the scene and during transportation. In Illinois more than 5,000 EMT-As have been trained and tested to national registry level. Ongoing EMT–A training programs have been established at every trauma center.

ADVANCED EMERGENCY MEDICAL TECHNICIAN

The advanced emergency medical technician level is achieved through advanced life-support training courses. These programs are sponsored and given at regional and areawide trauma centers, and are designed to expose the student to a complete spectrum of medical and surgical emergencies with emphasis on cardiac arrhythmia detection and control.

TRAUMA NURSE SPECIALIST

To provide better nursing care for trauma patients, the Illinois program has developed a four-week intensive course given at regional trauma centers for trauma nurse specialists. Because of this course, nurses have taken on an expanded role in the total care of the critically injured; they are now participating more in actual patient care and clinical evaluation. These nurse specialists have been instrumental in introducing other educational opportunities for nurses in their local area, where they take an active role in ongoing critical and trauma care education.

TRAUMA-EMERGENCY MEDICAL SERVICES COORDINATOR

The trauma-emergency medical services coordinator[27] position has been filled by experienced, highly skilled, and motivated allied health persons who have had vast experience with the initial management, evacuation, and follow-up care of the military wounded. These are men who have gained administrative and teaching experience while serving in the Armed Forces Medical Corps.

The trauma-EMS coordinator at each center is under the direct supervision of the staff trauma physician and provides assistance in a variety of emergency care problems. His job involves the supervision of training for ambulance personnel and the planning and operation phases of the communication and transportation components of the area emergency care delivery system. His excellent background and experience have been retooled for civilian use, and he has become a well-recognized community asset for the improved delivery of emergency trauma and medical care.

EMERGENCY DEPARTMENT PHYSICIAN

To provide postgraduate and continuation courses for physicians interested in careers in this area, three residency programs in emergency medicine have been established in Evanston, Peoria,[29] and Chicago. New patterns of staff coverage of emergency departments are evolving in Illinois and are subsequent to the areawide trauma-EMS hospital categorization. Increased demand for physician emergency department coverage is being realized as emergency department visitations continually increase across the state. The development of areawide trauma-EMS plans in downstate Illinois has provided a mechanism for physician coverage for small neighboring area hospitals collectively that individually could not support such services in the past.[14]

TRAUMA SURGEON

In the past there has been some controversy in North America as to who should be the "traumatologist." European surgical and trauma training devotes extra time to structural injuries and neurosurgical problems.[30] This concept has not developed in America, primarily because of the depth and length of the general surgical and subspecialty training programs. The ready and continuous abundance of expertly trained surgical specialists rarely requires the general surgeon to venture beyond his usual area of expertise. However, under special circumstances, and especially in rural areas, the general surgeon is many times required to extend himself, especially in the area of fractures and structural injuries, regardless of his basic training background.

The role of the trauma surgeon in a well-functioning system is that of a team captain who directs the overall management and establishes the treatment priorities in the care of the multiple injured patient. He is skilled in resuscitation, shock, ventilation, blood volume restitution, and the overall management of the critically injured. Special talents include the critical care management of the severely injured in terms of the use of fluids and blood substitutes, ventilators, physiologic monitoring devices, acid base and respiratory parameters, sepsis control, coagulopathies, and endocrine and metabolic derangements. He must have a sound knowledge in the area of surgical pathophysiology and all its manifestations that occur in the critical trauma victim.

Besides his clinical skill in surgery and intensive patient care, the trauma surgeon must be intimately familiar with and understand systems development. He is continually looked to for guidance and professional teaching in prehospital emergency care programs that require a developing comprehension of epidemiology, biostatistics, and community and rehabilitation medicine. His spectrum of interest must parallel the experiences of his patients from the scene of the accident through transport to the emergency room, operating and intensive care units, and on to rehabilitation.

TRAUMA–EMERGENCY CARE EDUCATION PROGRAMS

All education programs of the Illinois trauma-EMS program are implemented with the help of trauma-EMS and trauma-EMS nurse coordinators, and taught by appropriate professionals within the community. These programs are developing in close conjunction with selected community colleges, universities, and health education centers. This approach is consistent with the development of area health education systems (AHES) now underway in Illinois.

Communications

The second priority in the Illinois trauma system, after hospital designation, was the development of a comprehensive, uniform, practical, and workable medical emergency communications capability, which includes simple two-way radio voice, telephone patch, and dedicated phone lines. The most important aspect of a communications subsystem is that it complements the medical needs of the entire trauma-EMS system. This includes central dispatch and medical control of mobile elements of the system. A medical resources guidance system at each regional center is being developed for patient care advice, interpretation of bioelectrical data, and triage at the scene of the accident and during transportation to appropriate designated treatment facilities. Necessary communications engineering has been adapted effectively to serve emergency medical requirements as they have been identified.

The medical communications design of the Illinois trauma-EMS system is called the medical emergency radio communications of Illinois (MERCI). The Illinois MERCI system is being developed along established regional administrative and medical service patterns. The MERCI system has capitalized on existing resources, and when completed will provide a well-disciplined medical dispatch and control system for day-to-day emergency control and disaster response. MERCI regional communication control centers monitor ambulances within their entire region and physicians can be "phone patched" to ambulances for medical advice en route. The medical control unit at the regional center can maintain up-to-date inventories of hospital bed capabilities, medical staff availability, blood supplies, and other medical resources. A MERCI operations manual[31] has been published and is now available to assist users of the system.

In the 18 counties surrounding Springfield (region 3A), the telephone-radio multichannel console is located at the Springfield regional trauma center, St. Johns Hospital, where medical control is maintained. Radio base stations (hospital-to-hospital) are located at trauma centers in Decatur, Lincoln, Litchfield, Jacksonville, and Quincy, and have intercom connections to St. Johns by dedicated phone lines. These radio-telephones provide a competent dual-purpose (radio and telephone) regional communications network for everyday emergencies as well as disaster control backup. All mobile ambulance radios in a region can be in communication with a physician at a local hospital base station or at the regional communications center. Nontrauma center hospitals are integrated into this regional MERCI network with "hands free" telephone intercom systems.

In a recent airplane crash in St. Louis, Missouri (July 23, 1973), all radio communications in the disaster area were monitored at the Springfield regional communications center via the radio-telephone link at the Litchfield local trauma center. This bistate communications coverage provided St. Louis with the medical disaster backup of Springfield, the nearest regional medical center, where necessary resources could have been effectively mobilized as needed.

Transportation

PRIMARY RESPONSE SYSTEM

Solutions to the problem of providing upgraded ambulance services must be stylized to meet the specific local needs and to capitalize on the existing resources of each community. In Illinois the trauma-EMS coordinator[27] works with physicians, private ambulance operators, local governments, and municipalities to develop realistic and workable answers to what many communities have considered an insoluble health problem. By identifying existing medical resources in community hospitals, colleges, industries, and even prisons, and by assisting in federal (Department of Transportation) grant applications, the trauma-EMS coordinator has been instrumental in introducing ambulances of nationally accepted design criteria[10] to many communities, particularly in rural areas. Previously, many of these communities had no real comprehension of an acceptable ambulance service.

As the Illinois plan for development of trauma care centers is based on the premise that not every emergency room can or should provide comprehensive care for the critically ill and injured, it is also axiomatic that not every community will be able to sustain an ambulance service adequately. Other solutions to providing such care are necessary and are being explored. An overall statewide ambulance strategy has been developed to assist physicians, health planners, and interested community leaders in the solution of their local ambulance problems.[32] The main impetus of this strategy is the maximal utilization of existing resources, as described in the Vienna Project.

The Vienna Project

Vienna, Illinois (region 4), is a small rural town with a population of 3,025 located in Johnson County at the southern tip of Illinois. Johnson and neighboring Pope County ambulance services had been provided by four independent funeral directors, who had since given notice that they were discontinuing ambulance services. Vienna has a minimum security prison with 24-hour medical dispensary. A plan was worked out by the trauma-EMS coordinator stationed at the Carbondale regional trauma center to establish a 24-hour emergency ambulance service stationed at the prison in conjunction with the prison clinic to serve the bicounty area. This has provided approximately 11,500 people with around-the-clock ambulance service upgraded to national standards. The ambulance is dispatched from the regional radio center in Carbondale or from the local trauma center in nearby Harrisburg, and responds to emergencies in the immediate bicounty area.

An EMT-A training program has also been sponsored by Vienna in conjunction with the Vienna prison. The program trains and utilizes clinic personnel, prison residents, and interested community persons, and has provided a positive rehabilitation EMT-A training program for the residents at the prison and an additional source of ambulance technicians.

SECONDARY RESPONSE SYSTEM

After a critically ill or injured patient is delivered to a small community hospital or a local trauma center and is successfully resuscitated, a real dilemma exists. A necessary secondary transfer is many times extremely difficult and its success is limited by available transportation resources and personnel. Often the level of care provided is far lower than that received in the primary hospital and the patient worsens during the trip. To partially solve this problem, the Division of Emergency Medical Services and Highway Safety is developing overland critical care vans[13] which will be stationed at the regional trauma-EMS centers. These vans will be equipped to provide specialized intensive care for patients (trauma, cardiac, high-risk infant) while they are being transported to centers for more sophisticated definitive care.

Another component of the Illinois secondary transportation response system is helicopter evacuation used primarily for hospital-to-hospital transfers. Over 200 missions were flown during the past year to support local physicians with critical trauma and seriously ill medical patients. All trauma center hospitals now have heliports. Maximum effective utilization of the helicopter program has been possible by physician requests through the trauma coordinator at each center.

Over the past year, some 48 fixed wing medical evacuations were completed, mostly from southern and rural Illinois to special regional spinal cord injury and pediatric trauma centers in Chicago.[18]

Program Evaluation: The Trauma Registry

A trauma registry[6] has been developed at the trauma unit of Cook County Hospital and the Research Resources Laboratory of the University of Illinois at the Medical Center, Chicago. Utilizing the technologic advances in data processing, this unique information storage and retrieval system facilitates a detailed, multifactorial analysis of a critical national health problem. In addition to recording the clinical management of the injured patient, this registry contains data on demographic, epidemiologic, and health care delivery factors.[7-9]

Since the trauma registry first became operational in January 1971, over 25,000 patient records have been processed into a permanent data base. These records were obtained from a network of hospital-based registries established in the trauma centers of the Illinois statewide trauma system. By utilizing this regionalized network of hospital-based registries, the Illinois system is attempting to monitor its program for clinical and operations effectiveness. The registry approach is being used to study the effect of the trauma program as it is implemented regionally across the state. This registry network is utilized as a statewide program monitor as well as an individual hospital-based and hospital-oriented trauma data processing system. The trauma registry utilizes the IBM Model 155 computer located at the Research Resources Laboratory of the University of Illinois at the Chicago Medical Center. Data are processed by a commercially available software package, the Series-100 Information Retrieval Software System (IRS) marketed by the Computer Corporation of America. Statistical evaluation is performed with the UCLA Biomedical Statistics Package.

Program Evaluation

A recent highway death study[4] described the effectiveness of the trauma program in central Illinois during the first year of operation. The special emphasis of this report was the effect of the changing character of trauma patient distribution for all vehicular-related deaths within region 3A.[33] In this area there are 17 general hospitals, four of which were designated trauma centers (during the program implementation period) at Lincoln, Jacksonville, Litchfield (local trauma centers), and at St. Johns Hospital in Springfield (regional trauma center).

During the study period of this report, the central 14 counties in region 3A experienced an increase in auto accidents (27 percent), an increase in persons sustaining injury (16 percent), and a decrease in the percentage of deaths (15 percent).[33] Of particular significance was the steady decline in the percentage of deaths per person injured, from 2.8 to 2.1 percent for the study period.

This same trend has continued in the region throughout the second full year of the trauma program operation. This initial study has subsequently been expanded to include an 18-month preprogram and a two-year operational period in the same 14-county area (see Fig. 1 and Table 1). All highway-related accidents, injuries, and fatalities in this region were collected for the preprogram (control), implementation, and full operation periods from available Illinois death records, state police

TABLE 1. **Preprogram (Control) and Initial Full Implementation Year Comparison**

	Preprogram Period July—Dec. 1970 Jan.—June 1971	Full Operation Period Jan.—June 1972 July—Dec. 1972	Percentage Change
Deaths	190	170	−10
Accidents	13,459	15,061	+12
Injuries	6,952	6,843	−1.5
Death-to-injury ratio (%)	2.7	2.5	−7

TABLE 2. **Comparison of Six-Month Preprogram (Control) and Full Operation Periods**

	Preprogram Period Jan.—June 1971	Full Operation Period Jan.—June 1973	Percentage Change
Deaths	73	52	−29
Accidents	6,085	7,115	+17
Injuries	2,922	2,959	+1
Death-to-injury ratio (%)	2.5	1.8	−28

and Department of Transportation records, as well as the trauma registry.

In Figure 3 the total number of highway accidents in this area is represented by the top hatched line, the total number of vehicular injuries is shown by the bar graphs, and the ratio of deaths per injury is graphed in the solid lower line. The data have been grouped in six-month intervals to show sequential changes and to enable comparison of the selected periods. A six-month implementation period was identified because it required six months (from July to December 1971) to designate the four primary trauma receiving centers in this region.

An overall comparison of the deaths, accidents, injuries, and death-to-injury ratio (percent D/I) for preprogram and full operation periods is shown in Table 1. Note that while there was an increase in the number of accidents (+12 percent) and a slight decrease in injuries (−1.5 percent), there were decreases in deaths (−10 percent) and in the D/I ratio (−7 percent). Every comparable six-month period in this study (12 time period comparisons) showed decreases in the number of vehicular deaths and the D/I ratio, usually in spite of increased incidences of auth accidents. The one exception to this overall tendency was the comparison of July to December 1971 and July to December 1972, where no change in death rate (0 percent) occurred. During this period, the number of accidents decreased (−5 percent) as did injuries (−13 percent), and the D/I ratio increased (from 2.5 to 2.9 percent). Seasonal effects may have a significant influence on these data.

The most significant six-month period comparison so far observed is the preprogram period (January to June 1971) and a comparable full program period two years later (January to June 1973) (Table 2). This comparison, two years apart, shows significant and remarkable changes. The comparisons of the January to June periods for the years 1971 and 1973 indicate a 29 percent decrease in vehicular accident deaths with a 17 percent increase in the number of accidents and a slight decrease (1 percent) in the number of related injuries and a 28 percent decrease in the D/I ratio (from 2.5 to 1.8 percent).

It appears that significant decreases in deaths from vehicular causes have occurred in region 3A over the first two-year period of the Illinois trauma program. These and other supporting data[4] indicate that a significant impact may result from a trauma center approach due to a redirection of relatively small numbers of the most critically injured patients within a region to designated trauma center hospitals.

The effectiveness of a regional trauma-EMS system can be measured by the overall area experience of patient deaths from highway-related accidents (or other types of trauma) as described above, and by the effectiveness in the redistribution of patients to appropriate treatment centers for initial and definitive care.

Utilizing patient data entered into the trauma registry data

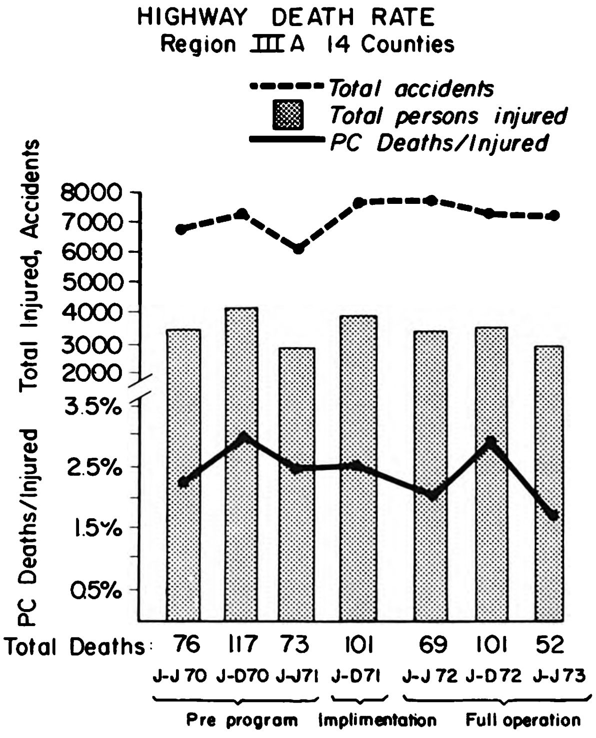

FIGURE 3: Vehicular accidents, injuries, and death/injury ratio for preprogram, implementation, and full operation periods (in six-month intervals) for the central 14 counties of region 3A (see Tables 1 and 2).

TABLE 3. Patients with Abdominal Injuries

Total admissions	1,132
Total survival	1,058
Percent survival	93.5
Median age	28.5 years
Range	1 - 88 years
Sex:	
Male	726 (64.1%)
Female	406 (35.9%)

TABLE 4. Mechanism of Injury

Vehicular	499 (44.1%)
Industrial, farm	111 (9.8%)
Home and recreational	330 (29.2%)
Violence	186 (16.4%)
Other	6 (0.5%)

Note the large number of vehicular-related injuries, followed by home and recreational injuries.

base, the following study was developed to show some functional characteristics of the system with regard to patient distribution, survival, frequencies of patient redistribution (transfer), severity of injury, surgical and intensive care demands, and other epidemiologic considerations. These parameters will establish baseline data for evaluating future trends in resource utilization and effectiveness of trauma care as future progress is made in improving transportation and communications between trauma centers, the mobile (ground and air transportation) components, and the continued training and education of trauma care personnel within a region.

Patients were selected from the trauma registry and analyzed to illustrate the behavior of major abdominal and multiple injury patients within the Illinois statewide trauma system. Cases presented represent patients treated by hospital trauma centers from all regions of Illinois (except Cook County Hospital) during the initial year of program development. Trauma patient data from Cook County Hospital were excluded from this study to avoid biasing statewide totals with the numerous cases of violent injury unique to this institution and not seen in such preponderance at other trauma centers.

Clinical data abstracted from hospital records and supplemented by direct patient interviews by trauma coordinators were coded into the trauma registry and reviewed to assure accuracy and consistency. Data were entered into the main storage bank via online video terminals located at trauma center hospitals. Retrieval and analysis of data were performed with the Datatext system.[24] From the trauma registry data base of more than 25,000 cases, a group of 1,132 patients admitted to trauma centers was selected who had received a diagnosis of a clinically identifiable injury to the abdomen. In the group studied, no initial consideration of severity of abdominal injury was made. Therefore this patient group represents a wide range of severity of clinical injury, from suspect injury requiring only observation to massive abdominal trauma with subsequent major surgical intervention. This was done to provide some description and understanding of the regional triage and patient distribution based on the magnitude of injury in each patient.

Table 3 presents epidemiologic and vital statistics for this group and includes patients sustaining a clinically identifiable injury to the abdomen who were admitted and treated at trauma centers (excluding Cook County Hospital) from mid-1971 to mid-1973. The mechanism of injury is tabulated in Table 4, which shows the predominance of vehicular trauma, with the automobile as prime causative factor. Of the total 1,132 admissions to trauma centers, 1,052 were admitted directly, 80 were transferred from other hospitals, and 19 were dead on arrival. Reasons for these 80 transfers from an initial care facility included limited staff and/or facilities (45.0 percent), special clinical problems requiring special physicians and/or equipment (41.4 percent), other miscellaneous reasons (7.5 percent), and records were not available or instructive in five cases (6.3 percent).

A larger number of direct patient admissions of this study group went to local centers, with proportionately fewer going to areawide and regional center hospitals (Table 5). This is consistent with the wider and more strategic distribution of local trauma centers in the rural areas of Illinois. Individually, these 19 local trauma centers admit smaller numbers of critical patients but collectively they are more active than the fewer and more centrally located advanced centers. A reversal in the secondary distribution of patients to regional centers is noted with a higher incidence of transfer admissions. The severity of patient injuries admitted to the advanced treatment centers is reflected in the lower survival rate in both the direct (93.3 percent) and transfer (78.4 percent) patients admitted to the regional trauma centers. The increased number

TABLE 5. Death and Distribution of Abdominal Injury Patients

	Class			
	REGIONAL	AREAWIDE	LOCAL	TOTAL
Direct admission	298	342	393	1,033
DOA	1	10	8	19
Transfer admission	51	22	7	80
Percent of total	14.6	5.9	1.7	7.1
Direct admission survival*	278	332	382	992
Percent of total	93.3	97.1	97.2	96.0
Transfer admission survival	40	19	7	66
Percent of total	78.4	86.4	100.1	82.5

*Calculation of trauma center survival rates excludes those patients who were dead on arrival. No transfer patients were admitted DOA.

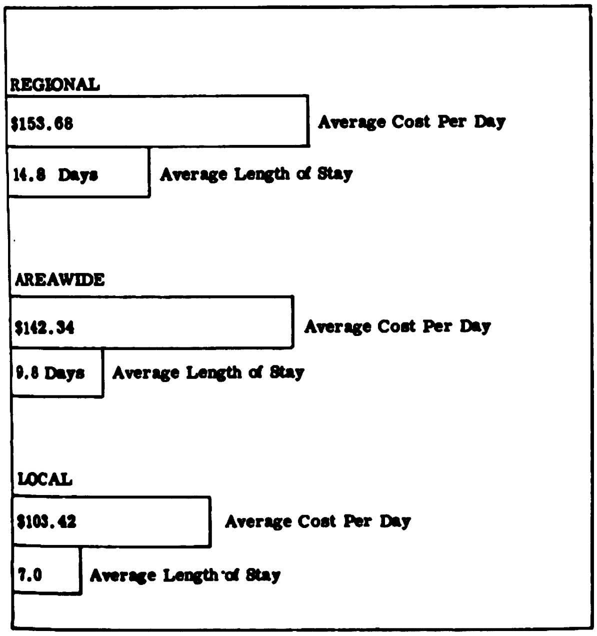

FIGURE 4: Average hospital costs and length of stay for abdominal injury patients studied (see Tables 3, 4, and 5).

of dead on arrival to local and areawide centers may reflect the less well-developed transportation capabilities in these communities during the first year of the trauma system operation. Relative primary and secondary transportation distances also appear to be significant in these findings. Distance from site of injury to an initial care facility was available for 940 cases of the 1,033 direct admissions, and averaged 7.9 miles. Of the 80 transfer patients, secondary travel distances for 77 patients reveal that the patient was retransported 28.7 miles to reach definitive care at the advanced trauma center hospital.

A breakdown of the gross anatomic involvement of abdominal and concomitant injuries also suggested that the more severely injured are being appropriately triaged to the more advanced trauma care hospitals. Greater numbers of clinically identifiable serious injuries, in addition to the abdominal trauma, were noted in the nonsurviving and transfer patient groups. Nonsurviving patients in both the direct and transfer groups experienced a greater number of associated central nervous system injuries.

In order to look at the cost effectiveness, or at least the cost accountability, of the system, the actual hospital costs (excluding physicians' fees) of this injury study group were obtained from the discharge records and compared to their length of hospital stay. The bar graph in Figure 4 shows the relationship of these two variables averaged for each trauma center level. This hospital cost/length of stay comparison shows that the more seriously injured were admitted to the regional and areawide centers where they remained longer and received more expensive critical care. This increased individual patient cost and hospital stay is consistent with a regional critical care plan for trauma. As patients are successively and successfully triaged to hospitals capable of more sophisticated and expensive care, it can be argued that more appropriate care is made available and a better utilization of these costly critical care resources is maintained. Enhanced professional (specialty) utilization and essential critical care skill maintenance is the result. The expenditure of comparable amounts of money at the local trauma centers is not feasible as the critical care manpower, resources, and proficiency do not exist at this level.

These data reflect the efforts toward an effective redistribution of the critical and potentially critical trauma patients now occurring in Illinois. Transfer patients appear to be selected by the magnitude of their clinical problems and care requirements. These data, in conjunction with the decrease in overall death rates reported for region 3A, give an initial indication that a regionally designed systems approach to trauma patient care has been successful in terms of patient survival and better utilization of specialty care capability in Illinois. These data will need to be evaluated with additional information and compared by longitudinal studies within Illinois and to other areas of the country that have not adopted this or similar trauma-EMS regionalization programs.

The main issue in a regional trauma system is to provide each patient with his most specific care needs. It is well understood that certain specialized definitive care procedures are only available at advanced medical centers. It is also accepted that all life-threatening problems (resuscitation) and basic trauma diagnostic procedures must be made available at all trauma centers. Relatively nondemanding standard general surgical procedures should be performed when indicated at all levels of hospitals within a system. However, very sophis-

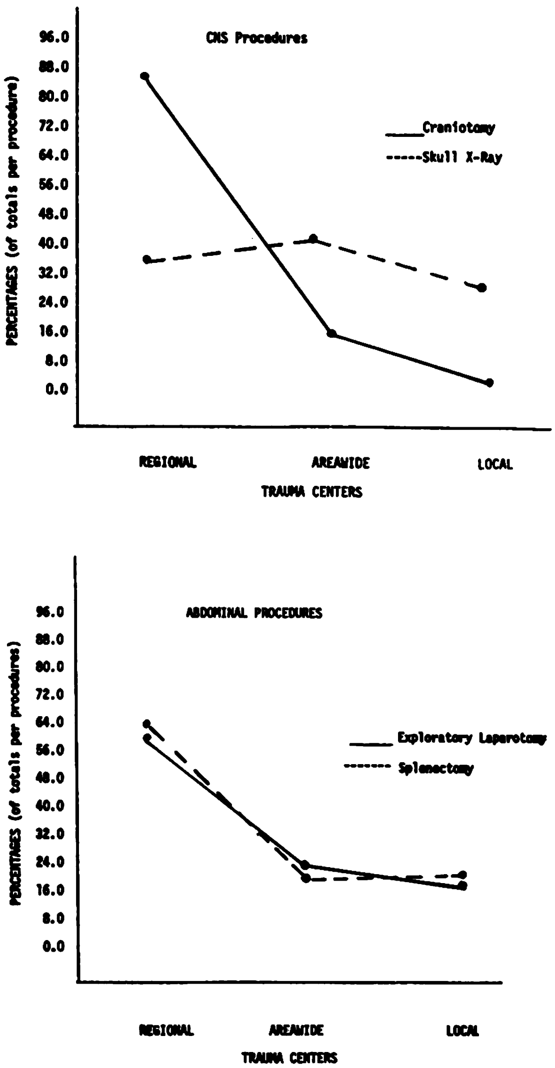

FIGURE 5: Experience with selected treatments for central nervous system (top) and abdominal injuries (bottom) as reported from different levels of trauma centers in Illinois.

ticated treatments are, by necessity, restricted to the advanced centers.

The activity level of the different levels of trauma centers in routine and specialized procedures was evaluated. A spectrum of routine diagnostic skull x-rays, specialized surgery (craniotomy), and standard abdominal laparotomy and splenectomy, as experienced in the various levels of Illinois trauma centers for the initial year, is shown in Figure 5. Note that central nervous systems injury diagnosis by skull x-ray is available and well utilized at all trauma centers, while the majority of surgical intervention (craniotomy) is performed at regional centers where neurosurgical specialists are always available. By comparison, the operative intervention for abdominal trauma is more proportional (laparotomy and splenectomy) and appears to be quite similar at each trauma center. The apparent increase in frequency of abdominal laparotomy and splenectomy at the regional centers may reflect their greater collective experience with both transfer and direct admission patients.

These data have been assembled to help describe some of the clinical aspects of a systems approach to trauma patient care. All trauma center experience and the developing trauma registry data base are now being extensively analyzed to provide critical output analysis of the epidemiology, clinical care, manpower requirements, cost effectiveness, and future systems modifications throughout Illinois.

Discussion

Better recognition of the magnitude of the trauma problem in the United States can only serve to substantiate further the need for better organization and increased efficiency in dealing with the trauma patient, both prior to arrival and in the hospital. Accidents are currently the third commonest cause of death in the United States[35] and first in the man-years lost to the nation, surpassing cancer and heart disease in their impact on our most important human resources.[36] In Illinois alone, there are more than 7,000 accidental deaths each year,[37] and in the nation as a whole over 110,000.[38] Moreover, traumatic death takes its toll on the highly productive under-40 age group, weighing heavily in terms of losses to young families and also in national productivity. A most significant aspect of this health problem is that critical autopsy studies have shown that many (from 18 percent[39] up to 50 percent[40]) of the deaths are the result of improper or delayed definitive care and were not directly attributable to the injuries sustained.

The development of the statewide trauma care system in Illinois in 1971 was directed toward decreasing unnecessary trauma deaths, and has resulted in the development of a statewide appreciation of the trauma problem. This program has utilized the existing, but then poorly organized, community and university hospitals, medical care, and professional resources. Central to this program approach was the premise that optimal care of the trauma patient can best be provided by the designation of a clearly identified hospital facility within each community, adequately staffed and equipped with essential life-support capability available on an around-the-clock basis. Haphazard transportation of trauma victims in an unplanned manner to the "nearest" hospital has resulted in too many unnecessary deaths in this country and is no longer excusable in light of past military and accumulating civilian experience. Expedient provision of care consistent with the degree of injury sustained can only be assured when trauma patients are rapidly moved to designated centers with subsequent patient transfer to appropriate definitive treatment centers whenever necessary.

From the Illinois experience it appears that the most important first step to be taken against our nation's most "neglected disease" is the designation and upgrading of strategically located, fixed medical care resources and the development of an area hospital as a trauma center. Trauma center designations bring community (professional and public) awareness and impact to this critical problem and provide impetus for immediate progress in the solution of the many complex problems of modern EMS communications, transportation, and medical technology that are essential and must be integrated into a sound, sophisticated, and effective trauma and emergency medical services systems program. Surgeons in each community have a major role in this effort as trauma appears to be an effective leading edge in the successful development of regional programs for the improved delivery of trauma, emergency medical, and many other components of total health care. Improved trauma care is dependent on the strength of intercommunity hospital linkages, and surgeons, more than any other emergency physicians, must assist in the development of regional patterns of patient distribution and care.

Because of the trauma program initiative, over the past three years Illinois has gained considerable experience in EMS planning and operations and has subsequently completed a statewide hospital categorization program for all other aspects of comprehensive emergency medical services. The development of a trauma care system in 1971[3, 4, 12] and the subsequent expansion of this program into a total emergency medical services system, [13, 14] involved initially a functional categorization of selected trauma center hospitals for a specific patient group—the critically injured—and has now been extended to include 271 acute care hospitals for all aspects of emergency medical care.

Categorization of hospital emergency capability just to comply with bureaucratic regulations or restrictive legislative mandates will not, of itself, improve the quality of emergency medical care. Categorization of hospital emergency medical care must be done in relationship to patient needs, community capability, and improved resources utilization. This concept of national scope should involve the effectiveness of utilization of emergency personnel and facilities, with appropriate attention to such elements as quality of care, cost, community acceptance, as well as the applicability of categorization to urban and rural areas.[41] The statewide categorization program in Illinois was geared toward presenting the potential benefits of this effort to emergency medical patients, physicians, nurses, allied health workers, and hospitals, and tailored to meet area needs of 40 individual EMS plans across the state.

The success of the Illinois trauma program has been due, in part, to the classification of treatment centers based on a hospital's care capability and the distribution of selected trauma patients by the seriousness of their injuries. In this system, patients are sequentially transported to more advanced centers for specialized intensive trauma care as their clinical needs are identified. This basic areawide triage of trauma patients is now beginning to show results of better care for the critically injured.[33] It is the general impression that trauma patient care is now improving in all areas in Illinois, in trauma centers, and in the prehospital (primary) and interhospital (secondary) phases during transportation. In fact, prehospital mobile intensive care is now being developed or under consideration by most major communities in Illinois, as is the continual upgrading of these basic services in the rural areas.

Summary

1. A program of regionalization of critically injured trauma patients has been ongoing in Illinois since July 1, 1973.
2. The Illinois trauma system was initiated with the functional categorization of some 47 local, areawide, and regional and three special regional hospital trauma centers strategically located across the state, and established a framework for a statewide comprehensive emergency medical services program.
3. Program concepts, subsystems components, and trauma registry clinical data have been presented to describe the dynamics of this trauma-EMS care system.
4. Trauma patient care, because of its complex requirements, provides an excellent model from which to design a basic emergency health care delivery system, and one that can be expanded to include all types of emergency medical problems.
5. Because of the obvious demanding clinical needs of critically injured trauma patients for comprehensive care and the necessity for consolidation of medical resources for these patients at all community levels, surgeons should take a leadership role in regional and areawide trauma-EMS planning and implementation in their local communities.

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FACILITIES—THE MARYLAND EXPERIENCE

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Introduction

The State of Maryland has a comprehensive Emergency Medical Services system which includes several sophisticated, specialized treatment facilities centrally located in Baltimore. A Med-Evac helicopter program developed with the Maryland State Police provides a rapid, effective system to bring the emergency critically ill and injured patients from anywhere in the state to the specialty referral centers, which offer the most appropriate care.

Maryland Institute for Emergency Medicine

The Institute [1] has come a long way since 1961 when a two-bed Clinical Shock Trauma Unit was funded by the Office of the Surgeon General, U.S. Army. Out of these modest beginnings grew a statewide network for emergency medical services with the Institute as the focal point. In 1973 an executive order gave the Institute new emphasis, a more independent structure, and a larger mission. Now serving the entire State the Institute functions as the hub of the statewide emergency medical services program and houses the communications control center (SYSCOM). In addition, it is a patient care, research and educational resource center concerned with enhancing our understanding of multiple trauma and subsequently our ability to provide care to victims of life-threatening injuries. Each year approximately 1200 critically ill or injured patients are transported via helicopter to the Institute. A majority of the patients are victims of multiple trauma and shock resulting from accidents of all kinds including highway crashes, violence, drownings, poisonings, industrial mishaps, and falls.

The Institute occupies a five-story building on the University of Maryland at Baltimore campus. A trauma admitting area, in constant readiness for the critical emergency, is equipped to manage seven simultaneous admissions. Teams of surgeons, nurses, residents and anesthesiologists are on duty at all times to provide emergency resuscitation and stabilization without delay. Immediate surgery, so often needed by the multiple trauma victim, is performed in one of the two operating rooms adjacent to the admitting area. Immediate access to surgery has become one of the most essential components of successful treatment.

Vital laboratory tests are performed in minutes in the Institute's clinical STAT laboratory which communicates results to the admitting area staff via a teleprinter system.

Once the patient is stabilized he is moved to the 12-bed critical care recovery unit where he is monitored intensively by sophisticated computerized devices. Physicians and nurses are attuned to respond quickly and decisively to the unexpected as most patients in the unit are in extremely critical condition. As the patient's status improves, he is transferred to the 14-bed intensive care unit and then to the twenty-two bed step-down area which is similar to a general hospital ward. From here the patient is transferred into the general hospital, to another hospital, nursing home, rehabilitation facility, and in some cases to his home.

New medical education and training programs are constantly being developed and disseminated statewide. The Institute's staff travel throughout the state and other states delivering multi-media educational presentations to physicians, nurses, ambulance attendants, paramedics, and others who provide emergency medical care. They also respond to requests for participation in national seminars and programs on emergency medical care, particularly those relating to multiple trauma.

The research program has contributed to the Institute's 80 percent survival rate for its critically ill and injured patients. Both the clinical and basic research programs have contributed to the development of new therapies and surgical techniques for treating multiple trauma patients and actively disseminate their findings throughout the medical community. A research and development program in biometry, communications systems and medical engineering is also pursued.

The Baltimore Regional Burn Center

The Baltimore Regional Burn Center at Baltimore City Hospital[2] has a comprehensive burn program designed to reduce mortality, provide early closure of the wound, preserve the function of limbs, minimize the scarring and avoid unnecessary disfigurement and deformity. By promoting early psychological readjustment, early social and economic gains are made at the same time as improved evaluation of long term problems, shortened hospitalization and decreased cost.

Over 100 seriously burned patients of all ages are seen annually. Geographically, 50 percent of these burn victims come from Baltimore City by ambulance, either directly or from referring institutions, 40 percent come from various Maryland counties via helicopter; and the remaining 10 percent are brought from neighboring states.

The nine-bed unit is staffed with a medical team of well trained full-time doctors and nurses including plastic surgeons, general surgeons, psychiatrist, pediatricians, anesthesiologists and internists. In addition to nursing personnel, a full-time social worker, physical therapist as well as volunteer workers from the Burn Victims Aid Society of Maryland provide daily care to the burned patient in social, rehabilitation and readjustment problems.

Treatments are aimed at reducing burn wound sepsis. Topical burn agents are applied frequently. In the unit's own operating room designed especially for burn surgery surgeons perform early surgical excision of burn esclar and early closure of burn wounds by skin grafting. The unit is organized to provide the most efficient treatment in the management of burn victims in a strict isolation environment. It is equipped with modern cardiac, pulmonary and inhalation equipment. A research laboratory is used for quantitative culture of burn wounds. A new facility has been added to this laboratory to study the epidermis migration and effect on topical burn agents.

Neonatal Program

The Maryland State Intensive Care Neonatal Program (MSICNP)[3] is cooperative program of Baltimore City Hospital, University of Maryland Hospital and Johns Hopkins Hospital. Organized in 1971 the system assists community hospitals in the recognition and management of sick newborns and provides transportation and care of ill neonates. During the first five years 1173 infants were transferred to the three hospitals participating in the program.

Baltimore City Hospital's intensive care nursery provides space for 25 infants. The University of Maryland and the Johns Hopkins Hospital have beds for 20 infants each, making a total of 65 beds. Each unit is staffed by a full-time neonatologist, assisted by one or two neonatal fellows, four house staff in training, students, highly trained nurses and social workers. Around-the-clock consultants are available in pediatric specialties necessary for total care of sick newborns. Each unit has sophisticated equipment for the care of the ill neonate including infant warmers, isolettes, ventilators and micro laboratory facilities available 24-hours a day.

The state police helicopter system has become the backbone of the neonate program. Special battery-operated incubators designed to transport babies with their own oxygen supplies are located throughout the state. U.S. Army Air Ambulances at Fort Meade provide backup for the helicopter system. Many community ambulance services also transport infants, especially when the helicopters are grounded by bad weather. The Baltimore City Department Ambulance Service is invaluable in city transfers and in transporting patients from the University of Maryland heliport to the University Hospital.

The system is activated when a referring physician decides an infant is to be transferred. Since the equipment and number of personnel at each hospital are different, referral may take place at various levels of problems. For example, some hospitals may refer all of their premature infants and others may refer only those with severe abnormalities or those requiring respiratory care.

Which hospital the baby goes to depends on the daily census of each unit. As a general rule, four out of seven infants go to Baltimore City Hospitals and three of seven to the University of Maryland. Infants scheduled for Baltimore City Hospitals requiring cardiac or other surgery have also been sent to Johns Hopkins Hospital. Joint critique of any given baby's care is handled by the director of each nursery unit and the referring physician. Records are reviewed periodically with the referring hospital's staff.

Pediatric Trauma

The Pediatric Trauma Center[4] at Johns Hopkins is the first unit designed especially for the delivery of emergency care for children in a university hospital. Children brought into this unit have the advantages of centralized diagnostic facilities and of specialty consultation in all surgical and pediatric disciplines. In addition, they are treated in an environment designed especially for them.

The emergency facilities on the first floor of the new Edwards A. Park Building are operational 24 hours a day, and include both surgical and medical components, x-ray facilities, and blood and chemistry laboratories. This unit is organized to provide primary resuscitation and initial management of extensive and multiple injuries in children. It is also staffed to provide the highest quality treatment for simpler injuries and emergency illness for children from the immediate geographical area, the East Baltimore community.

Many types of injuries are managed in the trauma center: poisonings and caustic burns from ingestion of toxic substances, electric shock and flame burns, machine injuries from wringers, bicycles and power mowers and such, sport injuries from competitive athletics, drownings, injuries resulting from major automobile accidents and battered children.

A child with multiple or major injuries is delivered by ambulance or helicopter to the trauma evaluation room. Because of the limited reserves of small children and the rapidity with which they may deteriorate, transportation of an injured child assumes increased importance. This requires special training of ambulance and helicopter personnel in resuscitation of infants and simplified techniques of treatment in transit.

The Pediatric Trauma Center is not designed to compete with other excellent emergency facilities in the Baltimore area but rather supplement available care in other community hospitals and thereby prevents expensive and often unreasonable duplication of highly specialized techniques for the management of major injuries in children.

Raymond M. Curtis Hand Center

This center[5], the only one of its kind in this part of the county, was established at the Union Memorial Hospital in 1975.

It consists of three units; the acute trauma unit, a microsurgical laboratory and an extended care facility with therapists specializing in the care of injuries of the hand and upper extremity. Comparable functioning centers are located in Durham, North Carolina (Duke Medical Center), and Louisville, Kentucky (University of Louisville affiliated Hospitals).

The acute trauma unit is staffed by specialists in Hand Surgery, Orthopedic Surgery, Plastic Surgery, Neurosurgery and Vascular Surgery, who provide very advanced treatment. Microsurgery teams re-implant amputated extremities and digits and reestablish circulation to injured extremities.

The extended care facility consists of ten beds to which patients are transferred from the general hospital following their acute treatment. This unit has its own Physical Therapy and Occupational Therapy Departments, special therapeutic facilities, and light and heavy duty workshops to retain the reimpaired hand.

Since the surgical teams of doctors, nurses and technicians do not perform the delicate procedures daily, a microsurgical laboratory is available where the techniques of repairing these minute structures can be practiced.

The Center is a major teaching unit for residents and other physicians at a post-graduate level in the sub-specialty of hand surgery. A few fellowships are available to general surgeons, orthopedic surgeons and plastic surgeons who have a great interest in this special area of surgery.

Future Directions For EMS Facilities

The future of Maryland's EMS facilities will reflect national needs. As the trauma center concept grows, university-affiliated centers will become regional resource centers for research and education, perhaps with a center in each of the HEW regions. There will also be a need for satellite trauma centers dedicated to patient care without costly teaching and research components.

As the importance of EMS services and facilities and trauma care gain greater recognition, there should be a renewed campaign for a National Institute for Trauma within the National Institute of Health. The need for such an Institute was pointed out in 1966 and deserves reemphasis now as trauma care is developing.

Once these various levels of EMS facilities are established around the country, citizens will be assured of receiving the excellent trauma care they deserve.

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MANPOWER — THE HOSPITAL TRAUMA TEAM

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As a nation, we have followed a laissez faire policy with respect to trauma in patients, distributing them randomly through the community and haphazardly through the hospital, attended by whomever happens to be assigned to hospital duty at the time, irrespective of the surgeon's exposure to trauma during his training or the extent of his subsequent experience. Traditionally, the practitioner within the community with most time to spare — sometimes the least busy because he was the least competent — would seek and be given the duty of caring for the injured. Coldly examined, this arrangement constituted a very rational and understandable approach, superficially appearing to fill the hospital's responsibility to such patients and at the same time protecting the busier members of the medical staff. All too often, trauma patients are regarded as an encumbrance, as these patients inconveniently disrupt planned elective procedures and orderly office hours. Furthermore, injuries are common at night and over weekends. Adding to the difficulty was the fact that until the introduction of new programs such as Medicaid and Medicare, no payment was readily available either to the hospital or to the physician for a substantial number of these patients. Finally, the surgeon frequently had no intensive care unit or special care facility geared to the needs of the injured, and no regular, experienced team to help with the urgent multiple problems of the severely injured which are so liable to change from hour to hour in the acute phase. In essence, there have been too few surgeons well versed in the intricate problems of trauma and no integrated team to help them.

A few institutions, mainly large city-county hospitals, which of necessity dealt with large numbers of injured patients, developed identifiable trauma services with specific policies, personnel and training programs, the needed supporting equipment and subsequent critical rather than perfunctory analyses of their results. Almost as an outgrowth of these, the concept of trauma centers has been slowly emerging, each with a research base and a group of individuals whose exclusive or at least primary interest is in trauma and its many ramifications such as hyperalimentation, ventilatory support, sepsis, energy metabolism and, more recently, the delivery of care. At the same time, large hospitals in the metropolitan areas mainly but also in towns serving rural areas, have reorganized their emergency departments to ensure efficient care for the injured. Often, these changes have been stimulated by the competition which has developed where well trained EMS personnel have begun to operate selectively.

The Current Situation

The USA has improved considerably over the past decade but the provisions made for the care of the injured remain far from ideal. Too often, a patient may still not be matched to the level of expertise and care appropriate to his injury. The most obvious advance has perhaps been made in the approach to the severely burned patient where there is now almost universal acceptance that burn centers give the patient a vastly better chance for life and maximal function than does care in the standard hospital. Communities, hospitals and physicians have not been loath to transfer the badly burned patient as this type of injury constitutes a severe and long-term drain on the resources of the institution in terms of care, time, nursing, and the prevention of the spread of sepsis within the hospital. Recognition that patients with massive injuries not due to burns merit special care in special centers has not been reflected in practice to any significant degree. With emergency medical technicians now able to begin intravenous infusions, establish patent airways, and provide ventilatory support, a new challenge has been presented. There can be no question that patients are best taken to a truly optimal facility rather than to the nearest hospital available. It is tragic that a patient may be salvaged by the EMS team only to be brought to a hospital where no trained physician is immediately available to deal with any life-threatening problem expeditiously. Man is a hardy animal and the fact that he survives when a highly inappropriate therapy is given — or, alternately, survives when appropriate therapy is denied to him — should not be permitted to cloud the issue. We presumably aim to lose no patient who can be saved and always to reduce disability to an irreducible minimum. Improved EMS services have therefore greatly magnified the challenge. It is no longer enough for the physician to be ***reasonably*** knowledgeable or *moderately* organized or ***relatively*** available. Too often, the critical decisions in trauma, unlike pneumonia or appendicitis, are made in the first 30 minutes. What the patient needs to be assured of is that when he gets to the hospital he will be met — and met immediately— by a team with many interlocking skills geared to his surgical needs. If this premise is correct, laws protecting EMT's from malpractice suits for bypassing hospitals nearer to the site of the accident as the patient is transported to the most appropriate hospital need to be strengthened.

Manpower and facilities cannot be divorced. Both are quantifiable. In an era of quality assessment programs, public accountability and increased sensitivity to professional responsibility, it is imperative that each institution, its board of trustees and its medical staff review the capacity of the hospital to care for the injured. Too often, the availability of expensive modern equipment and attractive physical facilities have been used as the main indices of acceptability. Too often, the lack of immediate availability of trained personnel able to make appropriate judgements and to use the sophisticated equipment intelligently has been ignored or given cursory attention. Furthermore, while the initial resuscitative and surgical treatment of the injured is often of vital importance, the need for supporting facilities and personnel such as an intensive care unit, respiratory therapists, blood bank, and angiographers in the precarious postoperative period is often overlooked.

Optimal conditions for the care of patients with special diseases have been set out in a number of areas such as the cardiovascular and cancer fields. Following this lead, the Committee on Trauma of the American College of Surgeons has recently evolved and recommend a plan of categorization which would be applicable to all institutions caring for the injured patient. Each would be given a specific designation which would reflect the hospital's capabilities as measured objectively by the range and availability of personnel (medical, nursing, paramedical), the organization of the hospital staff, the provision of specific beds and supporting services designed to meet the needs of the injured patient, the sophistication of the equipment available, educational and research programs, and the establishment of agreements with other institutions for special patients. Following the guidelines, each hospital can determine how it may fit into a categorization process. The hospital staff would have the opportunity to make its own determination of the level at which it wishes to operate or whether indeed it wishes not to enter the field of trauma. Following the objective requirements recommended in the report of the committee, the institution could review its facilities and personnel and determine the investment of money, educational effort and staff it is prepared to devote to this field. On this basis, an objective measurable inspection process of both facilities and personnel could be made by a disinterested body which could make recommendations on their assessment of the quality of the services provided. Such a review could and should be open, honest, and apolitical, with final judgment based on the quality of the trauma manpower team as much as on the hardware available. Any institution found to encourage the channeling of patients with major trauma to its Emergency Department because of perceived economic benefit to the hospital and staff but where the pool of talent needed in a trauma team is not available could be strongly discouraged and in fact disbarred by local councils. It would seem preferable to have the trauma segment of any inefficient institution out of business rather than to have the patients brought there. Such a move would no doubt raise a wide range of passions among physicians, administrators, and boards of trustees. Nevertheless, if we as surgeons are to have the interests of the injured patient at heart, it is essential that such peer review be instituted without delay and that the results be made publicly available.

Future Needs

We have need for a cadre of surgeons who are prepared to devote the major portion of their academic and professional lives to the study and practice of trauma. To achieve this, the academic surgeon concentrating on trauma must be recognized as doing work as potentially important as that done by the cardiac or transplantation surgeon. Indeed, measuring the total contribution to human health, surgeons who deal with trauma contribute measurably more by virtue of the volume and nature of the patient load. Professionally, the academic surgeon must be assured adequate earning capacity and appropriate status within the hospital and the university faculty. He should be backed by a team of surgical assistants and associates, nurses and technical personnel, who are trained in the field of trauma.

Institutions where this type of individual may develop should be defined. The Board of Managers of the American Association for the Surgery of Trauma has recently circulated to its membership a request for information from individuals who have the facilities and the faculty to provide this type of educational experience for young surgeons who may be interested in making a career of caring for the trauma patient. While specialists or super-specialists are needed for the Trauma Centers and busier hospitals, most trauma will continue to be treated by surgeons outside specialized centers. Consequently, all surgeons should have adequate practical exposure to trauma during their period of training, and the American Board of Surgery should be more specific in their demands in this respect. Residents receive inadequate practical experience in the management of trauma where their hospital receives few injured patients. A system where residents may be exchanged for short periods between programs, sharing the stronger features of each, should be encouraged.

No surgeon is an island. The complex composition of a well functioning trauma team should be recognized and established. Such a team is composed of (1) surgeons from all specialties of whom one is recognized as the captain of the team, integrating the care of the patient and serving as a liaison between the multiple specialties involved; (2) anesthesia personnel skilled in intubation, resuscitation and ventilation, who are essential; (3) nursing personnel permanently attached to the trauma team both, in the emergency department and in the hospital, who are skilled in moving the injured patient with a minimum of risk, maintaining the equipment of the unit and dealing with the often distraught families of the injured; (4) radiologists with a special skill in angiography, the use of isotopes and, today, the use of computerized tomography, especially for head injuries.

In addition, an observation ward and intensive care unit should be present where considerable numbers of injured patients are received and should be adequately staffed at all times.

Recommendations

1. Categorization of trauma units and hospitals who accept injured patients should be carried out without fear or favor and should follow the lines suggested by the Committee on Trauma of the American College of Surgeons or any similar agreed-upon system. This implies regionalization of the severely injured. While the social, economic, and political ramifications of such a policy inevitably invite uncomfortable visions of direction from without, patients with major injuries are best served by care in centers appropriately staffed and equipped. Institutional egos may be dented in the process but unless optimal patient care is ensured by an institutional commitment to the funds necessary to provide the appropriate environment, there would seem to be no honest alternative.

2. Periodic inspection of the entire team and hospital, and continuing auditing of the level of performance should be made. The hospital should have a defined trauma service staffed by a trauma team rather than a disorganized group of health care mercenaries. The major institutions should have a planned educational program at all levels so that the injured patient is not at the mercy of the unskilled.

3. There should be demonstrated availability of a team at all times and analyses of results should be conducted on a regional basis. Organizations such as the Committee on Professional and Hospital Activities, which has been sponsored by the American College of Surgeons, the American Hospital Association and others, might well be the mechanism through which we measure results, so that we establish a series of minimal acceptable standards, matched to the claims of expertise offered by the individual institutions.

4. Establishment of institutions with special potentials for training individuals in the field of trauma is overdue. Computer-based or similarly planned systems for the interchange of residents, transcending institutional barriers and producing cross-fertilization and the strength of hybridization would be most helpful in disseminating knowledge.

5. Recognition by the various Boards of Surgery of the essential need for practical exposure during residency training should be encouraged. Setting theoretical questions is not enough. Decision making about the injured patient under conditions of tension is an essential part of the psychomotor development of a surgeon.

6. There should be continuing study of cost factors. Such a study should consider the number of dollars involved in the care of the patient and correlate the end results measured in terms of disability, so that we may determine whether a new system does indeed produce superior results. The time for relying on unproven assumptions set forth in seductive paper programs has passed. Ultimately, we depend on human skills, experience and commitment more than any single factor, and the concept that further expenditures on elaborate systems or equipment warrants dispassionate challenge in a society which does not have unlimited means.

RESEARCH IN TRAUMA MANAGEMENT

Jonathan E. Rhoads, M.D.

Trauma, like cancer, is a very broad group of pathologic conditions. It can affect almost any site or combination of sites and it occurs in a variety of forms, from the stab wound to the high velocity bullet, to the thermal burn, etc. It follows, therefore, that research in trauma can be extremely varied. Some of the most interesting research in recent decades has undoubtedly been in the field of shock. Beginning with the studies of Blalock and Harkins on the shift of body fluids in burn shock,[1,2] the tremendous importance of the body fluids has been emphasized and reemphasized. Physiologic saline solution was at first strongly lauded; later its use was decried in many forms of shock, and still later more precise studies showed how effective it could be if enough is given, both in burn shock and in hemorrhagic shock. Balanced saline was even better, and in rats McCarthy and Draheim showed that mildly hypertonic solutions were superior.[3]

The role of malnutrition in susceptibility to hypovolemic shock is almost axiomatic; nevertheless, its demonstration in controlled animal experiments drove home the point that persons previously malnourished are particularly sensitive to blood loss and presumably many other forms of trauma.[4]

The evaluation of blood substitutes, plasma substitutes, plasma extenders, etc. has occupied much of this century. The original experiments with gelatin were early in World War I (1915.) Acacia solutions had a vogue in the 1920s and 1930s; human blood products, human serum albumin and other fractions, were developed especially by the work of Cohn early in World War II.

During the war years (late 1930s and early 1940s) several countries developed separate plasma volume extenders. The Germans developed polyvinylpyrrolidone and the Swedish scientists, dextran. Bone gelatin was further perfected, and much experimental work was done with other preparations, such as human globin made from hemoglobin, bovine albumin and a variety of polymerized chemical compounds such as polyglucose. More precise comparisons of the various electrolyte solutions with plasma were made through the 1940s and 1950s in animal shock models.

In recent times, research has been directed to oxygen-carrying chemicals, chiefly highly fluorinated compounds, and some of these have been found useful, if not superior, to blood in organ perfusion experiments in the laboratory. They have been demonstrated to be tolerated in some species of animals but so far as this reviewer is aware, none have been found suitable in man thus far. Current work by Sloviter and others involves efforts to disperse the materials and to coat the particles with lipid membranes.[5]

It is probable that much further work will be done in the field of plasma substitutes and blood substitutes, as we still do not have an ideal substitute for plasma, nor do we have a viable synthetic substitute for the oxygen-carrying function of hemoglobin.

Another line of endeavor which has been of great interest has been the study of the affinity of human blood for oxygen. If this is too low, the blood does not pick up oxygen as readily as it should in the lungs, or in the case of the fetus, in the placenta; if the affinity is too high, it does not release oxygen appropriately in the tissues. In certain cases of septic shock, it has been observed that cardiac output is increased and the oxygen difference between arterial and venous blood has been decreased. In 1967, Benesch and Benesch and Chanutin and Curnish demonstrated that the oxygen dissociation curve in blood was affected by the concentration of 2,3-Diphosphoglycerate in the red cells.[6-8] Subsequently Dr. Leonard Miller, Dr. Harvey Sugerman and their pediatric associates Dr. Frank Oski and Dr. Maria Delivoria-Papadopoulos made a number of related clinical observations. They observed that the 2,3-DPG level was reduced in certain cases of septic shock, with a significant shift in the oxygen dissociation curve, making it difficult for the tissues to take and use the oxygen in the blood which was circulating through them.[9] This mechanism was frequently present in respiratory distress syndrome in premature infants and it was found that fetal hemoglobin had lower 2,3-DPG values than adult hemoglobin, possibly to facilitate the fetal blood picking up oxygen in the placenta. A number of babies with this serious difficulty have been saved by exsanguination transfusion techniques, using adult blood.

Carrying the shock problem back to still more basic levels, attempts have been made to study the effects of shock at the intracellular level. Dr. Leena Mela studied the mitrochondrial respiratory chain for some of the reactions going on in the rat liver cell after the animals had endured a period of shock before sacrifice and has done much to define the conditions which dissociate electron transfer from energy transfer. She has been able to clearly differentiate alterations in mitrochondrial function in shock from that due to pure hypoxia.[10] Dr. Raleigh White, IV was able to show corresponding morphologic differences with the electron microscope.[11]

With a wholly different research approach, a number of shock and trauma units have made clinical application of the best methods of diagnosis, prognosis, and treatment now available. They have advanced our understanding of priorities in trauma, they have accumulated the carefully analyzed clinical experience which makes possible rational decisions regarding on-site first-aid, transportation, resuscitation, the best priorities to observe in the treatment of multiple injuries and have developed a truly multidisciplinary approach to the badly injured patient. Notable among these units is the one headed by Dr. R Adams Cowley at the University of Maryland in Baltimore. It is probably the best model of an emergency care system for the victims of highway accidents and many other forms of trauma.

While we think of trauma in its acute phase, when it may threaten life through asphyxia, hemorrhage and shock, there are also the problems of setting fractures and maintaining the fragments in satisfactory position. In addition, there are problems with delayed union and non-union. Here, the recent research endeavors have included the use of low voltage electrical currents across fractured ends. The pressure between the ends of the bone has also been regulated and studied with the relation to fracture healing. The findings in animal experiments seem to indicate that some pressure between the ends of the fragments promotes healing, but that too much delays it.[12,13] Since it is such a broad field, each person who reviews this field would select different topics for emphasis, but perhaps the few samples I have cited are sufficient to remind us that shock and trauma are more than ever a rich field of exploration and that much progress is being made.

Other highly fruitful avenues of trauma research include studies of wound healing such as those of Dunphy and Hunt and their associates, studies of hemorrhagic phenomena after multiple transfusions[14]—a subject on which I do not believe the last word has been spoken; DIT –disseminated intravascular thrombosis, so extensively studied at WRAIR, the shock-lung syndrome, including the occurrence of pneumothorax with

Positive End Expiratory Pressure; the occurrence of renal tubular necrosis, its prevention and its therapy, including the use of the renal failure solutions employed intravenously by Dudrick and his associates in Houston, aimed at recycling urea without overloading the circulation.[15,16] The role of hormones such as cortisone—used successfully by Lillehei et. al. in Minneapolis—in cases of septic shock needs further definition.[17]

It must be remembered that about half of the trauma deaths are due to intracranial injury. I recently was called about an 8 year old girl who fell off a bicycle and hit her head. She was hospitalized and watched for signs of increased intracranial pressure. When they appeared, her head was opened but by that time it was already too late; there was irreversible brain damage. It is the belief of Dr. Thomas W. Langfitt, who saw her in consultation, that some such cases can only by recognized in time to save them if the intracranial pressure is measured continuously.[18] His animal studies indicate that brain swelling from edema or cerebrovascular congestion can increase intracranial pressure sufficiently to produce cerebral ischemia and more brain swelling. This vicious cycle can result in irreversible brain damage before decompression is achieved unless it is detected before the development of the usual clinical signs. Does this mean that every child who falls off a bicycle and is transiently unconscious must be trephined, or how should the indications by defined?

These and many other problems both in massive trauma and in regional or focal trauma cry out to be studied. Meanwhile as Dr. Thomas Morse and many others point out, federal support for research in trauma—our fourth cause of death and probably our greatest cause of disability— receives less than one percent of the support accorded cancer. It was in part to correct this discrepancy by increasing public awareness of this need, that the American Trauma Society was formed eight years ago.

We need to stimulate good young people to devote themselves to research in this field. We are told that even the limited funds available through the National Institute of General Medical Sciences have not been fully utilized because the grant applications received have not fared well in the peer review process.

I would urge you, therefore, to convert your research ideas into grant requests and to involve a number of our ablest young people in the all important business of increasing our knowledge in prevention of trauma, the early identification of internal injury, in quick and skillful transportation, trauma center management, and in the rehabilitation of the victims of trauma.

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SECTION II
Trauma Management Basic Considerations

INTRODUCTION

John M. Howard, M.D.

A bullet traverses the thigh and a wound has been created — but it isn't just the thigh which has been injured — the entire body has been injured. It isn't just the thigh which responds — the entire body responds — it isn't just the thigh which may live or die — the entire patient may live or die.

The injury consists of at least three separate injuries: dead tissue, reduced blood flow, infection, and perhaps, starvation.

We have now made tremendous progress in stopping the bleeding and replacing the blood loss—and the patient survives—but his continuing defensive responses—physiological responses—may become injurious responses—fatal, pathological responses.

The elucidation of the adrenal responses to injury over the past several decades produced the most significant advances in our lifetime of our understanding of the physiological responses to injury. These responses, especially those of the adrenal medulla, when considered in conjunction with other influences on vascular tone (renin, angiotensin, serotonin, bradykinin, etc.,) may now contribute to fatal syndromes in the post-resuscitation phase. Perhaps our greatest advances in the coming years might be in preventing increased cerebral edema, acute renal failure, stress bleeding in the gastrointestinal tract, paralytic ileus, and pulmonary shunting by pharmacological blockage of these responses; thereby improving the delivery of oxygen and nutrients to these "post resuscitation target cells."

Consider the following: Are the regulations of the U.S. Food and Drug Commission, as they apply to the use of pharmacological blocking agents in the resuscitative and post resuscitative phases, unduly retarding advances in clinical development?

Another question: Isn't the technology currently available to permit a timely approach to the synthesis and manufacture of human serum albumin?

SHOCK AND RESUSCITATION FOLLOWING TRAUMA

Robert F. Wilson, M.D.

I. Etiology

Shock following trauma is usually due to blood loss; however, severe hypovolemia may also be caused by fluid loss from burns or into contused tissue or paralyzed bowel. Hypoxia in the face of a reduced cardiac output can further impair peripheral cell metabolism, causing release of lysosomal enzymes and vasoactive substances which can greatly complicate the problem, particularly by interfering with the microcirculation. Direct trauma to the heart can cause myocardial contusion (resulting on occasion in impaired function, muscle death or arrhythmias) or, in rare instances, pericardial tamponade (due to bleeding into the pericardial cavity).

II. Diagnosis

The early diagnosis of shock is extremely important. The quicker aggressive treatment is begun, the more likely the patient is to survive. Unfortunately, the most frequent criteria used to diagnose shock clinically, such as a systolic B.P. less than 80 or 90 mm Hg, severe oliguria, metabolic acidosis, and evidence of poor tissue perfusion (cold, clammy skin and clouded sensorium) often occur relatively late, when the chances for a successful outcome are greatly reduced.

A. BLOOD PRESSURE

The arterial blood pressure may be considered to consist of three parts: the *diastolic pressure* which correlates with the amount of arterial vasoconstriction present; the *pulse pressure* (the difference between the systolic and diastolic pressures) which is primarily related to the stroke volume and to the rigidity of the aorta and its larger branches; and the *systolic pressure* which is determined by a combination of all these factors.

Of the three pressures mentioned above, the pulse pressure is the most important because it provides some indication as to whether blood flow is increasing or decreasing.

1. Changes with Hemorrhage

In previously normal adults, the systolic pressure is often maintained relatively well until a blood volume deficit of at least 15 to 25 percent has occurred; however, the pulse pressure will often fall with only a 5 to 15 percent deficit. If a patient who is hypotensive due to hypovolemia is given just enough fluid to restore his systolic B.P. to normal, he probably still has a blood volume deficit of at least 1000 to 1500 ml.

2. Unobtainable Cuff Blood Pressure

In patients with severe vasoconstriction and/or a greatly reduced stroke volume, the vibrations produced as blood begins to flow past the artery compressed by the blood pressure cuff may be too weak to produce audible Korotkoff's sounds. Thus, there may be a tremendous discrepancy between the intra-arterial blood pressure and the pressure obtained by the cuff technique. If there is any difficulty obtaining a consistent and clear cuff blood pressure and the patient's condition is not improving rapidly with therapy, an intra-arterial catheter should be inserted.

B. URINE OUTPUT

The timed urine output (without diuretics) is an extremely important measurement, particularly in hypovolemic patients, as there is often a reasonable correlation between renal blood flow and blood volume and cardiac output. The urine output may fall substantially long before there is any other evidence of impaired tissue perfusion.

C. ACID–BASE CHANGES

1. Respiratory Alkalosis

Patients with trauma, shock, or sepsis tend to have tachypnea and hyperventilate with minute volumes that are more than 1½ to 2 times normal. This is a nonspecific response. If, however, the effects of the trauma, shock or sepsis are not corrected, the resultant metabolic acidosis and/or hypoxia will cause the patient to hyperventilate even more.

2. Metabolic Acidosis

As shock progresses, increasing anaerobic cellular metabolism results in lactate accumulation and the development of metabolic acidosis. By the time a significant metabolic acidosis is present in arterial blood, the shock process is generally quite advanced.

D. TISSUE PERFUSION

1. Skin Changes

If the skin is cold and clammy, the patient usually has a low cardiac output and a high total peripheral vascular resistance.

2. Mentation

A cloudy sensorium or increasing lethargy or restlessness may be early signs of poor tissue perfusion or sepsis. On the other hand, an alert, oriented, interested individual probably has good cerebral perfusion, regardless of what other measurements may indicate.

3. Arteriovenous Oxygen Differences

If venous blood from a central venous pressure (C.V.P.) line or the pulmonary artery becomes less saturated (*i.e.*, has less oxygen), tissue blood flow and cardiac output are falling. On the other hand, if the oxygen saturation in the venous blood increases, the cardiac output is probably rising.

III. Treatment

A. CONTROL OF THE PRIMARY PROCESS

A constant consideration in the treatment of any critically ill or injured patient is early diagnosis and control of the primary process. In the patient with trauma, particular efforts must be made to discover sites of continuing severe blood loss which can be controlled surgically. Pericardial tamponade, hemopneumothorax, airway obstruction, and peripheral ischemia due to vessel damage must also be corrected promptly.

B. SPECIFIC THERAPY

1. Ventilation and Oxygen

In any critically ill or injured patient, the most important initial consideration is maintenance of an adequate ventilation which in these individuals should generally be at least 1½ to 2 times normal or about 12 to 16 liters per minute. If an injured patient is not hyperventilating, one must suspect that he has a significant problem involving his central nervous system, airway, chest well, diaphragm or lungs, and vigorous efforts should be made to diagnose and correct the abnormality promptly.

We have become progressively more aggressive in inserting endotracheal tubes and providing early ventilatory assistance. However, it is extremely difficult to do this, particularly in the awake patient, unless one has the skill to adequately anesthetize the nose and insert a nasotracheal tube atraumatically.

a) *Oxygen*

Even if ventilation is adequate, virtually all patients with severe trauma or shock will benefit from the administration of oxygen. These patients should be given enough oxygen to maintain an arterial PO_2 of at least 80 to 100 mm Hg. If there is any indication of myocardial ischemia, we prefer to give 100 percent O_2, at least until the tissue perfusion has been restored.

2. Fluids

By far the most effective treatment that we have found for all types of shock, particularly following trauma or surgery, is the early and aggressive administration of fluids. In the injured patient with shock, volume replacement is begun rapidly with 2 to 3 liters of a balanced electrolyte solution through 2 or preferably 3 large I.V. catheters. After the first 2 to 3 liters of crystalloids, at least ¼ to ½ of the additional fluid given is colloid such as plasma or albumin. Blood is used rather liberally in an attempt to keep the hemoglobin at 12.5 to 14.0 gm%.

If the blood pressure in a recently injured patient does not return to normal following the rapid administration of 2 to 3 liters of a balanced electrolyte solution in 20 to 30 minutes, the patient is losing blood and/or fluid quickly, and the possible need for emergency surgical control of bleeding sites should be considered.

If the patient requires multiple transfusions, fresh frozen plasma may improve the colloid osmotic pressure and help restore many of the clotting factors (except platelets) that are deficient in old bank blood. Warming of the blood as it is given reduces the incidence of cardiac arrhythmias caused by rapid administration of cold, acidotic and hyperkalemic blood. The new blood filters help decrease the incidence and severity of acute respiratory failure secondary to embolization to the pulmonary capillaries of aggregates that form in the stored blood. Such filters should be changed after every 4 units of blood, particularly if the blood is more than 10 to 14 days old.

The amount of fluid to be given to individual patients is determined by multiple factors, including the response of the blood pressure, pulse rate, urinary output, and skin profusion, and the number and location of any rales that persist or increase in spite of efforts to prevent or correct atelectasis. If the patient is in severe shock or does not respond promptly to his initial fluid therapy, the C.V.P. response to further fluid administration should be checked carefully.

The C.V.P. *level* in critically-ill and injured patients is extremely variable and frequently correlates very poorly with the patient's fluid needs; the *response* of the C.V.P. to a fluid challenge is much more meaningful. If the C.V.P. rises minimally the blood pressure, and if urine output improves, further fluid should be given until adequate tissue perfusion is obtained. However, if or when the C.V.P. begins to rise abruptly, with little or no improvement in vital signs, the rate of fluid administration should be greatly decreased or the fluids stopped until the C.V.P. falls back to base-line levels.

In most instances, changes in the C.V.P., which reflect filling pressures in the right heart, correlate fairly well with changes in the pulmonary wedge pressure (P.W.P.), which reflects left ventricular filling pressure. Following an acute myocardial infarction, however, the patient may have an isolated acute left ventricular failure and a high P.W.P. in spite of a low C.V.P. On the other hand, patients with severe sepsis or respiratory failure who are hypovolemic and have a low P.W.P. not infrequently have a high C.V.P. because of a pulmonary vascular abnormality at the capillary or venular level.

3. Acid-Base Therapy

Most acid-base problems in shock will improve spontaneously if adequate ventilation and tissue perfusion are provided. Severe respiratory alkalosis is best corrected by reducing pain and anxiety and by adding dead space if the patient is on a respiratory. Occasionally, analgesics or sedation in multiple small I.V. doses may be used, but only after the hypovolemia has been corrected.

The best method for correcting the metabolic acidosis of shock is to improve tissue perfusion. However, if a severe metabolic acidosis persists in spite of fluid-loading, particularly if the pH is less than 7.20, sodium bicarbonate should be given.

4. Inotropic Agents

a) *Digoxin*

In our opinion, all patients who remain in shock despite adequate fluid administration have some element of heart failure and should be given digoxin. The amount of digoxin needed in patients with trauma or shock is extremely variable and is often much lower than normal. Consequently, this drug should be administered in multiple, small I.V. does with E.K.G. strips taken before each dose.

b) *Dopamine*

Dopamine has become our favorite agent for raising blood pressure in patients who remain hypotensive in spite of fluid loading. In small doses, less than 2 to 4 mcg/kg/min., it may increase renal and splanchnic blood without any apparent change in cardiac output or blood pressure. In slightly larger doses, it will usually significantly increase the blood pressure with little or no change in the systemic vascular resistance, C.V.P. or P.W.P. Its main effect appears to be an increase in left ventricular contractility. If the amount of dopamine infused is increased to more than 20 to 30 mcg/kg/min. its vasoconstrictor properties may become more dominant and, in occasional patients, the cardiac output may begin to fall because of a progressive increase in systemic vascular resistance. Dopamine appears to be a relatively safe drug; however, if it is administered too rapidly, troublesome tachyarrhythmias occasionally will develop.

c) *Calcium*

During shock, the mobilization of calcium is impaired and ionized calcium levels in the serum may fall, particularly following massive transfusions, to the point of impairing cardiovascular function. Consequently, a gram of calcium chloride is given after every 2 to 4 units of blood. In patients with persistent hypotension and poor tissue perfusion, even more calcium may be required.

d) *Isoproterenol*

In the relatively infrequent shock patient who has a pulse rate less than 100/min isoproterenol in doses of 1 to 2 micrograms per minute may be quite helpful. In this low dosage range, a significant positive inotropic effect can usually be obtained with only mild-moderate increases in pulse rate.

5. Steroids

a) *Small (Physiologic) Doses*

Because of the possibility that subclinical adrenal insufficiency may be present, all patients with shock that is unresponsive to the aforementioned standard therapy should be given at least 200 mg of hydrocortisone by rapid I.V. injection. Continued therapy will depend on the response.

b) *Massive (Pharmacologic) Doses*

Although there is general agreement that physiologic doses of steroids are beneficial and indeed necessary, in patients with adrenal insufficiency, the use of massive doses of steroids in patients with shock and normal adrenal function is extremely controversial. Massive steroids appear to be valuable in experimental shock by stabilizing capillary, cellular and lysosomal membranes, by causing some vasodilation and secondarily increasing cardiac output and by improving cellular metabolism and oxygen transfer at the tissue level. Several clinical investigators have described patients who improved dramatically after 30 mg of methylprednisolone succinate or 6 mg of dexamethasone phosphate per kilogram body weight. There is question that the earlier massive steroids are given, the better the response. However, we will generally only use these agents when it appears that the patient is not improving adequately with standard therapy.

6. Vasopressors

In general, vasopressors should be considered potentially lethal drugs which should be given as a temporary measure when there appears to be no other rapidly effective method for restoring an adequate coronary or cerebraw blood flow. In older patients with significant (70 to 80 percent) coronary or cerebral arterial stenosis, blood flow to the heart or brain may require normal or higher pressures, and vasopressors may be indicated temporarily to correct hypotension in such individuals while other more definitive treatment is being instituted.

Our current favorite vasopressor solution, if none of the previously mentioned therapy (including dopamine) has been effective, consists of four ampules of levarterenol bitartrate (Levophed) and two ampules of phentolamine (Regitine) in 500 ml of 5 percent glucose-in-water. Regitine in this dosage may prevent excessive vasoconstriction but it does not significantly alter the blood pressure or cardiac output. Furthermore, if the Levophed should extravasate into tissue around the vein, the Regitine may prevent the extensive local necrosis which might otherwise be caused by the excessive vasoconstrictor effect of the norepinephrine. In instances when the patient appears to have excessive vasoconstriction, the concentration of Regitine may be increased to two ampules for each ampule of Levophed.

7. Vasodilators

If the patients shows evidence of excessive vasoconstriction and poor tissue perfusion in spite of all the above therapy vasodilators may occasionally be bery helpful. However, these drugs should not be used in patients who are hypovolemic, because vasodilators may increase vascular capacity by up to 2 to 3 liters, making the patients even more hypovolemic. In addition, even if the blood volume is adequate, vasodilators will often cause the blood pressure th fall by at least 5 to 10 mm Hg. If the patient is already hypotensive and has significant vascular disease, such as a drop in blood pressure may seriously jeopardize coronary and cerebral blood flow.

Of the various vasodilators available, we prefer chlorpromazine (Thorazine) in multiple small I.V. doses beginning with 1 to 2 mg every 3 to 5 minutes and increasing the dose until an adequate improvement in skin perfusion and urine output is noted. Recently nitroprusside has become increasingly popular as a vasodilator, particularly in patients with acute myocardial infarction shock. After the P.W.P. has been raised to 15 to 20 mm Hg, this agent in doses of 0.5 to 2.0 mcg/k/min can significantly reduce the C.V.P., P.W.P., and systemic vascular resistance while raising cardiac output and improving tissue perfusion. In the vasoconstricted patient, massive doses of steroids may also produce significant vasodilation and improvement in cardiac output.

8. Diuretics

Patients with shock, sepsis or severe trauma who develop oliguric renal failure have an extremely poor prognosis. If the urine output is less than 40 to 50 ml/hour in spite of adequate fluids and an adequate blood pressure, 5 to 10 mg of furosemide (Lasix) is given I.V. The dose of furosemide is then doubled every 15 minutes until the urine flow is at least 50 to 100 ml per hour or until the dose of furosemide exceeds 500 mg.

If more than 20 mg of furosemide is given without adequate results and the patient does not appear to be overloaded or in congestive heart failure, an I.V. infusion of 12.5 to 25.0 grams of mannitol is given along with the progressive furosemide therapy. If oliguria persists in spite of all this treatment, we will add 100 mg of ethacrynic acid I.V. If this also fails, we assume that the patient is in renal failure and treat him accordingly.

9. Antibiotics

Patients with prolonged shock have decreased resistance to infection. Consequently, at the earliest indication of contamination or overt infection, antibiotics are begun after first obtaining appropriate smears and cultures.

10. Heparin

Varying amounts of intravascular coagulation are often present in patients with severe persistent shock. Even under the best of circumstances, however, it may be extremely difficult to differentiate between clotting abnormalities due to dilution by large quantities of old bank blood and those due to intravascular coagulation. Furthermore, excessive bleeding which is thought to be due to a coagulation abnormality is often due to inadequate technical control of injured vessels.

In the very rare instances in which severe disseminated intravascular coagulation (D.I.C.) is unequivocally present, all open vessels have been controlled, and there is no injury to the brain or eyes, the cautious use of heparin by constant I.V. infusion may be considered.

IV. Reversible Causes of So-Called Irreversible Shock

Not infrequently, shock following trauma may be so severe or so unresponsive to standard therapy that the process appears to be irreversible. Under such circumstances, it is wise to reevaluate the patient to be certain that some reversible causes of the persistent shock have not been overlooked.

Some of the more frequent treatable causes of persistent shock include:

1. Inadequate fluids due to:
   - a) failure to appreciate the amount of fluid or blood loss
   - b) an incorrect impression that the patient is overloaded because
     - i. he either has already been given large amounts of fluid
     - ii. the C.V.P. is inaccurate or deceptively high
     - iii. because rales (due to atelectasis but assumed to be due to fluid overload) are heard

2. hypoxia or inadequate ventilation
3. unrecognized pneumathorax
4. acid-base or electrolyte abnormalities
5. hypothermia
6. previous prolonged treatment with antihypertensive drugs
7. adrenal insufficiency
8. cardiac tamponade

Summary

Regardless of its etiology, inadequate tissue perfusion, or hypotension following trauma should be treated rapidly and aggressively according to a previously designed plan of action. The response to therapy must be monitored closely and continuously. The most important steps in management of these patients include: 1) appreciating the extent of the perfusion deficit (even if the blood pressure is normal); 2) early ventilatory assistance if there is any tendency to hypoventilation 3) maintenance of a normal or higher arterial PO_2; 4) correction of any fluid deficits as rapidly as possible, and 5) maintenance of an adequate perfusion pressure of about 80 to 90 mm Hg systolic in older patients in whom coronary or cerebral vessels may be diseased.

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THE PHYSIOLOGY OF TRAUMA

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Survival or death following severe trauma is dependent upon the dynamic balance between the magnitude of the entire injury inflicted both locally as well as generally throughout the body and the effectiveness of the physiological responses which preserve vital metabolic activity and organ function. When for any reason the systemic responses are overwhelmed and unable to compensate for malfunction of one or more systems, significant metabolic impairment is followed by failure of multiple organs. The "Physiology of Trauma" consists of the responses by each system to certain well defined stimuli produced by injury during or after the initial insult. To understand the nature of the stimuli and the physiological responses it is essential to comprehend the full extent of the damage done by major trauma. Local effects may impair the function of a vital system with far reaching metabolic consequences. Examples are the effects of a crushed chest on gas exchange or the reduction of cardiac output secondary to severe hemorrhage. Tissue necrosis and invasive infection are commonly associated with serious injury. The function of distant tissues may be deranged by circulating agents emanating from the wound: bacteria, toxins from dead tissue or bacteria, and potent peptides from derived protein degradation or from activated precursors in the blood.

Among the principal stimuli which result from severe tissue injury and secondary damage to the whole body are: 1) fluid volume reduction, 2) elevation of metabolic rate and circulatory demand, 3) hypoxemia or low flow causing tissue hypoxia, 4) invasive infection, 5) starvation with protein malnutrition.

The protective reactions in response to these major stimuli are numerous. Yet they fall into certain classes in regard to their function in preserving the integrity of the organism. Among the more important classes are: 1) Hemostasis, essential to maintenance of blood volume; 2) Cardiovascular, respiratory, and renal responses, principally under neuroendoctrine control, to meet the extra demands for function imposed by altered metabolic requirements or to compensate for failure of a damaged vital system. (For this set of reactions Dr. Walter Cannon (1) coined the term "Homeostasis"); 3) Containment of tissue necrosis and infection by inflammation, the immunological system and macrophages; 4) Mobilization of body fuel substrates to furnish energy for continued tissue function under adverse circumstances; 5) and finally, wound healing essential to the restoration of tissue integrity and function.

The purpose of this paper then, is threefold: to define the nature of the injury to the entire body and the stimuli, to describe the pattern of physiological responses associated with survival, and to relate both to the clinical post traumatic course.

Knowledge of injury, stimulus, and essential responses facilitate recognition of deviations from the normal pattern of recovery. By comparing the behavior of the major systems during the course of recovery with the effects of organ failure, it is possible to demonstrate the importance of appropriate therapy in converting the pattern of failure and death to the physiological one of survival and recovery. Since space precludes presentation of details which are dealt with elsewhere (2) (3), it will be necessary to illustrate by a broad outline the integrated reactions under neuroendocrine and other controls.

The Injury and the Post Traumatic Course

No two patients behave in exactly the same fashion following major trauma. Many factors such as the presence or absence of hemorrhage, chest injury, or infection alter the pattern. The extent to which the patient responds depends upon the severity and extent of the injury. However, for convenience and to illustrate the sequence of stresses and physiological reaction the post traumatic course can be divided into four phases: 1) *Injury*, 2) *Adaptation*, 3) *Tissue Necrosis and Infection*, 4) *Resolution and Healing*. It must be recognized that in many cases these phases may not be clinically distinct, but may overlap. Should the injury increase, due for example to failure of a major system or to overwhelming infection, a reversion to shock may occur.

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TABLE 1 THE GENERAL INJURY OF TRAUMA

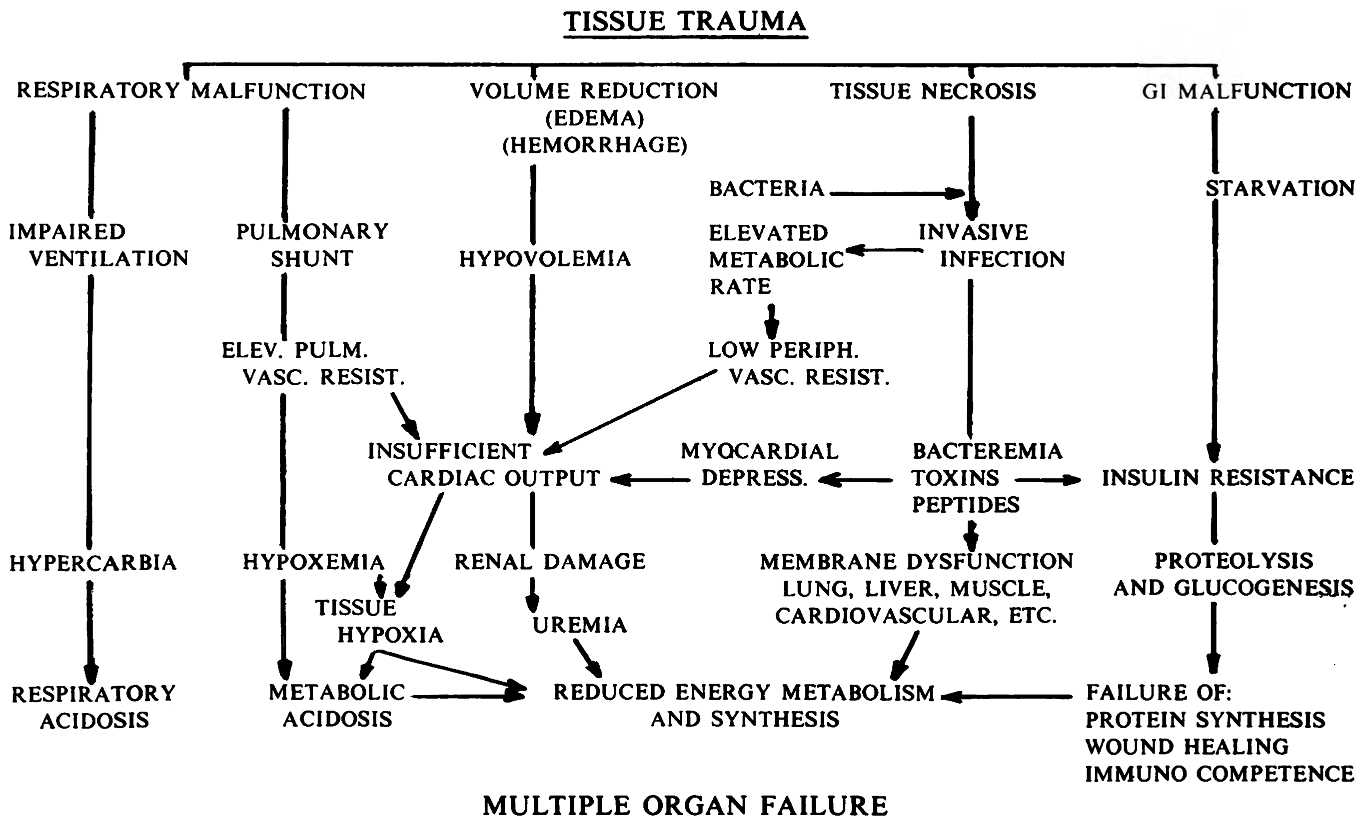


TABLE 2 RESPIRATORY, HEMODYNAMIC, AND METABOLIC VALUES, COMPARING UNEVENTFUL SURGICAL CONVALSECENCE WITH NONINFECTED TRAUMA AND SEPSIS

	Uneventful Convalescence	*Post Trauma (no sepsis)*		*Sepsis*	
Respiratory	Maximal Response	High Output (Post Shock)	Low Output Hypovolemic Shock)	High Output (Maximal)	Low Output (Shock)
PaO_2(FIO_2= 1.0) (mmHg)	388±44(8)	198±50(24)	221±49(6)	108±38(28)	106±29(16)
Shunt Estimated (%)	12±8%(6)	20±8%(10)	14±8%(6)	28±7%(28)	34±8%(16)
$PaCO_2$ (mmHg)	36±6(28)	32±3(30)	28±6(14)	30±5(32)	34±5(16)
Art. Blood pH	7.39±0.03(30)	7.43±0.04(22)	7.16±0.11(14)	7.47±0.08(32)	7.22±0.11(14)
Hemodynamic					
Cardiac Index (L/M²/Min)	3.6±0.3(30)	4.3±1.0	1.7±0.7(12)	4.8±1.6(32)	1.9±1.1(16)
Central Venous Pressure (cmH_2O)	5±3(21)	10±4(21)	2±3(14)	12±6(32)	16±6(16)
Pulm. Art. Mean Pressure (mmHg)	18±4(6)	21±5(8)	14±4(6)	28±5(14)	29±5(13)
Left Atrial (Wedge) Pres. (mmHg)	8±2(5)	12±5(6)	7±5(6)	13±5(14)	15±5(13)
Mean Arterial Pressure (mmHg)	87±10(30)	78±14(21)	57±1—(14)	89±12(32)	62±9(16)
Metabolic					
Metabolic Rate(k cal/M²/day)	980±210(16)	1131±213(17)	—	1240±250(18)	1040±169(12)
Body Temperature (Tr°F)	100.7±1.4(30)	101.6±1.6(24)	97.5±1.1(14)	102.9±1.7(32)	99.1±2.1(16)

Average values ± std. deviation (number of patients)

TABLE 3 SEPSIS IN TRAUMA, DEFENCE RESPONSES AND TREATMENT

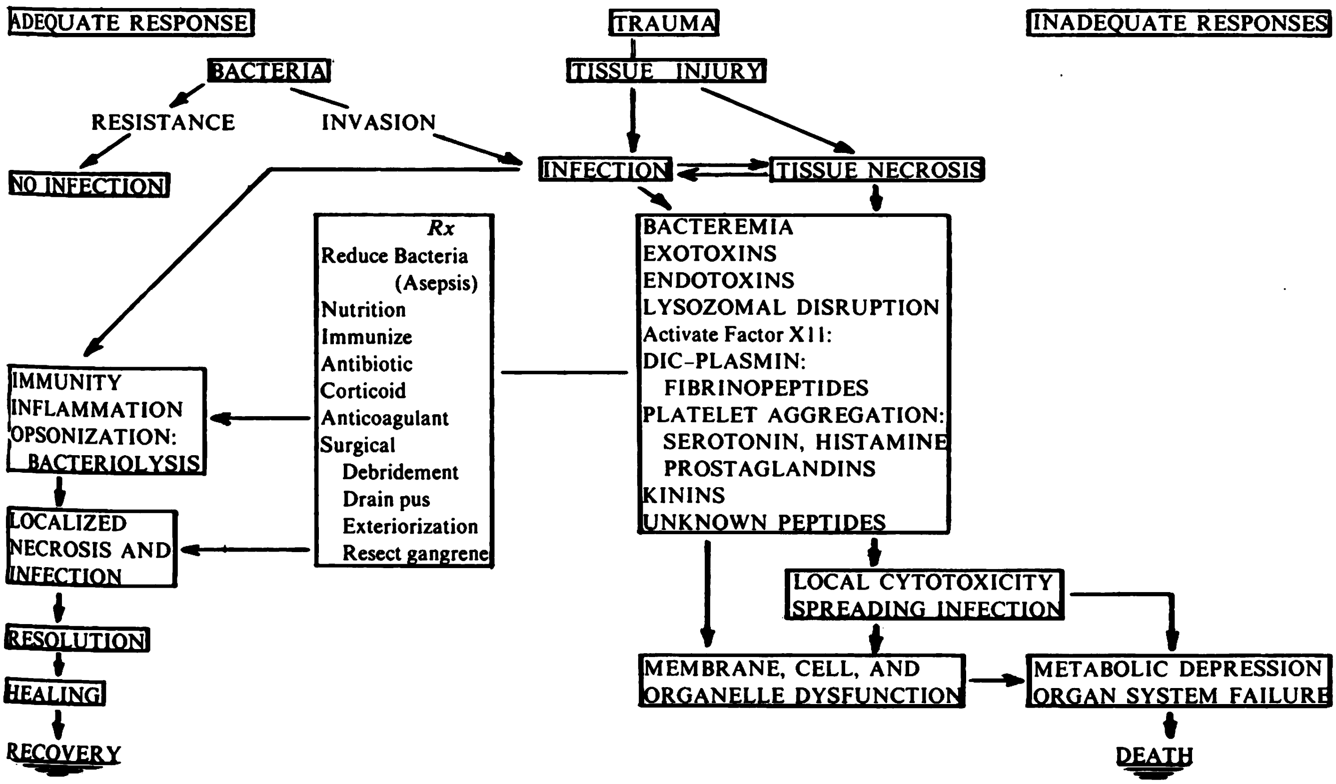
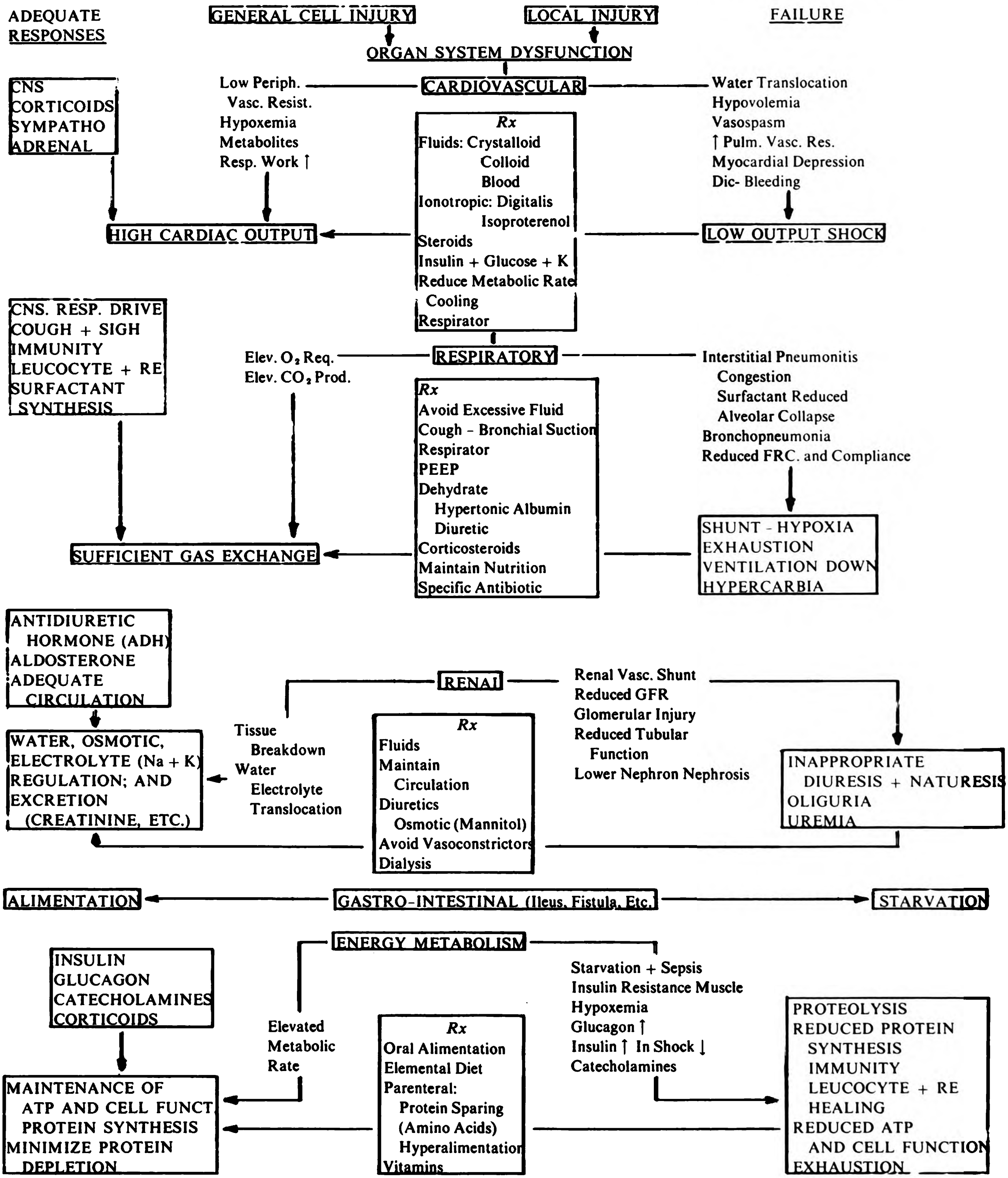


TABLE 4 INJURY, RESPONSES, AND TREATMENT OF VITAL ORGAN SYSTEMS DURING INFECTION



Because of the many factors of injury which are difficult to quantitate, shown diagrammatically in Table 1, attempts at establishing a scale for grading the magnitude of an injury in relation to the deleterious effects upon the body as a whole are not entirely satisfactory (3) (4). However, it is evident from the data in Table 2 that the demand imposed upon the circulation and respiration after clean surgery are significantly less than those which follow the large but noninfected injuries such as a fractured femur. Even more impressive are the responses which occur following the onset of extensive fulminating sepsis. Thus, stimuli and the demands for function of vital organ systems are generally in proportion to the extent of the total tissue injury in all parts of the body.

In the early phase of *Tissue Injury* malfunction of tissues injured locally by physical trauma may result in severe metabolic effects. The formation of edema and blood loss reduce blood volume and venous return. Cardiac output declines. The resulting hypotension stimulates a sympatho-adrenal discharge accompanied by secretion of antidiuretic hormone (ADH) from the pituitary and aldosterone from the adrenal. Trauma to the chest wall or lung may impair respiration and gas exchange. Tissue hypoxia supervenes resulting in lactacidemia and acidosis. The metabolic rate often declines below normal. Frequently hypothermia is present due to heat production reduced below the ambient loss. Death, if it occurs at this stage, is the result of the metabolic chaos of insufficient transport but is recognized clinically as circulatory shock or respiratory insufficiency.

The second phase, *Adaptation*, is entered relatively quickly—within hours, if the responses mediated through the central nervous system, the various endoctrines including adrenal steriods, and the sympatho-adrenal system are sufficient to preserve cellular energy production. In response to baroreceptor stimuli venoconstriction occurs to increase venous return. If cardiac output remains insufficient to satisfy circulatory requirements, arteriolar constriction continues. Water and sodium are retained secondary to ADH and aldosterone. Typically respiratory gas exchange is increased in response to the lactacidemia and metabolic acidosis engendered by tissue hypoxia. Respiratory alkalosis is common at this stage. If the cardiac output rises sufficiently to satisfy requirements for oxygen and substrate transport the metabolism increases above normal as shown in the third column of Table 2. Fever develops.

TISSUE NECROSIS AND INVASIVE INFECTION:

The importance of invasive infection in major trauma is emphasized by comparing the incidence of infection in clear surgical wounds with that which occurs in severely injured patients. In the former the range is variously reported 4.7 to 13.5 percent (5) (6). On the other hand, following major trauma serious infection frequently develops. It is most common among patients who have involvement of the colon or who have contaminated wounds, especially if ischemia and necrosis of tissue are present. In studies by the author (7) of patients who died one week or more following injury, major sepsis was present in 68 percent of those over the age of 60 years and in 52 percent of those under the age of 60. These findings not only point to the diminished resistance of the post-traumatic patient but also to the decreased ability of the aged to resist or withstand post-traumatic infection.

The focus of necrosis and infection is localized by the inflammatory reaction aided by the reticuloendothelial and immunological systems. However, the stress remains. Toxic agents continue to diffuse from the site of inflammation and circulate to all parts of the body. Spiking fever is frequently present. The characteristic metabolic abnormalities include lactacidemia, proteolysis, and a negative nitrogen balance (8) (9). Both the cardiac output and the metabolic rate are elevated. If for any reason the cardiac output falls below a level sufficient to satisfy the high circulatory demand, hypotension and vasoconstriction accompanied by the severe metabolic consequences of tissue hypoxia ensue. Acute tubular necrosis and renal failure may occur in conjunction with low output by the cardiovascular system (10). A common cause of death late in this phase is malnutrition due to gastrointestinal failure (3). Protein depletion and reduced protein synthesis impair the production of secretory proteins, enzymes, and antibodies. Immunocompetence disappears (11). Wound healing ceases (12). Multiple system failure follows accompanied by weakness, liver failure, bronchopneumonia, uremia, and death (13).

The usual course of survival continues by *Resolution* of necrotic tissue and the septic focus. Pus may be drained or resorbed while necrotic tissue is sloughed. Healing by deposit of collagen is accompanied by a return to normal metabolism and function throughout the body. Recovery is completed by restoration first of proteins and subsequently of fat stores throughout the body.

THE ROLE OF NECROSIS AND INFECTION IN THE TOTAL INJURY OF TRAUMA:

At least four mechanisms exist by which tissue necrosis and invading bacteria may adversely affect distant organs throughout the body: 1) Bacteremia or septic emboli may lead to invasion by "seeding" of remote tissues. Examples are septic microemboli which may lead to metastatic abscesses, commonly in liver, lung, kidney or brain. 2) The endotoxins or exotoxins produced by certain bacteria may affect cellular function directly. 3) Inflammation and local necrosis result in the release of proteolytic enzymes from the lysosomes of destroyed cells which are capable of breaking down proteins, pigments, etc. to form highly toxic peptides and other products. 4) Both endotoxin and the peptidases from injured tissues can activate a variety of circulating vasoactive peptides, induce intravascular clotting and plasmin activity, or cause platelet aggregation and release. In general, the circulating agents of this fourth group are peripheral vasodilators which at the same time cause an elevation of pulmonary vascular resistance (14). Common to all of these substances is the ability to alter the function of membranes ranging from abnormal capillary permeability to interference with transport and enzyme activity in cell walls or organelles.

Endotoxin is removed from the blood by the reticuloendothelial system in a short period of time; a large part is found in the liver, spleen and lung (15). The lipid fraction is thought to injure the function of many cells and organelles directly by complexing with the molecular structure of membranes (16). Cell death, principally of macrophages, at the site of necrosis and infection results in the release of a variety of lysozomal enzymes some of which are potent proteolytic peptidases. Activation of Hageman Factor (Factor XII) by such peptidases or by the complex of endotoxin, antibody, and complement leads to initiation of the clotting cascade and the production of disseminated intravascular coagulation (DIC). The release of thromboplastin from damaged tissue, injured vascular endothelium, and aggregated platelets accentuates clotting and the propagation of DIC, consumptive coagulopathy and thrombocytopenia. The simultaneous conversion of plasminogen to plasmin by Factor XII breaks down fibrin clot to release fibrinopeptides. Fibrinopeptides may be produced in any area where thrombi are lodged (17). Platelet aggregation which result from tissue injury or infection is accompanied by platelet release of a variety of vasoactive substances. These factors include serotonin, ADP and ATP, and protaglandin E_2 and F_2a as well as histamine in some species including man.

In the blood another series of powerful vasoactive substances, the kinins, also are activated by Factor XII. Attar *et al.* (18) have found evidence of the presence of kinins in the blood of septic patients. Kallikreinogen is converted to kallikrein which in turn by specific peptidase activity produces bradykinin and other kinins by breaking the peptide bond to remove the terminal amino acid leaving the active nonapeptide (19). Measurements made in seriously ill septic patients (20) demonstrated a significant reduction of prekallikrein in the plasma of those who were hypotensive at the time of observation. In the same group bradykinin was elevated above the normal value of three nanograms per ml. in 65 percent of the hypotensive patients and in only 16 percent of those without hypotension.

The relative importance of any or all of these substances remains to be proven, but it does appear from clinical observations and experimental data that both endotoxin and the peptides play significant roles in injuring the lung (21) and in altering energy metabolism (22).

Systemic Responses

1) HEMOSTASIS:

Following tissue disruption hemorrhage usually occurs either externally, into the tissues, or within the cavities of the body. Two responses are essential to prevent exsanguination. The first is vasoconstriction which is principally a neuronal reflex mechanism. The second is clotting which consists initially of platelet aggregation (23), and subsequently the formation and deposit of fibrin. Usually bleeding does not cease unless both vasoconstriction and clotting take place.

Initiation of the clotting cascade is by thromboplastin derived either from tissues or from platelets (24). Exposure of blood to collagen activates Hageman Factor (Factor XII). Adrenalin released by the sympatho-adrenal system in response to tissue injury potentiates the clotting mechanism (25). It is thus apparent that the factors which participate in clotting must be present.

Thrombosis within the vascular system is limited by naturally occurring antagonists to the factors in the clotting cascade (26). Factor XII activates plasmin (27). An excess of any of these anti-clotting mechanisms or a deficiency of any clotting factor results in continued bleeding. Treatment consists of restoring platelets, the deficient factors, or inhibitors, the simplest method being the use of fresh blood transfusions.

2) INFLAMMATION, IMMUNITY, AND PHAGOCYTOSIS:

The pathogenic potential of bacteria depends upon their ability to invade, survive, and multiply within host tissues. Quantitatively the number of organisms required to cause cell necrosis is frequently quoted at 10^6 per gram of tissue or ml. of biologic fluid.

The host defense against bacteria is dependent upon the establishment of an inflammatory reaction and upon the presence of antibodies (IgG and IgM), complement, opsonins, and phagocytosis. In man polymorphonuclear cells and tissue macrophages are responsible for destruction of bacteria. Leukotoxins cause these cells to stick to the capillary membranes and to pass by diapedesis into the interstitial spaces of injured or infected tissue (28). Many of these reactions fail to occur in tissue rendered ischemic by injury.

The lysosomal enzymes contained in the granulocytes include powerful peptidases capable of activating the inflammatory response. Prekallikrein is converted to kallikrein, a specific peptidase capable of activating the kinogens to kinins by splitting off a single amide (29). Of particular importance is bradykinin which is activated also by Hageman Factor XII (19). Bradykinin causes not only arteriolar dilation but also venular contraction; both elevate filtration pressure. At the same time capillary permeability is increased by opening the intercellular junctions. Edema forms. Proteins and cells escape into the interstitial spaces.

Complement and other humoral factors including specific and nonspecific immunoglobulins play a role not only in attracting neutrophils and tissue macrophages, but also in initiating opsonization. Upon contact with bacteria the immunoglobulin components trigger the complement cascade which produced the chemotactic stimulus. In contact with the bacteria the neutrophil actively ingests the organism to form a phagosome. By degranulation the lysosomal enzymes are emptied into the phagosome. Antibacterial enzymes, thus, come into contact with ingested bacteria. Normal neutrophils are capable not only of absorbing and killing the organisms but digesting them. However, this process may be impaired in the presence of abnormal neutrophil function. In burns, for example Warden *et al.* (30) found that chemotaxis is altered, and there is clear evidence that cycles of inability to kill bacteria exist. This can be demonstrated in vitro by survival of culturable bacteria within neutrophils. Alexander *et al.* (28) have demonstrated that the incidence of sepsis in burn patients is directly related to abnormalities of neutrophil function. MacLean *et al.* (13) examined the role of immunoglobulins, complement, neutrophil phagocytic and bactericidal function, lymphocyte reactivity and a variety of cutaneous reactions to antigens. All appeared to be somewhat irregular in relation to the incidence of sepsis and other complications, with the exception of skin reactivity. This is a function of B and T lymphocytes. The presence of anergy was associated with a high incidence of sepsis. They found that complete anergy as defined by failure to react with PPD (purified protein derivative), Trichophyton, mumps, Candida, and Varidase (streptokinase-streptodornase) as well as inability to induce a response to dinitrochlorebenzine (DNCB) resulted in 100 percent mortality. In 18 relatively anergic patients who only reacted to a number of the antigens there were five deaths, three being from sepsis. No mortality occurred from infection in any patients who had a normal cutaneous reaction to all antigens.

Although difficult to prove, a clear roll for malnutrition in the etiology of sepsis exists. Brostrian and Blackburn (31) have demonstrated a close relationship between the development of anergy and failure of protein synthesis in seriously depleted patients when the serum albumin fell to a level below 2.5 grams percent. Law and associates (11) in a recent review concerning the role of malnutrition in loss of immunocompetence concluded that reversal of protein calorie deficit in surgical patients may protect against infection by improvement of lymphocyte and neutrophil function.

3) CARDIAC OUTPUT AND FLUID VOLUME CONTROL

The volume of blood pumped into the aorta per minute is a function not only of the heart itself but very importantly of the peripheral vessels. In health the peripheral vascular resistance is in great measure determined by "Autoregulation." Precapillary sphincters which open and shut in rhythmic fashion adjust blood flow to greater volume in response to muscular work or to extra energy expenditure by a tissue. The sphincters normally in a tonic state, relax in response to a local reduction of oxygen tension or to acute accumulation of carbon dioxide and other metabolites (principally lactic acid). An elevation of extra cellular hydrogen ion concentration probably plays a part in reducing the arteriolar response to catecholamines. Vasodilator nerves of muscle are active in alarm. Arteriovenous shunts in the skin are under nervous control for dissipation of heat. In the presence of exercise the flow of the blood to the skin may amount to as much as 2 liters per minute in order to maintain the normal gradient of 0.5 degrees C between the medulla and the skin surface. As additional arterioles, capillaries or shunts open in response to extra demand for circulation, the peripheral vascular resistance to the flow of blood is reduced. The number of impulses from the baroreceptors in the carotid sinus, the aortic arch, other great vessels, and the chambers of the heart is reduced in response to a slight fall of arterial pressure. Through the integrated system of the central nervous system a series of reflex reactions take place to restore blood pressure by increasing cardiac output. Secretion of catecholamines from the sympathetic nerve endings promote a general augmentation of vascular tone, particularly that of the veins (32). The increase of vascular tone in the peripheral vessels increases the "main systemic pressure" as defined by Guyton (32). The result is an increase of blood flow to the right atrium.

As a part of the response to diminished baroreceptor signals the sympathetic cardiac accelerator nerves (beta adrenergic) increase the heart rate. Vagal (parasympathetic) activity is lessened or overcome. The cardiac chambers are reduced in size, and the force of the myocardiac contraction is inccreased (33). If the demand is great or if anxiety is present epinephrine is released into the circulating blood by the adrenal medulla.

In considering the total effect of lowered peripheral resistance, venous tone, blood volume and cardiac contractility on the determination of cardiac output, the concepts of cardiac function and systemic vascular function become of importance in understanding the hemodynamic abnormalities encountered in hypovolemia, heart failure and other circulatory changes observed following trauma and in sepsis.

Except for a brief period during recovery from anesthesia, uncomplicated convalescence from clean surgery is not a cardiovascular stress. Cardiac outputs remain near normal (7) (21). On the other hand, the peripheral vascular resistance is low following major injury or sepsis in patients who do well. To satisfy this elevated circulatory demand the cardiac output is increased, as shown by the data from clinical studies in Tables 3, 4, 5. In post-traumatic patients the average maximal cardiac index is 5.1 $L/M^2/min$. In the septic group it is 4.8 $L/M^2/min$. Although elderly patients tend to maintain slightly lower cardiac indices than the younger group, the response in relation to their normally lower resting values is approximately the same.

The metabolic rates (Table 2) of patients who are post-traumatic and septic is elevated approximately 32 percent while the average cardiac output increased by 76 percent above normal. The apparent inappropriate reduction of peripheral resistance can be explained in part by very low vascular resistance in areas of inflammation, the skin for heat dissipation, and in the kidneys. However, it is also true that flow in skeletal muscle of a resting extremity is proportional to cardiac output (34). This strongly suggests the possibility that alterations of muscle metabolism may also have an important role in causing relaxation of arterioles. This concept is supported by the increased production of lactate under these conditions (7). Another is that vasodilator substances may be circulating. Clinical and experimental observations support both possibilities (22) (35).

Patients who do not maintain elevated cardiac indices during the adaptive and septic portions of their clinical courses tend not to recover. Among those who remain hypotensive and acidotic for 24 hours or more, the mortality exceeds 70 percent. Arteriolar vasoconstriction, secondary to sympatho-adrenal activity and catecholamine secretion, occurs when cardiac output is insufficient to satisfy the circulatory demands of all tissues. Reduced oxygen delivery, acidosis and death follow.

At any stage of the post traumatic course, there are three principal causes for inability of the cardiovascular system to satisfy the elevated circulatory demands under these conditions. All have therapeutic implications. They are hypovolemia, right heart failure due to high pulmonary vascular resistance, and biventricular myocardial depression.

A) Hypovolemia:

Blood volume may be reduced by bleeding or by translocation of water, electrolytes and protein from the plasma into the inflammatory area and also into interstial spaces of other tissues, including the lung. Splanchnic pooling is typical of dogs in shock. In this and certain other species, liver venous sphincters contract when acidosis develops. However, in man and primates this mechanism of "splanchnic pooling" does not appear to be important as a mechanism of reduced venous return.

A reduction in blood volume results in a rapid response of the sympathetic nervous system mediated through baroreceptors. Heart rate rises; venoconstriction is followed by arteriolar constriction, if cardiac output remains insufficient to satisfy the circulatory demand. Blood volume is restored by two principal mechanisms. The first, depending upon the magnitude of the hypovolemia, is initiated by the fall in capillary pressure following a decline in both arterial blood and capillary pressure. Protein free fluid moves from interstitium to the capillaries, restoring approximately 20 to 50 percent of the depleted blood volume. Capillary oncotic pressure declines as does the interstitial fluid pressure. Equilibrium is thereby reestablished. The second phase of blood volume restitution depends upon a simultaneous increase in plasma protein, primarily albumin (36). Since protein synthesis does not begin for a day or two after hemorrhage, the albumin must be performed and delivered to the circulation principally through the lymphatics. Since lympathic flow depends primarily upon interstitial pressure, in the absence of exogenous fluid, fluid to maintain interstitial pressure must come from the cells. Boyd and Mansburger (37) have called attention to the increase in plasma osmolarity (hyperglycemia) which occurs in severely injured patients and animals. An increase of circulating amino acids may also contribute to the elevated osmolarity. The degree of fluid shift from cells after hemorrhage presumably is dependent upon the osmolarity of the extracellular fluid, which is variable. Gann and associates (38) have shown by experimental adrenalectomy that cortisol secreted at a physiological rate plus certain other adrenal factors are essential to promote the hyperosmolarity of extracellular water following hemorrhage. Experiments on hypophysectiomized animals (39) demonstrate that one or more pituitary factors also must be involved in the ability of the intact animal to restore extracellular fluid volume and osmolarity. Although the details of the central neuromechanisms controlling hormonal secretion in response to hemodynamic changes are poorly understood, it appears that atrial receptors, particularly those in the right atrium, are dominant (40). Recent studies by Gann et al. (41) have shown that the signals from the baroreceptors project to cells in the dorsal rostral pons, and subsequently to the medial dorsal hypothalamus, and thence, to the pituitary.

RENAL RESPONSES:

Another aspect of the response to the stimulation of hypovolemia is a reduction of blood flow to various vascular beds by arteriolar constriction. Among these are the kidneys. Because of the very high ratio of renal blood flow (RBF) to kidney weight, it is possible for the kidney to preserve function despite reduced blood flow after injury. Renal vascular resistance may nearly double as a result of partial glomerular efferent arteriolar constriction with a proportionate fall of RBF and still be able to maintain a normal glomerular filtration rate (GFR). A progression of hypovolemia leads to constriction of both afferent and efferent arterioles accompanied by a reduction of RBF below 500 ml/min and GFR below 80 ml/min. A further reduction in blood volume if prolonged causes acute tubular damage and renal failure.

The tubules of the juxtaglomerular nephrons actively absorb sodium against a gradient, creating a hypertonic medullary interstitium which facilitates the further absorption of salt and water. This process is accentuated by aldosterone secreted by the adrenal medulla in response to renin produced by the juxtaglomerular apparatus (42). This process is stimulated by a reduction of perfusion pressure to the glomerulus (43). The distal tubule also exchanges sodium for potassium or hydrogen depending upon the availability of circulating potassium. Following the onset of hypovolemia these aldosterone effects are accentuated.

Water is reabsorbed in the collecting tubules as they pass through the hypertonic medullary interstitium. Antidiuretic hormone (ADH) secreted by the pituitary increases the rate of water reabsorption. ADH secretion depends upon plasma volume, and osmolarity (44). Alterations of this highly integrated system occur primarily to retain water and salt and to excrete potassium and metabolites which may accumulate in the plasma after injury.

Cellular recovery with restoration of normal membrane function and the "sodium pump" especially in regions of edema formation, cause a return of sequestered fluid to the intravascular space from both cells and the interstitium. Polyuria develops, at times insufficient to meet the need for excreting excess water and electrolytes if renal damage has occurred due to ischemia. Induced diuresis may be the best method of correcting this situation. At times an "inappropriate polyuria" may be present after trauma when blood volume is not elevated. This phenomenon is particularly prone to occur in the presence of severe infection, and probably is due to hyperosmolarity of serum and wash out of the hypertonic interstitium due to the vasodilation characteristics of sepsis (10). The danger of this situation, as occurs with the inappropriate use of diuretics, is a serious reduction of blood volume leading to a secondary arteriolar vasoconstriction and further serious injury to the kidneys.

B) *Elevated pulmonary vascular resistance* is typical of the seriously injured or septic patient. As shown by the data in Table II the pulmonary mean arterial pressure was 28 mm Hg in the septic patients compared with 22 mm Hg in the post traumatic and 19 mm Hg in those patients making uneventful convalescence. PA pressure may go much higher to 60 mm Hg or more. Right heart failure may be manifest by an elevated central venous pressure in the face of a cardiac index below 2.5 L/M²/min. The diagnosis is confirmed if left atrial pressure (wedge) remains low despite fluid infusion. As will be discussed in the following section, reduction of pulmonary vascular resistance occurs when oxygenation of arterial blood and functional residual capacity improve. Therefore, treatment of this aspect of cardiac failure in the septic or injured patient is best carried out with respiratory support using a well regulated ventilator and endotracheal tube. This is particularly true in the elderly who frequently do not have adequate strength to breath sufficiently as pulmonary compliance declines. The respirator improves metabolism not only by improving oxygenation of blood but also by relieving the work of respiration. Both lower the demand for circulation.

C) *Reduction of myocardial contraction* also plays a role in "hypodynamic" post-traumatic or septic shock (45). Vito and Hechtman (46) observed that patients with peritonitis exhibit "Starling curves" suggesting heart failure. As the left atrial pressure is made to rise by infusion of albumin the cardiac output starts to fall as left atrial pressure approaches 15 mm Hg. This is not observed in normal people. Also, it has become evident that administration of ionotropic agents frequently cause an improvement of cardiac output when left heart failure is present. Administration of digoxin or isoproterenol may result in a rise of cardiac index from 2.2 to 4 L/M²/min. with a significant reduction of lactacidemia. More recently dopamine infusion has been employed for this purpose. In refractory cases of low output septic shock in which blood insulin is low, (less than 12μU/ml, administration of glucose, potassium, and insulin (1 unit per kilogram of body weight) has proven effective in restoring the high cardiac output essential for recovery (47).

Not infrequently, in the elderly, a high cardiac output cannot be maintained because of coronary sclerosis or old myocardial fibrosis. It is this group in which an aortic balloon assist pump may improve the chance of survival. Other patients start by keeping up an excellent high cardiac output, only to develop a sudden coronary occlusion and heart failure. This event is common after four days to a week in those over seventy who have cardiac indices more than 4.5 L/M²/min. Support by respirators, moderate cooling, and elimination of the septic or gangrenous focus are the best preventive measures.

4) RESPIRATORY RESPONSES:

The seriously injured or infected patient is more than usually prone to pulmonary complications. All too often death is the result. The importance of the lung lesions associated with trauma and particularly with sepsis was emphasized by the high incidence of pneumonia and respiratory failure in the wounded military personnel in the Vietnam war (48). As a measure of the magnitude of the problem in civilian practice, a survey of 8,000 consecutive admissions to two general surgical services, (Medical College Hospital, Charlestown, S.C., and Fifth (Harvard) Surgical Service, Boston City Hospital) disclosed that overall hospital mortality was 2.1 percent; respiratory insufficiency was responsible or contributed to death in 57 percent of those who died. This value rose to 70 percent when sepsis was present. Szaner and Zukanka (49) report the postoperative incidence of pneumonia in patients over 70 years to be 42 percent with a mortality of 73 percent among those who developed pneumonia.

Pulmonary Morphological Abnormalities:

Assessment of the lung at autopsy is difficult because of the usual prolonged course and agonal changes in patients who die of sepsis. At thoracotomy, for drainage of mediastinal sepsis or for other reasons early in the septic course, the lungs appear grossly normal, except for punctate hemorrhagic areas diffusely scattered on the visceral pleura. Serous pleural fluid, at times containing small quantities of hemoglobin, may be present. At this stage, culture of such fluid usually is negative.

Biopsies of apparently uninvolved lung in the early stage (Phase I) are characterized by: 1. interstitial septal edema, 2. intravascular congestion, 3. infiltration of leukocytes which are predominantly large mononuclear cells or lymphocytes, and

4. diffuse focal alveolar collapse (21), referred to by Border (50) as "focal atelectasis". In certain specimens, proteinacious material may be observed within some of the open alveoli. The so-called alveolar pseudomembrane described in some cases may be partially dried or insoluble intra-alveolar protein. It is not always present, and its significance is not clear. Some peribronchial and peritubular interstitial hemorrhage may be present.

When the lung lesion progresses to the late stage of bronchopneumonia (Phase II), it becomes more edematous. At autopsy, the weight is increased by 50 to 100 percent above normal. It is red, resembling liver tissue, and inflates with difficulty. Histologically, there is much interstitial edema containing fibrin. Proteinacious fluid is present in the alveoli, many of which are collapsed. There is massive infiltration of septal and peribronchial tissue by polymorphonuclear leukocytes which are also present in large numbers in airways and alveoli. Certain areas appear to be totally consolidated by inflammatory reaction. Intra-alveolar and interstitial accumulations of red cells are common.

Clinical Pattern:

Moderate hypoxemia frequently occurs within 12 to 24 hours after severe trauma or the onset of fulminating sepsis. While the patient breathes air, the arterial oxygen tension (PaO_2) may fall to the range of 50 to 60 mm Hg despite the presence of subnormal arterial carbon dioxide tension ($PaCO_2$) of 25 to 35 mm Hg. At this stage, examination of the chest may disclose only coarse breath sounds. The lung fields by X-ray may be clear or, at most, exhibit a slight degree of ground glass appearance. No doubt, this phenomenon is due to the fact that the focal alveolar collapse found in the early stage (Phase I) of the pulmonary lesions is not sufficiently confluent to produce X-ray density. Subsequently, if it is not possible to halt the progression of the pulmonary lesion prior to the development of bronchopneumonia, coarse rhonchi, decreased breath sounds, and other evidence of confluent pneumonia or atelectasis may be obtained by physical examination. X-ray then shows a mottled appearance or the course density characteristic of bronchopneumonia and edema.

As the pulmonary lesion progresses, pulmonary vascular resistance increases, as shown by the data in Table 2. The elevated pulmonary arterial (PA) pressure contrasts with the normal behavior of the pulmonary circulation in which recruitment of capillaries prevents an elevation of PA pressure, as the cardiac output rises as in exercise. Not infrequently, the pulmonary arterial hypertension accompanied by the high circulatory demand of sepsis leads to right heart failure. Central venous pressure under these circumstances may rise to values of 25 cm H_2O or higher. At the same time measurements of pulmonary occluded (wedge) pressure with the Swan-Ganz catheter may show normal values for the left arterial pressure. Thus, it is demonstrated that there is resistance to blood flow in the lungs which becomes particularly pronounced in the late stage of bronchopneumonia. The rise in pulmonary vascular resistance bears a direct relationship to the degree of shunting and hypoxemia.

Pulmonary Function:

The respiratory alkalosis and hypoxemia typical of the early interstitial penumonitis are evidence of both excess ventilation and the presence of a pulmonary shunt. The latter, defined as a reduction of the ventilation-perfusion ratio (51), is the result of venous blood passing through the capillaries of unventilated or inadequately ventilated alveoli. The exact measurement of shunt requires knowledge of mixed venous and arterial oxygen content as well as cardiac output (52). However, a reasonable measurement may be made by determining the alveolar-arterial gradient of oxygen tension ($PaO_2 - PaO_2$) (21). Making allowance for vapor pressure of 50 mm Hg at body temperature, the alveolar oxygen tension with an FIO_2 of 100 percent is 700 mm Hg, and PaO_2 with a normal lung should be between 450 and 500 mm Hg. As A-a gradient of greater magnitude than 300 mm Hg is evidence of a shunt or venous admixture. Whereas, the normal degree of shunting ranges from 3 to 6 percent, values up to 20 percent are found during the early phase with clinically clear lungs. As bronchopneumonia develops, shunts of 30 percent or more are not uncommon when PaO_2 falls to 60 mm Hg on 40 percent O_2 respiratory mixture and to 120 mm Hg when breathing 100 percent O_2.

As the lung lesion progresses, Proctor et al (53) observed in wounded septic military personnel that the increase of shunting which rose from 10 to 30 percent during five days, was accompanied by a reduction of compliance which elevated the work of breathing. Powers and his associates (54) found a similar relationship regarding the functional residual capacity (FRC). The highest shunts were accompanied by a reduction of FRC from 2 liters to less than 500 ml. These findings are confirmed by studies comparing patients who had been in hypovolemic shock with those who were septic (21). At low cardiac outputs, when the lung lesion limits oxygenating capacity, increased oxygen extraction and low mixed venous pO_2 values increase the A-a pO_2 gradient. Thus, both the degree of shunt and the cardiac output are of importance in determining the PaO_2 (55).

As the work of ventilation increases, the circulatory requirement to perfuse the muscles of respiration also rises. The circulatory stress is further augmented by the arterial oxyhemoglobin desaturation which parallels both the reduction compliance and FRC. Thus, a respirator, at times supplemented by positive-end-expiratory pressure (PEEP), when properly employed with a cuffed endotracheal tube, may accomplish three beneficial functions: 1) Collapsed alveoli may be reexpanded to reduce shunting and increase PaO_2. 2) The work of ventilation may be eliminated. 3) Improvement of the first two functions often reduces the circulatory demand and the requirement for cardiac output.

5) METABOLIC RESPONSES: ENERGY PRODUCTION AND PROTEIN SYNTHESIS

Provision of energy for vital processes in the face of elevated metabolic demands is closely related to proteolysis. In turn, degradation of protein for oxidation of amino acids for energy production leads to a reduction of protein synthesis. Since the pioneer work of Cuthbertson (8) it has been known that trauma is characteristically associated with proteolysis and marked negative nitrogen balance. More recently sepsis has been recognized as an even stronger stimulus (3) (56). It is true that under these conditions the energy production tends to shift to a metabolic pattern dependent upon glucose (45). For this reason proteolysis has been thought of as a reaction to furnish the necessary glucose. As will be demonstrated, the cause of protein breakdown is not quite so simple.

A deficiency of even one RNA charged amino acid in the sequence of protein synthesis by the endoplasmic reticulum stops the process. Therefore, wasting and protein deficits of many types are prone to occur in injured or septic patients who have insufficient alimentation. This is particularly true of patients who initially are malnourished before surgery. Furthermore, severe protein deficiency may occur very rapidly in the course of not more than two to three weeks after injury or the onset of severe sepsis, if not aggressively treated with enteric or parenteral alimentation. Vital cellular functions which include ion transport, maintenance of osmotic gradients, synthesis, motion, and the numerous other requirements for energy are dependent upon the production of high energy phosphate bonds, the medium of biological energy utilization. The conversion of adenosine diphosphate (ADP) to adenosine triphosphate (ATP) involves the transfer of 7700 K calories per mole in the processes of anaerobic or oxidative phosphorylation. Vast quantities of energy are derived from complete degradation of substances: carboydrate = 4K calories per gram, protein = 4K calories per gram, and fat = 9K calories per gram. Oxygen as the hydrogen acceptor is required for their ultimate oxidation to carbon dioxide and water. In the absence of oxygen energy production is dependent upon the inefficient anaerobic degradation of glucose to lactate which gives two molar equivalents of ATP in contrast to 36 produced by the carboylic acid cycle of oxidation. The utilization of this energy to avoid its simply escaping as heat is dependent upon the cytochrome system to carry out the process of phosphorylation.

It is obvious that many of the pathways by which vital energy conversion is effected may be seriously impaired both locally by the ravages of trauma or invasive infection and in distant tissues by membrane alterations caused by circulating peptides or other agents including endotoxin. The availability of substrate fuels, the transport of oxygen and metabolites, the presence of induction of enzymes in the various cellular energy producing or synthetic pathways all may be affected during serious illness. Changes in the endocrine pattern, body water, electrolyte concentration, and the function of such vital organ systems as the circulation, respiration and kidneys also significantly change metabolic patterns. When because of failing gastrointestinal activity, as occurs in the difficult situations of peritonitis or retroperitoneal abscesses, starvation is superimposed, survival becomes dependent upon the endogenous fuel sources supplemented by those which can be introduced by parenteral routes. Unfortunately, in sepsis the utilization of endogenous fuel stores, particularly protein, is not economical. Thus protein depletion, weakness, and failure of protein synthesis for wound healing and antibody production, among other factors, may be late causes of death in the infected starved patients. In short, cell survival is dependent upon continued ATP production. Lack of high energy phosphate bonds for any reason leads to deterioration of structure, function and ultimate death in any cell.

To appreciate the significance of the metabolic abnormalities encountered in trauma and sepsis, it is necessary that the pathways of body fuel storage and utilization be reviewed briefly. Cahill (57) has referred to insulin as the "overall fuel control in mammals." In the fed state blood glucose is in the range of 6 to 7 μU/ml and blood insulin is approximately 45 μU/ml. Insulin promotes storage of glucose as glycogen and fat. Proteolysis and lipolysis are suppressed by elevated blood insulin. In the fasted state available glycogen is eliminated within 12 to 24 hours. All that remains as available body fuel stores are fat and protein. Protein is continuously degraded and resynthesized. Branch chain amino acids are oxidized in the muscles. By transamination to pyruvate, alanine is produced and carried with other glucogenic amino acids and lactate to the liver for conversion to glucose. As blood glucose declines in fasting below 4 μM/ml, insulin falls to a range between 5 and 15 μU/ml. Within a few days adaptation to starvation takes place. Lipolysis increases with greater availability as free fatty acids (FFA) which rises in the blood to a range of 1.3 to 1.9 μEQ/L. Approximately 20 to 25 percent of the FFA is converted to ketones by beta oxidation from which the liver derives its energy. Ketones which rise to 1 μM/ml or more are oxidized in place of glucose by nearly all tissues with the exception of the myeloid cells. RQ falls to nearly 0.7 indicating that fat has become the major metabolic fuel. The blood glucose then is maintained at approximately 4 μM/ml while the consumption of amino acids is reduced to that which can be derived from as little as 25 grams of protein per day. This modest proteolysis is equivalent to a negative nitrogen balance during starvation of no more than 4 to 5 grams of urinary nitrogen per day.

The metabolic rate or caloric expenditure of energy in trauma and sepsis is elevated 20 to 40 percent above the normal resting values (21) (58). This is demonstrated by the data in Table 2. On the average 2800 K calories are consumed per day by a severely injured infected 70 kilo man. The values observed in elderly patients are slightly below those of the younger group. Again this is an elevation of equal proportion to the slightly lower basal metabolic rate observed in older people. In the injured or septic state accompanied by starvation, as occurs with peritonitis, utilization of available body fuel substrate (fat and protein) differs significantly from the economic pattern in uncomplicated normal starvation. Since the early observations of Cuthbertson and his colleagues (8), severe and continued protein catabolism has been recognized as a characteristic feature of the post-traumatic and septic state. Negative nitrogen balances ranging from 10 to 35 grams or more per day represent a breakdown of 60 to 200 grams of protein per day. Since the available protein in the average adult amounts to no more than 5 KG and less in an older person who is malnourished, it is evident that a limit exists in the duration that proteolysis of this magnitude can be tolerated. The mortality approaches 100 percent according to Studley et al (59) when 30 percent of body weight has been lost. Extensive protein catabolism is accompanied not only by muscle weakness, but also a severe reduction of protein synthesis, loss of immunocompetence, and failure to heal wounds.

The septic injured patient tends to be hyperglycemic and hyperinsulinemic. Blood sugar concentrations ranging from 4 to 7 μM/ml and blood insulin in the range from 30 to 50 μM/ml are observed. Lipolysis is suppressed by the elevated blood insulin. Consequently blood FFA falls to levels below 0.5 μM/ml. An explanation for certain of these apparently paradoxical observations lies in the abnormal resistance of various tissues to insulin which is associated with trauma and sepsis. Howard et al (60) described a diabetic type of glucose tolerance curve after wounding or in the presence of severe sepsis. Subsequent observations disclosed that this "pseudodiabetes" exists despite a normal or even exaggerated rise of blood insulin in response to glucose load. Kinney and Long and their associates (58) (61) found under these conditions that the rate of glucogenesis from amino acids is increased as is the body glucose pool. Both appear to be related to elevated glucagon levels in the blood which range from 600 or more in sepsis compared with concentrations of less than 125 μU/ml in normal persons. Glucagon stimulates hepatic glucogenesis. However, the administration of glucose fails to reduce either the negative nitrogen balance or the rate of hepatic glucogenesis (62). In fact, exogenous glucose tends to increase the blood insulin to higher levels and further to suppress lipolysis thereby reducing the available FFA and ketones for oxidation (63). The result is a further increase of the fuel deficit and a greater utilization of amino acids reflected by a further increase of negative nitrogen balance. Data from measurements of peripheal fuel utilization indicate that despite the high blood glucose and insulin levels in the traumatized or septic patients, the utilization of glucose is not increased in the peripheral tissues. More importantly a large portion of the glucose taken in by the leg is converted to lactate. Only 2 ATP equivalents are produced by anaerobic glycolysis in contrast to 46 ATP equivalents when full oxidation of glucose occurs. Experimental work by Ryan et al (64) and Clowes et al (45) suggest that this state of affairs is in part due to failure of induction of pyruvate dehydrogenase which is insulin sensitive and is rate limiting in the conversion of pyruvate to acetyl CoA. The entry of glucose into the Krebs cycle is limited. Thus, a fuel deficit is present which is accentuated by the suppression of lipolysis by the attendant hyperinsulinemia. FFA and ketone utilization by the leg is remarkably reduced compared with the normal fasted state. The branch chain amino acids must be oxidized in the muscle to satisfy the energy requirements. This is reflected in the increase of alanine release which is produced by transamination of pyruvate. It appears that an insulin resistance occurs in muscle which then establishes the fuel deficit which leads to oxidation of branch chain amino acids and the release of alanine.

Since lactate, alanine, and glycerol can only be cleared from the blood by hepatic glucogenesis, the glucose synthesis in the liver is augmented. Glucagon secretion by the pancreatic alpha cells is stimulated by elevations of alanine and other amino acids in the blood (62). Characteristically glucagon values in excess of 500 μU/ml are found under these conditions in contrast to the normal level of 125 μU/ml.

A different picture exists in the low output traumatic or septic shock states. Insulin normally is secreted by the B islet cells of the pancreas proportionally to the blood glucose concentration. The secretion of insulin also is directly affected by the state of the circulation as well as by sympathoadrenal activity and the concentration of catecholamines. In hypovolemic shock insulin secretion is depressed (65) and blood glucose is high. In low flow septic states in which an intense sympathoadrenal response is occurring, the circulating insulin is low. Patients whose cardiac indices were below 2.8 L/M^2/min. have blood insulin averaging only 6 μU/ml., as contrast with those in the high output state whose blood insulin values average 46 μU/ml (45). Because of the observed low insulin values in septic shock, insulin 1.5 units/kg body weight accompanied by glucose and postassium has been found to produce a remarkable increase of cardiac output and restoration of the usual pattern of metabolism in certain hypotensive septic patients (45) (47).

Summary

In Tables 3 and 4 are summarized the injury, stimuli, controls and adequate responses of major organ systems which lead to recovery after severe trauma. On the right side are the inadequate responses which more often than not result in death. It is reemphasized that survival and recovery are physiological phenomena. Death is failure of the physiological responses to preserve the metabolic integrity of the organism as a whole.

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CIRCULATORY, METABOLIC AND RESPIRATORY CHANGES FOLLOWING ELECTROLYTES AND 5% ALBUMIN SOLUTION IN RESUSCITATION

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Introduction

A critical question for us is: "Is human serum albumin really necessary for resuscitation?" The experience of many surgeons in the last decade has been that resuscitation can be achieved successfully with blood and salt solution with the addition of little albumin. If this is the case, it is an important observation not only from the medical point of view but also from the financial one. The economics of the situation are as follows. A bottle of albumin solution, 50 gms of albumin in a liter of salt solution, costs approximately $100. The dextrans cost approximately $3 per liter. Salt solution alone costs approximately $1 per liter.

The problem of the possible need for albumin can be reduced to two questions. 1) Can an equivalent degree of resuscitation be achieved with either albumin or salt solution? 2) Does either fluid produce respiratory failure or pulmonary edema? We have been trying to answer these questions over the past years. This paper is an account of our activities in this area.

Methods and Materials

CIRCULATORY STUDIES (1)

Adult male baboons, *Papio doguera*, weighing between 18 and 30 kilograms were used as the test animals. For each experiment, to facilitate handling, the baboon was tranquilized while still in a cage with an intramuscular injection of 1 milligram of I-phenylcyclohex piperidine hydrochloric acid per kilogram of body weight.

Insertion of Monitoring Catheters.

Each baboon initially underwent a thoracotomy on the left side under endotracheal anesthesia produced with nitrous oxide-oxygen-succinylcholine chloride. Siliconized vinyl catheters were placed in the thoracic aorta by way of the left subclavian artery, which was sacrificed, and through purse string sutures, into the pulmonary artery and both atria. The catheters were filled with 1,500 U.S.P. units of a concentrated heparin solution. The free ends were ligated and subcutaneously placed on the lateral aspect of the left side of the thorax.

Preliminary Procedures.

After a two- to three-week recovery period, the baboon was again tranquilized. Any additional general anesthetic, necessary to maintain a lightly anesthetized condition, was given intravenously in the form of 25-milligram increments of pentobarbital sodium. Under local anesthesia, a plastic siliconized catheter was inserted through the femoral artery into the thoracic aorta and through the femoral vein into the vena cava. The baboon was then placed in the prone position, the anterior thoracic wall being protected by padded axillary supports. Under local anesthesia, the four ends of the thoracic catheters were exposed, the remaining concentrated heparin solution aspirated, and the catheters filled with 1.5 cubic centimeters of dilute heparin solution. Each thoracic catheter was connected to a pressure transducer and, by means of a preamplifier and a direct writing, multichanneled polygraph, pressures were continuously recorded from the four thoracic catheters. The transducers were positioned approximately at the level of the right atrium. Each pressure recording system was calibrated against a mercury manometer before and after every study. The baboons were not heparinized.

Experimental Model: Hemorrhage.

The study was divided into three periods: baseline, hemorrhagic shock, and resuscitation. After a 30-minute baseline period, hemorrhagic shock was induced by removing blood through the femoral artery catheter into a sterile plastic bag containing 67.5 cubic centimeters of acid citrate dextrose solution, at a rate adjusted to reduce mean arterial pressure to 60 millimeters of mercury during a 15-minute interval. This pressure was maintained for 60 minutes. Additional blood was then removed during a five-minute period to further reduce mean arterial pressure to a level of 40 millimeters of mercury for 70 minutes. Pressure was regulated by withdrawing or returning blood as required.

Treatment Groups

On the day prior to study, each baboon was placed in one of four treatment groups by random selection. Treatment began in all groups at the completion of the shock period and was partitioned into four 30-minute intervals, T_1, T_2, T_3 and T_4. These intervals were alternated with 30-minute observation periods. Each of the four treatment groups will be discussed separately.

No Treatment - group 0.—These baboons received no treatment after the end of the shock period.

Whole Blood - group 1.—The shed blood was reinfused into these baboons and additional amounts of freshly drawn, citrated, group specific, homologous baboon blood were given as required during treatment periods T_1 through T_4.

The blood, when given, was infused at an average rate of 130 cubic centimeters per minute. A maximum of 250 cubic centimeters was drawn from each donor. The criteria for infusion of all test fluids will be described in detail.

Colloid - group 2.—Baboons in this group received, as required, an infusion of 5 percent human serum albumin in saline solution during treatment periods T_1, T_3, and T_4, at an average rate of 115 cubic centimeters per minute. During treatment period T_2, the baboon's own red blood cells were returned after being washed in isotonic saline solution and packed to a hematocrit value of 70 percent. No other fluid was given during treatment period T_2.

Saline Solution - group 3.—Baboons in this group received, as required, an infusion of 0.9 percent sodium chloride during treatment periods T_1, and T_4, at an average rate of 160 cubic centimeters per minute. During treatment period T, the baboons' own red blood cells were returned, as in group 2, after being washed in isotonic saline solution and packed to a hematocrit value of 70 percent. No other fluid was given during treatment period T_2.

Infusion Protocol.

The test fluids in the three treatment groups were infused until either the mean arterial pressure had returned to its baseline value or the mean right atrial pressure was 7 millimeters of mercury higher than its baseline value, at which time infusion was stopped. Infusion was resumed whenever arterial pressure decreased below its baseline and the mean right atrial pressure did not exceed its baseline by more than 4 millimeters of mercury.

Data Collection

During each experiment, ten data collection points — S_1 through S_{10} — were scheduled (Figure 1). At each of these points, pressures were recorded from the polygraph. In addition, cardiac output determinations, in replicate, were estimated by the dye dilution method by use of a cardiodensitometer system. Known amounts of idocyanine green were injected into the pulmonary artery catheter followed by a 7-cubic centimeter flush with isotonic saline solution. Arterial blood was aspirated at 20 cubic centimeters per minute for dye sampling by means of a withdrawal pump. After each determination, the blood was reinfused. The calibration factor for the cardiodensitometer was determined during the baseline interval and again after the first and second treatment periods.

Pulmonary vascular resistance (PVR) was calculated from the following standard formula:

$$PVR = (MPAP - MLAP)/CO$$

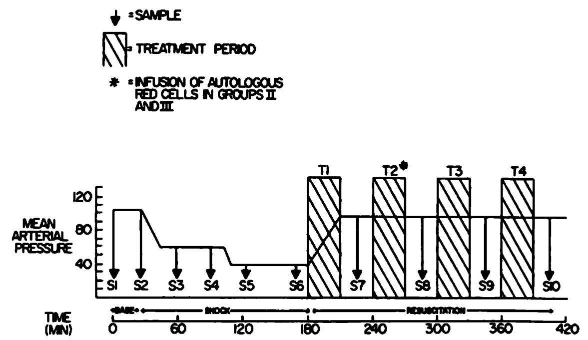


FIGURE 1: Experimental design and sampling periods. In subsequent figures, the results measured at several periods have not been presented for the sake of brevity. These include the first baseline sample, S_1, and the first three shock samples, S_8 through S_6.

where MPAP is the mean pulmonary artery pressure; MLAP, the mean left atrial pressure; and CO, the cardiac output.

Also, at each sampling point, 10 cubic centimeters of blood was withdrawn for replicate chemical studies. Arterial lactic acid was determined by an enzyme method. Each sample was immediately deproteinized and anaerobically withdrawn from the aortic catheter. For determination of $p^{o}2$ levels, blood was anaerobically withdrawn from the aortic catheter. Measurements were immediately made using an ultramicro pH-blood gas analyzing system. A Goldberg hand refractometer was used to measure plasma total protein.

For measurement of hematocrit, capillary tubes and a microcentrifuge were used. All information for subsequent computer analysis was recorded on coding sheets and punch cards.

ELECTRON MICROSCOPY STUDIES (2)

Technique of Lung Fixation with Buffered Glutaraldehyde.

At the conclusion of the experiment, the baboon was placed in the supine position and the extremities were restrained. A small dose of pentobarbital was given intravenously. The thoracic cavity was entered through a midline sternal-splitting incision. Then, a purse string suture was placed in the main trunk of the pulmonary artery and a plastic-siliconized catheter threaded into the left pulmonary artery. A similar catheter was threaded through the endotracheal tube to the left main bronchus. By cross-clamping the hilus of the right lung, the left lung was isolated. A dual method of perfusion fixation was initiated. The perfusion pressure in the arterial system was maintained at a steady 40 centimeters of water. After a few minutes of perfusion with buffered glutaraldehyde through the vascular bed, the ascending aorta was clamped, thus reducing the quantity of the perfusate needed. Approximately 500 to 700 milliliters of the perfusate was given in 30 minutes. Another 20 to 40 milliliters of the perfusate—the volume of fluid to fill the main stem bronchus and its branches—was instilled into the bronchus manually through the catheter. The catheter then was removed and the endotracheal tube clamped. At the end of 30 minutes of this dual fixation, the lung was firm in consistency and resembled liver in gross appearance. The lung was removed, and tissue samples were taken from different areas. Next, the baboon was sacrificed. With this method, the lung is fixed in a living animal, which reduces artifacts to a minimum. Further fixation of lung tissue was achieved by immersion in the perfusate for two hours at 4 degrees C and, subsequently, in 2% osmium tetroxide in Veronol buffer (barbital buffer) for two hours at 4 degrees C. Fixed tissues were dehydrated quickly in acetone and embedded in Araldite (epoxy resin) or Epon 812 (epoxy resin).

Technique of Electron Microscopy.

Ultrathin sections were cut from adjacent areas of sections used for light microscopy and mounted on a copper grid, where they were stained with an alcohol solution with uranyl acetate and viewed in an RCA EMU 3H 4 microscope.

Results

CIRCULATORY INDEXES

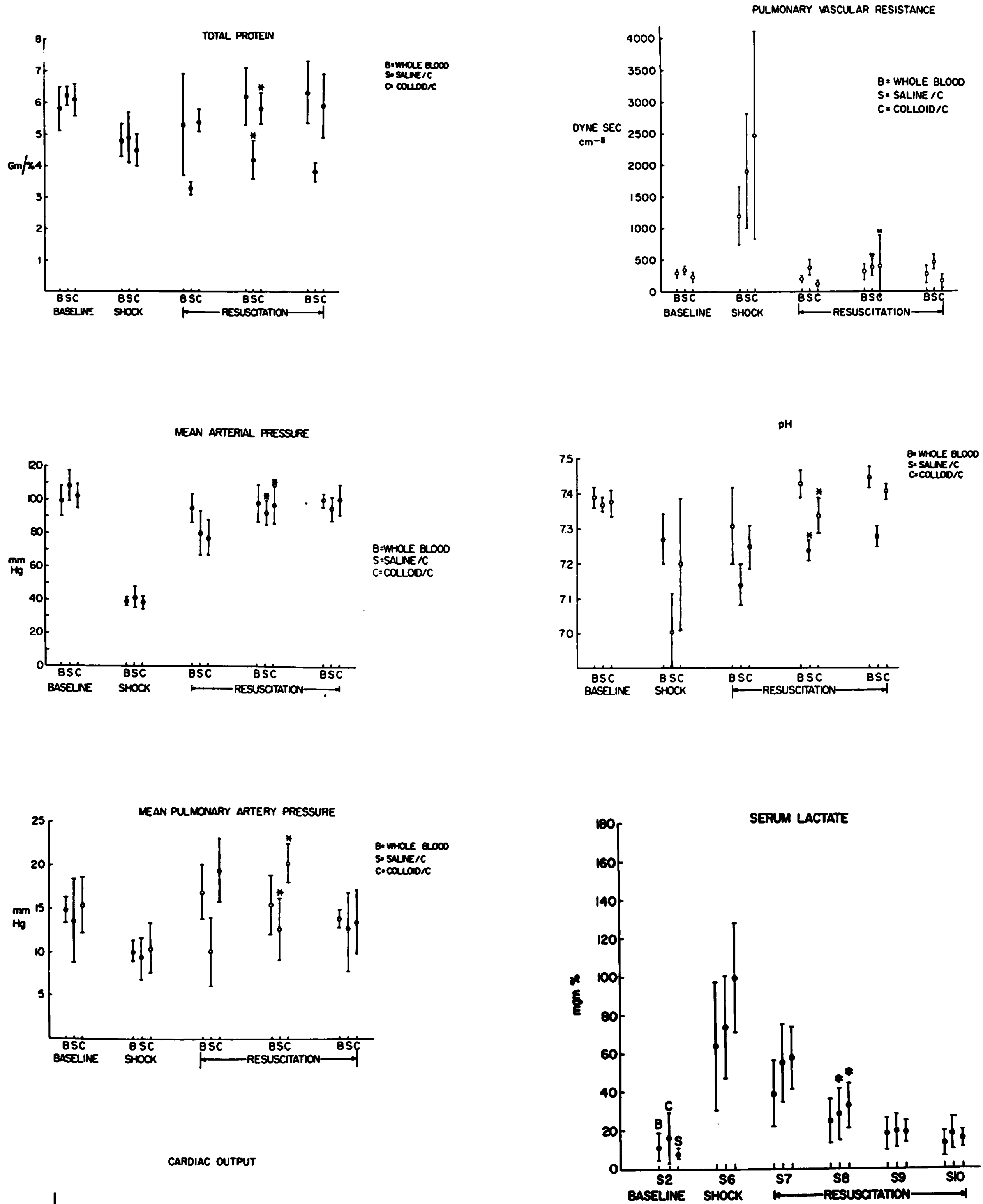
All three groups (Table 1) lost approximately 35 cc/kg during the hemorrhage period, which is about 50 percent of their total blood volume. To restore and maintain their circulation during the resuscitation period for four hours, the blood group required about 50 cc/kg. The colloid group required a slightly greater volume. In contrast, the amount of saline required to achieve resuscitation was three times as high as the other groups.

Figure 2a contains the plasma total protein in grams % during baseline shock, and various periods of resuscitation. We see the mean and standard deviation for the blood group (B), for the colloid group (C), and the saline group (S). This trio will be represented at each of the observation points. In shock the total protein concentration falls and then with treatment the groups separate. The whole blood and colloid groups return to control values, 6 gms %, whereas the saline group falls to close to 4 gms %.

The arterial pressure changes are seen in Figure 2b. There are no differences during resuscitation at any point between the groups. We can restore the arterial pressure and hold it there for four hours with any one of the three treatments. The variation in pulmonary artery pressure is seen in Figure 2c.

TABLE 1 Mean Volumes Removed and Infused in the Three Groups Receiving Test Fluid
Standard Deviations are shown next to the Mean Values

Treatment Group	Number of Animals	Mean Volume Removed (cc/kg)	Mean Volume Infused (cc/kg)	Infused Volumes Removed Volume
Whole Blood	9	37.8±5.3	52.1±20.8	1.37
Colloid/Cells	13	37.2±7.1	52.6±18.9	1.41
Saline/Cells	11	34.7±8.9	143.9±22.4	4.14



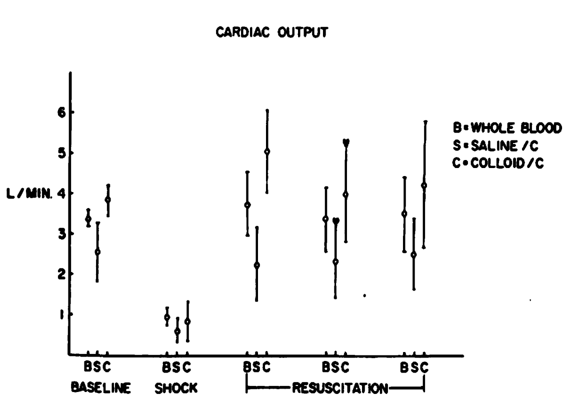


FIGURE 2a, 2b, 2c, 2d, 2e, 2f, and 2g: Mean value for eight circulatory indexes measured at selected sampling points. The bars indicate one standard deviation above and one standard deviation below the mean. In this and subsequent figures, the treatment groups are presented in the same order at each sampling point – B, whole blood, C, colloid, S, saline solution. The asterisks indicate the first sampling period following infusion of the shed red blood cells in the colloid and saline solution group.

It falls in shock, and at the end of the study, all values have returned to basal levels.

The cardiac output is seen in Figure 2d. The output falls in shock, as expected. With resuscitation it returns to control levels.

Pulmonary vascular resistance is shown in Figure 2e. The values go up in shock and then with treatment they come back to normal and are not different in any of the three groups. Also there are no differences from their basal values.

The changes in pH are seen in Figure 2f. In shock the pH falls. With treatment the groups separate. The saline group has a lower pH than either of the other two groups. This difference is related to excess chloride in isotonic saline.

A more direct way to look for defects in perfusion is the serum lactate level (Figure 2g). If saline was less effective in restoring perfusion to the cells, then it should be reflected in an inability of the cells to clear the elevated lactate level that was observed during shock. The data show that the lactate goes up in shock, but there are no differences between groups in the decline in lactate. By the end of the study there are no differences from control levels.

PULMONARY STUDIES

Figure 3 contains the experimental model. Lungs were excised at the end of study, or 24 hours later, and dessicated to constant weight. The amount of water in the lungs was then calculated. The first two groups (Figure 4), groups 1 and 2, are animals shocked and resuscitated with saline. Group 1 was sacrificed the day of the study and group 2 was sacrificed the day after. Groups 3 and 4 were treated with albumin and sacrificed the same day (group 3) or 24 hours later (group 4). For the numbers not to be significantly different from controls, the 95 percent confidence intervals must intercept the control interval. They do in each case, indicating no increase in lung water in any group.

Figure 5 shows the changes in the dead space to tidal volume ratio. That is, pulmonary edema should be reflected in a relative increase in dead space. We see that the confidence intervals intercept zero, so the dead space to tidal volume ratios at the end of the study with Ringer's or with albumin were not different.

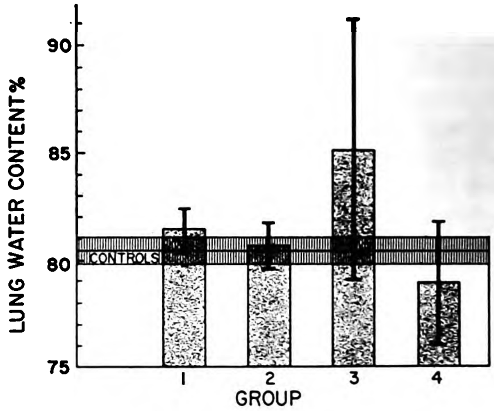


FIGURE 4: Mean value (±95 percent confidence interval) for control lung water content is represented by vertically lined strip. Group 1 portrays the mean value ±95 percent confidence interval for saline-treated animals sacrificed the same day; Group 2 represents saline-treated animals killed 24 hours after the study; Group 3 shows the albumin treated group sacrificed the same day; Group 4 represents albumin treated animals sacrificed 24 hours after the study.

Electron Microscopy Observations.

Figure 6 shows a cross section through an alveolar capillary region from the lung of a control baboon. Clear separation of the main components of the barrier can be seen. The endothelium forms an uninterrupted lining characterized by the presence of numerous, densely arranged pinocytotic vesicles distributed throughout the cytoplasmic processes of these cells. The alveolar wall is lined by epithelial cells which, in structure, are quite similar to the endothelial cells and posses similar thin cystoplasmic extensions. The cystoplasmic processes in either type of cell have a paucity of organelles. In the normal lung, the interstitium is narrow, and several distinct zones can be differentiated. Most of the area usually consists of the fusion of the basement membrane of the endothelial and epithelial layers. The minimal interstitial space measured about 800 Angstrom units and is most prominent where the capillaries come in closest contact with the alveolar area and where both alveolar capillary linings are thinnest. In other regions, the basement membrane of the endothelium and the epithelium are separated by extensions of fibroblast, which

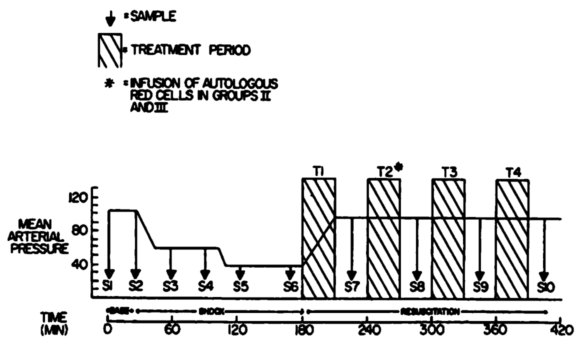


FIGURE 3: Schematic representation of experimental model. After 60-minute baseline rest period, shock induced by arterial hemorrhage and mean arterial pressure reduced to 60 mm Hg for one hour, then to 40 mm Hg for a second hour. Resuscitation during periods, T_1, T_3, and T_4 with one of the test solutions. Shed packed red cells returned during T_2. Blood and expired air samples, as well as measurements of respiration accomplished at points S_1, S_2, S_3, and S_4. Half of animals killed at point S_3 and remainder at S_4.

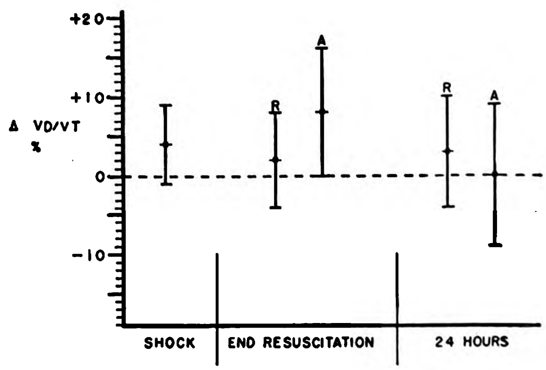


FIGURE 5: Change in dead space to tidal volume ratio. Baseline VD/VT was 44 ±4 percent. Shown is the mean change ±95 CI during shock and after resuscitation with either 5 percent albumin in Ringer's lactate (a) or Ringer's lactate alone (r).

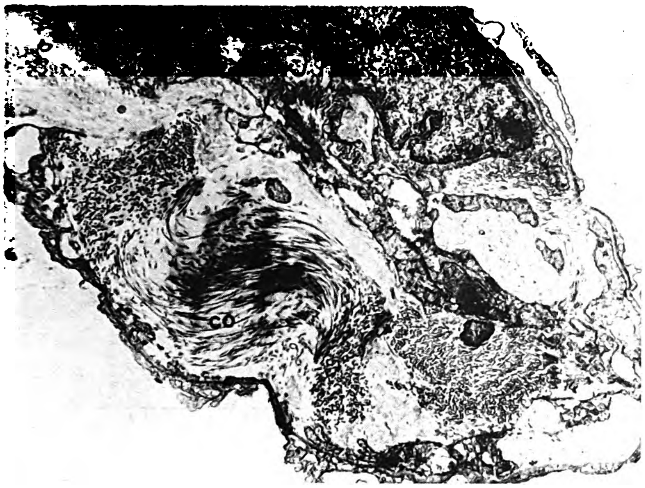


FIGURE 6: The thick portion of the alveolar capillary membrane is shown in detail. The endothelial and epithelial layers are separated by whorling bands of collagen fibers (CO). The distribution and disposition of collagen fibers are well seen. X6,480.

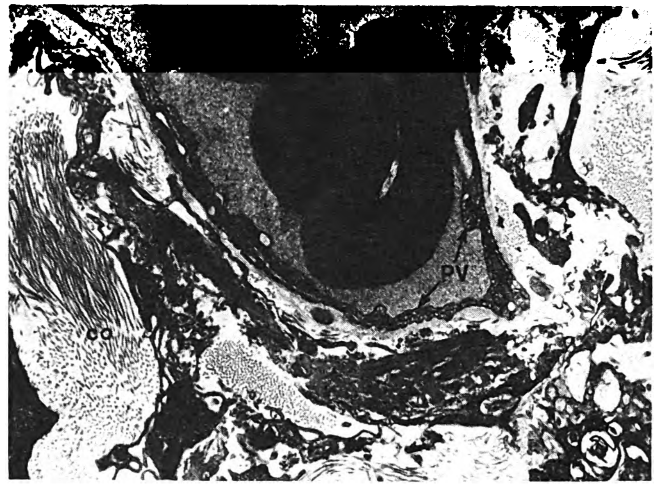


FIGURE 7a: The architecture of a baboon lung is shown after hemorrhagic hypotension. Note the marked increase in pinocytotic vesicles (PV) in the endothelial lining. Within the interstitium the presence of edema, osmophilic smudges and dispersion of collagen (CO) are evident. In the lower right, the cytoplasm of a granular pneumocyte is seen. No structural alteration can be found within the cell. X5,982.

makes the width of separation quite variable. In some other areas, the gap is filled primarily with collagen fibers and fibroblastic extensions as well. These wide areas usually contain larger and coarser collagen fibers. The interstitial collagen fibers are of special interest, because the earliest sign of interstitial edema is dispersion of these individual fibers.

Effects of Hemorrhage Shock.

Figure 7a shows the principal changes in lung structure after hemorrhagic shock. The development of interstitial edema and increased endothelial pinocytosis are the most important changes. Dispersion of the individual collagen fibers—an indication of interstitial edema—and increased endothelial pinocytosis are clearly evident. The smudged areas represent pools of edematous fluid. In Figure 7b, dispersion of the individual fibers is shown in greater detail.

Effects of Saline Solution Resuscitation (3, 4).

After saline solution resuscitation (Figures 8a–8d), there was a decrease in the number of endothelial pinocytotic vesicles, collagen fibers regained their packed periodic configuration, and the concentration of interstitial sodium precipitate declined to a prehemorrhage appearance. The only evidence of residual interstitial edema was the occasional presence of small, smudged areas. In none of the lung sections was there any evidence of the increased interstitial edema present in the shock state, and, in fact, most of these sections were indistinguishable from those of the control state. In contrast, in the albumin-resuscitated animals, the alveolar capillary membrane resembles the appearance seen in the shock state, i.e., a substantial degree of interstitial edema surrounding collagen fibers (Figure 9). The importance of this observation remains to be defined.

Discussion

The controversy regarding the types of fluid to use in the treatment of hemorrhagic shock is not new (5). In 1891, Lane treated a patient suffering from hemorrhagic shock with an infusion of saline solution. The patient recovered, and Lane thought he had found the remedy for shock. However, his conclusion was challenged by two physiologists, Sherrington and Copeman, who studied the changes in plasma specific gravity in rabbits and found that infused saline solution rapidly left the intravascular space. Thus began an interesting and important issue that is not yet settled.

Previous reports have focused this issue to a debate on the relative merits of various asanguineous fluids in early resuscitation from hemorrhagic shock, specifically saline solution versus colloid solution. We have searched for differences in circulatory parameters after resuscitation with either saline or colloid solution. Both asanguineous fluids were found to be equally effective in restoring circulatory and metabolic parameters.

A further objective of this study was to test the hypothesis that saline solution infusion in the treatment of hemorrhagic shock induces interstitial pulmonary edema. This hypothesis is based on Starling's Law stating that the net movement of fluid across semipermeable capillary membranes is governed

FIGURE 7b: Dispersion of individual collagen fibers can be seen in greater detail. At the left, the osmophilic smudges can be seen. X21,315.

The absence of evidence of pulmonary edema in this study after saline solution resuscitation is in accordance with the results of earlier physiologic studies carried out in our laboratory in the intact baboon. For example, we have found that dynamic lung compliance levels are not different from control values after saline solution resuscitation from hemorrhagic shock (6). In known states of pulmonary edema, lung compliance values fall as the lungs stiffen. In addition, measurements of alveolar arterial oxygen gradients are not increased after saline solution resuscitation. Pulmonary edema causes an increase in the gradient by enhancing ventilation perfusion imbalances. Furthermore, direct measurement of lung water content by desiccation techniques has failed to show evidence of increased pulmonary water content after saline solution resuscitation.

Summary and Conclusion

A séries of studies in baboons has been carried out comparing the effects of saline or colloid resuscitation. Both solutions effectively restore the circulation. Neither was associated with the development of pulmonary edema.

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VISCERAL PROTEIN MALNUTRITION

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I. Concept of Visceral Protein Malnutrition

We would like to introduce at this time the concept of visceral protein malnutrition. This entity is characterized by a generalized restriction in protein synthesis in the liver, gastrointestinal tract and pancreas. It has as its peripherally observable components: hypoalbuminemia, jaundice, slight elevation in SGOT and SGPT, hepatic glucose output not normally responsive to intravenous glucose in association with some degree of hyperglycemia, reduced plasma ketone bodies relative to a comparable degree of calorie restriction, and enhanced ureagenesis relative to starvation. This state, if prolonged, is eventually associated with multiple systems organ failures which as a first approximation, may also be considered to reflect limited protein synthesis. (1). The late gastrointestinal stress ulceration, but not the early, probably directly reflects the visceral protein malnutrition as does the observed alterations in pancreatic function, both exocrine and endocrine.

Visceral protein malnutrition appears to be largely secondary to an inadequate supply of a balanced mixture of amino acids and largely independent of calorie malnutrition. It does not occur with pure starvation in healthy man except terminally, but does occur with the chronically critically ill state. It therefore has its importance as an early warning sign of protein malnutrition which if left untreated leads to total body protein malnutrition and secondary multiple systems organ failure. Hypoalbuminemia has its importance under these conditions, not only because of its implication for colloid osmotic pressure and wound healing, but because of its being a commonly available test which gives an index of visceral protein malnutrition. The object in nutritional support is not just to raise the plasma albumin by exogenous albumin but to treat with amino acids the visceral protein malnutrition which produced the hypoalbuminemia and therefore the several other protein dependent activities of the liver and gut which are also restricted by visceral protein malnutrition.(1) It appears clear at this time that intravenous glucose, unless accompanied by the proper quantity of amino acids, will make the visceral protein malnutrition worse.(2) It also appears clear that the physiologic state in which the visceral protein malnutrition occurs alters the quantity of amino acids required, and does so by enhancing the quantity of balanced amino acids converted to glucose,(2) as well as by enhancing the requirement for branched chain amino acids, so that a balanced amino acid mixture for a well man is not a balanced amino acid mixture for a sick man. The second part of this alteration appears to be directly related to the rate of hepatic ketogenesis and carnitine synthesis and their effects on muscle energy metabolism.(3).

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II. Neuroendocrine Consideration

Our view is that the catabolic states associated with trauma and sepsis are normally characterized by their progress through a hypercatabolic state to a stress catabolic state and finally to a starvation catabolic state. The starvation catabolic state may then be converted by feeding, to an anabolic state with survival. This progress occurs in the absence of persistent organ failure and sepsis.(2)

The hypercatabolic state and the stress catabolic state, if they are short term, enhance the possibility of survival by sacrificing the unused muscles of ambulation for energetic and synthetic substrate.(2,3) In the hypercatabolic state which occurs acutely with trauma and sepsis and lasts as long as the elevated glucocorticoids, muscle protein is used not only for energy but also to induce a visceral hyperanabolic state by virtue of muscle releasing a complete mixture of amino acids in addition to the unbalanced mixture released for energetic substrate.(4) The hypercatabolic state enhances the circulation by direct sympathetic stimulation, while further supporting it by enhanced hepatic release of at least albumin and clotting proteins, and in addition providing an enhanced supply of glucose and ketone bodies from the liver and fatty acids from the adipose tissue. Thus the hypercatabolic state represents a maximal attempt by the body to supply all cells except muscle with enhanced energetic substrate at a time when teleologically this appears critical to survival.(2)

The stress catabolic state lacks the glucocorticoid response, and therefore the visceral anabolic component of the hypercatabolic response, but retains the energetic component related to muscle.(3) The distinguishing characteristic of the stress catabolic response is that it may last for a prolonged period because of persistent sepsis, pulmonary failure, subclinical circulatory failure, pain, anxiety and almost any organ failure. Because of its duration very large quantities of energy and nitrogen may be involved on a cumulative basis but not on a daily basis. The stress catabolic states may be divided on the basis of the systematic plasma insulin and its response to glucose into at least three categories: relative hyperinsulinemia, normoinsulinemia and hypoinsulinemia. These categorizations clearly exist. However, because of the interplay of compensating and decompensating factors produced by other neuroendocrine metabolic factors, it is at present very difficult to attribute very much just to changes in plasma insulin or even portal vein insulin. A better index is the insulin glucagon ratio as a function of plasma glucose. This is true not just because of insulin glucagon and glucose but also because the glucagon and glucose may also be utilized as general index of sympathetic nervous system activity in terms of direct innervation, while inhibited insulin response may be utilized as an index of plasma epinephrine and humoural sympathetic nervous system activity.(2)

There are, therefore, several gradations of the stress catabolic response on the basis of neuroendocrine response which are so distinct that they might better be categorized as separate stress catabolic states. Another way of categorizing the stress catabolic states is on the basis of energetic substrate considerations. This is much simpler but must eventually be related to the elements of neuroendocrine control.

III. Energetic Fuel Considerations

A consideration of energetic substrate relationships demands some knowledge of the various organs' requirements for energetic substrate. The brain can burn only glucose or ketone bodies. The adaptation to the use of ketone bodies requires time, a high level of plasma ketone bodies, and is only partial. The heart and respiratory muscle can burn almost any substrate but require carnitine for long chain fatty acid oxidation. The liver can burn almost any substrate for energy except ketone bodies. The gut can burn almost any substrate. In contrast to these organs, muscle has a very restricted ability to burn glucose and an almost obligatory requirement for long chain fatty acids or ketone bodies. The biochemical mechanisms are largely unknown but the vivo studies are clear.(3) Again, as with the heart and respiratory muscle, the oxidation of long chain fatty acids requires carnitine as a transport agent in order for the long chain fatty acids to cross the mitochondrial wall to produce ATP via the Krebs cycle. The utilization of ketone bodies by skeletal muscle for oxidative production of ATP is carnitine independent as it also is with the myocardium and respiratory muscle.(5) Skeletal muscle may utilize glucose either from the plasma or from its glycogen stores in the glycolytic cycle to produce ATP with corresponding production of lactate. Normally this occurs when ATP production by the mitochondria from fatty acids and ketone bodies is inadequate because of excessive consumption of ATP by exercise.

A. MUSCLE LIVER RELATIONSHIPS

Muscle therefore presents specialized requirements for energetic substrate relative to the rest of the body and interacts in a very special way with the liver, because the liver supplies both the carnitine required for long chain fatty acid oxidation and in addition supplies the ketone bodies required for oxidation in the absence of, or presence of inadequate, carnitine. Fortunately, muscle carnitine appears to have a half life in the range of 20 days, so that muscle carnitine changes are relatively slow, even if the liver completely stops producing carnitine. It appears to be this long time lag which permits survival in many cases. In the presence of carnitine, limited long chain fatty acid oxidation, and limited plasma supplies of ketone bodies, muscle may obtain ketone bodies for oxidation from leucine and isoleucine. These may be obtained either from other organs via the plasma or from the breakdown of muscle protein. Leucine and isoleucine are essential amino acids. Their consumption by muscle produces an amino acid imbalance in which all other amino acids are present in relative excess. A normal role of the liver is to clear amino acids present in excess for ureagenesis and gluconeogenesis, so that the systemic body is continuously presented with a balanced mixture of amino acids. This is modified when leucine and isoleucine are derived from muscle protein by the muscle amino acid enzymes, which may extensively interconvert amino acids. This activity of muscle allows many of the amino acids which become excessive by consumption of leucine and isoleucine to be transported from muscle to liver in the form of alanine and glutamine. There are clearly exceptions to this general rule. How extensive they are is difficult to judge. However, it appears clear that at least tryptophan and proline are not changed by muscle and are transported per se to the liver for degradation. Since tryptophan stimulates hepatic aggregation of ribosomes, and thus hepatic protein synthesis independent of its role as an essential amino acid, the muscle release of tryptophan is probably important in preserving hepatic protein synthesis under adverse conditions.

B. STARVATION MUSCLE LIVER RELATIONSHIPS

The muscle liver interrelationships therefore appear to be of considerable importance. In starvation enhanced hepatic output of ketone bodies and carnitine, by limiting muscles' consumption of leucine and isoleucine, limits hepatic amino acid gluconeogenesis and ureagenesis, while simultaneously presenting a balanced plasma concentration of amino acids to all organs for protein synthesis. This occurs because the rise in plasma ketone bodies is associated with a rise in plasma leucine and isoleucine relative to the condition without hepatic ketogenesis. In addition, the same change inhibits muscle release of other amino acids so that their concentration is properly regulated relative to leucine and isoleucine. Under these conditions organ protein synthesis is normally controlled by the neuroendocrine system, since the cells are supplied by the plasma with the proper building blocks.

C. MUSCLE LIVER RELATIONSHIPS–STRESS CATABOLIC STATE

This basic system may go awry with the stress catabolic states. How much it goes awry depends upon the hepatic output of ketone bodies and carnitine. The one extreme is the starvation catabolic state described. The other extreme is a complete absence of hepatic ketogenesis and carnitine synthesis. In the complete absence of hepatic ketogenesis, muscle will obtain ATP from long chain fatty acids to the extent permitted by muscle carnitine. Since hepatic synthesis of carnitine has ceased, the muscle carnitine may be expected to progressively fall, and therefore, the ability to oxidize long chain fatty acids will be progressively limited. In the absence of hepatic ketogenesis, this commonly implies a progressive increase in consumption of the two essential amino acids, leucine and isoleucine. This necessarily implies a fall in their muscle cell concentrations and therefore restricted muscle protein synthesis. It also implies enhanced release of the amino acids which are present in relative excess, and therefore enhanced hepatic amino acid gluconeogenesis and ureagenesis. The hyperglycemia produced limits long chain fatty acid mobilization as a source of muscle energy, independent of changes in carnitine. For awhile hepatic protein synthesis will be maintained because of the corresponding release of tryptophan which probably allows hepatic protein synthesis at lower plasma concentrations of leucine and isoleucine. This mechanism is probably aided by enhanced cellular transport of amino acids.

D. STRESS CATABOLIC STATE–MUSCLE BLOOD FLOW

To the extent that muscle is unable to generate sufficient ATP from leucine and isoleucine, the ATP may be expected to fall and the ADP rise. This will activate the glycolytic cycle, so that glucose may be consumed for ATP generation. However, it simultaneously will enhance production of lactate, ammonia, and other components, while restricting muscle consumption of oxygen. These are all well known muscle vasodilators. Therefore enhanced muscle blood flow, with reduced oxygen consumption and enhanced lactate production, will be observed. These are the characteristics of systemic arteriovenous shunting observed in such patients.(6) Further, since the agents are washed by the blood toward the venules, this mechanism of vasodilation would not affect arteriolar function and would specifically produce venular vasodilation. Therefore, when specifically stimulated the sympathetic nervous system could shut off such flow, and venous blood volume would have to be increased in order to obtain a given central venous pressure. This would explain two other characteristics such patients commonly have and account for the need at times for very large blood volumes in order to obtain a given central venous pressure. Finally, since ADP also produces platelet aggregation, this mechanism would account for the disseminated intravascular coagulation observed.(7)

E. MUSCLE LIVER RELATIONSHIPS—LIVER FUNCTION

In addition to the preceding changes the activation of the muscle glycolytic cycle would be expected to enhance hepatic lactate gluconeogenesis, and therefore hepatic blood flow and oxygen consumption. In effect, the muscle oxygen consumption deficit is transferred to the liver, so that total body oxygen consumption does not change. Under these conditions, one would observe an hepatic glucose output not normally responsive to intravenous glucose, because the basis of the enhanced hepatic gluconeogenesis is not regulation of plasma glucose, but clearance of an unbalanced amino acid mixture and control of plasma lactate concentration.(4) This characteristic would tend to induce the enzymes of glucongeogenesis which clearly have a high priority in hepatic protein synthesis and thus become a self perpetuating state. In addition it would be associated with restricted hepatic protein synthesis, because of the unbalanced amino acid mixture presented to the liver and the low concentrations of leucine and isoleucine.(1) The proteins synthesized would be only those with high priority. What this means at this time is difficult to say but it clearly includes reduced synthesis rates relative to physiologic demand for albumin, transferin, retinol binding protein and alpha 2 HS glycoprotein.(8)

F. MUSCLE LIVER RELATIONSHIPS—PROLONGED STRESS CATABOLIC STATE

With additional time, the consumption by muscle of leucine and isoleucine would be expected to limit protein synthesis generally throughout the body.(1) Again various priorities in protein synthesis would undoubtedly be preserved. However, this limited protein synthesis might include the amino acid enzymes within muscle, so that less of the amino acids made excess are transported as alanine and glutamine and more are released in the same form as produced by muscle protein breakdown. It might also include a decrease in hepatic amino acid enzymes, so that the liver is less able to clear the amino acids released by muscle. Thus, the observed rise in the plasma amino acids methionine, tryptophan, proline and phenylalanine might be expected to occur in association with the low leucine and isoleucine.(8) Further, since the same amino acid enzymes produce tyrosine from phenylalanine the fall in plasma tyrosine in association with high phenylalanine would be expected. These changes might eventually lead to sympathetic nervous system exhaustion.(3,7)

The rise in plasma tryptophan in association with the low leucine and isoleucine would be expected to enhance the brain neurotransmitter serotonin and thus lead to a lethargic to comatose state. Further, since the rise in plasma tryptophan is ultimately related to the fall in muscle carnitine the plasma tryptophan and long chain fatty acids would be expected to be tightly correlated as a function of time. This is also observed.(8)

G. PROLONGED STRESS CATABOLIC STATE—MULTIPLE SYSTEMS ORGAN FAILURE

Finally the generalized restriction in protein synthesis is probably characterized not only by decreased hepatic and muscle protein synthesis but also by decreased protein synthesis in other organs. This could therefore include late gastric stress ulceration, decubital ulcers, wounds that dehisce, inadequate granulation tissue formation in open wounds and areas of sepsis, skin donor sites that do not heal and skin graft sites where the graft does not take, lack of right ventricle myocardial protein synthesis in response to increased pulmonary artery pressure, decreased cellular immunity, and finally, decreased phagocytosis, particularly in the fixed phagocytes of the liver. There are many consequences of these changes. The one most commonly noted is that such patients are much more likely to have bacteremias with normally noninvasive organisms and have much greater difficulties in clearing such bacteremias.(1)

IV. Muscle Liver Relationships Therapeutic Manipulations

The preceding has discussed visceral protein malnutrition and its relationship to certain muscle-liver cycles and eventually to multiple system organ failure. In the first case, maximal hepatic ketogenesis and carnitine synthesis were allowed. This occurs with starvation. Under these conditions visceral protein synthesis is reduced but is still appropriate to physiologic need and visceral protein malnutrition does not occur. In the second case no hepatic ketogenesis or carnitine synthesis was allowed. This quickly produces visceral protein malnutrition in association with hyperglycemic glucose oxidative state.(8) The time required to reach a state of multiple systems organ failure largely depends upon muscle mass and muscle carnitine prior to the onset of the stress catabolic state.

Various clinical manipulations may also influence these inter-relationships. Thus intravenous glucose, by restricting hepatic ketogenesis, is particularly apt to accelerate the development of visceral protein malnutrition and multiple systems organ failure.(8) This occurs not only because it restricts hepatic ketogenesis, but also because if accompanied by an insulin response, it is apt to prevent amino acids from leaving the muscle to support hepatic protein synthesis, and to inhibit long chain fatty acid mobilization and therefore muscle oxidation of long chain fatty acids.

Intravenous amino acids with glucose, to the extent it stimulates hepatic ketogenesis and because they are directly cleared by the viscera, will stimulate visceral protein synthesis while limiting the use of leucine and isoleucine for fuel by muscle.(9)

The stress catabolic state in response to sepsis, pulmonary failure, circulatory failure and probably any severe stress has as hepatic characteristics restricted ketogenesis, enhanced hepatic gluconeogenesis, and probably reduced hepatic insulin clearance. Probably the restricted hepatic ketogenesis in major part produces the enhanced hepatic gluconeogenesis. However, there is probably also a component in which neuroendocrine modulation of hepatic functions causes more of all amino acids to be converted to glucose independent of induced amino acid imbalances.(2) It is clear under these conditions that the hyperglycemia which occurs is associated with a reduction in plasma long chain fatty acids.(8,9) This may be made worse by reduced hepatic insulin clearance with a rise in systemic plasma insulin but also occurs independently of changes in plasma insulin.(8,9) Other observations show that with time the muscle carnitine is reduced.(5) Thus under these conditions a gross reduction in available muscle energetic fuel occurs as plasma ketone bodies, plasma long chain fatty acids, and as tissue carnitine. These are precisely the conditions under which the most drastic systemic arteriovenous shunting is observed.(6) This shunting appears to be made worse by intravenous glucose and alleviated by intravenous amino acids.

The prolonged stress catabolic state therefore requires increased quantities of amino acids for therapy. In essence, one is providing exogenous leucine and isoleucine for oxidation in place of endogenous hepatic ketogenesis.(9) Unfortunately, with the present amino acid mixtures this means that more of all the other amino acids are supplied. This stimulates further hepatic amino acid gluconeogenesis and further inhibits hepatic ketogenesis and long chain fatty acid mobilization. However, if hepatic protein synthesis is sufficiently stimulated so that the excess amino acids may be properly cleared the patient will improve. If increased hepatic protein synthesis occurs in association with a rise in hepatic carnitine synthesis, then muscle may obtain energy from the plasma triglycerides which are synthesized in increased quantities under these conditions. The associated rise in insulin allows activation of lipoprotein lipase, which frees long chain fatty acids from the plasma lipoprotein triglycerides and thus provides muscle with long chain fatty acid fuel in the presence of low long chain fatty acids that occur in the post prandial state.(2) This is probably an essential condition to the successful use of standard hyperalimentation.

If the muscle carnitine cannot be increased, then all that can happen is that hepatic protein synthesis is stimulated, but muscle continues to consume leucine and isoleucine. If this occurs, the patient will improve in certain parameters related to hepatic function, but no other basic changes in the disease state will occur. Under these conditions, life will be prolonged but the patient will not survive.

A third possibility is that the liver is so gluconeogenic that hepatic protein synthesis cannot be achieved. This probably occurs with epinephrine restricted insulin secretion and is certainly associated with considerable hyperglycemia. Under these conditions the concentrations of all amino acids not utilized by muscle and specifically catabolized by the liver will rise. These amino acids will include methionine, tryptophan, phenylalanine, lysine, and several others. In addition, the amino acids specifically produced by the liver from other amino acids will fall. This certainly includes tyrosine. The resulting endogenous amino acid concentration imbalance is associated with the lethargic to comatose state, a severe generalized restriction in protein synthesis, and precedes death.(8,9)

Observations compatible with all the three preceding possibilities have been made.

PRACTICAL THERAPEUTICS

Intravenous glucose is far cheaper than intravenous amino acids. The elemental diets are far cheaper than the intravenous hyperalimentation and provide the advantage of much more effective therapy for visceral protein malnutrition. Since intravenous hyperalimentation suppresses hepatic ketogenesis it can only work if it stimulates hepatic carnitine synthesis, hepatic lipoprotein synthesis, and muscle tissue lipoprotein lipase, so that muscle may obtain energy from the plasma triglycerides. The most effective way of stimulating these entities is probably to begin with intravenous amino acids without glucose. This has the additional advantage of helping to clear hepatic fat by stimulating hepatic lipoprotein synthesis and thus stimulating hepatic circulation while reducing portal vein pressure and ascites.(2) Finally the duration of time man can stay on pure intravenous glucose without significant harm is largely related to his muscle mass. Resuscitation from shock requires intravenous glucose.

Thus in practical therapeutics glucose is generally required for resuscitation. The muscular person may be left on intravenous glucose for five to seven days without significant harm if he is doing well. This sort immediately eliminates most patients at the least possible cost. In contrast, the previously malnourished individual with poor muscular mass or the patient with good muscular mass who is obviously going to have a prolonged course should be placed on isotonic peripheral amino acids shortly after resuscitation. This is particularly true if sepsis is already present or there is extreme risk of life or limb threatening sepsis. It is probably also true of the patient with pre-existing cirrhosis.

The duration of time that support with intravenous isotonic amino acids can be allowed largely depends upon the mass of fat and the ketonemia which occurs. Ketonuria may easily be checked in such patients. Its appearance and persistence suggests strongly that all is going well. The plasma glucose measured on this regime may be surprisingly low without signs of cerebral hypoglycemia. It is clear that our present normal values of plasma glucose of 75 to 125 mgm per 100 ml are hyperglycemic. The true normals are lower, but how much lower is poorly defined. Values of 40 to 50 mgm per 100 ml are commonly observed in starvation. At times values down to 25 are observed without signs of cerebral hyperglycemia.(10)

The preceding isotonic amino acid requirement provides somewhat more than 1 gm/kgm/day of protein equivalent. The disappearance of ketonuria on this regime is associated with hyperglycemia and the appearance of a significant organ failure. This is most commonly sepsis but may also be pulmonary or circulatory failure, severe pain and anxiety, renal failure or probably any life threatening crisis. The first maneuver in response to the disappearance of ketonuria is therefore diagnostic and primary treatment of the organ failure. When this has been vigorously undertaken the quantity of amino acids per kilogram may be increased from 1 gram/kgm/day to 4 to 6 grams/kgm/day. This is done in an attempt to further enhance visceral protein synthesis while providing additional leucine and isoleucine for use by muscle. If the patient remains in this state for more than 5 to 6 days without improvement, it is probably wise to add the elemental diet via the gastrointestinal tract as a further stimulant to visceral protein synthesis. This may be done even in the patient with an ileus if a Cantor tube is passed to the jejunum and a nasogastric tube placed in the stomach on suction. The elemental diet may be delivered to the jejunum which has motility, while the stomach with its tendency to acute gastric dilation and subsequent air fluid distention of the small intestine, is maintained on suction. This route has the advantage of specifically stimulating gastrointestinal mucosal protein and hepatic synthesis while interposing all the normal hepatic controls to entry into the systemic body. It has the disadvantage of further inhibiting hepatic ketogenesis but is used under conditions where this has already been largely shut off. However, it does prevent the use of the reappearance of ketonuria as a good sign.

These two measures together have allowed patients to survive whom we would not have expected to survive before.

Intravenous hyperalimentation under our schemata is reserved for the patient with organic bowel dysfunction or the patient in whom we cannot introduce a jejunal tube for use of the elemental diet. The use of intravenous hyperalimentation is always preceded by a period of a few days of isotonic amino acids. This may be continued so long as there is a good ketonuric response, the patient appears to be doing well, and there is a good fat mass on board. The patient who is cachetic is started on isotonic amino acids but transferred to intravenous hyperalimentation or the elemental diet within two to three days. Granted this underlying schemata, intravenous hyperalimentation is used much less commonly than a few years ago. The use of intravenous hyperalimentation proceeds by steps. Most such patients placed on standard hyperalimentation do well if their sepsis and all ancillary organ failures are vigorously treated per se. For those in whom this cannot be achieved, we decrease the amount of glucose and increase the amount of amino acids so the calorie to nitrogen ratio is decreased, while the protein per kilogram is increased and the total calories are not greatly changed. Standard hyperalimentation provides approximately 150 calories/gram of nitrogen with 3000 calories and somewhat less than two grams of protein per kilogram per day. For the patient who is not doing well on standard hyperalimentation, we increase the protein to a range of four to six grams per kilogram per day and attempt to reduce the calorie to nitrogen ratio from 150 to the range of 50 to 75. This is done to provide more stimulus to visceral protein synthesis and hepatic carnitine synthesis while providing more neucine and isoleucine to muscle.

There is another category of patient which must be briefly discussed. These are the patients who are lethargic, who half eat, and commonly have decubital ulcers. These patients, if they are placed on isotonic peripheral amino acids while allowed to continue eating, commonly wake up and eat much better. When continuing their amino acids while allowing them to eat we have been very much impressed with the way in which their decubital ulcers begin to granulate and commonly heal without skin grafting. It would appear that these patients are suffering from visceral protein malnutrition with a lethargic state secondary to a high tryptophan and a low leucine and isoleucine which is corrected by exogenous amino acids.

Summary

The concept of visceral protein malnutrition as a precursor to multiple systems organ failure and its relationship to important muscle liver cycles provides a significant improvement in the rationale of nutritional support of the chronically critically ill patient. It allows a rational understanding of many apparently unrelated observations in such patients based upon known normal inter-relationships in normal man. It predicts all of the variations observed so far in chronically critically ill man. An understanding of the underlying pathophysiology and the ways in which it may be altered therapeutically has allowed us to keep alive patients who previously we would never have expected to survive. These are such difficult and unusual patients that it is highly unlikely controlled studies can ever be performed. However, the detailed sequential observations we have made on approximately 20 such patients are consistent with the pathophysiology described. These will be published separately.

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THE "VIP" APPROACH TO THE BEDSIDE MANAGEMENT OF SHOCK

Max Harry Weil, M.D., Ph.D., and Herbert Shubin, M.D.

The most useful concept which has emerged from the work of the shock units is the need for a systematic approach to the routine management of shock, regardless of cause. Since treatment cannot be delayed and yet diagnosis is essential, an orderly sequence of maneuvers is needed by which diagnostic insights are gained by the physician as treatment is carried out.

We propose a method, based on a three-letter mnemonic, VIP, for ensuring such an orderly sequence of therapeutic-diagnostic maneuvers. *VIP* refers to ventilation, infusion, and pumping, in that order. A postscript, PS, has been added to refer to fourth and fifth elements of therapy. *P* refers to pharmacological or drug treatment. Examples of this fourth element of management include the administration of vasopressor and vasodilator drugs, corticosteroid hormones, and other agents for the purpose of improving perfusion. *S* refers to specific or surgical management. Examples of the fifth element include relief of cardiac tamponade by pericardiocentesis; incision, drainage or excision of grossly infected tissue which may be the cause of bacterial shock; and surgical management of vascular obstruction due to an embolus or dissecting aneurysm.

In this context, application of a standardized technique of fluid challenge uses the PAWP or CVP measurement to guide both the *I* and *P* priorities of management. Neither CVP nor PAW of themselves indicate hypovolemia.

Aliquots of between 50 and 200 ml of crystalloid fluid (isotonic saline or dextrose solution) or colloid (5% albumin solution) are administered in a systematic manner and changes in these pressures during and after infusion are assessed. Pulmonary artery wedge pressure, or alternatively, pulmonary artery diastolic pressure (PADP) measurements are obtained during a 10 minute observation period. Fluid is then administered through an intravenous route other than that used for pulmonary artery or central venous monitoring. If the PAWP or PADP is less than 11 torr the fluid is infused at a rate of 20 ml/min for a period of 10 minutes. If PAWP or PADP ranges from 11 to 18 torr, 10 ml/min are administered; when it is greater than 18, we employ fluid challenges of 5 ml/min. If, during infusion, the PAWP or PADP increases at any time by more than 7 torr above the initial pressure and remains at this level for more than one minute, the infusion is discontinued. When the pressure increases more than 3 torr but less than 7 torr, infusion is discontinued at the end of 10 minutes. In most cases, the PAWP or PADP will decline to within 3 torr of the starting pressure. If this occurs, an additional aliquot of 200, 100 or 50 ml of fluid is administered over the next 10 minutes. The process is then repeated until the pressure values during any one 10 minute challenge increase to greater than 7 torr or increase by more than 3 torr without decline during the 10 minute waiting period. Usually, several liters of fluid may be required to restore effective circulation. A comparable 5,2 rule is used when central venous pressure is monitored. The full attention of a well trained physician or nurse clinician should be committed for purposes of fluid challenge.

Suggested Readings

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SECTION III
Trauma Management General Considerations

INTRODUCTION

Oscar P. Hampton, Jr., MD., F.A.C.S.

This section deals specifically with physician management of the injured. It includes discussion of initial evaluation of the patient as a whole, measures to be provided promptly particularly for the critically injured and special problems encountered in children, patients with massive burns, multiple injuries and sepsis as a complication following injuries. In addition, anesthesia and problems of cardiopulmonary resuscitation for injured patients is discussed. The faculty are internationally recognized as experts on their respective subjects.

This session, the second in a series of three on Trauma Management, is a natural sequel to the first session on Basic Considerations and a natural predecessor to the third session in which management of injuries to the various body systems or anatomical parts will be covered.

Those of you fortunate enough to attend the three sessions - surgeons, other physicians, nurses who work in critical care units, operating theaters or emergency departments and allied health personnel — will have been treated to a superior continuing education program on Trauma Management as an important part of the emergency medical services system.

ANESTHESIA FOR THE TRAUMATIZED PATIENT

A. H. Giesecke, Jr., M.D. and J. F. Lee, M.D.

To consider anesthesiology and its role in the care of the trauma patient is appropriate at this time. *Life* magazine, in its bicentennial issue, listed 200 American developments which most influenced the course of the world's history. Two of these developments were related to medicine. The first was the public demonstration of the anesthetic efforts of ether in Boston on October 16, 1846, and the second was the development of a vaccine for poliomyelitis.

The first use of anesthesia for the surgical treatment of battlefield casualties was at the battle of Buena Vista in the Mexican-American War in February, 1847. Ether and chloroform by open drop technique dominated the practice of anesthesiology for the next 80 years. A new era began with the use of ultrashort acting barbituates in 1934. Nonflammable, nonexplosive anesthesia became widely available when halothane was introduced in 1956. A variety of nonflammable anesthetic drugs and an amazing proliferation of electrical gadgets for use by the surgical team have followed in the last 20 years. This phase of the history of anesthesia is about to close due to the demonstration of some visceral toxicity associated with the halogenated agents. The opportunity will exist in the next few years to begin a new era in anesthesia. I cannot predict what form it will take because so many social, technologic, scientific and ethical forces must impact on it and modify its shape.

Although the equipment and the drugs of future anesthesiologists cannot be accurately predicted, the traumatized patient will form a large share of his practice for many years to come, because the massive intellectual and financial efforts to solve atherosclerosis and cancer are bound to bear fruit and trauma will emerge as the nation's leading cause of death.

The anesthetic management of the severely injured patient is a multifaceted problem. The traumatized patient may present any or all of the following magnified complications which distinguish him from the elective patient:

(1) lack of comprehensive preoperative evaluation; (2) airway problems; (3) multiple injuries; (4) alcohol intoxication; (5) full stomach; (6) shock.

These complications will exert considerable influence on the ultimate prognosis of the trauma patient and will be considered separately.

Preoperative Evaluation

Frequently the urgency of trauma surgery precludes a comprehensive preoperative history physical exam and laboratory workup. Civilian trauma, in contrast to military trauma occurs in a cross-section of the population and involves the extremes of age and people with the whole host of human afflictions. The morbidity and mortality of trauma can be directly related to preexisting state of health. In an analysis of 1161 anesthetics in acute trauma in 1964, the overall mortality rate was found to be 5.34 percent. However, patients with preexisting cardiovascular disease died at a rate of 10.4 percent. Those with preexisting central nervous system disease had a 9.3 percent mortality. Those with multiple systems disease had a mortality of 9.2 percent. A history of preexisting diseases, allergies or the nature of chronic drug therapy must be sought even in the severely injured, unreliable patient. Cardiovascular compensatory mechanisms may be severely impaired by the combination of previous drug therapy, severe trauma and anesthesia.

Airway Problems

One significant prerequisite in the successful resuscitation of the traumatized patient may be prompt establishment and maintenance of the airway. During the acute phase of traumatic emergencies, this prerequisite may be met by oral or nasal intubation or tracheostomy. Preoperative tracheostomy has definite indications and is not a panacea for all respiratory problems. As a rule, preoperative tracheostomy is required in patients with fractures of both mandibular condyles and the symphysis, in combined mandibular and maxillary fractures, and in patients in whom tracheal intubation is technically impossible. Otherwise, an oral or nasal tracheal intubation is preferable, because intubation is more rapid and less traumatic than a tracheostomy. An immediate, frantic tracheostomy should be a rare necessity and may be deferred. If indications persist, tracheostomy is performed in a more orderly manner over the endotracheal tube. Intubation should be done under direct vision with a laryngoscope, so that loose fragments of bone, teeth or tissue will not be carried into the trachea by the advancing endotracheal tube. If the intubation is performed under vision these loose fragments can be removed with forceps as they are seen, and blood and mucous can be suctioned away leaving a clear unobstructed path for the tube.

On the patient's arrival in the operating room three basic problems require rapid appraisal and control: (1) The adequacy of ventilation based on the estimation of tidal volume, breath sounds, skin color and chest movements. (2) The adequacy of circulating volume evaluated from pulse rate, blood pressure levels and urine output. (3) The status of the heart may be assessed by the use of continuous cardioscopic and central venous pressure monitoring.

The patient should be oxygenated by mask, allowing time for placement of intravenous infusions, further appraisal of the patient's status, and protection against hypoxia during induction. Preoxygenation may, however, be impossible in patients with traumatic distortion of the face and neck, airway obstruction from blood or debris, or where the urgency of the surgical emergency precludes the time required. If general anesthesia is selected for the emergency repair of trauma, tracheal intubation is necessary to facilitate control of ventilation and to protect the airway. After consideration of the preanesthetic condition, the patient may be intubated awake, or following rapid induction.

Induction of anesthesia is probably the most hazardous time in the anesthetic period. During this time, hypotension, hypoxia, arrhythmias and vomiting are prone to occur. The patient in hypovolemic shock or with CNS depression has a reduced perception of pain and memory. Awake intubation may avoid many dangers which may occur on induction of anesthesia, is generally easily performed and is far less distressing to the patient than most physicians anticipate. Use of topical anesthesia will facilitate awake intubation in the more alert patient with a full stomach or hypotension. Evidence confirms that intubation with topical anesthesia is a safe procedure in the patient with a full stomach, although the theoretical possibility exists that aspiration could occur due to reduced sensitivity of laryngeal tissues.

Intubation under general anesthesia will require consideration of other factors such as restoration of circulating volume and identification of associated injuries of the cervical spine, thorax or abdomen. The stomach should be decompressed with a nasogastric tube prior to induction even though several hours have elapsed since the last meal.

Rapid intravenous induction is accomplished by injection of a small dose of d-tubocurarine (3 mg) followed in 2 to 3 minutes by a thiobarbiturate (100–300 mg) and a full-paralyzing dose of succinylcholine (60–120 mg). Diazepam (10–20 mg) or ketamine (50–100 mg) may be substituted for thiopental depending on the patient's condition. A cuffed endotracheal tube is inserted when paralysis is complete. The lungs must not be manually ventilated until the endotracheal tube is in place and the cuff inflated. Only when intubation has been unsuccessful and hypoxia must be prevented or treated, can manual ventilation of the lungs under the mask be condoned.

As soon as the patient loses consciousness, an assistant exerts firm backward pressure on the cricoid, compressing the esophagus between the broad, flat posterior aspect of the cricoid and the body of the sixth cervical vertebra. In this way, gastric fluids are prevented from entering the pharynx from below. Cricoesophageal compression must be maintained from the injection of the thiobarbiturate until the endotracheal tube cuff is inflated and the airway is secure.

Having secured the airway, ventilation is established with special attention to the following points:

1. Adequate respiratory exchange is provided to maintain oxygenation and prevent atelectasis.
2. Respiration is controlled in order to reduce the diversion of cardiac output to the work of breathing.
3. Respiratory adequacy can be monitored by blood-gas analysis to assure that pH, P_aCO_2 and P_aO_2 are in a normal range.
4. Careful attention is given to the breath sounds because pneumothorax may develop quickly in the anesthetized traumatized patient.

The endotracheal tube may be left in place as long as 48 hours to support ventilation or maintain the airway until the patient can satisfactorily perform these functions. Meticulous care is as important for the indwelling endotracheal tube as for the tracheostomy. Complications of long term intubation are very similar to those of tracheostomy. Reported in the literature and frequently seen clinically are obstruction from cuff slippage; cuff overinflation; kinking or inspissated secretions; erosions; laryngeal granulomas; ulcerations, tracheoesophageal fistulae; and infection from maxillary sinuses to the alveoli. Post-intubation granulations are rate complications, but meticulous care by physicians and nursing staff is the key to their prevention, including complete humidification of the inspired atmosphere, frequent suctioning with sterile catheters and periodic instillation of mucolytic agents such as actelycystine.

In the desperate asphyxial emergency from supraglottic obstruction, oxygenation can be established by insufflating oxygen at a high flow through a 15-gauge needle inserted into the larynx via the cricothyroid membrane. This procedure will allow an orderly approach to establishing an adequate airway by tracheal intubation or by tracheostomy. Many recent developments have improved a trauma patient's chances of survival with respiratory obstruction. In the field, the use of the esophageal airway by the EMT's, and evacuation of the unconscious injured in the lateral or prone position have saved many lives. In the hospital, catheter-guided endotracheal intubation and fiberoptic intubation have made intubation possible in cases which were previously felt to be impossible.

Multiple Injuries

Problems arise in determining priorities for operative intervention when injuries involve multiple areas. In patients with head injuries, the associated injuries of the abdomen, groin, axilla or neck may compel initial consideration. One must, however, be alert to changes in the patient's neurologic status during the course of anesthesia. The pupils may be the best indicators. Conversely, if the head injury is the primary target of the surgical effort, the anesthesiologist should be alert for the progression of associated trauma such as pneumothorax, hemoperitoneum and cardiac tamponade. Shock is rarely a manifestation of head injury, and its occurrence in the presence of head injury should lead one to suspect injuries in other areas. Unusual diagnostic skill may be needed to define the appropriate associated injury, the effects of which are manifest only after a surgical procedure is progressing in another area. For example, hemorrhage from a torn spleen or liver may be minimal and compensated as an operation to correct extremity trauma begins. The occurrence of shock, as the procedure progresses, may compel an accurate definitive diagnosis and proper corrective surgery. Under these circumstances, treatment with osmotic diuretics, vasodilators, vasopressors, or other drugs used as adjunctive therapy of shock will influence the vital signs and confuse the diagnosis.

Alcohol Intoxication

Animal studies have given the impression that the manifestations of shock are more severe in intoxicated specimens than in sober ones. Efforts to confirm this impression in humans have been unsuccessful. The morbidity and mortality of patients with blood alcohols less than 250 mg% do not seem to be adversely influenced with the exception that preoperative respiratory complications are higher in the intoxicated group. Intoxication with substances other than alcohol in relation to anesthesia has not been well studied, although anesthetic depth is potentiated by marijuana intoxication and antagonized by acute amphetamine intoxication. The acute pulmonary edema associated with heroin abuse can present the anesthesiologist with severe problems. Severe and even fatal drug withdrawal syndromes which occur in the postoperative period may complicate the care of the patient in the recovery room and intensive care unit. Hepatitis, endocarditis and malnutrition may also complicate the convalescence in the drug-abusing traumatized patient. The following suggestions should be heeded in dealing with intoxicated traumatized patients. Blood replacement should be early and complete. Fluid therapy should be adequate to maintain good urine flow. Glucose (150–200 gm/d) should be given to prevent hypoglycemia. In the selection of anesthetic drugs the anesthesiologist should be aware that hepatic biotransforming enzymes have probably been induced. Patients may be mentally tolerant to depressant drugs but have normal sensitivity in the cardiovascular respiratory or renal systems, hence an adequate dose for the brain may produce hypotension. Temperature should be carefully monitored.

Full or Non-Emptied Stomach

The primary hazard of the full stomach is vomiting and aspiration of the vomitus. Shock, anxiety, abdominal or central nervous system trauma may cause peristalsis to cease at the time of the accident. Therefore the time elapsing from the last meal to the accident is more important than the time from the last meal to the induction of anesthesia; whenever possible, the induction of anesthesia should be delayed until it is certain that the stomach is empty. When delay of a surgical procedure is not feasible, regional anesthesia should be selected for these patients. However, regional analgesia is contraindicated in patients having hypovolemia and is technically contraindicated in agitated, intoxicated patients. Awake intubation and the rapid controlled induction with cricoesophageal compression are alternatives when the induction of general anesthesia is mandatory.

In spite of these precautions the occasional patient will aspirate gastric contents either before, during or after anesthesia. Aspiration of vomitus generally assumes one of two clinical pictures. First is aspiration of undigested food particles resulting in respiratory obstruction and distress. Depending on the amount of material aspirated, patients may have acute fulminating respiratory distress, with cyanosis and cardiac arrest or a milder more chronic course leading to labor pneumonia and lung abscess. The findings are usually localized to an area of the lungs. A second form, results from aspiration of liquid gastric secretions which are acid and cause a chemical pneumonitis. This form of aspiration is probably more common and is just as hazardous in terms of morbidity and mortality. The primary manifestation is generalized bronchospasm, labored respirations and cyanosis. The hypoxia may lead to cardiac arrest. Therapy of the acute episode includes endotracheal suctioning, and intravenous anti-inflammatory steroid, and ventilatory support with increased inspired oxygen concentration. Bronchoscopy is probably indicated only if the patient has aspirated food or other foreign matter. Tracheobronchial lavage with warmed saline solution to dilute the acid aspirant is recommended by many authorities, but its efficacy and safety remain controversial. A preinduction dose of antacid has been recommended prior to induction of anesthesia in obstetrical patients but its use in trauma patients is yet to be defined.

Shock

Manifestations of hypovolemic shock were present in eight percent preoperatively and 12 percent intraoperatively of a series of 1161 patients requiring emergency surgical correction of traumatic injuries. The simultaneous infusions of type specific whole blood and balanced salt solutions (BSS) are recommended for the resuscitation of patients in hypovolemic shock. The volume of infusion must depend on the estimated blood loss and the severity of trauma.

BSS are infused to correct the deficit in functional extracellular fluid (FECF) volume which has been demonstrated to occur in hypovolemic shock and severe tissue trauma. The efficacy of this form of therapy has been confirmed by numerous reports involving both experimental shock in animals and hemorrhagic shock in man. However, differences of opinion exist regarding the validity of the experimental techniques used to demonstrate the FECF deficit. Some investigators have been unable to support the concept of selective FECF deficit in hemorrhagic shock or operative trauma and have warned against unwarranted infusion of large amounts of salt containing solutions particularly in elderly patients with cardiovascular, hepatic or renal disease. The following principles are used as guidelines to the rational and moderate approach: (1) BSS are not a substitute for whole blood. Whole blood, or its equivalent in component therapy, is still the primary therapy for blood loss and shock. (2) Blood should be given whenever losses exceed 20 percent of the estimated blood volume. (3) BSS are intended to replace FECF which is functionally sequestered as interstitial or intercellular edema. (4) Our practice is to give lactated Ringer's solution to hypotensive emergency room patients while type specific whole blood is being obtained. During surgery, blood loss is replaced with blood plus lactated Ringer's solution at seven to 15 ml/kg/hr. The quantity depends on the general condition of the patient, the severity of tissue injury and the area of peritoneum or pleura exposed. Patients with cardiac or renal disease deserve special consideration and care in fluid therapy, although in general they tolerate a mild overload better than a mild deficit. (5) Intravenous infusions should be warmed to avoid myocardial hypothermia and irreversible cardiac arrhythmias. Warming of blood will also reduce the concentration of potassium in the plasma and to some extent reverse the acidosis of banked blood.

Other important considerations for the care of hypovolemic shock include the following, although not necessarily in the order in which they are listed: (1) Calcium gluconate may be given to antagonize hyperkalemia, to prevent citrate intoxication and to strengthen the force of myocardial contractions. (2) Sodium bicarbonate may be given to correct the acidosis produced by anerobic metabolism and infusion of acidotic blood. (3) Steroids in large doses may be given although their efficacy is not firmly established. (4) Vasodilators are felt by some to offer protection to the microcirculation during the low flow state as well as reduction in cardiac work. Chlorpromazine and phenoxybenzamine are currently the most popular drugs for this purpose.

The pharmacologic treatment of shock including vasoconstrictors, steroids and diuretics should be relegated to a secondary role following sincere efforts to correct ventilation and volume. Having accomplished these goals, if evidence of severe vasoconstriction persists, vasodilators may be helpful.

Choice of Anesthetic

The patient with severe hypovolemic hypotension will be apathetic or unresponsive to painful stimulus or to spoken questions and commands. He will have a weak or imperceptible pulse and blood pressure, cold-blanched skin, dry conjunctivae, dilated pupils and gasping respirations. This patient needs no anesthetic agent at all. An endotracheal tube should be inserted without anesthesia and ventilation should be established with oxygen. As the bleeding is controlled surgically and circulating volume is restored, the patient's responsiveness may return. Anesthetic agents can then be added to the inspired oxygen. Care must be exercised to distinguish pain from hypovolemic anxiety or hypoxic delirium. Premedication should be minimal, and should be given slowly by the intravenous route. The low flow state associated with hypotension may result in delayed effects of subcutaneously administered drugs. Barbiturates may precipitate maniacal behavior in the injured patient, and narcotics may depress respirations and increase intracranial pressure, undesirable in the patient with head injuries.

Regional anesthesia was used in 15 percent of the 1161 patients in our 1964 survey. In selected patients regional anesthesia is extremely safe and effective. However, regional anesthesia should not be selected for the drunk, combative, hypoxic or excited patient. In such cases the technique is doomed from the start, and the failure serves only to crystallize opinion against regional anesthesia in traumatized patients. Spinal anesthesia should not be used in the hypovolemic patient as venous pooling from sympathetic paresis will result in dangerous hypotension.

General endotracheal anesthesia usually provides good operating conditions. Control of airway, ventilation and oxygenation is more easily assured. The choice of agent or combination of agents is largely academic. Ultrashort acting barbiturates should be used with great care as cardiovascular collapse may be rapidly precipitated by even very small amounts in the presence of shock or compensated shock. The use of halothane in the hypovolemic patient is subject to controversy. A commonly used technique is nitrous oxide, oxygen, relaxant and controlled ventilation. It should be remembered that complete suppression of sensation is not necessary and may be dangerous if achieved by deep anesthesia. Extensive surgical procedures may be accomplished in analgesic planes of anesthesia, supplemented by judicious use of muscle relaxants.

Monitoring for Trauma Patients

Blood pressure, pulse, skin color, capillary filling time and pupil size should be monitored during all anesthetics. In addition, the central venous pressure should be monitored to detect early cardiac failure and overload with colloid solutions such as blood or dextran in severely injured patients or those with a history of heart disease. The hourly urine output should be monitored to determine the efficacy of fluid therapy. The urine output should be at least 50 ml./hr. if the extracellular fluid volume is being adequately replaced with a balanced salt solution and the patient is not in renal failure.

Postoperative Management

The manifestations of multiple traumatic injuries may not all appear at the same time. Following successful operative correction of damage in one or more areas, the patient must be observed for evidences of injury in other sites. The usual principles of good recovery room care must be applied. These include oxygen by mask, at least until the patient is awake and oriented, frequent position changes, deep breathing and coughing, chest physiotherapy, frequent monitoring of the blood pressure, pulse rate, adequacy of ventilation, urine output, fluid infusion and gastric suction. The progressive state of emergence from anesthesia and external evidences of continued or recurring blood loss should be noted.

Summary

The importance of trauma as a cause of death and disability in our society is increasing daily. The trauma patient presents challenges in establishment of adequate ventilation, resuscitation of shock, diagnosis of associated injuries and evaluation of pre-existing medical conditions. The patient's prognosis depends on how well these challenges can be met in the time available prior to surgical correction. The choice of anesthesia varies from the use of oxygen alone for the patient who is unconscious from shock, central nervous system trauma or alcohol intoxication to the full range of anesthetic agents for the patient in whom homeostasis has been completely corrected. In spite of the controversy over fluid therapy, simultaneous infusions of type specific whole blood and a balanced electrolyte solution probably represent the most effective primary therapy for hypovolemic shock.

Acknowledgement

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CARDIOPULMONARY RESUSCITATION IN SEVERE TRAUMA

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In 1961 Van Wagoner, reporting a three year study of deaths following trauma, concluded that one out of six (96 cases) would have had an excellent chance of survival had a prompt diagnosis been made on admission and adequate treatment instituted.[1] In an analysis of 159 deaths following motor vehicle accidents Frey concluded that 28 (17.6 percent) were probably salvageable had appropriate resuscitations therapy — endotracheal intubation, relief of tension pneumothorax, intravenous fluid therapy — been available early in the course of their management, at the scene in 12, during transit in 11, and in hospital in 2 patients.[2] Gertner et al reporting on 33 highway deaths in which the main injuries were intra-abdominal, estimated that half of these might possibly have been salvaged by prompt and proper diagnosis and aggressive treatment.[3]

In the State of Maryland in 1969 there were 799 fatalities the result of motor vehicle accidents. Five hundred fifty-seven of these deaths occurred in rural counties, a rate four and a half times greater than in the urban counties (Table 1) which closely agrees with the figure reported in California by Waller and with the national figures.[4] Some have attributed this gross disparity to the inadequacy of the medical resources of rural areas to meet the needs of major trauma, while others have pointed to the type of accident and the increased severity of the trauma. The obvious delay, necessitated by distance, in reaching victims and in transporting them to medical aid is

TABLE 1. Maryland Motor Vehicle Accidents — 1969

	Injured			Deaths		
	Carried from Scene	Total	Rate per 100,000 Population	Total	Rate per 100,000 Population	Case Fatality/ Accident Ratio
Baltimore City	9,237	17,211	1,900	128	14.3	.0074
Urban Counties (Excluding (Baltimore City)	5,176	14,664	611	114	4.75	.0082
Rural Counties	10,089	25,272	2,751	557	60.6	.022

Source — Accident Records Division, Maryland State Police

still another factor which must play a role.[5] In Vietnam, Army aeromedical evacuation assured that no soldier was more than 35 minutes away from a facility capable of providing immediate, resuscitative life-saving treatment. In 1966, Congress, in recognizing the need for action in highway accidents, identified the helicopter as providing the superior means of transportation.

The Maryland Institute for Emergency Medicine was opened in 1969, dedicated to the reception, resuscitation and management of critically ill and injured patients. In 1970 a helicopter evacuation program (Med-Evac) was introduced as a cooperative venture with the Aviation Division of the Maryland State Police, bringing virtually all of the State of Maryland and portions of adjoining states within one hour flying time.[6]

This paper will describe our experiences in evolving the system of reception and resuscitation of critically injured patients currently in use in the Institute, the results achieved with the system and problems which we see as still to be resolved.

Initial Experiences

In the initial 12 months following its opening in June, 1969, the Institute, known at that time as the Shock Trauma Unit (STU), functioned essentially as a referral center with a small full-time physician staff. One fellow covered the unit at night. Patients were admitted directly into the unit, and surgeons, anesthesiologists and other specialists were called in from the University Hospital residency staff and faculty as needed. If surgery was required, the patient was transported to the main hospital operating rooms.

The helicopter evacuation program which was fully functional by mid-1970, opened a Pandora's Box. The number of admissions increased rapidly month by month (Figure 1). As in Vietnam, the use of the helicopter, while enabling a larger number of seriously injured patients to reach hospitals alive, who would not otherwise have survived, resulted in a significant increase in the number of dead-on-arrival (DOA), 5 percent in 1972. The helicopter accounted for 80 percent of all admissions, 90 percent having sustained acute trauma, 70 percent the result of high speed automobile accidents (Table 2). Seventy-five percent of the automobile victims were males, 60 percent in the 15–35 year age group, greater than one third having intoxicating levels of blood alcohol on admission.

Of the automobile trauma arriving by helicopter, three-quarters came from the scene, greater than 90 percent reaching the Institute within one hour of their accident. This contrasted with the remaining quarter who were first taken to the nearest hospital. It was five hours before 90 percent of this latter group arrived (Figure 2). In an analysis of patients who survived the first 24 hours it was of interest to note that the mortality in the group admitted via another hospital was twice that of those flown directly from the scene. The major difference was the result of an increase in renal and hepatic failure which could be attributed to the delay in instituting aggressive effective resuscitation.

Emphasis was therefore placed on the rapid evacuation by helicopter of critically injured patients directly from the scene to the Institute. Other than attention to the airway and stopping of external bleeding, the delay necessitated by the insertion of intravenous lines or the application of a G-suit was not normally considered justifiable.

The peak time for admissions proved to be the weekends, the hours around midnight, particularly during the summer months and the short transportation time along with the severity of the trauma quickly pointed out the inadequacies of the staffing methods. The movement of such critically injured patients by corridor and elevator to operating rooms

TABLE 2. MIEM Admissions 1972

Acute Trauma

Motor Vehicle	413	(70.0%)
G.S.W.	65	(11.0%)
Falls	36	(6.1%)
Assault/Strike	18	(3.1%)
Burns	18	(3.1%)
Stab	14	(2.4%)
Drug Overdose	12	(2.0%)
Crush	5	(0.8%)
Drowning	4	(0.7%)
Asphyxia	1	(0.2%)
Others	4	(0.7%)
	590	

Others

Post Trauma Complications	19
Post Surgical Complications	15
Acute Abdomen (Abd. An. 6)	10
Acute M.I.	4
C.V.A.	7
Others	12
	67

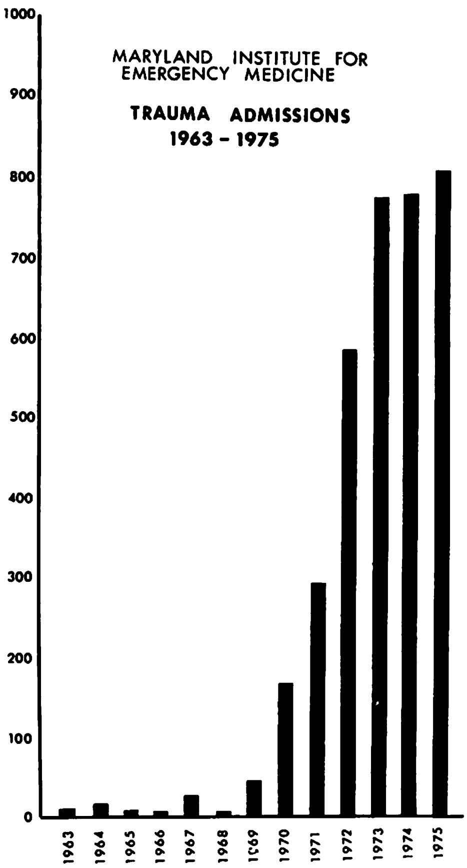

FIGURE 1

some distance away was a hazardous undertaking.

The opening of an admitting area for the reception and resuscitation of the patients and the assignment of resident rotations from the University Hospital mitigated the problems to some degree. It became apparent, however, that to fully utilize the advantages afforded by the helicopter, the rapid transportation had to be matched by, on the patient's arrival, the immediate institution of life saving measures by experienced personnel who were standing by, round the clock, "thinking trauma," with supporting facilities designed and equipped for the task. In 1972 funding was sought and obtained to recruit adequate numbers of full time personnel.

Today the Institute is staffed by trauma teams, each team consisting of a surgeon and an anesthesiologist, both of whom have completed their specialty training and spend a minimum of one year in the Institute, each supported by rotating residents and specialty trained nurses. One team "lives in" for 24 hours and is backed up by second and third on-call teams and by faculty on radio call.

Resuscitation

When called to the scene of an accident, the helicopter notifies Systems Communications (SYSCOM), which is located within the Institute, who in turn place on alert the "on call" team, the admitting and adjoining operating room areas. If, after triage at the scene, the decision is made to transport the patient to the Institute, a confirmation call is made by the helicopter and an estimated time of arrival (ETA) is given. On receipt of an ETA, the anesthesiologist accompanied by a nurse proceeds to the helipad to meet the helicopter. The remainder of the team assemble in the admitting area where they await, gowned and masked, the patient's arrival. At this stage only the team members are present. A preexisting systems approach with each member having predesignated duties allows a planned smooth drilled resuscitation. The surgeon acting as team leader coordinates and establishes priorities.

With the rapid transportation, while many patients arrived in extremis, many arrive before obvious signs of deterioration have become apparent. This group of patients has been transported to the Institute because the degree of catastrophe and the state of the patient at the scene led the ambulance and/or helicopter crews to suspect that the patient had sustained life-threatening injuries. The physicians continue with that high degree of suspicion. Had the patient ingested alcohol or drugs or been exposed to carbon monoxide fumes prior to the accident? Could there have been loss of consciousness, hypotension, asphyxia, aspiration, at any time at the scene or during transportation? Few patients are capable on arrival of giving a reliable history, if indeed, any.

Resuscitative measures must be carried out along with or frequently preceding diagnosis. It has been established that the major determinant of survival in shock is adequacy of oxygen transportation and ill-effects will be determined by the degree and duration of any defects of oxygen delivery and by organ susceptibility to oxygen lack. Secondary and tertiary insults will compound the damage. The principles have all been well established: ensure adequate ventilation, control hemorrhage, reestablish adequate blood volume.

VENTILATION

The need to intubate in the presence of an obstructed airway, obvious respiratory insufficiency or loss of consciousness appears well recognized. Less often appreciated is the large VD/VT ratios present in shock but not always apparent clinically despite compensatory minute ventilation of up to 25 liters per minute. The superimposed handicap of alcohol, drugs or head injury, the mechanical defects of cervical or thoracic cord or thoracic cage injury, or pneumothorax and the possible presence of pulmonary contusion or the consequences of aspiration or prior hypoxia may prevent such compensation in addition to adding their own contribution to the production of respiratory insufficiency.

Intubation and mechanical ventilation with high inspired concentrations of oxygen is therefore initiated early and not delayed until respiratory insufficiency is grossly apparent. The suspicion of the presence of head injury necessitated hyperventilation to an arterial carbon dioxide level of 25 ± 5 Torr. Tension pneumothorax is repeatedly excluded on admission, throughout and following resuscitation. Endotracheal tubes

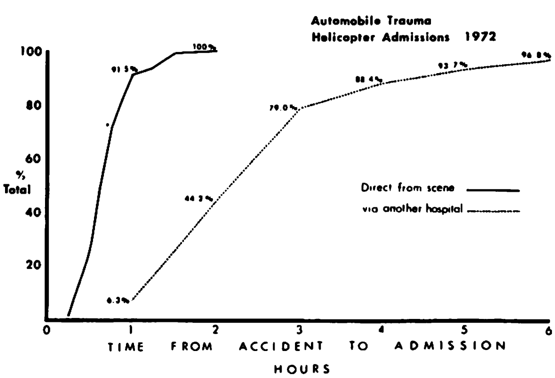

FIGURE 2

with large volume, low pressure cuffs are used for intubation. While the risk of the presence of a cervical fracture is ever present a careful intubation under optimal conditions with sedation and complete muscle relaxation in the hands of experienced personnel has not been found to precipitate any neurological deficit. The use of mechanical ventilation using a volume-limited ventilator (Engstrom 300) is standard practice in the admitting area as is the addition of 5 cm H_2O of positive end-expiratory pressure as soon as volume replacement is deemed adequate.[7] In excess of 75 percent of patients admitted to MIEM are intubated.

CONTROL OF HEMORRHAGE

Any significant external bleeding is controlled initially by direct pressure dressings or packing until the patient is stabilized. If a wound has been packed before arrival no attempt is made to remove the pack until the patient is intubated, adequate intravenous lines established, and the patient stabilized.

While tourniquets are no longer currently used in the control of arterial bleeding, we have on occasion applied them to the lower limbs, in an attempt to restrict venous return into massive pelvic injuries. The presence of extensive associate lower limb injuries has necessitated combined arterial and venous occlusion. The duration of application of tourniquets must, of course, be minimal but may buy time until blood supplies can be replenished — the risk of loss of a limb being balanced against saving a life.

Partial G-suits, whose function is to decrease the venous bed have not found a use in the Institute to date but may have a place very occasionally in buying time, recognizing the problems that they limit access to the abdomen, restrict access to the lower limbs for the placement of additional intravenous lines, may precipitate pulmonary edema in the presence of myocardial insufficiency and they require very cautious release to prevent hypotension.

Abdominal lavage forms an integral part of the evaluation of the abdomen in MIEM and has replaced the classical diagnostic methods. It is performed in some 80 percent of all trauma admissions.[8] When the lavage reveals gross bleeding in the presence of profound shock, it may be necessary in the admitting area to control abdominal bleeding manually until the patient can be resuscitated and/or moved to the operating room. When necessary, surgery will be undertaken in the admitting area.

REPLACEMENT OF BLOOD VOLUME

It is our practice in all cases of major trauma to initially insert four large-caliber intravenous lines, two above and two below the diaphragm until we identify the major site of injury — lest we are subsequently forced to discontinue, for example, the lower limb IV's in the face of massive pelvic injury. In the upper limb, the median basilic, and in the lower limb, the long saphenous vein are the first choices. When percutaneous puncture proves difficult, we proceed immediately to a cutdown.

In multiple trauma patients suffering from hemorrhagic shock, volume replacement by blood is the logical choice. With massive volume replacement, fresh blood would be ideal but the urgency of the need makes it quite impractical to consider its use in an emergency admission. Banked blood, while providing oxygen-carrying capacity and colloid, has the major drawback of being deficient in both platelets and clotting factors. Since 1972 we have elected to use blood component therapy. Initially we administer plasma protein fraction (PPF). While we are prepared to administer up to 1250 ml before proceeding to packed cells, despite rapid transportation many patients are found to have hemodiluted in the interval between their initial trauma and arrival at the Institute. The initial volume of PPF is therefore determined by the initial hemoglobin but does not exceed 1250 ml or serious hemodilution will frequently be encountered. If the mean arterial blood pressure stabilizes at greater than 60 mmHg and the hemoglobin is greater than 10 G it may be permissible to await fully cross-matched blood. However, there is no hesitation in proceeding with packed cells, matching 1 unit packed cells for every 250 ml PPF administered. While ORh-negative is the first choice, if this is not available PRh-positive is used.

The risk of transfusion reactions must be taken when possible death is the alternative. Ten units of packed cells are immediately available in the admission/operating room area at all times. Empirically 2 units of fresh frozen plasma are given after each 5,000 ml of reconstituted blood (1 unit packed cells + 250 ml PPF = 500 ml). After every 10,000 ml, or if the platelet count falls below 50,000, 10 units of platelets are administered. Hypothermia will frequently be encountered unless deliberate attempts are made to warm all intravenous fluids. The temperature should in any case be monitored in all admissions as the presence of hypothermia will negate any efforts at defibrillation or attempts to improve cardiac output.

After adequate volume replacement has been ensured and optimal cardiac output obtained after a sustained period of shock, if urine output is inadequate the administration of a diuretic such as Furosemide is indicated.

While loss of intravascular volume is the foremost cause of hypotension in the major trauma victim, failure to reestablish an adequate blood pressure despite attempts to optimize cardiac output by adequate preloading must raise the question of a severe brain stem or high cord injury. The presence of poor output in the face of a rising central venous pressure must demand the exclusion of tension pneumothorax, hypoxic or traumatic injury to the myocardium, or pericardial tampanade. Myocardial insufficiency consequent to low mean arterial pressures and/or hypoxia has been encountered relatively frequently, usually becoming apparent in the operating room or early in the postsurgical management.

Should cardiac resuscitation be required in the presence of suspected chest wall, lung or liver injury, thoracotomy and direct cardiac massage are indicated.

MONITORING

Initially monitoring of the pulse and observation of jugular veins must suffice, but the early placement of indwelling arterial and central venous cannulae permits not only continuous direct observation of waveform but also the quantitative measurement of mean arterial and central venous pressures as trend indicators. Pulmonary arterial catheters, formerly inserted in the Critical Care Unit, are now being inserted more frequently in the admission and operating room areas, to allow use of the pulmonary wedge pressure to optimize cardiac output. Such sophistication has significantly reduced the incidence of oliquric renal failure over the past 18 months and has allowed the early identification of myocardial insufficiency, which in the past frequently went unsuspected in this young group of patients until pulmonary edema presented.

Emphasis is placed on the use of mean arterial pressure in the assessment of adequate perfusion pressure. The use of

TABLE 3. MIEM Admission Studies

Blood gas, Arterial	General Drug Screen
Mixed Venous	Lactate
Oxygen Saturation	Total Protein
Carbon Monoxide Saturation	H_2O Concentration
P_{50}	Osmolality
Hemoglobin, Hematocrit	Sodium
Type and Cross Match for	Potassium
6 units packed cells	Chloride
CBC and Differential	Glucose
WBC	BUN
Platelet	Creatinine
Prothrombin	Amylase
Fibrinogen	6/60 Flex
Australia Antigen	
Qualitative VDRL	

intracranial pressure measurement by means of intraventricular catheters in severe head injuries, permits the measurement of cerebral perfusion pressure (CPP = $P_{art} - P_{ic}$).

Arterial and pulmonary arterial lines provide ready access for arterial and mixed venous blood samples, the arterial/venous oxygen content difference providing an excellent additional trend monitor of cardiac function (Table 3).

ANESTHESIA

The intense catecholamine release initiated by trauma and/or hypoxia will constrict the vascular beds and falsely elevate arterial and venous pressure values. The introduction of anesthesia early in the resuscitative phase will permit controlled modification of the sympatho-adrenal response with realistic pressure values and improved perfusion. Initially the combined use of a short acting narcotic, Sublimaze, (fentanyl citrate) and a short acting muscle relaxant (succinylcholine) combined with nitrous oxide/oxygen will usually prove adequate until bleeding has stabilized or been controlled and is rapidly reversible should neurological evaluation be desired. It is then our practice to proceed to halothane/curare/nitrous oxide, the halothane providing in our experience a more reliable means of modifying the sympatho-adrenal response.

There are other obvious advantages in the provision of relief from both psychological stress and the pain necessitated by positioning for x-rays. Also, anesthesia permits the rapid placement of IV and arterial lines, performance of abdominal lavage, the x-raying of joints to exclude ligamentous evulsion and an immediate surgical incision to be made if it becomes necessary.

The continuance of anesthesia in the postsurgical period until stabilization occurs should be considered.

Evaluation and Priorities

As with resuscitation, an agreed protocol on priorities in evaluation prevents omissions and disagreements due to personal preferences and whims (Table 4).

A superficial evaluation will be made during transport to the admitting area while the nurse cuts off all clothing. The adequacy of respiration and of circulation can be assessed, as can the level of consciousness, the state of the pupils, the presence and nature of limb movement.

On arrival in the admitting area while resuscitation is initiated, the ongoing evaluation continues, being specifically aimed initially at the identification of life-threatening injuries, the normal order of priorities being — (1) Thoracic Injuries — Observing for obvious open wounds, uneven chest movement, displacement of the trachea, subcutaneous emphysema. Any suspicion of a pneumothorax demands the urgent insertion of a chest tube before x-ray. An *upright* chest x-ray is performed on *every* patient, a widened mediastinum observed in such an x-ray being an indication for an aortagram. (2) Abdominal Injuries — Abdominal lavage to exclude intra-abdominal bleeding (spleen, liver, kidney, major vessels) is considered "a priore." Injury to the gastrointestinal tract is a low priority as a life-threatening lesion.

In the absence of an intra-abdominal or intrathoracic cause of bleeding and associated hypovolemia, the pelvis has become apparent as a major source of morbidity and mortality following high speed automobile trauma. Massive volume replacement is required with attention to replacement of deficiencies in platelets and clotting factors once identified.

While not taking precedence over life-threatening thoracic

TABLE 4. MIEM Admission Priorities

First:	1.	Two minute evaluation — can patient speak, move extremities, space and time orientation, etc.
	2.	Establish airway and provide adequate ventilation, with 100% oxygen.
	3.	Control external hemorrhage (and order blood).
	4.	Begin colloid infusion.
	5.	EKG monitor.
	6.	Emergency assessment of systems. Look at all parts, front and back, alert specialists.
	7.	Insert nasogastric tube.
Second:	1.	Draw baseline chemistries — blood gases, etc.
	2.	Establish catheters, intra-arterial, central venous, and urinary.
	3.	Emergency investigations (peritoneal lavage, x-rays, etc.)
	4.	Decision for emergency surgery.
Third:	1.	Systematic examination.
	2.	Systematic investigation.
	3.	Specialty consultations.
	4.	Multidiscipline discussion on further management.

Those measures listed under "First Priority" will normally require only a few minutes; the next line of priorities are more time-consuming. By this time, unless emergency surgery is mandatory, the patient's general state should be acceptable and a more detailed assessment with multidiscipline consultation as indicated will follow.

or intra-abdominal injuries, suspected expanding intracranial lesions will require prompt investigation and attention. Awareness of the possible occurrence of cervical fractures in association with head injuries mandate x-ray of cervical spine in such cases, although in our experience the incidence is limited to about 2 percent.

While orthopedic injuries have a low priority in the initial management, their contribution to hypovolemic shock is often frequently overlooked while attention is being diverted to intrathoracic and intra-abdominal injuries. Despite primary attention being directed to the correction of life-threatening injuries, it is our practice, whenever possible, to complete all necessary surgery, including orthopedic and plastic, at the time of initial surgical intervention.

Results

Our initial experience in 1969/70 showed that respiratory insufficiency was the cause of death in over 30 percent of the deaths in the unit, and significant pulmonary pathology was identified in greater than 80 percent of all autopsies performed. It became apparent that multiple factors might be operative in the production of respiratory insufficiency associated with major trauma and that such possible operative factors occurred early following the initial trauma. In late 1971 the decision to introduce aggressive ventilatory management utilizing early intubation and mechanical ventilation with the preventative use of positive end-expiratory pressure (PEEP) was followed by a rapid reduction in mortality due to respiratory failure.

The recognition that in the presence of severe head injury, arterial carbon dioxide tension levels ($PaCO_2$) in excess of 30 Torr resulted in a rapid rise of intracranial pressure dictated that in all cases demonstrating an impaired level of consciousness on admission, the presumption be made of head injury until proven otherwise. All such patients are, therefore, hyperventilated to a $PaCO_2$ of 25 $\pm$ 5 Torr during resuscitation, surgery and into the postoperative period until neurological evaluation excludes brain injury. Elevated intracranial pressures in the Critical Care Unit are now the exception rather than the rule. There was a fear that hyperventilation might result in excessive shift of the oxygen dissociation curve to the left with resultant decreased ability of the hemoglobin to release oxygen, but no ill effects have been observed clinically, and preliminary observations of P_{50} values have shown rapid compensatory changes with return of the dissociation curve to a normal position presumably due to 2-3 DPG. The place of steroids in the management of head injury is at present under study in the Institute, a one year double-blind study having been in progress since September, 1975.

The overzealous use of broad spectrum antibiotics in 1971/72 saw the frequent development of superinfection in the respiratory tract by Pseudomonas. This phenomena was successfully combated by the Institution of stringent antibiotic policy controls.

Early attempts to minimize the risk of the Respiratory Distress Syndrome (RDS of Trauma) utilized, in addition to aggressive ventilatory management, the restriction of fluids sufficient to maintain a basal urine output of 30 to 60 ml per hour and the early use of 25 percent albumin if the development of interstitial edema was suspected. With this regime we encountered a high incidence of oliguric renal failure with its associated high mortality. By the use of more liberal fluid administration dictated by the response of pulmonary wedge pressure measurements, the restriction of the indications for 25 percent albumin to deficient colloid pressure, and the use of preventative levels of PEEP of 10 or 15 cmH_2O, the incidence of oliguric failure has been significantly reduced. The observation of UP creatinine on admission and repeated within 24 hours has allowed the earlier identification of potential renal failure, with the necessity to secure optimal renal perfusion by continuous optimal pre-loading.

Following the introduction of multiple intravenous line insertion to facilitate rapid infusion, cardiac arrest was observed in six cases in association with hypothermia (below 33°C) which was attributed to failure to warm all infusates. Today all intravenous lines in the admission and operating areas routinely incorporate warming coils.

In an attempt to evaluate the results of the system of reception, resuscitation, operative and critical care management in current use, an analysis was made of all patients who had sustained multiple trauma as the result of high speed automobile accidents and who were transported to the Institute by helicopter 1972 through 1975. During this period there has been a reduction of the mortality in the admitting area by 43.8 percent and in the operating room by 70.8 percent. The mortality in the Critical Care Unit over the same period has shown a 37.3 percent increase. The total mortality has decreased by 21.2 percent (Table 5).

An analysis of 56 deaths occuring in 324 patients transported by helicopter directly from the scene of the accident during 1974 is presented in Table 6. Of the eight deaths in the admitting area, three died from severe craniocerebral trauma, the remaining five succumbing from exsanguination despite operative intervention — three from lacerations of the heart chambers and two from liver lacerations. Of the fourteen patients who died in the operating room, three died from craniocerebral trauma associated with abdominal organ hemorrhage, while ten died from exsanguination (liver 4, lung 2, thoracic aorta 2, Inf. vena cava 1, pelvis 1). A single elderly patient died from cardiac failure attributed to hypoxia secondary to severe bilateral lung contusions. Of the 310 patients who arrived alive, 20 of the 42 deaths (47.6%) were the result of severe craniocerebral trauma with brain death.

While any attempt to reduce this latter figure must include the mandatory wearing of diagonal and lap seat belts, during 1975 we introduced the practice of the insertion of "esophageal obturators" at the scene or during transportation by the helicopter crews in all patients in deep stupor or coma as part of a prospective study and have recently presented the results

TABLE 5. MIEM Helicopter Admissions
Acute Auto Trauma

		Deaths			Deaths
	Arrived Alive	Admitting Area	Operating Room	Admitted CCU	In CCU
1972	341	25 (7.3%)	16 (4.7%)	300	23 (6.7%)
1973	443	36 (8.1%)	24 (5.4%)	383	35 (7.9%)
1974	455	19 (4.2%)	18 (4.0%)	418	38 (8.4%)
1975	437	18 (4.1%)	6 (1.4%)	413	40 (9.2%)

TABLE 6. Automobile Trauma - 1974: 324 Patients Transported Directly from Scene of Accident

		On Arrival: Systolic BP		On Arrival: Level Of Consciousness				Primary Cause of Death					
		> 80	< 80	Alert	Lethargic	Stuperous	Comatose	Brain	C #1	Hemorrhage	Cardiac Failure	Renal Failure	Sepsis
Early Deaths:	14 DOA*	--	--	--	--	--	--	4	2	8	--	--	--
	8 Admission Area	1	7	0	1	2	6	3	--	5	--	--	--
	14 Operation Room	1	13	3	2	2	7	3	--	10	1	--	--
	36	2	20	3	3	4	13	10	2	23	1	--	--
Late Deaths:	20 Critical Care Unit	8	12	3	1	7	9	** 13	--	1	1	1	4

* All patients DOA were believed to be alive when left scene of accident

** Brain Dead, therapy discontinued within 1 to 7 days of admission

of our preliminary experiences. We consider that the esophageal obturator offers a practical contribution to the management of the airway at the scene and during transportation of the unconscious, traumatized patient. We have been unable to draw any conclusion, with the small sample to date, as to whether a greater number of lives have been saved by its use.

Massive liver and pelvic fractures with venous disruption continue to present a surgical challenge as yet unresolved. In the Critical Care Unit sepsis plays a major role in mortality and morbidity.

Summary

We have presented the system developed in the Maryland Institute for Emergency Medicine. Based on rapid evacuation of the critically injured directly from the scene, a specialty referral center with facilities appropriate to the needs of such patients is staffed by fully trained full-time surgeons and anesthesiologists round the clock, seven days a week. Preparedness, an agreed protocol based on a high degree of suspicion and aggressiveness have been the keystones in the achievement of the results presented.

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INITIAL TREATMENT OF THE TRAUMA VICTIM

Donald D. Trunkey, M.D.

As soon as the critically injured patient arrives, essential steps must be carried out simultaneously. One is assessing the injury and the second is starting resuscitation. Often these are done at the same time. In order to assess the injury adequately the physician must quickly remove all of the patient's clothing and examine him from head to toe, noting respiration and skin temperature. It is important to roll the patient over and examine his back side. Too often we may completely miss the posterior wounds which actually are the lethal injury. Concomitant with this initial assessment, someone should attempt to obtain a history from either the ambulance attendants or from witnesses of the accident to determine when and how the patient was injured, how much blood was shed at the scene, and how long the delay was between injury and transportation.

The two major priorities are ensuring adequacy of the airway and restoring circulation, in that order. The physician should ascertain (with his fingers, if necessary) that there are no dentures or foreign bodies in the upper airway. Adequate suction and lighting should be at hand. Insertion of an oropharyngeal airway may be necessary to keep the tongue of a comatose patient from falling backward and obstructing the pharynx. Oxygen can be administered by mask and good ventilation obtained without the aid of endotracheal tubes and special mechanical devices. Room air, administered through an Ambu type mask and bag, is adequate for the initial few minutes. Endotracheal intubation can be done after things have settled down, but may be imperative if secretions cannot be cleared from the upper airway because of maxillofacial injury or aspiration of fluid. Emergency tracheostomy is rarely necessary.

Having assured the passage of oxygen from the environment into the lungs, the next step is to assure that it is transported from the lungs to the brain. This requires an adequate circulation and is dependent on the pump and the amount of circulating volume. If there is no pulse when the patient is admitted to the emergency room, closed chest cardiac massage should be started as soon as the airway is established. Large bone catheters should be inserted through cutdowns in upper and lower extremity veins. It is then necessary to differentiate between primary pump failure and defective circulating volume. This is done by examining the neck veins. If the neck

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veins are distended, resuscitation should be directed primarily toward the heart; if they are collapsed, initial therapy should consist of volume resuscitation.

The cardiac problem that can be corrected most quickly is pericardial tamponade. Tamponade should be suspected in any patient who arrives in the emergency room in shock, has elevated central venous pressure of distended neck veins, and has a penetrating wound which may have hit the myocardium. Tamponade may also be suspected in patients who have had blunt trauma to the anterior chest. If tamponade is suspected, pericardiocentesis should be carried out immediately. An 18-gauge spinal needle should be inserted from the paraxiphoid area obliquely upward toward the left shoulder at an angle of 45 degrees with the skin. The aspiration of as little as 10 to 20 ml of blood may be all that is necessary to provide dramatic relief. A left anterior thoracotomy through the fourth intercostal space, with opening of the pericardium and evacuation of the clot, should be done if the patient does not respond to aspiration or is in extremis, or if tamponade promptly recurs. Any bleeding from the heart can be controlled by sticking a finger into the hole to prevent further blood loss until the patient can be more adequately resuscitated and taken to the operating room for definitive repair. Using such techniques, it is possible to save at least 50 percent of all patients with penetrating wounds of the heart, provided the patient shows some sign of life when first seen.

Other myocardial injuries that may lend themselves to surgical therapy include myocardial contusion and myocardial infarction. Myocardial contusion may cause bleeding from epicardial vessels and present as tamponade. Contusion may result in impaired pump function and therapy processes as it would with primary myocardial infarction.

The second component of restoration of circulation involves assessing vascular volume. Shock may be divided into mild, moderate and severe, based primarily on clinical criteria (see Table 1). The physician should not rely on pulse and blood pressure, for these two signs may change only very late in shock, particularly in healthy young adults.

Mild shock is present when approximately 10 to 20 percent of the blood volume has been lost, and it is manifested by poor perfusion of the skin. The patient appears pale. The skin is cool to the touch, starting first in the extremities and progressively involving the trunk. As shock becomes more profound, there is activation of the sympathetic nervous system, with sweating superimposed. The patient usually complains of feeling cold and is often thirsty. Tachycardia may or may not be present.

Moderate shock occurs when 20 to 40 percent of the blood volume has been lost. Physiologic mechanisms come into play to preserve the remaining blood flow to the heart and brain at the expense of all other viscera. The key to monitoring of this stage of shock is the urinary output. For this reason all patients who show signs of mild shock are catheterized and urinary output is carefully monitored. If urinary output is below 0.5 ml per kg of body weight per hour, it may be assumed that there is pronounced hypovolemia and poor renal blood flow, and that at least 20 percent of the blood volume is depleted.

Severe shock occurs when more than 40 percent of the blood volume has been lost. By clinical definition, severe shock means inadequate perfusion of the two most critical organs, the heart and brain. The cardinal cerebral symptoms are restlessness and agitation, progressive deterioration into stupor and coma, and finally death. Cardiac manifestations at this time may include arrhythmias and evidence of myocardial ischemia on the electrocardiogram. This classification of shock has to be modified for older patients who may have an arteriosclerotic vascular system with a fixed peripheral vascular resistance or a low cardiac index and cannot bring protective hemostatic mechanisms into play. In these patients as little as 10 to 20 percent blood volume loss may cause symptoms of moderate or severe shock.

With these criteria, assessment of the volume status should take but a few seconds and treatment should be begun immediately. This consists of the placement of large bore catheters in venous cutdowns. At San Francisco General Hospital we prefer either infant feeding tubes approximately 3 mm in diameter or intravenous extension tubing 5 mm in diameter. The actual cutdown sites may vary depending on the clinical situation; however, the preferred anatomical sites are the basilic vein at the antecubital fossa and the long saphenous vein at the ankle. Both of these are large veins located in a relatively constant anatomical area. The number of cutdowns varies from one to three, depending on the severity of the shock. In urgent emergency situations percutaneous subclavian or internal jugular catheterizations have no role. Such catheters may produce additional complications and are unreliable in the patient whose blood volume is depleted. The veins in these patients will be collapsed, insertion will be more difficult and complications such as pneumothorax may compound the problems. Subclavian catheterization should be reserved for patients who have pure cardiac emergencies and full vessels or for patients in whom elective placement of the central line is indicated. One of the cutdowns should be in a thoracic location to enable monitoring of central venous pressure. Central venous pressure, in itself, however, is not a reliable gauge of the severity of shock but does tell whether the venous system is empty or full, whether attention should be directed primarily toward volume or cardiac malfunction, and whether resuscitation is moving in the right direction.

As soon as a cutdown has been established, approximately 30 ml of blood is obtained. Part of this is immediately sent to the blood bank for type and crossmatch of whole blood. Part is spun down and a hematocrit reading is obtained, although it must be remembered in acute volume loss that the hematocrit may be normal and misleading. The remaining blood can be spun down and kept for laboratory determinations of such things as serum electrolytes, glucose, blood urea nitrogen and

TABLE 1: Characteristics of Various Levels of Shock

Level of Shock	Blood Volume Deficit	Effect	Signs
Mild	0 – 20 percent	Peripheral vasoconstriction	Cold, pale
Moderate	20 – 40 percent	Decreased visceral organ perfusion	Oliguria, anuria
Severe	40 percent +	Decreased heart and brain perfusion	Restless, agitation stupor, coma

creatinine, or even for toxicology. These need not be done routinely but only as history or further assessment indicates.

As restoration of the airway and effective circulation are going on, other life-threatening problems should be assessed and treated. The most important is hemorrhage. If blood loss is external, it is rarely necessary to use a tourniquet for control. Direct pressure is almost always successful. Severe, ongoing internal hemorrhage is recognized by progressive deterioration of vital signs. If the circulatory status of the patient is critical and does not respond to 2 liters of crystalloids introduced rapidly for 5 to 10 minutes or if there is a temporary response followed by a fall to the previous baseline in 10 to 15 minutes, internal hemorrhage is severe and prompt and definitive surgical treatment is required. An x-ray film of the chest is helpful if it can be obtained en route to the operating room. If the x-ray film shows the chest to be normal, the problem lies in the abdomen. If arrest from hypovolemic shock occurs, a left thoractomy and cardiac massage should be done. It is impossible to resuscitate an empty heart with closed chest massage. Maximal use of what volume is left can be achieved by clamping the supradiaphragmatic aorta. The number of these patients saved will not be high.

Tension pneumothorax must be recognized if the patient is to survive. Patients with this condition usually have air hunger or respiratory distress and the trachea is deviated to the opposite side. Other findings include distension of neck veins (as is found in cardiac tamponade), decreased breath sounds on the side of the lesion and tympany on percussion. Do not wait for an x-ray film of the chest to confirm tension pneumothorax but immediately insert a chest tube into the suspect hemithorax. It is preferrable to insert all chest tubes in the mid-axillary line in the fifth, sixth or seventh intercostal space. The reason for this is that the patient often has a hemothorax in addition to pneumothorax and drainage of both can be accomplished most adequately if the tube is in this location.

Once these immediate problems are treated and the condition of the patient has stabilized, or if the patient has arrived in a semi-stabilized condition, then one may use the extra time to carry out further clinical assessment. This would include appropriate x-ray films to see if there is sequestered blood loss in the pleural space, abdomen or in pelvic or long bone fractures. In addition, one may elect to do paracentesis or peritoneal lavage to evaluate abdominal pain or distension, particularly in a multiply injured or comatose patient. Then the central nervous system should be examined. The initial assessment should include a quick neurologic examination including respiration, level of consciousness, gross motor and sensory function, reflexes and eye signs. If the patient is comatose, his neck should be protected and his head kept in an axial orientation when he is being moved. Cervical x-rays should be taken as soon as practical to rule out cervical fractures. If level of consciousness decreases or lateralizing signs develop during observation, increased intracranial pressure may be assumed. Craniotomy may be necessary. Next, a progressive survey of other systems is conducted. A careful abdominal evaluation is indicated. If the patient has hematuria, special diagnostic studies such as intravenous pyelogram and cystograms are indicated to rule out rupture of the kidneys or bladder. Arteriograms may be obtained for wounds near vessels, particularly those in the mediastinum, the thoracic inlet, the base of the skull and the extremities.

When a patient comes into the emergency room and is conscious, the physician must explain to him what he is doing. During the resuscitation the patient will be very anxious because he thinks he is dying. In addition, he will often be in pain and the resuscitative effort may cause some discomfort. It is good to offer him comfort and reassurance in order to reduce apprehension and the anxiety that may contribute to neurogenic shock.

The Physiology of Fluid Resuscitation

The determinants of fluid shifts across an intact capillary endothelial membrane are those forces described by Starling in 1896. Hydrostatic and osmotic pressures in addition to the permeability of the membrane affect capillary filtration and fluid exchange. The hydrostatic pressure tends to drive fluid from the capillary lumen to the interstitium, whereas the colloid osmotic pressure tends to attract fluid from the interstitium into the capillary lumen. Both of these forces are obviously influenced by the permeability of the membrane.

Several factors may increase capillary permeability including sepsis, hypovolemia, thermal injury and cold injury. The exact etiology of this capillary leak is unclear but the degree of leak correlates well with the severity of the insult. The capillary leak is usually confined to the area of injury or sepsis but will become systemic if the insult is severe or is left untreated.

Following severe injury a capillary leak occurs in the local area and when very extensive this alteration is generalized. This may also be seen following most septic complications and occasionally with severe hypovolemic shock. During resuscitation this capillary leak must be considered relative to the other two driving forces affecting fluid exchange. An increase of hydrostatic pressure above that considered normal will tend to augment the capillary leak. It therefore becomes impossible to completely fill the cardiovascular system without increasing the losses into the interstitial fluid.

An increase in capillary permeability will also affect attempts to restore colloid osmotic pressure by infusion of colloids or their substitutes. Infusion of relatively low molecular weight (below 100,000) solutions will simply continue to leak across the capillary endothelium. If lymphatics are damaged or the solutions are administered indiscriminately interstitial colloid oncotic pressure would increase resulting in further interstitial edema.

Clinical experience has shown that patients with a severe insult do better when the initial resuscitation consists of crystalloid. Colloid should be used sparingly or not at all. Optimally, the colloid should be added when the capillary endothelium has regained its integrity. This probably occurs at some time between 18 and 24 hours post-injury. Enough colloid should be given to restore plasma protein concentrations to normal values. This will aid interstitial fluid mobilization and stabilize plasma volume.

It also becomes apparent that one must temper the amount given with the initial resuscitation, since increasing hydrostatic pressure above physiological levels as measured by atrial filling pressures can also be harmful in respect to increasing interstitial fluid and causing overload. Successful resuscitation will be dependent on consideration of all three of these Starling forces. The use of resuscitation formulas is to be condemned, particularly since they do not consider response of the patient to the volume load.

Table 2 lists the various solutions available for resuscitation of shock. The two main categories are crystalloids and colloids. In the crystalloid group we favor use of a balanced salt solution such as Ringer's lactate or acetate. Shock is almost always accompanied by metabolic acidosis and correction of this acidosis can be achieved with the balanced salt solution plus judicious use of sodium bicarbonate. Overcorrection of the acidosis is probably more harmful than a mild acidosis.

TABLE 2: Fluid Resuscitation of Shock

1. Crystalloids:
   - A. Isotonic sodium chloride
   - B. Hypertonic sodium chloride
   - C. Balanced salt solution
     1. Ringer's lactate
     2. Ringer's acetate
     3. Normosol, Plasmolyte, etc.
2. Colloid:
   - A. Blood
     1. Low-titer 0 negative blood
     2. Type-specific
     3. Typed and crossed
     4. Washed red cells
     5. Fresh red cells
   - B. Plasma and its components
     1. Plasma - fresh frozen
     2. Albumin
     3. Plasmanate
   - C. Plasma substitutes
     1. Clinical dextran (M.W. 70,000)
     2. Low molecular weight dextran (M.W. 40,000)

Alkalosis is associated with a left-shifted oxyhemoglobin dissociation curve and therefore a stronger affinity of hemoglobin for oxygen and a resultant decreased O_2 transport.

Controversy still exists regarding the use of lactate in resuscitation fluids since, theoretically, this could add to the lactic acidemia. Careful studies measuring lactates in profound shock have not confirmed this theoretical possibility. Ringer's acetate may be used which provides more bicarbonate on a equimolar basis and, in addition, the acetate enters into the Krebs cycle at a lower level than lactate. Solubilized bicarbonate solutions are available, however, these are quite expensive.

Optimal resuscitation will be determined by many factors including: restoration of adequate peripheral perfusion, a urine output at or near 0.5cc/kg/hr, atrial filling pressures at or near normal and an alert, oriented patient.

Suggested Readings

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POSTOPERATIVE CARE OF THE MULTIPLY INJURED

Constantinos P. Chilimindris, M.D., F.A.C.S.

The immediate postoperative phase of the multiply-injured patient presents one of the most challenging problems in critical care medicine.

The Critical Care Team

Because of the multidisciplinary factor, the most efficient care could only be provided by a full time team of critical care personnel headed by a clinical director upon whom absolute authority and responsibility for the patient's total medical management is conferred. Full time surgeons, surgical residents, critical care nurses, respiratory therapists, and laboratory and x-ray technologists specifically assigned to the unit complete the trauma-surgical intensive care team.

Initial Postoperative Evaluation and Continuous Monitoring

Following completion of the operative procedures, all trauma patients are directly transferred to the Surgical Intensive Care Unit rather than the General Recovery Room. The endotracheal tube is routinely left in place until such time as the patient is fully awake, breathing without effort, and maintaining satisfactory arterial blood gases. Most patients with non-thoracic trauma require mechanical ventilatory support for at least 24 hours following surgery. Adequacy of ventilation is particularly critical in the immediate postoperative period, and insufficiency should be suspected if there is weak, shallow or labored breathing and retention of secretions with inadequate air movement on inspection and auscultation of the chest. Patients with serious thoracico-abdominal trauma or respiratory insufficiency from any cause require prolonged controlled ventilatory assistance. If abnormal tracheobronchial secretions are not present, ventilatory assistance may be carried for three to five days by means of an endotracheal tube. Longer periods of support require a planned and properly done tracheostomy. We prefer to do a tracheostomy in the operating room with an endotracheal tube in place and an experienced anesthesiologist in attendance. A volume controlled respirator is used exclusively in severely injured patients because it can be regulated to maintain constant tidal volume regardless of changes in airway resistance and pulmonary compliance, and it aids in diminishing the work of breathing. The use of controlled volume respiratory assistance requires either an unconscious patient or depression of the patient's own respiratory effort by sedation. The use of muscle relaxants to paralyze such patients is inadvisable since cardiac output and tissue perfusion may be further impaired as a result of venous pooling by the drug's action on vascular tone. The patient's circulation is given maximal rest by such controlled volume assistance, but at the same time, failure of the ventilator can be a danger which must be recognized immediately and manual assistance provided with an Ambu bag, when the patient's respiratory center has been depressed. The key to rapid assessment and of adequacy of ventilation is prompt and repeated determination of arterial pH and arterial blood gases. The oxygen concentration, tidal volume and rate are adjusted to maintain as closely as possible to pO_2 of 75-90 mm Hg and a pCO_2 of 30-40 mm Hg. FiO_2 of 40 percent is usually adequate and only exceptionally FiO_2 of 60 percent or higher is needed for short periods. Prolonged high oxygen concentrations may result in primary lung damage and thus, pO_2 must be frequently monitored. Initial postoperative evaluation of the patient's status is accomplished as soon as possible by measurement and recording of the vital signs, arterial blood pressure, central venous pressure, arterial blood gases, chest x-ray EKG, and hourly measurement of the urine output.

Arterial Pressure

Arterial pressures obtained by cuff and sphygmomanometer suffice for the average patient, but are inaccurate in shock patients. Direct measurement by insertion of a radial artery catheter is the optimal method of monitoring systemic pressure by connection to a pressure transducer and direct digital recorder. This catheter also provides access for arterial blood samples for arterial blood gas determinations without repeated arterial punctures.

Central Venous Pressure

Insertion of a catheter into the superior vena cava is usually accomplished by direct puncture or a cutdown of the jugular or antecubital veins. Percutaneous catheterization of the subclavian veins has become fashionable, but it should be pointed out that this small, but significant risk, of complications such as pneumothorax, arterial hemorrhage, catheter shearing and misplacement could prove lethal in the critically ill patient. Application of iodophor (Betadine) ointment or other topical antibiotic ointment is applied to the catheter entrance site followed by the application of occlusive sterile dressings. The catheter is removed as long as its use is no longer mandatory and the tip cultured. A chest x-ray is routinely obtained to determine catheter tip location as well as the presence or absence of a hemothorax or pneumothorax.

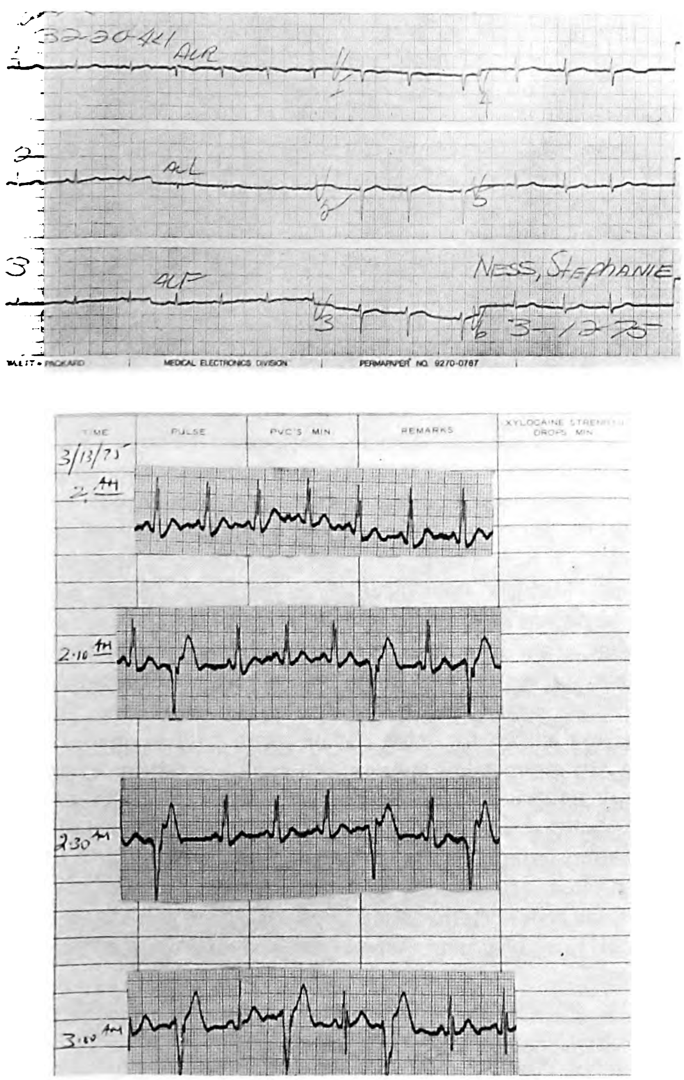


Figure 1 (A) Normal EKG obtained on admission in a 20-year-old female with a steering wheel injury.

(B) Multiple PVC's observed on continuous EKG monitoring 2 hours following admission. Xylocaine therapy was required for 36 hours before this serious arrythmia disappeared.

Electrocardiograph

The application of limb leads has for the most part been replaced by positioning of three leads in a triangle on the thorax to provide oscillographic display of the heart rate and rhythm. This becomes absolutely essential in patients with thoracic injuries who may frequently develop serious arrythmias secondary to occult cardiac trauma. (Figs. 1A and 1B.)

Chest X-ray

A portable chest film obtained immediately postoperatively gives the following valuable information: 1) position of the endotracheal tube or tracheostomy tube, 2) location of central venous catheter tip, 3) presence or absence of a pneumothorax or hemothorax which may have developed during anesthesia (Figs. 2A and 2B.), 4) presence or absence of pulmonary vascular congestion or pulmonary edema, and 5) lung contusion or intra-pulmonary hematomas which are not usually present on the initial chest film.

Urinary Output

Monitoring of hourly urinary output is absolutely essential in the management of the severely injured patient. In the absence of renal disease or glycosuria, the hourly urine output is an index of the degree of hypovolemia and the guide to the adequacy of restoration of blood volume toward normal levels. A steady reduction in hourly urine output in a normotensive patient is highly indicative of progressing hypovolemia. This should be treated with appropriate volume replacement and not with furosamide (Lasix) which should be reserved for fluid overload or congestive heart failure. This is one of the most common pitfalls that many physicians especially those on the house staff fall into during the postoperative period of a patient's management. Post-traumatic renal insufficiency begins with prolonged hemorrhage and shock, most commonly associated with major vessel injury, intra-abdominal or retroperitoneal injury and trauma affecting multiple systems. Other causes include hemolysis from transfusion incompatibility, myoglobinuria from extensive muscle injury, sepsis, and the use of vasopressors in the initial resuscitation of shock. Equally important is the incipient loss and sequestration of large quantities of extracellular fluid in extensive soft tissue injuries and the intramural and intraluminal collections in visceral organs in addition to the chemical peritonitis produced by intra-abdominal spillage of digestive juices. The principles of renal failure prevention are recognition of the problem or causative factor, adequate replacement of circulating blood volume with appropriate colloid and crystalloid solutions and establishment of urine flow. Alkalinization of the urine with sodium bicarbonate is recommended to prevent precipitation of acid hematin in situations where hemolysis or myoglobinuria are suspected. When volume replacement and alkalinization fail to produce a response, 25 gms. of mannitol is given every two hours until adequate urine flow is established.

Other Determinations

Major shifts of water and solute occur after severe trauma,

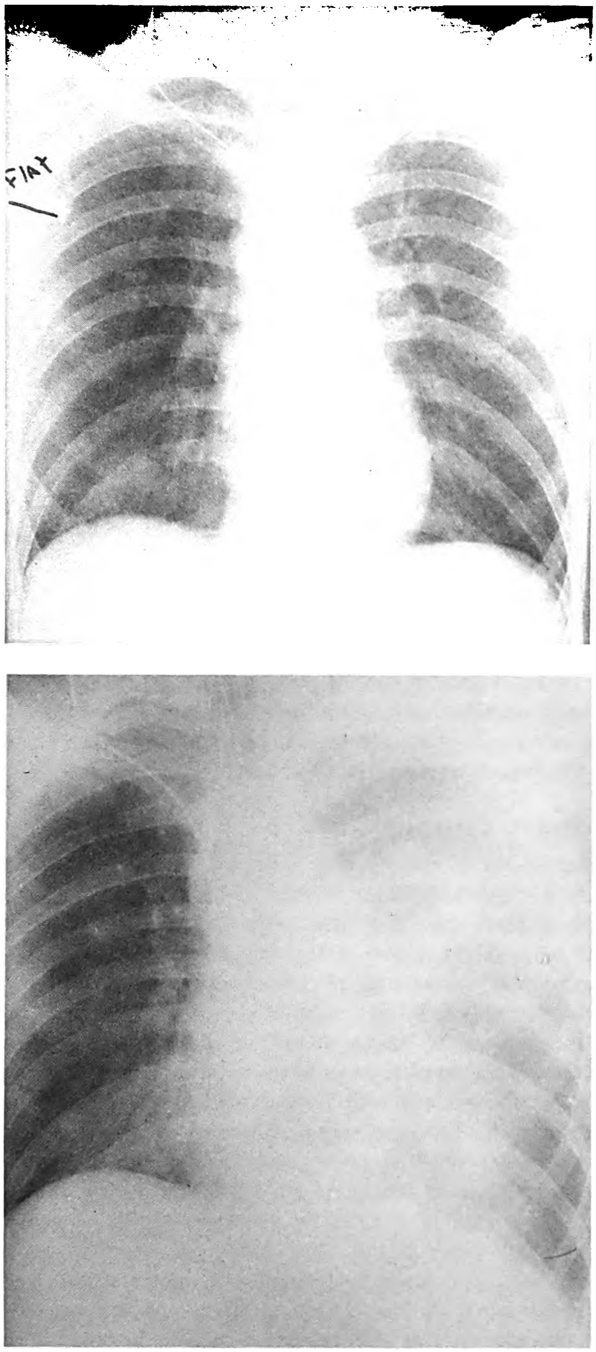


Figure 2 (A) Admission chest film of a 21-year-old male with severe head, spine, and abdominal injuries.
(B) Chest film of the same patient obtained immediately postoperatively while patient was hypotensive. A massive hemothorax (1100 cc's) was drained with a chest tube.

extensive surgery, and subsequent resuscitative efforts in these states. These changes are chiefly caused by metabolic, neuroendocrine and cardiovascular responses to trauma. Serial determinations of electrolytes, BUN, creatinine, total proteins, and osmolality of serum and urine have proven to be among the most valuable tests in monitoring these changes.

Postoperative Shock

When postoperative shock is present, a comprehensive, but rapid reevaluation of the patient is mandatory in order to institute effective therapy. The basic underlying defect must be corrected. The chief causes include: 1) continuing blood loss, 2) inadequate fluid replacement, 3) unrecognized other trauma such as hemothorax, pneumothorax, or cardiac tamponade, 4) myocardial insufficiency secondary to hypoperfusion, myocardial contusion or secondary to anesthetic agents, and, 5) septic shock from abdominal visceral injury.

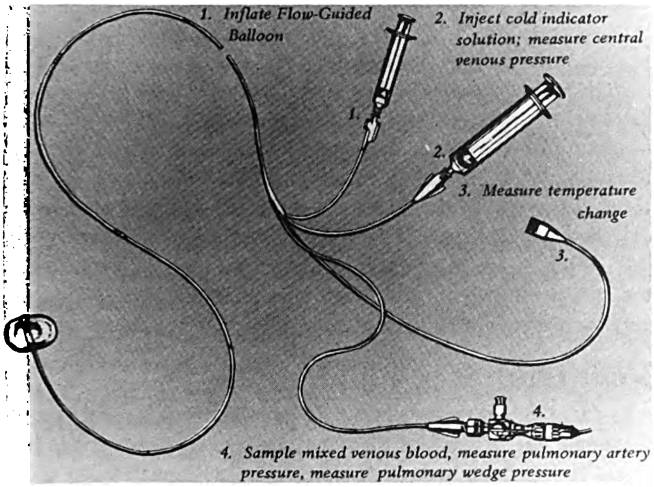
If no significant improvement is noted following conventional methods of management with volume replacement and correction of ventilatory and metabolic aberrations, a need for more sophisticated monitoring and evaluation becomes necessary. Arterial blood pressure, preferably by arterial cannulation, central venous pressure, pulmonary wedge pressure, pulmonary artery pressure and cardiac output are evaluated. This latter information can be obtained with the use of the Swan-Ganz thermodilution catheter. (Figs. 3A and 3B.) Low cardiac output, low arterial blood pressure, and low central venous pressure which does not rise with crystalloid infusions are indicative of hypovolemia and that blood and colloid solutions are required. An elevated central venous pressure and increased wedge pulmonary pressure that rises with rapid administration of fluids with no change in cardiac output is indicative of impairment of the pumping mechanism. This represents myocardial insufficiency and should be treated accordingly.

Pulmonary embolism produces a similar response, but is relatively rare in the immediate post-traumatic state. A normal or slightly elevated central venous pressure associated with a high cardiac output and marked hypotension is indicative of low peripheral resistance most commonly seen in septic shock. Adequate volume replacement, appropriate broad spectrum antibiotics for anaerobic and aerobic organisms and digitalization would be the first things to do in this situation. Should these measures fail, then consideration of the use of inotropic agents and steroids should be given. The most valuable criteria of successful resuscitation are the presence of adequate cerebration and restoration of adequate urine output with normal specific gravity or osmolality.

Thoracic Trauma

Chest wall and pulmonary injury secondary to blunt trauma is recognized as a major cause of morbidity and mortality in high speed automobile accidents. In spite of the large volume of blunt thoracic trauma treated in our institution (only second to musculoskeletal injuries), serious complications of consolidation, pulmonary infection and respiratory distress syndrome have been significantly reduced with early aggressive therapy. Multiple intercostal nerve blocks to relieve pain, encouragement of coughing and clearance of the airway, early drainage of the pleural space of air and blood by tube thoracostomy, no matter how small, intermittent positive pressure breathing, oxygen and humidification by mask and fluid restriction suffice for most patients with mild to moderate injury. In more severe injuries with early appearance of pulmonary infiltrates or progressive deterioration of pulmonary function refractory to high FiO_2, intubation and mechanical ventilation using positive end expiratory pressure (PEEP) is instituted immediately. Serial chest films (at least once daily) and serial determination of arterial blood gases (at least 4 hourly) are of utmost importance in the followup of these patients.

Once circulating blood volume is adequately replaced in these patients, it is our practice to exercise restriction of crystalloid infusions and to keep the serum albumin level above 3 gms.% with colloid infusions. Deterioration of PO_2 following administration of colloid solutions and appearance of interstitial edema on x-ray are indicative of capillary vascular damage with protein leak and further infusions are stopped. Mechanical ventilation is continued until pulmonary function is adequate. Patients with an intact thorax require



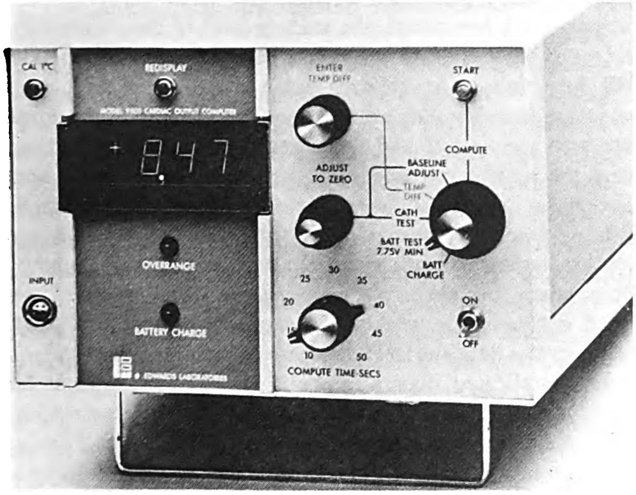


Figure 3 (A) Swan-Ganz thermodilution catheter.
(B) Edwards model no. 9500 cardiac output computer.

mechanical ventilation for three to four days whereas patients with flail chest and other complications require ventilatory support for a much longer period of time.

Massive Transfusion

If there is a single medical crisis that taxes the resources of a hospital's blood bank, it is the patient who requires massive transfusion over a short period of time, *i.e.*, the exchange of total blood volume within one 12-hour period. For an adult, this means a total of 10 units of blood within a 12-hour period and for a child, this could be as little as one unit. Banked blood presents certain problems secondary to storage. It is cold, it is acid and has a high potassium content; it is high in citrate and ammonia and low in platelets; fibrinogen and other clotting factors. In addition, it contains significant debris of cellular elements and their breakdown products. It is then reasonable to assume that the best way to replace blood loss would be by the administration of washed packed erythrocytes and fresh frozen plasma. Although this is desirable, it is impractical when massive transfusion is required in a very short time. Availability of fresh frozen plasma is limited and time for thawing is required, not to mention cost. Packed erythrocytes and either plasmanate or human serum albumin are used in our institution at present with the addition of one unit of fresh frozen plasma for every 5 units of banked blood transfused. The intravenous tubing is warmed whenever possible during transfusion and blood filters are used routinely. Sodium bicarbonate in the range of 50 mEq. for every 3 or 4 units is also injected to combat metabolic acidosis secondary to shock as well as stored blood acidity. Ordinarily, the platelet count does not drop below 50,000 in cases of dilutional thrombocytopenia and usually returns to normal in 3-5 days. However, if transfusion is massive, within the first 12–24 hours, platelets may invariably be required. After the tenth unit of stored blood is infused, two units of platelets or one unit of ultra fresh whole blood is given as the eleventh unit and for every fifth unit thereafter. A more severe drop in platelets which continues with replacement should suggest the possibility of another cause such as disseminated intravascular coagulation (DIC) which calls for full evaluation of the patient's coagulation mechanism. Administration of platelets in DIC or other platelet destruction syndromes is futile and has no therapeutic value whatsoever. The administration of calcium following massive transfusions with stored blood has been recommended by many, but the concentration of calcium required for normal coagulation is such that this is not necessary except in patients with severe liver disease. Mobilization from body stores is usually adequate to compensate for the infused citrate. Hypocalcemia, even to the extent of clinical tetany has had no demonstrable effect on hemostasis.

Total Parenteral Nutrition

TPN is considered in most patients with multiple system trauma especially when such abdominal injuries are present which preclude enteral alimentation for an undetermined period of time. Multiply injured and burned patients show extreme hypermetabolism secondary to a multitude of factors. Due to endocrine and catabolic changes, they demonstrate an increase in urinary nitrogen loss, increase in blood urea nitrogen, increase in blood sugar and low insulin levels, and their negative nitrogen balance is difficult to reverse. Hyperglycemia and excessive glycosuria when receiving TPN is, therefore, not unusual in these patients and exogenous insulin is liberally given as required. Feeding such hypermetabolic patients does not essentially change the rate of their metabolism, but spares protein via the 6-3-C atom cycle.

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AN OVERVIEW OF EMERGENCY CARE FOR CHILDREN WITH MAJOR INJURIES

J. Alex Haller, Jr., M.D.

So much has been written and said in the professional and lay press about the tragic loss of children from congenital heart disease, lung abnormalities, and cancer that it is easy to overlook the fact that half of the children who die in the United States succumb from the immediate or after-effects of major injuries! Almost one-half of the deaths in the childhood years from 1 through 14 years in the United States are a result of major trauma, as compared with approximately one death in ten from injuries in the total general population. A similar situation is present in all of the industrialized nations of the world. For example, in 1964 Stolowski reported that more than one-third of the childhood deaths in Germany were a result of major trauma. Although cardiovascular diseases, cancer, and pulmonary disease lead major injuries as the cause of death in the American population as a whole, trauma is the leading cause of death in children by a wide margin.

The death of an otherwise normal child is always a great tragedy and is the usual situation in a child dying from trauma. On the other hand, crippling injuries to a child and the resulting need for rehabilitation may have an even greater impact on our health care system than the child's death per se. The expenditure of resources and personnel, as well as the economic loss from termination of work potential when a child is seriously handicapped are relatively enormous when compared with similar costs resulting from adult injuries. This is true not only because of the long-term nature of such rehabilitation, but because of the difficult problems of growth and development which must take place simultaneously in an immature child. These adjustments to severe disability and a child's image of himself as an incomplete individual may be overwhelming to the young patient, unless highly trained professionals participate in the process of rehabilitation. It has been estimated that more than 100,000 children are seriously crippled in the United States each year by accidents, and that another 2,000,000 may be temporarily incapacitated by their injuries. As the number of children increases in our country, along with the general population increase, the problems of emergency treatment, resuscitation, and management, as well as long-term rehabilitation of children with major injuries will inevitably increase and put further strains on our overburdened health care system.

Main Causative Factors in Nonpenetrating Injuries to Children

In attempting to evaluate children with nonpenetrating injuries, it is helpful to consider the kinds of forces which might be responsible for these injuries. These can be arbitrarily identified as crushing, compressing and decelarating forces. Crushing injuries are those in which the child's body is mashed against an unyielding surface, such as a loading platform or wall; a moving missle comes against the body. This is somewhat different from the compressing injury in which there is usually a vector force of motion across the body, such as the passage of an automobile wheel over the child's body. This introduces an additional factor of movement and the tearing stress associated with it.

By far, the most important group of forces are those associated with decelarating or accelerating injuries in which different organ systems are set in motion depending upon their masses. This results in differential vector or ripping forces within the body. This may result in a tear, for example, at the stanchion points of the small intestine, the ligament of Treitz and the ileocecal area. Whiplash forces may be brought to bear which result in disruption of the intestine with perforation. Other forms of decelaration injuries may occur in the vascular system and in solid organs.

Blunt Injuries in Children

By far, the commonest group of injuries which we see in the childhood age group are blunt as opposed to penetrating injuries. It has been estimated that at least 80 percent of life-threatening injuries in children occur as a result of blunt trauma. Blunt trauma introduces a number of significant factors which complicate the management of the patient. For example, blunt injuries are much more frequently associated with head injuries in children and the evaluation of a semi-comatose patients adds an additional problem of lack of contact with the patient and the absence of important feedback from the patient in response to pertinent questions. In addition, blunt trauma is associated with the imponderables of little evidence of external injury, and yet, the possibility of life-threatening internal mischief. It is this type of injury, a blunt injury, which emphasizes the need for highly experienced professionals working in emergency facilities for the initial evaluation and resuscitation of children. No injury is more complicated than a major blunt one; and yet, so frequently patients are initially evaluated by the least experienced members of the emergency care team. This fact underlines the importance of reevaluating our staffing policies in emergency rooms, and considering the addition of full-time emergency medical staff with experience in blunt trauma to supervise the training of younger health professionals and to be available for the important judgment decisions associated with the management of blunt injuries. Rarely are such professionals available in our university teaching centers; more frequently, the senior medical student or first-year house officer is the individual upon whose shoulders these important decisions rest.

Penetrating Injuries in Children

Penetrating injuries do occur in childhood. In perhaps 20 percent of the abdominal injuries seen in major emergency rooms there is a penetrating force. These are not as difficult to evaluate and manage because most penetrating injuries will require an exploratory operative procedure. Various kinds of diagnostic studies which employ injection of contrast media have been used in children as well as adults, and they have their place in overall management. By and large, a penetrating injury is an indication for surgical exploration as soon as the patient has been totally evaluated and is relatively stable.

Specific Types of Blunt Abdominal Injury

The retroperitoneal area is an especially difficult one to evaluate if blunt injuries have occurred. For example, compression injury to the pancreas may result in a hematoma in the body of the pancreas with leakage of activated pancreatic juices into the retroperitoneal space. Autodigestion may occur if this is not recognized, and yet, there may be very little evidence of this form of injury when the child is first evaluated. The retroperitoneal area is a relatively quiet area in terms of physical signs, and only later will evidences of peritoneal irritation become obvious. The same may be said for more extensive injury to the pancreas, including transection in which major hemorrhage may occur. The evidences for specific cause of hypovolemic shock are not easily ascertained. The adjacent duodenum may be injured from the same compression force resulting in either retroperitoneal perforation or an intramural hematoma with resulting obstruction to the lumen. These must be considered in the differential diagnosis with any blunt injury to the abdomen.

The solid organs, liver, spleen, and kidney, may also be injured from blunt trauma. Blunt injury to the kidney may result in transection of a portion of the parenchyma and laceration of the blood vessels and drainage system. An expanding hematoma in the retroperitoneal area still represents an indication for exploration, although the use of aortography has greatly improved the ability to diagnose specific injuries and more and more frequently, partial resections rather than nephrectomy for major injuries to the kidney are possible. Extravasation of urine or IVP contrast medium on the IVP is no longer an absolute indication for exploration because some of these injuries can heal, and if the patient is stable, a more conservative approach is indicated. Blunt injuries to the liver may result in major fractures of the parenchyma with both hemorrhage and bile leakage, and may require emergency partial hepatectomy. Techniques of hepatic artery ligation and careful intraoperative cholangiography have improved overall salvage of these potentially lethal injuries.

The commonest solid organ to be injured is the spleen, and rupture of the spleen remains one of the commonest indications for exploratory laparotomy. The spleen in childhood has a very important immunologic function, especially in a child's resistance to certain types of infections. The spleen is the primary source of antibodies against incapsulated gram positive organisms, such as the pneumococcus. Thereafter, attempts to preserve the spleen are indicated and recent suggestions that suturing of the splenic capsule may be possible to preserve the spleen are of great interest. Further experience is necessary before being able to make a final decision on the indications for this conservative approach. Certainly, following splenectomy, all children should be placed on prophylactic penicillin to prefent the occurrence of overwhelming infections which have now been very well documented as a major threat to the splenectomized child.

Blunt injury to hollow viscera may result in compression perforation or perforation due to tearing of the mesentery and intestine. These may also be difficult injuries to diagnose initially because there may be very little evidence of peritoneal irritation, especially in a child with a head injury who is semicomatose from the concussion effects. Careful observation in the hospital for this type of injury is imperative, so as not to overlook insidiously developing peritonitis. After 24-36 hours of leakage from the intestine, clearcut evidence of peritoneal irritation should be present and with expeditious exploration and repair, purulent peritonitis, a much more serious complication than chemical peritonitis, can usually be avoided.

Thermal Injuries

A major burn is one of the most serious diseases of childhood! The immediate mortality associated with an extensive burn is still quite high and the associated morbidity of a major burn is often overwhelming in terms of commitment of professional personnel as well as financial load on the family. The anguish of debridement followed by multiple skin grafting procedures adds to the severity of the injury to the child. In addition, long-term rehabilitation, cosmetic disfigurement, and emotional adjustments in an immature child adds to the tragedy of this preventable injury.

Vascular Injuries

Vascular injuries in children have become a significant problem, especially in regional referral centers. Penetrating trauma is responsible for most of these vascular injuries, but they may also result from blunt trauma. By far, the commonest cause of vascular injuries in major diagnostic centers is the complication of an invasive diagnostic study, such as cardiac catheterization and aortography. This statement of fact does not imply that these tests should not be carried out, but serves to underline the potential hazard of such tests, particularly in young children, and to emphasize the importance of having skilled personnel and excellent facilities for these highly specialized studies.

Unusual Responses of a Child to Major Injury

A small child may respond differently from an older patient and adult to major injuries. For example, paralytic ileus following blunt abdominal trauma may be of greater consequence in children because abdominal distention in a young child may elevate the diaphragm and interfere more with limited pulmonary function. In a relative sense, paralytic ileus is, therefore, of greater consequence in an infant or young child. The same may be said for small blood losses in a small patient whose blood volume is limited. A closed fracture of the femur, for example, in a 10-year-old may be associated with 300 or 400cc of blood lost into the soft tissues. The same amount of blood for a similar injury in an adult would be of little consequence; but in the child this may represent 15-25 percent of the total circulating blood volume and contribute to hypovolemic shock. Unless these relative differences are recognized, such blood losses may not be considered significant in the smaller patient. Major heat losses may occur in a young child who is unclothed in an air-conditioned emergency room for proper evaluation and who may remain for several hours in such an environment. A drop in core temperature of several degrees may interfere with normal enzymes function and other metabolic processes. These changes may add a further metabolic insult to a child's response to stress of trauma.

Congenital abnormalities rarely complicate evaluation and management of adults with major injuries. They can cause serious complications in young children whose congenital anomalies may not have been detected and may not have interfered with reasonably normal function up to the time of injury. For example, a five-year-old with a 50 percent second and third degree burn recently went into profound congestive heart failure during the resuscitative process of fluid and electrolyte replacement. He was then found to have an asymptomatic ventricular septal defect, but under the stresses of rapid fluid replacement, acute myocardial decompensation and heart failure occurred. Possible complications of unrecognized congenital abnormalities must be remembered in the total evaluation of a child under treatment for major trauma.

The rapidity with which metabolic and cardiovascular responses can occur serves to emphasize the importance of good monitoring systems to evaluate the responses of young children to emergency treatment. While monitors are useful in adults, they are mandatory in a small patient because minor changes in response to treatment must be detected early to prevent more serious sequelae.

Head injuries are much more commonly associated with blunt trauma in children than in adults and, as noted above, complicate the overall evaluation of the child. It may be that a child's head is relatively larger and therefore more exposed to trauma than is the adult, or that the child's head is less well supported on the neck and shoulder girdle. Whatever the exact explanation for the high incidence in children, the fact remains that head injuries are very frequently associated with blunt trauma in children. Aside from the errors in diagnosis which may result from evaluating an obtunded child, the lethal effects of subdural hematomas and progressive cerebral edema from blunt trauma are major causes of death in the childhood age group.

The emotional impact of an emergency room experience cannot be overemphasized. A child with a relatively minor injury is often triaged into a corner of a general adult emergency room while patients with life-threatening injuries are given their proper first priority. The scenes which a young child may see during a two-hour stay in such an environment are formidable in terms of emotional impact. Gunshot wounds, stab wounds, drunken adults in various states of disarray, all represent horrible visual experiences to an immature child. Unless these are necessary components of the child's emergency room experience, perhaps better care can be administered to a child in an environment which is designed and staffed for his age group. For many years we have recognized that children require special needs and have designed pediatric departments and children's units within our larger medical centers. The same approach is overdue in our emergency room areas. Whether we design separate but equal facilities for children alongside adult units or whether we identify committed areas for children within our adult emergency room environments is an individual decision for each regional medical center. The important principle is that appropriate areas must be designed and staffed especially for children and their special needs and these facilities must contain the best available quality care for the management of both life-threatening injuries and minor injuries to children.

If a compromise in the organization of these facilities must be made, it would be far better to bring children with life-threatening injuries into an adult environment where the resuscitative efforts are so much more important than the environmental influences and dedicate the special areas for the evaluation of children with minor injuries. A child who is semicomatose or in shock is not likely to remember the environmental aspects of his resuscitative treatment. But, a child with a cut finger, a stubbed toe, or a minor burn may have a longer lasting effect from emotional trauma than from his physical injury!

The identification of such specialized children's units within the total emergency facility offers a number of other important possibilities for improvement of patient care. Pediatricians in training can work in such units and be given the opportunity of managing children with various injuries and accidents; heretofor, pediatric house officers have been excluded from this environment by traditional training programs which rotate surgical house officers but not pediatric house officers through such facilities.

The importance of identifying a captain of a trauma team does not need to be further emphasized. However, the possibility that a pediatrician with special training in emergency medicine might function in this important role has not been widely suggested. Clearly, such an emergency room pediatrician should not be designated captain of the trauma team by fiat, but rather he must be appointed to this position *after* completing appropriate intensive training in the emergency care of children.

Children, as well as adults, with multiple systems injuries are at great risk from being divided up by organ systems for management by different surgical specialists. For example, the child with a head injury, a fractured femur and hematuria may have a neurosurgeon, orthopedic surgeon and urologist each demanding that his particular injury receive priority in management. Under these circumstances, the child trauma victim desperately needs an advocate and one who can intelligently establish priorities in management and organize the team effort in resuscitation and continuing treatment. An emergency physician with pediatric background may represent the best such child advocate. A pediatrician is also more likely to detect other conditions and problems than is a physician with primary surgical orientation. This point is particularly pertinent in the management of children with minor injuries because in the course of their treatment, significant systemic and social family problems may be discovered and can be appropriately managed.

Another important opportunity available in dedicated units for emergency care of children is the training of physician's assistants with a particular interest and ultimate experience in the management of children. These physician's assistants work under careful supervision of physicians and can carry out management of minor injuries, including suturing and treatment of sprains, strains and soft tissue injuries. They can be trained more rapidly than physicians and can represent very important compounds of an emergency care team.

Of course, highly skilled surgical specialists must be immediately available to such emergency facilities for the care of children. Hopefully these surgical specialists would have special expertise in the management of children's surgical problems and would be familiar with some of the unique features of the care of children.

Any consideration of the design of such dedicated outpatient emergency facilities must be combined with the development of inpatient facilities which are dedicated to the continuing care of injured children. These include an operating room always available for life-threatening emergencies requiring immediate surgery and the availability of pediatric anesthesiologists as a part of the treatment team. Intensive care units designed for children and staffed for their care may also parallel intensive care facilities for adults depending upon inpatient organization in individual regional centers. A helicopter receiving area is necessary for expeditious transport from the scene of injury as well as for the transfer of newborn infants with life-threatening emergencies. These combined facilities can be expected to deliver high quality care with special emphasis on the unusual needs of children and would then represent a proper Regional Trauma Center for children.

Communication and Transport Systems

Recent experience in several medical centers has emphasized the importance of two-way radio communication between ambulance personnel at the scene of an emergency and medical personnel in a receiving hospital. This voice system makes it possible to notify a hospital that a child will be transported to their special facilities and also the two-way communication enables physician and emergency medical technician at the scene to discuss management. Advice on special forms of treatment, such as management of flail chest, may be given directly to the emergency medical technician.

Transport of children from the emergency scene into the emergency room often requires special instrumentation including small airways and splints and miniaturized equipment. The use of this equipment must be included in the emergency medical technician training courses and should be a special part of the communication and transport system. Half of the preventable deaths associated with major trauma are estimated to occur between the scene of the accident and arrival in the emergency room. Only by better training and communication with improved transport can this inexcusable loss of life be prevented.

Children's Trauma Registry

Within such specialized facilities it then becomes possible to establish a statistical survey system, or trauma registry, in which each child with a major injury is documented within a protocol and this data is available for careful retrospective evaluation and computerization. Careful, frequent review of the results of treatment and patterns of trauma will be invaluable in subsequent training of emergency medical personnel and in the design of appropriate facilities for the treatment of children. Within the emergency room department, these registries can be used for inservice education, review of patient care, and discussion of better management. An ongoing clinical pathologic conference remains the best form of teaching and the best means of improving delivery of emergency care.

With this approach to individual evaluation and management of children within our emergency room environments, we have the opportunity to develop new systems of communication and delivery, better methods of resuscitation and evaluation, and ultimately better total care for the child with a life-threatening injury. The successful management of a major injury in a child is a great challenge to the entire emergency health care system and represents a most important investment in terms of long-term survival and ultimate contribution to our society. It is a worthy commitment in terms of a career goal for every physician, as well as for those who are generally interested to the care of children with major injuries.

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TEACHING INITIAL MANAGEMENT OF SHOCK IN CHILDREN

Thomas S. Morse, M.D.

The keys to management of hemorrhagic shock are recognition, replacement and arrest of further bleeding. If these objectives are achieved promptly, recovery is virtually assured unless a vital organ has sustained a lethal injury. If inadequate tissue perfusion is allowed to continue, a very simple problem soon may become so complicated that the most sophisticated techniques cannot save the patient.

In order that treatment of injured children of all ages may be initiated with confidence and precision, a simple plan of evaluation and early management is used at the Children's Hospital, Columbus, Ohio. Once the airway has been cleared and adequate ventilation assured, circulation becomes the prime consideration.

Hemorrhagic Shock

Hemorrhagic shock is characterized by hypotension, tachycardia, cool, pale or slightly cyanotic extremities, restlessness or obtunded sensorium and oliguria. Hypotension results directly from the diminished blood volume. Tachycardia is a compensatory mechanism, as is increased peripheral vasoconstriction which produces the cool, pale extremities. The central nervous system aberrations result from cerebral hypoxia due to inadequate perfusion of the brain. Oliguria results both from reduced glomerular filtration secondary to hypotension and from renal cell hypoxia. Whenever oxygenation of the brain and kidneys is inadequate, the same is true of the myocardium. If myocardial hypoxia persists, hypovolemic shock is complicated by a cardiogenic component. Eventually all body cells, which at first were hungry for oxygen, become incapable of utilizing it and death invariably follows.

Normal Values

Familiarity with the normal blood volume of children is fundamental to rational initial management. Blood volume relates directly to body weight and for practical purposes is 40 ml./lb. regardless of the age or size of the child.

The upper limits of normal for pulse rate are 160/min. in infants, 140/ml. in pre-school children and 120/ml. in everyone else. The normal systolic blood pressure in mm. of mercury for children from 1 to 20 years old is 80 plus twice the age in years. The normal diastolic pressure is two-thirds the normal systolic pressure. Thus for a five-year-old child, $80 + 5 \times 2 = 90$ mm. Hg. normal systolic pressure; $90 \times 2/3 = 60$ mm. Hg. normal diastolic pressure.

Normal urine output varies between wide extremes but averages 1 ml./lb./hr. in small children and 0.5 ml./lb./hr. in older children and adults.

Recognition of Shock

For practical purposes, an injured child is in shock if tachycardia and cool, pale extremities accompany a systolic pressure below 77 mm. Hg. An initial diagnosis of shock must be made before the rate of urine output can be measured. The first avoidable error is failure to recognize the *presence* of shock. An even more common mistake is failure to recognize the *development* of shock after initial evaluation has been completed. The only way to be sure that these mistakes are never made is to assume that shock is present or will develop in every significantly injured child and to insist upon frequent determination and accurate recording of the pulse rate and blood pressure.

Initial Management

A previously healthy child who is in shock after an injury has lost at least one-fourth and usually not more than one-half of his normal blood volume. Most children presenting to the Emergency Department in hemorrhagic shock have lost between 10 and 20 ml./lb. of blood.

RINGER'S LACTATE SOLUTION

An intravenous line is established, blood drawn for hematocrit, typing and cross matching, and a bolus of Ringer's lactate solution equal to 10 ml./lb. of body weight is injected rapidly over a period of 5 to 10 minutes. The response to this initial bolus of electrolyte solution determines further management. If the blood pressure returns to normal, Ringer's lactate solution at a maintenance rate of 1500 ml./M^2/24 hrs. is continued, and the pulse rate and blood pressure are measured at frequent intervals. If these remain normal, one can be confident that blood loss is not continuing and that blood transfusion will not be needed.

If the pulse rate remains elevated and the child is still hypotensive, a second bolus of Ringer's lactate solution equal to 10 ml./lb. of body weight is given as rapidly as the first. The need for this second bolus implies that blood transfusion will be needed because dilution of the patient's remaining blood will have reduced its oxygen carrying capacity.

BLOOD

After the child has been given an amount of Ringer's lactate solution equal to one-half of his blood volume, he should be given the freshest whole blood available. Because it should be given rapidly in boluses, the blood should be warmed to body temperature with the use of a blood warming coil. Each bolus should bear a definite relationship to the normal blood volume. The first bolus is usually 10 ml./lb.

CENTRAL VENOUS PRESSURE

In our experience there is no danger of overloading the circulation of a child in hemorrhagic shock until he has been given Ringer's lactate solution and blood as described above. A central venous catheter is of no value in the *initial* management of hypovolemic shock, and attempting to insert one before giving the child 20 ml./lb. of Ringer's lactate solution and 10 ml./lb. of blood is generally a waste of valuable time. After these fluids have been given, many children are nomotensive and stable. They do not need central venous lines. Those who are not completely resuscitated by the above measures are candidates for insertion of a central venous line which can be very valuable in their further management.

URINARY CATHETER

Tissue perfusion is adequate when the sensorium is lucid, the skin warm and pink, and the rate of urine output normal. The most reliable and easily documented of these parameters is the hourly urine output which should be at least 1 ml./lb./hr. If the patient is rapidly and easily stabilized, a urinary catheter is superfluous, but when the indications for a central venous catheter are present, an indwelling Foley catheter should also be inserted. Both catheters carry a risk of introducing infection; both should be inserted with calm care and precision *after* the initial steps described above have been taken, and both should be removed as soon as they are no longer needed.

HEMATOCRIT

The hematocrit is of little value in the initial management of children in hemorrhagic shock, but is extremely helpful in the hours which follow. It reflects changes more slowly than do the vital signs, central venous pressure and rate of urine output. It's greatest usefulness is as an indicator of gradual blood loss. When massive replacement of rapid blood loss is necessary, the hematocrit serves as a guide to the ratio of blood to electrolyte solution needed. The hematocrit should be kept between 35 and 45. Changes in serial hematocrit are more valuable than any single determination.

Occult Bleeding

Children who require more than 10 ml./lb. of whole blood in addition to 20 ml./lb. of Ringer's lactate solution often are still bleeding. The detection of continuing bleeding is much easier if blood is replaced rapidly in boluses than if it is infused at a constant rate. Vital signs, hematocrit and rate of urine output are recorded before and immediately after each bolus is administered. Changes in these pre- and posttransfusion values reflect primarily the influence of the rapid intravenous intake. During the subsequent period of maintenance fluid administration changes in hematocrit, pulse rate, blood pressure and rate of urine output quickly reflect a decreasing blood volume due to ongoing hemorrhage. If continuing blood loss and replacement are proceeding simultaneously, recognition of ongoing blood loss may require a much longer observation period.

Fractures of the pelvis or major long bones may be associated with loss of more than one-fourth of the total blood volume, and bleeding from fractures may continue for many hours after injury. Provided vital signs, hematocrit and rate of urine output are followed with a high index of suspicion, the physician will not be caught unawares when occult bleeding causes shock. A more dangerous error is to assume that because major fractures are present, they are responsible for all of the loss of blood. This erroneous assumption may lead to failure to recognize potentially lethal lesions such as fracture of the liver or spleen.

Significant occult bleeding is usually intra-abdominal and is manifested by abdominal tenderness. In simple injuries the diagnosis of intra-abdominal bleeding is not difficult, but in more complicated injuries many factors may be present which make a clinical diagnosis unreliable or impossible. The most common complicating factor is a head injury. Since tenderness is the most important clinical fracture of intra-abdominal bleeding, head injuries which obtund the sensorium deprive the clinician of his most valuable observation. Pelvic or rib fractures may produce pain when the abdomen is pressed upon, and one cannot be sure whether the patient is reacting to motion of the fracture or whether abdominal tenderness is being elicited. Renal injuries produce tenderness and hematuria. The co-existance of rupture of the liver or spleen is easily missed if all of the tenderness is mistakenly attributed to a renal injury. These combined injuries are common. Of 44 children with left renal injuries, 11 or 25 percent also had ruptured spleen.

ABDOMINAL PARACENTESIS

Paracentesis is not needed in perfectly lucid children who have no abdominal tenderness. It is not indicated if the diagnosis of an intra-abdominal injury requiring operation has been made on clinical grounds. We use paracentesis liberally in patients with head injuries, fractures of ribs or pelvis and in those with hematuria. Paracentesis is done with an angiocath*. We have not found peritoneal dialysis catheters necessary. The finding of gross blood which does not clot indicates an intra-abdominal injury. If blood does not return, 10 ml./lb. of saline is infused. This corresponds to about 1.5 to 1.8 liters in the adult, and nearly always assures a return via the angiocath. An RBC count of over 100,000/cu. ml. or an inability to read news print through a test tube full of the effluent is taken as significant.

*Desseret Company, Salt Lake City, Utah.

Conclusion

Common errors in the management of injured children include failure to recognize shock, failure to recognize continuing blood loss, and inadequate replacement due to lack of familiarity with the normal blood volume of children. A simple plan has been presented which allows relatively inexperienced physicians to initiate the care of injured children confidently and expeditiously. The care of children with hemorrhagic shock is facilitated when the first physician to treat them knows how to make an appropriate beginning.

CURRENT MANAGEMENT OF PATIENTS WITH THERMAL INJURY

Basil A. Pruitt, Jr., M.D., F.A.C.S.

An extensive burn from whatever cause alters the function of all organ systems in the body and patients with such injuries require intensive, multidisciplinary care throughout their hospital course. Initial resuscitation resembles that of other injured patients with emphasis on fluid replacement and maintenance of adequate ventilation. Following resuscitation, wound management is the central theme of burn patient care with the goals of prevention of infection, early wound closure and maintenance of function. Life-threatening complications involving any or many organ systems may occur at any time until the burns are healed or grafted. Convalescence is prolonged and repeated operative procedures may be necessary for optimum rehabilitation.

Cell injury or death due to thermal injury results in increased capillary permeability with loss of intravascular fluid into the interstitial space in the form of edema. Since the 1940's several resuscitation formulae have been developed and each has been reported to be clinically effective, a fact which reflects the physiologic tolerance of the majority of burn patients. In the very young, the elderly or patients with preexisting cardiopulmonary disease, the formula being employed should be modified according to the individual patient's needs and response.

The most widely employed formulae today emphasize electrolyte-containing fluids, and it appears as if colloid-containing fluids have no greater volume-augmenting effect than an equal volume of electrolyte-containing fluid during the first 24 hours postburn. The risks of volume overloading can be minimized by calculating the first 24-hour electrolyte-containing fluid need as 2 ml/kg/percent burn (using the actual extent of burn even in those patients with burns of more than 50 percent of the total body surface) and adding to that only if necessary to maintain adequate organ perfusion. In the second 24 hours postburn, as capillary permeability returns toward normal, fluid loading can be further minimized by the use of colloid-containing fluids to replace any persistent blood volume deficit and 5 percent dextrose in water to replace evaporative and metabolic losses.

Following resuscitation, the burn patient characteristically has elevated renin and aldosterone levels and markedly increased evaporative water losses, a situation favoring retention of salt and loss of salt-free water. Fluid therapy from the third postburn day onward should, therefore, minimize salt-loading and provide sufficient fluid to permit the gradual excretion of the salt load administered during resuscitation while permitting a 1 - 2 percent body weight decrease per day, so that body weight returns to preburn levels on or about the tenth postburn day. Evaporative water loss can be estimated according to the formula: Evaporative water in ml/hr = (25 + percent of body surface area burned) X total body surface area in square meters. The amount of electrolyte-free fluid administered will need to be adjusted as indicated by the indices of hydration, which include body weight, serum sodium concentration and serum osmolality.

Current monitoring techniques include use of central venous pressure and Swan Ganz catheters in volume-sensitive patients, but urinary output is the most readily available index and is satisfactory in the vast majority of burn patients. An hourly urinary output of 30 - 50 cc in the adult and proportionately less in children is indicative of adequate fluid replacement, and there is no documented need for greater urinary volumes. Oliguria in the first 48 hours postburn is indicative of inadequate replacement, not acute renal failure, and is treated by increased fluid administration. Diuretics are indicated only in patients with significant loads of hemochromogen in their urine, *i.e.*, patients with high voltage electric injury, patients with deep burns involving muscle and burn patients with associated soft-tissue injury, and those patients with extensive burns who receive their estimated fluid replacement plus additional fluid and remain oliguric. Promptly instituted, adequate resuscitation has significantly reduced the occurrence of oliguric renal failure in even extensively burned patients, as indicated by this occurrence in only 57 of 1,889 burn patients treated during a 16-year period (only 12 patients required dialysis and the other 45 cases were temporally related to terminal sepsis).

Circumferential burns of the extremities may, as edema forms beneath a tight, unyielding eschar, impair circulation to distal unburned parts. Cyanosis of distal unburned skin, impaired capillary refilling, and progressive neurologic change, especially paresthesias of a limb with proximal circumferential burns, are clinical indications of a need for escharotomy. These clinical signs are relatively insensitive and the presence or absence of distal pulses as assessed by use of the Doppler ultrasonic flowmeter is a more reliable guide to the need for incision of the eschar in the midlateral and/or medial line of the involved limb. Circumferential burns of the trunk may restrict the ventilatory excursion of the chest wall and respiratory gas exchange will be improved in such patients by escharatomies in the anterior axillary line and, if the burn extends onto the anterior abdomen, along the costal margin.

Inhalation injury, a chemical tracheobronchitis due to the

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inhalation of smoke or other irritating products of incomplete combustion significantly increases the mortality associated with a given sized burn in the burn size range wherein a 30 - 60 percent mortality is anticipated. ^{133}Xenon perfusion ventilation lung scans, fiberoptic bronchoscopy, and pulmonary function testing in combination are useful and accurate in making an early diagnosis of inhalation injury. Changes in pulmonary function, particularly depression and alteration in the configuration of the maximum expiratory flow volume curve and decrease in flow at various fractions of vital capacity are the most sensitive indicators of inhalation injury. Use of any two of the three diagnostic modalities eliminates falsely negative results and ensures that all patients with this disease receive treatment. Treatment of inhalation injury consists of a graduated therapeutic response dependent upon the severity of pulmonary insult and the patient's ability to maintain satisfactory blood gas levels and mechanical patency of his respiratory tract. Recent studies suggest that steroids, even in massive doses, do not significantly influence the consequences of severe inhalation injury. Tracheostomy should be reserved only for those patients in whom there is associated chest wall injury, inability to handle secretions and/or volitus, or in whom prolonged access to the lower tracheobronchial tree is deemed essential.

Ileus, which commonly accompanies burns of more than 20 percent of the total body surface, necessitates placement of a nasogastric tube in such patients and its use until gastrointestinal motility is restored. Prophylactic antibiotics previously recommended are no longer advised and antibiotics should be administered only on specific indications.

Following resuscitation, wound care is the principal concern in the treatment of the burn patient. All wound care is directed toward preventing infection, preserving viable tissue, maintaining function, and bringing about early closure of the burn wound.

Excision of the burn wound is limited by the availability of donor sites and the blood loss associated with the procedure itself. Scalpel excision to the level of the investing fascia is best employed for unequivocally full-thickness burns of limited extent and excision and even amputation of nonviable tissue in the case of patients with high voltage electric injury. Tangential excision has been found useful in the treatment of deep second-degree burns of the dorsum of the hand, other limited areas of partial-thickness thermal injury, and by the group at the Boston Shriners Burns Institute as treatment for patients with extensive thermal injury whose wounds are immediately autografted while the patient is receiving immunosuppressive therapy.

The majority of burn wounds are treated by means of topical chemotherapy to prevent the proliferation of microorganisms in and invasion through the eschar. Several topical chemotherapeutic agents are available and three have been shown to be of documented clinical effectiveness in the prevention of Pseudomonas burn wound sepsis, *i.e.*, mafenide acetate (Sulfamylon) burn cream, 0.5 percent silver nitrate soaks, and silver sulfadiazine burn cream. Each agent has limitations and advantages and they should be employed with flexibility. None of the available topical agents sterilize the burn wound, and the burn wound of any given patient may escape from bacterial control. The burn wounds must be examined in their entirety each day for the signs of burn wound invasion and any suspicious area biopsied, with the biopsy specimen examined microscopically in search of the histologic criteria of burn wound infection. Escape from microbial control necessitates alteration of wound care to include use of Sulfamylon, a diffusable agent, excision if the involved area lends itself to such, and subeschar infusion of antibiotics to which the invading organism is sensitive. Despite use of these modalities, burn wound sepsis is associated with an extremely high mortality rate and salvage is minimal.

Following separation of the bulk of the eschar, control of the microbial population is continued by the use of serially applied biologic dressings, which also promote further maturation of the granulation tissue of the wound bed in preparation for definitive isograft coverage. Cutaneous xenografts can also be used as biologic dressings in this situation, although they are not as effective as cutaneous allografts. Amnion is another available biologic dressing material, but it must be covered with dressings to prevent desiccation. There are no synthetic skin substitutes presently available which approach biologic dressings in terms of clinical effectiveness.

Despite the control of invasive burn wound sepsis, the most common cause of death in burn patients prior to 1964, by effective topical chemotherapy, infection remains the most common cause of death in the burn patient today. The most frequent complication is airborne pneumonia (bronchopneumonia) but hematogenous pneumonia metastatic from an infected burn, a previously cannulated suppurative vein, or an occult perforated ulcer may present as a solitary focal pulmonary infiltrate. The sudden appearance of a solitary or multiple focal pulmonary infiltrates on a chest roentgenogram of a burn patient necessitates a search for the primary septic focus with examination of every previously cannulated peripheral vein and excision of the entirety of a suppurative vein when identified. Treatment of bronchopneumonia is the same as for any other surgical patient.

Acute ulcerations of the stomach and duodenum, as in the case of other physiologic disturbances and complications, are burn size related and are exaggerated by sepsis and other complications. Gastritic and duodenitic mucosal changes occur within hours postburn in 80 percent and 72 percent of patients with burns of more than 35 percent of the total body surface. In slightly more than one-fourth of such patients, these lesions progress and clinically significant hemorrhage or perforation occurs in approximately 13 percent. Vagectomy with excision of the ulcer, if possible, is the operation of choice. Musocal ischemia appears to be a significant initial etiologic factor, but acid production and mucosal hydrogen ion permeability increase in those patients with progressive disease who develop clinically significant lesions. Prophylactic antacid therapy significantly reduces the occurrence of clinically significant ulcer complications.

Other life-threatening complications may involve any of the organ systems in a patient with an extensive burn, as indicated by the reported occurrence of acute bacterial endocarditis, hemorrhagic pancreatitis, massive adrenal hemorrhage, acalculous cholecystitis, disseminated intravascular coagulation and central nervous system and peripheral nerve disturbances in extensively burned patients. The metabolic demands placed upon the extensively burned patient exceed those of any other patient and the nutritional requirements are correspondingly magnified. Metabolic care and nutrition of the burn patient require constant attention to create a microenvironment to minimize metabolic stress and to provide adequate nutritional substrates.

Following closure of the burn wound, significant functional limitations may require intensive and prolonged physical and occupational therapy for their amelioration or correction. Moreover, hypertrophic scar formation may persist and actually increase following initial closure, necessitating multiple operative procedures for cosmetic and functional rehabilitation. The etiology of hypertrophic scar remains undefined and no totally satisfactory prophylaxis is available. Definition of the cause of hypertrophic scar formation is needed and will permit the development of effective prophylaxis or pharmacologic treatment thereof.

As indicated by the preceding, the medical care of an extensively burned patient is people intensive, requiring physicians, nurses and other health personnel of wide experience and thorough training. Of the estimated two million burn patients in the United States each year, approximately 16,000 will require burn center care because of the extent of their burns, the presence of associated inhalation injury, the presence of associated mechanical trauma, or because of the etiology of their burn, *i.e.*, high voltage electricity or chemicals. Burn care in the United States is, in general, well regionalized, with burn centers in all but a few geographic areas in the United States. The most significant limitations in the United States burn care system today are: (1) the irregularity of referral of patients with extensive burns, and (2) the shortage of experienced or specially trained physicians and nurses for the staffing of existing and projected burn units and burn centers.

TRAUMA MANAGEMENT — INFECTION

W. A. Altemeier, M.D.

Trauma continues to be the fourth leading cause of death in the United States, and infection, one of its major complications, continues to add significantly to its seriousness as a national (and international) health hazard. The development of infections associated with trauma produces important consequential effects on morbidity, mortality, disability, wound healing and the quality of life — both physical and psychological.

Considering its continuing high incidence and these serious consequences, it is difficult to understand the relatively small amount of interest of physicians and the overall effort and money expended in solving this problem. Although improved recently, they must still be considered to be minimal and inadequate at best.

Clinical experience and microbial studies have shown that the general use of modern antibiotic therapy for more than a third of a century has failed to decrease the overall incidence of surgical infections. In addition, the widespread use and misuse of antibiotic therapy has complicated some of the problems related to the prevention of infection.

The complexities of modern surgical practice related to the concentration of large numbers of patients with established infections in hospitals, the large number of individuals with severe trauma, the extension of prolonged surgical operations and supportive procedures to a rapidly increasing number of high-risk patients, and the growing use of drugs which decrease bodily resistance to infection have further accentuated the problem of infection control.

Incidence of Infection

Accurate data on the incidence of infection in trauma patients in the United States is not available. Table 1 indicates the incidence of hospital admissions, operations, and infections estimated to have occurred during the year 1967.

ETIOLOGIC FACTORS: NON-MICROBIAL

While microorganisms are the basic cause of infections in the post-trauma patient, it is essential to recognize and remember that a number of non-microbial factors are of great importance in the etiology of infections. The physician and bacteriologist frequently emphasize the bacterial etiology of wound infections, and other etiologic factors of considerable importance may be overlooked. (Table 2)

It is important to keep in mind that the presence of unhealthy, irritated, or dead tissue in wounds invites and supports the growth of virulent and to lesser degrees non-virulent bacteria. Healthy tissues on the other hand possess a remarkable resistance to bacterial colonization and invasion of wounds.

Impaired circulation also decreases local resistance and may produce local derangements in the physiologic state of the wound with the development of a wound pablum favorable to bacterial growth and subsequent invasion. Maintenance of an adequate blood supply therefore is another prime consideration.

Consequently, compound fractures, burns, gunshot and high explosive wounds, fracture dislocations, extensive lacerations, crushing injuries, mine injuries, or similar types of wounds which contain torn devitalized muscle and dirt, have been particularly prone to develop infections.

The multiplicity of severe wounds in one person may so compromise his treatment that adequate debridement of one or more of his wounds becomes impossible. Because of severe shock, hemorrhage, or the association of wounds, the local treatment of wounds may necessarily assume a relatively secondary role in relation to his early overall treatment.

There are other non-microbial factors which may predispose or contribute to the development of wound infection, and these are considered to be of increasing importance. (Table 3)

TABLE 1: Hospital Infection U.S.A. — 1967

Estimated Incidence	
Hospital admissions	31,600,000
Surgical operations performed in the operating room	18,800,000
Estimated number of postoperative wound infections for all types of operations (7.4 percent of operations)	1,391,200
Estimated number of other hospital-acquired nosocomial infections	2,101,037

TABLE 2: Wound Infections

Etiologic Factors Other Than Bacterial

1. The presence and amount of devitalized tissue remaining in the wound.
2. The existence or development of impaired local circulation.
3. The presence and types of retained foreign bodies.
4. The location, duration, and nature of the wound.
5. The type, thoroughness, and time of treatment.
6. Multiplicity of severe wounds in individual patients.
7. The local and general immunity response of the individual.
8. The general condition of the patient.

TABLE 3: Other Factors Contributing to Development of Infection in Trauma Patients

1. Age
2. Extreme obesity
3. Remote active infection
4. Duration of operation
5. Associated diseases: diabetes, uremia, and cirrhosis
6. Other debilitating diseases
7. Antibiotic, steroid, and other drug therapy

ETIOLOGIC FACTORS: MICROBIAL

A large number and variety of microorganisms have been identified with surgical infections including those complicating wounds or other types of trauma.

On the basis of laboratory studies done in the Surgical Research Bacteriology Laboratory of the University of Cincinnati during the past 32 years and a review of pertinent literature, Table 4 showing microbial etiologic agents has been developed. The types of microorganisms have varied considerably with reference to their incidence and relevant importance.

The number and types of contaminating bacteria can increase the probability and severity of wound infection, but the mere presence of virulent bacteria in a wound per se does not make infection of that wound a certainty. The physiologic state of the tissues within the wound before and after treatment has been shown to be more important than the presence of such bacteria. Continuing contamination by bacteria is another important factor.

Types of Infection

The types of infection complicating trauma may take many forms, and various classifications of them have been developed. Table 5 is based essentially upon anatomical and pathophysiological considerations of post-trauma surgical infections.

In exploring the possible reasons for the apparent failure of antibiotic therapy to prevent post-trauma and nosocomial infections, our attention has been focused on the probability that many surgical infections were related to diagnostic and supportive therapeutic procedures which invaded the physiologic interior. These were, therefore, to be considered ***nosocomial*** or ***hospital-acquired***.

The more important causes of nosocomial infections will be described under the specific categories shown in Table 6.

TABLE 4: Surgical Infections: Microbial Etiology

I. Aerobic Bacteria
   - A. Gram-positive coccus
     - Staphylococcus
     - Streptococcus
     - Streptococcus pneumoniae (Pneumococcus)
   - B. Gram-negative coccus
     - Neisseria catarrhalis
     - Neisseria gonorrhoeae
   - C. Gram-negative bacillus
     - Escherichia coli
     - Enterobacter aerogenes (Aerobacter aerogenes)
     - Enterobacter cloacae
     - Klebsiella
     - Pseudomonas aeruginosa
     - Proteus
     - Proteus inconstans (Providencia stuartii)
     - Serratia marcescens
     - Citrobacter
     - Alcaligenes faecalis
     - Salmonella
     - Hemophilus influenzae
   - D. Gram-positive bacillus
     - Bacillus anthracis
     - Bacillus species
     - Corynebacterium
     - Diptheroids
     - Mycobacterium tuberculosis
     - Mycobacterium marinum (Mycobacterium balnei)

II. Microaerophilic Bacteria
   - A. Gram-positive coccus
     - Streptococcus
       - Hemolytic
       - Nonhemolytic

III. Anaerobic Bacteria
   - A. Gram-positive coccus
     - Peptococcus
     - Peptostreptococcus (Anaerobic Streptococcus)
   - B. Gram-positive bacillus
     - Clostridium perfringens
     - Cl. novyi
     - Cl. septicum
     - Cl. histolyticum
     - Cl. tetani
   - C. Gram-negative bacillus
     - Bacteroides species
     - B. fragilis
     - B. melaninogenicus
     - Fusobacterium

IV. Mixed Infections
   - Aerobic and anaerobic microorganisms
   - Gram-positive and Gram-negative microorganisms
   - Synergistic microorganisms

V. Fungi
   - Candidiasis (Candida albicans)
   - Blastomycosis (Blastomyces dermatitidis)
   - Coccidiodomycosis (Coccidioides immitis)
   - Histoplasmosis (Histoplasmosis capsulatum)
   - Sporotrichosis (Sporotrichum schenkii)
   - Phycomycosis (Mucor species)
   - Aspergillosis (Aspergillus niger)
   - Fusarium species
   - Actinomycosis (Actinomyces israelii,)* (Arachnia propionica)
   - Nocardiosis (Nocardia asteroides)*

VI. Viruses
   - Herpesvirus
   - Poxvirus (vaccinia)
   - Varicella (Herpes zoster virus)
   - Cytomegaloviruses
   - Mumps virus (Parotitis and pancreatitis)
   - Poliovirus
   - Hepatitis virus (infectious and serum)
   - Rabies virus

*No longer considered fungi

TABLE 5: Post-Trauma Surgical Infections

I. Wound Infection Following Injury, Surgical Operations, or Other Treatment.
   - Cellulitis with erythema, swelling, or increased tenderness
   - Suppuration or liquefaction of tissues
   - Abscess
   - Burns
   - Septic necrosis of tissues
   - Septic thrombophlebitis in vicinity of local wound
   - Clostridial infections and gas gangrene, tetanus

II. Regional Post-injury Extension
   - Direct extension through adjacent tissues
   - Lymphangitis and lymphadenitis
   - Thrombophlebitis
   - Peritonitis
   - Central nervous system infection, including meningitis and brain abscess
   - Mediastinitis
   - Retroperitoneal cellulitis

III. Organ or Visceral Infection

IV. Systemic Infection Occurring Post-injury or Operation
   - Bacteremia
   - Septicemia

V. Nosocomial (Hospital-Acquired) Infections

URINARY TRACT NOSOCOMIAL INFECTIONS

Current surgical practice frequently requires prolonged or frequent use of urinary bladder catheterization or instrumentation. In our study of 398 gram-negative septicemias, the source was related in 56 percent of the cases to the urinary tract. In 48 percent of the cases, the onset was related to instrumentation or operation. In 82 percent of all of the cases of *E. coli* and *Aerobacter aerogenes* septicemia, the sources of infection were the urinary tract, and in 75 percent of the cases caused by *A. aerogenes*, the urinary tract was the portal of entry.

RESPIRATORY TRACT NOSOCOMIAL INFECTIONS

The second most common source of nosocomial infections was the respiratory tract which accounted for 22 percent of the infections of this type. One-half of these had tracheostomies. Emergency tracheostomy, while a useful and lifesaving procedure in severely injured or seriously ill patients, may become the route of life-threatening pulmonary infections caused by *Staphylococcus aureus. Pseudomonas aeruginosa*, or other virulent bacteria of the hospital environment. There is great need for improved and safer procedures for the care of tracheostomy patients.

TABLE 6: Causes of Nosocomial Infections

1. Wound Infections
   a. Primary
   b. Secondary
2. Intraveous Therapy
3. Tracheostomy Care
4. Anesthesia
5. Urinary Tract Procedures
6. Leucocyte Suppression
   a. Cancer Chemotherapy
   b. Immunosuppressive Drug Therapy
   c. Irradiation
7. Steroid Therapy
8. Blood Transfusion
9. Preoperative Antibiotic Bowel
10. Miscellaneous

NOSOCOMIAL INFECTIONS FROM CONTINUOUS INTRAVENOUS THERAPY OR MONITORING

More recent experience has emphasized the importance of prolonged intravenous therapy with indwelling catheters or needles as another active source of postoperative infections. This has been particularly evident in high-risk debilitated and aged persons. A recent survey at the University of Cincinnati showed that 70 percent of patients with indwelling intravenous catheters for 72 or more hours developed significant areas of thrombophlebitis or active cellulitis with resultant discomfort, fever, and increased morbidity. A new syndrome called "Third Day Surgical Fever" has been described as a gram-negative septicemia occurring three days postoperatively in trauma and other high-risk patients. It is obvious that better methods are needed for continuous intravenous infusion of fluids, electrolytes, and hyperalimentation fluids.

In addition, it is recommended that all hospitals develop plans of intravenous therapy to minimize related infections.

IMMUNOSUPPRESSIVE THERAPY

Surgical practice has been extended by various types of immunosuppressive therapy such as that used in organ and tissue transplantations, and anticancer chemotherapy. Thus, many patients are now necessarily made highly susceptible to infection. With greatly impaired resistance, such patients require special attention with special surgical techniques, antibiotic treatment, isolation and reverse isolation techniques, and critical supportive nursing care. Infection, however, remains a frequent complication in patients with immunosuppressed states, and our special attention is indicated for the prevention and control of these nosocomial infections.

STEROID THERAPY

Surgical practice also currently requires various forms and degrees of steroid therapy, one of the complications of which is increased susceptibility to nosocomial infections. The incidence of postoperative wound infection is more than three- to five-fold, and that of other nosocomial infections can be expected to be markedly increased. Recognition of this infection potential and the institution of appropriate and effective methods for the prevention and control of nosocomial infections is important.

ANTIBIOTIC-RELATED NOSOCOMIAL INFECTIONS AND OTHER COMPLICATIONS

There is increasing evidence that intensive and prolonged antimicrobial therapy is contributing to the development and changing pattern of nosocomial infections. Examples include the following:

1) Increasing incidence of gram-negative invasive infections.
2) Emergence of secondary infections by bacteria of little or no virulence such as *Serratia*.

3) Increasing incidence of fungal infections. Long-term intravenous infusion or hyperalimentation has been incriminated as a factor leading to the development of yeast infections in a wide variety of surgical conditions.
4) Greater incidence and variety of serious viral infections.
5) Gastrointestinal bleeding associated with septicemia.
6) Increasing incidence of "L" form infections.

Summary

1. The dimension of infection in surgical patients is real, continuing, demanding, and urgent.
2. The introduction and general use of the germ concept, antiseptic technique, asepsis, immunization procedures, and antibiotic treatment have *not* eliminated or decreased *overall* incidence of infection. As some are prevented or controlled, others have taken their place.
3. Infection is a dynamic process with significant changes both during course of infection and in general patterns.
4. Clinical and laboratory experiences indicate that antibiotic therapy has been an important factor in contributing to the continuance and dynamics of infection.
5. More knowledge is needed regarding the significance of infection as related to its causes and dynamics.

SECTION IV
Trauma Management Body Systems

INTRODUCTION

William E. DeMuth, Jr., M.D.

This program is without doubt the most enthusiastic one ever devoted to the full spectrum of emergency medicine. Our session, Trauma Management — Body Systems, is a logical sequel to the more general subjects such as shock, metabolism, organ failure, already discussed.

Time does not permit us to discuss system injuries as they relate to associated injuries, but it must be remembered that most serious injuries involve more than one body system. The session on General Considerations, moderated by Dr. Hampton earlier today, was largely devoted to the inter-relationship, conflicts, and priorities involved in the management of patients with multiple injuries or those with major single injuries. The central theme is a systematic approach to management of the critically injured.

It is our purpose to describe methods of management of serious system injuries. Our panel are recognized experts in their respective fields of interest. They will describe concepts and techniques which experience has demonstrated to be effective.

DIAGNOSTIC CONSIDERATIONS IN ABDOMINAL TRAUMA

Robert J. Baker, M.D.

Effective management of the patient with abdominal trauma requires a rational, systematic approach to both evaluation and treatment. Several new, innovative diagnostic techniques have proven valuable in the past 5-10 years, and their use will be reviewed. Despite the more sophisticated instrumentation and 24-hour laboratory availability, the most effective method of detecting significant intra-abdominal injury still remains the repeated, careful physical examination of the patient's abdomen. One difficulty inherent in this approach is the fact that the most experienced physician is required to make repeated examinations; subtle changes in the abdominal findings, and the final determination as to the worsening or improvement in the patient's condition, can be missed if several observers see and examine the patient at different times.

In addition to local abdominal changes, a systematic evaluation of the entire patient is extremely important, and is really the initial order of business in assessing the patient with abdominal trauma or, for that matter, trauma to any organ system. Since many of the patients whom we observe have suffered multiple injuries, the abdominal findings must, of necessity, be presumed to be the third most important area; the first is the respiratory system, and the second the cardiovascular. Obviously, any interference with gaseous exchange, or with cardiac output or peripheral tissue perfusin, must take precedence in correction over the intra-abdominal damage which may have occurred, unless that injury is deemed to be contributing significantly to cardiovascular instability. It is not uncommon to see a patient with a ruptured spleen or ruptured liver whose bleeding is so severe that effective resuscitation is impossible until the abdomen is opened and the bleeding site tamponaded. This can be detected early by the failure of the patient to respond to the first 1,000–2,000 cc of colloid infused, assuming that such an infusion is undertaken with as rapid an infusion rate as possible. If the patient's state of shock, or cardiovascular instability, is unresponsive to the infusion, immediate operation is essential, once one determines that the intra-abdominal injury is the site of hemorrhage. Obviously the assessment of the patient continues during the minutes required to infuse a large volume of colloid, but untoward delay in order to obtain X-rays or other specific tests may result in death, if the patient is in shock. The basic principle is that shock which is refractory to a one to two liter colloid infusion, administered as rapidly as possible, necessitates immediate operation; no further diagnostic evaluation is possible, beyond that which has taken place at the bedside.

Systemic Evaluation of the Multiple Injury Patient

The systemic evaluation of the injured patient, especially one with multilocular injuries, is difficult if the patient is unable to respond coherently. As far as the history is concerned, it is frequently impossible to obtain an adequate history from the patient, at which point someone should telephone or otherwise communicate with a relative, close friend, or other individual who has knowledge of the medical history of the injured patient.

1. HISTORY

The history should, by the use of a simple mnemonic, "AMPLE," include at least the following information: "A" equals allergies or idiosyncrasies to various drugs, antibiotics or other substances; "M" indicates medications which the patient uses, prescribed on a regular or sporadic basis; "P" is for previous illnesses, hospitalizations, operations; "L" is the time of the last meal (if not known, presumed to be within 4 hours); "E" means events preceding injury.

This mnemonic is quite helpful for general screening of the patient's history with regard to further care of his injuries; as an example, the knowledge of *allergies or idiosyncrasies* to drugs or other agents which the patient may receive is, obviously, of first importance. It is remarkable how frequently allergic patients are given a semisynthetic penicillin, when a simple question as to penicillin allergy would have prevented such an accident. Use of broad spectrum antibiotics such as cephalothin, carbenicillin, or other agents with a penicillin-commonality must be avoided.

Use of *medications* is one of the more important concerns which should be allayed prior to operative intervention or protracted supportive care. Such drugs as digitalis, diuretics, antihypertensive agents, anticoagulants (coumadins), or protracted heparin therapy all are of key importance to the physician who is treating the patient. One of the commoner traps into which the unwary trauma surgeon falls is the unsuspected use of, or, more frequently, failure to inquire about such use of preparations containing small doses of adrenal steroids. Any patient on steroids who is subjected to major trauma may develop acute hypoadrenocorticism, even if the dosage has been very small. A careful history should be obtained from the patient, or someone who knows his daily medication regimen, as to the use of mixtures or nostrums containing steroids. Patients complaining of arthritis-like symptoms, or "rheumatism," unfortunately are not infrequently given small doses of steroids in combination with aspirin, phenylbutazone, or other agents. Although the steroid dose has hardly been therapeutic, if treatment has continued for more than one to three months, adrenal cortical suppression may result. It is wise to provide exogenous steroids during the acute posttraumatic period to such a patient in order to avoid the risk of acute Addisonian crisis. Further, the requirements for replacement steroid treatment in such a setting are three to four times basal levels.

The item concerning *previous illnesses*, past hospitalizations, or operations is self explanatory. The time of the *last meal* is of considerable import, since the stomach empties very slowly or not at all after major trauma. A patient who has left his home with a full stomach and is subject to trauma is apt to be taken to the operating room some hours later with the same full stomach. When in doubt, obviously the stomach should be intubated and the contents aspirated in order to prevent tracheobronchial aspiration during the induction of anesthesia or at the conclusion of the procedure.

The *events preceding injury* are of help, if such information is obtainable. For example, the patient who is driving a vehicle and sustains a myocardial infraction may strike a moving or fixed object, because he suddenly became unconscious consequent upon sudden fall in cardiac output and cerebral hypoxia. Only the patient or a companion would be able to give such a history. When the patient was admitted following the auto accident, the shock noted might have had nothing to do with the accident, but rather resulted from the major cardiovascular effect of the acute coronary occlusion. A patient who becomes dizzy and falls down a flight of stairs can present with perplexing findings if the vertigo was caused by an impending cerebrovascular accident. If he had complained to someone else about the symptom, reconstruction of the sequence of events is possible, thereby averting a serious diagnostic error.

The *nature of the wounding force* is also of some importance, though rarely is accurate information available about the precise nature of the wounding forces and object. For example, it is usually possible to determine whether the patient was driving a vehicle or was a passenger, but it is not likely that one could be sure that the individual was thrown from the vehicle by the force of impact, or even whether a seat belt was in use. In the case of personal violence or assault, the wounding instrument might well be known to the authorities or to whomever brought the patient to the hospital. The implications of a baseball bat swung at the abdomen are somewhat different from those when an individual was walking down the stairs, slipped, and struck his abdomen against a staircase post. Under any circumstances, it is worthwhile to attempt to determine the nature and magnitude of the wounding force, although it is not necessarily of direct diagnostic importance.

2. PHYSICAL EVALUATION

It is necessary to rapidly survey the major body systems which determine survival of the patient in the intraoperative and postoperative period, should the patient prove to require operation. Assessment of the cardiovascular system and of the respiratory apparatus are of prime importance, and it is noteworthy that occasionally the examining physician fails to carefully auscultate not only the thoracic cage, but also the neck. It may be possible to detect aspirated material, blood clot, bits of bone or teeth, or other foreign substances in the tracheobronchial tree by listening to the rush of air past such a partially obstructing object in the trachea or upper bronchi. The best place to detect such foreign materials is at the base of the neck, where coarse rhonchi or other abnormal sounds should lead one to suspect the possibility of aspirated foreign material. In addition, the quality of the respiration (wet versus dry) helps to point up the necessity for aspirating the pharynx and supraglottic area, since wet respiratory sounds heard in the neck frequently result from secretions which have pooled in the pharynx when the patient is supine in the ambulance or on a stretcher.

The central nervous system is usually examined, but the most frequent error is failure to record the findings carefully. If another observer or consultant is required later, he would be helped by careful notation in the chart of the state of consciousness, orientation as to time and place, appropriate or inappropriate responses to questions, and other pertinent data concerning cerebral function as evaluated at the bedside. These findings are of considerably more import than the presence or absence of Babinski signs, or the finding of other abnormal reflexes. The three basic observations of diagnostic significance are: (1) state of the sensorium, (2) pupillary reaction and size, and (3) presence of intact or deficient motor power in any extremity or extremities. The performance of a funduscopic examination for CNS trauma during the initial stages is not helpful, since it takes from 24 to 72 hours for papilledema to result from acute head trauma. However, it is worthwhile to examine the eyes with an ophthalmoscope, looking primarily for a dislocated lens, retinal hemorrhage or retinal detachment. The musculoskeletal system, aside from detecting evidence of gross fracture, requires careful, judicial attention. Especially important is an assessment of the cervical spine: if the patient is conscious and awake, having him gently turn the head from side to side, flexing the cervical spine by touching the chin to the chest, as well as extension, is very helpful, since the patient who is able to perform these movements without undue pain can be assumed not to have a serious or potentially catastrophic fracture dislocation of the cervical spine. On the other hand, the unconscious patient, or the patient who is unable to cooperate, cannot be assumed to have a stable neck, and the only truly emergency X-ray which is required in the uncooperative or unconscious patient with multiple injuries is the X-ray view of the cervical spine obtained with a lateral portable film. If the cervical vertebral bodies are found to be properly aligned, without "stepping" or malalignment, this may be presumed to be evidence of an intact cervical spine, and the patient may safely be moved from the examining room table to a cart or hospital bed. On the other hand, if the cervical spine film demonstrates a questionable "step-deformity," or fracture, then the neck and head should be carefully buttressed with sand bags or folded blankets, and no movement which is not absolutely critical for survival of the patient should be undertaken until adequate cervical spine films are obtained, and the patient is put into a head traction device. Under no circumstances should a lumbar subarachnoid puncture be attempted until neurosurgical consultation is obtained.

The abdominal examination is the very essence of the detection of intra-abdominal trauma. There is no substitute for careful, repeated evaluation of the abdominal findings, including areas of tenderness, rebound tenderness, and measurement of abdominal girth at the umbilicus. The latter is extremely important, since it will help to detect subtle degrees of increasing distention, either from intraperitoneal fluid or blood, or intraluminal gaseous distention. Should a mass be found, it may represent rupture and contiguous hematoma formation of the liver, kidney or spleen. In a child or very thin adult, it is occasionally possible to feel an intramural hematoma of the duodenum or a fractured pancreas. In addition, the presence or absence of peristaltic sounds, their pitch and frequency, and the finding of rebound tenderness should be carefully noted and recorded. Bruises, contusions, or other external signs of abdominal injury should also be recorded. With penetrating trauma, obviously, the site of entrance of the knife or missile is critical, and an attempt should be made to plot the course of the missile by evaluating any wounds of exit; in the absence of exit wounds, X-ray evaluation in three planes (2 views) of the location of the projectile prior to exploration can modify the operative approach.

Investigation of Intra-Abdominal and Retroperitoneal Injury

When the patient is first admitted with intra-abdominal or flank injury, a number of routine studies are done, including complete blood count, urinalysis with microscopic examination, and blood chemistries. Included in the latter should be serum amylase and, occasionally, serum lipase. In addition, urine amylase, either from a single specimen or a two hour sample, is uniformly submitted to the laboratory for evaluation. In the event that either amylase, serum or urine, is elevated, the presumption must be made that the patient has sustained a significant pancreatic, duodenal or jejunal injury. Further approach to that patient depends on the clinical findings and the progression of symptoms, such as paralytic ileus, abdominal tenderness, distention, etc. The serum lipase is complementary to the serum amylase, and rarely yields significantly different information; it is only of benefit if the amylases are normal. Admission hematocrit is measured, since fluid resuscitation will normally be accompanied by a fall in hematocrit, of a predictable amount, and a more rapid or steeper decline in the hematocrit is suggestive of continued hemorrhage (Table).

Abdominal paracentesis has been a valuable adjunct to the

TABLE 1: Investigation of Intra-Abdominal and Retroperitoneal Injury

TEST	ORGAN INJURY DETECTED
1. CBC, chemistries (amylases, etc.)	1. Systemic effects (e.g., DIC) Pancreas
2. Abdominal paracentesis	2. Rupture of solid viscus (hemoperitoneum) Hollow viscus trauma
3. Infusion pyelography	3. Kidney (bladder)
4. Urethrocystogram	4. Urethra, bladder
5. Plain films of the abdomen and chest	5. Liver, retroperitoneal hematoma Hollow viscus
6. Diagnostic pneumoperitoneum	6. Liver, spleen
7. Radionuclide scanning a. ^{198}Au b. ^{99m}Tc-sulfur colloid c. ^{197}Hg chlormerodrin	7. Spleen Liver Kidney
8. Gastrointestinal contrast studies	8. Esophagus Stomach Pancreas
9. Angiography	9. Spleen Liver Kidney Arteries Pelvic fracture
10. B-mode sonography	10. Pancreas Liver Spleen Kidney

physical examination of the abdomen, and is one of the most commonly used diagnostic tests in abdominal trauma. There are two basic techniques which can be employed, the first is simple needle aspiration, the second being some form of peritoneal lavage. Aspiration is done with a short bevel 18 gauge needle, a three-way stopcock, and a standard 10 or 20 cc syringe. It is only necessary to infiltrate the skin with 1% lidocaine (mepivicaine); the deeper structures should be left unanesthetized, as it is useful to know when the peritoneum is penetrated by the needle. The patient perceives this as sudden sharp pain, and will inform the operator about the event as soon as it occurs. Use of the so-called "four quadrant tap" should be discouraged, since the needle may damage the liver or the spleen which is enlarged or which has been pushed downward by clot between the viscus and the diaphragm. Rather, the patient is turned into the left lateral decubitus position (lying on his left side), and allowed to remain in that position for three to five minutes. At the end of that time, the needle is introduced perpendicular to the projection of the parietal peritoneum at a distance approximately 2 cm inferior to the umbilicus and at the lateral edge of the rectus sheath. It is quite important not to penetrate the body of the rectus muscle with the needle since this may cause undue hemorrhage into the muscle, especially if the deep inferior epigastric artery is damaged by the needle tip. When the needle is introduced at the lateral edge of the rectus sheath, there is very little danger of properitoneal or muscular bleeding, which would obscure the finding of abdominal tenderness in that quadrant. When the peritoneum has been penetrated, gentle suction is applied to the syringe, using care that the three-way stopcock is correctly manipulated so that no air can enter the peritoneal cavity. If air enters the peritoneal cavity, subsequent X-rays will show pneumoperitoneum, leading to considerable uncertainty as to the source of the air, specifically, whether it was introduced at the time of paracentesis or whether it had escaped from a damaged hollow viscus. For this reason, many surgeons prefer to obtain X-ray films prior to performing paracentesis. Nevertheless, if later in the hospital course it becomes important to reexamine the abdomen by X-ray, the presence of air in the second set of films poses the same dilemma if paracentesis was performed after the first study. If fluid is obtained from the paracentesis, it should be subjected to standard studies: microscopic examination for red cells or white cells; laboratory evaluation for concentration of amylase, bilirubin and protein; pH measurement of the fluid. If the tap on the left side of the abdomen is negative, it is reasonable to turn the patient into the right lateral decubitus position, and repeat the paracentesis in the right lower quadrant, at the mirror image site of the left lower quadrant aspiration. The disadvantage to using the right lower quadrant is that the cecum is a more anterior structure than the sigmoid colon, and is frequently quite dilated in the face of abdominal trauma; since this is the case, there is a greater hazard of penetration of the cecum by the needle in the right lower quadrant than is the case with the sigmoid in the left lower quadrant.

Peritoneal lavage has become quite popular, and merits considerable attention. If the needle paracentesis is positive, there is no need to proceed further, but appropriate steps can be taken in keeping with the findings in the fluid obtained by needle paracentesis. On the other hand, if needle paracentesis is negative, then peritoneal irrigation or "lavage" technique should be employed in order to augment the needle paracentesis. The lavage is performed in the midline just below the umbilicus, having ascertained that the bladder is empty either by having the patient void or by catheterizing the bladder. A very small skin incision can be made and a peritoneal lavage catheter, of the standard commercial type used for peritoneal dialysis, can be inserted through a small stabwound in the fascia and peritoneum. This catheter should be secured with a pursestring suture through the fascia. If desired, a plastic arterial catheter equipped with a central fine trocar can be substituted. This has the advantage of speed, since it does not require a skin incision, but has the distinct disadvantage of being a relatively blind procedure. It is quite possible to pass the arterial catheter into the lumen of the intestine, rather than into the free peritoneal cavity.

When the catheter of either type has been inserted, 500 ml of buffered Ringer's lactate (25 ml of 7.5% sodium bicarbonate should be added to the 500 ml of Ringer's lactate in order to buffer the fluid to an alkaline pH) should be instilled through the catheter over a 10–15 minute period. The patient can be gently turned from side to side, and the fluid allowed to drain by gravity at the end of the 15 minute period. A red blood cell count should be done on the fluid; if this is higher than 100,000/cubic millimeter, it is considered a positive abdominal paracentesis, and operation should be carried out forthwith, since the high concentration of red cells indicates free blood in the peritonteal cavity. At this concentration of red cells, the fluid is quite pink and is opaque in the test tube. In addition, the fluid should be studied for the presence of polymorphonuclear leukocytes and should be analyzed chemically for both amylase and bilirubin, considering the dilution factor resulting from the 500 ml infusion. The yield is much higher with peritoneal lavage than with needle aspiration, but lavage is unnecessary either if the needle aspiration is positive, or if there is an indication for surgery aside from the paracentesis.

Infusion pyelography has been utilized for some time in order to assess the urinary tract during the course of the initial investigation. When the patient is first seen, and a negative history for dye (iodide) sensitivity is obtained, 100 ml of 50% Hypaque (diatrizoate) is infused in the first liter of intravenous fluids which are administered. When the abdominal X-ray films are taken, the collecting system will have filled and an excellent pyelogram will be readily obtainable, without the delay of having to inject the dye in the Radiology Department. Further, a view of the pelvis will usually show a diagnostic outline of the bladder, and dye extravasation from the bladder may often be seen after such an intravenous infusion, if there is major bladder wall disruption. It has recently been emphasized that, if the male patient cannot void, or, on attempting to void, there is a small amount of blood seen at the urethral meatus, this is presumptive evidence of rupture of the urethra from blunt pelvic trauma. Under these circumstances, *urethrocystography* should be undertaken rather than damaging attempts at passage of a urinary catheter. A sterile bulb syringe with 50 cc of 50% Hypaque is introduced into the external urethral meatus, and gentle pressure applied with the thumb and index finger to close the urethral orifice around the tip of the syringe. Following slow injection of the dye, exposure of an X-ray film will yield positive information about the presence of a urethral injury. In the event that the urethrocystogram is normal, a catheter can be introduced into the urinary bladder with appropriate care. On the other hand, if there is a dye extravasation into the periurethral tissues, a catheter should not be placed, but rather the patient should be subjected to cystostomy, in order to avoid further trauma to the urethra and the possibility of periurethral infection. It is almost impossible to satisfactorily repair the instrumented, torn urethra because of the extensive scarring which results.

Plain films of the abdomen in abdominal trauma are frequently quite helpful; the usual films which are taken are the supine view, the upright PA chest film, the upright abdomen, and a view with the patient in the left lateral decubitus position. The presence or absence of psoas shadows, especially if the psoas is present on one side and not on the other, abnormal air in the peritoneal cavity or in the retroperitoneal space, and the presence of the foreign body in the case of gunshot wounds of the abdomen can be detected with these radiographs. Further, when the pyelographic dye has been infused during the initial resuscitative effort, definitive evidence of the presence of two functioning kidneys can be obtained from the flat film of the abdomen. The chest film gives useful general information about the heart and lungs, but infradiaphragmatic injury may cause a unilateral pleural effusion.

Radionuclide scanning for evidence of rupture of the spleen (using 198 gold or 99m technetium-sulfur colloid) has been extremely helpful if a gamma camera scanner is available for use shortly after admission. This is not time-consuming, and is an accurate and highly effective screening technique for rupture of the spleen, since any defect in the spleen following abdominal trauma should be presumed to be intraparenchymal hematoma. The definitive decision as to the optimal mode of treatment can be facilitated with an adequate scan. Likewise, the liver can be scanned with the same colloids, although liver scanning is not as effective nor as accurate as is scanning of the spleen, because of the large bulk of liver which one sees via the gamma camera; also, there is sometimes uneven uptake of the isotope by the large liver mass. The kidney can also be evaluated (using 197 mercury chlormerodrin), and renal scanning can serve a very useful purpose in assessing renal function, above and beyond the use of the infusion pyelogram.

Angiography has been extremely popular in evaluating abdominal trauma, and may be accomplished by either the flush aortogram, with the angiographic catheter tip in the aorta at the level of the eleventh thoracic vertebra, or selective arteriography of the branches of the abdominal aorta may be undertaken for specific visceral evaluation. Spleen and liver are well outlined by coeliac injection; renal arteriography is employed in patients with an abnormal renal scan. The retroperitoneum and retroperitoneal vessels are best opacified with the flush aortographic technique. All of these techniques require that the patient's general condition is satisfactory and stable, that he be able to tolerate one to two hours in the X-ray Department, and that he be properly attended in the course of the study; the patient must not be allowed to slip into shock or to develop serious respiratory difficulty during the diagnostic procedure. A special case can be made for the use of selective arteriography in pelvic fractures with major blood loss. The tip of the catheter can be placed in the common iliac or in the hypogastric vessels, and the bleeding point identified. It is sometimes necessary to cannulate both right and left sides in order to detect the dye blush of a lacerated major channel causing severe retroperitoneal hematoma in the face of pelvic fracture.

B-mode sonography is a newly developed technique which has proven to be extremely useful in detecting fluid filled cavities in various parts of the abdominal cavity. For example, a perinephric hematoma, with a collection of blood mixed with urine in the perirenal space, can usually be detected best by sonography; occasionally this type of injury will result from a relatively minimal parenchymal tear, in which both scan and the angiogram reveal very little. Under such circumstances, the unmasking of such a fluid filled cavity by sonogram would certainly lead to the recognition of the perirenal hematoma and its appropriate treatment. The same principle holds with regard to the pancreas, except that the only effective way to assess the damaged pancreas is with sonography. A collection of fluid in the lesser peritoneal cavity or in the base of the transverse mesocolon can usually be detected by the sonogram, whereas this area is relatively resistant to diagnostic investigation by other usual techniques. Large intraperitoneal or retroperitoneal collections of fluid, pus, or blood can also be detected by the sonogram.

Summary

The essential ingredients in the diagnosis of intra-abdominal injury include repeated, careful examination of the abdomen, abdominal paracentesis and an array of special techniques that can be utilized, if available. In addition, an ample history and an intelligent physical examination yield invaluable information. A high index of suspicion and an awareness of the subtle findings in both intra-abdominal and retroperitoneal trauma are required in order to achieve a successful outcome in an acceptably high percentage of patients.

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MANAGEMENT OF PANCREATIC AND DUODENAL INJURY

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Because the duodenum and pancreas are well protected against most blunt impacts by the adjacent liver, the lower lateral rib cage, and the vertebral column, these organs are infrequently injured after blunt abdominal trauma. This anatomic advantage, however, provides less protection against missiles and knives. Furthermore, patients with pancreatic and duodenal injury are in danger of having their injury temporarily overlooked because their retroperitoneal location tends to minimize and thereby delay physical findings. Such delay significantly increases post-operative morbidity and mortality, primarily on the basis of cardiorespiratory insufficiency. Success in treatment of pancreatic and duodenal injury, therefore, requires early diagnosis followed by appropriate surgery.

Early Diagnosis

The diagnosis of pancreatic and duodenal injury differs for ***penetrating*** and ***blunt*** wounds. Identification of penetrating wounds to the pancreas and duodenum is usually made during laparotomy performed on the basis of intraperitoneal penetration and/or suspected intraperitoneal organ injury. Any question during laparotomy about proximity of the penetrating wound to either the pancreas or duodenum is then resolved by thorough exploration of the lesser sac and direct visualization of the pancreas and duodenum. Although theoretically possible, it is very rare for a patient to have a penetrating wound to either the pancreas or duodenum without penetration into the free peritoneal cavity causing at least minimal hemoperitoneum.

Early diagnosis of blunt pancreatic and duodenal injury continues to be a surgical problem. The classical clinical signs and symptoms of intra-abdominal sepsis are masked by the retroperitoneal location, thus causing a delay in recognition. Increased effectiveness in making early diagnosis of blunt pancreatic or duodenal injury depends upon: (1) anticipation, (2) recognition of early abdominal physical findings, (3) appreciation of the low incidence of associated intraperitoneal injuries, and (4) utilization and interpretation of appropriate diagnostic aids. The cause of delay in diagnosis and treatment is usually physician inadequacy and not due to patient delay in seeking care. The most common reasons for physician error are, failure to appreciate significant physical findings in the intoxicated patient or the patient with associated head injury, and failure to recognize the roentgenographic signs of retroperitoneal duodenal perforation. It must be emphasized that patients with blunt pancreatic and/or duodenal injury may have a negative pericentesis and peritoneal lavage. Delay in diagnosis of serious pancreatic or duodenal injury for more than 24 hours increases the mortality rate from 5–8 percent to over 70 percent; most patients who survive after such a 24 hour delay before operative intervention have significant morbidity requiring prolonged hospitalization. This is particularly true in those patients who have severe combined injury to both the pancreas and duodenum where the mortality rate after a 24 hour delay in operation approaches 90 percent.

The most common *physical findings* in patients with retroperitoneal duodenal rupture or pancreatic injury are minimal abdominal pain and tenderness which is apparent immediately after injury but usually decreases over the next 1 to 2 hours only to worsen by 6 hours. This transient decrease in abdominal findings may provide a false sense of security to the treating physician who misinterprets this injury as an abdominal wall contusion. Any patient, therefore with mild to moderate abdominal pain and/or tenderness which is greater at 6 hours than at 2 hours should be suspected of having retroperitoneal pancreatic or duodenal injury. Just as significant is the appearance of abdominal findings in the intoxicated patient as sobriety approaches. Shock on admission, or shortly thereafter, is not a reliable sign of retroperitoneal injury. In contrast, hypovolemic shock leads to an early laparotomy for hemoperitoneum, at which time the retroperitoneal pancreatic or duodenal injury is found incidently. Unfortunately, most patients with blunt retroperitoneal duodenal or pancreatic injury do not have associated intraperitoneal injury. A negative pericentesis and peritoneal lavage, as indicated already, do not rule out blunt pancreatic or duodenal injury.

No specific laboratory tests will reliably lead to an early diagnosis of blunt duodenal injury. The serum amylase may or may not be elevated whereas leukocytosis with a shift to the left accompanies retroperitoneal sepsis seen when the diagnosis has been inordinately delayed. Patients with blunt abdominal injury, however, should have a serum amylase determination done upon admission and a repeat determination done at 6 hours if there are any abnormal abdominal findings, however minimal. This is helpful in providing an early diagnosis for pancreatic injury. Although the initial serum amylase concentration correlates poorly with the presence of blunt pancreatic injury, a rise in serum amylase at 6 hours in a patient with minimal or moderate abdominal tenderness is very significant and warrants laparotomy with thorough exploration of the lesser sac. One can, however, observe patients who have a rise in serum amylase at 6 hours when all of the abdominal findings have returned to normal; such patients, however, are admitted for a 48 hour period of observation.

The most helpful diagnostic aids for blunt duodenal rupture are flat and upright films of the chest and abdomen. The interpretation of such roentgenograms unfortunately often leaves something to be desired. A retrospective review of abdominal roentgenograms on patients treated on the Emergency Surgical Service at Detroit General Hospital, showed that a 95 percent of patients with complete blunt duodenal perforation had scoliosis and/or obliteration of the right psoas shadow within 6 hours of injury. These findings which indicate retroperitoneal irritation or inflammation and are highly suggestive of duodenal rupture after blunt trauma were frequently ignored causing delay in therapy. Specific findings of retroperitoneal duodenal rupture, namely, air bubbles distributed along the right psoas margin, upper pole of the right kidney, or along the lower mediastinum were present within 6 hours in 60 percent of patients. These findings likewise were frequently overlooked by the surgeon and usually missed by the radiologists, thus identifying an educational void for both specialties. Any patient, therefore, with scoliosis and/or obliteration of the psoas shadow requires an emergency meglumine diatrizoate (Gastrografin) swallow while lying on the right side to facilitate passage of the contrast material into the retroperitoneal space. Roentgenograms taken more than 24 hours after blunt duodenal rupture show extensive dissection of retroperitoneal air throughout the confines of the right gutter and into the pelvis. Free intraperitoneal air is uncommon in patients with blunt duodenal rupture. Its absence, therefore, should provide no sense of security to the examining physician. The diagnosis of intramural duodenal hematoma is usually made incidently at the time of laparotomy for other organ injuries or because of duodenal obstruction from the intramural hematoma in the post injury period. This diagnosis of duodenal obstruction is confirmed by barium swallow which shows a coil spring or bird's beak deformity from compression of the lumen by the intramural hematoma. Both the abdominal and thoracic roentgenographic findings in patients with pancreatic injury are minimal and usually not helpful in making an early diagnosis. Later changes after pancreatic injury include a "ground glass" appearance in the mid-abdomen due to lesser sac sepsis, but by this time the golden period for operative intervention with a good likelihood of success has passed.

Treatment of Duodenal and Pancreatic Injury

The success of treatment of both pancreatic and duodenal injury is directly related to the severity of injury, delay in operative intervention, and the presence of a combined pancreaticoduodenal injury. The severity of injury, therefore, should be carefully classified in order to assist in making treatment recommendations.

Duodenal injury can be classified into 4 separate groups as follows: Class I is duodenal hematoma, contusion, or serosal tear without complete perforation or associated pancreatic injury; Class II is complete duodenal perforation without pancreatic injury; Class III is any type of duodenal injury in association with a minor pancreatic injury such as contusion, hematoma, or laceration which does not involve the main pancreatic ductal system; Class IV is any duodenal injury in association with major pancreatic injury such as transection, massive contusion, or multiple lacerations and hemorrhage in the head of the pancreas (severe combined injury).

Pancreatic injury, likewise, can be categorized into severity of injury as follows: Class I is contusion, abrasion, or laceration to any portion of the pancreas, but not involving the main pancreatic duct; Class II is severe laceration, penetration, or transection of the body and tail (left of the portal vein) with probable injury to the main pancreatic duct; Class III includes transections, large lacerations, expanding hematomas, or smashing injuries to the head of the pancreas (right of the portal vein) without associated duodenal injury; Class IV includes large lacerations, transections or crushing injuries to the head of the pancreas in association with duodenal rupture (severe combined injury).

Operative Approach

Following appropriate resuscitation and induction of anesthesia, a midline laparotomy provides the easiest access to the pancreas, duodenum and other intraperitoneal organs which may be injured. During laparotomy, all patients with possible pancreatic or duodenal injury require complete exploration of the lesser sac. Criteria for lesser sac exploration include (1) air bubbles anterior or lateral to the duodenum near the ligament of Treitz or within the transverse mesocolon; (2) bile staining anywhere; (3) hematoma over the duodenum along the base of the mesentery or adjacent to the greater curvature of the stomach; and (4) penetration or near penetration by a missile or knife. The lesser sac is most quickly explored by dividing the greater omentum between the stomach and colon just outside the arcades of the left and right gastroepiploic vessels. This permits thorough inspection and palpation of the anterior, superior, and inferior pancreatic margins and the anterior and lateral surfaces of the duodenum. Alternatively, the lesser sac may be opened by detaching the greater omentum at its colon attachments prior to retracting the stomach cephalad and the transverse colon caudad. When examination of the pancreas and duodenum through this exposure is normal, no further mobilization is needed unless there is hematoma posterior to either organ or active bleeding. Mobilization of the body and tail of the pancreas with spleen anteriorly and medially from its avascular retroperitoneal attachments provides complete exposure to the posterior body and tail of the pancreas up to the level of the portal vein. Examination of the posterior duodenum and head of the pancreas is best achieved by reflecting the hepatic flexture of the colon inferiorly and performing the standard extended Kocher maneuver to the level of the superior mesenteric artery. Both techniques, when used in combination, provide complete exposure of the pancreas and duodenum without jeopardizing the vascularity of either organ.

Repair of duodenal injuries varies with the extent or class of injury. Intramural duodenal hematoma or serosal tear (Class I injury) diagnosed incidently during laparotomy for peritonitis or hemoperitoneum is best treated by evacuation of the hematoma with careful serosal reapproximation. Intramural duodenal hematoma diagnosed later because of duodenal obstruction may be observed nonoperatively for one to three weeks with reasonably good expectation for resolution of the hematoma and alleviation of the obstruction. Rupture of an intramural hematoma during this period of observation is rare. Patients showing no relief of duodenal obstruction during a prescribed period of observation require operation, evacuation, and careful serosal reapproximation. Gastrojejunostomy may be added after evacuation of the hematoma if duodenal narrowing appears to be significant. Morbidity in such patients treated in this manner is negligible.

Type II duodenal injury, namely complete perforation without pancreatic injury, is usually best treated by simple transverse closure in two layers using a continuous 3/0 absorbable suture for the internal layer and interrupted 4/0 non-absorbable sutures for the external layer. Fortunately, most perforations are transverse, occur along the lateral antimesenteric border, and involve only 25 to 75 percent of the duodenal circumference so that transverse closure is readily accomplished. Complete circumferential duodenal transections can usually be treated by an end-to-end anastamosis if the transected margins appear viable. Alternatively, reconstruction may be achieved by an end-to-end duodenojejunostomy with oversewing of the distal duodenal stump. Longitudinal tears require longitudinal closures to prevent unusual distortion and tension at the suture line. This may produce excessive duodenal narrowing for which a gastrojejunostomy should be performed. Vagotomy need not be added for all patients requiring gastrojejunostomy but appears to be indicated in patients with a history of an ulcer diathesis or with a greater likelihood of developing postoperative stress bleeding because of associated solid viscus injuries and severe shock. Severe edema around the margin of perforation may preclude a safe primary closure; such perforations may be covered by a jejunal serosal patch. Alternatively, this type of edematous injury may be repaired by a Roux-en-Y side-to-end duodenojejunostomy. Fortunately, few patients require these more complicated or extensive types of reconstruction for Class II injuries and are best treated with simple closure.

Abdominal drains are not routinely employed for patients with Class I and Class II duodenal injury. Such drains, however, may be indicated as part of treatment for associated injuries such as to the liver. Tube duodenostomy or jejunostomy with retrograde passage of a suction catheter into the duodenum is rarely indicated for Class II injury and may be associated with increased morbidity. In contrast, a simple and safe technique for internal decompression of the duodenum can be provided by placing a number 18 nasogastric tube with extra holes across the pyloris into the duodenum to provide both gastric and duodenal decompression.

Duodenal injury in combination with contusion, hematoma, or peripheral laceration of the pancreas (Class III injury) is best treated by primary repair of the duodenal injury and drainage of the pancreatic injury if performed within the first 24 hours of injury. The morbidity following operation in most patients with Class III injury is related to the pancreatic injury. Postoperative pancreatitis is common but it usually responds to conservative management consisting of nasogastric suction and fluid replacement. Delay in operation in patients with Class III injury, in contrast, is associated with multiple complications, especially pneumonitis, pancreatitis, sepsis with cardiorespiratory insufficiency, renal failure, duodenal cutaneous fistula, and occasionally death after simple closure. Patients with Class III injury operated upon more than 24 hours after injury, therefore, should have the duodenal diverticulization procedure. This consists of vagotomy, hemigastrectomy, gastrojejunostomy, tube duodenostomy, and primary repair of the duodenal perforation. This procedure decreases the likelihood of duodenal fistulization and, furthermore, provides for a controlled end duodenal fistula rather than an uncontrolled side fistula which is associated with local, undrained sepsis and the above named complications. Furthermore, the duodenal diverticulization procedure allows for continued nutrition in the postoperative period despite the presence of a fistula.

Class IV or severe combined pancreaticoduodenal injury presents a great surgical challenge. The mortality rate after simple closure of the duodenum plus drainage of the pancreatic injury is unacceptable. Such patients have a very high incidence of intraperitoneal and retroperitoneal sepsis, undrained sepsis around both pancreatic and duodenal fistulae, breakdown of the duodenal repair, and severe end organ failure secondary to sepsis. Such patients require, therefore, either the duodenal diverticulization procedure or pancreaticoduodenectomy. The decision rests on the suspected involvement of the main pancreatic duct. Resection of the injured pancreas and duodenum is indicated for severe lacerations or disruptions of the head of the pancreas with obvious ductal injury. A few patients have undergone total pancreatectomy as part of an extended Whipple operation for severe combined injury to the duodenum and head of the pancreas. This operation, therefore, should remain within the scope of the surgeon's armamentarium. The final role of total pancreatectomy for severe combined injury, however, awaits further clinical reports. Certainly, the few patients having this procedure performed for trauma have not had excessive morbidity from pancreatic insufficiency as long as pancreatic supplementation is provided. Patients with severe lacerations, contusions, or disruptions of the head of the pancreas but with an intact pancreatic duct are better treated by the duodenal diverticulization procedure. While doing the duodenal diverticulization procedure, it is crucial to resect all of the distal antrum which on occasion may be obliterated within a periduodenal and peripancreatic hematoma. Incomplete removal of the distal antrum will ensure the postoperative development of a marginal ulcer and severe bleeding. The duodenal diverticulization procedure has also been frequently used in patients with severe pancreatic and duodenal injury from penetrating trauma. The vast majority of these patients have done well. When the surgeon is unable to determine whether a severe combined injury involves the main duct, it is safer to perform the duodenal diverticulization procedure, accepting the possibility of a subsequent pancreatic fistula. The advances which have been made in all aspects of total patient care, especially intravenous hyperalimentation during the past 10 years make survival after pancreatic or end duodenal fistula much more likely.

Minor pancreatic injury such as contusion, hematoma, or small laceration (Class I injury) of the body and tail of the pancreas obviously not involving the main pancreatic duct is best treated by obtaining hemostasis followed by drainage.

Once hemostasis is obtained at the site of injury, the capsule over the injury should not be reapproximated as this may lead to the subsequent development of a pancreatic pseudocyst. Although sump drainage has been frequently recommended for pancreatic injury, soft rubber penrose drainage provides good drainage if the abdominal wall drain site is large enough to accommodate two fingers. Furthermore, soft rubber drains eliminate the hazard of hollow or solid viscus fistula which all too frequently follow sump drainage. Furthermore, drains laid down to the pancreas need not be routinely left *in situ* for 10 to 14 days to see if a fistula develops; pancreatic fistula drainage will be apparent well before the soft rubber drains cease to drain. When drainage ceases, therefore, they should be gradually advanced and removed to prevent subsequent problems related to the retrograde migration of infection.

Major lacerations, fractures, or intraparenchymal hematomas (Class II injury) of the body and tail of the pancreas are best treated by distal pancreatectomy with splenectomy. Following distal pancreatectomy, several options are available including Roux-en-Y pancreaticojejunostomy or simple closure of the resected margin in a "fish mouth" manner. The main pancreatic duct should be ligated if visible, and hemostasis along the margin of resection is best obtained by the strategic placement of 6 to 8 5/0 non-absorbable sutures. The splenic artery and vein running along the posterior superior margin of the pancreas require careful ligation with non-absorbable sutures. The placement of deep intraparenchymal sutures along the superior and inferior margins of the pancreas for hemostasis is not necessary since these sutures tend to crush the pancreas and cause pancreatitis. Likewise, routine Roux-en-Y pancreaticojejunostomy after distal pancreatectomy is not indicated but rather is an outgrowth of surgery in patients with diseased pancreatic tissue and impaired antegrade flow because of ductal obstruction. Patients with pancreatic trauma, in contrast, have normal antegrade flow so that retrograde leakage from the resected margin which has been approximated in a "fish mouth" manner is infrequent.

Class III pancreatic injury, namely severe laceration, transection, intraparenchymal hemorrhage or contusion of the head of the pancreas in the absence of duodenal injury is best treated by the duodenal diverticulization procedure if the main pancreatic duct is uninvolved. Involvement of the main duct, at this level, requires completion of the pancreatic transection to the right of the portal vein. The margin of resection in the head of the pancreas is then approximated being sure to ligate the main pancreatic duct which, at this site, is large enough to be easily recognized. The distal pancreas may then either be resected or preserved by performing a Roux-en-Y pancreaticojejunostomy with the expectation that the distal pancreas will remain viable and not develop a pancreaticojejunal fistula. This extensive subtotal pancreatectomy allows the surgeon to treat injuries to the head of the pancreas to within 2 cm of the duodenum without fear of incapacitating pancreas insufficiency or duodenal ischemia.

Class IV pancreatic injury is the same as Class IV duodenal injury, namely, severe combined injury. The selection of treatment, therefore, is based upon the integrity of the main pancreatic duct. Injury to the main pancreatic duct can be identified at the time of operation by leakage of pancreatic secretions at the site of injury or extra ductal extravasation of a contrast agent. A duodenotomy and retrograde cannulation of the ampulla of Vater will allow injection of radiopaque dye or one of the blue dyes when disruption of the main duct will be apparent by leakage of dye into the pancreatic tissue. Alternatively, if such facilities are available, per oral fiberoptic retrograde cannulation of the pancreatic duct may be performed during laparotomy. Based upon such studies, the surgeon can predict with some accuracy whether the main pancreatic duct is ruptured and thereby proceed to a pancreaticoduodenectomy in the presence of rupture or a duodenal diverticulization procedure if the duct appears intact.

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THORACIC INJURIES

R Adams Cowley, M.D.

It is difficult to discuss Thoracic Trauma — past, present, and future — without first describing the evolution of thoracic surgery. Violence and warfare have furnished opportunities for observation of the injured and have enabled therapeutic trials which could not otherwise been obtained. From the beginning the cause of thoracic injuries can be generally attributed to war, violence, and now the increased tempo of living. The major causes of death in ancient time were attributed to hemorrhage, hypoxia, shock and infection. The thorax was the last body cavity to enter the sphere of the surgeon.

One of the feared problems associated with thoracic trauma was injury to the heart. Such trauma was always associated with lethality. This fatalistic attitude persisted from the time of Homer.[1] The prophecies of Billroth[2] and Paget[3] did nothing to further the advancement of thoracic surgery. It was Rehn in 1897 who broke this line of thought by successfully closing a heart wound. Sherman in 1902 aptly said "the road to the heart is only two or three cms in a direct line but it has taken surgery over 2400 years to travel it. . . and it took surgery 98 years to pass from the pericardium to the epicardium, across a space that is such only potentially."[4]

In ancient times, problems associated with trauma to the chest wall, the viscera, the lungs, and the cardiovascular system made patient care nearly impossible. The anatomy of the lungs, mediastinum, and pleura and their relation to the mechanics of breathing were not understood. Aseptic technique and antibiotics were not available for surgery on or within the chest, and there was no recourse for blood loss. Surgical intervention for thoracic wounds was limited to probing for foreign bodies, removal of arrows and lances which generally resulted in exsanguination, and the application of occlusive dressings for pleural tears. To prevent further blood loss either the chest wall defect was closed tightly or the open wound packed with gauze. One of the first efforts at chest wall closure was by Theordoric, (1267) not to prevent blood loss but loss of heat from the body.

The knowledge of the principles of closed tube drainage were unknown until 1876 when Hewitt developed mechanical methods, and von Bulau applied water-seal suction near that time or soon thereafter.[5] But there was little agreement on how thoracic wall injuries should be managed although all understood a patient with a "sucking" chest wound was terminal. Even in World War I the method of preventing air from entering the chest and at the same time providing egress for blood or air was neither understood nor practiced.

Before the turn of the century, successful intrathoracic surgery was prevented because of an inability to manage an open and uncontrolled pneumothorax. The use of the cuffed endotracheal tube was unheard of. Even though the patient was rendered unconscious, the lungs had to maintain function for survival. To keep the lungs inflated, two basic approaches were used: 1) the application of positive pressure at the entry of the airway and 2) the application of negative and positive pressure to the open chest by use of a special operation room chamber.[6] It remained for Meltzer and Auer in 1909 to develop endotracheal intubation to allow mechanical breathing and its clinical application today in thoracic surgery must be credited to these men.[7] However, Barthelemy and Dufour[8] had recommended the use of insufflation endotracheal anesthesia two years earlier.

Prior to World War II, local anesthesia was used for thoracic procedures in order to control bronchial secretions and the danger of aspiration during draining procedures for empyema. Local techniques insured that the patient could cough and control his secretions. Nitrous oxide and local anesthesia later became the technique of choice.

Before 1897 the surgeon was entirely dependent on physical examination to interpret intrathoracic desease. Thus, the possibilities of Roentgen's discovery of x-rays were rapidly exploited as a diagnostic tool. This discovery also led to the development of other diagnostic modalities such as bronchography and bronchoscopy to locate and remove foreign bodies, drainage of the tracheobronchial segments and later biopsy of the tracheobronchial wall to confirm suspected diagnoses.

In dealing with hemorrhage, replacement of blood loss by transfusion was mandatory for the development of thoracic surgery as a specialty. However, the technique of blood transfusion was not without its problems as manifested by the number of pyrogenic reactions, miscrossmatchings of blood, etc.

The surgical battle with pulmonary tuberculosis need not be mentioned except as a reminder that the surgical management of this disease was not unlike warfare in extending our knowledge of thoracic surgery first by extrapleural techniques to create collapse of the lung by altering the chest wall and later intrapleural techniques such as lobectomy, pneumonectomy and segmentectomy. All contributed towards the present day management of thoracic trauma.

The treatment of purulent effusions also underwent evolution similar to other developments in thoracic physiology, such as open and closed drainage of empyema cavities once the lung had become adherent to the chest wall. Steps to insure closure of the empyema cavity by thoracoplasty need not be mentioned. However, in World War II interest was rejuvenated when it became evident that blood did clot in the pleural cavity and often became infected. Drainage was soon replaced with lung decortication where the peel was removed and the entrapped lung expanded.

What of thoracic care today? We owe much to our present day knowledge of the treatment for thoracic and thoracoabdominal wounds and injuries to the distinct advances made during World War II. A description of these efforts can best be found in the papers of Samson and Brewer.[10,11]

While many of the precepts proven practical in the second World War have remained valid, the amazing advances in medicine have added refinements in management and have resulted in further improvements and refinements of techniques.

Samson outlines the general advances made in respiratory care during the past 25 years to include:

"1. Better understanding of pulmonary function, pulmonary dead space, shunts, etc.
2. Lung scanning and angiography
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The performance of prompt thoracotomy continues to be conservative. From World War I the mortality rate for intrathoracic wounds fell from 50 percent to less than 9.6 percent in Vietnam. With modern techniques of diagnosis and improved patient care, 75 to 80 percent of chest wounds in Vietnam did not require thoracotomy. Today, the need for immediate or early thoracotomy in trauma is about 5 percent.[10]

Samson further cites some of the more striking technical advances that have come in the cardiovascular field to be:

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All sorts of previously nonreparable types of heart and great vessel trauma can now be repaired. In addition the mortality rate is being erroded away by faster evaculation, maximum resuscitation, proficient surgery and better postoperative care and rehabilitation.

Further development is needed in the following areas:

1. Refinement in blood component therapy and even more important blood replacement substitutes.
2. A better understanding of blood coagulopathy problems to prevent continuous bleeding and oozing and to provide for a proper technical repair and postoperative control.
3. Better respiratory techniques including hopefully, a new means of lung inflation during and after chest surgery so that as the body attempts to raise secretions and foreign particles there is no resistance to the normal physiology by air flow pushing this debris towards the lung periphery.
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In addition to the great historical strides made in understanding anatomy, physiology, diagnosis and surgical techniques and equipment, thoracic surgeons are involved in developing new fields, such as critical care medicine and traumatology which hold great promise for the future.

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Marvin M. Kirsh, M.D., Herbert Sloan, M.D.

Introduction

Over the past 10 years we have treated 38 patients with an acute rupture of the descending thoracic aorta. The purpose of this report is to examine the results of those patients treated surgically and to determine what factors influenced the survival rate in our patients with acute transection of the thoracic aorta.

Clinical Experience

Since 1964 we have treated 38 patients with an acute rupture of the descending thoracic aorta. The patients' age range was from 17 to 72 years. Twenty-nine were involved in automobile accidents, 7 in motorcycle accidents and one each in a car-pedestrian collision and airplane crash. The clinical findings in our patients were deceptively meager despite the severe nature of the injury. Only 15 patients sustained chest wall contusion. In two patients there was no clinical evidence to suggest that aortic rupture had occurred. The clinical findings in our patients are illustrated in Table 1. Associated injuries which occurred alone or in combination in all of our patients are illustrated in Table 2. The chest roentgenographic findings are illustrated in Table 3. The commonest abnormalities were widening of the superior mediastinal shadow (100 percent) and in abnormality in the aortic contour (98 percent).

The diagnosis was confirmed by aortography in 36 patients. Two patients were operated upon without a preoperative aortogram. Both underwent a celiotomy because of suspected

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Upper extremity hypertension	16
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TABLE 2: Associated Injuries with Aortic Rupture

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Abnormal aortic contour	37
Deviation trachea to right	14
Depression left main stem bronchus	13
Left pleural effusion	15
No roentgenographic findings	1

massive intra-abdominal hemorrhage. Retrograde femoral arteriography was used in 33 patients and in the remaining 3 the axillary approach was used. All but two patients had pseudoaneurysm formation at or near the ligamentum arterosium. The pseudoaneurysm was located in the descending midthoracic aorta in one patient who also had fracture dislocation of the thoracic spine. In the remaining patient there was complete aortic obstruction just distal to the left subclavian artery. The area of intimal dissection was visualized as a linear lucency within the lumen of the aorta. Extravasation of contrast medium into the mediastinum was not observed. The time interval from injury to operation is listed in Table 4. Only three patients were operated upon more than 48 hours after sustaining aortic rupture. In these patients mediastinal widening was present in the initial chest roentgenogram but was not fully appreciated. An aortogram was obtained when progressive mediastinal widening was seen on subsequent chest roentgenogram after injury. Repair was carried out at 5, 6, and 7 days respectively.

The surgical techniques used for repair of the aortic rupture and their results are listed in Table 5. The majority of repairs were carried out utilizing an external shunt composed of plastic arterial cannulae connected to Tygon tubing. The hematoma surrounding the transection often covered most of the descending thoracic aorta and extended over the transverse aortic arch. Aortic dissection from within the pericardium allowed us to encircle the aorta proximal to the left subclavian artery without entering the mediastinal hematoma and possibly releasing its tamponading effect. Distal control was also obtained well outside the area of mediastinal hematoma. Purse string sutures were then placed in the ascending aorta and in the aorta distal to the transection. Stab wounds were made in the center of each purse string suture, and cannulae inserted into the aorta. The aorta was then cross-clamped and flow was established through the shunt.

The site of rupture in all but one of the patients was in the region of the aortic isthmus just distal to the left subclavian artery. The aortic tears varied from a small laceration to a complete circumferential separation, the latter occurring in 10 patients. Aortic continuity was restored in all patients with a woven graft, even in cases of incomplete transection. When the repair was completed and the aorta unclamped, the cannulae were removed and the purse string sutures and pledgets were tied.

The overall survival of 38 patients is 81 percent. Twelve patients had coexisting intra-abdominal injuries which required a celiotomy. Six of these underwent repair of abdominal injuries before repair of aortic rupture. Five of the six died of exsanguinating hemorrhage from the aortic rupture prior to completion of celiotomy or after celiotomy, but before a thoracotomy could be performed. Retrospectively it was felt that celiotomy could have been deferred in these six patients because none of them actually had massive intra-abdominal bleeding. In contrast six other patients who underwent celiotomy immediately after repair of aortic rupture survived.

Repair was done by one of two methods, partial cardiopulmonary bypass or external shunt (Table 5). Six of 11 patients who underwent repair using partial cardiopulmonary bypass failed to survive the postoperative period. Two died of associated head injuries, one died of low cardiac output, one of sepsis and one from an obstructed tracheostomy tube. Twenty-three of 27 patients who underwent repair using the external shunt are alive and well. One patient is institutionalized as a result of brain damage secondary to his head injury; one patient developed paraplegia postoperatively because the cannula used was too small; one died as a result of uncontrollable hemorrhage which occurred when the aorta was torn where it was cross clamped; and one patient died during the operation as a result of his associated head injury.

Complications occurred in 19 patients, pulmonary complications being the most frequent and occurring in 11 patients. Respiratory insufficiency were severe enough in 10 patients to require prolonged ventilatory assistance. Vocal cord paralysis occurred in 6 patients. Other complications included intestinal obstruction from adhesions, perforated sigmoid colon, renal failure, and chronic subdural hygroma and pulmonary embolus.

Discussion

The pathogenesis of the ruptured aorta had been dealt with intensively in the literature and will not be discussed here.

The most common site of rupture in the descending aorta is at the isthmus with 80 to 90 percent of aortic tears occurring in this location. Other sites of involvement include the distal descending aorta at the aortic hiatus in the diaphragm, the midthoracic descending aorta and rarely, the origin of the left subclavian artery. Greendyke and Lundevall and others found a 20 percent incidence of multiple aortic ruptures in traffic accident victims examined at autopsy.

In the diagnosis of acute traumatic aortic rupture, it is imperative to maintain a high index of suspicion and a constant awareness of the likelihood of this lesion in victims of high speed decelerating injuries, whether or not there is external evidence of chest injuries. One-third to one-half of the patients reported in the literature had no external evidence of thoracic injury at the time of initial physical examination.

Clinical findings of importance are the acute onset of upper extremity hypertension, especially if it is coupled with evidence of continued blood loss, difference in pulse amplitude (determined by palpation or auscultation) between the upper and lower extremities and the presence of a harsh systolic murmur over the precordium or posterior interscapular area. Upper extremity hypertension occurred in 43 percent of our patients and in 31 percent of the patients reported in the literature. It has been attributed to compression of the aortic lumen by a periaortic hematoma with or without subadventitial dissection. If the aortic lumen is narrowed by this process, or if the torn intima and media form a flap which acts as a ball valve, partial aortic obstruction occurs. This produces the "acute coarctation syndrome" as described by Malm and Deterling with hypertension in the upper extremities and a difference in pulse amplitude between the lower and upper extremities. Although a difference in pulse amplitude was an infrequent occurrence in our patients it has been reported to occur in 37 percent of the patients reviewed by Symbas. The systolic murmur was heard in 31 percent of our patients and in 26 percent of the 200 patients reviewed by Symbas. The murmur is thought to be due to the turbulent flow across the area of transection.

TABLE 4: Time Interval from Injury to Operation

12 hours	29
24 hours	4
48 hours	2
more than 5 days	3

TABLE 5: Surgical Techniques Used for Repair of the Aortic Rupture

	Number	*Survived*	*Died*
External shunt	27	25	2
Partial left heart bypass	11	6	5

Radiography of the chest is invaluable in arousing suspicion of aortic rupture. The importance of careful evaluation of the chest roentgenogram cannot be overemphasized since it is apparent from a review of the literature that too many patients have succumed because the presence and significance of radiographic abnormalities were not appreciated. An increase in the width of the superior mediastinum is an important sign suggesting traumatic rupture of the aorta. Alone, however, it is nonspecific and may represent the magnification resulting from portable supine radiographic technique or mediastinal hematoma from sources other than the aorta. Obscuration of the aortic knob shadow, loss of sharpness of the aortic outline, depression of the left mainstem bronchus, deviation of the trachea to the right, left pleural effusion, obliteration of the medial aspect of the apex of the left upper lobe, opacification of the clear space between the aorta and pulmonary artery alone or in combination are other chest roentgenographic findings most often seen in patients with acute aortic rupture. Although these findings are highly suggestive of acute traumatic rupture of the aorta they are not diagnostic even when associated with upper extremity hypertension or a systolic murmur. Each radiographic finding may be seen separately or in various combinations in patients without aortic disruption. Since a widened mediastinum is not always caused by an aortic rupture nor is rupture of the aorta always associated with a widened mediastinum, a definitive diagnostic procedure is necessary.

Aortography is the only definitive technique of establishing the diagnosis of acute aortic transection and should be performed on any patient who has sustained a high speed decelerating injury or blunt trauma to the chest, whether or not there is external evidence of thoracic injuries, whether or not there are clinical findings suggesting aortic rupture, and whether or not there are changes in the chest roentgenogram.

With aortography it is possible to determine the site or sites of rupture and to estimate the size of the false aneurysm. Retrograde femoral arteriography using a long soft "J" shaped catheter passed under fluoroscopic control was used in the majority of our patients without difficulty. We prefer this approach because the examination can be performed easily, even in the severely injured or uncooperative patient. This approach also allows angiographic evaluation of other areas of suspected injury.

Characteristically, the aortogram demonstrates the presence of a pseudoaneurysm without estravasation of contrast material at or near the ligamentum arteriosus. However, any segment of aorta may be involved. The intimal tears are usually visualized as irregularly filling defects within the lumen of the aorta. Since the transection can be complicated by medial dissection this should be carefully searched for when evaluating the aortogram.

Because of the ever-present menace of sudden lethal secondary rupture of the false aneurysm, repair of the lesion should be performed as soon as the diagnosis is made, the site or sites of rupture localized and a planned order of management of associated injuries is established. Aortography should always precede thoracotomy unless contraindicated by a rapid deterioration in the patient's condition. A brief delay to establish management priorities in these ofttimes multiple injured patients is advisable. The decision whether to first perform a celiotomy or thoracotomy must fit the circumstances. Initially in our experience, repair of the coexisting abdominal injuries were carried out prior to thoracotomy in six patients, five of whom succumbed before thoracotomy could be performed. In none of these patients was there a bloody pleural effusion until exsanguination occurred. This experience, as well as the fact that the untreated aortic rupture follows such an unpredictable course, makes us feel that aside from rapidly progressing craniocerebral injuries such as epidural hemorrhage or massive intra-abdominal hemorrhage, traumatic rupture of the aorta deserves the highest priority and its repair should be carried out first. Since repair of the aorta can be carried out with a shunt that does not require systemic heparinization, intra-abdominal bleeding will not as a rule increase during the thoracotomy. In the event that intra-abdominal bleeding increases during the thoracotomy, exploration of the abdomen can be done by incising the diaphragm or extending the incision into the abdomen. Prior to doing this, the surgeon should secure proximal and distal control of the aorta.

When aortic repair is carried out, ischemic injury to the spinal cord and kidneys must be avoided, the cerebral vessels spared from hypertension and acute left-heart failure prevented. The techniques most widely used to accomplish these goals are left heart bypass or femoral vein to femoral artery partial bypass. Despite careful control of left atrial pressure with these techniques, either alone or in combination, left atrial hypertension and pulmonary edema occasionally have developed. A more common problem associated with the necessary total-body heparinization has been excessive bleeding from the dissection necessary to isolate the aorta. Heparinization may also increase intra-abdominal or intracerebral bleeding. The latter occurred in two of our patients and the resultant brain damage was responsible for their death. Postoperative hemorrhagic diathesis resulting from alteration in coagulation factors during extracorporeal circulation has also been reported to occur with its attendant complications. If the aortic rupture is complicated by proximal medial dissection into the ascending aorta partial bypass must be used. An advantage of femoral vein to femoral artery bypass is that in the rare event of free rupture at the onset of operation, partial bypass can be initiated while thoracotomy and aortic cross-clamping are performed. To avoid these problems during the time of aortic cross-clamping and to achieve the goals previously discussed we employ an external shunt composed of plastic arterial cannula connected to Tygon tubing and which does not require systemic heparinization. Two sizes have been used: a 7.5 mm cannula connected with ⅜-inch tubing and a 9 mm cannula connected with ½-inch tubing. The tubing is filled with 30 cc saline containing 1000 units of heparin to prevent clotting when there is no flow through the shunt. Once adequate flow through the shunt begins, clotting does not occur. To ensure adequate flow through the shunt, the clamps on the shunt must not be released until the aorta proximal to the rupture is clamped. In addition air can be evacuated from the system by inserting a #21 gauge needle capped with a three-way stopcock into the Tygon tubing. Previous studies have shown that flow in the distal aorta with a 7.5 mm cannula is 2000 cc/min. while the flow with a 9 mm cannula is 4000 cc/min. This technique cannot be used if there is associated medial dissection complicating the transection. If on the aortogram there is a suggestion that dissection has occurred, the operation should be performed with a pump standby. Because the marked mediastinal hemorrhage and its surrounding reaction prevented adequate mobilization of the aorta, and because of the marked friability of the aortic wall, we were unable to perform a primary end-to-end anastomosis as advocated by Alley, McGough and others. Instead, aortic continuity was established with a woven graft in all of the patients, even those with an incomplete transection.

Although the mortality rate for repair of acute aortic rupture was 18 percent in this series we agree with Laforet that a "vigorous surgical attack is justified in all cases of acute traumatic rupture of the aorta as it is a catastrophic situation that justifies heroic aggression."

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MANAGEMENT OF FLAIL CHEST: AN ANALYSIS OF 88 CASES

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The mortality from blunt thoracic trauma, especially if flail chest is present, remains appreciable even if there are no serious associated injuries[4,8,9,11,12]. The introduction, in 1956, by Avery et al[1], of internal pneumatic stabilization, using tracheal intubation and mechanical ventilation, was initially heralded as a great advance. Recently, however, several authors[11,12,13] have questioned whether mechanical ventilation has produced any real reduction in mortality rate. Others[6,10] have called attention to the not insignificant incidence of complications from tracheostomy and mechanical ventilation.

The purpose of this study was to analyze our own results with a series of 88 patients with flail chest, who were treated between January 1973 and December 1975.

Clinical Material

During the period January 1973 — December 1975, 88 patients with flail chest were treated in the Maryland Institute for Emergency Medicine. The criteria used for inclusion of patients in this series were: (1) obvious paradoxical motion of the chest wall, regardless of how many rib fractures were evident on the admission chest roentgenogram, or (2) fractures of four or more ribs shown on the initial chest roentgenogram. The reason for the use of the latter criterion was the policy which was in effect during most of this period, whereby tracheal intubation and mechanical ventilation were instituted either at the heliport or immediately upon arrival in the Admitting Area, in any patient who had sustained obvious severe blunt chest trauma. This practice obviated the opportunity to observe these patients while they were breathing spontaneously to see whether they would develop paradoxical chest wall movement. Four was the number of the rib fractures arbitrarily chosen because it was our experience, before the policy of immediate intubation and mechanical ventilation was put into effect, that the overwhelming majority of patients having four or more ribs fractured did, in fact, develop paradoxical motion of the chest wall. In the entire series of 88 patients, only eight patients had less than four fractured ribs, and all eight fulfilled the first criterion, that is, they had obvious paradoxical motion of the chest wall. In two of the eight, the flail was caused by fractures of the sternum and costal cartilages and thus no rib fractures were visible on the posteroanterior chest roentgenogram.

The 88 patients fell naturally into two groups. Group I consisted of 29 patients who, in addition to having flail chest, fulfilled our criteria for the diagnosis of pulmonary contusion. These criteria were: (1) a history of blunt trauma; (2) moist rales heard on auscultation over the injured lung, either on admission or during the first two hospital days, accompanied by hemoptysis or blood-stained tracheal secretions; (3) the appearance, on chest roentgenogram, within 6 hours after injury, of an opacity in the lung that did not conform to lobar or segmental boundaries; (4) an elevation in the alveolar-arterial oxygen tension gradient ($A\text{-}aD_{O_2}$) above 50 mm Hg with the patient breathing 30 percent oxygen, on admission.

Group II consisted of 59 patients who had flail chest but who did not satisfy the above criteria for the diagnosis of pulmonary contusion. Many of these patients undoubtedly had some degree of pulmonary contusion, but if they did not exhibit a roentgenographic opacity characteristic of contusion within the first six hours and did not also fulfill the other criteria, they were not included in Group I.

The patients in Group I had an average of 7.72 ± 2.89 rib fractures per patient — bilateral in 12 patients — whereas those in Group II had an average of 5.64 ± 3.18 rib fractures per patient and these were bilateral in 10 patients. Among the patients in Group I, 6 had pneumothorax, 7 had hemothorax, and 14 had hemopneumothorax. Fifteen had subcutaneous and mediastinal emphysema. Only 2 patients had neither hemothorax nor pneumothorax. In Group II, 11 patients had pneumothorax, 6 hemothorax, and 16 hemopneumothorax. Subcutaneous and mediastinal emphysema was present alone in 3 patients and was combined with hemo-, pneumo- or hemopneumothorax in 11 others. However, in Group II there were 15 patients who had neither hemo-, pneumo- or hemopneumothorax or surgical emphysema.

The major extrathoracic injuries which these patients had sustained were divided into the following categories: head, face, abdomen, and others, According to this categorization, the patients in Group I had sustained an average of 1.9 ± 0.7 major extrathoracic injuries whereas those in Group II had sustained an average of 1.6 ± 0.99 major injuries outside the thorax.

At the time of admission, while they were breathing approximately 30 percent oxygen, the patients in Group I had a mean PaO_2 of 63.55 mm Hg while those in Group II exhibited a mean PaO_2 of 112.1 mm Hg.

Methods

As a background it should be mentioned that prior to three years ago, patients admitted to the Maryland Institute for Emergency Medicine with flail chest were treated with a volume ventilator that had no provision for positive end-expiratory pressure (PEEP). Attention was focused on the chest wall instability and mechanical ventilation was not initiated until significant respiratory distress or hypoxemia had developed. Ventilation was continued until the chest wall was almost completely stable — which, in a patient with severe flail, frequently required two and a half to three weeks. The morbidity and mortality from pulmonary infection was high.

Both the orotracheal tubes which were introduced at the time of initiation of mechanical ventilation and the tracheostomy tubes which were used if ventilation had to be continued beyond 48 hours, had low volume, high pressure cuffs. Consequently, the incidence of tracheal stenosis was high.

The incidence of pneumonia and atelectasis while the patients were undergoing mechanical ventilation also were high. Atelectasis was seen not only during mechanical ventilation but more especially upon discontinuance of ventilation if this occurred too soon.

During the past three years the following treatment plan had been adopted for flail chest. A patient with minimal flail, without serious associated injuries, who is maintaining satisfactory blood gases (a PaO_2 above 60 mm Hg on room air) and is having no difficulty clearing his tracheobronchial tree of secretions, is treated with nasal oxygen and observed for 24 hours with frequent monitoring of his blood gases. Such situations are quite uncommon in the Institute. Patients with more severe flail, or patients with any degree of flail in association with one or more of the following factors, are treated by immediate tracheal intubation and mechanical ventilation. These factors are: preexisting chronic pulmonary disease; an impaired level of consciousness; intra-abdominal injuries resulting in ileus; skeletal injuries necessitating immobilization; and renal failure. The tube used for orotracheal intubation is of the plastic (Portex) variety with a low pressure cuff. The ventilator used is the Engstrom 300. A positive end-expiratory pressure (PEEP) of 5 cm. H_2O is routinely applied. If a PaO_2 of at least 60 mm Hg on an FIO_2 of not greater than 0.40 is not maintained, then the PEEP is increased to 10 cm. At the same time, however, a Swan-Ganz catheter is inserted into the pulmonary artery for more accurate monitoring of the pulmonary circulation.

If shock is present on admission, resuscitation is accomplished by the use of whole blood, plasmanate, or albumin in preference to crystalloids. Ringer's lactate is not used at all.

If the admission chest roentgenogram shows even a minimal pneumothorax or if chest wall emphysema is present even in the absence of detectable pneumothorax, a tube thoracostomy in the second or third intercostal space is performed, the tip of the tube being directed to the apex. If hemothorax is present or develops, a basilar chest tube is inserted in the fifth or sixth intercostal space laterally. A hemopneumothorax is usually treated with two chest tubes, one apical and one basilar.

At the end of 48 hours of mechanical ventilation, the situation is reassessed. If the patient is maintaining a PaO_2 of well above 60 mm Hg on an FIO_2 of 0.3 to 0.4, the PEEP is removed and ventilation continued with intermittent positive pressure. If, after two hours, blood gases are still satisfactory, the ventilator is removed, and humidified 40 percent oxygen is delivered to the orotracheal tube using a T-tube. After a further two hours, if blood gases remain satisfactory, the orotracheal tube is removed.

If the patient cannot tolerate removal from the ventilator and orotracheal extubation at 48 hours, a tracheostomy is performed, with the orotracheal tube still in place, in the operating room. The tracheostomy tube used is a Portex, with low pressure cuff. The tracheotomy is performed through the second tracheal ring. With this relatively high tracheotomy, and cuff complications that develop, such as tracheal stenosis or tracheoesophageal fistula, are more likely to be accessible through a cervical incision. If the cuff causes erosion of the anterior tracheal wall, this is less likely to involve the innominate artery than with tracheostomies placed at a lower level.

After a further period of treatment of the pulmonary injury with mechanical ventilation using PEEP, when the PaO_2 is above 60 mm Hg on an FIO_2 of 0.3 to 0.4, removal of the patient from the ventilator is carried out in much the same fashion in which it was done at 48 hours. If removal is successful, the tracheostomy tube is left in place with humidified air containing 40 percent oxygen being delivered to it by T-tube. One or two days later, if there has been no deterioration of blood gases and if the patient has demonstrated his ability to cough effectively, the tracheostomy tube is removed.

Function tests such as vital capacity and maximum inspiratory force have not been found helpful in determining when the patient is ready to come off the ventilator and therefore they are not routinely used. Intermittent mandatory ventilation (IMV) is not employed, as we have not found it to be of any real assistance in weaning the patient from the ventilator.

The availability during the past two years of an adequate number of well-trained chest physical therapists has led to a marked reduction in incidence of atelectasis, not only while the patient is on the ventilator, but especially after he is taken off. Chest physical therapy has been a factor in reducing the number of days of ventilation required and also is greatly decreasing the number of instances where ventilation has had to be reinstituted. Bronchoscopy for removal of retained secretions, which was formerly required on almost every patient with flail chest at least once during their course, is now required only for the very occasional patient. Chest physical therapy is begun actively as soon as the patient is stabilized on the ventilator and is continued during the post-ventilation period and until he leaves the hospital. The principal precaution taken is that if the fractured ribs causing the flail are located laterally or posterolaterally, the patient is not turned onto the injured side for the first week.

Operative stabilization of fractured ribs is not performed as a primary procedure but only if the chest must be entered for another indication, such as a massive hemothorax or a ruptured hemidiaphragm. Such stabilization with intramedullary pins was carried out in four cases in the present series. A fractured sternum, on the other hand, if it was unstable, was considered an indication, in itself, for open reduction since this can be accomplished with simple wiring under local anesthesia. Such an open reduction was performed on one patient in the present series.

In summary, the principal features that distinguished the treatment of flail chest used in the Institute during the past three years, in contrast to the prior period, were: (1) Treatment directed primarily at the underlying pulmonary contusion rather than toward the chest wall instability. This means that mechanical ventilation was instituted early — almost prophylactically — rather than after serious hypoxemia had developed, and that PEEP was used routinely. (2) Active chest physical therapy throughout the period of treatment.

Results

There was a difference between Group I and Group II in the number of days of mechanical ventilation required. Group I patients required a mean of 16.3 ± 23.9 days of mechanical ventilation, whereas those in Group II needed a mean of 6.3 ± 5.25 days. However, the difference between the means of the two groups was not statistically significant ($p = > 0.05$). The mean number of days of mechanical ventilation required in the entire series of 88 patients was 9.6 days. This mean duration of mechanical ventilation was appreciably shorter than the average of 12 to 14 days required under the treatment regimen that was in use prior to January 1973.

Among the 29 Group I patients, there were two deaths (6.9 percent), one from brain injury and one from renal failure.

Among the 59 patients in Group II, there were six deaths (10.2 percent). Three deaths were caused by shock (two hemorrhagic shock and one irreversible shock), one by a myocardial infarct, one by brain injury, and one by hypoxemia. Thus in the entire series of 88 patients, only one death — that from hypoxemia — could be, in part, attributed to the thoracic cage-pulmonary injury.

Nonfatal intrathoracic complications were more frequent in Group I. In this group the complications consisted of: atelectasis, 10 instances; pleural effusion, 3; lung abscess, 2; pneumonia, 2; pulmonary cysts, 2; adult respiratory distress syndrome, 1; myocardial infarct, 1; and heart failure, 1. Only 9 patients had no nonfatal intrathoracic complications.

In Group II, the nonfatal intrathoracic complications consisted of: atelectasis, 7 instances; pneumonia, 5; pneumothorax, 3; pleural effusion, 2; congestive heart failure, 2; renal failure, 1; respiratory failure, 1; multiple organ failure, 1; and pulmonary cyst, 1. Thirty-one patients had no fatal and no nonfatal intrathoracic complications.

Discussion

Until 25 years ago, flail chest was treated by some type of external splinting or traction, such as that used by Jones and Richardson.[7] In 1951, Carter and Giuseffi[3] pointed out the usefulness of tracheostomy in patiensts with crushed chests, not only to permit removal of secretions but also to reduce the amount of dead space and to decrease resistance to breathing. In 1952, Jensen[6] recommended the use of tracheostomy with a positive pressure ventilator to improve ventilation in patients who had sustained crushing injuries of the chest. However, the use of mechanical ventilation for flail chest did not receive wide acceptance until Avery, Mörch and Benson[1] in 1956, introduced the concept of "internal pneumatic stabilization" using a piston respirator. Since that time, tracheal intubation with mechanical ventilation has been the generally accepted method of treating severe flail chest.

Although this method simplifies the care of patients with flail chest, a reduction in mortality rate has not been clearly proved.[11] Further, an appreciable incidence of complications has been described in connection with tracheostomy and mechanical ventilation.[6,10,13] Because of the risk of these complications, there have been recent efforts to find ways of treating flail chest without mechanical ventilation.

Moore[9] sought to avoid tracheostomy and mechanical ventilation by operative stabilization, that is, by intramedullary pinning of ribs, costal cartilages, and sternum. However, in his series of 50 patients so treated, there were 11 deaths, two of which were due to respiratory failure, one to fat embolus and one to air embolus. Eight patients required tracheostomy and 6 patients — 4 who required tracheostomy and 2 others — required mechanical ventilation. Such a method seems to us to be too radical. The high mortality rate figures do not support its use except in institutions where expertly conducted, low-risk mechanical ventilation is not available. Our only indication for operation stabilization is in patients in whom the chest is being opened for another indication, and in this situation we find that intramedullary pinning of the more severely displaced rib fractures, as the chest is being closed, seems to lessen pain and reduce the number of days of mechanical ventilation required.

Trinkle and colleagues[13] on the other hand believe that most patients with flail chest can be treated without mechanical ventilation, if the underlying pulmonary contusion, which they believe is invariably present, is appropriately treated. Their treatment for contusion consisted of: restriction of intravenous fluids; furosemide (Lasix); methylprednisolone; salt poor albumin; and the use of plasma or whole blood, rather than crystalloids, to replace blood loss. Supplemental nasal oxygen was given as needed to maintain a PaO_2 above 80 torr. Mechanical ventilation was utilized only if the arterial P_{O_2} could not be kept above 60 torr on room air or 80 torr with supplemental oxygen. The group of patients so treated was small (11 patients), and one of these had to be removed from the study because of failure to meet the criteria relating to arterial P_{O_2}. Three of the remaining 10 patients required mechanical ventilation — two for less than 24 hours after operations for other injuries and one for four days because of a pulmonary hematoma. There were no deaths among the 10 patients and only two complications — one instance of clinical pneumonia and one of a sputum culture positive for a pathogenic microorganism. The results in this group of 10 patients compared very favorably with those in an apparently comparable group of 19 patients treated by tracheal intubation and mechanical ventilation.

We agree with Trinkle's contention that some degree of pulmonary contusion occurs in every flail chest injury, and that therapy should be directed primarily toward the contusion rather than toward the chest wall instability. However, we do not find, at least with the type of severely and multiply injured patients seen in our institution, that the majority of flail chest patients can be treated without mechanical ventilation. Many of our patients would not meet Trinkle's criteria, relating to the effect of oxygen administration on arterial P_{O_2}, for inclusion in the group treated without mechanical ventilation.

Rather, our approach to the pulmonary contusion accompanying flail chest has been to institute mechanical ventilation more or less prophylactically, on admission, before the patient's contusion becomes fully manifest or has an opportunity to worsen. By the same token, PEEP is included in the ventilation therapy because we have found that PEEP is more effective in treating contusion than intermittent positive pressure ventilation.

We feel our results justify our choice of method.

Summary and Conclusions

A series of 88 patients with flail chest injury were treated by the routine use of tracheal intubation on admission followed by mechanical ventilation using 5 cm of PEEP. Chest physical therapy was begun as soon as the patient was stable and was continued until discharge from the Institute.

The mean number of days of mechanical ventilation required was 9.6.

There were 8 deaths (9.1 percent). All those who died had major injuries in at least two organ systems outside the thorax. In all 8 this included a head injury and in 2 the head or brain injury was the primary cause of death. In only one patient, who had injuries to 3 organ systems beside the thorax and in whom death was attributed to hypoxemia, could the thoracic cage-pulmonary injury be said to have played a significant part in the patient's death.

Complications directly attributable to the tracheal intubation and ventilation therapy were minimal: 7 instances of pneumonia, 2 of lung abscess, and 3 of pneumothorax.

We conclude that routine immediate tracheal intubation and mechanical ventilation, using PEEP, is the treatment of choice for flail chest injury.

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FACIAL INJURIES

McDonald K. Hamilton, D.D.S.

In the critical multiple injured patient, facial trauma is one of the last problems to be cared for and rightly so as these injuries usually do not present a life or death situation. Occasionally, if a major vessel has been transected the situation can be serious, requiring immediate attention, but not in most cases. The soft tissue injuries are taken care of when the patient is stabilized, but the osseous structures are often left to be repaired at a later date. In the past, this made little difference as many of these patients died.

Today, with the great advances in emergency medicine, many of these patients are now surviving; not only surviving, but returning to lead useful lives.

During their recuperation they and/or their families become concerned with inadequate function and abnormalities of the facial region. If the recuperative period has been short and surgical intervention allowed early, then standard methods for reducing facial fractures are utilized. If several weeks have gone by, the fractures will be in varying stages of healing. This is when new and innovative methods of reducing these fractures must be employed.

The following are examples of various modes of treatment of facial injuries from early to delayed.

Occasionally a patient will receive a severe LeFort III fracture along with a closed or open head injury. In this particular situation with the patient comatose or semi-comatose and bruxing continually, the middle third of the face acts as a pump, and if the cribriform plates have been violated, each time the muscles of mastication coupled with the mandible compresses the face, cerebral-spinal fluid rhinorrhea results. In such a case, we were asked by the neurosurgeons not to repair the facial fractures, but to stabilize the maxilla to prevent the bellows action with resultant loss of cerebral spinal fluid and increased possibility of infection.

A head frame was considered, but because of the patient's combative nature and cranial injuries this idea was discarded. The decision was made to use a combination of a comparatively new and an old method to temporarily stabilize the fracture until the patient had improved enough for definitive treatment.

The Joe Hall Morris bi-phasic pin fixation kit was used; a pin was screwed into the mandible beneath the mental foramen bilaterally. An orthodontic head gear was then placed on the patient and attached to the pins. This was not rigid enough to prevent the pumping action. Using self curing acrylic and the bar forming mold from the bi-phasic pin kit, uncured bars were placed from the head cap to the pins. When they cured, a rigid network was formed between the cranium and the mandible preventing the bellows action and the cerebral spinal rhinorrhea.

A second case illustrates immediate intervention and reduction of facial fractures. A man shot three times, once in the lumbar region of the back, a second time in the cervical region and a third time in the infraorbital area on the left side was admitted for immediate operation. An exploratory laporotomy produced negative results from the bullet in the back. The bullet in the neck passed through soft tissue only and did no damage, but the bullet entering the left infraorbital region destroyed the left eye, shattered the left lateral rim of the orbit, damaged the zygomatic arch and forced the zygoma three centimeters inferiorly.

The zygomatic arch was repaired through the exit wound of the bullet. An incision was then made over the zygomaticofrontal suture line. From this incision the zygoma was lifted into position. There was a 3 cm gap from the zygomaticofrontal suture line to the zygoma due to the destruction of the bullet. Wire was used to suspend the zygoma with no additional replacement of the lateral rim. The floor of the orbit was not explored at that time as the globe was to be enucleated at a later date. After placement of an artificial eye the results were gratifying.

If a patient has not been able to undergo surgery over a period of weeks then the problem of healing comes into play. After the patient is asleep, an attempt to move the maxilla anteriorly is made using right and left disimpacing forceps. If this is successful, then a head frame is placed to hold the middle third of the face in the proper position to achieve a normal Class I occlusal relationship.

In cases where both the mandible and middle third are fractured it is necessary to repair the mandible in order to achieve a stable base on which to set the maxilla. An example of such a case is a man injured while bulldozing a tree. The tree fell toward him inflicting a depressed frontal fracture, an impacted LeFort III fracture and bilateral fractures of the condyles of the mandible.

Three weeks went by before clearance was given for repair of the facial fractures. Because of the length and complexity of the procedures to repair the facial injuries it was decided to do the operation in two stages. The first stage would be to repair the fractured condyles and establish a stable base, and do a second procedure later to bring the middle third forward. The first procedure was accomplished without difficulty. Post-operatively he developed blockage of a cerebral artery with resulting Diabetes Insipides. Four weeks passed before clearance was obtained to complete the second stage.

Because of the length of time since the accident, considerable healing had taken place. An attempt to disimpact the maxilla was unsuccessful. Therefore, an alternative method was done. An intra-oral incision was made from second molar to second molar high in the mucobuccal fold of the maxilla. Wires were placed in the zygoma and pyriform aperatures bilaterally. Wire passing awls were then used to pass the wires through the skin.

The wires were attached to a head frame bar. Ropes were attached to the bar leading to pulleys of an over head frame and three pounds of weight were placed. Within twenty-four hours the middle third of the face had been moved anteriorly approximately one centimeter allowing for a Class I molar relationship. The weights were removed and the wires attached to the head frame to hold the middle third in the correct position. Normal healing followed.

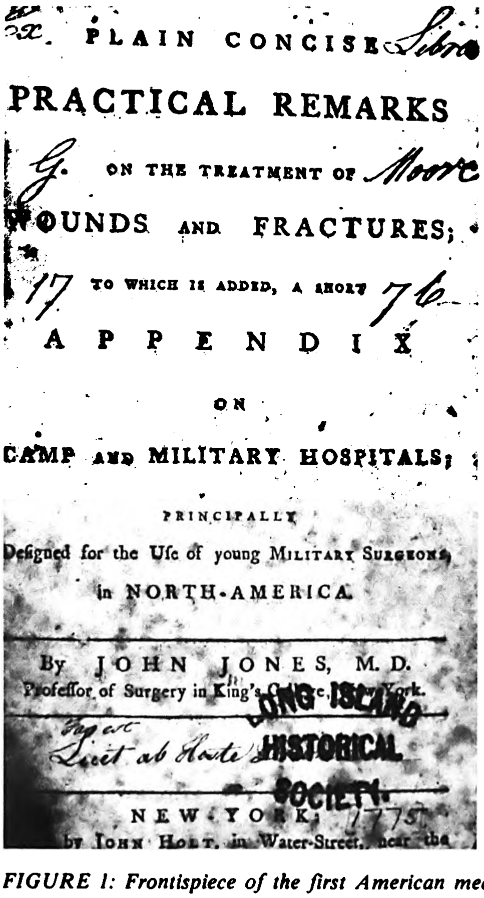
Although there are many and various types of facial fractures, and there are as many and various methods of reduction and fixation, an attempt has been made to illustrate several types that were challenging. Perhaps, ten years ago, these patients would not have survived to have their facial fractures repaired.

MUSCULOSKELETAL INJURIES THE PAST, PRESENT, AND FUTURE

Gerald W. Shaftan, M.D., F.A.C.S.

Just two hundred years ago, George Moore a young surgeon living in the far west of Long Island, the area that is now known as Brooklyn, purchased this first American medical text written by Dr. John Jones (Figure 1). Jones, another native Long Islander, was Professor of Surgery and co-founder of the King's College Medical School in New York. This book was specifically written for the use of young surgeons who might be experiencing their first exposure to wartime injuries in the struggle with the British for independence. His sympathies are clearly shown in his introductory remarks in which he states that "if any of you, by observing the following rules, should save the life, or even limb of but one citizen, who has bravely exposed himself in defense of his Country, I shall think myself richly rewarded for my labour."

Jones' book demonstrates his British and European training and most particularly the influence of Sir Percivall Pott on his management of fractures which undoubtedly prompted Mr. McLean to take this advertisement in the endpaper



PLAIN CONCISE
PRACTICAL REMARKS
ON THE TREATMENT OF
WOUNDS AND FRACTURES;
TO WHICH IS ADDED, A SHORT
APPENDIX
ON
CAMP AND MILITARY HOSPITALS;
PRINCIPALLY
Defigned for the Ufe of young MILITARY SURGEONS,
in NORTH-AMERICA.
By JOHN JONES, M.D.
Profeffor of Surgery in King's College, New-York.
LONG ISLAND HISTORICAL SOCIETY.
NEW-YORK:
by JOHN HOLT, in Water-Street, near the

FIGURE 1: Frontispiece of the first American medical textbook by John Jones, M.D. Purchased by Dr. George Moore in 1776.

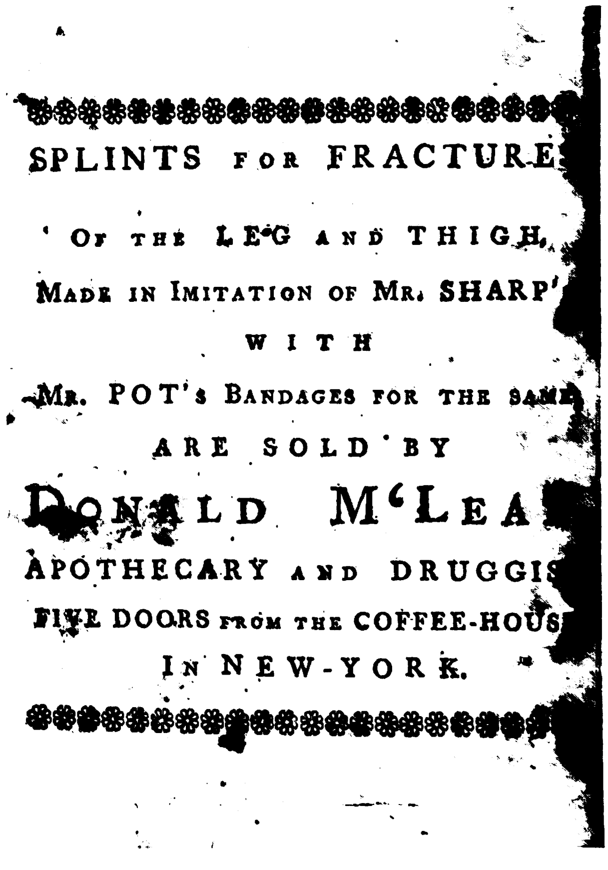
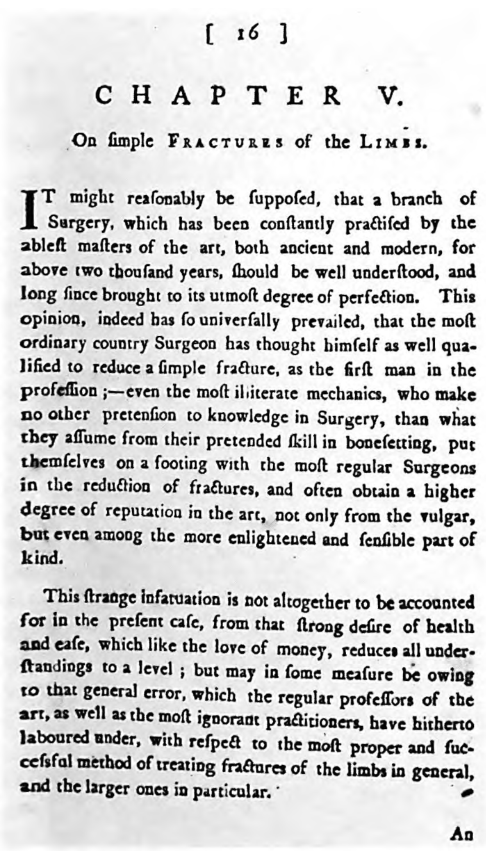


FIGURE 2: Endpaper advertisement from the same book.

(Figure 2). Jones recognized that "The simple incised wound, when unattended with any considerable hemorrhage, or great loss of substance, is always to be healed. . . by approaching the lips of the wound, until they come into the most exact contact, and preserving them in that situation, by suture or bandage, until the union is accomplished." Jones, in fact, anticipated the application of Steri-strips, with his "sticking plaster" which made the use of suture unnecessary. He well describes cleaning the wound of "coagulated blood and all foreign bodies," as well as the debridement of lacerated wounds so that "they may be reduced merely to the state of a simple incised wound, by the assistance of the knife; and a suture will then not only forward the cure, but prevent deformity; which every good surgeon will always endeavour to avoid." He even discussed the repair of sharply divided tendons which were "treated like other simple incised wounds".

It is in the care of fractures that Jones' text is most modern (Figure 3). He recognized the necessity of putting the fractured limb into a neutral position "by which means the muscles or moving powers, are immediately put into a state of the utmost relaxation, and their action upon the bones or levers entirely removed, which restores the patient to a state of ease and quiet". Regarding the necessity for callus union, he notes that "if the bones can be brought into exact and even contact, a small quantity is sufficient to unite them; but when they lap over each other, a larger portion becomes necessary to constitute a firm and solid union." The "compound fractures" were to be handled in a similar fashion and while amputation sometimes was necessary, as the result of initial tissue destruction or subsequent suppuration, even the principle of counter incision for dependent drainage of infection was noted. Amputation, of course, was most often by the guillotine method but open flap amputation, with secondary closure, "until the parts unite by the first intention" was described.



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CHAPTER V.

On ſimple FRACTURES of the LIMBS.

IT might reaſonably be ſuppoſed, that a branch of Surgery, which has been conſtantly practiſed by the ableſt maſters of the art, both ancient and modern, for above two thouſand years, ſhould be well underſtood, and long ſince brought to its utmoſt degree of perfection. This opinion, indeed has ſo univerſally prevailed, that the moſt ordinary country Surgeon has thought himſelf as well qualified to reduce a ſimple fracture, as the firſt man in the profeſſion;—even the moſt illiterate mechanics, who make no other pretenſion to knowledge in Surgery, than what they aſſume from their pretended ſkill in boneſetting, put themſelves on a footing with the moſt regular Surgeons in the reduction of fractures, and often obtain a higher degree of reputation in the art, not only from the vulgar, but even among the more enlightened and ſenſible part of kind.

This ſtrange infatuation is not altogether to be accounted for in the preſent caſe, from that ſtrong deſire of health and eaſe, which like the love of money, reduces all underſtandings to a level; but may in ſome meaſure be owing to that general error, which the regular profeſſors of the art, as well as the moſt ignorant practitioners, have hitherto laboured under, with reſpect to the moſt proper and ſucceſsful method of treating fractures of the limbs in general, and the larger ones in particular.

An

FIGURE 3: Start of the Chapter on the "Management of Fractures". Note the similarity to Sir Percivall Pott's: "Some Few General Remarks on Fractures and Dislocations" published twenty-six years earlier.

It may seem that we have come a long way from John Jones. Debridement has been refined with the recognition that not only skin but devitalized muscle and bone are better excised than permitted to spontaneously slough. Antiseptics and antisepsis has made pus not only not laudable but not inevitable. Antibiotics and antisera have permitted a greater margin of error in the exactitude of our excision of contaminated and necrotic material but the basic principles laid down by Theodoric in the Thirteenth Century have been extended but not altered. After two hundred years we have increased the rapidity and quality of our care. Extremities that wound have seemed certain candidates for amputation in 1776, are salvageable by modern neurovascular and osteosynthetic techniques. As I look at the patients with extremity injuries handled in our Emergency Department each day, however, I feel that Jones, perhaps with a refresher course as part of his continuing education program, could have handled the vast majority with the armamentarium which was available to him, without too much fear of malpractice suits.

In 1976, our practice at the Kings County Hospital Center, in Brooklyn, of course, does in many ways differ significantly from our historical forebears. While the vast majority of soft tissue extremity injuries require only simple debridement and closure, our appreciation of the use of fine sutures and accurate tissue approximation to avoid subsequent deformity is acute and the fine monofilament synthetic suture material formerly used only on the face is now routine for most extremity lacerations. While debridement and wound irrigation with 1% kanamycin solution are our primary defense against local infection, 48 hours of systemic antibiotics, usually a broad spectrum combination of penicillin and tetracycline, are additional insurance against sepsis.

If the wound, following debridement, is considered clean, especially if there has been vascular or neural repairs or open reduction of fractures every attempt is made to affect primary wound closure either by the local rearrangement of skin flaps or by autologous split thickness skin grafting. When the adequacy of debridement is uncertain or when there is a suspicion that sepsis may develop, the technique of delayed primary wound closure, used so successfully during the latter part of the Viet Nam conflict, has proven to be a tremendous boon in the acute management of more massive wounds. Porcine xenograft used as a temporary biologic dressing has simplified the acute care of these injuries, especially when multiple other system injuries coexist. It has also made us less fearful of using long slash decompressive fasciotomies rather than the more restrictive subcutaneous fasciotomy formerly advocated. Now when there is any question of increased muscle compartment tension due to direct injury or ischemia it becomes simple to directly open the muscle compartment through skin and fascia and cover the resultant defect with this readily available material which can easily be removed when the wound is ready to be closed. In this regard the use of fibulectomy-fasciotomy, as suggested by Kelly and Whitesides and popularized by Ernst and Kaufer has provided superb decompression of all compartments of the leg (Figure 4). While indications for fasciotomy have been well delineated in the literature, we have simplified our indications, paraphrasing the classic maxim about tracheostomy, when you think you might need a fasciotomy— do it.

The repair of vascular injuries of the extremity certainly is one area in which the modern surgeon markedly diverges from his predecessors and this will be discussed, in detail, in a sub-

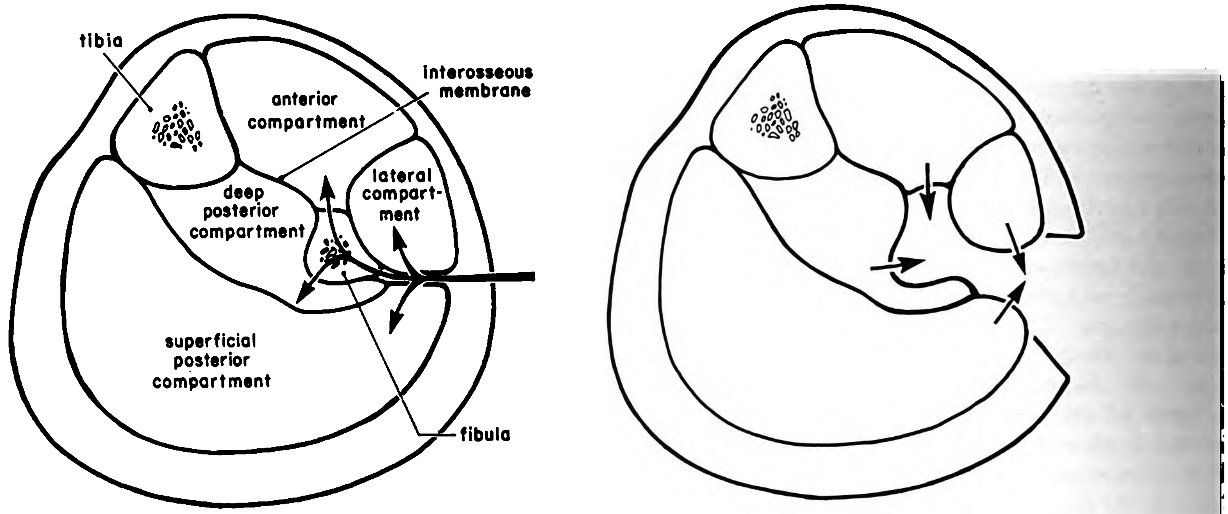

FIGURE 4: Cross-section of the leg showing the relationship of the compartments. Note that the deep compartment which contains the blood vessels is not readily accessible except through the bed of the fibula. (After Ernst, C. B. and Kaufer, H. Fibulectomy-Fasciotomy. Jrnl. of Trauma 11:365, 1971).

sequent paper. Unless the osseous and soft tissue damage of the distal extremity is irreparable, arterial repair, with the restoration of circulation, is always attempted primarily. While direct repair is usually feasible for incised lacerations, those arterial injuries due to gunshot wounds or blunt trauma represent so much loss of vascular substance that autogenous vein graft replacement is the method of choice. We believe that, where possible, associated femoral or popliteal vein transection similarly should be repaired, especially if major collateral channels are destroyed.

By like token, clean incised nerve transections are always repaired primarily, especially in the forearm and hand, but when there is considerable adjacent tissue destruction or loss of a portion of the nerve by crush or gunshot laceration, the ends are debrided, tagged, and definitive repair, which may include cable grafting, is deferred until a closed clean wound has been achieved. Our present preference for primary nerve repair is for perineural alignment of the fasciculus and/or funiculi with 8-0 to 10-0 sutures and then a tensionless epineural repair with 6-0 or 7-0 monofilament sutures. Nerve contusions, when visualized, are treated expectantly and there is no attempt at primary internal neurolysis.

Ideal fracture treatment was epitomized by Clay Ray Murray in 1945, as follows: "To 'wish' the fracture fragments into place with the concomitant abolition of all soft-part pathology, to hold them fixed by 'moral suasion', to allow the patient to immediately resume his normal activity." Precise operative fracture fragment reduction and rigid internal fixation, after the principles of the Swiss-German A-O Group, is our approach to ideal fracture care. While in some situations open reduction and internal fixation is not warranted because of a stable closed restoration of osseous alignment, we believe that in most instances the patient is better served by accepting the minimal risk of rigid operative fixation. In particular, the open fracture, in which the need for debridement of the wound, in truth, constitutes an open reduction, with all the problems of elective open reduction magnified, almost demands rigid fracture fixation before wound closure to minimize the subsequent problems of infection.

I do not mean to suggest that internal fixation is a panacea for avoiding infection in the face of wound contamination. A contaminated wound is a surgical anathema and all our training, both military and civilian, has been to convert this contaminated and fertile field for infection into a healthy vital area that will not support bacterial proliferation. An open fracture primarily requires meticulous debridement. Following this debridement, however, and only following it, to avoid a continuing damage to soft tissue, we believe that it is optimal to accurately restore the skeletal integrity. We have no evidence clinically or experimentally that the placement of

FIGURE 5: Initial angiogram showing lower third femoral fracture with arterial cut-off at fracture site.

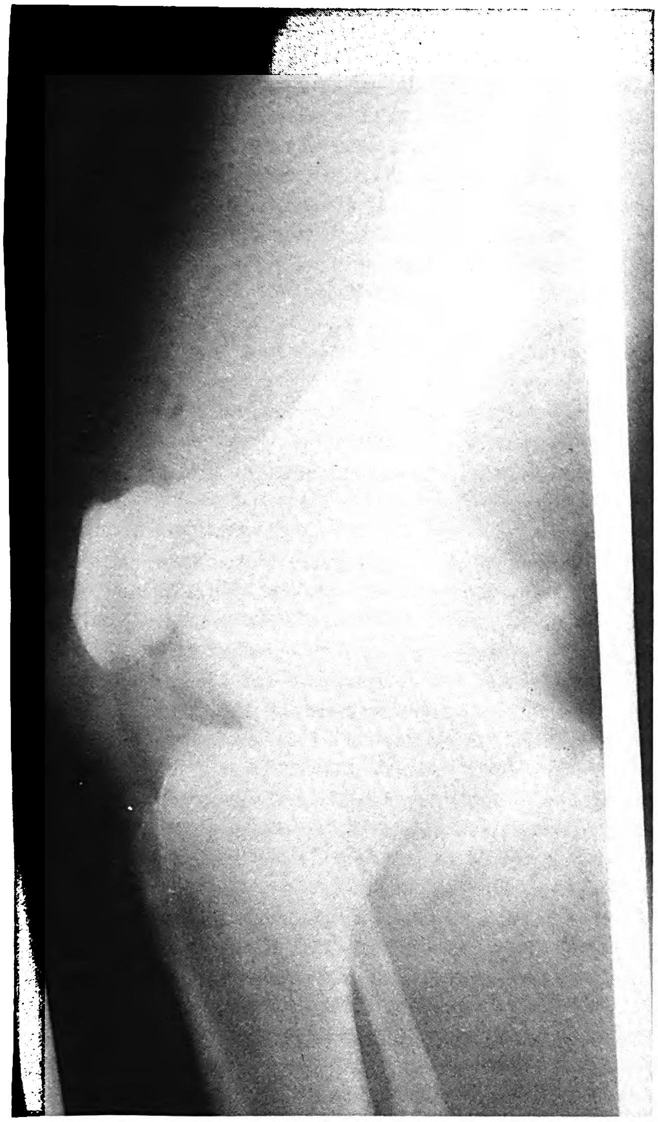

FIGURE 6: Later film in series showing dye extravasation in popliteal area probably from venous laceration.

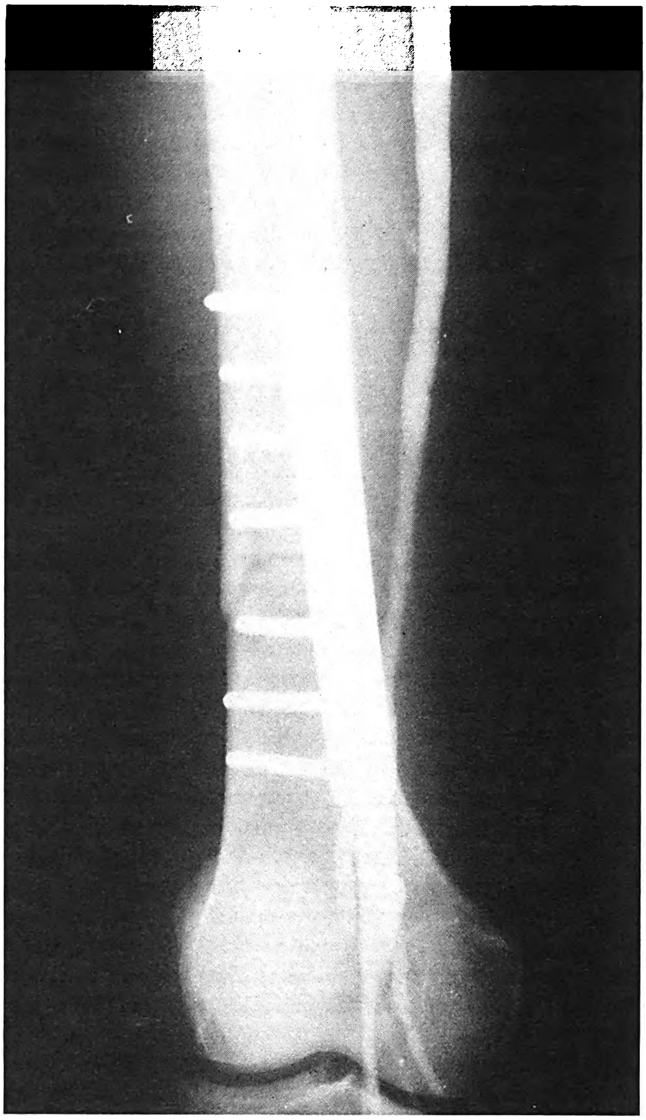

FIGURE 7: Two month postoperative venogram showing maintenance of vein patency and the heavy plate used to produce osseous alignment and stability.

rigid internal fixation devices increases the likelihood of wound or bone suppuration.

The following case will serve to illustrate some of our concepts of management:

C. G. was a 35 year old black male who, as a pedestrian, was struck by a car. There was an obvious fracture of the lower third of his right femur which was maintained in a Thomas splint and he was brought into the hospital with stable vital signs but with coolness and pulselessness in the distal right leg (Figure 5). Angiography showed a block in the distal femoral artery just above the popliteal space. A later film showed extravasation into the popliteal area (Figure 6). Through a standard popliteal incision both the femoral artery and vein were found to be transected just below the level of the femoral shaft fracture. A proximal extension enabled us to stabilize the fracture fragments with a medially placed seven hole broad plate. The femoral vein then was repaired after extraction of clots with a Fogarty catheter and arterial continuity was similarly restored. Upon release of the occluding arterial clamp the femoral vein was noted to fill well and there was a good strong dorsalis pedis and posterior tibial pulsation. Subcutaneous fasciotomy of the leg was carried out which subsequently proved to be inadequate and a more extensive complete leg fasciotomy subsequently was required. Arterial and venous continuity have remained good (Figure 7). The patient required subsequent bone grafting because of delayed healing of his femoral fracture and he is now working with a full range of useful motion in his knee and ankle.

The plating of the bone is rapid even if occasionally not ideal. The plate often may be used to bridge a large gap of unstable fragments but following fixation, it permits rotation of both the extremity and the patient to expose the injured vessels and to repair them. Subsequent nursing care is simplified and the occasional need for reoperation with repeat repair or thrombectomy is so much easier in an internally stabilized extremity. Lastly, postoperative recuperation is shortened because prolonged traction is not required. There have been instances where, because of the preference of the surgeon, internal fixation has not been done simultaneously with vascular repair. In those cases even enthusiasts like us have severe reservations about operative bone fixation which requires mobilization of a previous vein graft or arterial anastomosis.

It is obvious that in two hundred years we have made rather disappointing progress in the management of extremity injury compared to the vast improvement in abdominal, thoracic, and cerebral trauma care. In what direction can we look for future improvement? I believe that the greatest advance in the area of musculoskeletal trauma would be the certain control of bacterial infection. If we were able to avoid sepsis in open injuries, extremity reconstruction would be vastly simplified. The operative repair of skeletal injuries would be routine without the specter of infection hanging over the heretical surgeon who uses internal metal rather than external plaster or plastic. Improved biologically replaceable osteogenic bone cements might then seriously replace the present "hardware store" contraptions. Part of the avoidance of infection also would be an accurate way of determing tissue viability, allowing precise excision of devitalized tissue, as well as techniques to assure vascular supply to the extremities after arterial and venous repairs. We also can look towards techniques of altering neuronal metabolism so that axonal growth can be stimulated to speed functional muscle-nerve unit restoration following anatomic nerve reconstruction.

Finally, we can look to the manipulation of the immunologic processes to permit not only nerve and blood vessel banking but joint and possibly even limb transplantation making the legend of Cosmos and Damian a definitive answer to musculoskeletal destruction of the extremity.

CLOSE RANGE SHOTGUN BLASTS TO THE LIMB WITH ARTERIAL, VENOUS, NERVE, BONE AND SOFT TISSUE DISRUPTION

Charles E. Lucas, M.D., F.A.C.S.

During the first half of the 20th Century, the principles of treatment for severe extremity wounds have become established and refined. These principles include resuscitation, control of bleeding, adequate debridement of soft tissue disruption, stabilization of the fracture, and soft tissue coverage of the fracture. Following these principles, limb salvage became a function of both adequate blood supply and successful patient long-term immobilization. The addition of an arterial injury greatly jeopardized limb salvage since the collateral flow often was inadequate with associated soft tissue disruption. The amputation rates for lower limb vascular injury became well established during World War I being 80 percent, 50 percent, and 72 percent respectively for the common femoral, superficial femoral, and popliteal arteries. Most of these injuries did not have associated massive soft tissue loss; the addition of massive soft tissue injury increases these rates precipitously.

The introduction of primary arterial repair in World War II and its subsequent refinement in both the Korean and Vietnam conflicts brought about a dramatic reduction in the amputation rate of patients with vascular and combined vascular and soft tissue injuries. During these years, the principles of vascular repair became established as technical expertise flourished, sutures and knowledge of sutures improved, and the use of the autogenous saphenous vein graft allowed reconstruction of extensive injuries. Throughout these years, however, a continuing challenge has been the treatment of the high velocity rifle wound or close range shotgun blast causing extensive arterial, venous, nerve, bone, and soft tissue injury. The purpose of this report is to outline, on a priority basis, the principles of treatment which must be followed to maximize limb salvage after such injuries. These principles include resuscitation, hemostasis, decision to attempt limb salvage versus primary amputation, adequate debridement, arterial repair, venous repair if feasible, the role of fasciotomy, type of wound management, and the problem of the exposed vascular repair. Since most of these injuries involve the thigh, frequent reference is made to the thigh although the principles of treatment apply to all limbs.

Resuscitation

The close range shotgun blast to the limb is potentially fatal from hypovolemic shock if quick and effective resuscitation are not provided. Correction of hypovolemic shock and control of external bleeding must be instituted immediately. Although resuscitation of shock is presented elsewhere, it is worth repeating that these patients frequently require early transfusion with type specific, uncrossed matched blood as the degree of hypovolemia and shock often precludes waiting a full 45 minutes for cross matching of whole blood. Likewise, these patients require at least two large bore intravenous routes to facilitate rapid infusion of blood and electrolyte solution. This large volume need is reflected in a group of 25 consecutive patients treated at Detroit General Hospital for comparable wounds; they required an average of 18 transfusions during resuscitation. Some patients required internal cardiac massage as part of their initial resuscitation prior to making any attempt at limb salvage.

Control of local bleeding can be achieved by the application of large gauze pack dressings and a tight ace wrap. Some wounds with massive soft tissue disruption have deep, irregular crevices which prevent effective compression with gauze dressings and ace wraps; bleeding from such wounds will respond to reinforcement by a large sphygmomanometer over the dressing or proximal to the wound and inflation well above systolic pressure. Occasionally, inability to control hemorrhage despite these techniques requires that the patient be taken directly from the emergency vehicle to the operating room where operative hemostasis is obtained while resuscitation is continued. While it is theoretically desirable to have complete local hemostasis in the emergency room, the frustrations of obtaining hemostasis in the midst of shattered muscle, skin, and subcutaneous tissue often leads to continued hemorrhage until extensive operative debridement of the devitalized and marginal tissue has been completed.

Primary Amputation

Any patient with severe prolonged shock from a close range shotgun blast to the limb is likely to develop severe cardiorespiratory, cerebral, and renal insufficiency following resuscitation and operation. When it appears that the multi-organ sequelae of hypovolemic shock will be a severe threat to life, any attempt at limb salvage must be questioned. Specifically, any patient sustaining cardiac arrest from hypovolemia and having residual signs of cerebral ischemia should have a primary amputation to enhance the potential for salvaging life. It is a difficult clinical judgment, however, to decide upon primary amputation in a patient with less shock but in whom it is felt that the long protracted attempt at limb salvage will cause further bleeding, hypovolemia, poor organ perfusion and potential death. Ideally, the decision to do a primary amputation should be made initially since delay and reoperation only increase the chances of morbidity and potential death. Those factors which influence the decision to do a primary amputation in patients with massive local injuries include the number and severity of systemic injuries, age of patient, and severity of shock upon arrival to the emergency room. It is interesting to note that primary amputation in our experience has uniformly been associated with survival, whereas inappropriate attempts at resuscitation have all too frequently resulted in death. It appears that "the surgeon's ego" must be balanced with good, clinical judgment.

Debridement of Devitalized Tissue

The most frequent error in the treatment of this injury is inadequate debridement of the involved soft tissue. The usual causes of inadequate debridement are inexperience and uncalled for attempts to preserve marginally viable soft tissue for covering exposed bone or vessels. This latter compromise usually makes the subsequent problems with sepsis worse so that the bone or vessel which is covered with inadequately debrided soft tissue becomes exposed to worse sepsis than would have occurred if they had been left exposed primarily. The former problem of inexperience can only be corrected with frequent exposure to such injuries, but useful aids for achieving adequate debridement include: (1) small entrance wounds often cover extensive underlying soft tissue damage; (2) injured non-viable muscle will often bleed since the blood vessels of such muscle respond to the shock of impact differently from the muscle cells themselves; (3) muscle cell contractility or absence thereof is a more reliable guide to viability; (4) primary wound closure over marginally debrided soft tissue results in further soft tissue swelling which further decreases blood flow to already ischemic muscles; (5) even the most experienced of trauma surgeons have difficulty in recognizing exactly the proper level of debridement so that a second look procedure at 36 to 48 hours is usually indicated.

The combination of inadequate debridement of soft tissue and primary approximation of the wound is an unacceptable error in judgment and is associated with at least a 50 percent incidence of subsequent amputation. In contrast, almost all patients treated with adequate debridement followed by open wound care survive with limb salvage.

Treatment of Arterial Injury

The extensiveness of these wounds usually mitigates against simple primary repair, resection and end-to-end anastamosis, or single suture repair of multiple pellet perforations. Such procedures can only be performed when the muscle on which the artery lies does not have to be significantly debrided. Otherwise, the artery, repaired primarily, will be lying on a bed of non-viable muscle resulting in sepsis and perforation of the primary repair. Alternatively, if the underlying muscle is significantly debrided, the primarily repaired artery will be lying free in the wound without being in close adjacent proximity to healthy viable soft tissue from which it can receive its oxygen supply. This, likewise, will result in secondary rupture with life threatening hemorrhage.

The only acceptable alternative to primary simple repair in these patients is extensive resection of the artery to the level where the surrounding muscle and soft tissue have been debrided proximally and distally followed by arterial reconstruction by contralateral autogenous saphenous vein graft if the patient has a usable vein. When this injury occurs in hard-core drug addicts without usable saphenous veins, a dacron prosthesis is required. Whether a dacron or autogenous vein graft are used, the length should be sufficient to not only bridge the gap between the proximal and distal artery, but also to allow the graft to be in contact with healthy, viable soft tissue from which it can receive its oxygen supply. When the central blast defect involves primarily one muscle compartment, the vein graft can be rerouted through an alternate muscle compartment thereby avoiding the septic complications which occur when the vein graft is left adjacent to non-viable tissue. Alternatively, when the central blast involves most of the muscle compartments to some degree, the vein graft should be of sufficient length so that it can rest on the healthiest appearing muscle at the base of the wound and covered with a biologic dressing such as split thickness porcine skin grafts. A theoretically desirable technique to obviate the need for biologic dressing covering over an exposed vascular repair is the primary rotation of a muscle flap or complete muscle belly. This technique is well established in the treatment of exposed vessels after radical neck or radical groin dissections, but has not been very successful in the treatment of close range rifle wounds or shotgun blasts. Our experience has shown that these flaps, when rotated primarily at the first operation, usually necrose despite meticulous attempts at preserving the blood supply. This frustrating complication occurs over a number of days despite the initial healthy appearance of the rotated muscle flap or muscle belly. The ultimate failure of such flaps appears to be the related local sepsis which gradually involves the rotated muscle which then necroses. Such local sepsis is an expected problem with these wounds, it responds after several days of local care and systemic antibiotics.

Success with the split thickness porcine skin grafts as a biologic dressing for exposed vascular repairs has obviated the need to primarily rotate a muscle flap. These biologic dressings are applied over the exposed vein graft and artery whereas the rest of the wound is covered with fine mesh gauze and fluff dressings. The biologic dressings are removed every 24 to 48 hours, depending upon the amount of wound drainage and sepsis. These frequent changes of the biologic dressing aid in controlling wound sepsis and promote the development of granulation tissue coverage over the exposed vessel and vein graft. A layer of fibrin and subsequent granulation tissue form and keep the exposed vessel moist protecting it from the trauma produced by the microdebridement of removing the fine mesh gauze. Once the granulation tissue becomes pink over the exposed vein graft, it is covered with an autogenous split thickness skin graft. Utilization of this technique has allowed us to modify one of the time honored principles of vascular trauma, namely, amputation is indicated for any patient in whom the vascular repair cannot be primarily covered by soft tissue. The technique of frequent biologic dressing changes utilizing split-thickness porcine skin grafts appears to be a reasonable alternative to this time-honored principle. Like all arterial repairs for trauma, the Fogarty catheter should be routinely used to remove distal clot followed by the local administration of heparin to prevent clot formation during the period of repair.

Treatment of Venous Injury

The treatment of venous injuries has gone full cycle in the past 10 years from a recommendation of routine ligation to that of routine repair. Certainly, most patients with simple venous injury should have primary repair since most venous repairs will remain patent and have not been associated with pulmonary emboli as was feared in the 1960's. Unfortunately the extensiveness of close range shotgun blasts often necessitates the resection of large segments of the superficial femoral and the saphenous veins as part of the soft-tissue debridement. This precludes any type of primary end-to-end repair of the femoral vein; any attempt at venous repair would have to be accomplished by way of a vein graft. This becomes impractical since the contralateral saphenous vein is being used to replace the resected artery so that little is left to repair the involved femoral vein. Furthermore, by this point in the operation, the patient has usually lost several units of blood and the operation has usually lasted several hours. It is not recommended, therefore, that extensive attempts be made to accomplish a vein graft repair of the injured femoral vein which would then be exposed and in danger of delayed rupture or thrombosis. The hazards of prolonging the operation and increasing the number of transfusions under such circumstances outweigh the potential benefits. Such patients should have the injured saphenous and femoral veins ligated if there is a large central defect. These patients are then treated with compulsive, prolonged elevation for a number of weeks during which time the residual edema, which is usually severe, will gradually reside and the limb will return to normal. All such patients, however, require fasciotomy.

Fasciotomy

The combination of hypovolemic shock, massive soft tissue disruption with loss of small venules and lymphatics, and venous ligation necessitates decompression of the lower limb in all of these patients. Indeed, lack of fasciotomy, in our experience, is the second most common cause of limb loss, second only to inadequate debridement. This experience is shared by the Viet Nam data where failure to perform a fasciotomy led to a secondary amputation in 60 percent of patients requiring delayed amputation. Although most patients will respond to a standard medial and lateral fasciotomy utilizing a full-thickness incision of the skin, subcutaneous fat, and fascia, Ernst and Kaufer have recently reintroduced the concept of performing fibulectomy-fasciotomy to decompress all four compartments of the leg in patients with extensive injury, profound shock and venous ligation. Fibulectomy-fasciotomy is also the safest procedure in patients with severe injury, delay in treatment, and venous ligation when there is loss of motor and sensory function preoperatively. Recent attempts are currently being made to measure, at the time of surgery, the tissue pressures in the superficial compartments of the leg in order to determine when and what type of fasciotomy is indicated. Until further data is available, it is recommended that the standard lateral and medial fasciotomy be performed when the interstitial pressure is above 20 cm H_20 but below 45 cm H_20, whereas fibulectomy-fasciotomy is recommended for patients with increased interstitial pressure above 45 cm H_20. In addition to interstitial pressure measurements, post-operative loss of pulsation or evidence of poor runoff by arteriography indicate need for more extensive fasciotomy which must be performed immediately to prevent muscle death.

Fibulectomy-fasciotomy may also be staged during operation. A rapid lateral fasciotomy incision made while hemostasis is being obtained allows for some muscle expansion to occur while the arterial reconstruction is being performed. If it is evident after the arterial reconstruction that high tissue pressures remain in the superficial muscle compartments, then the fibulectomy can be performed with decompression of the remaining three muscular compartments of the leg.

Nerve Injury

For reasons which are not entirely clear, the main nerves running through areas of extensive soft tissue disruption are usually severely contused but not severed. The nerve appears to have more resiliency against the blast effect than do the surrounding soft tissue, artery, vein and, to some extent, the bone. No specific treatment is needed for the contused nerve except to keep it from drying out if it is exposed. This can be accomplished by the use of split-thickness porcine skin grafts, as was described above, for exposed arteries. Clinically, these patients typically have diffuse loss of nerve function below the site of injury even though the nerve is grossly intack. This loss of function will persist for several weeks but one can anticipate a gradual return of both motor and sensory function at the rate of at least 1 mm/day. Patients presenting with anesthesia and paralysis below the site of injury to the mid thigh can be expected to have a gradual return of function over the next three to six months. Most of the leg muscles have function within six months whereas sensation has almost always returned to the foot by this time. Over the next 12 months, this motor function and sensory function will return close to former levels. There frequently, however, is a permanent loss of function of the perineal nerve even though the injury has occurred well up in the thigh. This results in a permanent foot drop.

One of the most common complications of temporary loss of nerve function during the initial postoperative period is the development of a decubitus along the posterior aspect of the heel when the patient is being maintained on balanced skeletal traction. This occurs in most patients with this injury despite compulsive attempts to keep this portion of the heel well protected with soft-dressings or foam rubber padding. It is important, therefore, to anticipate this problem in order to minimize, as much as possible, this very frustrating complication.

Fracture Treatment

The diffuse disruption of soft tissue and associated structures precludes the safe use of internal fixation. This creates a problem in the postoperative period because of instability with threatened disrupture of vascular repair whenever the patient is moved. When it is possible, the fracture is treated by means of a posterior mold or the combination of an anterior and posterior to mold to prevent excessive movement and also to provide a protective dressing. This can be used for prolonged periods in patients with humeral, tibial, and forearm injuries. Patients with femur fractures, however, must be placed in some type of fixation. Over the past few years we have been using balanced skeletal traction to accomplish this end; this allows for dressing changes to be performed in the operating room every 24 to 48 hours, at which time the split-thickness porcine skin graft which is covering the exposed vascular repair can also be changed. This technique is very cumbersome and requires a number of operative and ward personnel to transport the patient to and from the operating room. It also causes some discomfort to the patient. It may be that other types of extraskeletal fixation described elsewhere in this symposium may be applicable for this type of combined soft-tissue, vascular and bone injury.

Using this technique of balanced skeletal traction, the wounds are changed every 24 to 48 hours and split thickness porcine skin grafts are applied to exposed vessels and nerves until a reasonably thick layer of granulation tissue has formed. These dressing changes are carried out on the ward after the patient can tolerate the procedure without anesthesia. By this time the local wound sepsis usually resolves and the deep crevices in the wound gradually fill in with granulation tissue; soon thereafter, the patients becomes afebrile and systemic antibiotics can be discontinued. Continued purulent drainage on the dressings often persists but if the underlying wound appears pink, no further systemic antibiotics are needed as long as the patient remains afebrile. As soon as the deep crevices of the wound have filled in with pink, healthy granulation tissue, autogenous split-thickness skin graft is applied and the patient is then placed in the appropriate cast for subsequent healing. By this time adequate lymphatic and venous collateral have developed providing complete mobilization of edema. One can anticipate that the ultimate time of bone healing will be about three months longer than that which occurs with less complicated wounds. This is true not only because of loss of soft tissue and muscle, but frequently on the basis of some loss of bone itself, thus requiring a longer time to bridge the gap and develop good healing. Using the above techniques, the long term expectation for return of function in patients with these injuries is good.

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THE TREATMENT OF OPEN AND CLOSED EXTREMITY FRACTURES

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Introduction

In spite of myriad advances made by modern surgery, both the historical and current literature are replete with the problems, complications and various methods of management of open and closed extremity fractures. In spite of years of treatment concerns three basic principles have withstood the test of time. These include: adequate debridement of open wounds, proper timing of wound closure and adequate fracture immobilization. As simple as these principles seem, it appears they require cyclical relearning and reinforcement. The early days of the Korean War were associated with incomplete debridement, numerous wound closures and primary metal fixation with wound sloughing, infections, gas gangrene and amputations expectantly following. These deficiencies were quickly remedied, however, as the lessons of previous wars were relearned.

The etiology of open and closed fractures require that a sufficient amount of force be applied to the extremity to disrupt normal bone. It is readily assumed that open fractures require more force than closed fractures even though this may simply reflect the direction and not the amount of force. There is no question, however, that open fractures are usually associated with more soft tissue damage than closed fractures and that increasing soft tissue damage is reflected in problems in fracture healing.

A fracture is considered open when the fracture site and the fracture hematoma communicate with the exterior. In a closed fracture the fracture hematoma remains intact. The vast majority of open fractures are associated with variable loss in the integrity of the skin and proper fracture management dictates that every effort should be directed toward the restoration of the integrity and function of the soft tissues. This concern begins in the field and is extended in the hospital as definitive fracture care.

Principles of Management in the Field

The principles of the management of open and closed fractures as taught to emergency medical technicians must be strictly followed without compromise. This is best accomplished by formally educating, reeducating and reinforcing a programmatic approach to the injured victim by paramedical personnel.

Our approach is to emphasize that a rapid initial survey (triage) should be made not only of the patient but of the entire scene. As the patient is approached, as accurate a history of events as possible should be taken. Almost simultaneously the patient should be checked for airway patency, breathing and pulses. The extremities are evaluated for swelling, deformity or paralysis. The state of consciousness, or any change in the state of consciousness is noted. This information is then tabulated for evaluation by the receiving physician. At no time is the patient neglected for recording observations.

After the initial evaluation, a treatment plan is formulated and implemented. Emergent problems recognized are dealt with immediately. The recognition of a need for basic life-support measures and their implementation should be a matter of seconds. Closed fractures are splinted and elevated as conditions permit. Open fractures require additional procedures. Clothing should be cut away from the wound. Bleeding can be controlled with direct pressure over a dry, sterile dressing. Obvious gross foreign debris like leaves or twigs which can be easily removed, should be done so as aseptically as possible. Protruding bone fragments should not be pushed back into the wound. Smaller bone fragments with soft tissue attachments should be protected. Impaled objects should be stabilized and transported with the patient. Wounds are then covered with dry, sterile compression dressings and the extremity is splinted. Open fractures of the hand and wrist or foot and ankle can be splinted with rigid external devices, air splints or pillow splints, which should extend as high up the extremity as possible. Open fractures of the femur can be managed with rigid splints crossing the knee and hip joint, or traction splints. Traction splints seem less desirable for open fractures when they pull protruded bone edges back into the wound. Fractures of the upper arm and shoulder region are best managed by splinting the involved extremity to the chest with a sling and swathe dressing.

The patient is then transported to a medical facility. In general, fractures require more care in transport than speed in transport. The exception to this rule is the practice associated with an arterial injury manifesting itself as a cool, cyanotic extremity when logistic or traffic problems may play a role in delaying definitive treatment.

Management of Fractures in the Emergency Room

In the emergency room, the proper management of open fractures or closed fractures complicated by neurovascular compromise is predicated on an immediate and thorough history and physical examination. The consequences of the forces causing a serious extremity fracture must be evaluated in terms of their effects on other body systems. Intravenous fluids are started immediately. The number of intravenous lines considered sufficient, or the requirement for central venous or peripheral arterial monitoring devices, is entirely dependent upon the seriousness of the injury. At the same time blood samples are drawn for laboratory testing and typing and cross matching of whole blood. Fluid resuscitation is begun with lactated Ringers solution supplemented with colloids until type specific blood is available. Foley catheters are inserted to more accurately measure urine output. In the presence of open wounds, tetanus toxoid is administered as indicated. If the wound is particularly contaminated, if the immunological history indicates an immune mechanism compromise or if the immunological history is not known, human hyperimmune globulin may be used. The wound should be cultured and the material placed in the proper bacteriological media. After wound culturing, broad spectrum systemic antibiotics may be started. In examining the wound, its depth should not be probed nor should protruding bone fragments be manipulated. A sterile dressing should then be applied followed by the application of an appropriate splint, had this not previously been done in the field. Standard roentgenographic examination can then be performed to better evaluate the extent of skeletal injury. This should be done with the fracture properly immobilized. Do not remove the field immobilization if it is adequate and appropriate. In the case of open fractures, the patient is then moved to the operating room where more definitive treatment is undertaken.

Skin Preparation Prior to Surgery

The primary prerequisite for the adequate debridement of soft tissue wounds is the proper preparation of uninjured and exposed skin about and between all wounds. All agents used to routinely prepare the skin for surgery are to some extent toxic to living cells. Every attempt must then be made to protect the wound, an area already compromised by trauma, from the additional trauma of chemical irritation by aseptics. Gauze sponges applied to the wound will not only prevent chemical irritation but also prevent bacteria from being washed into the wound during the cleansing process. Skin cleansing should be done as atraumatically as possible. The wound and overlying skin should also be protected from injury by the motion of sharp bone fragments. This may necessitate the retention or improvisation of splints. The patient is then sterilely draped in the manner of any clean, orthopedic operative procedure.

Wound Debridement

Thorough wound debridement is by far the most important step initiated in managing open fractures. The objective of wound debridement is the maintenance or restoration of soft tissue viability. Soft tissue function is best restored by promoting optimal conditions for the healing of injured soft tissues by detecting and excising non-viable and necrotic tissue, foreign matter, especially organic material, and physically reducing the amount of bacterial contamination. The restoration of soft tissue function prevents infection and promotes bone healing.

The process of debridement includes fluid lavage and surgical excision of tissue. Lavage mechanically flushes away necrotic and foreign debris including clotted blood. It helps identify non-viable tissue and dilutes the wound bacterial count. The fluid should be directed in a gentle stream to all recesses of the wound. Profuse amounts of fluid are required, the majority of evidence suggesting the more fluid used, the lower rate of infection. The question of whether antibiotics should be added to the fluid remains in question. There are several studies documenting the beneficial effects of antibiotic solutions, but the solutions are also combined with exceptional surgical technique including meticulous tissue healing and profuse amounts of solution used several times during the procedure. The decrease in the infection rate may be the manifestation of cautious and effective surgical technique rather than the antibiotics.

The surgical extension of nonfunctioning tissue is approached systematically, beginning superficially with the skin and progressing to the deeper layers. The skin incision should be planned carefully to allow thorough exploration of the wound, yet promote as early wound closure as possible. Small perforations and puncture wounds can be easily converted to elliptical incisions, or in the true minimal puncture wound made from within, the wound may be cleansed thoroughly, covered with sterile dressing plus an antibacterial ointment of choice and then immobilized by plaster. Larger lacerations may require surgical extension proximally and distally in order to effectively mobilize soft tissue and thus facilitate closure at the appropriate time.

Attention should then be directed to the subcutaneous tissues. Care should be taken to avoid further compromise of the vascular supply to the overlying skin. Care must also be taken to prevent freely resecting undamaged superficial venous channels until it can be ascertained that deeper veins are intact and that the extremity will have adequate venous drainage. Bulging muscle through fascial defects warrants additional surgical release of the fascia. Non-viable muscle provides an excellent media for growth of numerous organisms including anaerobic types which noticeably propagate in devascularized muscle. There is no infallible principle to guide the surgeon in determining the viability of muscle tissue, therefore, several factors should be taken into consideration. When the color of the muscle appears normal, viability is suggestive. Darker appearing muscle, however, may be secondary to submyonesial hemorrhage. Muscle which briskly contracts when cut is obviously viable but noncontractile muscle may be viable. Lacerated muscle which demonstrates a capillary ooze also suggests viability. If there is any reasonable doubt concerning the viability of skeletal muscle, it should be removed.

Bone

Bone has a relatively sparse blood supply, and this is variably compromised with an open fracture. Contaminated bone edges require profuse irrigation even to the extent of using a soft bristle brush followed by excision of the edges. As much of the periosteum as possible should be retained. Soft tissue attachments to bone fragments should be treated atraumatically to prevent further compromise of an already tenuous blood supply. Creating gross deformity of the limb to better visualize the fracture site should be avoided, as this maneuver may compromise the integrity of soft tissues. Clotted plugs formed at the opening of the intramedullary canal should be removed and the opening of the canal profusely irrigated. Care should be taken not to impact contaminated tissue into the medullary canal. Smaller unattached bone fragments in a potentially contaminated area should probably be removed as they are difficult to clean and their effect in promoting healing, as with a primary bone graft in a clean wound, may not be of value. Larger fragments, however, present another problem. Removal of larger fragments may leave significant gaps in the long bones making the resultant non-union difficult to manage. Larger fragments should probably be thoroughly cleaned and replaced but, since no absolute criteria have been established, replacing a fragment is strictly a decision made on the basis of the judgment and experience of the surgeon in reference to the wound and finally the entire patient.

Foreign Bodies

There seems to be little question that foreign bodies add to the morbidity of open fractures. Organic material may evoke a severe inflammatory response of its own making differentiation from infection difficult. This is especially seen in knife cuts to the hand made while cutting meat or fish. In addition, foreign bodies may harbor a variety of organisms associated with persistent infection precluding satisfactory healing. In general a thorough debridement includes the removal of foreign bodies as long as healthy tissue is not sacrificed.

Hematoma and Dead Space

Both hematoma and dead space (destined to be filled with protein-rich transudate) provide a bacterial innoculum with a rich media in which to proliferate. In addition, the hemoglobin fraction of the red blood cell in the hematoma may locally irritate compromised tissue. Obvious hematomas have been noted to be associated with up to 30 percent incidence of clinically detectable wound infections. Every attempt should be made to maintain meticulous hemostasis and eliminate dead space.

Skin Closure

There are numerous studies in the literature which attest to the importance of soft tissue coverage in maintaining the stability of open fractures and promoting union. Primary closure of open fracture wounds should be undertaken at the time of initial wound debridement if at all possible. However, numerous factors concerning the character of the wound need be considered to avoid *premature* wound closure.

Closure can be effected in a number of ways at varying times. (Table 1) The decision to effect a primary closure is based entirely on the judgment of the surgeon. Small puncture wounds caused from within by bone spikes adequately debrided before four to six hours have elapsed can be closed primarily. The key is adequate debridement, not neglecting this basic principle because of the size of the wound, and wound closure without tension. If there is serious question as to the adequacy of debridement, closure should be delayed. Wounds left open should not be tightly packed with sponges as this blocks drainage. If the wound is left open, the wound should be inspected and cultured about the third day, and consideration should be given to secondary closure on or about the fifth to seventh days. If the wound is clean, the defect should be closed if technically feasible. The Korean experience documented the fact that wounds treated in this manner heal faster and with greatly diminished infection rates.

TABLE 1: Skin Closure. Closure options available in wound management.

1. Primary Closure
   a) Immediate suture of wound (with or without drains)
   b) Immediate suture with relaxing incision(s)
   c) Immediate suture, relaxing incision(s) and complimentary skin grafts (fresh or freeze dried allografts)
   d) Immediate skin grafts — split thickness
   e) Immediate skin grafts — full thickness
2. Delayed Closure (approximately five to seven days)
   a) Secondary suture (with or without drains)
   b) Secondary suture with relaxing incisions (with or without complimentary skin grafts)
3. Secondary Closure
   a) skin grafts
   b) rotational flaps
   c) pedicle flaps
4. Secondary Intention (granulation and epithelialization)

Management of the Fracture

After an adequate debridement of the wound has been effected, attention should then be directed to definitive and appropriate management of the fracture. Appropriate management of the fracture requires that the method chosen will promote union, minimize further soft tissue damage, maintain length and joint alignment while minimizing the chances of infection. The attainment of this end implies adequate fracture fixation or immobilization during the healing phase of treatment in the presence of adequate soft tissue coverage.

Fracture fixation or immobilization can be attained using either external devices or internal devices. Some of the various external devices used to effect fracture immobilization include plaster casts and splints, weight-bearing casts and braces, skeletal pins in plaster, skeletal pins and other external holding devices (Charnley apparatus, Hoffmann device, Roger-Anderson device), and skeletal pins and traction.

Plaster casts have served generations of surgeons well. They are applied with ease and are particularly useful in stable fractures at the more distal end of the extremity in association with smaller wounds. Wounds can be inspected with ease by windowing the cast. Window edema can be prevented by replacing the window after wound inspection. The disadvantages of simple methods are that the joints above and below the fracture site must be immobilized and may present a long term problem in rehabilitation. Drainage into the cast may present with foul odors and wound toilet may be difficult or impossible. In addition, wet casts are applied over dry, sterile dressings covering wounds, and sporadic reports have appeared in the literature where highly pathological organisms, notably *Clostridium welchii*, have been cultured out of plaster.

Some of the disadvantages of simple plaster methods have been eliminated by making casts more functional. The results are most impressive in the treatment of lower extremity fractures where weight bearing casts have been used. The beneficial effects of maintaining function in the management of lower extremity fractures has been emphasized by a number of authors notably Dehne, Brown and Urban, and Sarmiento. The problems associated with weight bearing casts may require some consideration. Open wounds may be difficult to manage in the weight bearing cast and total contact may not always be attained. Shortening of the involved extremity has not surfaced to become a major problem. In our personal experience, we have found that the reduction is occasionally lost through angulation of the fragments even though our orthoses appeared to meet the requirements that the fracture be stabilized. Short leg casts make correction of angulation utilizing wedging techniques difficult. Long leg casts allow for better correction of angulation problems but require incorporation of the knee joint into the cast. Casts have also been made more functional by changing the material of which they are constructed. Fiberglass casts, for example, have eliminated some of the problems of plaster casts associated with moisture and, in fact, have allowed the use of hydrotherapy in wound care.

Another method of management of instability problems in fractures is the use of skeletal pins incorporated in plaster casts. If, after a short leg cast is applied, angulation is a problem, wedging easily corrects the deformity. Care must be taken to avoid distraction at the fracture site, for pins will hold a fracture distracted (predisposing to non-union) as well as holding the fragments in position.

After pins have been inserted into the extremity, methods other than plaster techniques may be employed. Most notable among these are the Charnley apparatus, and the Vidal-Audrey method using Hoffmann's instrumentation. Both methods provide a great degree of stability and a significant reduction in the incidence of infection but the Hoffman instrumentation provides a greater degree of variability in managing specific fracture problems. The device has numerous variations and may hold fragments in compression and hold comminuted butterfly fragments in position. The problems of fracture distraction by such patent devices must be under continuous professional scrutiny.

Traction is another highly useful method of treating both open and closed fractures. It is used more frequently with fractures of the lower extremity and the proximal portions of the upper extremity. It has numerous variations including the concomittant use of frames, splints and casts to allow management of peculiar fractures and open wounds on any part of the extremity. It can be readily adjusted to correct deformity. When sufficient soft tissue and bone union have occurred, the traction can be readily substituted for other methods.

Internal Fixation of Fractures

The question of the use of various internal fixation devices to stabilize fractures in the presence of an open wound has for generations remained a controversial issue. While numerous systematic and local complications have been reported with the use of internal fixation devices in open fractures, some authors have questioned the actual role the fixation device played in the complication. While there may be numerous indications for the open reduction and internal fixation of closed fractures, it is the sum of our experience that indications for open reduction and internal fixation methods in the management of open fractures is uncommon and usually contraindicated. Internal fixation devices should only be used in open fractures when, based on the judgment of the surgeon, there appears to be no other way to preserve the extremity. This may occur when an extremity has a tenuous blood supply and the patient requires long distance transportation to other facilities by unusual methods. In general, vascular injuries to either the arterial or major venous channels are repaired directly or grafted. The success rate of arterial repair is approximately 90 percent except in the popliteal area where the results approximate 50 percent. Various methods of external fixation, including traction, have been shown to stabilize the extremity sufficiently to allow healing of the vascular repair in most circumstances. There will, however, be cases when fracture stabilization cannot be maintained using external devices and consideration is then given to internal fixation devices to avoid jeopardizing the vascular repair. Nerve repairs are tedious and time consuming procedures and rightly should be. The prognosis is guarded even in the best of circumstances. There is rarely an indication for nerve repair in a contaminated wound. Using internal fixation devices in an open wound to protect a nerve repair is not indicated.

The most frequent complications of internal fixation include infection and delayed union or non-union. Infection is the most significant of the complications and numerous organisms have been implicated. (Table 2) There is little doubt that the open treatment of various closed fractures results in an increasing evidence of infection. (Table 3) There is slightly more variance, however, in the reported incidences of infection in the literature in regard to the management of open fractures with various methods. When numerous studies are compared, there appears to be an increasing rate of infection when internal fixation devices are used even though numerous factors re-

TABLE 2: Infection. Organisms commonly cultured from wounds associated with open fractures.

1. Gram positive (pyogenic):
   - *Staphylococcus aureus*
   - *Staphylococcus albus*
   - Hemolytic streptococcus
2. Gram negative:
   - *E. Coli*
   - Proteus sp.
   - Pseudomonas sp.
3. Polymicrobic combinations:
   - *Staphylococcus aureus* and *E. Coli*
   - *Staphylococcus aureus* and Pseudomonas sp.
   - *Staphylococcus aureus* and Proteus sp.
   - *E. Coli* and Pseudomonas sp.
4. Others:
   - Clostridial sp.
   - Various anaerobes

TABLE 3: Tibial Fractures. A comparison of the infection rate with various methods of treating open and closed tibial shaft fractures.

1. Closed Fractures	
closed methods	rare
closed nailings	1-2%
open reduction with internal fixation	4-6%
2. Open Fractures	
closed methods*	5-15%
internal fixation	10-30%

*Includes simple casts, weight-bearing casts, and pins and external fixation devices.

quire consideration. On the other hand, there is also some evidence to suggest that rigid internal fixation may actually lower the infection rate by reducing local trauma. It has also been documented, however, that a problem occasionally more significant than an infected non-union is an infected union. As osteoid seams are laid down around bacteria, the bacteria become relatively inaccessible to normal body defense mechanisms and proliferate to involve major portions of long bones. Performing a complete debridement on an infected, healed fracture is almost impossible and more readily performed on the non-united fracture. In addition, some surgeons have documented that healing will occur, and infection be eliminated, from non-union sites with thorough debridement of the area followed by the application of bone grafts.

Delayed and non-union are most often associated with open fractures, infection, soft tissue and bone defects, unacceptable reduction and vascular insufficiency. In regard to treatment, several authors notably Dehne, Witschi and Omer and Sarmiento have shown very low incidences of delayed or non-union treated with plaster and early weight bearing methods of tibial fractures while others have shown higher incidences of delayed or non-union of tibial fractures when open methods were compared to closed methods or significant percentages of delayed or non-union when only internal fixation methods were employed. It is our impression that adequate soft tissue coverage followed by external fixation methods promotes union with less risk than with the use of internal methods.

Summary

In summary, the appropriate treatment of extremity fractures begin with adequate management in the field. Hospital care involves maintenance of the patient's vital signs, then fracture care. Every attempt should be made to attain soft tissue coverage and fracture immobilization by closed methods to best avoid the complications of extremity fractures.

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CENTRAL NERVOUS SYSTEM INJURIES

Joseph Ransohoff, M.D.

The response of the central nervous system to trauma is unique among all body systems with regard to its lack of resilience, limited regenerative capacity and the devastating effects that permanent central nervous system dysfunction may have on the entire organism. Central nervous tissue of semi-solid consistency, is easily deformed by stress and is subject to serious compromise from shearing forces. Brain stem damage leading to coma vigil or high cervical injury leading to permanent quadriplegia and a respirator dependent life are striking examples which serve to highlight the critical role of the central nervous system in the body's economy. To date, whereas isolated fragments, as in tissue culture, show capacities for regeneration, no evidence has been forthcoming to suggest that central nervous system tissue in man has the capacity for regeneration with recovery of useful function following actual disruption of physical continuity. Thus, brain lacerations and spinal cord lacerations produce irreversible deficits. Whereas major laboratory efforts are underway to study the problem of mammilian central nervous system regeneration, the most promising clinical and laboratory efforts are currently directed towards a better understanding of the phenomenon of ischemia and edema of CNS tissue with emphasis directed towards the control of these secondary phenomenona which in and of themselves can lead to irreversible damage and death.

In recent years the most dramatic model of the CNS's capacity to self-destruct has been seen in the experimental model of spinal cord injury. Here, a known force impacting the spinal cord can produce permanent and irreversible paraplegia if untreated, and yet, immediately after the injury little or no pathologic change can be seen. The relentless progression of

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this process is initiated by the appearance of petechial hemorrhages in the central gray matter, progressing over hours to complete the dissolution of the central cord, and spreading edema into the surrounding long white pathways to the point of complete dissolution of the spinal cord within 24 hours. This progressive, self-destructing process evolving over time in an animal who is rendered immediately and permanently paraplegic has led to a great flurry of laboratory investigations in an attempt to arrest the pathological events with the hope of preserving anatomical continuity and physiological function.

There are, however, constraining anatomical differences between spinal cord and brain which tend to protect the latter against the forces of edema if not ischemia and which give rise to the well documented difference in prognosis in a patient with an immediate paraplegia with little likelihood of recovery as against the very real possibility of the patient in coma following head injury having a reasonable chance for significant improvement, if not total recovery. The anatomical configuration of the spinal cord encased by an intimately applied, relatively inelastic pial membrane, contained within which are the closely packed pathways supplied by a longitudinally oriented arterial circulation, a small blood volume, and no significant amount of intramedullary spinal fluid allows this structure little possibility of escaping from the effects of hemorrhage, ischemia and the inevitable edema which represents the response of the CNS to any type of injury. In contradistinction, the brain contains within itself a significant spinal fluid resevoir and an equally significant circulating blood volume, both of which provide for considerable capacity for adjusting to the effects of post-traumatic swelling. Furthermore, there are major areas of cerebral tissue which can be permanently destroyed without producing clinically significant neurological deficits. Irrespective of the gross anatomical variances, there is no question that the pathophysiological processes in both brain and spinal cord which develop as sequelae of trauma are identical as one studies the basic cellular and membrane changes which follow. Central nervous system trauma research must direct itself towards these basic phenomena if further significant advances are to be expected.

Traumatic central nervous system edema is now generally accepted to be of vasogenic origin based on a breakdown of the tight junctions in the CNS capillary bed as well as alterations in glial membrane structure. This perturbation of membrane function results in a disturbance of the sodium potassium pump mechanism and a disruption of the membrane bound enzyme systems which account for the critical preservation of energy metabolism and transport functions without which central nervous tissue becomes rapidly and irreversibly damaged.

The role of the brain stem reticular system appears to be the site of key processes, not only for the maintenance of consciousness in terms of its upstream or cephalad function, but also in the maintenance of adequate functioning of most general organ systems as it relates to the downstream function of this key brain stem area. Recently experimental studies have documented the effect of brain stem lesions on cerebral metabolic rate and cerebral blood flow but have shown as well serious effects upon pulmonary, cardiac and renal systems, mimicking the dysfunction in these areas often seen in man following serious head injury. Our research laboratories have demonstrated not only the cerebral effect of brain stem reticular lesions in animals but also systemic sequelae including pulmonary edema and necrosis, cardiac ischemia and endothelial necrosis and renal tubular dysfunction. These phenomena occur in the absence of increased intracranial pressure.

In an effort to study the effects of trauma on central nervous system membrane function, laboratory efforts have been directed towards the hypothesis that lipid peroxidation by the release of free radicals may account for many of the disturbances in energy metabolism and membrane permeability seen after trauma leading to experimental edema. The limiting membrane of central nervous system cells, the plasma membrane, while differing in quantitative ways amongst different cell types, is a bimolecular leaflet of phospholipid and other amphipathic substances, like cholesterol. The hydrophilic ends of these lipid molecules are directed to the outer surface of the membrane where they are in contact with aqueous milieu. The hydrophobic ends of these amphipathic lipid molecules are directed towards each other in a double layer to form the hydrophobic mid zone of the membrane. The fatty acid tails of phospholipids which form this hydrophobic zone are in the cis configuration, the chain bending at 123 degrees at every double bonded site. This important characteristic of central nervous system membranes accounts for the interstices within this hydrophobic zone. Membrane bound molecules are inserted into these archways, including the membrane bound enzyme and protein molecules responsible for the maintenance of the cell's internal environment and continued function. Free radical processes catalyzed by the presence of heme rapidly destroy the structural continuity of the hydrophobic membrane zone and may well account for membrane dysfunction and subsequent edema in response to trauma. Glucocorticosteroids are known to insert physically into the hydrophobic mid zone of plasma membranes and may well protect against the effect of lipid peroxidation. Indeed, considerable experimental evidence is accumulating to indicate that steroids protect membrane function rather than directly effecting edema *per se* and that once membrane stabilization has occurred, the edema fluid is removed by the normal body processes. Cats, for example, treated with dexamethasone before or shortly after spinal cord injury have significantly better recovery and less histological abnormality in the spinal cord than untreated cats. But the course of post-traumatic edema is similar. Electrophysiological studies measuring spinal cord conductivity show recovery of evoked responses in the cordicosteroid-treated animals independent of the degree of edema. In a similar fashion, dexamethasone drastically diminishes the EEG abnormalities which develop in response to a standard cold lesion applied to the brain. This effect also does not appear to be mediated by the dexamethasone diminution of edema.

An interesting by-product of this research has been the demonstration of the effect of ethanol on the central nervous system's response to trauma. In an effort to develop a model of CNS trauma, in both brain and spinal cord which would minimize the physical effects of energy expended to the CNS tissue, animals were pretreated with intravenous ethanol. The degree of membrane breakdown and subsequent edema was greatly magnified by the exposure to ethanol, a substance which is known to potentiate the breakdown of lipid cell membranes.

A number of therapeutic regimes other than steroids are under intense investigation in various experimental laboratories relative to the protection of central nervous system following trauma. The barbituates have been shown to have protective function in ischemic hypoxia of central nervous system tissue and the role of these agents in trauma is just entering a new phase. Other agents under investigation include the use of DMSO, both as a therapeutic agent itself and as a carrier for other substances and the use of hypothermia, antioxidants, both naturally occurring and artificial, and the role of experimental surgical procedures.

Finally, in both experimental animals and in human subjects following trauma the use of physiological monitoring of central nervous system conductivity is a burgeoning area of research. Both evoked cortical potential for evaluating spinal cord function and evoked potential studies involving input via various cranial nerves may well serve to document the site of physiological dysfunction, if not anatomical lesion sites. Hopefully, these studies will serve as a method of distinguishing the primary effects of injury from the secondary effects of edema, herniation and compression which so often confuse the pathological findings seen after death.

Whereas the experimental problems related to the CNS's response to trauma are similar, if not identical, in spinal cord and brain tissue, the clinical syndromes and therapies required are fairly sharply demarcated by the foramen magnum. The management of spinal cord injury and head injury will, therefore, be briefly reviewed in terms of newer developments as separate clinical issues.

Spinal Cord Injury:

Early identification and proper triage probably represents the most important single factor in the preservation of spinal cord function, not irrevocably destroyed by the initial impact. This issue presents as one of the most difficult problems for those involved in the treatment of the acute spinal cord injury. The devastating effect of continued abnormal motion of the fractured spinal column to the underlying cord may well account for the hopeless aspect of most complete injuries by the time they reach an institution for definitive treatment. Complete immobilization of the fracture site is the sine qua non of good spinal cord therapy as preached in every spinal cord center. Yet, the horse may well be long out of the barn by the time the patient is correctly immobilized. A few states are well advanced in the early recognition and management of spinal cord injuries, including Florida, Arizona and the metropolitan area around Chicago, but these are, indeed, the exceptions and, unfortunately, the financial plight of most urban centers makes it unlikely that this problem will reach an early solution. Once these patients have reached a spinal cord center, a multitude of highly trained specialists are required to care for them, including neurosurgeons, neurologists, orthopedists, as well as specialists in pulmonary, physiology and highly trained nursing staffs. I believe an apparent dichotomy between the orthopedic and rehabilitation professions and the neurosurgeons and neurologists is more apparent than real. There is no one, who to my knowledge is involved in the treatment of these patients who does not fully understand the need for immediate immobilization of the fracture site. There is no one who does not understand the need for immediate attention to all of the body systems including skin, bowel and bladder which come under the purview of the physiatrists. Neurosurgeons and neurologists, however, who are interested in attempting to preserve and, indeed, to restore neural function, are involved in the initial documentation of the status of the spinal cord, including both physiological and radiographic studies. Evoked cortical responses have been demonstrated to establish the conductivity of the posterior columns when clinical examinations suggested a complete lesion. Other electrophysiological studies including the tonic vibratory response and electromyographic feedback are less well established. Myelographic observations with both air and positive contrast media are essential to document the presence of cord swelling. The role of spinal cord angiography is not well established but may have a place in evaluating the total paraplegic with normal myelography. All of these studies are important, however, in the evaluation of therapeutic regimes designed to preserve spinal cord function.

Attempts at therapy for the treatment of spinal cord injury includes chemotherapy with cortical steroids and at times local hypothermia. When surgical intervention is carried out it must be conducted with full awareness of the need of immediate and permanent stabilization, whether with the use of internal or external or a combination of these methods of fixation. Unfortunately, many orthopedists and almost all physiatrists except those working in close conjunction with acute spinal cord centers, tend to lump all surgical efforts as meddlesome laminectomies, which long ago have been proven to be of no help. Better understanding of the aims and goals of this clinical research is essential if an end can be seen to this foolish wasteful argument. There is no question that improvement has been seen following the removal of external compression, either by boney or displaced disc fragments. Indeed, a number of patients have shown improvement following spinal cord incision (myelotomy) when some function was present prior to operative intervention. There is, however, a major problem relative to definition of terms, and this relates to the question of complete paraplegia. One would presume that the definition of complete paraplegia would be quite simple. This is not the case. Patients who appear complete on neurological examination and yet in whom preserved evoked cortical potential has been found, as already mentioned, are often demonstrated to indeed have some minimal preservation of posterior column activity when reexamined in the light of the physiological studies. The presence or absence of reflexes, for example, is often not included in the definition of complete. Certainly, the time course of recovery and the elapsed time without any discernible spinal cord function are the critical aspects of the equation, when one asks the emotionally charged question — have you ever seen a complete paraplegia recover? There is no question, however, that only by continued study and therapeutic trials based on definitive laboratory work will any inroad be made into an improved functional return of spinal cord activity beyond that achieved by stabilization. A recovery of function enhances the effectiveness of the intensive rehabilitation programs which devote so much time and energy in their efforts to return paraplegic patients to a functional state in society.

Head Injury:

If one takes into account the already mentioned inherent capacity of the central nervous system above the foramen magnum to adjust for edema, swelling and areas of tissue death the problem of the treatment of head injuries is not that much farther along the road to solution than is the treatment of spinal cord injury. Great advances have been made in the techniques related to intracranial pressure monitoring. There is no question that these methodologies have permitted a more rational use of the various therapies directed towards the reduction of intracranial pressure, including the osmotic diuretics, the cortical steroids, hyperventilation and total respiratory control, and profound barbituate induced hibernation. The measurement of cerebral blood flow, both generalized and regional, by intravenous, intra-arterial, and more recently, the inhalation techniqies have been important in documenting the role of hypoxia ischemia and should yield a good deal more valuable information in the next few years. As already mentioned, the physiological studies (evoked somatosensory potentials) currently developing in a number of centers can also be expected to yield valuable information concerning the reversibility of central nervous system trauma in response to various therapeutic modalities.

One cannot discuss the new advances in cerebral trauma without mentioning the technique of computerized axial tomography which has revolutionized the treatment of head injury. The presence of hematoma, brain swelling, and ventricular dilatation can be determined in a few moments with noninvasive techniques. The results of early definition of patients requiring surgery will be interesting to observe. Hopefully, the deteriorating neurological signs which currently alert neurologists and neurosurgeons to the presence of an expanding intracranial mass can be avoided in the future, although one cannot be certain that this will have a great impact on the eventual outcome. Certainly, however, the transient phenomenon of uncal herniation with brain stem compression manifested by pupillary dilatation, hemiparesis and a deteriorating state of consciousness cannot be of benefit to the traumatized brain.

Where are we then in the treatment of central nervous system trauma? The application of the advances in bioengineering to medicine have impacted heavily on the clinical care of patients with central nervous system trauma. We are far better able to document the pathological and physiological phenomena which develop in our patients. In the laboratory, we are searching ever more diligently for the molecular basis of the pathophysiological phenomena associated with CNS injury. We are undoubtedly rendering far better patient care as a result of these experimental and clinical studies. We have not yet learned, in my opinion, to reverse what often appears to be a relentlessly irreversible destruction of brain and spinal cord tissue which are the sequels but not the result of the initial injury.

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ILLINOIS EMS AND SPINAL CORD INJURY: THE MIDWEST REGIONAL SPINAL CORD INJURY CARE SYSTEM

Paul R. Meyer, Jr., M.D., F.A.C.S.

Etiology

Traumatic spinal cord injury is a not uncommon entity in the United States. Somewhere between 8,500 and 10,000 new injuries occur annually — 55 percent quadriplegic and 45 percent paraplegic. A review of 332 spinal injury admissions[4,8] between 1972 and 1974 revealed 89 (26.8 percent) the result of automobile accidents; 84 (25.3 percent) the result of gunshot wounds; and 64 (19.3 percent) the result of falls or falling objects. Diving injuries amounted to 31 (9.3 percent); motorcycle accidents 11 (3.3 percent). When reviewing 109 dorsolumbar spine injuries (T_1 through L_5), gunshot wound was the highest cause of injury - 37 (34.0 percent); falls - 26 (23.9 percent); and automobile accidents - 23 (21.1 percent). (Table 1)

Center Development

The development of the federally sponsored (Office of Human Development — Rehabilitation Services Administration - Health Education and Welfare) spinal cord injury system at Northwestern University occurred in 1972. This program ran a parallel development course with the Illinois State Emergency Medical Service Trauma Program. In January of 1973, the Midwest Regional Spinal Cord Injury Care System was designated by Governor Daniel Walker of the State of Illinois and David Boyd, M.D., Director of Illinois EMS, as one of two special trauma centers in the state; one for critically injured children, the other for acute spinal cord injuries. Forty-nine other trauma centers also comprised the state trauma network.[7] These centers were classified into three categories: local, area, and regional centers. Local trauma centers have the services of a full-time physician in the emergency room; area trauma centers have greater capability; and regional trauma centers are university based. Each trauma center has an assigned trauma coordinator whose responsibility is to provide intercenter communication, and to assist the physician in the administrative management of patient's transfer, actual transport, and necessary care while en route between trauma centers.

Transportation

The mode of transportation of the spinal injured patient

TABLE 1: Common Etiological Causes of Spinal Injuries Noted in Combined Admission of System (under 72 hours of injury) and Non-System (above 72 hours of injury) patients, 1972—74.

Etiology	Number	Percentage
Auto	89	26.8
GSW	84	25.3
Fall	64	19.3
Water	31	9.3
Misc.	18	5.4
Hit	16	4.8
Sports	13	3.9
Motorcycle	11	3.3
Pedestrian	6	1.8
	332	100.0%

has been decided in the following manner: Between 0 – 45 miles ground transportation is utilized, except during peak traffic periods. During such times, helicopter retrieval of patients may be indicated. Likewise, a patient who has sustained multiple trauma along with a spinal injury is a candidate for rapid air transport. Helicopters are principally used when patients are retrieved from distances up to 75 miles and fixed wing aircraft are utilized for the transport of patients from distances further than 75 miles.[6,7] (Figure 1)

Spinal Injury Center Growth

The midwest Regional Spinal Cord Injury Care System at Northwestern University has grown significantly over the years. (Figure 2) In 1972, 16 patients were admitted to the spinal injury service within 72 hours of their trauma; in 1973, 29 patients were admitted under 72 hours; in 1974, 26 patients under 72 hours; and, in 1975, 82 patients were admitted under 72 hours. Of these patients, 90 percent arrived within 24 hours; 80 percent within 10 hours; 60 percent within 6 hours; and 48 percent within 5 hours of their injury. All totaled, the Midwest Regional Spinal Cord Injury Care System in the year of 1975 cared for and evaluated the following patients:

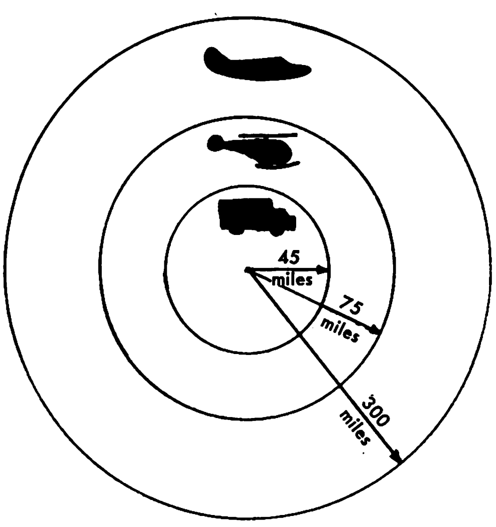

FIGURE 1: Mode of Transportation of the Spinal Cord Injured Victim:

0 – 45 miles = Ambulance
45 – 75 miles = Helicopter
Greater than 75 miles = Fixed Wing

Multitrauma patients may require air transport, irrespective of distance

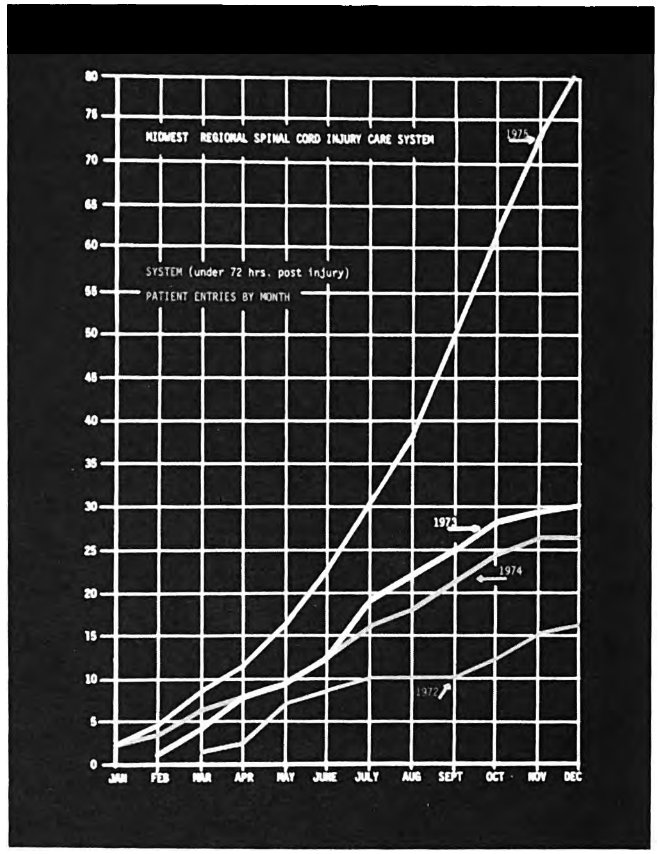

FIGURE 2: Growth of the Midwest Regional Spinal Cord Injury Care System Between 1972 and 1975. Note significant increase in rate of admission (145%) between 1974 – 1975.

84 acutely injured patients under 72 hours; 56 acute injuries arriving after 72 hours; 107 old patients requiring admission; and 160 outpatients for evaluation. This is a total of 407 spinal injury patients evaluated in the Midwest Regional Spinal Cord Injury Care System (MRSCICS) in 1975.

Catchment Area

The spinal injury system at Northwestern (MRSCICS) covers a catchment area extending out from ground zero Chicago, 200 miles in all directions. This takes in portions of the state of Wisconsin, Iowa, Indiana, Ohio, Michigan, and all of the state of Illinois.[7]

Federally Sponsored Spinal Cord Injury Systems

There are presently eleven (11) federally sponsored spinal cord injury programs in the United States. These are: The University of Washington, Seattle, Washington; Stanford University, Santa Clara Valley, Santa Clara, California; Craig Rehabilitation Hospital, Denver, Colorado; Barrow Neurologic Institute and Good Samaritan Hospital, Phoenix, Arizona; Texas Institute of Rehabilitation and Research, Houston, Texas; University of Alabama Hospital, Birmingham, Alabama; University of Virginia, Woodrow Wilson Rehabilitation Center, Charlottesville, Virginia; New York University–Institute of Rehabilitation Medicine, New York; University of Minnesota Hospital, Minneapolis, Minnesota; Tufts University, Boston, Massachusetts; and Northwestern University, Wesley Pavilion of Northwestern Memorial Hospital – Rehabilitation Institute of Chicago, Chicago, Illinois. (Figure 3)

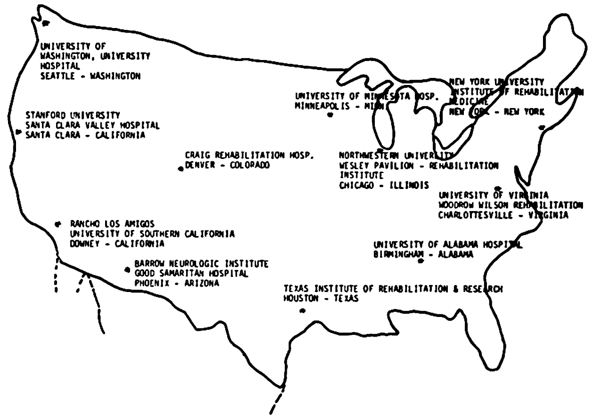

FIGURE 3: Federally Sponsored Spinal Cord Injury Centers.

Spinal Cord Injury Statistics

The closest estimate of the number of spinal cord injuries occurring annually in the United States is between 35 and 38[4] per million population. With a U.S. population of 215 million, approximately 8,200 to 10,000 new spinal injuries occur annually. This would be an average of 164 to 200 spinal cord injuries occurring per state, per year. Based upon these statistics, therefore, it could be anticipated that in metropolitan New York 276 spinal injuries would occur annually; Los Angeles - 98; Baltimore - 31; Houston - 42; New Orleans - 17; Miami - 10; Chicago - 119, and within the catchment radius surrounding Chicago, 700 new spinal injuries annually.

Improved Management

One of the most striking improvements in the management of spinal cord injury has come at the roadside. This is principally due to the Illinois EMS System[7] and the advent of the trained Emergency Medical Technician/Ambulance driver and paramedic. Their training in the management of the acutely traumatized patient, including the spinal cord injured, has brought to the scene of the accident improved and correct extrication techniques while eliminating fear of further trauma during patient retrieval. This applies to trauma involving both the spinal column and the head.

During the last three years, the number of complete (irreversible) spinal cord injuries seen in the Midwest Regional Spinal Cord Injury Care System has reduced from 70 percent complete neurologic loss below a fixed level and 30 percent incomplete loss of function — to 50 percent complete and 50 percent incomplete. The most likely reason for this significant improvement noted in the entire acute spinal cord population is: early referral, improved retrieval, resuscitation and transportation. It is possible that the early administration of drugs has also contributed. Steroids and Mannitol, administered with the hope of reducing post-traumatic spinal cord edema, and Dextran, a plasma expander, used to maintain blood pressure and improved spinal cord capillary blood flow may have had some influence in bringing about this noted improvement.

The development of a temporary cervical immobilizing orthosis at Northwestern University, with support from the Illinois EMS System may also have influenced the above figures. This device, used across the state, allows the cervical spine injured patient to be transferred and transported from accident scene to ambulance, and from stretcher to Stryker frame or x-ray table without the worry of a change in head, neck, thorax relationship occurring. Credit must also be given to the excellence of care provided all spinal cord injured patients transferred to the city of Chicago by the State helicopter pilots under the leadership of Duane Moore, Chief Helicopter Pilot, Division of Aeronautics, Department of Public Health, State of Illinois, and the members of the Chicago Fire Department. These members of the total trauma system effort have voluntarily taken part in EMT/A and paramedics certification, and have received uninterrupted support from the State legislature and from the Mayor, Honorable Richard J. Daley, and the Fire Commissioner, Robert Quinn of the City of Chicago. Credit is also extended to Murray Brown, M.D., Commissioner of Public Health, Chicago, Paul Mesnick, M.D., Director, EMS — Chicago, and James O'Heir, State Trauma Coordinator, Northwestern Memorial Hospital, Chicago, and Eileen Meyer, R.N., Nursing Supervisor and the entire nursing staff of the Acute Spinal Cord Injury Unit of Northwestern Memorial Hospital without whom this activity could not function. Four nurses on this Unit are EMT/A certificated.

Emergency Room Evaluation

A major contributor to the improved care of the spinal cord injured patient in Illinois is the state trauma coordinator assigned to each center. His job description includes the procurement of appropriate transportation and the making of arrangements for patient transfer. He also provides the receiving hospital emergency room with the patient's estimated time of arrival. This allows for notification and reception by appropriate spinal cord oriented medical and nursing personnel, along with the procurement of specialized fracture and spinal cord equipment as may be required for this patient, i.e., Gardner Wells skull tongs; Stryker frame; weights; Thomas splint, skeletal traction apparatus; or vital sign monitors. (Figure 4) Patients most frequently arrive on "scoop" type stretchers or backboards. Those with cervical spine injuries have their head either taped and/or sandbaged to the frame on which they have been transported. Either of these is adequate as long as the airway is maintained and the patient, during transport, is monitored by an appropriately trained nurse, respiratory therapist, or paramedic. Following patient admission, a careful neurological evaluation is repeated by both the orthopaedic and neurosurgical staff. Once the evaluation is completed, the patient is then placed in appropriate skeletal traction. A rule of thumb is 5 lbs. per level of injury (C_6 = 6x5 = 30 lbs.). A respiratory consult in the emergency room is requested for all cervical spine injuries. Where the presence of fractures of the spine are difficult to ascertain on routine radiographic evaluation, tomographic x-ray studies

FIGURE 4: Standard Spinal Cord Injury Emergency Room Equipment Available in Northwestern Memorial Hospital Acute Center: ***Stryker Wedge Frame; Gardner Wells tongs (foot of frame); "Crash Cart" for ancillary equipment; vital sign monitors.***

are obtained. This must be highly coordinated with radiology and the radiologist. Other equipment which may be required, and should be immediately accessible are respirators and cardiac and respiratory rate monitors. It is recommended that all spinal injured patients having fractures at or above the level of C_6 be carefully monitored with sequential blood gases beginning on admission and repeated during the first three days. These are the same patients who will require cardiac and respiratory monitoring. It has been our experience that patients sustaining injuries of the cervical spine in the areas of C_4 may, as a result of intermedullary spinal cord hemorrhage and edema, have an ascending lesion, which secondarily may produce involvement of the phrenic nerve and result in apnea or significant involvement in the rate and efficiency of spontaneous respiration. Because such is a possibility, patients should be monitored very carefully during the first 72 hours following injury.

Frequently Seen Complications

A review of complications most commonly noted in a group of 109 dorsal-lumbar spine injured patients, 21 percent sustained concomitant fractures of either long bones or ribs; 31 percent had problems related to cardiopulmonary or vascular system; 100 percent had at some time during their hospital course, urinary sepsis; 7 percent gastrointestinal involvement; 20 percent skin involvement; and 21 percent miscellaneous complications. Similar complications exist in the neck injured patient with neurologic involvement, with the noted exception of significantly fewer long bone fractures and a much greater incidence of respiratory complication (greater than 80 percent). Overall mortality of all spinal injured patients over a four-year period within MRSCICS is 7 percent. During this period of time, mortality has been reduced from 4 percent in the patient's first year post-injury to 2 percent in the third year following injury.

Myelogram or Surgical Indications

With the experience of having managed over 480 acute spinal injured patients in a four year period, the following philosophy concerning the indications for myelography or surgery have evolved. In those patients found to have on admission a complete neurologic injury below a fixed level, neither myelography nor emergency surgery are thought indicated. The same is true when the neurological evaluation reveals an incomplete neurologic lesion below a fixed level with evidence of improving neurologic function. Where an incomplete lesion, on the other hand, is noted to be deteriorating, even though minimally, there does exist the possible indication for myelography. Depending on the findings, there may be surgical indications. This is not the case in those instances where there is rapid deterioration of neurologic function in either the cervical or thoracic region. When this occurs, it is most likely the result of infarction or loss of blood supply to the spinal cord. In these instances, the neurologic changes will often be irreversible. Similarly, in thoracic spinal injuries where a complete neurological paraplegia exists, without either fracture or displacement of vertebral processes on roentgenograms, and a negative myelography, the etiology of the paralysis is loss of spinal cord vascularity. Surgery, therefore, is not indicated.

When a neurologic examination on admission reveals the spinal cord lesion to be incomplete, and an initial improvement in the neurologic level rapidly plateaus, a myelogram may be indicated. In some cases, surgery may follow. In the case of gunshot wounds of the spine, only those resulting in injury to the esophagus and trachea, or produced by high velocity missiles, require debridement. Injuries to other vital organs or systems take precedence over spinal debridement at all times. It has been our experience that over 85 percent of the low velocity gunshot wounds admitted to the Spinal Cord Injury Unit have been managed solely with antibiotics and debridement of the wound of entrance. No infections have followed. The remainder of the cases required debridement because of: surgeon's choice; the wound was produced by a high velocity missile; or involved vital organs. Gunshot wounds involving the trachea and the esophagus must be debrided and these structures repaired to reduce the chances of leakage into the mediastinum, resulting in mediastinitis. Seldom is there an indication for the removal of the projectile from the neurocanal. Removal is indicated when the projectile is noted to be free and either ascending or descending within the canal. The consequence of leaving the projectile is the formation of a foreign body granuloma or arachnoiditis. No evidence exists in the world literature to support debridement of gunshot wounds in the hope of obtaining neurologic improvement.[2]

Attention and awareness must be placed on skin care and potential skin problems in the neurologically insensitive patient. Because vascular complications may follow surgical wound edema or hematoma, postoperative dressings must be carefully monitored to prevent vascular occlusion without the perception of pain on the part of the paralyzed patient. The traumatic elimination of this warning signal may allow the development of catastrophic problems. Therefore, all lower extremity postoperative dressings, except for the skin-dressing interface, should be removed on the first postoperative day, and elastic above-the-knee stockings applied. Such stockings are utilized to reduce the incidence of thrombophlebitis (3 percent) and pulmonary embolism (5 percent) noted in 109 dorsolumbar spine injuries. Likewise, we advise the daily removal of such stockings for both skin care and leg examination. Spenco® sponge rubber foot cushions are recommended for prevention of heel pressure areas and ankle equinus deformities. The Stryker® wedge frame is used for all patients in cervical skeletal traction, and all unstable preoperative dorsal-lumbar spine injuries. Although some spinal injury services utilize other means of immobilization, the Stryker® wedge frame, we believe, allows the best means of providing good nursing care to the severely injured spinal patient. Once the cervical, dorsal or lumbar spine is considered stable (either surgically or non-surgically), the patient may be transferred to a standard bed, and out-of-bed activities of daily living begun. Simultaneously, the patient may be transferred to an active rehabilitation facility for aggressive rehabilitation.[5,6]

Other Benefits of Spinal Centers

Occasions arise where spinal injury patients will sustain lesions of the cervical spine cord (C_1, C_2 and possibly C_3) interrupting spontaneous respiration and necessitating the use of a respirator. Where that portion of the spinal cord providing cell bodies and axons to the phrenic nerve (C_3, C_4, C_5) remain intact (upper motor neuron injury), these patients may become candidates for phrenic nerve electrode stimulation of respiration known as "electrophrenic respiration." This technique was pioneered by William Glenn, M.D., Department of Cardio-Thoracic Surgery, Yale University[7]. The procedure is not indicated for spinal cord lesions at the C_4 or C_5 neurologic level, and is not necessary (due to normal spontaneous respiration) below this level.

The use of direct spinal cord hypothermia following acute cord trauma at this time remains primarily a laboratory tool, although in certain instances it has been used clinically[1]. In animal experiments it has been demonstrated that using a normal saline solution at or near 0 and 3 degrees centigrade to bathe the spinal cord will reduce the severity of intramedullary hemorrhage and outward migration of blood and blood products from the central gray matter of the cord to the spinal cord white matter and pia mater. This phenomenon usually results within four to six hours post-injury. Once it has occurred, the pathological destructive changes are irreversible. In order for the hypothermia procedure to be clinically effective, therefore, the patient must be retrieved, evaluated and operated upon within a four hour time period. Seldom is this possible, not even in the above-average clinical setting where a highly efficient trauma and spinal injury system exists as in Illinois, in Chicago and at Northwestern University. Therefore, hypothermia as a clinical procedure is not indicated at this time.

The only other major catastrophic injury other than spinal cord injury requiring as many individuals (20) in the care process of each individual patient is the burn patient. It is therefore logical that these two traumatic catastrophic injuries are appropriately suited for system health delivery. The average quadriplegic patient's first initial total hospital stay will be 150 days, costing on the average of $35,000. The administration of an acute spinal cord injury program must therefore be highly disciplined, with a cadre of nurses trained in the use of all combinations of monitoring and life-support equipment. To insure the performance of this task, the recommended nurse — patient ratio on an acute spinal injury unit should be 1 : 2.

Indicators of Success

From statistics gathered on 19 cervical spine injuries, 11 of whom were operated and 8 conservatively managed, 91 percent of the former and 88 percent of the latter patients (average of 89 percent) improved neurologically between admission and discharge. All patients received steroids and 50 percent received Mannitol. Those patients not operated received only drugs and orthotic management; those who were operated received drug therapy, surgical procedures and orthoses. The most significant feature is the improvement in both groups. The common denominators are early retrieval and early drug therapy administration. Between June 1972 and December 1975, an 84 percent increase in spinal injury catchment area admissions occurred. The admission rate in 1975 was 145 percent above that of 1974. This increase demonstrates improved catchment area physician utilization of the Illinois Trauma and Spinal Injury Systems. Eighty (80) percent of the patients admitted in 1975 arrived under 10 hours of injury. Combining all system (under 72 hours) and non-system (over 72 hours) patients, a decrease in neurologic injury completeness was noted. This is interpreted as revealing an improved neurologic status in patients arriving in the Spinal Injury Center in 1975 over 1972. Also noted is a decrease in the first year mortality rate (4 percent to 2 percent) in the third year post-injury.

The overall results of the combined Illinois Trauma – Spinal Cord Injury Systems are: more patients arriving in the Spinal Injury Center; less neurologic loss; and an improved survival rate. An increase in the number of patients returning to gainful vocational/educational endeavors, at less cost, has also been noted. It is estimated that through the MRSCICS Systems approach to spinal cord injury care, between 1972 and 1975, the cost of hospital care has been reduced an average of $5,500. This amounts to $2.9 million dollars saved in health care funds locally in 1975. Projecting this nationally, this would bring about an annual saving of approximately $28 million dollars.[6]

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SECTION V

Workshops on Special Problems in Trauma Management

AN EMERGENCY MEDICAL SERVICES DIVISION WITHIN THE FIRE DEPARTMENT

Robert J. Wilder, M.D.

Many of the ambulance services in the United States are a part of fire departments. Because of the small number of persons in the ambulance units, compared to the large number of individuals involved in the fire suppression units, the ambulance group has frequently been given second consideration. With the rapid improvement in emergency medical care it has become apparent that the ambulance units are equally as important as the fire suppression units. A new organization within the fire department is needed to provide proper consideration for both fire suppression and ambulance units. In the Baltimore County Fire Department such a new organization is being developed.

The Baltimore County Fire Department is divided into three divisions; a Fire Suppression Division, an Emergency Medical Services Division, and a Training Division (Figure 1). The organization table in Figure 1 indicates that the Training Division is staffed from both the Fire Suppression side as well as from the Emergency Medical Group. Using this technique officers and men are available to move from the Training Division into the working divisions when additional personnel are needed. This also allows officers to be constantly involved in their work and not be waiting for emergency situations or disasters.

The Emergency Medical Services Division is responsible for all emergency medical problems and, of course, will run the ambulance service. This Division is staffed by an administrative Deputy Chief, a Batallion Chief, and a series of Captains and Lieutenants. Each ambulance unit will be staffed with two paramedics (Figure 2). Officers for the Emergency Medical Services Division will rotate between the Medical Division and the Training Division. The Lieutenants of the Emergency Medical Services Division will be primarily responsible for difficult rescues and resuscitations, multi-alarm fires, multiple casualty situations, and disasters (Figure 3). Thus, as indicated in Figure 4, an ambulance with two paramedics will respond to all calls and will triage at the scene. If necessary, a Lieutenant of the Emergency Medical Services will respond and if additional help is needed, the Captain and Battalion Chief are available.

This organization allows for additional help with difficult problems and provides a Field Commander for triage during difficult rescues and resuscitations, multi-alarm fires, multiple casualties, and disasters. While the Fire Suppression Commander is responsible for rescue and fire problems, the Emergency Medical Officer will be able to handle the medical problems. In addition, the Emergency Medical Services Division Officers will have ample opportunity to teach, maintain standards, and continue their own education in triage and disaster problems. It is even possible that Civil Defense Units which are still being maintained in many communities could be handled through the Emergency Medical Services Division of the Fire Department and thereby save the funds required for a separate organization.

The Emergency Medical Services Division should be a unit in all fire departments equal to Fire Suppression Units and should be responsible for all emergency medical services, triage in the field, and transportation. Fire and Medical Units have and do work well together.

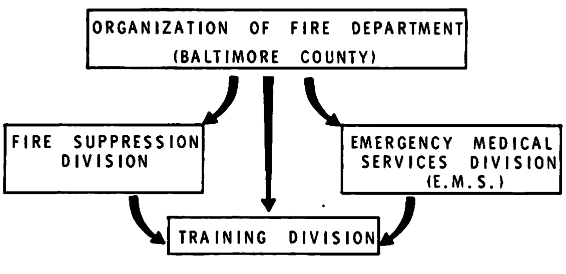

FIGURE 1

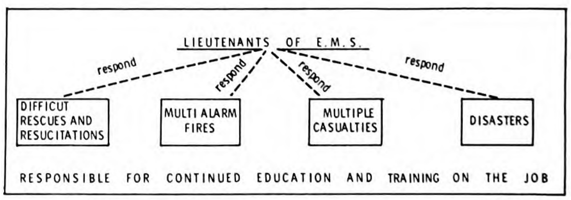

FIGURE 3

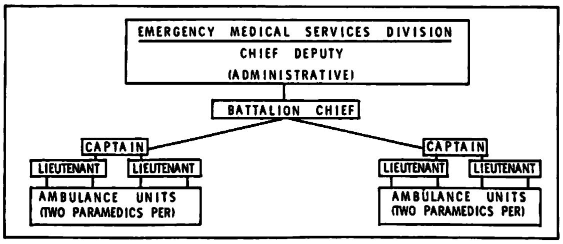

FIGURE 2

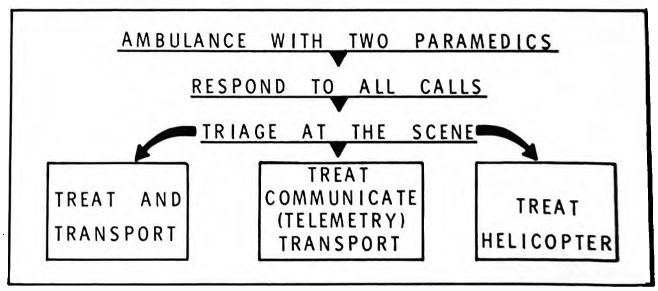

FIGURE 4

THE HOST RESPONSE IN SEPSIS

Clifford M. Herman, M.D., CAPT, MC, USN

I. Introduction

It has long been known that a combination of factors, rather than one factor alone, is responsible for the development of sepsis following trauma. These factors are generally considered to be the micro-organism, the local tissue environment, and the general defense ability of the host. Efforts to improve the prevention and treatment of sepsis have naturally been directed at all of these, with varying degrees of success.

The micro-organisms themselves have been the subject of intensive development of antibiotics. While considerable success has been achieved, they have not proven to be the definitive answer to the problem of the surgical patient with deep sepsis and septicemia. Imprecise and slow culture techniques, inherent inaccuracies of *in vitro* sensitivity testing, development of resistance, inappropriate usage, and undoubtedly other factors are at the bottom of this dissatisfaction. Whatever the causes, the result is as expressed by Dr. William A. Altemeier when he said "antibiotic therapy has not decreased the overall incidence of infections in post-trauma patients . . . while we have been successful in preventing or controlling some types of bacterial infections, others have taken their place."

Surgeons have paid great attention to creating a local environment in wounded tissues which would minimize the chances of infection and premote clean healing. Efforts to remove all dead tissue and foreign bodies, to avoid implanting bacteria, to carryout delayed closure of contaminated incisions, to ensure control of bleeding — all of these have been partially successful.

Despite sustained intensive activity in these directions, sepsis continues to be the principal cause of death in those who survive the initially successful treatment of their trauma. Furthermore, most of those who die of pulmonary failure following non-thoracic trauma are septic before their respiratory difficulties develop. The best chance for successful treatment of a septic trauma patient is still drainage of an abscess or excision of infected nonviable tissue. If no such surgical approach is possible, the outlook for the patient is poor.

Faced with these facts, attention has increasingly turned to the third factor — the injured person's ability to defend himself against systemic infection. When one considers two previously healthy young persons with similar injuries and treatment, one of whom recovers with no infection while the other dies with overwhelming septicemia, several questions must be raised. Are there some preexisting inherent differences between these two people? What are these differences? How might persons with inadequate defenses against infection be identified before or at the time of injury? Most importantly, how can their defenses be straightened to levels that ensure survival?

These questions were strikingly apparent to surgeons caring for combat casualties in Vietnam. Studies there showed that virtually all wounds were contaminated with gram-negative organisms by the fifth day after wounding, and that the organisms were predominantly Pseudomonas aeruginosa and Proteus. The antibiotics in routine use at that time not only were ineffective against these organisms but possibly enhanced their growth by suppressing gram-positive bacterial proliferation. With these conditions for serious gram-negative infection, it was a puzzle why most patients recovered without signs of systemic sepsis while others who were otherwise indistinguishable could not keep the process localized and were consumed by generalized septicemia.

Recent efforts to improve an injured patient's ability to avoid systemic spread of infection from injured tissues have taken several directions. Some of these are described in detail elsewhere in this publication and will only be mentioned briefly here.

II. Immunologic Therapy of Post-Traumatic Sepsis

A. Supplementation of Host Defenses. One general approach has been to augment the septic patient's defenses by treatment with components of the defense systems. This has consisted of administering such agents as donor granulocytes for their bactericidal function, serum fractions which enhance opsonization of bacteria, and various vaccines and antitoxins. These are intended to passively reinforce the patient's own antibacterial mechanisms. The results of this approach are not yet clear, with some hopeful suggestions of benefit in the reports up to this time.

B. Manipulation of Defensive Responses. Use of the term "immunologic" in this context requires some explanation. "Immunologic" or "immune" usually indicates a highly specific response to an agent which is characterized by very unique and foreign features, such as an organ allograft. Such a response usually involves circulating antibody and/or a special population of lymphocytes which are programmed to recognize and react to the particular foreign agent.

However, these responses often also include the participation of other circulating vasoactive materials and cells. These materials are listed in Figure 1. While they play an active, and perhaps essential, role in immune responses, their recruit-

1. Histamine; serotonin	7. Hageman factor (activated)
2. Slow reacting substance of anaphylaxis (SRS-A)	8. Lysosomal enzymes (from PMN's, macrophages, mast cells)
3. Kinins	9. Lymphokines
4. Prostaglandins	10. cAMP; cGMP
5. Plasmin	
6. Complement	

FIGURE 1: Mediators of Inflammation. Activation of these materials is responsible for many of the direct hemodynamic and indirect tissue features of systemic sepsis.

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ment does not depend on precise recognition of the antigenic nature of the stimulus.

These materials are part of a more diffuse system for response to more general types of stress or injury. They are involved in a great variety of reactions which can be loosely grouped together as inflammation. By the roles which these materials play, they can properly be considered as mediators of inflammation. They are the means by which the events of inflammation are produced.

Their activity in localized sepsis has long been recognized. In the classical descriptions of inflammation, the vascular bed becomes dilated by histamine, serotonin, and bradykinin. The resultant hyperemia delivers leukocytes enhanced by chemotactic factors derived from complement, lysosomal enzymes, and perhaps prostaglandins. With the increase in capillary permeability mediated by these same agents, there is extravasation of leukocytes and macrophages. The inflammatory process is amplified by elements of the clotting system (mainly Hageman Factor) and the fibrinolytic system (plasmin), along with leukocyte lysosomal enzymes and activated components of the complement and kinin systems.

The interaction of these materials at the site of injury, shown schematically in Figure 2, appears to be essential to

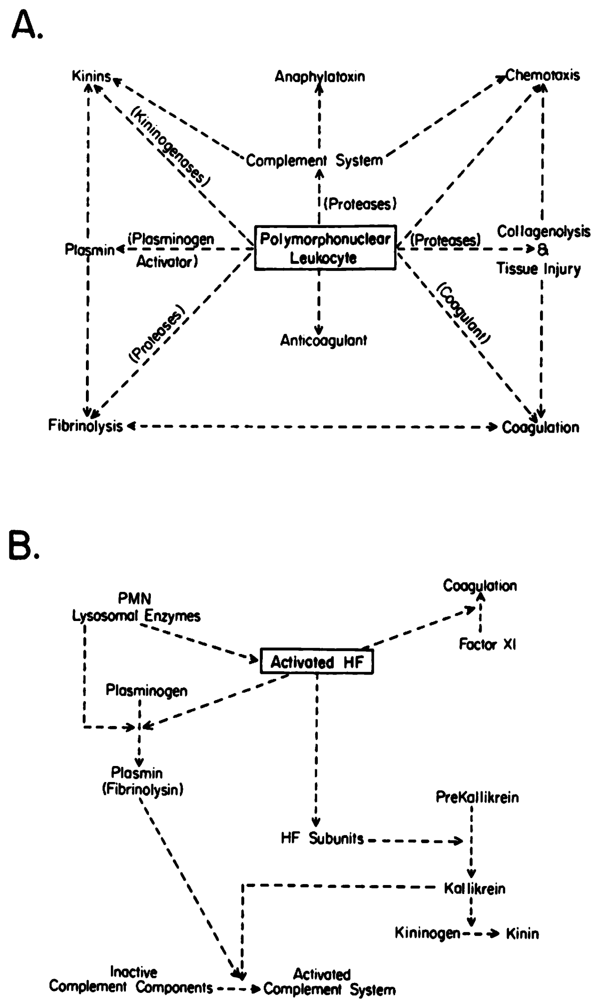

FIGURE 2: Interrelationships of the Principal Humoral Mediators of Inflammation from two perspectives:
A. Polymorphonuclear Leukocyte (PMN) at center.
B. Hageman Factor (HF) at Center. The pathways of interaction are the same in both cases.

the sequestration and local resolution of the tissue insult. In this sense the process seems quite clearly to be defensive.

In cases where the infection is not well localized, the picture of generalized inflammatory response is seen. The patient with systemic gram-negative sepsis shows overall activation of these mediator systems, with elevated blood levels of bradykinin, lysosomal enzymes, and prostaglandins. The effects of activated Hageman Factor are seen in the development of disseminated intravascular coagulation (DIC), with consumption of coagulation factors and simultaneous breakdown of fibrin. Complement is also activated and consumed, with a decrease in serum concentration of the hemolytic components.

The hemodynamic results are predictable. The patient's circulation behaves as if there is widespread vasodilation, with lowered peripheral vascular resistance, a need for large intravascular fluid volume support, and generalized capillary leaking. The DIC results in damage to multiple organs from obstruction of the microcirculation.

Such a situation suggests a dual nature for these mediators. On the one hand, their participation in a localized tissue infection or injury is clearly beneficial. On the other hand, their generalized excessive activation throughout the circulation can be devastating to the patient. In the same manner as the neuroendocrine response to stress, a certain level of activation is helpful but intense activation which is widespread and become prolonged can ultimately produce more harm than good for the patient.

Based on this view, a new concept of potential treatment for sepsis is beginning to emerge. This new experimental approach is attempting to determine which inflammatory agents are responsible for mediating which features of systemic sepsis. The responsible agents are then eliminated and the effect on the hemodynamic response to a standard animal model for septic shock are evaluated.

Because of the complex interactions of these mediators, with multiple reinforcing feedback pathways and several of them having the same actions, it is unlikely that any definitive beneficial effect will be produced by elimination of any single one of these materials. However, it should be possible to find some key combination of mediators, the therapeutic obliteration of which would eliminate or reduce the destructive hemodynamic events of systemic sepsis to a level which the body can overcome and survive.

This line of work is still highly experimental, but some early laboratory results are encouraging. For example, we have found that elimination of hemolytic complement activity by pretreatment with cobra venom factor will protect rheusus monkeys against the systemic and pulmonary vascular effects of endotoxin derived from certain strains of gram-negative bacteria. A next step will be to eliminate components of the clotting system, thus preventing DIC and blunting the reinforcement of kinin and plasmin activity.

These mediator systems are exceedingly complex, and this approach requires continual development of new biochemical and immunochemical techniques for its pursuit. While the final solutions remain elusive, the magnitude of the clinical problem of post-traumatic sepsis demands the difficult effort.

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THE ECOLOGY AND PREVENTION OF INFECTION IN THE TRAUMA PATIENT

Ellis S. Caplan, M.D.

In the past years we have become more aware of the enormous problem of hospital-acquired or nosocomial infections. The nosocomial infection rate depends to a very large degree on the extent of surveillance that takes place. The surgical service usually has the highest rate of nosocomial infections and on the trauma service, when present, rates as high as 50 percent have been reported. Nosocomial infection is a major cause of both morbidity and mortality in the traumatized patient. The organisms responsible for nosocomial infections have undergone remarkable change. In the pre-antibiotic era B streptococcus was the most common organism isolated. This was replaced by the large staphylococcus epidemic of the fifties. For reasons that are unclear staphylococcus has lost its role as the leading cause of nosocomial infection and has given way to the gram negative rods of relatively low virulence and possessing multiple antibiotic resistance patterns. Where do these organisms come from?

The equation shown in Table 1 gives a simplistic relationship between infection, the organism, and the patient. The steps toward obtaining the proper number of organisms begin with colonization. Once colonized the organisms can proliferate to obtain the required number to cause an infection. Host factors and/or parasitic factors interplay to promote or depress this proliferation. The body surfaces that regularly become colonized are the skin, the GI tract, the respiratory tract, and the GU tract. Host factors responsible for colonization of the skin include prolonged hospitalization, burns, and surgical wounds. Host factors that contribute to respiratory tract colonization include coma, hypotension, acidosis, azotemia, leukopenia, leukocytosis, respiratory tract disease, and endotracheal intubation. Host factors that lead to GI tract colonization include urinary tract catheterization, inhalation therapy, general anesthesia, and nasogastric suction. As far as the GU tract is concerned, by far the most important factor is the installation of an indwelling urinary catheter.

Unfortunately, the patient cannot be put into a vacuum, and many external factors play a part as the source of infection. These include the hands of the hospital personnel attending him, hospital food, the medications the patients are given, the hospital disinfectants including chlorhexadine, hexachlorophine and benzalkonium chloride. Other preventable causes of gram-negative sepsis in the hospitalized patient are shown in Table 2. In addition, many items that are commonplace in the hospital also have been cited as sources of gram-negative infections in the severely ill patient. These include aerators that are attached to the faucet. Faucet aerators have been reported to harbor many gram-negative organisms and are a good source of contamination of the environment as well as the patient. They should all be removed.

Hand lotions and skin conditioners frequently used in the hospital setting are another source that have been implicated to be contaminated with gram-negative rods. While they are sterile when leaving the factory; they quickly become contaminated during in-hospital use. Their use should be restricted to small unit doses suitable for one application and then discarded. The use of a reservoir container cannot be condoned as these are frequently found to support a variety of different organisms and again have been implicated as the source of nosocomial outbreaks. Even the ubiquitous adhesive tape has been identified as a source of nosocomial infection.

By far, the most frequently cited source of nosocomial infection is the indwelling urinary catheter, and this old "snake in the grass" is responsible for over 40 percent of the reported nosocomial infections. Catheters are implicated twice as often as any other source as the cause of gram-negative bacteremia. The risk of infection rises directly with the length of time the catheter is left in, and with any breaks in technique of insertion or care, which have been reported to occur at least in one of every three patients catheterized. Because of this, we must constantly be aware of the infection prevention techniques to be used to decrease the indwelling catheter as a source of sepsis in the traumatized patient. These techniques include avoiding their use unless absolutely necessary and evaluating each day whether or not it is justified to keep the indwelling catheter in. They cannot be left in for convenience. They must be inserted with strict aseptic technique. The meatal catheter junction should be cleansed daily with antiseptic and an antibiotic or bacteriostatic ointment applied. The system must be permanently closed and never opened. Irrigation, if indicated, should be done with a triple lumen catheter only. Aspiration of urine samples to obtain culture should be done with aseptic technique using a 25 gauge needle through the lumen of the catheter. The collecting bag must be maintained below the bladder at all times to prevent retrograde flow. If possible, catheterized patients should be separated from non-catheterized patients to reduce cross-contamination.

Another source of infection is the intravenous catheters that are part of almost every hospitalized patient and certainly a part of every traumatized patient. The frequency of infection related to the intravenous catheter rises sharply after it is in

TABLE 1

$$\text{Possibility of Infection} = \frac{\text{Number of organisms} \times \text{Virulence of Organisms} \times K}{\text{Patient's Resistance}}$$

TABLE 2: Preventable Causes of Sepsis in Hospitals

Instrument contamination	
Indwelling urinary catheters	Intravenous catheters and cutdowns
Tracheostomies	Intravenous equipment
Chest tubes	Inadequately sterilized instruments
Respiration nebulizers	Suction apparatus
Anesthesia equipment	Cardiac pacemakers
Internal prosthetic devices	
Fluid contamination	
Blood biologicals	
Irrigating solutions	
Germicidal solutions	
Acquired antibiotics resistance	
Superinfection or selective alteration of the gut, skin, or respiratory tract Flora.	
Poor patient care	
Pressure sores, thrombophlebitis from needles, draining wounds, inadequate dressing care, secondary infection of burns.	

place for 72 hours and this is even more marked if it is put in under less than ideal conditions. Infections are not only secondary to the catheter, but recent outbreaks of nosocomial sepsis have been traced to contamination of infusion products during manufacture. Any part of the infusion apparatus can serve as a source of entry. All invasions into the line must be viewed as a potential contaminating source. Prevention techniques include the use of the catheter only if essential and butterfly needles which sould be used whenever possible. Catheters must be inserted aseptically following iodine skin preparation. If they are inserted during emergency situations, the site should be changed as soon as possible. Antibiotic ointment applied to the insertion site and covered with a sterile dressing may decrease subsequent contamination. The dressing should be changed and cleansed with iodine preparation daily. The catheter and insertion site should be changed every 48 hours.

Another source of the acquisition of infection is the use of mechanical ventilation. These devices circumvent the normal defenses of the respiratory tract and the nebulizers and humidifiers have been implicated by various observers as a major source of infection. Frequently the source of infection is due to contaminated medications that are put into the nebulizers from multiple dose vials. The organisms can then grow and are efficiently deposited in the terminal lung units of the patient. Techniques necessary to decrease infections associated with respiratory assist devices include cleaning of all tubing, exhalation valves and nebulizers of particulate matter before packaging. The devices should be sterilized with gas or steam as liquid disinfectant is not adequate. The breathing circuit should be changed for each patient. The breathing circuit should be changed every 8 to 24 hours if used continuously or intermittently on the same patient. The nebulizer should be filled with only sterile water or sterile medication from unit dose or small multiple-dose vials. The water in the humidifier should be emptied and then refilled. An intensive surveillance program frequently monitoring these devices should be instituted.

Hand washing is the most important method available to control nosocomial infections. This was recognized over a hundred years ago by Semmelweis. The skin harbors two types of organisms, the transient flora and the resident flora. The resident flora multiply on the skin, are very difficult to remove, but usually do not cause infection. The transient flora, however, do not multiply on the skin and usually survive less than 24 hours. These are the organisms that are implicated in nosocomial infections. Because of their transient nature they are easily passed from hands to patient. They also can easily be removed by a 30 second vigorous rubbing of the hands under running water. This is almost as effective as using soap or an antiseptic. Since many of the organisms found on the patient can easily be transferred to another patient, proper handwashing before and after contact with the patient is necessary to break the chain of transmission. This is simple, cheap and effective if carried out properly. However, observations have shown that it is the rare physician or nurse that constantly practices proper handwashing. Recent recommendations from the Center for Disease Control reveal that at least 30 seconds of vigorous handwashing with soap and water before and after caring for each patient is probably sufficient to prevent infection.

In summary, as we have seen, the severely traumatized patient is exposed to a multitude of conditions that allow him to become colonized with both gram-negative and gram-positive hospital flora which may lead to an infection. In order to minimize these infections, we must remember what Lister said "You must be able to see with your mental eye the septic ferments as distinctly as we see flies or other insects with the corporal eye. If you do not see them, you will be constantly liable to relax in your precautions."

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Psychiatry — The Patient, The Family, The Trauma Center Setting

VOIDS IN CONSCIOUSNESS SECONDARY TO SEVERE TRAUMA

Nathan Schnaper, M.D., F.A.P.A., F.A.C.P., R Adams Cowley, M.D., F.A.C.S.

Introduction

The Maryland Institute for Emergency Medicine (formerly the Center for the Study of Trauma) serves some 1,000 patients annually. In its role as systems control center for a statewide Emergency Medical Service it admits immediately and without question patients from hospitals, referring physicians and accident scenes.

About 80 percent of the patients are helicoptered into the Institute directly from the highway crash. These traumatized patients arrive suffering varying degrees of shock and in varying levels of consciousness-unconsciousness.

Immediately upon arrival in the admitting area, the patient's clothes are cut away, catheters and intravenous lines are inserted, intubation performed, laboratory and x-ray studies made — all simultaneously. Peritoneal lavage, rather than inspection and palpation, is utilized to determine the presence or absence of intra-abdominal bleeding. Laparotomy and "definitive-as-possible" surgery is performed as indicated. Concomitant shock management is aggressive, with emphasis on adequate ventilation and volume replacement, rather on dependency on pharmacologic agents.

Once the patient is stabilized, he is transferred from the admitting area operation room on the first floor to a twelve-bed unit on the fourth floor. Here he is carefully and intensively treated by ever-present doctors, nurses and electronic and laboratory monitoring. Intensive therapy, begun in the admitting area, continues. This includes medications, physical aids and surgical techniques.

Psychological Aspects of Unconsciousness

The above is an all too brief summary of the function of the Institute. However, it will serve as background for our observations concerning the psychological aspects of unconsciousness on the part of the traumatized patient. The emphasis here is on unconsciousness rather than transient postoperative psychosis. Much has been written about the latter, particularly in open-heart and thoracic surgery.

Man at all times seeks to maintain an outer equilibrium with his environment and at the same time, an inner homeostasis. He can put on a coat to counteract the cold and simultaneously constrict his peripheral vasculature. These are physical and physiologic defenses. Man copes with his anxieties in his environment and in himself as well, with a system of defenses. Anxiety is an unpleasant feeling of apprehension and is accompanied by familiar somatic responses. In a situation in which one experiences conflict or threat of loss of love, security, or self-esteem, or fears personal injury, anxiety *signals* the defensive process. This process can be healthy or pathologic, constructive or destructive; the defenses used begin in earliest childhood and develop experientially.

Thus, the patient approaches this critically threatening period with his particular self-protective resources. Also available to him, kindly or cruelly, are his own developmental history and his life experiences, particularly his experiences with relatives and friends in similar situations.

While the defenses are generally mobilized by any threat, illness, surgery or narcosis, there are specific problems threatening the traumatized patient:

HELPLESSNESS

In any illness one becomes dependent upon someone else for healing and comfort. The defense of *regression* ensues. The caretakers are viewed as protecting (parental) figures. The more severe the physical injury, the more intense the feelings of separation from family and abandonment. Regression is proportionate to the severity of one's injury and intensifies his magical expectations of his helpers.

HUMILIATION

Injury and hospitalization not only engenders feelings of helplessness, but also desperate feelings of indignity toward hospital procedures; *e.g.*, the bedpan, catheters, blood taking, etc. The severely traumatized patient is exposed necessarily to this threat in the admission area which follows him throughout his hospital course. If he is unconscious, he will awaken later and retrospectively experience his humiliation. If he is semi-conscious in the admission area, he will view his clothes being cut off and the other procedures in a distortion perceived as assault and battery of his body.

BODY IMAGE

One's body image is the picture or concept one has of the physical appearance of one's body, both consciously and unconsciously. However, this can also include one's car and clothes or one's perception of his environment, all contributing to one's sense of identity. One's emotional investment in a particular organ is added to this. For example, the threat a woman feels when a breast is removed. If a violinist loses a finger he is devastated, but not so if he loses a toe. The reverse applies when a track star loses his toe. In the severely traumatized patient the threat of mutilation to his body image is frequently overwhelming.

MENTAL SYMPTONS

The implied threat here is the actual experience of uncon-

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sciousness or the threat of altered states of consciousness. Its basis may be in either a physical or an emotional etiology. Examples of physical causes are open-heart surgery, metastatic carcinoma and massive asphyxia, with resultant cerebral hypoxia. Emotional causes are usually a defensive dissociation to avoid an emotionally painful situation.

Observations

It is this last threat that is the concern of this paper. When a void in consciousness occurs, the experience is retrospectively filled with fantasies. Many patients are amnesic, but some, if given enough time and fed tid-bits of information by relatives, will report "dreams" they had while in the Unit. A predominant, almost universal, theme of the fantasies is being "held prisoner." The justification for being incarcerated is highly individualistic, predicated on the particular patient's development psychologically.

Interwoven, and perhaps interrelated, with the fancied imprisonment is a death-like experience. To the patient this is real. At times there is a conviction that one is dead; at other times there is doubt as to whether one is dead or alive. Some patients experience both the uncertainty and the conviction. Others, feeling the uncertainty, encounter and observe death.

Over a 12 month period 68 patients were interviewed in an informal way. Selection was based on recovery of consciousness and availability. By the latter, it is meant that the patients had regained their orientation and had their tracheostomies closed. Since the stay in the Unit is usually less than three weeks, patient follow-up frequently took place at another ward, another hospital or even the patient's home. Structure for the interview was a simple statement of the Institute's interest in what the experience was like retrospectively. At times it was necessary tc ask directly if there were fantasies or "dreams" and "was there ever any thought or feeling you might have been dead?". Several patients required three to five interviews.

Of the 68 patients interviewed, 43 claimed amnesia at the time of interview. Included in this group were six who expressed their amnesia vehemently and defiantly. Also in this group were two who denied amnesia, but in actuality were amnesic (one of which is alluded to in the discussion which follows). Another group of eight patients pleaded amnesia but subsequently were able to recall the experience. A third group consisted of 17 patients who were able to relate their experience retrospectively. The second and third groups (25 patients), using their individual verbal constructions, shared the "prisoner" theme and death-like experience (Table 1) (Table 2).

TABLE 1: Patient Recall of Experience

GROUP 1 – Claimed Amnesia	43
A. Amnesic	35
B. Expressed amnesia vehemently and defiantly	6
C. Denied amnesia, but amnesic	2
GROUP 2 – Pleaded Amnesia but able to Recall Experience	8
GROUP 3 – Related Experience Retrospectively	17
Total Patients Interviewed	68

TABLE 2: Recalled Themes in 25 Patients

"I was being held"	22
"being held" and "trying to escape"	14
"I am dead"	18
"Dead = just nothing"	15
"Dead = I don't know"	3
"Can't recall the accident, but I knew I was on the Unit" (not a prisoner)	3

Two clinical examples are presented to illustrate these phenomena.

Case 1: Mrs. T. A., a widow in her late forties, was admitted to the Institute by helicopter after driving over an embankment. She suffered facial lacerations, hematoma to her extremities, laceration of the right lobe of the liver, and a flail chest. She was resuscitated, stabilized, and underwent corrective surgery, after which, to facilitate positive pressure ventilation, she was administered curare hourly over a three-day period.

The following is a resume of an interview with Mrs. A. which demonstrates the concerns she experienced, especially about incarceration and death. Mrs. A. was not aware that her paralysis was induced by curare to help her breathe with the respirator. She inferred that there was a crisis when she heard the staff talking about not being able to stop the bleeding. She overheard a nurse remark about her probable death ("I don't know why we have to do this, she is going to die anyhow").

Mrs. A. said that her inability to move, see, or talk led to "frustration" and not knowing whether she was alive. She was reassured when someone said her name and touched her, at what appeared to be long intervals. She tried to urinate to ascertain whether she was alive.

After preparation for her second operation, Mrs. A. underwent her strangest illusion regarding death. She was on a stretcher in a corridor near an elevator and began to see "transparent" images of many people of all ages, in all sorts of garb. Regularly, groups would get on the elevator and leave, "like it was this day's toll of death." She concluded that these people were dying and that because she was not put on the elevator, "her time had not come."

Mrs. A. felt incarcerated and was "always trying to escape" by pulling the needles out of her arms. She denied she did so to gain attention but admitted that she disconnected the ventilator tubing, which set off an alarm in the nurse's station, to get the nurses to come to her. She tried vainly, by moving her lips, to get her daughter to take her away, and was very depressed when the visiting medic from the helicopter did not "save" her.

Mrs. A. thought that she was being sold into white slavery. She said that this caused her to "really panic." "And besides, this is ridiculous, I'm too old."

Mrs. A. thought that the nurses were very cruel to hold her prisoner but, in the last two days, realized that they were there to help her and that it was unnecessary to escape.

Queried, Mrs. A. said that she had not feared death but later admitted that she wanted to see her to-be-born grandchildren, to do many other things, and that she really did not want to die.

Case 2: A brief excerpt is presented on an interview with Mr. J., a man in his thirties. He was admitted to the Institute after sustaining a severe crush injury to his chest, resulting in massive asphyxia and subsequent neurological sequelae. He was caught between the chassis and the hydraulic-operated body of a dump truck while trying to lower the forward end of the body. He was extremely cyanotic. X-rays revealed a widening of the mediastinum. There was quadriparesis and intermittent decerebration. Petechiae covered his entire body. He was treated aggressively by surgical and medical means. He was given curare for three days to facilitate his adaptation to the ventilator. J's career on the Unit was for one month and was stormy. At the end of his stay he had recovered sufficiently to be transferred to another facility for rehabilitation, where he was interviewed. As of this date his only residual is a mild paresis of the right arm, which is improving.

J. said that since he was a truck driver, the mention of the word "accident" produced the fear of hurting someone with his big equipment. All he could see was running the truck into a schoolbus full of children or running over a car full of pregnant women. He denied the reality that his truck was parked during his accidental injury.

J. felt at one time that all the doctors and nurses were against him because he had wronged them. In a "dream" he had urinated in bed and attributed to this that people disliked him. He was not aware that a catheter was in place the entire time he was on the Unit.

In one of J's dreams he had two brothers, Hercules and Colossus, who wore armor and protected him. When he was to be transferred from University Hospital, he heard the word "university," and thought of plans to play football with his brothers, perhaps on some other college team. Questioned, he admitted his difficulty in distinguishing reality from dreams, giving more credence to the fantasies. Questioned further, he admitted that many times he wondered if he were alive or dead.

J. became very upset and sobbed when queried about a dream of a tombstone that his wife mentioned to the interviewer. In his dream it was as if he were looking at a television screen. There he saw his wife, wearing a black veil, and his children standing in a cemetery. He could see the headstone in front of them. On it was engraved his name. Recalling the dream was still painfully tearful to J. even at this later date.

Discussion

These accounts illustrate the need patients have to fill the void of consciousness that so frequently occurs in multiple trauma. It is the rule for patients to withhold their fantasies for fear they will be viewed as "crazy." There were some who acknowledge fantasies or "dreams," but refuse to discuss them and terminated the interview. (One patient, during his convalescence, denied being unconscious at any time. This despite his being penetrated by nine bullets and undergoing surgery).

Those patients who admitted fantasies did so with hesitation, and only after gaining trust in the interviewer. The three themes prevailed: being held prisoner, wrongdoing to justify imprisonment, and death. It is interesting that no patient expressed ideas or feelings pertaining to dying, but rather made reference to the state of death.

Denial, retrospectively, was the predominant defense mechanism utilized to deal with the possibility of being dead. In Case 1, the patient expressed the notion that she was "not afraid of death," still feared that she would not be able to see her children married, see her yet unborn grandchildren, "these are things I'd like to do;" and, "I'm not ready to die". In Case 2, as in Case 1, death is "nothing." J. describes with great emotion his death via seeing his name on the headstone. Denial is effected by not actually experiencing his own death, but rather, observing it. Even as he related the experience to the interviewer, he was uncertain as to whether or not he was still "dreaming" the scene and required reassurance that he was not.

The defense of regression must accompany any illness. As alluded to above, it is a response to the threats of helplessness and separation from protecting (parental) figures. In trauma, this withdrawal to an earlier stage of development is furthered by the feelings of mutilation and "shameful" body image changes. At the same time, once regression has taken place, the bed restriction becomes incarceration. To the now "child" this equates with punishment, *e.g.*, sent to his room, spanked severely, etc. The child, seeking an explanation in his own mind for the punishment, out of guilt, offers acts of "bad" behavior. J. exemplifies this reasoning in attributing his confinement to having killed a busload of school children, a car full of pregnant women and urinating in bed. At the same time he conjures up the armor suited protecting brother figures of Hercules and Colossus. (He has no brothers and his education was limited to the eleventh grade).

Not only does this incarceration have a physical meaning for the "child," but an emotional meaning for the "adult" as well. For it symbolically imprisons the mature adult at the earlier developmental stage to which he has regressed. This magnifies and deepens the helplessness and humiliation referred to above; the patient is not really a child but an adult aware of his childlike position.

Management

Multiple trauma requires immediate and aggressive therapy. One cannot do psychotherapy with a dead person. When time is the essence, one cannot be mindful of the humiliation a patient might feel when his clothes are being cut away. Once the patient is stabilized, there is time to be aware that the patient is a person who is feeling threatened and has mobilized his defenses. This is not to imply that the trauma team neglects a humane concern for the patient.

Some suggestions arise in conversation with patients about their experience. When a patient is unconscious (or seemingly so, as with curare), he needs to be spoken to, called by name, touched and handled as gently as possible. Ominous prognostications and their medical discussions within earshot of the patient should be avoided. All of this is, of course, obvious, but perhaps requires restatement.

As to the patient's "crazy ideas," Mrs. A's response to the interviewer's question concerning the staff's attitude toward them is relevant and succinct: "To the patient these ideas are very real, I am afraid. I think it would be useful if the staff were told that people have these feelings and say strange things. Then they would be able to talk with the patient in a different tone of voice and kind of reassure them, because I kept feeling like they were really not helping me and they were really keeping me prisoner."

The staff reactions are significant. There are many emotional compensations for both the physicians and the nurses. There is realistic responsibility and gratification of omnipotent fantasies. There are also stresses compounded by fatigue. The staff works long hours and dedication is paramount. When lives are saved, the atmosphere is full of good humor. When there are failures, irritation ensues. Staff cooperation is essential, nurse-nurse, doctor-doctor and nurse-doctor. The staff members are acutely aware of this interdependency and to the patient's benefit.

Conclusion

As with all human beings, patients have intrapsychic defenses. In the unconscious traumatized patient these defenses are quiescent. With the return of awareness, the defenses are mobilized to great intensity demanding an explanation for the void in consciousness retrospectively. While this is usually a homeostatic effort, it evokes painful distortions of death and imprisonment in the traumatized patient.

This preliminary report begs for further extensive research into the psychological implications of severe multiple trauma. War brings with it sudden overwhelming numbers of casualties.

The same applies to physical disasters such as earthquakes, airplane crashes, etc. The Trauma Unit, of which the Maryland Institute for Emergency Medicine is a unique example, is the proving ground for the competent management for these emergencies. Significantly, accidents are the leading cause of death in those between ages 1 and 37.

Beyond the physical management of trauma there is the urgent need for psychological investigation. These are some of the questions that need answers to complement the work of the traumatologist: What was going on emotionally within the patient prior to his accident? In a one-car accident, was there an unconscious wish for suicide? In a two-car accident, one car was the victim perhaps because the other may have unconsciously structured the "accident". If so, what recent or remote events in his life predisposed this situation. Does the alcoholic state mask something else going on? Why do some patients respond negatively to therapy, when clinically they should be improving? Are the fantasies of death and imprisonment derived from real or fancied guilt for the accident?

We hope further studies will provide answers to some of these questions. The therapeutic ramifications are limitless.

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FAMILY TREATMENT — A HOLISTIC APPROACH TO THE CARE OF THE MULTIPLE-TRAUMA PATIENT

Margaret M. Epperson, M.S.W.

Today we recognize that emergency centers and acute care hospitals become the caretakers for not only the true medical exigency but for the whole gamut of life crises from alcoholism to psychotic episodes. It is expedient then to provide, within these settings, crisis intervention services which go beyond the primary health goal of alleviating symptoms and curing acute medical problems.

Every patient we treat is a complex personal system that has interrelated physical, biological, intellectual, psychological and social components. None of these elements should be overlooked when health is impaired and one must be treated medically. No longer can hospitals be content to return to families patients who are medically improved but socially functioning cripples.

With multiple trauma patients particularly, because of the emotional effects of their physical trauma, the long-term nature of their illness, their extended recovery period and the high probability of residual physical disability there is a special need to provide professional psychological help. These patients need ongoing services to provide the support necessary in making the psychological adjustment to an altered body-image and for coping with the stress generated in the process of assimilating new roles in family/social functioning.

Historical Problem

Currently many hospitals provide psychiatric consultation and social work services for the multiply injured patient. Through these interventions the patient's psychosocial needs are assessed and some effort is made to meet these needs, at least to a minimal degree. However, to date, few medical centers provide any treatment for the emotionally traumatized family to which this severely injured patient must eventually return.

The problem of family adjustment to a sudden life-threat to one of its members must be dealt with as an integral part of the comprehensive medical care program. The family system has had no preparation for the sudden catastrophy that has befallen it, and at best, it is a fragile social unit with minimum resources and limited adaptive capacities. Special treatment must be afforded these families if they are to maintain an adequate level of functioning and be prepared for the eventual reassimilation of the damaged member back into its system.

Recent literature discussing critical care patients emphasizes the need to give special consideration to families of severely ill patients. Effective treatment for such families needs to be developed.

At Maryland Institute for Emergency Medicine in Baltimore, a study of 230 families of multiple trauma patients was made. The purpose of this study was to examine the process these families undergo during the acute crisis phase, determine the needs of families under sudden, severe stress, and to develop immediate, effective treatment methods of family intervention.

Theoretical Framework

Because many of the families studied were "fragmented" families (*i.e.*, families with one or more members temporarily or permanently absent), and because of the current differing views of the sociological composition of the so-called "modern family grouping," the definition of "family" used in the study is that of the philosopher-theologian, Thomas Aquinas. Aquinas defined family as the community of one's household—the person or persons one is living with.

The families studied had to deal with the reality that one of their members was suddenly in danger of death because of a road traffic accident, violent criminal assault, industrial mishaps, recreational miscalculation or some domestic tragedy. Charting the behavior of these families and noting their verbal responses allowed similar, repeating patterns to emerge.

Through identification of the meaning behind the observable behavior, the investigator was able to define a process of recovery from the crisis state, and to develop treatment modalities to help families through the various phases or stages. Each family's treatment time averaged two and one-half interviews, or approximately five hours of intervention.

The theoretical framework used for this descriptive study was the crisis model as developed by Dr. Erich Lindemann and Dr. Gerald Caplan. Crisis intervention is a brief treatment modality having the current crisis as its only focus. Its goal is to reestablish the equilibrium that is disrupted by the crisis situation.

"Crisis" in its simplest terms is defined by Caplan as "an upset in a steady state." This definition rests on the systems theory concept that an individual, a family or any social system strives to maintain a state of equilibrium through a constant series of adaptive maneuvers and characteristic problem-solving activities that allow for basic need fulfillment to take place. Whether a situation or event becomes a "crisis" depends greatly on how the family defines or interprets the event in light of its own cultural and historical experiences. What may be a crisis for one family may not be so for another.

One event that can, and most often does, disrupt the usual homeostatic state of a family is the sudden, catastrophic illness of one of its members. It is postulated that in a state of crisis the system's usual problem-solving mechanisms are insufficient and do not rapidly lead the system back to a state of equilibrium. Often families must find new solutions to deal with that which, up to the current crisis state, had been outside the realm of their family system's life experience. Most families need external help in coping with the high emotional impact of this particular kind of crisis situation. These families also need assistance in mobilizing their own adaptive capacities and activating those inner resources that would eventually help to reestablish the family's pre-crisis "steady state."

Description of Process

Families under sudden, severe stress appear to go through, or at least touch on, six distinct phases before the family system is able to reorganize, reintegrate and regain its homeostatic state. It is to be understood that families differ in regard to both the sequence of phases and in the rate by which family members pass through the various stages. Also, it is to be noted that some families skip over stages and eliminate them altogether in the adaptive process. Furthermore, all family members do not go through the phases at the same time, and each member is unique in his completion of the process. Each family member, like each family group is individualistic in his pattern of adapting. However, despite this diversity there remains a distinct, identifiable method of recovery to a "steady state."

HIGH ANXIETY

A period of high anxiety is most often the phase families go through first, and it is usually experienced by most family members at the same time. The high anxiety phase is characterized by great physical agitation, high-pitched voice, tight neck and shoulder muscles, and other body reactions such as fainting, nausea and diarrhea, found to be typical of persons under severe stress. Sometimes anxiety is manifested by withdrawal and body tenseness as if all one's energy is being used for body containment only. This acute anxiety can last anywhere from a few minutes to several hours.

Three things are done to help diminish the family's anxiety:

1) Brief, accurate information is given about the present whereabouts of the patient (*i.e.*, admitting area, operating room, or the critical care area). They are given a general patient condition report with the assurance that a physician and nurse will be in to give a complete medical report as soon as possible.

2) The life-saving methods and advanced technology of the Institute are explained. This seems to reassure the family that the patient has every advantage modern medicine can offer.

3) The family members are encouraged to ventilate about the initial impact of the news of this sudden catastrophe, *e.g.*, where they were, what they were doing and what they were told about the accident.

These three steps, coupled with definite information from the physician's report, are most often sufficient to relieve the anxiety to a level at which the family members can begin to consider other issues, *e.g.*, what does this mean, what to do now and other pragmatic considerations which lead to another phase, usually that of denial.

DENIAL

In the denial phase, the family, in an apparent defense attempt, tries to protect itself from the grim reality of the devastating effects the catastrophic event had on the patient. Such verbalizations as, "He's a healthy, strong boy; he can't be that badly off." "It can't be Mary, I was just talking to her this morning;" or "He can't tell me my son's paralyzed; I know my boy, he'll walk again."

The denial stage is important because it seems to act as a psychological preparation for any further bad news the family may get about the patient and because it seems to have in it an essential element of hope needed to carry on. Further, denial is a regression to a comfortable childhood stage of "magical thinking" that says, "In spite of what happened everything will be all right."

It is important for the therapist to maintain a balance in this situation by recognizing the need for denial as well as the need for the family to deal with the reality of what has happened and what now is. Statements such as "Mr. Jones, your son was such a healthy boy, it must be very difficult for you to believe that he is now paralyzed," are often helpful. Appropriate reiterating of like statements to the family conveys to them that the therapist understands and accepts their struggle with reality. These statements also act as a reminder of what is, without removing the denial defense.

Often the denial lasts until the family is able to speak directly to the patient, usually within a 48 hour period. Some family members hold on to their denial for long periods of time and special efforts must be made through follow-up sessions to help these persons deal with the reality of the situation.

ANGER

Anger expressed by families under sudden, severe stress seems to be amoeboid, taking many different shapes and directions. During this phase, anger can be directed towards oneself or another family member in an apparent attempt to place the blame, or part of the blame, for what has happened. It can be directed towards the physician and nursing staffs, the State Police, emergency medical technicians, the therapist and others. Often it is a diffuse kind of anger that lashes out at society or life in general for allowing to exist circumstances such as high speeds, lack of gun controls, or lenient drunk driving laws, that may have contributed to the tragedy.

During this phase, the therapist encourages ventilation of angry feelings. It is the therapist's task to help the family focus on the real cause of their anger. When families have a chance to really listen to their accusations they often see the illegitimacy of their charges. Eventually the family comes to realize that they are really angry at the patient himself for disrupting the family routine and causing great stress and disorganization within the family system. It must be noted, however, that there are times when outside agents are legitimately responsible, at least in part, for the accident.

It was of interest to the investigator that in families that appeared to have good, open patterns of communication, the expressed anger was often immediately directed toward the patient for being so "careless," "dumb," or "stupid" in putting himself in the dangerous situation which is now causing the family such stress. But these same families often expressed feelings of guilt for blaming the sick person for what had happened.

All families who express anger toward the injured member whether immediately or through a circuitous route, need reassurance that they are not "bad" persons for feeling angry. Often individual members need repeated "permission" from the therapist to say their angry words. Our society says that it is not nice to be mad at sick, helpless individuals. Consequently, some members experience a sense of uneasiness for blaming the injured member. Unless the anger family members feel toward the patient is expressed and dealt with, it can cause further destruction to the family system being later expressed in passive-aggressive behavior toward the patient during his rehabilitation.

REMORSE

The sense of guilt that families feel for blaming the patient for the current crisis is different from what is considered to be a period or phase of remorse. Guilt feelings say "somehow I have done wrong, I am culpable." Remorse, on the other hand, includes the elements of both guilt and sorrow. Remorse seems to describe best what family members feel about the part they may have played in contributing to the accident. They regret not only that the incident occurred, but that they did not, or could not, do more to prevent it. It is the "if only. . . . ." stage. Such statements as: "If only I had not bought him that car, this would never have happened;" "If only he had still been living at home he would not have been out so late;" "if only I had given him the money to get that car fixed this might not have happened," are typical verbalizations during the remorse phase.

It is important to listen to these expressions of remorse and try to inject some reality as to how much blame the family members can take for the accident. What is it that the family members actually could have done to prevent this tragedy from happening? Usually there is little, if anything, they could have done to prevent it, but the family can come to this reality only by open discussion.

What family members seem to need and want most during this phase is a reassurance that they are "okay" people in spite of what has happened. It is the task of the therapist to help the family relieve themselves of the burden of taking responsibility for the accident. It was a rare case that a family member could or should have taken legitimate blame for the tragic event.

GRIEF

The grief phase usually follows the period of remorse, but not always. It is to be remembered that each family system and each family member differs when going through the phases. The family, at one time or another, experiences an intense period of sadness, a grieving time when their sense of loss, even temporary loss, becomes almost overwhelming. At this time, tears and deep sobbing are frequent. Some family members withdraw into privacy. Tears shed during this phase are different from those that offer a cathartic release of tension in the anxiety phase. This stage is the beginning of a grieving process of which the duration and intensity depend on such factors as the medical condition of the patient, length of hospitalization, the family solidarity, and the degree of remorse experienced by the family.

During the grief phase the therapist remains with the family. Grief cannot be taken away, nor should there be any attempt to do so. Grief is a very natural, human response to the loss, or threatened loss of a love object. Most often the therapist just sits quietly with the family members offering a silent support. Many times physical closeness, holding a trembling hand, or embracing limp shoulders, conveys an empathy for and an understanding of what the family members are experiencing. These empathic gestures are often all that are needed to begin the flow of copious tears that gives some release to the deep emotional feelings of loss.

RECONCILIATION

Reconciliation usually occurs last and it seems to be a culmination point to the therapist's intervention during the acute family crisis. At this time the high state of anxiety is diminished, the reality of the situation is, or is becoming clearer to the family, usually anger and remorse have been expressed, and the grieving process begun.

Choosing an accurate word to describe what transpires during this phase is a problem of semantics. The word reconciliation is used because it differs from "acceptance" or "acquiescence" in that it connotes a "bringing together" or "bringing into harmony" all that has taken place. Reconciliation is not acceptance of what has happened; most families cannot accept the tragedy, especially if it appeared to be a senseless occurrence. This is a phase of putting things in place, of being reconciled to the fact that something terrible has happened that deeply affects, and will continue to affect, the total family unit. Included in this period of reconciliation is a realistic sense of hope that whatever hardship this tragedy may impose, the family can and will survive.

This is the time when mobilization of the family system's resources begins, if it hasn't already, to enable the family to adapt to the current situation and cope with whatever is to come. During this phase, a family solidarity seems to emerge and concretize through a concerted effort on the part of the family to plan for the future.

During this phase the therapist helps the family to start thinking about and begin to develop a feasible plan of action. What needs to be done now; who will be able to do these things; what are the available resources that can be utilized; who and what helped the family pull through previous crises. For a variety of reasons, either current or longstanding, some families appear unable to activate adequate coping mechanisms and must rely heavily on outside resources. In such cases appropriate referrals to community agencies must be made.

Discussion

No attempt was made in the study to consider the long-term effects of life-threatening situations on the family system. Others have made observations in this area. The purpose of the above presentation has been to discuss the process that families in the acute crisis stage, undergo when the family unit has been disrupted because of the traumatic, life-threatening injuries of one of its members. Also, treatment techniques utilized within the crisis theory framework are presented as methods of intervention that have been effective in treating families of critical patients brought to MIEM.

Future Direction

As more critical care centers are established across the country there will be a great need for trained personnel to work with the families of multiple trauma patients as well as with the patients themselves.

At MIEM a unique, multidisciplinary Family Services Division, comprised of various professionals with expertise in the human sciences, has been recently established to care exclusively for the psychosocial needs of patients and their families. A team comprised of two family social workers, a psychiatric nurse, a community liaison nurse, an alcoholism counselor, a chaplain and a consulting psychiatrist form the nucleus of this Division.

Each of these persons has specific areas of responsibility for patient/family care and, all work as a supplementary team in concert with the medical personnel. When referrals are made to the Family Services Division, by the physician/nurse teams, psychosocial assessments of the patient and his family are prepared and the completed evaluations submitted to and discussed with the referring team. These assessments become part of the patient's permanent medical record. When deemed advisable ongoing counseling sessions are provided, by the psychiatric nurse, for the patient. Simultaneously the patient's family receives treatment from the family social worker.

Plans for patient discharge and community agency follow-up services for both the patient and his family are coordinated by the community liaison nurse. In conjunction with the patient's primary nurse, the physician and the family social worker appropriate placement and post-hospital maintenance decisions are made and the care plans implemented. In the realm of psychosocial services, the Family Services Division offers the patient and his family continuity of care from the time of admission to the post-hospital placement of the patient.

Trauma centers such as MIEM are the wave of the future. These centers, if they are to provide a holistic approach to treating the multiple-injured patient, must consider and offer treatment for the psychosocial impact such a suddenly, severely injured person has on the family. The effects such a catastrophe has on the family system are both immediate and long term.

A family crisis intervention service as an integral part of the total, comprehensive, medical treatment program can offer supportive, therapeutic help to families during the acute crisis state. By providing such a service, families, having had the opportunity to work through the initial psychological effects of the tragedy and re-equilibrate the family system, will be better prepared to act as a supportive social system for the medically improved patient when he/she is eventually returned to the community.

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EFFECTS OF HUMAN CONTACT ON THE HEART ACTIVITY OF CURARIZED PATIENTS IN A SHOCK-TRAUMA UNIT

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Physicians use the terms "art of medicine" or "bedside manner" to describe that important aspect of medical practice which includes behaviors having profound emotional and physiologic effects on patients. Using a descriptive phrase such as "art of medicine" implies that the quality of the physician's actions producing these effects is different from the techniques used in "scientific" medicine. That is, it is generally believed the "art of medicine" involves phenomena that seem to elude precise scientific designation, and are so inconstant that precise designation or dissection into a set of measurable variables is

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difficult, if not impossible to accomplish.

Perhaps the most universally recognized aspect of bedside manner is the ability of the physician and other medical personnel to influence the measurement of blood pressure, heart rate, and other variables of cardiovascular performance. Indeed, this ability was recognized almost simultaneously with the discovery of the human pulse. For example, about 30 A.D., Aurelius Cornelius Celsus described the art of pulse-taking in "*De Medicina*" as follows[1]:

> "On the contrary, bathing, exercise, fear and anger, and any other state of mind, may often be apt to excite the pulse, so that when the medical man first comes, the anxiety of the patient, who is in doubt as to what he may seem to him to have, may upset the pulse. For this reason it is not the part of an experienced doctor that he seize the arm with his hand at once; but first of all sit down with a cheerful expression, and enquire how he feels, and if there is any fear of him, to calm the patient with agreeable talk; and then, at last, lay his hand on the patient's body. How easily a thousand things may disturb the pulse, which even the sight of a doctor may upset!"

And yet, in spite of both the antiquity and the ubiquity of this knowledge, the magnitude, generality, and most importantly the mechanisms of the effects of human contact on the cardiovascular system have not received careful attention. This lack of attention is due, in part, to the complex nature of clinical interactions, which are difficult to reduce to simple experimental models, and in part to the commonness of the knowledge that the phenomena exists.

Recently, we have described the effects of human contact on cardiac responses of patients in coronary-care units (CCU). In these patients even the simple act of taking the pulse produces significant changes in heart rate and more importantly can double the frequency of ectopic beats.[2-5] The cardiac effects of human contact have also been demonstrated in a series of experimental models developed to clarify some of the environmental, physiologic, and genetic mechanisms involved in these reactions. For example in both dogs and horses various routine types of human contact have been shown to produce large and at times profound cardiovascular changes.[6-11] These changes persist when the animal is paralyzed with curare indicating the central origin of the responses.

Our observations on the effects of human contact on the cardiac activity of CCU patients raise important questions about possible mechanisms that may meditate these heart reactions. For example, were the cardiac changes observed in CCU patients the result of respiratory or muscular changes? Are changes in the frequency of ectopic beats during routine medical interactions such as pulse taking idiosyncratic to patients with cardiac pathology? The current practice of using d-tubocurarine in a variety of clinical emergencies in a hospital shock-trauma unit provided a unique opportunity to answer some of these questions. By observing patients with and without cardiac pathology in whom respiration and muscular activity were controlled and whose heart rate and blood pressure were constantly monitored, the mechanisms and magnitude of cardiac reactions to human contact could be assessed.

METHOD

The patients in this report were the first four curarized patients analyzed by us from a larger series of 40 critically injured patients monitored in our University Hospital Shock-Trauma Unit. These patients all had varying types of respiratory support when monitored by us. In the larger series of patients, to be discussed elsewhere, 20 patients were artifically respirated tracheostomy patients, 10 of whom were maintained on d-tubocurarine, 10 patients were receiving humidified O_2 via a tracheostomy tube, and 10 patients had no artificial respirating support. All curarized patients were monitored by us regardless of their mental state or physical condition.

Physical Description of Unit

The patients in this study were those that had been admitted to the Maryland Center for Emergency Services of the University of Maryland Hospital. This Center was established for the aggressive treatment of severe medical emergencies that usually involved shock and trauma. This center is a twelve-bed air conditioned rectangular unit approximately 50 feet by 40 feet. A 9 by 12 foot octagonal central monitoring station was in the center of the unit elevated 1½ feet above the unit floor for unobstructed vision. This central station had desks for clinical personnel, telephones, patient records, central monitoring equipment, and a computer-operated scanning unit that monitored all patients. Twelve beds surrounded this station, three against each wall. All but two beds were open to the center of the unit and were separated from each other by a floor to ceiling partition of which the lower four feet was metal and the upper was glass. The beds could be screened by manual partitions although no curtains or other obstructive devices were built in. Each 11 by 7 foot bed unit was completely autonomous having medical and patient care supplies, refrigerator, sink and running water, Engstrom respirator, wall suction, wall air and oxygen, equipment for continuous routine recording of the electrocardiogram, systolic and diastolic blood pressure, and venous pressure as well as capability for the optional recording of cranial pressure, temperature, and pulmonary pressures. At the central station, all patients' electrocardiograms (ECG), arterial, and venous pressure waves could be printed out on paper on command or a digital monitoring system could display all moment-to-moment physiologic fluctuations as they occurred. A computer analyzed and displayed blood-gas readings while surveying each of the twelve beds every hour, subsequently printing out time, heart rate, blood pressure, temperature, respiration, and other events being monitored.

PROCEDURE

The purpose of this study was to replicate aspects of the observations previously made in our University CCU,[2-5] with patients in the Shock-Trauma Unit who were on d-tubocurarine and artifically respirated. Two types of interactions were studied: the first type was relatively simple spontaneous clinical interactions, such as a doctor's visit, in which neither the patient nor staff were aware they were being observed. The second type was planned interactions in which one of two graduate nurses, who were aware of the purpose of the study, either took the patient's pulse or held the patient's hand or touched their arm and verbally comforted them with the following types of statement:

> "(First name of patient), my name is (first name of nurse) and I am a nurse. I know you can't answer me when I talk to you even though you can hear me. That's because of your medication. You're receiving a drug called curare which has temporarily paralyzed you so that you are unable to respond in any way. The drug has also blocked your respiration so there is a machine at your bedside breathing for you which you may be able to hear. This medicine is an unpleasant but very necessary part of your therapy so please try to relax and bear with it. As I said before, the effect will only be temporary and once the drug is discontinued, you

will be able to move as before. We will try to anticipate your needs since you are presently unable to communicate them to us. There is always a doctor or nurse at your bedside so please try not to worry."

This statement was not memorized or delivered verbatim, but rather the nurse reacted to each patient in an individualized manner. Whenever possible a three-minute resting period prior to and following both types of interaction was obtained. While in one sense holding a patient's hand was among the simplest clinical interactions that we could analyze, even this interaction proved to be quite difficult to study within the context of the Shock-Trauma environment. Various clinical personnel were almost always at the patient's bedside and it was not uncommon for as many as 7 to 8 physicians and 4 to 5 nurses to be around the patient's bedside. Coupled with this intense clinical attention, the telephones at the central stations were constantly ringing and the paging intercom system was frequently calling various individuals. The various patient monitoring devices also had auditory cues. Given this complex array of stimuli we frequently had to watch a curarized patient for as long as 2 to 3 hours before a period would occur in which the patient was left unattended for as long as seven minutes, the minimum time period necessary to evaluate patient reactions. Since the patients were curarized for various periods of time, we had no precise means of determining whether the patient was conscious during the interactions. We relied on the attending physician's general assessment of mental status during periods when the curare effect was transiently reversed. However, one of the patients to be discussed in this report (patient 4) was studied immediately after he was given d-tubocurarine. Since he was talking with the physician as he was being given d-tubocurarine, it is reasonable to assume that he was conscious during our obser-varions. The research team did not participate in any clinical decision regarding these patients and had no prior knowledge as to when a patient might be curarized. We were able to monitor these patients only by remaining on 24-hour call.

DATA ANALYSES

Data were collected on polygraph paper run at a speed of 25 mm. per second. One-channel paper was used if the ECG alone was monitored, and when arterial pressure was available, four-channel paper was used. These recordings were obtained from the central console. The patients and staff were not aware of which patient and/or what we were observing. This method did, however, present one problem. If a patient in another bed should suddenly drop below or above safety range in any of the parameters being monitored, the central monitor would automatically switch over to that bed to record the change. In analyzing the data, these interruptions are indicated by a dotted line. In this paper only ECG changes will be reported. Rate changes were detected by two methods, (1) measuring R-to-R intervals with a Lansing ECG rule calibrated to 0.05 cm., then converting this number into heart rate, and (2) counting the R-waves in each successive 15 second period and multiplying by four, thereby obtaining four measures of heart rate each minute. All records were analyzed at least twice, and if any discrepancies in the analyses were noted they were counted a third time.

The observations were conducted by two graduate nurses, who alternately (1) collected data marking the beginning and end of each social interaction in pencil on the polygraph paper, and (2) interacted with the patients. Both nurses were aware of the purpose of the study. Graduate nurses were used both because of their familiarity with the milieu of the shock-

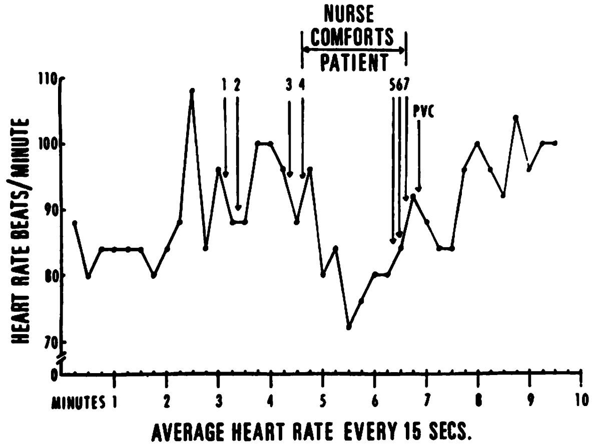

FIGURE 1: Fifteen second heart rate averages of patients before, during, and after nurse comforting patient. Averages are computed by multiplying the number of R-waves in a 15 second period by four. Note decrease in heart rate during comforting and PVC following nurse's departure. Key: (1) nurse No. 1 putting away supplies, (2) nurse No. 1 leaves unit, (3) nurse No. 2 enters unit, (4) nurse No. 2 holds patient's hand and talks to her, (5) nurse No. 1 enters and looks at monitor, (6) nurse No. 1 leaves unit, and (7) nurse No. 2 stops and leaves unit.

trauma unit, and because they were routinely assigned observation duties in this unit. Therefore, no special attention would be paid to their presence in this unit. One of the nurses (MEM) had participated in prior CCU studies and was quite familiar with the research protocol used in these studies.

Results

Patient No. 1. The first patient was a 31-year-old white female who suffered multiple injuries as a result of an auto accident. She had lacerations of the liver; bilateral pneumothoraces; and fractures of the face, ribs, femur, and ankles. On admission, she was described as combative and delirious but became alert and followed commands by the second hospital day. Her hospital course was complicated by persistent abdominal bleeding, persistent pneumothorax despite chest tubes, pneumonia, and finally septicemia and massive upper gastrointestinal tract bleeding. She remained on a respirator with tracheostomy. She was curarized on the sixteenth hospital day because of acute respiratory problems and remained curarized for the following eight days. At the time of curarization, she was described as alert and remained so until the day before her death, 38 days after admission to the hospital. The patient was observed on the twenty-third day after admission. At this time, she was on 12 mg. d-tubocurarine, intravenously every hour.

We monitored three episodes of human contact in this patient, two of which the nurse held the patient's hand and comforted the patient, while in the third interaction a nurse simply took the patient's pulse for one minute. Fig. 1 shows this patient's reaction during the first interaction in which a nurse held this patient's hand and comforted her. Several reactions outlined in this figure deserve notice. First of all, the heart slowed abruptly to a rate of 72 beats per minute when the nurse first held the patient's hand. The average heart rate before the nurse approached the patient's bedside was 84 beats per minute, the lowest rate was 80 beats per minute, and the highest rate was 108 beats per minute. While the nurse comforted the patient, six prolonged R-R intervals occurred, each of which were twice as long as the average beat-to-beat heart rate. Approximately 20 seconds after the

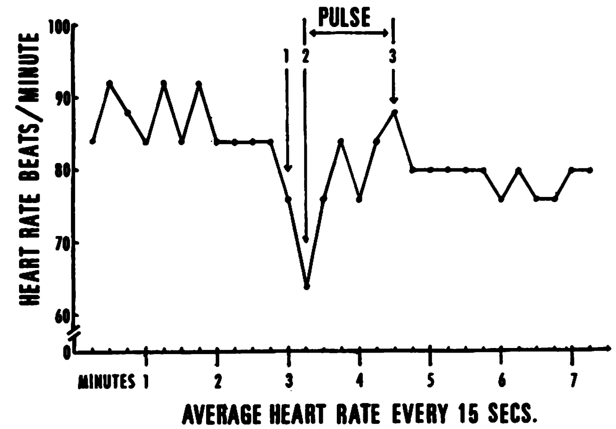

FIGURE 2: Patient's heart rate averaged every 15 seconds before, during, and after pulse taking by nurse. Note decrease in heart rate during pulse taking. Key: (1) nurse enters, (2) nurse takes pulse, and (3) nurse stops and leaves.

nurse left the patient's bedside, a premature ventricular contraction (PVC) occurred. This was the only PVC that occurred during the entire time the patient was monitored by us, a total of 26 minutes and 45 seconds. The nurse's departure from the patient's bedside was followed by a heart-rate increase.

The second time the nurse held the patient's hand and comforted her, the heart rate fell abruptly from an average rate of 104 beats per minute during the two-minute period pre-entry, down to 92 beats per minute with two prolonged R-R intervals. However, after the nurse left the bedside, the heart rate did not accelerate noticeably, but maintained an average rate of 98 beats per minute during the three-minute post period.

Fig. 2 shows the patients heart rate reaction when the nurse simply took the patient's pulse for one minute. As can be seen in Fig. 2, the heart rate abruptly slowed as the nurse approached the bedside and took the patient's pulse. The average heart rate for the three minute period pre-entry was 86 beats per minute and slowed as low as 64 beats per minute during pulse taking. After the nurse left the bedside, the average heart rate was 79 beats per minute.

Patient No. 2. The second patient was an 11-year-old white female who was hospitalized after having been struck by a car. She sustained a left frontal skull fracture and cerebral contusions as well as multiple pelvic fractures and a retroperitoneal hematoma. Initially comatose, by the eighth hospital day she was described as alert and oriented, with no localizing neurologic signs, when she rather suddenly became restless and confused and began to have marked respiratory distress, which was later attributed to tracheal stenosis and mucous plugs. Subsequently, tracheostomy and bronchoscopy were performed and adequate ventilation was obtained with a volume respirator. She was curarized during these procedures because of her extreme restlessness and confusion, and at the time of the study had been on curare two days. Periodic reversals of curare over the next several days revealed her mental state to be that of delirium. The patient subsequently recovered fully and was discharged after 33 days in the hospital. On the day of our observations the patient was receiving d-tubocurarine at a maintenance dose of 9 mg. per hour, intravenously. She was on an Engstrom respirator set at 20 cycles per minute without any sighs.

Two relatively uncomplicated clinical interactions were monitored in this patient. Fig. 3 shows the heart rate changes that occurred during a continuous 7.25-minute period when a nurse came to the bedside and held the patient's hand. The nurse did not speak to the patient during this interaction. As can be seen in Fig. 3, for the three minutes before the nurse approached her bedside, the patient's heart rate was cycling rather rhythmically from a maximum beat-to-beat rate of 125 beats per minute to a low of 105 beats per minute. No unusual changes in heart rate were observed during most of the period that the nurse held her hand. However, just as the nurse let the patient's hand go the heart rate increased to a peak rate of 136 beats per minute and then fell to about 95 beats per minute before cycling back into the pre-entry pattern. During this entire 7.25-minute observation period, both the highest and lowest beat-to-beat heart rates occurred within 30 seconds after the nurse let the patient's hand down.

Fig. 4 shows similar heart-rate changes that occurred during one of the clinical interactions that patients routinely experience in the Shock-Trauma Unit. In this interaction, which occupied a total of 9.55 minutes, a nurse came to the patient's bedside to adjust an intravenous (IV) drip and change the bandaid holding the IV needle in the patient's arm.

Before the series of events outlined in Fig. 4, the nurse had been writing at the bedside of the patient. However, until event No. 1 she did not touch the patient. As can be seen in Fig. 4, a series of repeated episodes of physical contact with the patient occurred while the nurse changed the bandaid that was holding the IV needle in the patient's arm. While this procedure may or may not have been associated with some degree of minor physical discomfort it is unlikely that any major discomfort was produced. Nevertheless, as can be seen in Fig. 4, the heart-rate pattern of this patient was altered

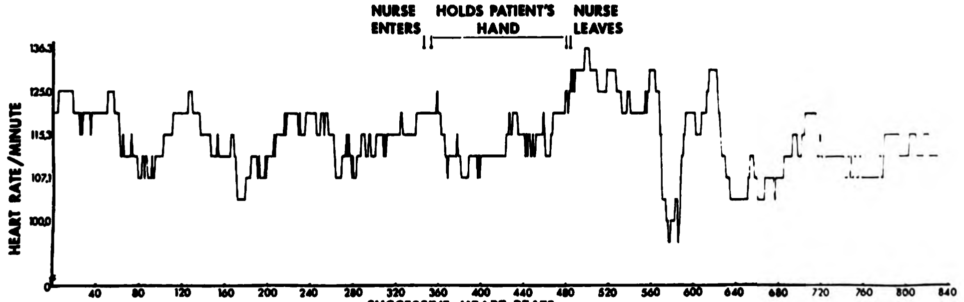

FIGURE 3: Beat-to-beat heart rate of patient before, during, and after nurse holding patient's hand. R-R intervals are converted to rate per minute. Note increase and then abrupt decrease in heart rate at cessation of hand holding.

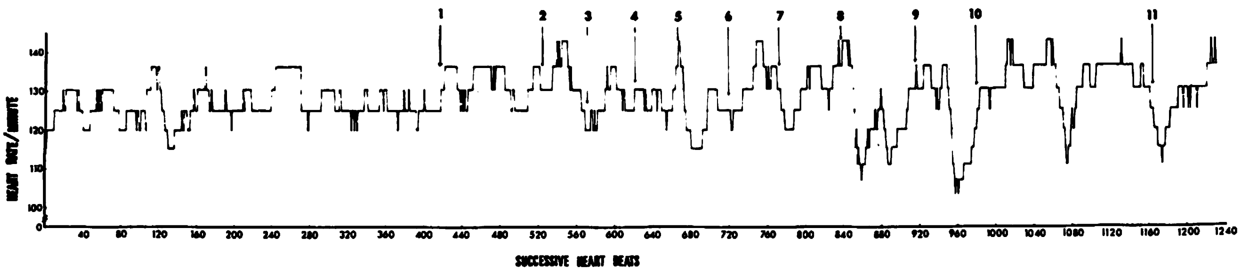

FIGURE 4: Beat-to-beat heart rate of patient while nurse cleans and retapes I.V. insertion site. See text for discussion. Key: (1) turning arm with I.V. and retaping it, (2) changing tape, (3) stopped, (4) touched patient and stopped, (5) touched patient and stopped, (6) applying Betadine, (7) working with I.V. disconnecting it, (8) rechecking tubing, (9) applying bandaid, (10) applying tape, and (11) stopped.

while the bandaid was being changed. The pattern and magnitude of both heart rate acceleration and subsequent deceleration were similar to that observed when the nurse simply held this patient's hand, as was shown in Fig. 3.

These two events were the only interactions we were able to monitor in this patient.

Patient No. 3. The third patient was a 54-year-old white male with a history of coronary artery disease and mitral insufficiency who underwent saphenous vein bypass and mitral valve replacement. He had a past history of "anxiety attacks" and alcoholism. An initial electrocardiogram showed ST depression but no other abnormalities. At the time of surgery, the right coronary artery was found to be completely obstructed and the right papillary muscle had been ruptured. The immediate postoperative period was complicated by hemolysis, atrial arrhythmia, and hypotension and the patient was transferred to the Shock-Trauma Unit for management of these problems. He continued to require isuprel and aramine to maintain his blood pressure and had various cardiac conduction disturbances ranging from nodal tachycardia to A-V dissociation with a junctional rhythm. At the time of the study, rhythm was junctional with retrograde conduction. On the fifth postoperative day, he developed ventricular fibrillation and died.

Although the patient was described as alert and responsive on the first postoperative day, his mental status deteriorated afterward. He was placed on d-tubocurarine in order to prevent his respiration from becoming out of phase with the respirator. During periodic reversals of the curare effects, he was described as ranging from semiconscious to unconscious and comatose. Our observations were made from 1 to 2 hours before the patient's death, at which point the patient was described as comatose.

In all, we monitored three interactions in this patient that occupied a total of 23.95 minutes. During the first two interactions, no significant heart rate changes were observed. These two interactions involved a nurse taking the patient's pulse and a nurse measuring central venous pressure. In neither of these interactions did the nurse speak to the patient. The final interaction monitored in this patient occurred about an hour before death. In this interaction, the nurse came in, held the patient's hand, and quietly comforted the patient. As can be seen in Fig. 5, the patient's heart rate and its variability changed abruptly during and after this interaction, from a resting average of 100 to an average of 96 during and after contact. During this entire period, the patient was in a junctional rhythm, and no electrocardiographic changes (other than the rate change) were noted during or immediately after the interaction.

Patient No. 4. The fourth patient was a 30-year-old white male who suffered anoxic brain damage as a result of traumatic asphyxia caused by a crush injury to the chest. In addition, he had a left brachial plexus injury. On admission to the Shock-Trauma Unit he was described as comatose but within a few hours, he progressed to delirium. Following endotracheal intubation, a tracheostomy was performed and adequate pulmonary ventilation was obtained with curare being used to control motor activity. The patient was observed by us on both the second and third hospital days. On both days he was described as having a clouded sensorium but responded appropriately to pain and simple commands. On the second hospital day, the patient was not given d-tubocurarine, while on the third day he was curarized and artificially respirated.

On his second hospital day, the patient was being administered oxygen via a *tracheostomy without curare*. We monitored three separate interactions on this day, the first involved

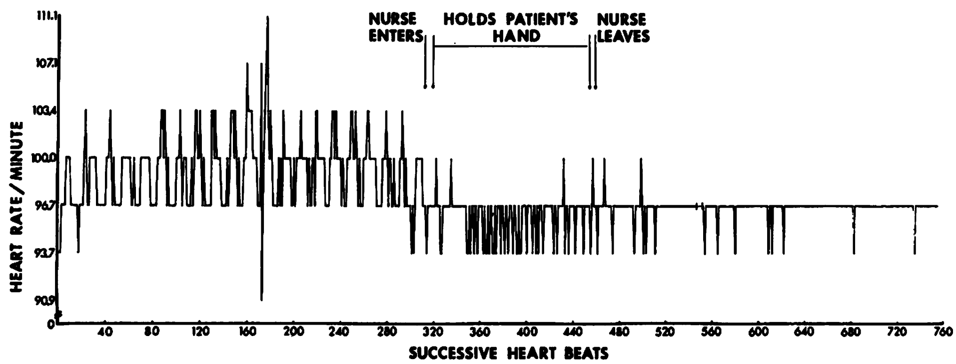

FIGURE 5: Beat-to-beat heart rate of patient before, during, and after nurse holds patient's hand and comforts him. Note decrease in heart rate during and after nurse's contact with patient.

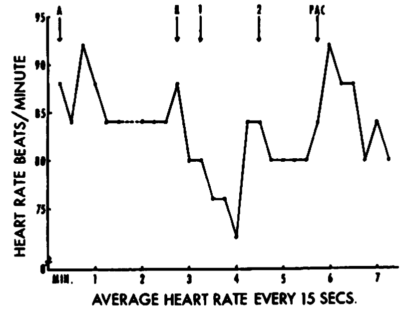

FIGURE 6: Beat-to-beat heart rate of patient before, during and after pulse taking by nurse. Note PAC following pulse taking. Key: (A) person in but remaining quietly by bedside, and (B) person out. (1) Nurse takes pulse, and (2) nurse stops taking pulse and leaves.

a nurse taking the pulse, the second involved a physician's examination, and the third involved a nurse holding the patient's hand and comforting him. Fig. 6 shows the abrupt heart rate deceleration that occurred when the nurse took the patient's pulse. Within 90 seconds after the nurse finished taking the pulse a premature atrial contraction occurred. As with patient No. 1, this was the only ectopic beat we observed during the entire period we monitored this patient. The second interaction involved a nine minute neurologic examination. Before this examination, the patient's resting heart rate was 80 to 84 beats per minute and rose to a maximum of 92 beats per minute when the physician instructed the patient to try to move his legs and toes. After the examination was finished the patient's rate returned to 80 to 84 beats per minute. During the third interaction in which the nurse held the patient's hand and comforted him, the resting heart rate before the interaction was 84 beats per minute and that rate did not change during the interaction. However, within 30 seconds after the nurse put the patient's hand down the heart rate rose 92 beats per minute (averaged each 15 seconds), fell to 76 beats per minute and then peaked again at 92 beats per minute before returning to the pre-entry pattern. It should also be noted that the heart rate of 92 beats per minute was the maximum rate that occurred when the doctor instructed the patient to try and move his leg. Finally, it should be pointed out that this pattern of heart rate acceleration, followed by heart rate deceleration was very similar to the pattern of heart rate reactions shown by patients Nos. 1 and 2 during a similar type of interaction under curare.

On the third hospital day, the patient was given d-tubocurarine and artificially respirated on an Engstrom respirator set at 20 cycles per minute without any sighs. At the time of our observations, he was given d-tubocurarine at a maintenance dose of 12 mg. per hour, intravenously. Just before he was given the d-tubocurarine, he was talking to the physician at the bedside. Only one complex interaction, parts of which are outlined in Fig. 7, was monitored by us. Our monitoring began right after the patient was first curarized and seven doctors came to his bedside. As is shown in Fig. 7, shortly after the doctors came to the patient's bedside, tracheal suctioning was initiated at which time the patient was taken off the respirator several times during a one-minute period. It is of interest to note that the maximum heart rate increase while seven doctors were discussing the patient was almost as great, although not as sustained, as that heart rate change elicited during tracheal suctioning. Immediately after tracheal suctioning, a nurse spontaneously held the patient's hand and comforted him and the patient's heart rate began to immediately and steadily slow back to the pre-suctioning level.

However, precisely after the six hundred fortieth heart beat shown in Fig. 7, the patient's wife telephoned the unit and for the following 5.5 minutes a nurse held the telephone to the patient's ear and the patient's wife spoke to him. Averaging the heart rate each 15 seconds during this period revealed that during the first minute of this conversation, the patient's heart rate immediately increased once again to 100 beats per minute. Again it should be noted that this rate increase was almost as great as the change during tracheal suction. After the first minute, however, the patient's heart rate progressively slowed down until he was averaging between 80 and 84 beats per minute quite regularly for the last two minutes of this conversation.

On both day two and day three, the patient's resting heart rate was approximately 82 beats per minute.

Discussion

In this study, we have attempted to gather descriptive clinical data in humans that would parallel observations previously made in other clinical situations, as well as replicate more precisely controlled animal studies.[2-11] It should be emphasized that no attempt was made in this study to present a precisely timed series of repeated experiments. The acute nature of the clinical situation precluded such formal experimentation. Indeed, some of the events monitored in this study would be impossible to ever replicate within the precise context that they occurred. They were simply unique human interactions. For example, we have never since observed a curarized patient listening to a telephone call from his wife precisely when we happened to be recording the patient's heart rate. Nor have we since held the hand and comforted

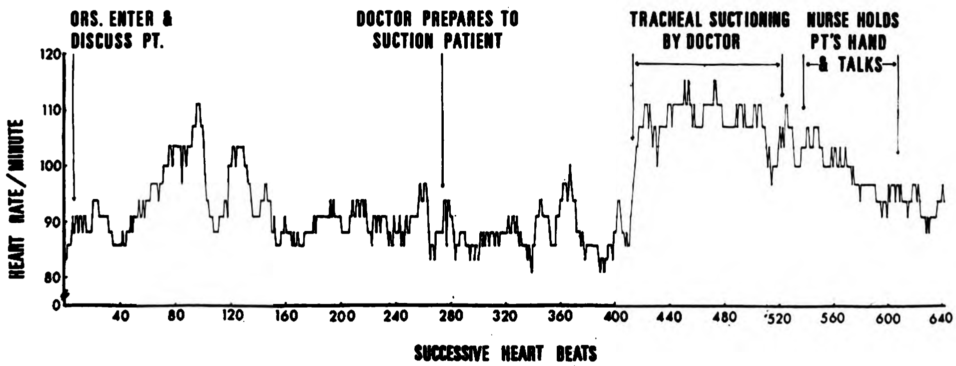

FIGURE 7: Beat-to-beat heart rate of patient during Doctors' rounds, tracheal suctioning, and comforting by nurse. See text for discussion.

another comatose patient one hour before his death. We recognize that the heart-rate changes seen in this patient at the very point the nurse held his hand could have been due to chance, and indeed there is no way to repeat the observation to conclusively answer the question. In every sense these were unique and poignant human interactions and the uniqueness of these observations from an empirical point of view must be recognized as both a strength and an unavoidable weakness.

In spite of the complexities inherent in these observations, however, we feel the data permit the strong inference that the heart rate of these patients was altered by these human interactions. It is tempting in this situation to infer an emotional effect of the observed interactions but it is not possible to do so because we have no data other than the heart-rate changes.

In the four patients studied, heart-rate changes were observed in association with various types of human contact. These observations indicate that heart-rate changes observed during human contact: (1) are not idiosyncratic to patients with intrinsic cardiac pathology, who had been studied previously,[2-5] (2) occur in patients whose musculoskeletal movements are blocked and who are respired regularly, (3) occur in the context of what would seem to be intense sensory bombardment, and (4) can be of a magnitude equivalent to such strong physical stimuli as tracheal suction which also involves the momentary turning off of the curarized patient's respirator.

Although curarization allows the heart rate changes to be observed independently of motor activity, it undoubtedly alters the patient's response to the environmental stimuli and, therefore, probably alters cardiac reactivity to such stimuli. The meaning of human contact to a totally paralyzed, completely passive, and helpless person can in no way be considered in the light of everyday normal experiences. In addition, these patients were all seriously ill (two died) most likely in some degree of physical discomfort, and with at least some clouding of consciousness. Under curare, they were unable to move or talk.

Only two of the four patients in this study were described as probably being conscious, the mental state of the others ranged from delirious to comatose during periods when the curare was reversed. It is important to note, however, that it was impossible to assess the patient's level of consciousness precisely at the time of the study. The relationship between heart rate responsivity and level of consciousness remains unclear.[12]

In evaluating the significance of these data, two widely held, contradictory, but frequently simultaneously held attitudes must be recognized. One attitude is that the data are trivial in the sense of being self evident. The second attitude is that the situation that generates these heart reactions is too complex to evaluate. Common sense or common knowledge tells us that noxious environmental stimuli or stimuli that changes emotional or motivational states will produce physiologic changes. But the simple type of social interactions we have studied cannot be equated with such stimuli, or be said to be linked to such kinds of emotional states. The physiologic effects of social and/or tactual contact have been poorly studied, and their effects are far from well understood. We can, however, conclude from out past work that such stimuli often exert potent effects on the cardiovascular system. Furthermore, although the "objective" aggregate of stimuli that comprise what we call human contact are complex, it is still possible to document highly regular responses, as is noted in this study, and has been pointed out in our CCU observations.[2-6]

Finally, one aspect of these experiments that deserves emphasis is that neither the patient nor many of the personnel interacting with the patients were aware they were being observed. In that sense, these data must be considered in a different light from the usual type of human experimentation in which the subject is quite aware that an experiment is being conducted in an environment that is clearly contrived. The overpowering reality of the clinical situation that formed the background of the observations made in this report cannot be ignored: it was one of life and death.

As has been emphasized in our previous reports it also seems that clinical personnel by their mere presence, can significantly change the cardiac system they may be attempting to monitor.

Summary

This study examines the effects of human contact on the heart rate of four seriously injured patients who were on d-tubocurarine and artificially respirated. All four patients showed significant heart rate changes during routine clinical interactions such as pulse taking or when a nurse held their hand and comforted them. Coupled with previous animal and human observations, these findings indicate that human contact can serve as a potent stimulus for change in cardiovascular functioning of other humans. These studies also indicate that heart reactions to human contact (1) occur in patients where musculoskeletal movements are blocked and who are respired regularly, (2) occur even in the context of intense sensory bombardment, (3) can be of a magnitude equivalent to such strong physical stimuli as tracheal suction, and (4) can occur even when the patients are described as unconscious and comatose.

The authors would like to thank Russell R. Monroe, M.D., Leonard Scherlis, M.D., Dean Marion I. Murphy and the staff of the shock trauma unit for their support in conducting these studies.

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EMERGENCY PSYCHIATRIC SERVICES: THE MOST FREQUENTLY UNDERDEVELOPED COMPONENT IN EMERGENCY MEDICAL SYSTEMS

H. L. P. Resnik, M.D.

Emergency psychiatric services are now receiving more and more attention from emergency medical service planners throughout the country. However, these services have been so underemphasized in the past that it will require a decade of concentration, subsidization, and training to ensure that citizens subject to such emergencies will be received with proper attitudes, experience, and training. A number of national and state legislative program developments have stressed the increasing importance of emergency mental health care, but these have yet to be developed in any uniformity. The techniques for delivering emergency psychiatric care have risen out of a large body of clinical experience in suicide prevention and crisis intervention, but have yet to be fully utilized by emergency medical caregivers.[2]

Emergency psychiatric services are an afterthought for most emergency medical service planners in this country and abroad. This is a result of gross neglect by psychiatrists as well as traumatologists. Psychiatric neglect has occurred by omission rather than commission. The past decade of psychiatric practice has witnessed a pendulum that has swung away from a medical model of practice to more nebulous community mental health networks, social support systems, and prior to that, long-term insight-oriented psychoanalytic therapies. Emergency psychiatric calls were largely considered an obligation to staff the Emergency Department to stem the flow of potential admissions, and to mollify our medical colleagues who segregated patients with emotional problems to certain areas. Only recently have full-time and volunteer psychiatric faculty been assigned to the Emergency Department for supervision and training of residents, often by telephone consultation alone.

Neglect of psychiatric emergencies by traumatologists is certainly more understandable. Often their experiences with their psychiatric colleagues have been ones in which they were afforded little practical assistance in the management of their physically damaged and often life threatened patients. Furthermore, they too were never taught to consider psychiatric emergencies in the same context as physically injured patients.

Everyone has a clear sense of the life and death nature of a medical emergency, and where psychiatric emergencies fit their framework such as a serious suicidal attempt, an acute drug reaction, delirium tremens, the medical management is indeed comfortable. Yet, there are emotional emergencies where the medical management model such as the laying on of hands, medications or bandages is definitely contraindicated. Examples are family or marital crisis, hysterical patients, rape victims, and patients with suicide gestures. For efficient, effective emergency care, the caregiver's use of self as a therapeutic instrument is greatly predicated upon attitudes and experience with emotional illness, and especially, psychiatric emergencies.

Emergency psychiatric services have been so underemphasized that it is a rare EMT training program that has a meaningful teaching section on the management of psychiatric emergencies. Yet I believe that a survey of emergency personnel, asking their estimate of the most difficult problems to manage, would reveal the psychiatric emergency near the top of the list. I want to categorically state that, I believe, the citizens of this country subject to psychiatric emergencies will receive the poorest care, except for selected localities, if they present to the emergency medical system with a mental health emergency such as suicide, alcohol, drugs, psychosis, rape or child abuse.

It will require a decade of liberal subsidy for specific training modules to be integrated in the EMS management of mental health crisis. It has only been four to five years that the operating guidelines for funding service programs were defined so as to include *both* physical and psychological emergencies (Emergency Medical Services Systems Act of 1973—Public Law 93–154). One year later, the Disaster Relief Act of 1974 under the Crisis Counseling Assistance and Training Section (42 USC 5183) included the emergency emotional needs of victims of disasters in the same sense as the emergency physical needs. With these two legislative mandates, psychiatric educators and clinicians were once again deemed essential to the emergency medical team. I have seen little progress in implementing these inclusions.

What is Emergency Psychiatric Care?

Some mental health professionals consider the patient to be in an emergency state only if he is suicidal, homicidal, or acutely psychotic. Dr. Howard Parad and I have defined a psychiatric emergency as a *sudden unforeseen isolated* incident which, if unresponded to, will result in life threatening or psychologically damaging consequences.[1] I believe the key words here are "life threatening" and "psychologically damaging." "Life threatening" is quite clear to everyone since it fits the medical model of trauma. However, "psychologically damaging" is a much more nebulous term. What we mean is that there are many emotional traumata that can result in psychologic scars that will potentially limit life's fullness, just as there are medical injuries that may potentially limit one's physical capabilities by leaving scars or healing improperly. We conceptualize that a *crisis* often is less impelling, occurs in a psychological setting that has been previously identified and has been gathering momentum over some time.

A number of treatment techniques have been reported under the fabric of brief crisis-oriented therapy for medical, psychiatric and disaster situations.[1,2,3,4]

The Main Elements of Crisis Intervention

The four stages of a crisis are: (1) a precipitating event, sometimes called stress or "stressor," (2) the perception of the event, (3) the response to the event, and (4) the resolution of the ensuing problem or an impasse. (Figure 1)

THE PRECIPITATING OR STRESSFUL EVENT

Mental health crisis are triggered by a variety of situations, usually involving change-producing events of special significance for the person or persons affected. These stresses may be divided into two categories according to the manner of their occurrence. There are accidental or situational stresses which occur without warning, and there are other life stresses which are more or less anticipated. An auto collision or the sudden death of a loved one are examples of unexpected stresses. The upset felt by a recovering psychiatric patient trying to adjust to the community following discharge from a state hospital or the fear of death experienced by a seriously injured victim following an accident are examples of anticipated types of stressful events. Obviously, we are all vulnerable to a variety of both expected and unexpected stresses.

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It is important to understand that almost any kind of event, ranging from those perceived as serious threats from an "objective" medical point of view to those that are of "personal" or "symbolic" importance, can pose a threat to the needs or goals of an individual at a particular time of his life. By a threat to life goals, we mean a hazard to such basic security needs as love or affectional ties, a sense of identity, or, most important of all, body integrity, one's very existence.

Thus, for a given person, a change in status or role or a loss of a loved one, a job, or self-esteem may be threatening and may make him vulnerable to breakdown. Of course, every stressful event does not lead to a crisis state; only those which are meaningful to the individual and which overtax his current coping capabilities lead to crises.

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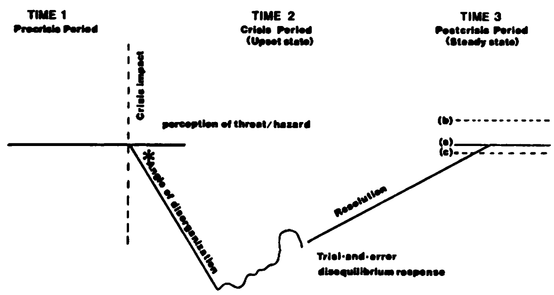

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Crisis resolution refers to the development of effective adaptive and coping devices through the use of the patient's own resources and through the intervention of health care personnel, family members, and significant others who steer him toward a solution to his problem. Thus, tension and anxiety, which have been mounting during the perception and response phases, begin to diminish during this period. Hopefully, the individual will once again be able to rely on his own problem-solving methods, as well as to use the new coping methods he has learned when other problems occur. In this sense, crises afford an opportunity for emotional growth.

We may roughly diagram the crisis sequence as shown in Figure 1.

In crisis intervention the main point to keep in mind is that, during the disequilibrium phase, when the patient's habitual coping mechanisms are proving inadequate, he is especially receptive to professional intervention. This is the time when a crisis worker can have major impact, insuring that the patient develops new and more effective problem-solving methods and emerges from the crisis with heightened emotional strengths.

Training Issues

In order for emergency medical personnel to intervene optimally from a medical and psychologic point of view, personnel should be attuned to psychological components which are all too frequently overshadowed by the medical care requirements. Every patient who has been physically injured has sustained an emotional shock as well! One's manner, words, attitude treat the victim as one's fingers, hands or ears respond to the physical injury. Many patients will recount that although in a state of shock they were quite aware of the words and behaviors of their caretakers. One can appreciably lower anxiety and fear, the *normal* concomitants of most accidents, by appropriate talk or touching behavior. Furthermore, it is quite to be expected and within a normal behavior response pattern for emergency workers themselves to have feelings about what they have seen or done. You can be an excellent worker and still be a responsive human being. You may feel nauseated, upset, scared, frustrated, angry or impatient. If you ask your colleagues or supervisors, you will find that they have and do feel this way.

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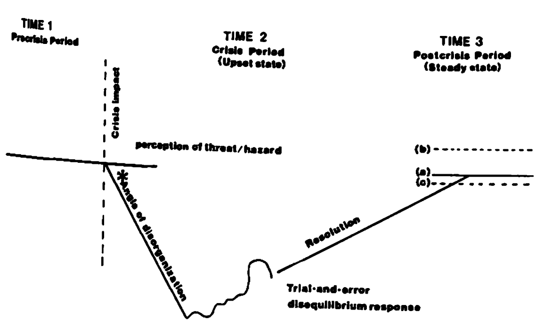

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In order for emergency medical personnel to intervene optimally from a medical and psychologic point of view, personnel should be attuned to psychological components which are all too frequently overshadowed by the medical care requirements. Every patient who has been physically injured has sustained an emotional shock as well! One's manner, words, attitude treat the victim as one's fingers, hands or ears respond to the physical injury. Many patients will recount that although in a state of shock they were quite aware of the words and behaviors of their caretakers. One can appreciably lower anxiety and fear, the *normal* concomitants of most accidents, by appropriate talk or touching behavior. Furthermore, it is quite to be expected and within a normal behavior response pattern for emergency workers themselves to have feelings about what they have seen or done. You can be an excellent worker and still be a responsive human being. You may feel nauseated, upset, scared, frustrated, angry or impatient. If you ask your colleagues or supervisors, you will find that they have and do feel this way.

Training in the management of psychiatric emergencies requires a certain experiential component that is not necessarily required in traditional medical management. Emergency medical instructors are more sensitized to their difficulty in teaching the management of psychiatric emergencies as I have learned from addressing such groups in Maryland, Michigan, and North Carolina. They need experienced psychiatrists and psychologists who can teach practical management techniques while simultaneously sensitizing the caregivers to their own attitudes. It would take an extraordinary psychiatrist or mental health professional to be able to effect that task in the two to four hours maximum that is currently allocated to most emergency medical technician's 81-hour training programs. What is really needed is a basic commitment on the part of emergency medical systems directors to make psychiatric emergencies themselves, as well as the emotional components of medical emergencies a high priority item rather than an afterthought because federal regulations require it for obtaining funds.

I have seen little to change my impression in the past years. I do not believe that any emotionally disturbed citizen generating an emergency medical call has a chance of receiving the same quality of care for his emotional wounds as he would for his physical wounds.

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Respiratory Insufficiency

THE PREVENTIVE USE OF PEEP IN MAJOR TRAUMA

T. Crawford McAslan, M.D. and R Adams Cowley, M.D.

Respiratory insufficiency is recognized as a frequent complication of major blunt trauma. While there has been ready acceptance of its association with direct thoracic trauma, it has been recognized for many years that respiratory failure could also follow non-thoracic trauma, that is in the absence of any clinical evidence of direct thoracic injury. During the First World War it was known as "Traumatic Pulmonary Massive Collapse" and in World War II as "The Wet Lung." The illness, characterized by cyanosis and tachypnea developing within the first 24 to 72 hours following trauma, was described by Grant and Reeve[1] in 1951 and by Mallory[2] in 1952. Moutier[3] had reported a similar syndrome in 1918 which he had observed following gunshot wounds of the head.

That significant arterial oxygen desaturation could follow many types of trauma has been recognized:

a) hemorrhage – Schnedorf and Orr,[4] Cournand,[5]
b) chest trauma – Whitman and Norman,[6]
c) skeletal trauma – Cournand,[5]
d) abdominal injuries – Cournand,[5]
e) burns – Cournand et al,[5] Richards,[7] Jackson.[8]

In any trauma victim, particularly in the presence of an impaired level of consciousness, the potential of hypoxic injury to the pulmonary capillaries or the initiation of chemical pneumonitis the result of aspiration is always present but perhaps masked by supportive ventilation and augmented oxygen administered by rescue personnel. In automobile victims, significant carbon monoxide levels may go unsuspected unless deliberately measured. The concomitant presence of a low hemoglobin, or poor cardiac function the result of tension pneumothorax, hypovolemia or either direct or hypoxic injury of the myocardium, will compound the deficiency of oxygen transportation. In the presence of any increased capillary permeability and in the presence of constricted arterial and venous beds in the compensated phase of shock, overzealous resuscitation, particularly with colloid deficient infusates, will further magnify the developing interstitial edema.

Despite the significant advance in the management of blunt thoracic trauma following the introduction by Avery et al[9] of "internal pneumatic stabilization" using intermittent positive pressure ventilation (IPPV), mortalities of 15 to 35 percent are still reported.[10,11,12]

Respiratory insufficiency associated with non-thoracic trauma (Wet lung, Shock Lung, RDS of Trauma) was formerly associated with a high mortality of 60 to 90 percent.[13] The application of the use of continuous positive pressure ventilation (CPPV) to the treatment of this form of acute respiratory insufficiency, first reported in 1967 by Ashbaugh et al,[14] resulted in a reduction in mortality to those of 15 to 30 percent currently reported.[15]

If the institution of therapy for respiratory insufficiency, whether the result of thoracic or non-thoracic trauma, is delayed until gross clinical signs are present, it is generally conceded today that, despite the use of CPPV, mortality will be high. As a result, various criteria have been established based on the alveolar/arterial oxygen tension gradients taken along with other factors, which may be used in the determination as to when to introduce mechanical ventilation of the patient utilizing a volume-limited ventilator and the application of positive end-expiratory pressure (PEEP).

This paper will present the experience in the Maryland Institute for Emergency Medicine in the development of our currently used methods of management of respiratory insufficiency associated with blunt trauma the result of high speed automobile accidents.

Definition of Respiratory Insufficiency

Campbell[16] has defined respiratory insufficiency as the inability of a subject at rest, breathing air at sea level, to maintain an arterial oxygen tension above 60 Torr. We define severe respiratory insufficiency, sufficient to require the placing of a patient on a mechanical ventilator, as the inability to maintain an arterial oxygen tension of greater than 60 Torr on an inspired oxygen concentration of 30 percent (F_IO_2 0.30) such as is approximately achieved on nasal oxygen, an Ayre's T-tube or a tracheostomy collar. This represents a shunted

TABLE 1: Incidence of RDS Following Major Trauma

Major Trauma Victims	Number Developing RDS	
238	32 (13.4%)	Simmons et al, Vietnam, 1968
122	47 (38.5%)	Wilson et al, Wayne State, 1969
147	43 (29.3%)	McAslan et al, Univ. of Md., 1971
36	12 (33.3%)	Powers et al, Albany Medical College, 1972
52	15 (28.9%)	James, Bowman Gray, 1973

TABLE 2: Mortality in RDS Following Major Trauma

Major Trauma Victims	Number Developing RDS	Deaths	
238	32	13 (40.6%)	Simmons et al, 1968
122	47	44 (93.6%)	Wilson et al, 1969
?	78	73 (93.6%)	Wilson et al, 1969
147	43	8 (19.0%)	McAslan et al, 1971
?	25	4 (16.0%)	Geiger et al, 1971
?	36	12 (33.3%)	Powers et al, 1972
52	15	4 (26.7%)	James, 1973
		Fat Embolism	
?	15	4 (26.7%)	McNamara et al, 1971
130	15	7 (46.7%)	Chan et al, 1973

fraction of the cardiac output of greater than 20 percent ($\dot{Q}s/\dot{Q}t$ = .20), assuming an arterial/mixed venous oxygen content difference of five volumes percent.

Incidence and Mortality

Using the above criteria we have demonstrated a 30 percent incidence of severe respiratory insufficiency in automobile trauma victims 24 hours after their initial trauma. This is in keeping with other reports in the literature (Table 1). A review of the published mortality in patients who develop respiratory insufficiency is presented in Table 2, the wide variation being dependent not only on the type of therapy but on how early the therapy was commenced.

Development of Respiratory Management Used in MIEM

We had observed during 1968/69 that the application of positive end-expiratory pressure using a volume ventilator (Engström 200) during cardiopulmonary bypass and continued into the postoperative period, resulted in a dramatic reduction in our incidence of "post-perfusion lung." It is interesting to note that an expiratory resistance control had been introduced in 1955 and a positive end-expiratory pressure control in 1956 on the Engström ventilator and were used to maintain the "functional residual air" during the anesthetic management of patients undergoing a thoracotomy.[17]

During the first 12 months following its opening in June, 1969 our Institute functioned mainly as a center for the referral of the complications of surgery and major trauma in addition to managing post open-heart surgical patients. Despite the use of volume limited ventilators and positive end-expiratory pressure, of 75 patients referred with severe respiratory insufficiency following automobile trauma during this period, 30 patients died, a mortality of 40 percent.

During 1970 the introduction of the helicopter evacuation program enabled us to admit, rapidly from the scene, victims of high speed automobile accidents. In 1970/71 it was our practice to manage patients who had sustained head trauma with hyperventilation to arterial carbon dioxide tension levels of 25 ± 5 Torr. Patients who had sustained a flail chest were also managed from admission with intermittent positive pressure ventilation. In all other patients, arterial blood gases were followed closely and, when a patient met the criteria of failing to maintain an arterial oxygen tension of greater than 60 Torr on an F_IO_2 of .30, he was placed on a volume ventilator (Engström 300) with an initial positive end-expiratory pressure of 5 cm H_2O. Fluids were restricted to that sufficient to maintain a basal urine output. Alveolar to arterial oxygen tension gradients were followed, using an automated respiratory gas monitoring system.[18] The F_IO_2 was restricted to 60 percent or less following our demonstration that high inspired oxygen concentrations increased intrapulmonary shunting.[19] Where an F_IO_2 of greater than .40 was required to maintain a PaO_2 greater than 60 Torr, the PEEP was increased stepwise in 5 cm H_2O increments, observing the response on the cardiac output as evidenced by the arterial/venous oxygen constant difference (a-$\bar{v}DO_2$). It was rarely found necessary to exceed PEEP levels of 15 cm H_2O, 10 cm usually proving adequate. This therapy was continued until the patient could maintain adequate levels of oxygen, that is, a PaO_2 greater than 60 Torr on an F_IO_2 of .30 or .40 with a PEEP of zero. In the case of patients with a flail chest, mechanical ventilation was continued until the flail had stabilized, frequently over a period of two to three weeks.

A major part of the defect in pulmonary mechanics in these patients had been shown to be an increase in airway resistance. We had, therefore, selected the Engström 300 ventilator since its inspiratory flow pattern included an inspiratory pause, allowing better equilibration of "fast and slow" alveolar units, in addition to possessing an end-expiratory pressure control. The peak (P max) and end-expiratory (P_{IE}) pressures allowed monitoring of changes in airway resistance and static compliance, respectively.

Using a regime described above during 1971, of 43 patients who developed respiratory insufficiency, eight patients died – a mortality of 19 percent.

By close monitoring of alveolar/arterial oxygen tension values (A-ADO_2) we had observed gradients developing progressively from admission, frequently attaining serious levels within a few hours, in patients who had sustained non-thoracic trauma (Figure 1). We were unable to predict which patients would develop these gradients — frequently observing this in the absence of shock levels of blood pressure or volume replacement in excess of 20 percent blood volume. It had also been observed in the absence of surgery and anesthesia.

In 1970 we had been able to demonstrate the effect of the application of positive end-expiratory pressure in significantly reducing the increase in airway resistance, the decrease in lung compliance and the development of hypoxemia associated with experimentally induced platelet aggregation in dogs.[20] This prompted us in 1972, to investigate the value of aggressive preventative respiratory management using PEEP in all patients who gave a history of being involved in major high speed automobile accidents and who were transported to the Institute. It was our hope that we could modify the course of the pathophysiology associated with the development of severe respiratory insufficiency whether the result of thoracic or non-thoracic trauma, and so secure a reduction in our mortality below that of the 19 percent we were then achieving.

The criteria for patients considered at risk were: a history of a major high speed automobile accident, suspicion of major blunt trauma, a mean arterial pressure less than 60 Torr at any time, however brief, greater than 20 percent blood volume replacement.

In addition, this preventative management was applied to (a) all patients who had impaired levels of consciousness and (b) patients who were diagnosed as having sustained a lung contusion (a non-segmental infiltrate present within 6 hours of trauma associated with an arterial oxygen tension on room air on admission of below 60 Torr). We did not consider that flail chest in itself was an indication, but in association with

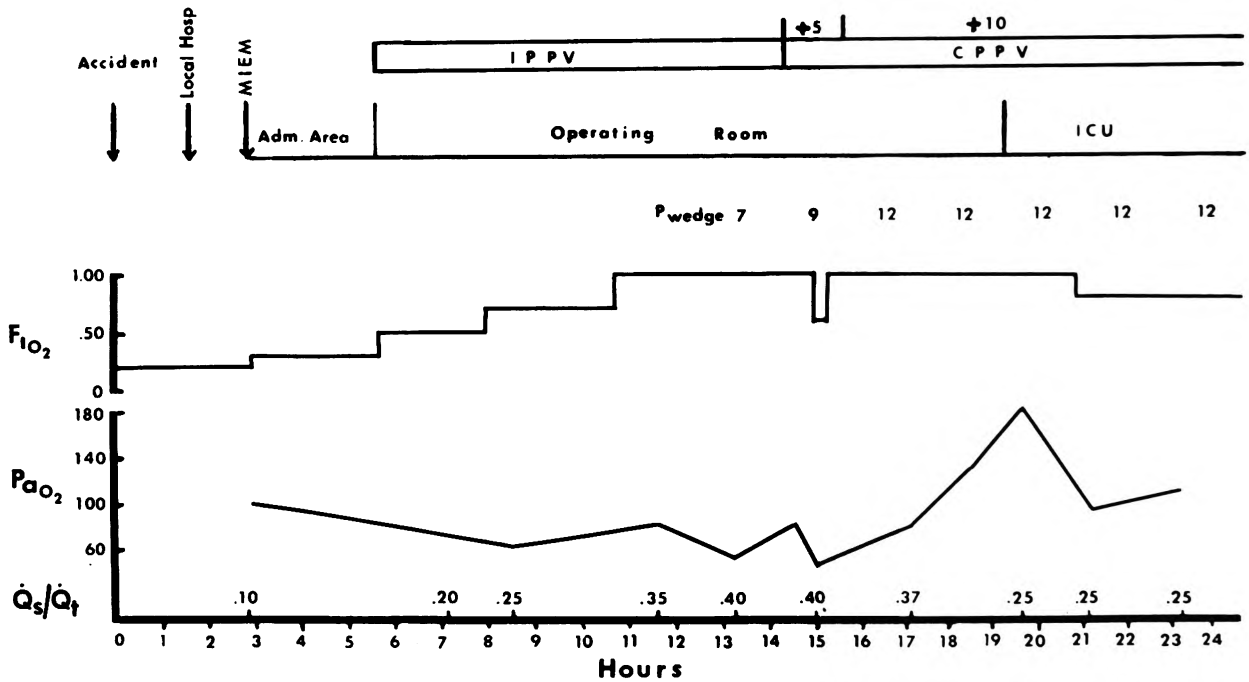

FIGURE 1: Illustration of progressive development of respiratory insufficiency within a few hours of an acute accident in which a pedestrian, a 22 year old male (173 cm, 77 Kg) sustained fractures of pelvis, left femur, tibia and calcaneus, fracture dislocation of right knee and left metacarpal (no head, chest or abdominal trauma). After first being moved to a local hospital he was transferred to MIEM about 3 hours after the accident. Despite a progressive increase in FI02 ultimately to 1.0, by 10½ hours after the accident his Pa02 could not be elevated above 60 mmHg ($\dot{Q}s/\dot{Q}T$> .40). Note that his P wedge was 7 mmHg. The introduction of 5 then 10 cm H20 PEEP on the Engstrom ventilator produced a rapid reduction of his intrapulmonary shunt. He remained in the ICU on the ventilator for 7 days, at which time he was permitted to breathe spontaneously. He subsequently had a normal convalescence.

pulmonary contusion, chronic lung disease, an impaired level of consciousness, intra-abdominal injuries likely to result in ileus, skeletal injuries necessitating immobilization or incipient renal failure, preventative ventilation with PEEP was initiated.

On arrival in the Admitting Area all patients meeting these criteria were intubated using endotracheal tubes with large volume, low pressure cuffs. After excluding the presence of a tension pneumothorax they were placed on an Engström ventilator at a frequency of 20. The minute volume was increased by increments until the respiratory drive was satisfied and the patient in phase with the ventilator. Where a head injury was suspected, patients were in addition, hyperventilated to a $PaCO_2$ of 25 ± 5 Torr. One hundred percent oxygen was administered until the initial arterial blood gas, P_{50}, carbon monoxide saturation and acid base values were obtained. As soon as cardiovascular stability had been achieved by control of hemorrhage and adequate volume replacement, a positive end-expiratory pressure of 5 cm H_2O was applied. There was continual close observation for the possible extension of a previously undiagnosed pneumothorax. Simultaneously other members of the team placed femoral arterial, central venous and/or pulmonary arterial catheters for monitoring with, in addition, four large calibre venous lines for infusion. Resuscitation and diagnosis proceeded simultaneously. Details of the resuscitation methods used in MIEM have been presented elsewhere in this conference.

The ventilatory management was continued into the adjoining operating room and subsequently to the Critical Care Unit, with serial monitoring of:

- alveolar/arterial oxygen tension ($A\text{-}aDO_2$)
- arterial/alveolar carbon dioxide tension ($a\text{-}AD_{CO_2}$)
- arterial/mixed venous oxygen content ($a\text{-}\bar{v}DO_2$)
- Hemoglobin
- P_{50}
- acid-base
- Maximum Airway Pressure (P max)
- End Inspiratory Pressure (P_{IE}')
- End Expiratory Pressure (P_{EE}')

If a PaO_2 greater than 60 Torr could not be attained on an F_IO_2 of .40 and provided cardiac output was deemed adequate, PEEP was increased in 5 cm H_2O increments. Optimal PEEP was defined as the value used before an increase in $a\text{-}\bar{v}DO_2$ was observed (Figure 2).

At the end of 24 hours or at 0800 on the morning following admission, the patient was re-evaluated. If he could maintain a PaO_2 of greater than 60 Torr or an F_IO_2 of less than .40 on a positive end-expiratory pressure of zero, and provided he was stable with no other impairment of major organ function, he was removed from the ventilator and extubated. Close monitoring was continued for a further 24 hours. If the criteria for respiratory insufficiency were subsequently met the patient was immediately reintubated and replaced on the ventilator.

If, 24 hours following admission, the patient was not considered able to be removed from the ventilator, ventilation was continued with monitoring as outlined above, with optimal PEEP, appropriate F_IO_2 and minute ventilation adjustments

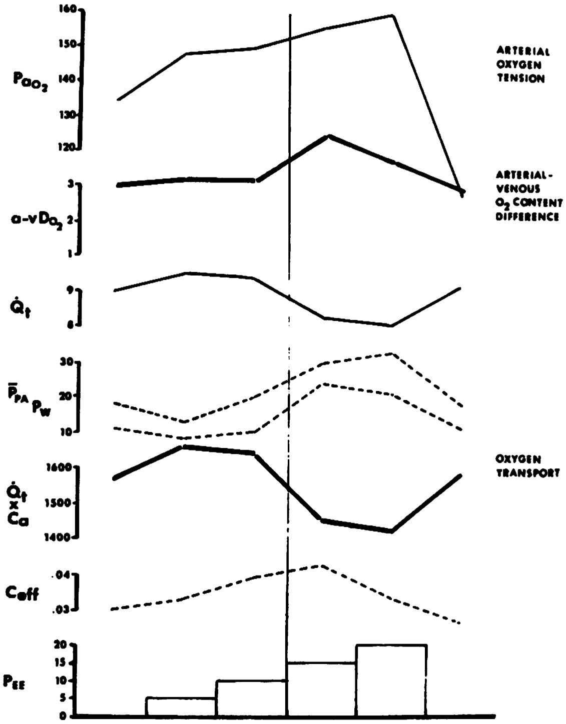

FIGURE 2: The determination of optimal PEEP by stepwise increase from 0 to 20 cm H20 then returning to 0 with 15 minutes at each step. While the Pa02 rose with each step increase, beyond 10 cm H20 the cardiac output fell and the a-vD02 increased. Oxygen transport also fell at this point. Optimal PEEP at this time was therefore 10 cm H20.

made as necessary. Re-evaluation as to fitness to be removed from the ventilator was customarily carried out each morning. Specific respiratory monitoring included arterial and mixed venous blood samples drawn 6 hourly routinely, respiratory gases monitored each hour automatically (RICS, Scientific Research Instruments, Baltimore, Maryland) and airway pressures recorded hourly. An x-ray of the chest was taken each morning. Respiratory physical therapy was carried out preventatively and therapeutically by full time therapists. If mechanical ventilation required continuance beyond 48 hours a tracheostomy was invariably performed using large volume, low pressure cuffs. Micropore filters were not used and steriods were not administered specifically for respiratory dysfunction.

Initially, during 1972/1973 it was our practice, following the initial resuscitation and stabilization after surgery, to restrict fluids to that sufficient to maintain a basal urine output of 30 to 60 ml per hour. If the alveolar/arterial oxygen tension difference progressively increased over the first 24 hours, 25 percent albumin (Salt poor) was administered along with Furosemide. It should have been apparent that fluid would not be specifically mobilized from the pulmonary interstitial space and frequently overzealous therapy resulted in depletion of total extravascular fluid. Many of the cases of renal failure observed during this period could, in part at least, be attributed to this therapy. From 1974, fluids were administered more liberally, using the response of the pulmonary wedge pressure to sequential volume challenge to obtain optimal cardial function, the lungs being "protected" by the use of "optimal levels of PEEP." The use of the albumin/Furosemide regimen was phased out.

When the patient met the criteria previously described, he was removed from the ventilator. Neither "weaning" nor intermittent manditory ventilation was practiced. If a patient failed to come off the ventilator when anticipated, mechanical ventilation was re-instituted for a further 48 hours before a further attempt was made, presuming the necessary criteria were then met. In pulmonary contusion the decision to discontinue ventilation was based not only on the above criteria but on the rate of clearing of the densities — 60 percent clearing in two days, 80 percent within three days.

Results

The results for 1972 through 1975 are presented in Table 3. During this period 1,676 patients were admitted alive to the Institute having sustained blunt trauma the result of high speed automobile accidents. Of these, 1,166 (69.6%) met the criteria for immediate intubation and mechanical ventilation with the application of PEEP. At the end of 24 hours, 649 patients were removed from the ventilator. The remaining 517 exhibited evidence of progressive respiratory insufficiency over the first 24 hours and were maintained on CPPV for varying periods, in two patients for 100 days. There were no deaths the result of respiratory insufficiency in this group during 1974 or 1975. It is of interest to observe that there were no deaths from pulmonary embolism, and not a single case of fat embolism was diagnosed clinically despite the occurrence of fractures of the lower limbs or pelvis in excess of 40 percent of the patients.

Complications Associated with CPPV

A fall in cardiac output associated with the use of CPPV has rarely presented any problem provided attention was paid to long standing principles of mechanical ventilation, namely:

1) adequate volume replacement,

2) provision of an expiratory pause of not less than twice the inspiratory time,

3) gradual addition of any increment of PEEP and selection of optimal PEEP, by observation of the response of a-$\bar{v}DO_2$.

TABLE 3: MIEM Helicopter Admissions
High Speed Auto Trauma

	Admitted alive to MIEM	Admitted to ICU 24 hrs.	Mechanical vent 24 hrs.	Deaths in ICU	Deaths from Respiratory Failure
1972	341	255	90	23	1
1973	443	333	108	35	2
1974	455	358	165	38	0
1975	437	370	154	40	0

4) attention to keeping the patient "in phase" with the ventilator,

5) caution in the presence of myocardial insufficiency, and

6) caution in the presence of "sympathectomized patients."

The problem of sepsis, in particular that of Pseudomonas superinfection, was a major cause of morbidity and mortality in our early experience and has continued to require continued vigilance. It has been brought within manageable bounds by: restriction in the use of prophylactic broad spectrum antibiotics, and scrupulous attention to sterility of equipment and to techniques of nursing and physician personnel.

Tracheal stenosis has in the past been a major problem associated with mechanical ventilation. During 1971, of surviving tracheostomies in our Institute, 4 required tracheal resection (14.3%). With the adoption of large volume, low pressure tracheostomy cuffs, the monitoring of cuff pressures and the earlier performance of tracheostomies, we have greatly reduced its incidence (Table 4). With the introduction of similar cuffs on endotracheal tubes since January 1, 1975, it is hoped to achieve a still greater improvement.

The complication of pneumomediastinum associated with CPPV in the absence of a pulmonary laceration is the result of maldistribution rather than that of elevated airway pressures as was shown by Machlin and Hamman some 30 years ago. Attention to keeping the patient "in phase" with the ventilator by satisfying the ventilatory drive, rather than resorting to intermittent curare or narcotics, largely eliminates the problem but does not excuse any lack of constant alertness as to its possibility. The insertion of subclavian central venous lines in patients on mechanical ventilators is recognized as being associated with an extremely high incidence of pneumothorax.

As the mean airway pressure is elevated, the central venous pressure becomes elevated, and the intracranial pressure reflects this increase, the rise being dependent on the intracranial compliance. We have not observed any serious rises using PEEP levels up to 10 cm H_2O. However, when patients are on continuous positive pressure ventilation, and in addition, are suffering from severe head injuries, close attention must be paid to cerebral perfusion pressures (Figure 3).

Conclusions

If, following major blunt trauma, the diagnosis of respiratory insufficiency is delayed until it is grossly apparent on clinical examination, a mortality in excess of 30 percent may be expected. If therapy is instituted with continuous positive pressure ventilation on the detection of a progressive deterioration of the oxygenation of arterial blood, the mortality can be further reduced to some 20 percent.

It is possible, by aggressive ventilatory management of all such patients from admission, throughout surgery and in the post surgical period, to reduce mortality due to respiratory insufficiency to insignificant levels.

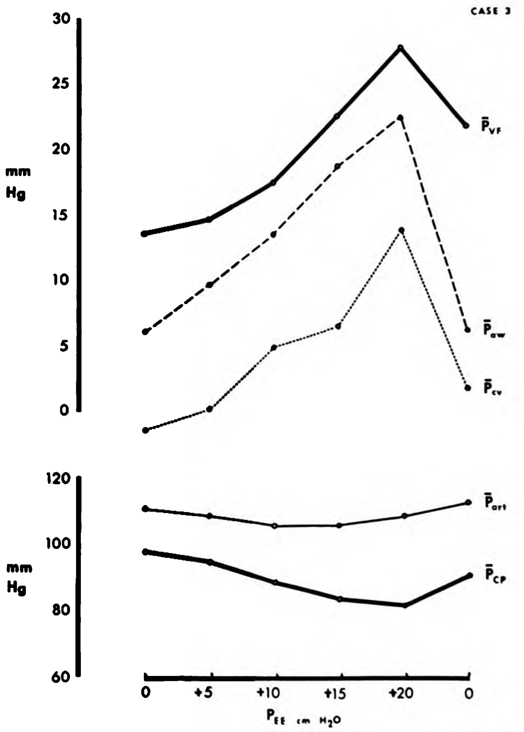

FIGURE 3: The influence on a patient with low intracranial compliance of stepwise increase of PEEP, 30 to 60 seconds at each step. The cerebral perfusion pressure fell at each step but at no time below 80 mmHg.

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TABLE 4: Incidence of Tracheal Stenosis Following Tracheostomy and Mechanical Ventilation

Year	No. of Admissions to ICU > 24 hrs.	No. of Tracheostomies	No. of Surviving Tracheostomies	No. of Patients with Respiratory Obstruction Requiring Surgery
1971	150	47 (31.3%)	28	4 (14.3%)
1972	255	76 (29.8%)	53	1 (1.9%)
1973	333	86 (25.8%)	61	2 (3.3%)
1974	358	98 (27.4%)	79	3 (3.8%)
1975	370	84 (22.7%)	59	1 (1.7%)

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RESPIRATORY INSUFFICIENCY INCIDENT TO THORACIC TRAUMA

Emil A. Naclerio, M.D.

Respiratory insufficiency is a common occurrence following thoracic trauma. Of special clinical importance is the fact that it often exists undetected and uncorrected, particularly in patients with retained bronchial secretions, and as such, may rapidly progress to profound respiratory failure, cardiovascular collapse and consequent sudden and unexpected death (Figure 1). Of equal importance is the fact that the seriousness of respiratory insufficiency is often masked by a deceptively reassuring clinical appearance of the patient.

Because respiratory insufficiency of some degree exists in practically every patient with chest trauma, even in the absence of overt symptoms or physical signs, alertness to its possibility is vital to its recognition. Once suspected and accurately diagnosed, respiratory insufficiency can usually be promptly corrected.

Etiologic Diagnosis

The etiologic diagnosis of respiratory insufficiency incident to thoracic trauma can frequently be made by a careful history and a thorough physical examination. These diagnostic means, in themselves, will often bring to light the presence of any one or combination of the underlying pathologic processes (mechanical thoracic defects) involved in chest injuries causing respiratory insufficiency (Figures 2, 3).

Roentgenologic studies of the chest and other appropriate laboratory studies — particularly blood gases — are essential in occult situations of respiratory insufficiency complicating thoracic trauma especially when there are minimal or no physical findings.

Respiratory insufficiency in patients with chest injuries occurs most commonly in those with severe chest wall pain secondary to multiple rib fractures, particularly when the rib fractures result in flail (stove-in) chest. Respiratory insufficiency is also common in patients with associated brain damage complicated by depressed medullary control of ventilation, and in patients with preexisting pulmonary disease, namely chronic bronchitis, asthma and emphysema. In these circumstances, the harmful functional effects of the injury are greatly exaggerated.

The pathologic processes which complicate thoracic trauma and cause respiratory insufficiency may be conveniently classified into three categories:

1) Those which result in hypoventilation. These include multiple rib fractures complicated by chest wall pain, flail chest incident to instability of the chest wall, pain of chest wall injury producing splinting, pneumothorax, hemothorax, diaphragmatic herniation and widespread atelectasis secondary to bronchial obstruction caused by retained bronchial secretions (Figures 2, 3). These pathologic processes are characterized by decreased tidal and minute volumes, decreased arterial oxygen tension (PaO_2) and increased arterial carbon dioxide tension ($PaCO_2$).

2) Those which impair diffusion of gases across the alveolar-capillary membrane. These include pulmonary hemorrhage, pulmonary edema and alveolar-capillary damage secondary to aspirated blood, gastric secretions or other foreign matter, or changes in alveolar integrity in systemic involvements incident to shock from acute hypovolemia or severe wound damage, sepsis, fat embolism, thromboembolism, fluid overload, and overtransfusion in patients with major extrathoracic vascular or organ injury.

These pathologic states incident to trauma are characterized by hyperventilation and reduction in PaO_2; the $PaCO_2$ may be normal or decreased. Severe ventilation-perfusion imbalance is frequently the true cause of what appears to be a diffusion abnormality.

3) Those which result in decreased pulmonary arterial perfusion and oxygen transport from pulmonary to systemic circulation for tissue oxygenation. These include traumatic states complicated by a diminished cardiac output such as injury to the myocardium with or without acute hemopericardium and tamponade, hypotension, diminished blood volume, and congestive heart failure.
These pathologic states are characterized by oxygenation failure and hypercapnia as a preterminal event.

The above categories frequently overlap; the net result is hypoxia (Figure 4).

Physiologic Evidence of Respiratory Insufficiency

HYPOVENTILATION

Simply stated, hypoventilation is an abnormal respiratory state in which there is failure to move sufficient air in and out

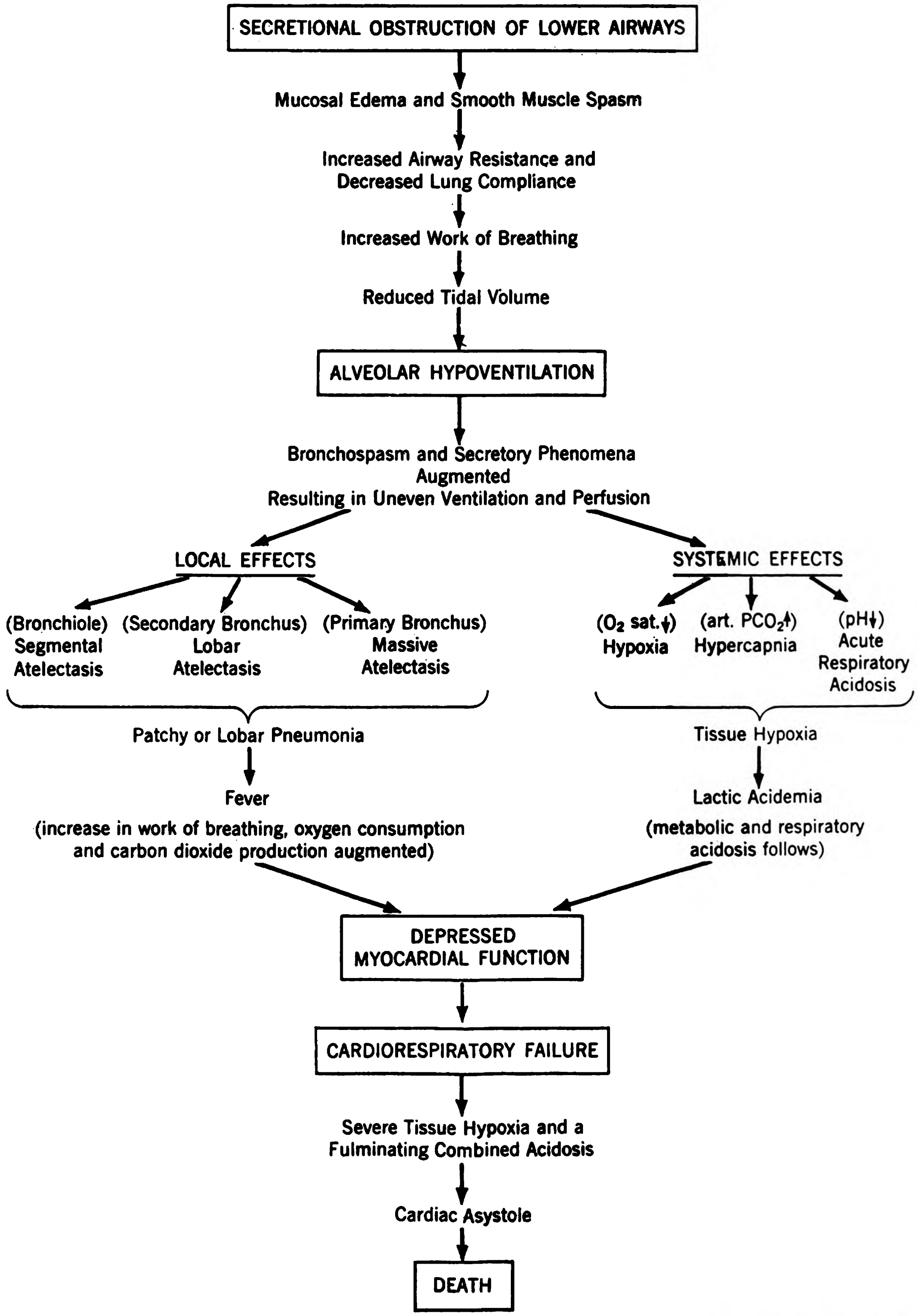

FIGURE 1: Schematic demonstration of sequence of physiopathologic events following persistent retention of bronchial secretions. Retained bronchial secretions exist to some degree in practically every patient with a chest injury. When severe and persistent, the consequences are serious and frequently lethal.

of the lungs. Consequently, respiratory exchange becomes inadequate to rid the body of excess CO_2 and to oxygenate the blood. The respirations are either too shallow or too slow to maintain a normal partial pressure of oxygen in the alveoli and to remove the accumulating CO_2. Hence, when the patient is breathing room air, the PaO_2 tends to fall and the $PaCO_2$ tends to rise. These findings are often the only indication of the seriousness of alveolar hypoventilation. When the $PaCO_2$ exceeds its normal range, respiratory acidosis results.

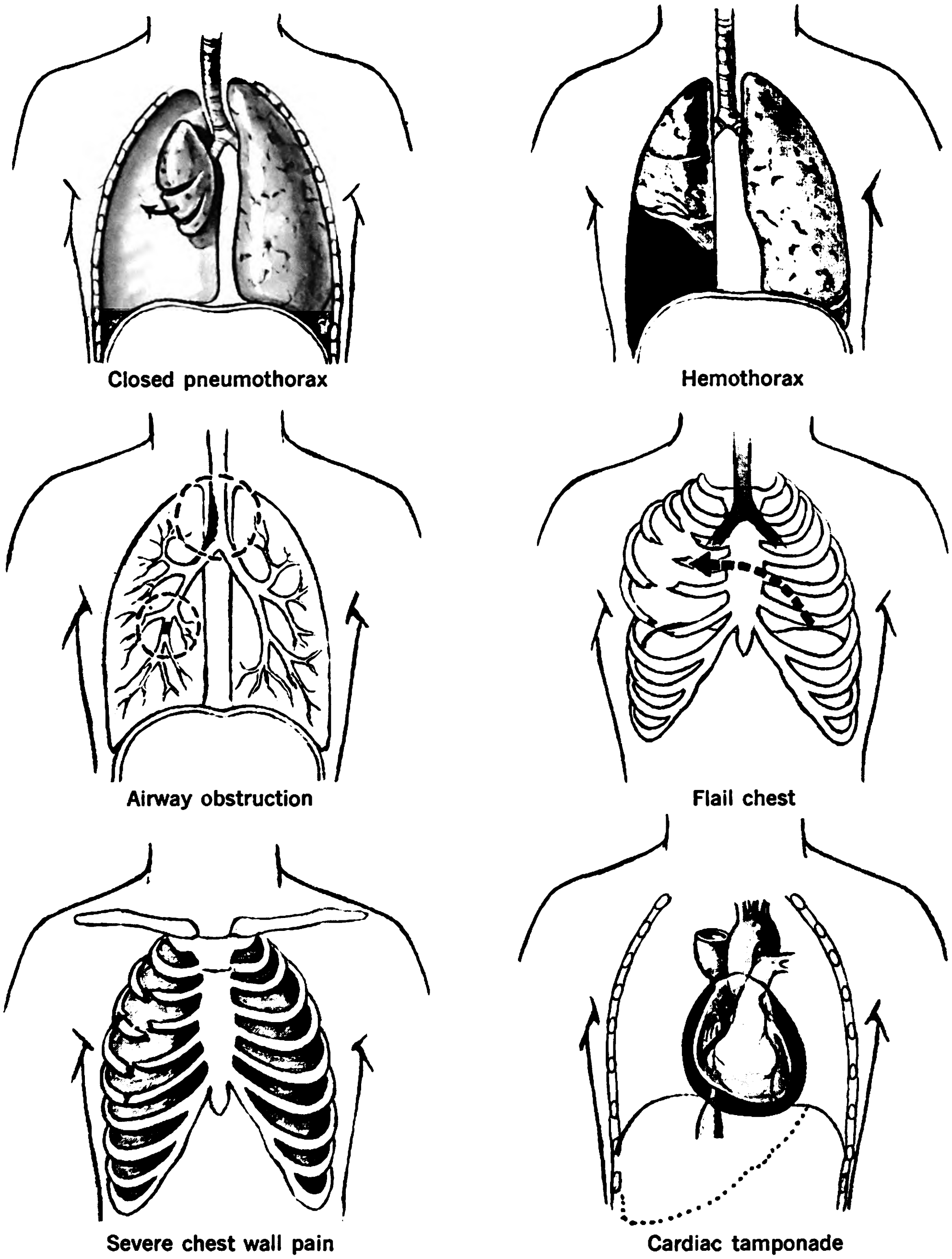

FIGURE 2: Thoracic Mechanical Defects. These common pathologic processes incident to chest trauma either separately or in combination, frequently lead to alveolar hypoventilation, ventilation-perfusion defects, and decreased pulmonary arterial perfusion and oxygen transport from pulmonary to systemic circulation.

If alveolar hypoventilation progresses and hypoxia becomes severe and persists, metabolic acidosis characterized by a base deficit ensues, due to the release of lactic acid consequent to anaerobic glycolysis in the tissues (Table 1).

VENTILATION–PERFUSION IMBALANCES

Ventilation-perfusion imbalances are of two main types but frequently exist simultaneously. In one type, alveoli are well perfused but poorly ventilated. Examples of this type of imbalance are widespread atelectasis and post-traumatic pulmonary insufficiency. These processes result in a significant veno-arterial shunt and are associated with a low PaO_2 and an increase in alveolar-arterial oxygen gradient. The $PaCO_2$ is usually normal or below normal. Measurement of the alveolar-to-arterial oxygen tension gradient is an expression of the magnitude of the shunt; it is easily determined by measuring the PaO_2 in the patient breathing a known value of inspired oxygen. However, to obtain precise characteristics of the interpulmonary shunt requires more elaborate physiologic studies.

In the other type of ventilation-perfusion defect, alveoli are well ventilated but poorly perfused. Examples of this type of ventilation-perfusion imbalance are severe hypotension and hypovolemia. In these circumstances, there is an increase in physiologic dead space, an increase in dead space volume to tidal volume ratio, and an increase in $PaCO_2$.

NONUNIFORM ALVEOLAR VENTILATION

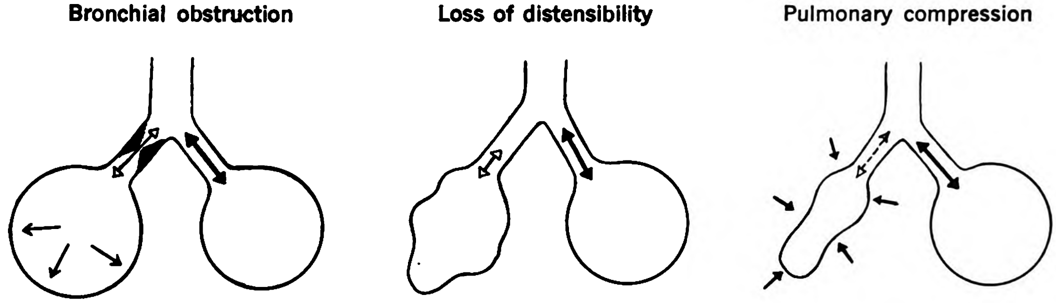

FIGURE 3: Schematically shows most common causes of uneven alveolar ventilation in patients with chest trauma: these, when severe, result in hypoxia, hypercapnia and acidosis (respiratory and metabolic). Left – Bronchial obstruction: retained bronchial secretions, inflammation of bronchial mucosa and aspirated foreign material. Middle – Regional loss of pulmonary elasticity: pulmonary contusion, hematoma of lung and atelectasis. Right – Pulmonary compression: pneumothorax, hemothorax, flail chest and diaphragmatic hernia.

FLAIL CHEST

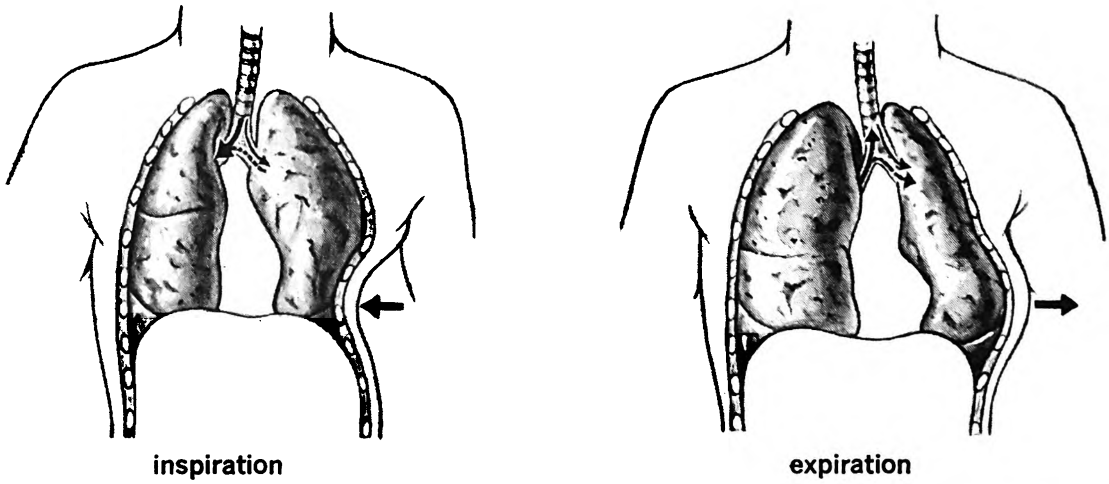

FIGURE 4: In flail chest immediate compromise of the thoracic cage as a pump and the lungs as a gas exchange mechanism ensues. Chest wall pain and suppressed cough reflex result in decreased tidal volume and retained bronchial secretions. Mechanical work of breathing to provide effective alveolar ventilation is greatly increased. Pulmonary dysfunction is further aggravated by edema and hemorrhage in contused lung; atelectasis and a low functional residual capacity follows, causing both impaired ventilation and ventilation-perfusion imbalance. Sequence of deteriorating events in these patients can be prevented by early use of mechanical ventilation.

Recognition of Respiratory Insufficiency

The clinical findings of acute respiratory insufficiency are those resulting from hypoventilation, hypoxia and acidosis. The signs and symptoms of respiratory dysfunction may be obvious and dramatic, but more often they are so subtle that even the astute observer may fail to realize that respiratory insufficiency is present.

When ventilation is only slightly impaired, clinical findings are often lacking. One may observe an increased rate of breathing at the expense of depth; this finding often gives a false impression of adequate ventilation. When ventilation is moderately or severely impaired, dyspnea is usually a prominent feature. However, the signs and symptoms of respiratory insufficiency are essentially those of hypoxia, hypercapnia and acidosis.

In many instances, the clinical findings simulate those of the underlying injury. For example, in the patient with a flail chest and associated cerebral damage, an elevated blood pressure, bradycardia and cyanosis may be ascribed to cerebral injury. However, laboratory studies — particularly blood gases — will demonstrate that the existing signs and symptoms are those of hypoxia, hypercapnia and acidosis (Table 2).

HYPOXIA

The clinical findings of hypoxia are many and most variable. They relate largely to the degree of decreased PaO_2 and the rapidity of its fall. Dyspnea is a common sign which is difficult to recognize in patients who have been sedated. Cyanosis, a manifestation of hypoxia, is not perceptible until the arterial oxygen saturation is below 80 to 85 percent; severe tissue hypoxia can occur in the absence of detectable cyanosis. Hence, cyanosis is a late sign of tissue hypoxia.

In mild states of hypoxia, there is usually an increase in heart rate, respiratory rate, cardiac output and blood pres-

TABLE 1: Ventilatory Insufficiency

Biochemical Triad	Arterial Blood Changes	Normal Range
Hypoxia	Arterial O_2 saturation decreases	Saturation (percent) 94.0–98.0
Hypercapnia	Arterial PCO_2 increases ($CO_2 + H_2O = H_2CO_3$)	CO_2 pressure (mm Hg) 38.0–42.0
Hydrogen ion increase (Hypercapnic acidemia)	pH falls below 7.30	pH 7.34–7.45

Table 1 shows the biochemical blood changes occurring in alveolar hypoventilation. The added factor of tissue hypoxia results in the production of excess lactic acid in the tissues with an accumulation of lactic acid in the blood (lactic acidemia); thus a metabolic acidosis is added to the hypercapnic acidemia already established. The resulting asphyxia is the direct but insidious cause of many misinterpreted grave symptoms and signs and often death.

Column 1 shows the clinical biochemical triad; column 2, the arterial blood changes; and column 3, normal ranges of the arterial blood gases.

sure. Hence, tachycardia, tachypnea and hypertension indicate early signs of hypoxia. However, if the hypoxia persists and becomes severe, bradycardia, arrhythmias and hypotension promptly follow with imminent cardiac arrest. Old or obese patients with relatively minor thoracic injuries and those with pre-existing pulmonary disease often pass very rapidly into the late or terminal stage of hypoxia and profound circulatory failure. Agitation, euphoria and a loss of judgment are characteristic features of hypoxia.

The initial clinical manifestations of tissue hypoxemia are often those of cerebral or myocardial dysfunction rather than signs of respiratory difficulty, principally because the brain and myocardium have the need for high O_2 consumptions.

HYPERCAPNIA

Certain manifestations of respiratory insufficiency may be caused by hypercapnia (CO_2 retention). An early sign of CO_2 retention is vasodilatation with increased cutaneous blood flow and diaphoresis. Increases in $PaCO_2$ also lead to an increased cardiac output, tachycardia and a rise in blood pressure, secondary to stimulation of sympathetic activity with increased circulatory catecholamines (epinephrine and norepinephrine). These findings occur in patients who are still able to respond to sympathetic activation.

A slight increase in $PaCO_2$ directly affects the respiratory center, leading to hyperventilation. However, if the carbon dioxide content is of a degree to result in central nervous system (CNS) depression and muscular weakness, hyperventilation will not occur. The degree of CNS depression incident to elevated blood levels of CO_2 varies greatly ranging from mild sedation to deep coma. Respiratory arrest may occur.

Other manifestations of hypercapnia consist of mental confusion, dull headache, visual disturbances, muscle twitching and cardiac arrhythmias. The combined depressant and stimulant effects of hypercapnia frequently accompanied by those of hypoxia, tend to produce a variable clinical picture.

ACIDOSIS (RESPIRATORY AND METABOLIC)

The principal effect of respiratory acidosis is depression of the CNS. The manifestations include somnolence, disorientation, slurred speech, hypotension and coma. The severity of these signs bears no clear-cut relationship to the level of $PaCO_2$, but is thought to be related to blood pH changes and other chemical changes in the cells or extracellular fluids of the brain.

Respiratory acidosis also affects the myocardium predisposing it to arrhythmias which result in a reduction of cardiac output. It also suppresses the responsiveness of cardiotonic drugs. Hence, acute respiratory acidosis may be easily mistaken for acute myocardial infarction.

An elevated $PaCO_2$ level leads to an increase in cerebrospinal fluid pressure, probably because of the increase in cerebral blood flow that develops during hypercapnic acidosis. This can often be of such severity to cause papilledema which may result in the misdiagnosis of cerebrovascular accident.

Metabolic acidosis in patients with thoracic trauma complicated by hypoventilation is rather uncommon compared to the frequency of acidosis caused by CO_2 retention. However, when the thoracic injury is associated with marked hypovolemia or severe pulmonary insufficiency with severe hyppoxemia (PaO_2 less than 50 mm Hg; O_2 saturation less than 70 percent), a metabolic lactic acidosis will invariably be present.

TABLE 2: Clinical Manifestations of Progressive Ventilatory Insufficiency

Phase I — Hypertension	Pulse slow and bounding
Phase II — Hypotension	Pulse rapid and thready
Phase III — Heart Irregularities	Pulse irregular and weak

Cardiorespiratory Failure and Death

Table 2 serves to point out the sequence of key clinical findings that frequently follow when acute ventilatory failure results in hypoxia, hypercapnia, and acute respiratory acidosis. Hypercapnia, particularly when associated with respiratory and/or metabolic acidosis, depresses every tissue function in the body as well as cardiac and cerebral function.

Restlessness, depressed sensorium, hypertension, hypotension and cardiac arrhythmias are the major signs of severe hyperventilation and metabolic acidosis.

Because lactic acidosis is commonly present with respiratory acidosis in patients with major injuries to the chest, measurements of arterial lactate levels are essential to make a precise diagnosis. Unlike respiratory acidosis, lactic acidosis requires urgent treatment with base as well as other indicated measures. At best, it is only slowly corrected.

Therapeutic Guidelines

The prevention of respiratory insufficiency is the principal aim in the management program. However, once the syndrome has developed, there are a number of areas of therapy that are the crux of management.

1) Treat the underlying pathologic process or processes causing acute respiratory insufficiency. This is of primary importance, and in itself, will often correct the respiratory insufficiency state.

2) Improve respiratory toilet. Encourage or initiate cough to eliminate retained bronchial secretions, maintain alveolar integrity, and re-expand areas of atelectasis. An effective cough often requires manual support of the chest to decrease pain. Intercostal nerve blocks may be necessary in patients with rib fractures complicated by severe chest wall pain.

Perform nasotracheal suction when necessary. When properly performed, nasotracheal suction will often eliminate the need for bronchoscopy and/or tracheostomy. In patients with continuing accumulations of bronchial secretions, or those who are uncooperative or unconscious, tracheostomy may be the procedure of choice. It is indeed gratifying to see a patient in extremis, gasping audibly for breath because of an abundance of secretions in the tracheobronchial tree, rapidly improve following tracheostomy.

3) Administer oxygen — Oxygen is often essential; it restores the PaO_2. However, while often helpful, in certain circumstances, it may prove hazardous. For example, high concentrations of oxygen, 50 percent or greater, are dangerous when given for 24 to 48 hours or more because of consequent alveolar damage (O_2 toxicity). Also, the presence of progressive ventilatory insufficiency with CO_2 levels slowly and insidiously rising to alarming levels, O_2 often tends to mask the development of cyanosis, and with removal of the "hypoxic drive" as the only stimulus to ventilation, O_2 administration may rapidly lead to sudden and profound respiratory failure.

Therefore, when administering O_2, if it is observed that the respiratory rate is becoming abnormally slow, or signs of respiratory depression are developing, controlled mechanical ventilation should be started at once to provide adequate concentrations of oxygen, and to decrease the $PaCO_2$ to normal levels.

4) Treat pulmonary infection — Antiobiotics are essential to prevent or control infection since infection in the lower respiratory tract often precipitates ventilatory inadequacy. When the bronchial discharges are purulent, the offending organisms should be identified by culture and sensitivity and gram stain studies, to indicate appropriate antibiotic therapy.

5) Intubate the patient and institute mechanical ventilation whenever the clinical circumstance or laboratory studies demonstrate that the patient is unable to ventilate adequately by himself, or is in a state of imminent or frank respiratory insufficiency. If mechanical ventilatory assistance is delayed in injury situations until there is clinical evidence of overt respiratory insufficiency, the rapidly developing lung changes will often be irreversible.

In critically injured patients, particularly those with major blunt trauma complicated by flail chest and associated pulmonary injury, immediate tracheal intubation and mechanical ventilation using a volume-cycled respirator with application of a positive end-expiratory pressure (PEEP) of 5 cm H_2O constitutes the initial treatment of choice (Figure 4).

In patients with severe hypoxemia, high physiologic shunts, atelectasis and elveolar instability, continuous positive pressure breathing (CPPB) and PEEP may be the only means by which oxygenation may be improved. It is contraindicated in patients with pre-existing emphysema or asthma and in patients with injuries complicated by hypovolemia or cardiogenic shock.

The laboratory values which may be useful as indications for ventilatory assistance are: (a) a PaO_2 of less than 50 mm Hg on room air, (b) need for more than 40 percent O_2 to maintain a PaO_2 of at least 60 mm Hg, (c) an alveolar-to-arterial oxygen tension difference ($AaDO_2$) greater than 350 mm Hg, (d) a $PaCO_2$ greater than 50 mm Hg, and (e) hypoventilatory states resulting in an arterial pH below 7.25.

6) Maintain water and electrolyte balance. In patients with major thoracic injury, particularly those with pre-existing chronic pulmonary disease, water and protein tend to enter the interstitial space of the lung because of loss of integrity of the capillary endothelium. Edema fluid accumulates primarily in the dependent portions of the lung even in the absence of increased capillary hydrostatic pressure. Patients on prolonged mechanical ventilation also tend to retain water.

Restriction of fluids and diuretics is therefore often necessary in chest trauma patients, especially for those with impending or actual respiratory insufficiency. In patients with normal pulmonary capillaries, limitation of fluids and/or diuretics tends to improve respiratory function.

7) Treat heart failure if it exists. Heart failure should be treated as aggressively as respiratory failure. Therapy is based upon the reduction of cardiac work load, improvement of myocardial contractility and the removal of excess body fluids.

Digitalis and other inotropic drugs should be administered cautiously since the hypoxic myocardium is particularly prone to arrhythmias. If hypovolemia is present, the ventricular filling pressure may remain low and will not rise until adequate volume is replaced.

8) Investigate for an associated consumption coagulopathy since this disorder (characterized by widespread intravascular coagulation and resultant consumption of clotting factors and platelets) often coexists with acute respiratory failure.

Treat this syndrome with continuous intravenous heparin. Through heparin's anticoagulant effect, an intact hemostatic mechanism will remain when the procoagulant stimulus abates. The administration of fresh blood or fresh platelet-rich plasma is essential to replace deficient clotting factors and platelets. Freshly frozen plasma in combination with platelet concentrates often proves effective.

9) Extracorporeal membrane oxygenation (ECMO): If the patient in severe respiratory insufficiency continues to deteriorate despite the use of the enumerated treatment measures, extracorporeal membrane oxygenation should be strongly considered.

Summary and Conclusions

Respiratory insufficiency is a potentially lethal problem in every patient with a chest injury. Even when it is not clinically apparent, considerable pulmonary shunting and ventilatory inadequacy may be present. Hence, the importance of a careful clinical examination and chest roentgenograms to identify the cause or causes of respiratory dysfunction in every trauma situation. For a precise evaluation, an arterial blood gas analysis for the degree of saturation, PO_2, PCO_2 and pH is essential.

It is emphasized that if respiratory insufficiency goes unrecognized, the resultant asphyxia often becomes the direct and insidious cause of a variety of grave signs and symptoms with cardiovascular collapse and death rapidly following. The death is frequently mistakenly ascribed to cardiac failure or a massive pulmonary embolus rather than to overt respiratory insufficiency. We physicians, therefore, must think of respiratory insufficiency as frequently and talk of it as freely and as comprehensively as we do of cardiac, renal and hepatic insufficiency.

This is of utmost importance because patients with respiratory insufficiency, regardless of degree, unlike those with insufficiency or failure of other organs, practically always fully recover, once the causative events have been accurately identified and intelligently treated.

Illustrations and Tables (partially revised(taken by permission from:
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Fluid Replacement, Blood Coagulation and Component Therapy

BLOOD COMPONENT THERAPY

R. Ben Dawson, M.D.

I. Current Concepts:

A. SHOCK AND VOLUME EXPANSION (albumin, plasma protein fraction-PPF)

Before discussing blood components as prepared in the community or hospital blood bank, there are several blood products which should be mentioned. They are used in therapy and are referred to as blood substitutes. These should be mentioned first because some of them are volume expanders and may be the first intravenous treatment used in the initial management of the bleeding patient, especially if shock is present or imminent. Albumin (5%) or plasma protein fraction, frequently abbreviated PPF, is seen as having a variety of roles. PPF is the albumin fraction of plasma with perhaps a few other proteins and like albumin, it provides the osmotic pressure of unit of plasma on a volume for volume basis. Both products are supplied in 250 ml and 500 ml containers. Everything harmful in plasma that we know of including the hepatitis virus is removed from these fractions and they are therefore safe as well as effective volume expanders. Other volume expanders that are used in the initial management of shock due to trauma or to blood loss are Ringer's lactate and normal saline. Dextran is the last choice of available blood substitutes for use as a volume expander because it adversely effects platelet function and interferes with testing for coagulation abnormalities. Hydroxy ethyl starch (HES) is also useful as a volume expander and is considered safe. However, HES is limited in supply. In summary, there is nothing better for volume expansion than 5% albumin or PPF. But this is their only use as they do not have any coagulation activity.

B. THERAPY OF COAGULATION FACTOR DEFICIENCY (FFP)

The soluble clotting factors are all preserved in fresh frozen plasma (FFP), the most useful transfusion component, besides platelets, for bleeding disorders. Also, FFP is frequently sufficient for treatment of specific deficiencies such as Factor VIII (Hemophilia), Factor IX deficiency (Christmas Disease) and fibrinogen deficiency or depletion. However, the more concentrated preparations of these soluble clotting factors are generally preferred since more activity can be given in a smaller volume. Except, FFP is currently recommended for Factor IX deficiency because of the high hepatitis incidence from IX concentrations.

C. PLATELET THERAPY

Besides red cells the components most used are platelets and fresh frozen plasma. In disseminated intravascular coagulation (DIC) one should remember that the most important laboratory tests are a decrease in the platelet count and decrease in the concentrations of Factor V and Factor VIII. Although levels of Factors V and VIII decrease in plasma during storage at room temperature or in liquid cold storage, their activity is maintained in fresh frozen plasma. If clotting Factor V and VIII cannot be specifically measured, the partial thromboplastin time (PTT) can be used as an estimate of these factors. In suspected disseminated intravascular coagulation the best rapid test to perform would be the platelet count or the platelet estimate from a stained blood smear and the PTT, and in addition, perhaps, a fibrinogen estimation. Although removal of the cause or therapy with heparin is usually all that is necessary in the treatment of DIC, at times it may be necessary to infuse platelets and fresh frozen plasma containing Factors V and VIII. When heparin is used for treatment of DIC, the above-mentioned tests should be used to follow the course and progression of therapy, whether platelets or fresh frozen plasma are used in addition or not. Only when the plasma fibrinogen concentration is extremely low as determined by reliable quantitative methods should fibrinogen be infused. Whereas fresh frozen plasma was formerly used in the treatment of Factor VII deficiency and hemophilia, the wide availability of Factor VII concentrates including the single unit cryoprecipitate, has made fresh frozen plasma no longer optimal therapy for this disease. It has become common practice to transfuse fresh frozen plasma to patients receiving massive transfusions of stored blood.[2,3]

D. SINGLE DONOR (HUMAN) FACTOR VIII RICH CRYOPRECIPITATE

The prime indication for clinical use of cryoprecipitate is the treatment of patients having classical hemophilia A or Factor VIII deficiency; however, cryoprecipitate is an effective treatment in patients having Von Willebrand's Disease and it may also be used as a source of fibrinogen in patients with hypofibrinogenemia. Each bag of cryoprecipitate contains about 100 units of anti-hemophilic globulin (AHG). A unit is defined as that amount of AHG present in 1 ml. of normal fresh plasma.

Spontaneous bleeding in hemophiliac patients will usually stop after raising their AHG level to over 30 percent once or twice. Clinical assessment of the patient should dictate further therapy; however, major surgical procedures should require that the patient have a minimal level of AHG of 30 percent for at least 5 to 10 postoperative days. One bag of cryoprecipitate per 6 kg of body weight is given as a priming dose followed by half of this dose every 12 hours for maintenance. Because activity of Factor VIII varies widely from preparation to preparation the patient should be monitored by laboratory coagulation tests and the clinical response assessed carefully. The cooperative efforts of clinical and laboratory personnel, if they are not the same, are required here as in many areas of transfusion therapy.

E. RED CELL TRANSFUSIONS

The accepted practice is that whole blood might be indicated for massive hemorrhage when multiple transfusions are required. This current principle is stated because it is a starting point for a new concept. The principle expressed by Douglas Huestis of red cells being the component needed in 90 percent of transfusion requests, needs to be reemphasized. Dr. Huestis and other blood bankers have routinely provided their hospitals with only packed cells, the requests for whole blood requiring special attention. To summarize this argument, I would say that the only clinical situation requiring whole blood is the exchange transfusion of the newborn. That situation requires fresh whole blood less than three or five days old and is really a special case, so there is really no indication for stored whole blood. If packed red cells are going to be used for multiple transfusion in massive trauma, then volume expansion will have begun simultaneously or before the red cell transfusions are stated. If blood loss is so massive that oxygen carrying capacity is critically low, several units of type 0 red cells might be used for an extreme emergency — bearing in mind that typing can be done in a few minutes and complete crossmatching accomplished during the time of initial management, when volume replacement is taking place.

A few general comments about whole blood are appropriate here. All patients' needs for blood or blood components can be met better with components, with less immediate and potential risk to the patient. For these reasons, whole blood will become less readily available as demand for components increases. Some hospital blood banks issue whole blood only on special request with the approval of the director. Finally, one of the reasons for using whole blood has been the presence of clotting factors in fresh whole blood. Now that testing for hepatitis is done on all donor blood, taking several hours, the clotting factors preserved in fresh frozen plasma are now more potent than those in most of the available fresh whole blood.

II. New Concepts

A. EVALUATION OF PLATELET THERAPY; CONTINUOUS INFUSION

Assuming a normal platelet count of 250,000, the number of platelets necessary to provide hemostasis is very low. There is not a definite threshold. However, hemorrhage is rarely seen to occur spontaneously if the platelet count stays over 20,000 and fatal intracranial hemorrhage is unusual in nonleukemic patients with a count over 10,000. In another series when patients had platelet counts less than 1,000, bleeding was the rule; that is, it occurred in 90 percent of the days. In contrast, when the count was 20,000 bleeding was observed in only 16 percent of the days. Spontaneous bleeding in another series was rarely seen with a platelet count over 30,000. The rate of decrease of the total platelet count is significant also. A slow decrease to 5,000 to 10,000 in a noninfected, afebrile patient may be well tolerated whereas a precipitously achieved 50,000 level may be accomplished by purpura.

Figure 1 shows that useful platelet counts by the routine phase microscopy method can be compared to a much more extensive chromium 51 tagging method. The coordinates are similar in this figure to the last in that we are following percent survival or decrease of circulating platelets over time. The solid line shows the decreasing platelet count in patients that were heparinized compared to those who were not. The dashed lines are the data on percent platelet survival from chromium tagging. Note that there is very little difference between the platelet count and the chromium 51 tagging method for determining percent survival. This is an important figure. It should make us realize that following effectiveness of platelet therapy by establishing whether or not the platelets circulate after transfusion is an easy technique, falling within the capability of virtually any clinical laboratory.

Figure 2 is a graphic model of different ways of administering platelets. In the bottom graph, 400,000 platelets have been given to a hypothetical patient with immune thrombocytopenia and half of the platelets are destroyed per unit time in a random fashion. At the end of the fifth unit of time fewer than 20,000 platelets would be circulating. By contrast, in the upper graph, 20,000 platelets have been given per unit time to the same hypothetical patient with the same removal kinetics; that is, half of the circulating platelets are removed per unit time. At the end of the fifth unit time and thereafter peripheral counts would be greater by the use of the multiple small doses than with the single large bolus. Only one-fourth as many platelets would have been transfused to obtain the effect. A continuous infusion is a logical extension of this model and the broken lines suggest the hypothetical peripheral count. The only assumption in this model is that a fixed proportion of platelets is removed from the circulation per unit and that hemostasis requirements remain the same by either mode.

Figure 3 compares the predicted effects of continuous infusion, based on the hypothetical model which was discussed, with that actually observed in two patients. The triangles represent one of the patients with severe isoimmunity; the circles represent the patient with idopathic thrombocytopenic purpura. The similarity between the hypothetical model and the actual observed effects of continuous infusions supports the hypothesis that the advantage gained is in part due to the expected removal kinetics.

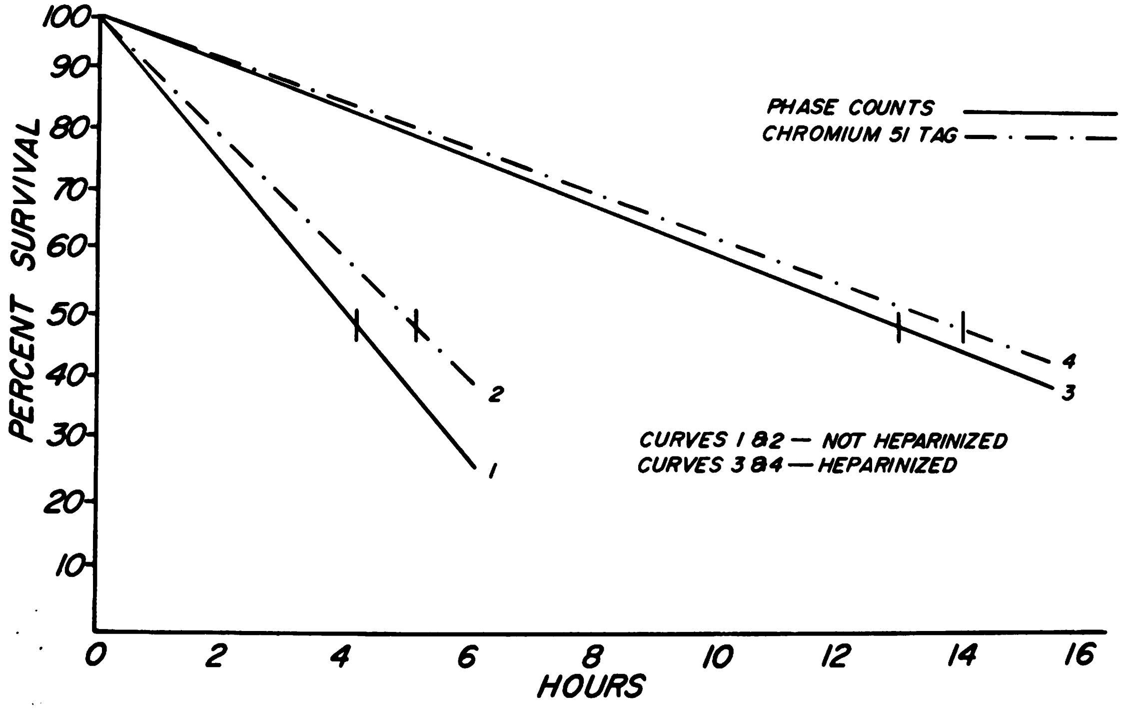

FIGURE 1: Chromium 51 Tagging and Platelet Counts

The platelet count desired in preparation for major surgery is a similar matter but deserves further comments. In the most respected of the hematology texts, *Hematology*, edited by W. T. Williams, E. Beuter, A. T. Erslev, and R. W. Rundles, New York, McGraw-Hill, 1972, 50,000 is the platelet count considered adequate to prevent hemorrhage during surgical procedures. The experience of Bergin and Zuck published in the Annuals of Surgery in 1973 suggested that 20,000 was an adequate level for minor surgical procedures, 30,000 for more extensive surgery and as a minimal level that ought to be maintained intraoperatively during long procedures when platelet utilization might be extensive.

B. ESTIMATION OF COAGULATION FACTOR ACTIVITY

Many general hospitals have some hemophilia patients requiring careful follow-up therapy. For example, beginning the evermore popular home therapy programs for hemophiliacs requires measurement of Factor VIII activity at intervals after appropriate therapy. Some institutions infrequently using Factor VIII preparations may not have laboratory capability for reliable Factor VIII assays. Almost all, however, can perform an activated partial thromboplastin time (APTT). Several groups including Pool's and Hatersley's have suggested the APTT as a reliable method for monitoring Factor VIII post infusion response. The relationship between the Kaolin activated APTT (Hyland) and the post-infusion one stage Factor VIII concentration is shown in Figure 4.

Fibrinogen therapy requires monitoring as well. As indicated earlier, fibrinogen coprecipitates with Factor VIII in the cryoprecipitation method of Pool and Shannon. In 1968, Shulman suggested that cryoprecipitates might be preferable

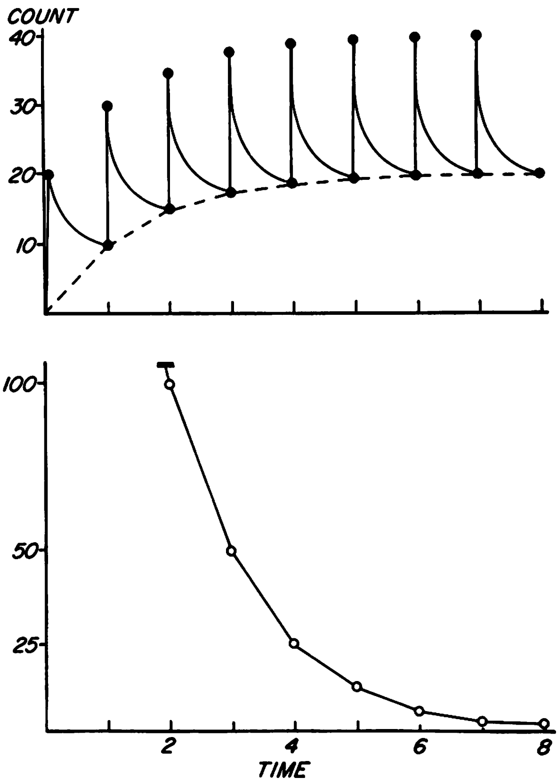

FIGURE 2: Different Platelet Administration Modes

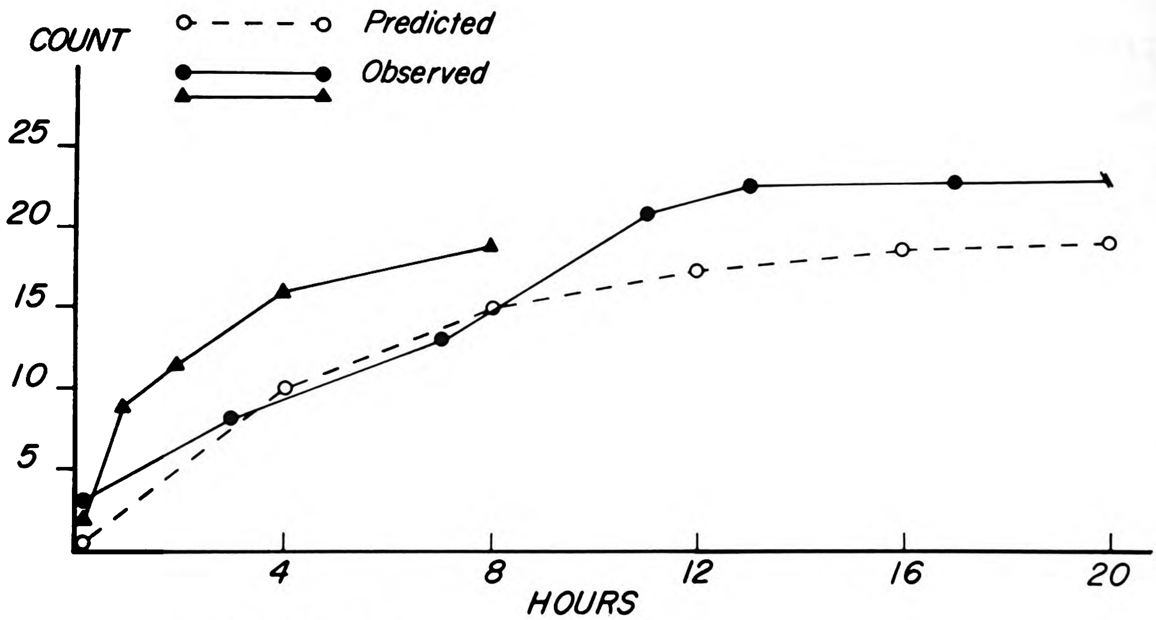

FIGURE 3: Continuous Platelet Infusion

to commercial fractions prepared from pooled plasma, due to the high hepatitis risk of the later. Also, in 1968, it was reported that hypofibrinogenemia due to consumptive coagulopathy was successfully treated with a cryoprecipitate. Hatersley's group also treated a congenital hypofibrinogenemic patient with cryoprecipitate. On the average, cryoprecipitate will contain approximately 150 mg of fibrinogen, but since yields from different donors by the same method may vary as much as twofold and slight differences in methods greatly influence the yield, each laboratory should assay its own concentrations.

Although there is no agreement regarding adequate levels of fibrinogen for hemostasis, a level of at least 60 milligrams has been advocated by some and Shulman has suggested 100 milligrams percent is the lowest safe limit. A sound recommendation may be that fibrinogen replacement should be recommended if the heat precipitable fibrinogen is less than 100 mg percent and the thrombin time is significantly lowered. If replacement is undertaken, the goal could be to maintain the plasma fibrinogen between 100 and 200 milligrams percent and the thrombin time nearly normal. Four units of cryo can raise the plasma fibrinogen by 125 milligrams to 150 milligrams percent if the hematocrit is about 40 percent.

Fibrinogen infused into congenitally deficient patients (afibrinogenemia) displays a double exponential disappearance curve, characteristic of all infused soluble procoagulants. A schematic representation of these curves is shown in Figure 5.

The shaded area (first component) is thought to represent mainly diffusion during which the extra-vascular concentration equilibrates with the intravascular. The distance from point A to point B represents a diffusion time which in the case of fibrinogen is 1 to 2 days. The distance between point B and point C represents a proportion of the procoagulant which diffuses extravascularly for fibrinogen; that is, approximately 50 percent. Thus, the slope of line AC is determined by the rate of disappearance (AB) and the degree of diffusion

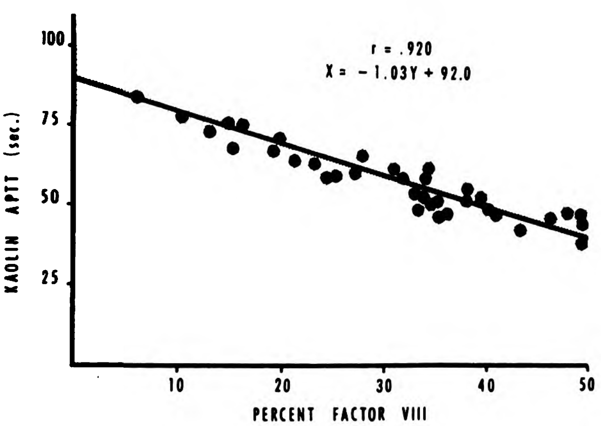

FIGURE 4: Factor VIII versus APTT

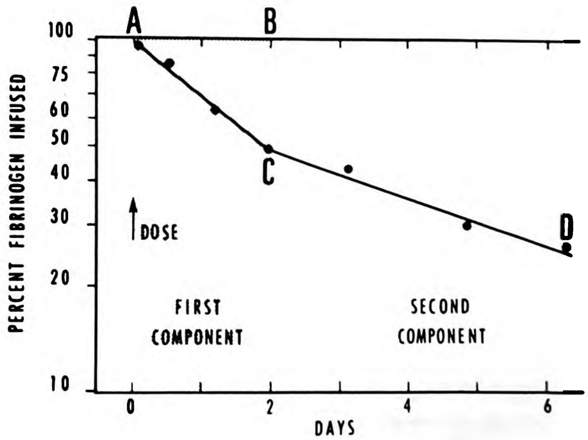

FIGURE 5: Fibrinogen Disappearance Curve

(BC). The slope AC varies for each of the commonly infused procoagulants.

The second component curve in the unshaded area represents the rate of metabolic destruction which can be calculated from the slope of line CD. In the case of fibrinogen it is approximately four days. As with the first component, the slope of this portion of the curve also varies with each of the common transfused soluble procoagulants.

Post-infusion assays, both functional, based on the thrombin time, and physiochemical, as by fibrinogen measurement, should be performed so that the clinician knows that the laboratory is supplying him with potent therapeutical material.

In a medium to large sized general hospital, one might maintain 20 type AB cryoprecipitates for the emergency replacement of fibrinogen. The experienced blood banker with a known donor population can collect these from persons whose blood has been known not to transmit hepatitis to recipients. Since there is a variation in the yield from unit to unit, two or more, or a portion of two pooled units are always used.

C. TREATMENT OF ANTI-COAGULANT OVERDOSAGE

Warfarin toxicity is a fairly common acquired coagulopathy but its therapy is frequently unsatisfactory. Vitamin K may be injected with a commercial concentration of the K dependent coagulation factors, II, VII, IX and X. However, in most clinical settings it is desirable to maintain anticoagulantion while at the same time gaining hemostasis. Vitamin K therapy of course, will render patients refractory to Warfarin therapy for several days, and the "prothrombin complex" concentrates have an unacceptably high risk of hepatitis for use in patients other than those with severe inherited deficiencies. For these reasons the following regimen is recommended by Zuck and Bergin.

Based on prothrombin time, excessive anticoagulantion is confirmed. Warfarin is withheld, but Vitamin K is not given. Two to three mls. per kilogram bodyweight of fresh frozen plasma, modified (cryoprecipitate-poor) is infused and the prothrombin time is determined 15 minutes following infusion. Additional plasma may be required to bring the patient to desired prothrombin time, although more than five ml per kilogram has not been required in the extensive experience of Zuck and Bergin.

The role of Factor VII in hemostasis is unclear, but its disappearance is quite rapid with the first component of 30 minutes and a second component of four hours. Since commercial thromboplastins are relatively sensitive to Factor VII, post-infusion monitoring with the prothrombin time will primarily reflect disappearance of the most rapidly metabolized factor. Depending on prothrombin time, timing and quantity of subsequent doses are determined. Although the half life of Warfarin varies widely among normal persons, the second day following Warfarin discontinuance, the endogenously synthesized prothrombin complex is usually apparent with Factor VII returning first. When the shortening of the prothrombin time suggests that this has occurred, daily dose (no loading) Warfarin may be reinstituted.

In Figure 6, therapy of a patient of Warfarin toxicity and a retroperitoneal hematoma is shown using one unit of modified fresh frozen plasma. At point A, one ml per kilogram was given and this was repeated at point B. At point C, one half of this dose was administered and no further replacement was required. Reversal of toxicity without interruption of anticoagulation was achieved and Warfarin was reinstituted on day three.

Figure 7 shows the first and second components of several soluble clotting factors integrated into the single exponential disappearance curve which is observed in the laboratory. Although the factors have different individual disappearance rates, if the plasma volume is roughly 40 mls per kilogram, the dose of 5 ml per kilogram will raise the activity of any factor, 8 to 12 percent above pre-infusion levels. These levels are similar to those encountered in patients under control with chronic oral anticoagulation. Most patients can be maintained readily, armed with data on disappearance rates and prothrombin times.

D. VOLUME RESUSCITATION IN TRAUMATIC HEMORRHAGE

The accepted therapeutic approach to a patient suffering from hemorrhagic shock with massive blood loss must of necessity require replacement of the red cells at an early stage of resuscitation. The use of colloids, albumin and PPF was discussed earlier. The time taken to crossmatch blood for a patient and the usual remote location of the blood bank has forced the use of group O packed red cells. Group O whole blood that was low in hemolytic titer of Anti-A was used extensively in Vietnam; indeed, 60 percent of the blood shipped to the Vietnamese bases from the United States was low titer

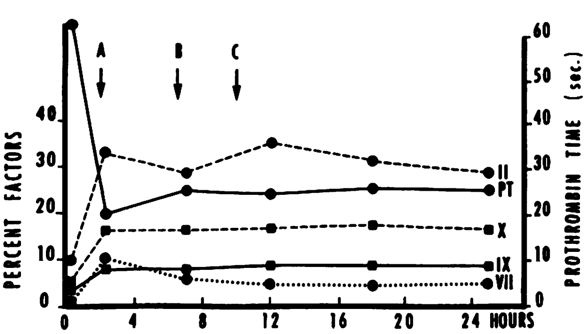

FIGURE 6: Fresh Frozen Plasma Therapy of Warfarin Overdose

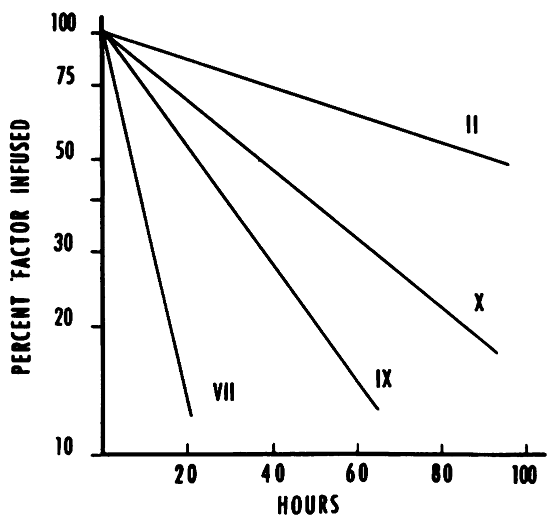

FIGURE 7: Prothrombin Complex Disappearance

group O. However, 25 percent of the patients receiving more than five units of this blood developed hyperbilirubinemia of the indirect fraction, suggesting a minor hemolytic transfusion reaction. At MIEM during a trial period, low titer group O blood was used, but then with the agreement of the Transfusion Practices Committee, we decided to use group O packed red cells, thus alleviating the potential problem of hemolysis due to Anti-A. Formerly, we had seen *in vitro* agglutination in post-transfusion samples during the whole blood trial period. Using packed red cells this is no longer a potential problem.

The increased availability of specific components derived from fresh whole blood helps economize blood usage in the community, while simultaneously meeting the needs of a major trauma service such as MIEM. The use of active blood component therapy in the resuscitation of major trauma has resulted in considerable advantages both for the consumer (the patient) and the suppliers (the blood bank).

In multiple trauma patients where the main cause of hypovolemia is loss of blood, replacement by blood is regarded by us as a procedure of choice. In an institution where approximately 250 units of blood are used each week, availability is sometimes imperiled despite efforts by the hospital and the Baltimore Red Cross Service. For this reason and because of major multiple trauma the physician is unable to await the crossmatch procedure, it is the MIEM routine to commence resuscitation with a plasma protein fraction unless the hematocrit is below 25 percent. Immediately on the patient's arrival, blood is sent to the laboratory for crossmatching, blood gases and various biochemical parameters. Plasma protein fraction is started immediately, but frequently the patient often needs oxygen carrying capacity as well. The ideal fluid, therefore, would be fresh blood, free from infection and perfectly crossmatched containing normal activities of the clotting components, as many of these will have been diluted or consumed in the major trauma patient's fight for survival. This is rarely available or attainable for large scale emergency use. However, most centers have developed a substitution therapy that seems to be ideal under the prevailing conditions. At MIEM – University of Maryland the aim has been: 1) to ensure adequate volume expansion; 2) to ensure an adequate amount of circulating red cells; 3) to provide automatically and prophylactically those active blood components which experience has shown will be depleted in many multiple trauma victims as a result of injury or subsequent fluid therapy; 4) to allow for the necessity for immediate transfusion in some victims where no time is available for crossmatching; 5) to ensure as much as possible a minimal risk of infection and immunological reactions.

This approach has been implemented by using the plasma protein fractions to replace the natural plasma of whole blood, packed red cells to ensure adequate circulating hemoglobin (these would ideally be washed to minimize infection and immunological reaction), planned fresh frozen plasma and platelet concentrate infusions at predetermined intervals in fluid therapy, and the uninhibited use of uncrossmatched blood whenever necessary. (Figure 8)

The active blood component therapy (ABC therapy for emergency trauma victims) has virtually eliminated a previous disturbing incidence of bleeding disorders following massive transfusions.

When massive transfusions (more than ten units of blood) are necessary in the emergency situation, such aspects as the age of the banked blood, the clotting factors and the temperature of the infusion tend to be forgotten in the heat of the moment. All are lessons which have been learned in open heart surgery and other more elective situations, but which have never been applied adequately to the emergency victim.

It is, therefore, essential to have the pre-existing planned routine not requiring initiation by the physician during this hectic period of resuscitation. At MIEM the arrangement which has been worked out with the University of Maryland Hospital Blood Bank is: 1) all IV stands have an associated "blood warmer" and all fluids are passed through this commencing as early as possible during the resuscitation procedure; 2) after every ten units of blood the blood bank provides two units of group compatible fresh frozen plasma; and 3) after every ten units of blood the blood bank provides four units of group compatible platelets.

The most important rule and perhaps the only essential rule for platelet compatibility is that type A platelets not be given to an O or B patient.

ACTIVE BLOOD COMPONENT THERAPY

PACKED CELLS - PLASMA PROTEIN - F.F. PLASMA - PLATELETS

MORE RED CELLS PER VOLUME INFUSED
MORE ACTIVE COTTING FACTORS PER VOLUME INFUSION
MORE ACTIVE PLATELETS (80% YIELD)

LESS PROTEIN BREAKDOWN PRODUCTS
LESS POTASSIUM NH_4 CITRATE
LESS RISK OF PLATELET ANTIBODY FORMATION
LESS RISK OF HLA ANTIBODY FORMATION
LESS SERUM ANTIGEN TRANSFER
LESS THROMBOPLASTIC ACTIVITY
LESS PLASMA ANTIBODIES, E.G. IGA

FIGURE 8:

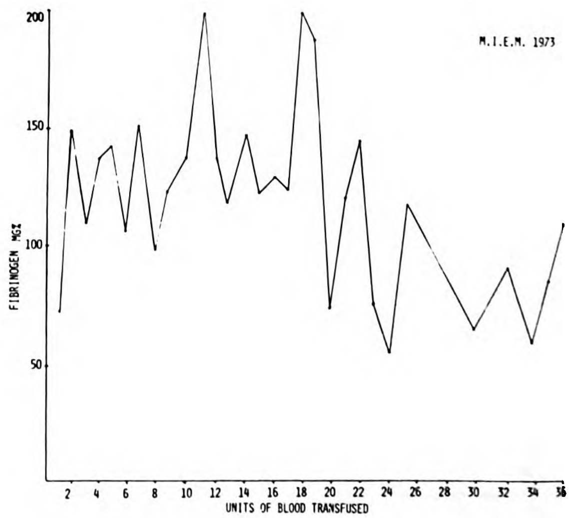

FIGURE 9: Fibrinogen in Massive Trauma

There are some useful estimates as to the levels of various clotting factors required to provide hemostasis. Gill and Champion have worked with some of these and derived some mathematical equations which can provide estimates of blood loss and needed blood replacement at various stages of a clinical situation. For example, they have found that fibrinogen levels rarely fall to critical concentrations for coagulation during massive blood transfusions. (Figure 9) However, of those factors that do become critically low, Factors V and VIII do so most frequently. The critical level of Factor V is 20 percent and for Factor VIII 30 percent. These are the levels necessary for hemostasis in surgery. Both of these are liable factors during blood storage so fresh frozen plasma is mainly used to prevent critically low levels of these soluble clotting factors.

An example of loss estimation is shown in Figure 10. In this patient, who had lost 50 percent of his blood volume at the beginning of replacement therapy, his blood volume has been replaced but he continued to bleed in spite of being transfused to normovolemia. Early in his course, at ten units of transfusion he had 30 percent of his original blood volume remaining and this might represent approximately 30 percent of original soluble clotting factors remaining in his plasma. At twenty units this would be down to 11 percent and at 30 units down to 4.1 percent as seen in Figure 10.

In Figure 11 factor depletion with packed cells and plasma protein fraction transfusion is estimated. One can see that at ten units of transfusion the estimated percent of factor remaining is 28 percent. This agrees with the estimate from the percentage of original blood remaining shown in Figure 10. At 20 units the percent of factor remaining is 8.1 percent and at 30 units is 2.3 percent.

With the objective of maintaining of between 50,000 and 100,000 active platelets per cubic millimeter after massive transfusion, it is decided to transfuse eight platelet packs per 20 units of blood transfused. When the platelet yield was increased from 60 to 80 percent, this was reduced to six packs per 20 units of blood transfused. The expected increase in platelet count is 10,000 per unit pf platelet concentrate, although this is not fully achieved in practice. This prophylactic use of platelet transfusions is under assessment at present, but the clinical impression currently is that when platelets are transfused in this manner, together with the prophylactic use of fresh frozen plasma as described, we have not experienced a single case of post-traumatic hemorrhage due to bleeding diatheses. The use of platelets in this manner has not abolished the post-traumatic thrombocytopenia, but it has enabled us to allow platelet counts to drop as low as 15,000 per cubic millimeter in the immediate post trauma phase without the hemorrhagic indications for therapeutic platelet transfusions. In other words, it appears that prophylactic use of platelets at the rate of four units per ten of blood or six per twenty, has eliminated post-traumatic hemorrhage requiring therapeutic platelet transfusion.

A distinction should be made between thrombocytopenia secondary hemorrhagic diatheses due to "transfusion wash out" and the disseminated intravascular coagulation due to massive trauma. Drs. Gill and Champion have shown that the fibrinogen concentration does not decrease during massive transfusion after trauma, and it has been pointed out by Zuck[4] that the fibrinogen concentration is a useful way of distinguishing "wash out" factor deficiency bleeding from DIC factor deficiency bleeding. Zuck has stated that a low fibrinogen concentration is part of the picture of DIC but not a part of the picture of "wash out" diathesis.

In the massively transfused patient the tendency has always been toward hypercoagulation, and thus it has been difficult to identify the syndrome of DIC in many patients at MIEM. The occurrence of the several clinical syndromes in the post shock state indicates by their timing that they are more related to the initial insult than to a later occurrence. An example of the role of DIC in the procedure of organ failure syndromes. Diagnosis of DIC in the three to five days after massive trauma must rely upon trend analysis of factors and of the products of fibrinolysis. The use of heparin has been widely discussed but no single control trial exists to support its application in the treatment of DIC. Anecodotal experiences continue to be quoted and it appears that heparin has indeed been useful in certain situations. Massive transfusion itself must modify the response of the patient in such a way that the balance is slightly tipped in favor of hemorrhage rather than profuse clotting. The philosophy which is used in practice here is to replace just sufficient clotting factors to provide for the patient to have the ability to continue coagulation, rather than an overshot of therapy resulting in widespread clotting. It is also of interest to note the rare occurrence of clinically apparent

10 UNITS	20 UNITS	30 UNITS
30	11	4.1

PERCENTAGE OF ORIGINAL BLOOD REMAINING IN A PATIENT WHO HAS LOST 50% OF HIS BLOOD VOLUME, HAS BEEN FULLY REPLACED AND HAS CONTINUED TO BLEED AND BE TRANSFUSED TO NORMOVOLEMIA.

FIGURE 10:

FACTOR DEPLETION WITH PACKED CELL AND PLASMA PROTEIN FRACTION TRANSFUSION

Units of Blood Transfused		% Factor Remaining
0		100
2		77
4		60
6		47
8		36
10	Maintain at this level	28
12		22
14		17
16		13
18		10
20		8.1
22		6.3
24		4.9
26		3.8
28		2.9
30		2.3

FIGURE 11:

deep vein thrombosis and pulmonary embolism in MIEM patients where the incidence in multiple trauma victims has been less than 0.5 percent in 1,000 admissions.

E. NEW EVIDENCE FOR THE IMPORTANCE OF 2,3-DPG AND THE POSITION OF THE O_2 CURVE IN TRANSFUSION THERAPY

Valeri has published studies on baboons showing increased cardiac output after transfusion with blood that was low in 2,3-DPG concentrations.[5] In a recent report, he shows decreased cardiac output in humans who received transfusions of blood that was high in 2,3-DPG concentrations.[6] In the baboon studies there was an inverse correlation between cardiac output and in the vivo P50 (determined by 2,3-DPG concentrations). Red cells having DPG concentrations that were 10 percent of normal were transfused and the baboons had higher cardiac outputs (3.07 liters per minute) than the animals receiving blood with DPG concentrations of 125 percent of normal who had cardiac outputs of averaging 2.53 liters per minute. This represented a difference of 18 percent in cardiac output. Also, the oxygen consumption in milliliters of O_2 per minute was higher (176) in the high DPG animals than in the 10 percent DPG animals (162) for a difference of 9 milliliters per minute. The arterial-venous difference in volume percent was 33; also, cardiac stoke volume was higher by 10 ml. in the low DPG animals and cardiac work was greater by 25 in the low DPG group, further heart rate was higher, 115 per minute, in the low DPG compared to 107.

In the recent study done at Boston University,[6] blood was supplied by Dr. Valeri to two groups of patients undergoing cardiopulmonary bypass operations and requiring blood transfusions during and immediately after surgery. There were 11 control patients who received fresh washed red cells that has been stored for less than five days. This had DPG concentrations of approximately 70 percent of normal and there were 6.9 units per patient on the average transfused. The eleven high DPG patients received 6.1 units per patient and the average DPG concentration was 150 percent of normal. Immediately after bypass surgery the arteriovenous oxygen difference was significantly higher in the high DPG group indicating better oxygen delivery to the tissue. At this time 2,3-DPG concentrations were 10 to 15 percent higher in the high DPG transfused group and P50's were 3 mm higher. There was no significant difference in PO_2. There was also a significant difference in oxygen consumption immediately after bypass, but no difference in cardiac index. There was a difference in cardiac output, 2.95 compared to 2.18, at the same pulmonary arterial wedge pressure. This difference was significant at the $P > 0.001$ level. The cardiac output was higher in the high DPG group than in the low DPG group.

Difference in morbidity in these two human groups receiving normal and high DPG blood were determined by assessing the needs during and immediately after surgery for drug or mechanical circulatory support. The support consisted of either Isuprel, a cardiotonic drug, or intra-aortic balloon ventricular ejection assistance. In the high DPG group one or the other form of assistance was required in four of the eleven patients. In the regular DPG transfused group, cardiac assistance was required in ten of the eleven patients.

In conclusion, the Boston University study shows that with blood that is high in DPG providing only a small increase in P50 of 3 mm of mercury there is increased oxygen consumption and a 40 percent increase in cardiac output. This increase in P50 or shift of the O_2 curve to the right is only a 15 percent change, but the measurements of cardiac function clearly show a difference between this high DPG group and the normal DPG group. The differences are shown by the measurements of cardiac dynamics and oxygen transport. In addition, there are striking differences in the morbidity of the patients; that is, the amount of pharmacologic or mechanical assistance required for adequate heart function in the immediate postoperative period.

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THE EFFECTS OF TRAUMA, VOLUME DEPLETION AND VOLUME THERAPY ON RETICULOENDOTHELIAL HOMEOSTASIS

Arlie R. Mansberger, Jr., M.D.

Metchnikoff in 1887, conducting in vitro experiments made the observation that certain cells, including leukocytes, ingested foreign material such as bacterial micro-organisms, and emphasized that the observed phenomenon was a manifestation of host defense. He further hypothesized that the serum contained substances called "stimulins" which acted on the leukocyte to stimulate its phagocytic activity. Eight years later, Denys and Leclef suggested that the substances in serum which promoted phagocytosis acted not on the leukocytes but rather on the bacteria.

A few years later in 1903, Wright and Douglas investigating the roles of "blood fluids" in connection with phagocytosis, reported a substance in normal human serum which stimulated phagocytosis by leukocytes and further speculated that this factor interacted with bacteria in a manner which enhanced phagocytosis by circulating leukocytes. They called this factor "opsonin" from the Greek *Opsono* meaning "I prepare victuals for."

These early observations on opsonic enhancement of the microphage (leukocyte) activity have been repeatedly confirmed. Only within recent years, however, has a similar degree of interest been focused on the role of normal serum opsonins, sometimes called humoral recognition factors (HRF) on the fixed macrophages of the hepatosplenic splanchnic reticuloendothelial system.

Evidence has been and is being accumulated that blunt trauma, missile trauma, thermal trauma, operative procedures and hypovolemic states adversely affect the natural immune mechanisms. Injury to the functional capacity of these normal bacterial defense processes is, in part, mediated through decreases in serum opsonic titer *and* activity which accompany injury.

For example, patients who are successfully resuscitated from shock often succumb in the postresuscitative period from overwhelming infection. Observations by Paine and Redfern confirms this phenomenon.

In a group of patients suffering hemorrhagic shock from a variety of causes, our laboratory demonstrated a severe depression of phagocytic index, complement titer and bactericidal titer of the serum. (Figures 1, 2 and 3) During the period of shock and for 12 to 18 hours thereafter the index was depressed. Following recovery from shock the phagocytic index gradually increased to levels which were well above normal ranges of activity. The opsonins measured (complement titer and bactericidal titer) showed a similar striking decrease during and for hours following the hypotensive episode. In contrast to the above normal "rebound" for complement titer following resuscitation, the bactericidal titer of the serum returned only to normal levels. The "rebound" of complement titer to supranormal levels *preceded* the return of enhanced phagocytic activity.

When attempts to restore circulating hemostasis were unsuccessful, opsonin levels and phagocytic activity continued to decline.

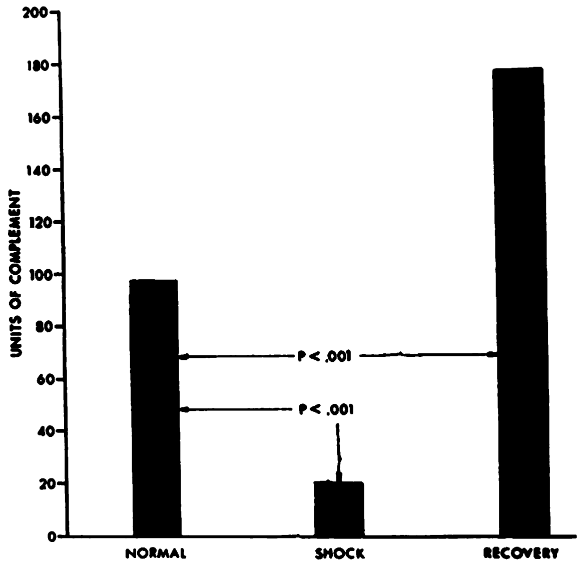

FIGURE 2: Serum complement levels in shock

Similar observations were made in patients in shock from trauma and from strangulation obstruction of the small bowel. (Figure 4)

In parallel animal studies, the effect of hemorrhagic shock on bacterial clearance (clearance of one-half of the injected bacterial population = T 1/2) as well as clearance of colloid (I^{131} tagged albumin) demonstrated that an increased T 1/2 or decreased ability to clear bacteria was a function of the magnitude of hemorrhage.

Consideration of bacterial clearance in terms of phago-

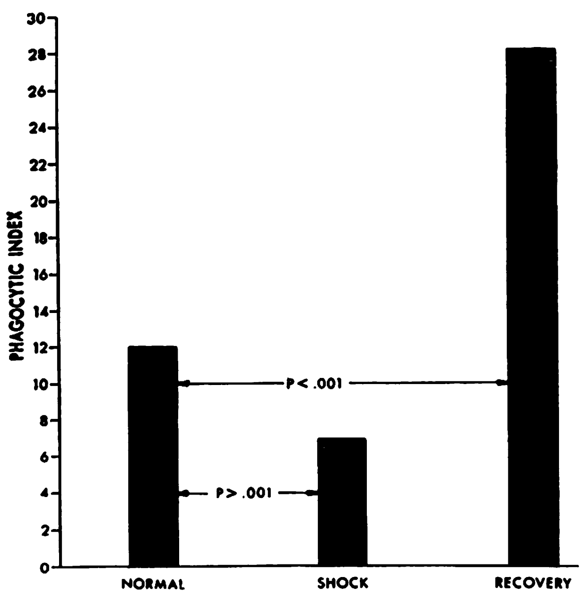

FIGURE 1: Alterations in phagocytic index in shock.

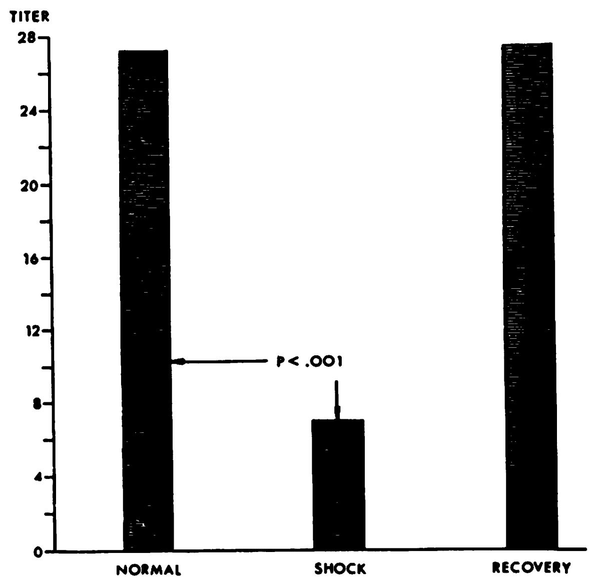

FIGURE 3: The bacterial titer in shock

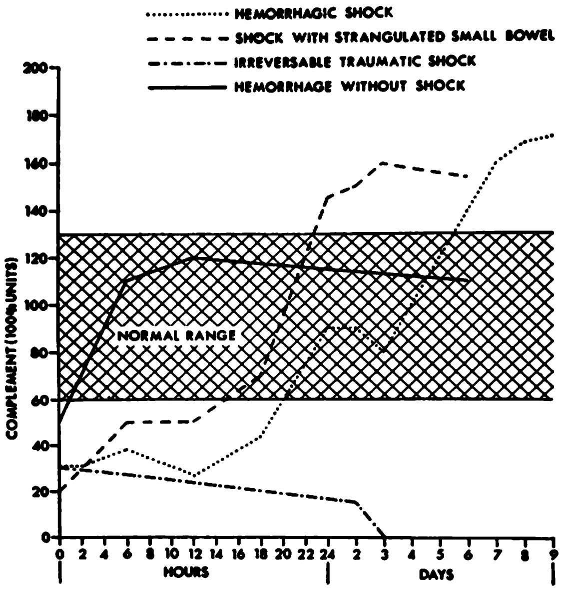

FIGURE 4: Serum complement activity in various forms of shock.

cytosis, and phagocytosis in terms of the sum of three or more distinct steps leads to analysis of bacterial defense in a relatively precise manner. Combination of events noted in dogs and man as a result of hemorrhagic shock allows the synthesis of a series of deficits at each step into a coherent hypothesis, culminating in the concept that bacterial phagocytosis, hence bacterial clearance, hence bacterial defense, is impeded. If bacterial invasion or multiplication precedes at a more rapid rate than clearance, the host is overwhelmed.

As soon as bacteria invade the tissues or blood stream, they are subjected to the actions of opsonins. The bactericidal titer of serum is a reflection of the action of these opsonins, specifically "natural antibody," humoral recognition factor and serum complement. Studies on the action of complement indicate that antibody (natural or immune) sensitizes the target allowing the first complement component to attach probably with combining sites on both the antibody molecule and the target cell or protein. This initiates the activity of the other components of complement, part of which is enzymatic (esterases). This is the opsonizing process which, having begun injury to the bacterium, renders it relatively more susceptible to phagocytosis. These studies and many others indicate that this opsonizing process is impaired in human patients as a result of hemorrhagic shock. Will not adequate volume replacement with banked blood restore opsonin levels to normal? The answer is an emphatic NO. When measuring T 1/2 bacterial clearance on dogs in shock we found that if animals received fresh homologous blood, or ACD collected autologous blood, improvement in clearance was minimal. By contrast, the infusion of ACD collected homologous blood stored for one week at 2° resulted in decreases of clearance which were greater than that observed when no infusion was carried out. These studies suggested that opsonins are thermolabile. Saba and Scovill have recently supported that suggestion by observations which indicated that opsonin activity of serum in cold storage is rapidly lost (half-life 14–15 hours).

Data presented in a recent excellent review by these same authors on the effect of trauma on host defense with particular reference to the fixed sessile macrophages of the reticuloendothelial system (particularly of the liver and spleen) suggests the presence of a depressant effect of surgical trauma on the RES system mediated by a deficiency in opsonic capacity. The collected findings, furthermore, do not support a major role for alternatives in hepatic sinusoidal blood blow, an adrenal storage release following surgery, or a blood borne RE inhibitory substance responsible for postoperative phagocytic depression.

Rather, the data suggests that in surgical stress, trauma, prolonged tissue ischemia or burn injury the excessive depletion of opsonic activity may reflect accelerated utilization of opsonins in the RES disposal of denatured protein or damaged tissue. It is also possible that opsonic protein may sequester in areas of tissue injury as an "obligatory immunologic response due to the affinity of this natural antibody like protein for effete tissue and denatured protein."

Once opsonized, the bacterium must be brought into proximity with the phagocytic cells, the bulk of which are in the reticuloendothelial system. This depends upon blood flow to organs such as the liver, spleen, lungs, lymphatic system and marrow. It is to be expected that such blood flow is decreased in shock (in contrast to operative trauma only) lengthening contact time and further impeding phagocytosis. If protein levels are low or if the RE system is not functioning properly, then extrahepatic particle localization occurs, particularly in the pulmonary capillary bed, and thus contributes to the development of acute respiratory distress.

When the opsonized bacterium is finally brought to the phagocyte, the "metabolic health" of the phagocyte will determine its ability to perform its function, the ingestion of the bacterium, fibrin clumps, foreign protein, platelet aggregates, etc. This will already have been decreased by impairment of opsonization and delayed by increased contact time in hypovolemic shock. If the phagocytic cell is anoxic and acidotic as a result of poor perfusion, it may be further impeded in its activity of engulfing and destroying the bacterium.

A little discussed factor affecting the metabolic health of the RES is hyper- or hypo-osmolality. The former occurs regularly in shock, the latter iatrogenically in trauma patients if improper fluid therapy is administered to the patient.

Serum osmolality increases sharply in a variety of shock states and has been suggested as a mechanism supportive of volume homeostasis.

Early in hemorrhagic shock, a moderate percentage of the increased osmolality can be accounted for by a rise in glucose levels through glycogenolysis. Sustained high serum osmolality values observed in shock are not a function of hyperglycemia since hypoglycemia occurs and hyperosmolality continues.

Another way of looking at the problem of hyperosmolality in shock is to monitor the difference between measured and calculated osmolalities. (Figure 5)

$$(\text{Calc. osmol} = Na^{+}(1.86) + \frac{BUN}{2.8} + \frac{\text{glucose}}{18} + 5\ \text{m0ms})$$

Roberts reported a group of critically ill patients in whom measured osmolal values exceeded calculated values by figures ranging from 40–100 m0sm/L of plasma. All but two of his patients died within a few days.

Holmes has used the wide discrepancy between calculated and measured osmolality as an indication for hemodialysis in patients severely ill with acute toxicity to drugs or to unknown commercial toxins. To my knowledge, osmolal trend monitoring has not been used as an indication for hemodialysis in shock, sepsis or trauma.

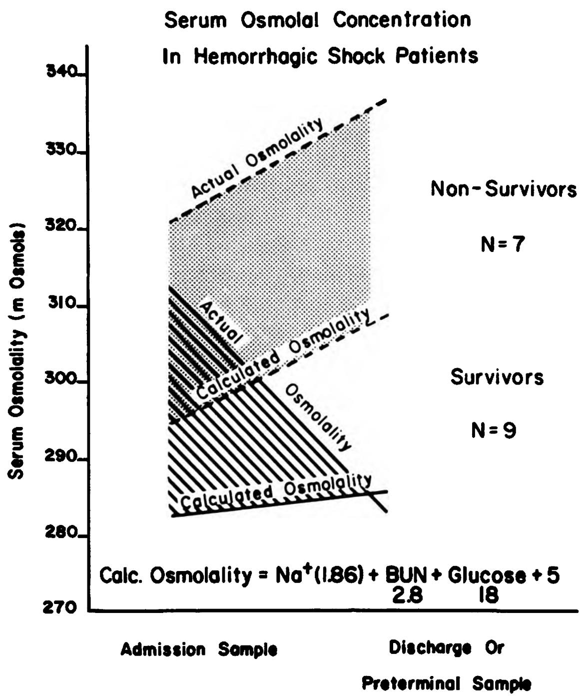

FIGURE 5: Note differences between measured and calculated osmolalities and return of osmolal homeostasis in surviving patients.

The detrimental effect of shock on bacterial defense, opsonins, macrophages and sessile macrophages may, therefore, be viewed as the sum of a series of impairments each of which may offer opportunity for correction with therapy. Experiments with dogs imply that our standard method of treatment of hypovolemic shock, the restoration of blood volume with stored homologous ACD bank blood, not only fails to correct the bacterial clearance deficit resulting from hemorrhage, but actually makes it worse. This may help to explain why we lose so many of our severely injured hypovolemic shock patients from infection after seemingly adequate resuscitation. Banked blood is lacking labile opsonins such as complement, and may contain substances that block or inhibit the RES such as free hemoglobin.

The isolation, purification, and preparation of opsonins in stable form would seem to offer future possibilities in terms of correcting the deficits noted after conventional treatment. Further information concerning restoration of adequate perfusion to organs such as the liver after volume restoration might help in terms of decreasing contact time and increasing phagocytic cell function after shock. Such an approach might aid in septic shock as well where studies in our lab indicate changes in opsonins similar to hypovolemic shock.

Recently a collaborative effort by Saba and Molnar has resulted in the isolation, identification and purification of opsonic protein in normal animal and human serum. The protein in thermolabile at 60°C highly dependent on microquantities of heparin for expression of its biologic activity and has a molecular weight of approximately 800,000.

Treatment of colloid with opsonins has been shown to result in the reversal of T 1/2 vascular clearance of foreign material. These observations along with those showing reversal of RE blockage by opsonization with normal serum or with fresh whole blood open the distinct possibility that opsonic therapy via injection of purified opsonic protein may provide a specific nontoxic method of altering or preventing post-traumatic reticuloendothelial depression. For the present, until these materials in purified form are available in our therapeutic armanentarium, fresh whole blood and fresh frozen plasma should be given to victims of trauma not only for their documented effects on coagulation defects, but also because of their enhancement of opsonic activity. Furthermore, in elective situations on high risk (for infection) patients preoperative treatment with Zymosan or BCG may be indicated as a "stimulant" to opsonin production.

Summary

Opsonic protein levels are significantly depressed in trauma, sepsis and in hypovolemic shock. Giving bank blood does not increase opsonic titer since the thermolabile opsonins with a half life of 15 hours are virtually nonexistant in bank blood. In fact, bank blood in large quantities is detrimental to bacterial defense because it "floods" the host with microparticulate matter and free hemoglobin which can cause RE blockade. If the RE system function is suboptimal — either because of opsonic protein depletion, RE blockade or metabolic ill health of phagocytes, extrahepatic particle localization occurs, particularly in the lungs. Factors affecting the metabolic health of the phagocyte include hypoxia, acidosis and hyperosmolality.

Therapy includes rapid early restoration of hemostasis, use of fresh whole blood, use of fresh frozen plasma, osmolal trend monitoring, and microphage transfusion in addition to other forms of blood component therapy based on specific indications.

Future therapy may include exogenous opsonin administration, hemodialysis based on osmolal trend monitoring, and administration of BCG or Zymosan in patient population known to be susceptible to shock in an attempt to stimulate opsonic protein production.

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HEMORRHAGE IN THE SEVERELY TRAUMATIZED PATIENT

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If hemorrhagic problems occur in the severely traumatized patient, they usually follow at two time intervals — either immediately or 36 to 48 hours after the traumatizing event. The immediate hemorrhage is directly related to the trauma and usually requires surgical treatment to control the loss of blood. The reappearance of bleeding several hours to two days later is frequently associated with deficiencies of the coagulation system, qualitative or quantitative platelet defects or biochemical alterations that result in striking derangement of both the coagulation and plasminogen-plasmin proteolytic enzyme systems.

The immediate bleeding from the trauma is often underestimated. If this bleeding, due to disruption of vascular integrity, is not completely corrected there will not only be a constant loss of blood but the amount of blood loss will be dramatically increased if coagulation problems occur. Bleeding due to loss of vascular integrity is not correctable by any form of medical therapy, but necessitates thoughtful attention of a skilled surgeon and proper placement of the silk sutures. The one exception when immediate surgical intervention is not indicated is in patients with congenital factor deficiency. When confronted with this problem appropriate replacement therapy must be given prior to and in conjunction with surgical correction.

Trauma in Congenital Factor Deficiency

Patients with congenital coagulation factor deficiency are not exempt from severe trauma. Actually, in today's society it is fairly typical for patients with hemophilia to thoughtlessly engage frequently in perilous activities. Factor VIII deficiency (hemophilia A), Factor IX deficiency (hemophilia B, Christmas disease), and von Willebrand's disease together constitute more than 95 percent of all known congenital factor-deficient disorders. The degree of hemorrhage in these disorders is typically disproportionately greater than the trauma received. The hemorrhage is rapidly progressive. There is no substitute for a prompt, thorough history. Initial studies should include a bleeding time, prothrombin time (PT), partial thromboplastin time (PTT), and a platelet count. If there is abnormal prolongation of either the PT or PTT, accompanied by a normal platelet count, then specific factor assays should be performed to correctly identify the deficiency state. Since both hemophilia A and von Willebrand's disease have low Factor VIII levels, they often cannot immediately be differentiated. A prolonged bleeding time plus a low plasma Factor VIII level is more suggestive of von Willebrand's disease. Treatment for these disorders is immediate replacement of the missing factor.

When the bleeding involves the joints and soft tissues of the extremities, without nerve compression, replacement of the deficient factor with an amount to raise the circulating plasma level of that factor to 15 to 25 percent of normal is usually sufficient to control the bleeding. If the hemorrhage is in the abdomen or thorax, sufficient treatment should be given to achieve a circulating level of 30 to 50 percent of normal of the deficient factor. If the diagnosis of a factor deficient state is established and the patient has experienced central nervous system trauma, the patient must be transfused with the missing factor in quantities to achieve a circulating level of 100 percent of normal.

When surgical procedures are indicated in these patients, a circulating plasma level of 50 percent or greater should be provided at the time of surgery. For calculation of the correct dose of a particular factor and selection of the appropriate source (fresh frozen plasma, cryoprecipitate, or factor concentrates), it is suggested the reader consult the textbook *Hematology*, edited by W. J. Williams and associates.

The disorders associated with acquired coagulation factor deficiency states are indicated in Table 1. These problems originate when there is direct damage to the liver or to those organs that normally supply the appropriate nutrients to the liver that are necessary for coagulation factor synthesis (Table 2). Abnormal proteins in the circulating blood frequently prevent the coagulation system from functioning properly and hemorrhage results.

As opposed to the congenital factor deficient states where usually only one factor is missing, in acquired disorders the deficiencies are usually multiple. In such situations there is usually prolongation of both the PT and PTT. In the dysproteinemias, the diagnosis is best confirmed by protein electrophoresis and immunoelectrophoresis.

Replacement therapy is not very useful in treatment of these acquired conditions and at best is only of temporary benefit. Reversal of the underlying problem with appropriate surgical or medical therapy is the correct way to treat this problem.

Hemorrhage Secondary to Thrombocytopenia

When the circulating level of platelets falls below $50 \times 10^9/l$, spontaneous bleeding often occurs. Thrombocytopenia seldom occurs in the immediate post traumatic period but frequently appears as complications set in and the health of the patient deteriorates. The most frequent causes of thrombocytopenia in this setting are sepsis, drugs, alcoholism, and disseminated intravascular coagulation. Even though the platelet count may be near normal, metabolic aberrations such as uremia may cause a qualitative defect.

The mechanisms whereby sepsis per se results in severe thrombocytopenia are poorly understood. Some infectious agents exert a suppressive effect on the bone marrow and prevent the release of platelets from megakaryocytes into the circulating blood. Destruction of platelets in the peripheral blood has been demonstrated to be the result of an immunologically mediated reaction. In these studies, low molecular weight soluble components of the infectious agent were capable of functioning as a haptene. Thrombocytopenia secondary to a bacterial or fungal process must be vigorously treated with appropriate antibiotic therapy.

Chronic alcoholics, often the subjects of severe trauma, may have severe thrombocytopenia. In this situation, the thrombocytopenia may result from a direct toxic effect on the

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TABLE 1: Coagulation Factor Deficiency

Congenital
Acquired
- Liver disease
- Malabsorption
- Pancreatic disease
- Hepato-renal syndrome
- Dysproteinemic states
- Malnutrition
- Vitamin K deficiency

Listed above are common disease entities that are associated with coagulation factor deficiency.

TABLE 2: Hepatic Synthesis

Coagulation Factors — I, II, V, VII, IX, X ?X1, XIII
Vitamin K — II, VII, IX, X
- Antiplasmin
- α-1-antitrypsin
- α-2-macroglobulin
- Antithrombin III

Listed above are those coagulation factors that are synthesized in the liver; those coagulation factors that are vitamin K dependent; and the naturally occurring inhibitors to the coagulation and fibrinolytic systems that are made in the liver.

marrow megakaryocytes, peripheral platelet destruction, folate deficiency and hypersplenism secondary to associated liver disease. Unless irreversible hepatic and/or marrow damage have taken place the cessation of alcohol, adequate diet, with appropriate vitamin supplementation, will correct the thrombocytopenia within days. During this time of recovery from the effects of alcohol, the use of drugs should be judiciously avoided unless absolutely indicated.

Thrombocytopenia secondary to drugs is not uncommon. In the setting of a traumatized patient now severely ill because of secondary complications, the concomitant use of 20 to 30 different medications is commonplace in modern day intensive care units. The number of drugs that have been documented to cause thrombocytopenia is large. In the majority of instances, the mechanism of the thrombocytopenia has not been identified. The thiazide diuretics are perhaps the most commonly employed agents with which thrombocytopenia has been associated. For a few drugs, (*e.g.*, quinine, quinidine) an immunologically mediated mechanism has been identified, that results in destruction of the platelets in the peripheral blood. Occasional reports have shown that some commonly administered drugs (*e.g.*, chloramphenicol) are toxic to the bone marrow. Other drugs, not applicable to the traumatized patient, that routinely damage the marrow are the anticancer chemotherapeutic cytotoxic drugs, such as cyclophosphamide, methotrexate, vinca alkaloids, and cytosine arabinoside. In the setting where the drug(s) exerts a toxic effect on the bone marrow, the thrombocytopenia is usually accompanied by anemia and leukopenia.

The correct treatment for this problem is immediate discontinuation of the drug and within four to five days the platelet count will return to near normal, unless there is profound renal failure or some extenuating metabolic state and the drug is not eliminated from the body. In the severely traumatized patient where certain medications are essential and thrombocytopenia is drug induced, the problem may be remedied by changing to a comparable agent that is slightly different in its basic molecular structure. In such circumstances where it is tempting to employ numerous medications, the problem of severe thrombocytopenia and hemorrhage should serve as an example that such problems can be completely avoided by not using medications, particularly if they are not absolutely indicated.

Several diseases frequently characterized by severe thrombocytopenia are listed in Table 3. At the time of the traumatic event, often the thrombocytopenia and the underlying condition are not apparent but become manifest because of the stress of severe illness. When thrombocytopenia appears, these disease states should be considered.

Hemorrhage Secondary to Blood Transfusion Therapy

In the severely traumatized patient it is particularly unusual not to have to administer blood or one of its components to maintain survival. Hemorrhagic diathesis due to blood therapy may be seen in the following situations: 1) after administration of incompatible blood; 2) infectious agents in whole blood or one of its components; 3) after large quantities of shelf-aged or outdated stored blood, with resultant pulmonary microemboli; and 4) after large amounts of blood components and volume expanders.

Hemorrhagic diathesis following incompatible blood transfusion was first recognized in 1922. The current incidence of hemorrhage in association with incompatible blood transfusion ranges between 8 to 30 percent. Although the early reports indicated that the hemorrhagic shock state resulted from pulmonary capillary thrombosis, current incidence supports an antigen-antibody reaction that initiates disseminated intravascular coagulation. Free hemoglobin does not activate either the coagulation or fibrinolytic system. The severity of the reaction is proportional to the volume of incompatible blood transfused but the shock is disproportionate to the volume of blood lost. The clinical diagnosis should be confirmed by detection of hemoglobinemia, hemoglobinuria, serologic testing, and retyping-cross matching of the patient's and transfused blood.

Treatment consists of immediate discontinuation of the blood being transfused, correction of hypovolemia, metabolic and respiratory acidosis and transfusion of compatible blood. Prompt attention to this problem with the above measures will quickly restore normal physiology and often avoid consideration of questionable therapeutic agents such as intra-

TABLE 3: Thrombocytopenia

Sepsis	ITP
Alcohol	Uremia
Drugs	Extracorporeal circulation
Hypersplenism	Collagen vascular diseases
Transfusion	Aplastic marrow
Transfusion reaction	TTP
Nutritional deficiency	DIC

Listed above are disease entities that are frequently associated with thrombocytopenia. Many of these disorders are frequently seen in patients who are seriously ill. Occasionally the thrombocytopenia is not present at the time of the initial traumatic event, but develops as complications arise.

venous heparin, fibrinogen, antifibrinolytics, and exchange transfusion.

Another problem following transfusion of blood or blood components involving an antigen-antibody interaction is post-transfusion purpura. This reaction is rare; it occurs seven to ten days following the transfusion, and is more common in patients who have been previously transfused or have an antecedent history of pregnancy. Specific treatment is not usually indicated.

Shock and hemorrhage following the infusion of compatible septic blood, recognized occasionally in the past, has been almost eliminated by current screening, blood testing, and aseptic donor and recipient transfusion techniques. Once the diagnosis is established, in addition to routine immediate supportive measures, treatment with appropriate antibiotics should be given on a long term basis to prevent endocarditis.

Hemorrhagic problems following transfusion of stored blood or outdated blood have been attributed to absence of coagulation factors and platelets in the aged blood, dilution of the recipient's coagulation factors and platelets by the stored blood, and transfusion of "debris" in the stored blood, the latter causing pulmonary capillary obstruction. During the time of storage changes in cellular elements alteration in protein structure and function take place in anticoagulated blood. Platelets, white blood cells, and fibrinogen-fibrin form aggregates which increase in number and size as storage time increases. It has been verified in man and animals that following transfusion these aggregates collect in and obstruct the small vessels of the lungs. This microvascular obstruction results in increased alveolar dead space and gross hemorrhage in the pulmonary parenchyma. As this pathologic process becomes widespread throughout the lungs, systemic hypoxemia and hypotension develop. There then results the clinical and laboratory features of disseminated intravascular coagulation.

Although it has been accepted that the aggregates in stored blood can obstruct varying portions of the pulmonary microvasculature, current debate exists as to whether or not significant pathophysiology results in the majority of even severe clinical situations.

Even though there exists an element of uncertainty regarding the etiology of this disorder, it would appear prudent to employ specially designed transfusion filters if large quantities of stored or outdated blood must be administered over a relatively short period of time in a given patient.

In a previously healthy then traumatized patient, even though appreciable volumes of blood components or volume expanders poor in coagulation factors and platelets are infused, the circulating level of coagulation factors and platelets in the patient does not decrease to levels that would initiate hemorrhage. In a recent study, it was conclusively demonstrated that the routine practice of administering fresh frozen plasma and platelet concentrates for a given number of packed red cells was unnecessary and wasteful. In an unusual previously seriously compromised patient (*e.g.*, severe hepatic failure and sepsis), whose circulating levels of coagulation factors and platelets are dramatically reduced, it would not be advisable to employ large volumes of agents (Plasmanate®, albumin, hydroxyethyl-starch) that do not contain these essential blood constituents.

Unlike any other recognized coagulation factor, it must be kept in mind that when platelets are present in markedly increased numbers, hemorrhage may result.

Disseminated Intravascular Coagulation

In the severely traumatized patient who is unfortunate enough to experience secondary complications, the most common cause of late hemorrhagic problems is disseminated intravascular coagulation (DIC). In such patients there is frequently concomitantly present several abnormalities listed in Table 4 that can trigger DIC. In such patients it is not possible for any one of these abnormalities to exist by itself. If there is severe hypoxia there also will be an element of hypotension, hypo-organ perfusion, etc., with resultant release of several substances into the circulation, any one of which is capable of initiating DIC. In the complicated severely traumatized patient the etiologies of DIC are potentially legion in number; some have been mentioned above.

TABLE 4: Disseminated Intravascular Coagulation

Etiologic Trigger Mechanisms — Traumatized Patients

- Hypoxemia
- Hypotension
- Hypo-organ perfusion
- Tissue maceration
- Tissue ischemia
- Metabolic acidosis / alkalosis
- Dysthermia
- Sepsis

Listed above are several pathogenic conditions that frequently exist simultaneously in the seriously ill patient and together are capable of initiating DIC.

Disseminated intravascular coagulation is a pathophysiologic process that is directly associated with an underlying illness that clinically manifests itself by bleeding or a tendency to bleed, the etiology of which can be identified by performance of the appropriate coagulation studies. The bleeding in DIC is usually generalized and seldom from a single focus. The tendency to bleed can be recognized by ecchymoses appearing after employment of the sphygmomanometer cuff or neurologic reflex hammer, or inordinate oozing following venipunctures.

Before ordering any laboratory studies, it is necessary to recognize the nature of the bleeding diathesis in DIC. It is essential to be aware that the abnormalities in DIC that can be recognized in the laboratory result from a disturbance of both the coagulation and the fibrinolytic systems. If the body biochemistry is altered so as to activate the coagulation system cascade, there is also prompt activation of the fibrinolytic system. As activation of the coagulation system proceeds, many of the intermediaries generated can directly activate the plasminogen-plasmin system and vice versa. The liver exerts vital influence on these processes (Table 2). Recently, numerous interconnections between the coagulation, complement, kallikrein, and plasminogen-plasmin systems have been identified. The point of emphasis is that in DIC there is simultaneous disturbance of both the coagulation and fibrinolytic systems. Being mindful of this two system derangement, one can correctly select the appropriate laboratory studies to make the diagnosis of DIC. The classic laboratory features of DIC are: abnormal clot formation (simply performed by placement of the patient's blood into a plain glass tube); fragmented red cells and a reduction in circulating platelets (observed on a peripheral blood smear); thrombocytopenia (platelet count often less than 75 x 10^9/l); reduction in plasma fibrinogen concentration (usually less than 0.5 g/l); and elevated titers of fibrinogen-fibrin degradation products (FDP-fdp, also designated FR-antigen). Sometimes serial measurements are necessary to establish the diagnosis.

The primary emphasis on treatment of DIC must be directed at the underlying illness. Disseminated intravascular coagulation is commonly seen in patients with sepsis of all varieties, neoplasia, liver disease, and many pathologic states associated with pregnancy. It can be seen in any illness (usually systemic) where the body biochemistry has been sufficiently altered to activate the coagulation and fibrinolytic systems. If the underlying illness is not recognized or cannot be controlled and reversed, the DIC will seldom be treated successfully. Supportive measures, including the maintenance of a viable blood pressure, adequate oxygenation of the blood, normal blood volume, adequate organ perfusion, urine output, etc., may be necessary to maintain survival. If blood loss is massive, red cell replacement is required. The use of fresh frozen plasma, platelet concentrates, cryoprecipitate, or fibrinogen are usually not helpful, particularly if the underlying process is not being controlled. The use of heparin in DIC is highly controversial and the subject cannot be detailed in this session. To all who enthusiastically endorse this therapeutic modality, let it be recognized that no properly controlled study in patients with DIC has ever demonstrated heparin to be efficacious. The use of anti-fibrinolytic, anti-platelet, and thrombolytic agents in DIC has only been anecdotal and has not been satisfactory.

Management of bleeding problems in the severely traumatized patient is always difficult. If possible, consultation with a skilled, experienced hematologist in a coagulation laboratory should be obtained. At all times the problems should be approached methodically and systematically, employing good judgment and thoroughly utilizing all presently available information. The needless use of excessive numbers of drugs and blood products, treating laboratory abnormalities in order to do something to the patient, in contrast to doing something for the patient, should be discouraged.

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THE INJURED CELL: MECHANISMS IN THE PATHOPHYSIOLOGY OF TRAUMATIC SHOCK

T. R. Border, M.D., T. LaDura, M.D., R. Seibel, M.D. and R. Chenier

I. What Cell

The title of this symposium immediately prompts the question "What cell under what conditions at what time?" The answer to us appears clear. Both the heart and brain get blood flow as long as there is any blood flow to be had. Both muscle and adipose tissue may tolerate prolonged periods without blood flow. The kidneys have some priority in blood flow, but survival may occur without renal function. The one set of organs which must keep working during shock and which have limited blood flow priority are the liver and gastrointestinal tract. The gastrointestinal tract must continue to function as an antibacterial barrier and the liver must keep functioning as a source of glucose and proteins for the other organs in the body. The problem is compounded for the liver acutely by the fact that it normally has a marginal oxygen supply with hypoxia limited metabolism in the lobule zone near the central vein and chronically by a number of continued insults in the post resuscitation period.

II. Clinical Problems

The clinical problems with traumatic shock, granted modern management of the circulatory failure and recognition of the component pulmonary failure may provide, seldom rest with achieving acute survival and almost always rest with achieving prolonged survival. These patients after acute resuscitation commonly enter a cumulative sequence of organ failure which ends weeks to months later with death in association with multiple systems organ failure.

For the past five years all of the trauma patients admitted to this hospital have been cared for by one group of three surgeons. The previous five years they were largely cared for by only one of this group. Two hundred and six of these patients were reviewed with 53 of them reviewed in detail. These 53 patients had an average of three major injuries apiece and 14 died. A review of these 14 deaths and general knowledge of all trauma deaths in this 10 year period shows that the patients who are to die, if they have maximal cardiopulmonary support, have a cumulative sequence of organ failures. These are: 1) pulmonary failure; 2) right ventricle failure; 3) hepatic failure; and 4) multiple systems organ failure.

III. Analysis of Clinical Problems

A. HISTORICAL

These are the patients who a few years back died of shock largely in the emergency room or very shortly after admission. Increasingly vigorous use of fluids, blood and positive inotropic agents prevented many such deaths and a fraction were salvaged. When this was prevented many of these patients then went on to die of acute respiratory distress syndromes at 7 to 14 days. This problem was then recognized, analyzed, effective therapy derived and another fraction salvaged. This, then, leaves us at the present time with a number of severe trauma patients who, with continued vigorous cardiopulmonary support, including use of the ventilator, have by direct measurement cardiac outputs normal or greater than normal without arterial hypotension and arterial oxygen tensions normal or above. These patients, with time, prior to modern nutritional support, developed hypoalbuminemia and jaundice in association with edema, oligura, hyponatremia, hypochloridemia, a respiratory alkalosis, a slight metabolic acidosis, wounds that did not heal, the lethargic to comatose state, decubital ulcers, open wounds, and areas of sepsis without granulation tissue, late gastrointestinal stress ulceration with bleeding, sepsis with normally non-invasive organisms, and finally died in association with massive bleeding and clotting defects. As postmortem their livers were frequently fatty and cirrhotic. The well muscled young people took much longer to die this way than the malnourished older individuals, but the cumulative sequence or organ failures with the multiple systems organ failure development after jaundice and hypoalbuminemia largely appeared the same.

With the introduction of hyperalimentation another slice of these patients were salvaged. However, there was still a group who remained hypoalbuminemic and in whom, although one could clearly give calories, there were no signs of protein synthesis, particularly as judged by plasma albumin. This group was particularly likely to have a fatty cirrhotic liver at autopsy.[2] Administration of albumin to maintain a normal plasma albumin in this group largely prevented the oliguric edema state with its associated hyponatremia, hypochloridemia and increased frequency of oliguric renal failure. This was also associated with a higher central venous pressure and better circulation, but now revealed an element of enlarging liver to palpation and ascites. Apart from these changes produced by large quantities of exogenous albumin these patients went on to die over a longer period of time, much as the patients prior to hyperalimentation died. As a first approximation those receiving hyperalimentation required less exogenous albumin to maintain the plasma albumin than those not receiving hyperalimentation.[3]

B. MULTIPLE SYSTEMS ORGAN FAILURE AND PROTEIN SYNTHESIS

This involves many organs and undoubtedly each organ has its own multi-factorial pathophysiology. A common theme in the hepatic failure with its hypoalbuminemia and the other subsequent organ failures is that of restricted protein synthesis relative to demand. This granted the sequence of changes observed involves first the gastrointestinal tract and liver and subsequently other organs. More generally it probably involves first those organs where immediate function depends upon immediate protein synthesis. This would include not only the liver and gastrointestinal mucosa, but also such things as cellular immunity, acute antibody synthesis,[3] pancreatic protein synthesis, granulation tissue synthesis and probably many others. Lastly it involves those organs where immediate function does not depend on protein synthesis. This would include the skin, heart, respiratory muscle and many others.

Thus, as a first very gross approximation the multiple systems organ failure with which these patients die may be viewed as a limitation of protein synthesis relative to demand. The liver, gastrointestinal mucosa and pancreas have very dif-

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ferent protein synthesis controls than the rest of the body in that, again as a first approximation, the dominant control of the rate of protein synthesis is the rate at which a balanced mixture of amino acids plus calories are provided.

In contrast in the rest of the body protein synthesis is largely dependent upon some facet of organ physical work plus neuroendocrine modulation and independent of the rate of supply of amino acids and calories.[2]

C. HEPATIC INSULTS: GENERAL

The liver is subject to a large number of insults in these patients. The initial shock and arterial hypoxia is an hepatic insult. The subsequent high central venous pressure required for adequate circulation produces hepatic edema which further limits oxygen availability by increasing the diffusion path. This also is an hepatic insult. The absence of food in the gastrointestinal tract produces a state of protein malnutrition for both the gastrointestinal mucosa and liver. A severe catabolic neuroendocrine setting produces mobilization of energetic substrate and amino acids from the liver to the systemic body and thus also stresses the liver. The administration of too many calories and too little nitrogen by enhancing hepatic liponeogenesis without adequately enhancing lipoprotein synthesis may produce a fatty liver and limit hepatic blood flow and thus insult the liver. If this is associated with an increased portal venous pressure it will also have a deleterious effect on the gut and may produce in the peritoneum ascites and edema which enhance bacterial growth. There are thus a large number of general hepatic insults which are persistently active in these patients.[2]

D. MUSCLE LIVER CYCLES: SEVERE STRESS AND SEPSIS

The onset of the trauma septic state has been well recognized to be associated with hyperglycemia and an hepatic glucose output not normally responsive to intravenous glucose infusion. It may also be recognized under conditions of isotonic amino acid infusion without glucose, as one of reduced ketonemia and ketonuria. It is further recognized as a state in which the hyperglycemia is associated with reduced plasma free fatty acids. There is, in addition, work showing that with time (one to two weeks), the muscle carnitine is reduced.[4] The reduction is of the same magnitude that limits long chain fatty acid oxidation in experimental diphtheritic myocarditis in the guinea pig. This does not limit oxidation of the carnitine independent energetic substrates. The carnitine independent energetic substrates are ketone bodies, essential branched chain amino acids, and pyruvate.[5] Muscle for unknown reasons appears to have a very limited oxidation of glucose and pyruvate.[6] Thus several factors change with the trauma septic state in the opposite direction from that normally important in starvation in preventing muscle oxidation of the essential branched chain amino acids. Under conditions of starvation, muscle oxidation of long chain fatty acids is enhanced by increased plasma concentrations and increased muscle carnitine while ketone body oxidation is enhanced by increased hepatic output and increased plasma concentration. The changes that occur with the trauma septic state would be expected to produce a muscle fuel deficit relative to both long chain fatty acids and ketone bodies which would be associated with enhanced muscle blood flow and amino acid oxidation and simultaneously with enhanced hepatic amino acid gluconeogenesis and ureagenesis. This is also observed.[3,8]

Muscle cannot metabolize tryptophan, proline, arginine and ornithine. Therefore to the extent amino acids derived from muscle protein are oxidized these amino acids are released. These are amino acids principally catabolized by the liver. If they are released at a rate at which they can be consumed by the liver then no plasma concentration changes will occur in tryptophan, proline, arginine, and ornithine. However, the same branched chain amino acid deficiency which limits hepatic protein synthesis may also be expected to limit hepatic enzymatic consumption of these amino acids. Thus it is probable that with the course of disease these amino acids will become elevated in concentration. This is particularly true of tryptophan which normally is slowly consumed. An increased concentration of tryptophan relative to the branched chain amino acids is associated with an increased brain serotonin and several changes of the lethargic to comatose state. This is also observed.[8]

If these changes persist without exogenous supplies of amino acids or in the presence of inadequate supplies, then eventually a deficiency of the essential branched chain amino acids might be expected to limit protein synthesis. This would be seen first in those areas which depend most immediately for function on protein synthesis but would eventually involve most organs in the body.[2] Thus, the first commonly done clinical measurement to be involved would be hypoalbuminemia.[8] Simultaneously such things as in vivo cellular immunity which depend upon immediate protein synthesis might also be involved. Subsequently, late gastrointestinal stress ulceration might occur and if associated with increased portal venous pressure might be associated with massive bleeding, ascites, and an enlarged liver. Later on a lack of formation of granulation tissue in decubital ulcers and areas of sepsis might occur. Further, the time course of these changes should be roughly the same as observed clinically because of the half life of carnitine which is 10 to 20 days. Thus a well muscled man should take much longer to develop a branched chain amino acid deficiency limiting protein synthesis than a poorly muscled man. The use of pure glucose intravenously by shutting off hepatic ketogenesis should accelerate multiple systems organ failure, while the use of amino acids intravenously should delay it. Further, as the muscle carnitine deficiency progressively limits muscle long chain fatty acid oxidation, progressively larger quantities of branched chain amino acids would be required to meet the muscle fuel deficit while supporting protein synthesis. This is also observed.[9] Finally, since the essential problem is a deficiency of branched chain amino acids, the use of exogenous albumin to treat hypoalbuminemia would be a very inefficient process because it has only a very small amount of isoleucine. Packed red cells would be no help at all because hemoglobin has no isoleucine.[3,8,9] If, at the same time, there are given, balanced amino acid mixture for normal man is given in adequate quantities to treat the essential branched chain amino acid deficiency, then one might expect difficulties with relative excesses of the toxic amino acids such as tryptophan and methionine. This has also been observed.[10] This would be particularly true of intravenous administration and much less true of gastrointestinal tract administration.[10]

E. RETURN TO MULTIPLE SYSTEMS ORGAN FAILURE

The pathophysiology of death from traumatic shock granted modern management has undergone a considerable change. The major set of unexplained organ failures are now related to multiple system organ failure. Many attributes of multiple systems organ failure begin and grow worse with a number of hepatic dysfunctions. Many of these may reflect the same insult involving several other organs as involves the liver. This would particularly be true of factors which limit protein synthesis in which the hepatic dysfunctions simply reflect a general body problem in a more measurable way. In addition to these hepatic insults, there are a number of insults that are relatively specific to the liver such as absence of oral intake, administration of too many calories relative to protein, and the hepatic effects of a catabolic neuroendocrine setting. Thus the liver has many insults operative in the shock and post resuscitative period.

The hepatic dysfunctions produced by these insults affect the function of many other organs. Thus the amino acid concentration abnormalities with a high tryptophan and phenylalanine and low concentrations of the essential branched chain amino acids and tyrosine affect cerebral function and probably neuroendocrine control of metabolism. Low concentrations of hepatic synthesized plasma transport proteins such as transferrin, vitamin A binding protein, and albumin may affect peripheral metabolism in many ways.[2] Hypoalbuminemia in the presence of a requirement for high central venous pressure for adequate circulation seems to produce inadequate circulation with oliguric edema, water retention, and an increased probability of renal failure.[1] It also contributes to tissue hypoxia changes. The muscle fuel deficit produced by inadequate carnitine synthesis and inadequate hepatic ketogenesis appears to contribute to systemic arteriovenous shunting, increased hepatic gluconeogenesis, restricted splanchnic protein synthesis, and the plasma amino acid concentration abnormalities.[3] Granted the important role of the liver in catabolism of several hormones the hepatic dysfunction may also contribute to several hormone changes which in turn further alters metabolism generally. An example of this is the systemic plasma insulin which normally depends upon both pancreatic secretion and hepatic clearance. Under these conditions hepatic clearance is reduced so that a greater systemic plasma insulin exists for a given rate of pancreatic secretion.[11] This reduces fat mobilization and enhances the glucose oxidative state with consumption of protein. It therefore appears that a persistent muscle fuel deficit could produce most of the changes observed with multiple systems organ failure.

F. HEPATIC SUPPORT REGIMES

A major advance in our management of the trauma patient may come from a carefully designed regime of muscle-hepatic support. This is a major unstated aim of acute cardiopulmonary resuscitation. We are not apt to improve cardiopulmonary resuscitation much further without new concepts. Glucose is clearly required for acute shock resuscitation.

In contrast to the acute problem major improvements may be made in the subsequent metabolic support in terms of muscle-hepatic support. Thus prolonged pure glucose support is bad for the liver, both because it induces hepatic lipogenesis without protein synthesis and because it interferes with the hepatic supply of ketone bodies and carnitine to the muscle and thus via a muscle fuel deficit enhances hepatic gluconeogenesis while further restricting hepatic protein synthesis. These effects are made worse by increasing the daily dose of intravenous glucose. No patient should be on pure glucose more than four or five days. This is justified for economic reasons and because most patients get better in that period of time.[3]

Amino acids or protein have as their effect of greatest importance, stimulation of hepatic protein synthesis. The proteins synthesized are thus utilized by the systemic body. This simple concept is complicated when muscle fuel deficits occur by consumption of the essential branched chain amino acids for fuel.[8,9] To the extent this occurs, the amino acids given cannot be utilized for protein synthesis and the amino acids not utilized by muscle are present in relative excess. Thus the dosage of amino acids given must be increased when one deals with the very sick patient. Persistent hypoalbuminemia under these conditions generally means an inadequate dosage of amino acids.

We badly need an intravenous carnitine independent muscle fuel to be given in association with standard hyperalimentation in these patients. If this prevents muscle oxidation of amino acids then a balanced mixture of amino acids for normal man would become a balanced mixture for sick man and the very sick man would not require an increased dosage of amino acids. Such a fuel might be the monoglyceride of acetoacetate.[12]

At this time, persistent hypoalbuminemia indicates for us the need for more amino acids while an enlarging liver with ascites indicates the need for less glucose. When one gets above the amino acid quantities given by hyperalimentation it becomes more important to give them via the gastrointestinal tract. This is true because the amino acids given in excess relative to the branched chain amino acids are those destroyed by the liver. This clearly alleviates the problems with amino acid toxicity, particularly from tryptophan and methionine.

An hepatic support regime clearly involves the usual cardiopulmonary support but also involves reducing central venous pressure, utilizing the gastrointestinal tract route, reducing the use of pure glucose, adjusting the ratio of calories to nitrogen, and probably involves the use of carnitine and carnitine independent muscle fuels. The effects of this on multiple systems organ failure remain to be investigated but may be considerable.

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CELLS IN SHOCK: THE EFFECTS OF ISCHEMIA MICROPROBE, MORPHOLOGICAL, AND BIOCHEMICAL STUDIES

Wolfgang J. Mergner, M.D., Ph.D.

Introduction

Shock induces metabolic disturbances secondary to hypoperfusion. Our studies on human tissue in trauma and shock obtained during the immediate autopsy procedure shows two types of cellular changes. One type of change which is seen particularly in patients who have survived the event of shock for some time and die secondary to other causes, represents chronic cell injury with attempts of cellular repair, marked autophagocytosis, and evidence of cell regeneration. In contrast, patients who die directly of shock show changes of acute cell injury and cell death as evidenced by electron micrographs (Fig. 1). Biochemical studies show correlations between morphological changes and functional changes (Figure 2). Patients who had organ failure and abnormal ultrastructural morphology have cell organelle failure in biochemical tests. Indeed, the event of shock with organ failure was in all instances associated with disturbances of the system which generates ATP (Figure 3).

Therefore, from the point of view of the single cell situated in an organ exposed to shock the disturbance of perfusion induced by shock is similar to ischemia produced under experimental conditions. Cells exposed to hypoperfusion and shock call into action a series of adaptive mechanisms such as glycogenolysis and anaerobic metabolism. After a period of time, cellular potential fails and cells die. The cellular reac-

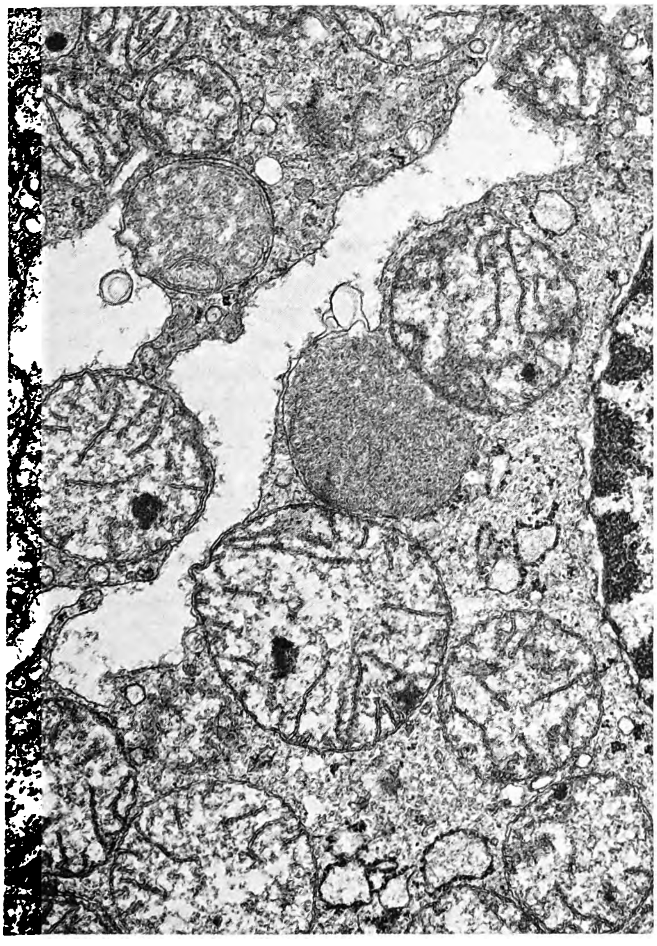

FIGURE 1: Electron micrograph of kidney cell from a patient who died with acute shock. Note the swollen mitochondria with flucculent densities. Flucculent densities are protein agglomerations.

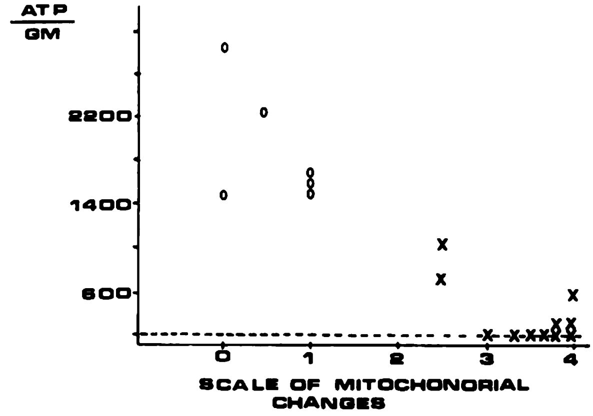

FIGURE 2: Correlation between cellular ability to generate ATP and morphological changes in mitochondria (human liver-substrate glutamatic; data from reference 3). (o No shock, X Shock).

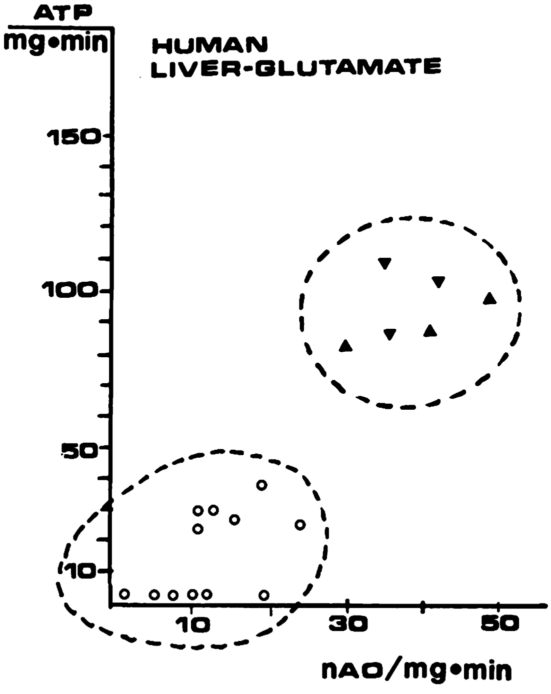

FIGURE 3: Clustering of patients characterized by parameters of respiration and generation of ATP tested on mitochondria. Patients with shock show alterations of both parameters (o) patients without shock do not show alterations of these parameters at the time of death (▲).

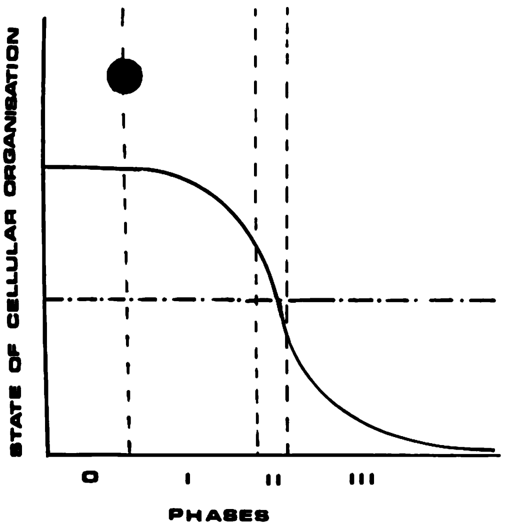

FIGURE 4: Phases of cellular reaction to ischemic cell injury. "I" indicates early phase, "II" transitional phase and "III" late phase. O is the lable for the normal state of cells. ● indicates the onset of cell injury.

tions can be subdivided into three categories, namely (1) those which occur before the "point-of-no-return" is reached (Early phase), (2) those events which occur at the "point-of-no-return" (Transitional Phase), (3) those which occur after the "point-of-no-return" has been passed (Late Phase). The purpose of our investigations is to gain insight into the cellular events which determine the "point-of-no-return" (Figure 4).

Models of Ischemic Cell Injury

Ischemia means (1) deprivation of oxygen supply, (2) deprivation of substrate supply, and (3) inability to remove products of cell metabolism. We studied cellular changes in animals by use of an *in vitro* and *in vivo* ischemia system. In *in vitro* ischemia, tissues are removed and incubated in a moist chamber under anoxic conditions at 37°C for the desired period of ischemia. Subsequently, tissues and organelles are studied. Changes in the tissues described here are rat kidney cortex and dog myocardium. The *in vivo* ischemic model involves ligation of a vessel. In the case of the kidney the abdominal aorta was ligated, in the case of the heart the circumflex coronary artery was ligated, which according to a model developed by Jennings and coworkers, induces ischemia of the posterior papillary muscle. The myocardial *in vivo* system permits clamping and reflow. Twenty minutes of reflow were permitted.

MICROPROBE ANALYSIS

Tissues for microprobe analysis was rapidly frozen with Freon 22 in a specially designed chamber. From there, tissue was sectioned by an ultracryomicrotome described by Christensen. The untreated and unstained specimens were examined under the electron microscope and the probe was placed over cell compartments for measurements of electrolytes within these compartments.

BIOCHEMICAL TESTS

Tests on isolated organelles were performed by atomic absorption techniques or by testing of volume changes of mitrochondria suspended in a solution of electrolytes. The proton gradient, which measures the pH shift following an oxygen pulse, was carried out according to Mitchell in a mixing chamber supplied with a pH electrode and a fast recording system. The ability to accumulate bivalent ions was tested by accumulation of calcium in the massive calcium loading system described by Lenninger and coworkers. Sequestration of calcium was tested by microprobe analysis and morphological identification of mitochondrial granules. Respiration was tested on tissue cubes in the Gilson respirometer and by the Clark oxygen electrode on mitochondria and submitochondrial particles, the so-called ASU particles of Racker. ATP production was measured by acceptor control, P/O ratio, and the activity of the ATPase enzyme. The ATPase enzyme was also examined for morphological alterations by negative staining techniques. We have found that the critical events take place in deficient ATP production and in ionic control of the cellular environment carried out by the plasma membrane and mitochrondria. The cell organelle which most likely contributes significantly to cell death is the mitochondrion. This discussion, therefore, focuses on changes of mitochondria as they occur during ischemia. (Table 1)

Early Phase of Injury

The early phase of cell injury includes morphological States I to IVa as described by Trump and coworkers. During this stage, the plasma membrane of cells in many organs develop early blebs. Mitochondria show changes which range from the disappearance of granules to condensation of the inner compartment and early swelling of the inner compartment.

PLASMA MEMBRANE IN THE EARLY PHASE

With the interruption of supply of ATP the membrane pumps cease to function. Therefore, the ionic control that is executed by the plasma membrane over the cytoplasmic content of electrolytes stop. The resultant electrolyte shift is one of passive exchange of electrolytes across the concentration gradient and equilibration with the extracellular pool. Potassium, for example, is in rather high concentration within the cytosol compartment. An early change observed is rapid exchange with the extracellular compartment. The magnitude of this shift is different depending upon whether or not reflow occurs, because the extracellular pool with which exchange can occur is limited in the no-reflow situation and practically unlimited with reflow. The rate of the initial exchange during the early phase, however, is identical in both situations (Figure 5).

Sodium, another cation, exchanges at a slower rate with the cytosol compartment. Sodium can serve as a very good indi-

TABLE 1: Normal

Electrolytes	K	Concentration High
	Mg	Concentration High
Ca-Transport	Ca	High Rate
Respiration	Succ.	Active
Phosphorylation	ATPase	Active With DNP
	P/O	High
	H^+	Active Gradient

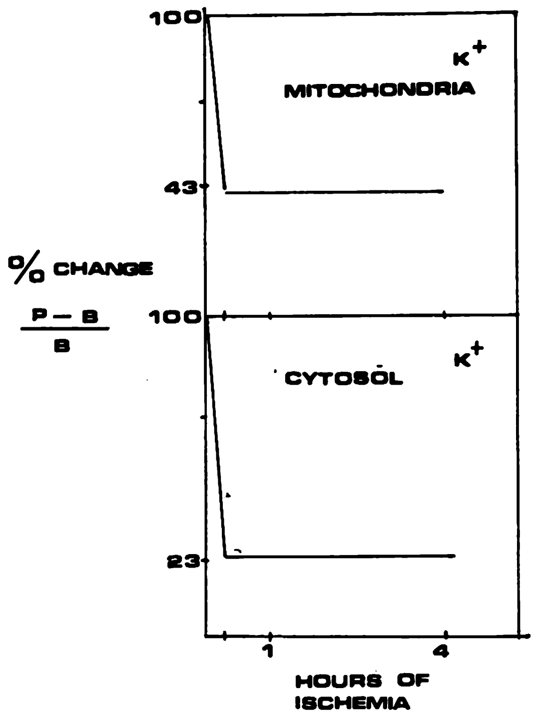

FIGURE 5: Data from microprobe analysis of the mitochondrial compartment and cytosol compartment. Shown is the rapid loss of potassium in reflow situation after the event of ischemic cell injury. (dog myocardium).

cator of the function of the plasma membrane. This is seen in the reflow situation where sodium in the cytosol continuously increases as ischemia persists. There is no sudden change in rate of sodium accumulation at any time during ischemia (Figure 6). This fact indicates to us that plasma membrane changes are mainly passive and accompany deficiencies of ATP production. It is unlikely that there are structural plasma membrane changes during the first phase.

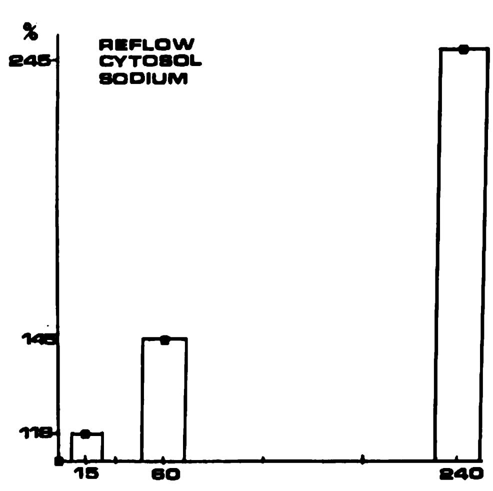

FIGURE 6: Graphs of microprobe analysis of cytosol. Measured is the content of sodium as a function of ischemic time (dog myocardium).

TABLE 2: Early Phase

Electrolytes	K	Decreasing
	Mg	Unchanged
Ca-Transport	Ca	Moderately Decreased
Respiration	Succ.	Increased
Phosphorylation	ATPase	Decreasing
	P/O	Slightly Decreasing
	H^+	Increased

MITOCHONDRIA IN THE EARLY PHASE (TABLE 2)

Changes of mitochondria during the early phase are marked by changes in permeability of selected electrolytes such as potassium. In our test system, we determined that the matrix content of potassium decreases rapidly (Figure 5). This induces a condensation of the inner compartment presumably on an osmotic basis (Figure 7). Isolated mitochondria measured by atomic absorption and those measured in frozen tissue sections probed by microprobe analysis gave identical results. In another test system using swelling of mitochondria in potassium chloride solution, we found membrane alterations marked by swelling which indicates a change in permeability. The mo-

FIGURE 7: Electron micrographs of mitochondria (Phase I) taken from a patient in shock and note the marked contraction and density of the inner compartment while the cytoplasma appears swollen. (Human renal cortex).

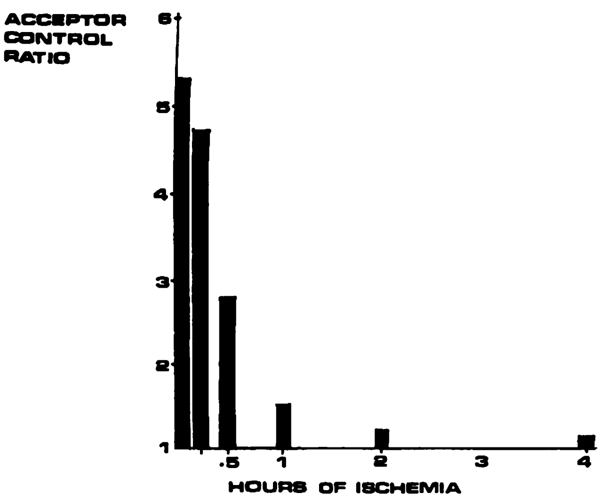

FIGURE 8: Changes of acceptor control as a function of ischemic time.

lecular basis of this change is not clear but this is a striking change and possibly related to other alterations such as uncoupling and inhibition of the ATPase. An increased proton gradient of isolated mitochondria following an oxygen pulse was also observed during this phase which we feel could also be related to an increased leak of potassium. Transport of calcium remains active initially, but decreases rapidly during the latter period of the early phase. At the same time the sequestration of calcium in mitochondrial granules decreases. This change, the decrease of granules, has been observed in prior studies on fixed tissue and was also seen in our studies on frozen sections of ischemic tissue. Electron transport, tested in mitochondria by oxygen consumption, is increased with succinate and α-ketoglutarate as substrates. We feel that this change apparently consists of removal of an inhibition of respiration during the early phase of ischemia.

The ATP generating system is most significantly altered in mitochondria during this early phase. Acceptor control, the ratio between State III and State IV respiration declines rapidly (Figure 8). State III is respiration stimulated by substrate and ADP together. State IV is respiration stimulated by substrate alone. The alteration of State III and State IV ratio is called uncoupling. During the same time interval 2,4-DNP stimulated ATPase decreased in activity (Figure 9). Findings in isolated mitochondria were reproduced in tissue homogenates. This inhibition of ATPase activity, an early

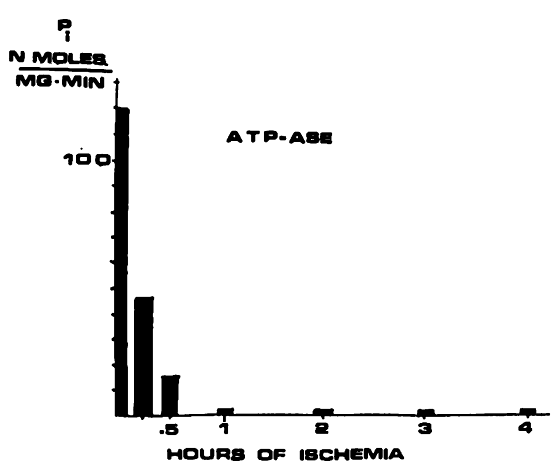

FIGURE 9: Changes of 2,4-DNP stimulated ATPase of inner mitochondrial membrane as a function of ischemic time.

event, is not accompanied by structural changes of inner-membrane spheres seen by negative staining in the electron microscope. Inner membrane spheres were identified as ATPase protein by Racker.

In summary, changes occuring during the early reversible phase of ischemic cell injury are related to a change in membrane permeability and are accompanied by changes in electrolyte concentration in cellular compartments. These changes in electrolytes are passive phenomena secondary to the absence of ATP as energy source to drive the membrane pumps. Functional changes which are observed during this early phase are defined as inhibition, and it is suspected that these functional changes are related to the shifts of electrolytes such as potassium in the matrix compartment of mitochondria. All the described changes are reversible.

Transitional Phase

The transitional phase represents State IVb of the morphological stages of Trump and associates. This stage is characterized by swelling of all mitochondria and the appearance of small fluffy matrix densities in those mitochondria. The plasma membrane shows the beginning of whorl formation. Some of these changes are seen in Figure 10.

PLASMA MEMBRANE DURING THE TRANSITIONAL PHASE

In the reflow model as well as the no-reflow model, no change in the rate of accumulation of sodium was seen during the transitional phase. A continuous decline in the potassium concentration was noted in the no-reflow model but no change was observed in the reflow model. Since the plasma-membrane ATPase remains unaltered for six hours of ischemia, the continuous decline of potassium and increase of sodium occur

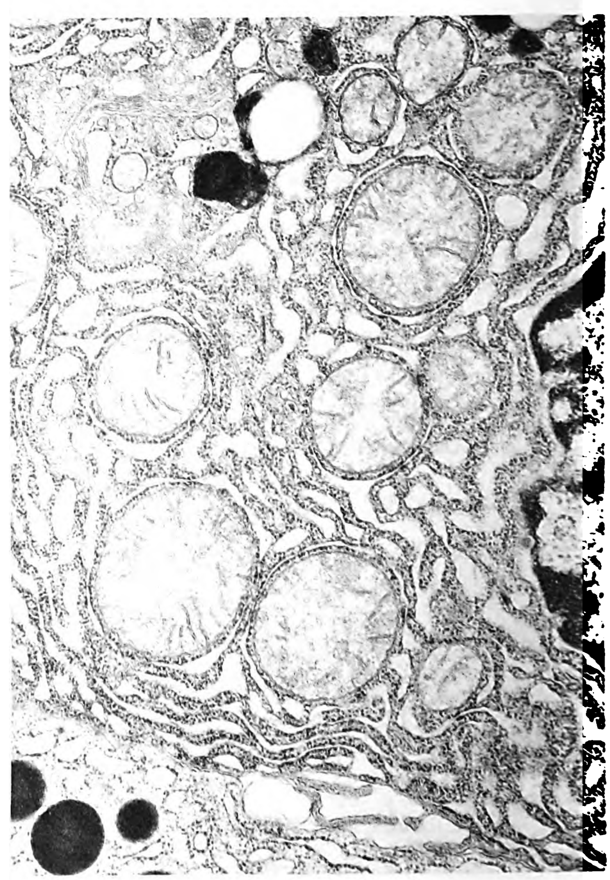

FIGURE 10: Early transitional phase; Human pacreas. Courtesy of Dr. Jones.

TABLE 3: Transitional Phase

Electrolytes	K^+	Decreased
	Mg^{++}	Decreased
Ca^{++}Transport	Ca^{++}	Decreased
Respiration	Succ.	Active
Phosphorylation	ATPase	Decreasing
	P/O	Decreasing
	H^+	Decreasing

because of the unavailability of ATP from the bioenergetic system. Furthermore, Laiho observed that during this transitional period, magnesium content of cells decreases. Magnesium is an intracellular bivalent cation which is structurally bound to the membrane of mitochondria and other organelles. Loss of magnesium indicates changes in mitochondrial membranes.

MITOCHONDRIA DURING THE TRANSITIONAL PHASE (TABLE 3)

During the transitional phase we see the beginning of a decline of the proton gradient (Figure 11). Rate of transport of calcium continuously declines and mitochondria apparently show no ability to sequester calcium in a reversible form, but the ability to form calcium phosphate crystals, or paracrystals, an insoluble precipitate still prevails during this interval. During this same time interval some reduction in the rate of succinate stimulated respiration occurs and the continuous decline of NADH stimulated respiration is initiated at this phase. Acceptor control remains low. The P/O ratio begins to decline sharply at this time interval (Figure 12). Studies by Markelonis and Garbus as well as by Trump and Collan have shown that during this time interval there is increasing liberation of free fatty acids from mitochondria. Certain phospholipids such as cardiolipin apparently are altered. The transitional phase, therefore, is marked by possible lipolytic action by lytic enzymes on mitochondrial inner membrane.

Late Phase

The late phase is morphologically characterized by further

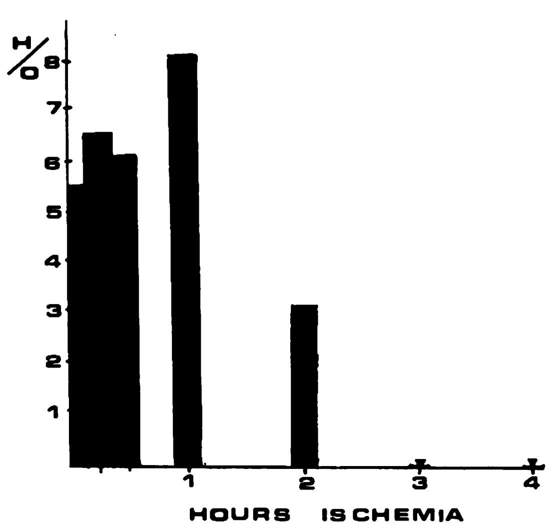

FIGURE 11: Change in proton gradient as a function of ischemic time.

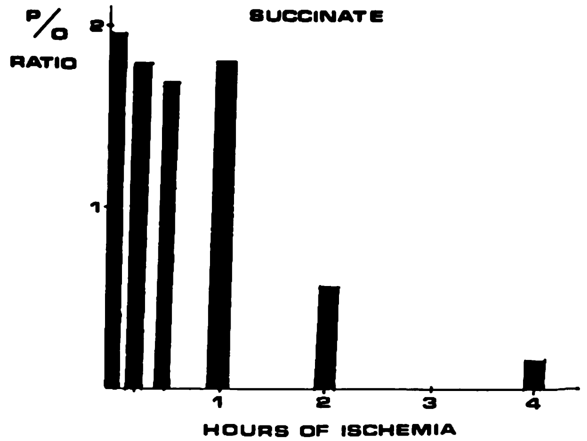

FIGURE 12: Change in P/O ratio supported by succinate as a function of ischemic time. Note the sharp decline in P/O ratio between the 1 and 2 hour time interval.

degradation. The plasma membrane looses its continuity and there is excessive whorl formation as well as loss of cell to cell connection, and the appearance of tubular forms and myelin forms. Mitochondria show swelling and large flocculent densities, and degeneration of cristae and inner membrane. (Figure 14).

PLASMA MEMBRANE IN THE LATE PHASE

There is still more sodium accumulation in the late phase in reflow situation, but not in no-reflow situations.

MITOCHONDRIA IN THE LATE PHASE (TABLE 4)

Mitochondria show in reflow situations the precipitation of calcium phosphate and large flocculent densities which Collan and associates have recently shown to be coagulate matrix proteins. Functionally, there is still a remaining ability to accumulate calcium, but at a low rate. There is also a persistance of succinate supported respiration (Figure 13). The rate is approximately equal to the initial State IV respiratory rate. NADH supported respiration and respiration utilizing substrates such as α-ketoglutarate decline during the early period of this late phase. This is observed in tissue cubes and isolated mitochondria, as well as in submitochondrial particles. All activities related to phosphorylation have ceased.

TABLE 4: Late Phase

Electrolytes	K	Decreased
	Mg	Decreased
Ca-Transport	Ca	Decreased
Respiration	Succ.	Active
Phosphorylation	ATPase	O
	P/O	O
	H^+	O

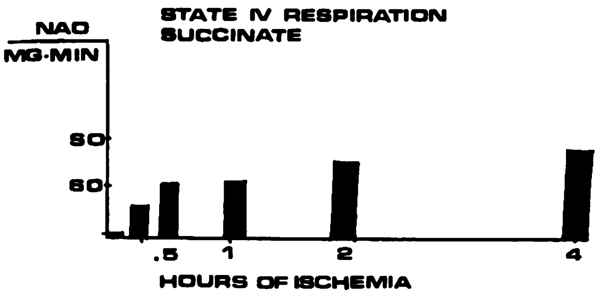

FIGURE 13: State IV respiration supported by succinate.

Cells in Ischemic Cell Injury; Alteration of Cellular Regulation

Each phase can be characterized by key events. The early phase, for example is characterized by ion shifts and subsequent inhibition of key enzyme systems in mitochondria involving the phosphorylation system. The transitional phase is characterized by lytic alterations of the inner membrane of mitochondria. The late phase is identified by continuous progress of degradative processes with some remaining function such as succinate supported respiration. Unresolved at the present time is the cause of the membrane alterations. The injury model used by Racker and coworkers implicates a critical function of phospholipases which, if activated, could induce a sequence of changes similar to the one observed in the ischemic mitochondria. These are permeability changes, uncoupling of mitochondria, and inactivation of the ATPase system while the electron transport system persists. It is significant that only externally added phospholipases to whole mitochondria had this effect. Phospholipases added to submitochondrial particles (in-side-out vesicles) destroyed the respiratory component first. It has been proposed by several investigators that the increased presence of calcium and possibly the failure to sequester calcium, marked by the early disappearance of mitochondria granules observed by Trump and Mergner and associates could be related to the activation of phospholipases. This change could be compounded by the influx of calcium into the cytosol compartment because of defective control of the plasma membrane calcium pump which increases the amount of available and nonsequestered calcium. Reflow situations are possibly more affected by calcium influx since a higher amount of calcium is available in the extracellular space. It can be reasonably proposed that the crucial event in the transitional phase determining the "point-of-no-return" is an enzymatic destruction of the mitochondrial inner membrane which results in loss of the proton gradient, loss of magnesium associated with the inner mitochondria membrane, and loss of the phosphorylating ability by these membranes.

REPERFUSION

Recent data by our laboratory as well as by other laboratories on reflow situations indicate that reflow could bring a marked acceleration of cell swelling. In some model systems such as the myocardium described by Jennings, the reperfusion has been determined to be detrimental. It accelerated the destruction process observed in the no-reflow system. Theoretically, these observations could be explained by an accentuation of the electrolyte shifts while cells are still in a state unable to restore control over the electrolyte functions, and have possible persistent inhibition of mitochondria function. The basic mechanism, however, is no-reflow and reflow situations is identical.

In conclusion: We have observed that mitochondria destruction occurs at a time when cells pass through the point-of-no-return. Mitochondrial destruction renders cells unable to survive. The plasma membrane in this view is a passive bystander of the basic alteration in mitochondria. (Figure 14).

Suggested Readings

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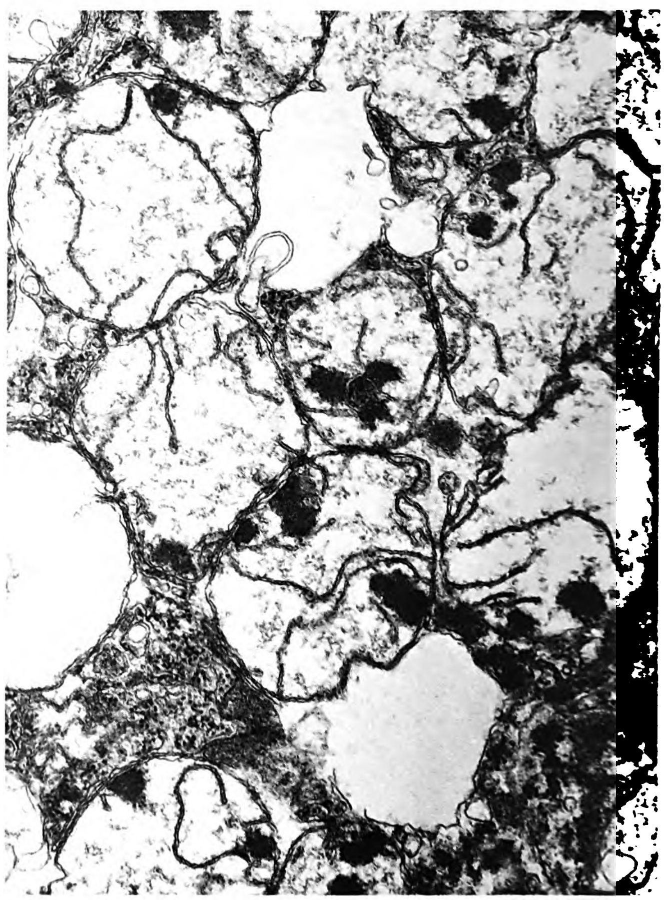

FIGURE 14: Mitochondria in late phase, human renal cortex. Note swelling and flucculent densities.

MITOCHONDRIA, OXIDATIVE METABOLISM AND PROSTAGLANDINS IN CELLULAR INJURY AND CELLULAR SURVIVAL

Joel Garbus, Ph.D. and George Markelonis, Ph.D.

If an aerobic organism, tissue, or cell is deprived of oxygen, there ensues a deterioration of cellular structure and function. The temporal progression of these changes has been extensively described and is, in many aspects similar to that seen in other modes of cell injury. Among the earliest biochemical changes are a rapid shift in the composition of intracellular ions, a reduction of pyridine nucleotides and a precipitous decline in the content of adenosine triphosphate (ATP). From these experimental observations, a causal sequence has been proposed for the initiation of anoxic cell injury; the deterioration of structure and function follow from the dimunition of the cellular content of ATP, in itself a result of the diminished availability of oxygen. The fall in ATP results in perturbations of the cellular metabolic economy which, directly or indirectly, impairs the process of oxidative phosphorylation. As the mitochondria is the locus of oxidative phosphorylation, a tenent of the postulated sequence is the susceptibility of the mitochondrion to anoxic damage.

Experimental studies of the effects of low perfusion or ischemia upon energy metabolism have induced demonstrated decreases in mitochondrial function and concomitant alterations in morphology. The experimental approach has been to subject the intact organism or isolated tissues to lowered perfusion or to total anoxia and then examine the mitochondria isolated from various tissues. Under these conditions the rate of decline of mitochondrial function parallels the relative susceptibility of various organs to anoxic damage: for example, mitochondria isolated from brain totally lose function after two to five minutes of anoxia, while liver mitochondria can withstand one to three hours of anoxia and still retain a modicum of function; kidney and heart mitochondria are intermediate in that they retain some function after one-half to one hour of oxygen deprivation *in situ*.

This methodology provokes the deterioration of mitochondrial function under conditions which we suppose simulates that which occurs in natural injury. That is, a fall in the cellular availability of oxygen and substrates, ionic shifts, lysomal activation, a fall in pH, and the elaboration of local tissue products such as kinins, catecholamines, and free fatty acids. The results of such studies therefore indicate a potential for the retention of mitochondrial function for varying lengths of time under these adverse conditions.

It occurred to us to pose the question: What would happen to isolated mitochondria allowed to remain in a well buffered medium of appropriate ionic composition, supplied with substrate but rendered anoxic? In short, the only perturbation in the medium capable of supporting normal mitochondrial function would be the lack of oxygen. Would mitochondrial function be retained for a longer period of time under these artificial conditions compared to the more adverse milieu of the injured cell? The answer in short is no. One such experiment is shown in Table 1. Similar experiments with mitochondria from other tissues indicate that survival time under these *in vitro* conditions is comparable to those seen *in vivo* anoxic experiments.

What is responsible, then, for the eventual deterioration of mitochondrial function in the *in vitro* medium? The major electrolyte, as in the normal cell, is K^+, with no possibility of Na^+/K^+ exchange; pH shifts are minimal; very few lysosomes are present; possible toxic factors derived from other cellular components are excluded. The factors involved in the alteration in function must be associated with changes in this relatively simple system, *i.e.*, in the mitochondria themselves as affected by low oxygen and therefore low ATP. Looking at the system very simply, what can go awry? Two related processes suggest themselves. With a fall in intramitochondrial ATP, Ca^{++} is extruded from the organelle. This acts as a cofactor in the activation of lipases which cleave fatty acids from mitochondrial lipids. The liberated free fatty acids (FFAs) act as detergents in deranging mitochondrial membrane structure and as uncouplers of oxidative phosphorylation, and promote the second of the adverse processes, the leakage of components of electron transfer, the pyridine nucleotides and cytochromes. The culprits then in the anoxic damage are the liverated fatty acids.

This line of reasoning provoked a study of the release of free fatty acids in isolated anoxic mitochondria. The results with the liver mitochondria of Table 1 are shown in Table 2. The concentration of all free fatty acids rise as the anoxic interval is extended and parallels the decrease in mitochondrial

TABLE 1: Oxidative Function of Anoxic Liver Mitochondria Compared to Aerobic Mitochondria

	Anoxic					Aerobic			
Time (hr)	State III* $nAO_2/min/mg$	State IV† $nAO_2/min/mg$	RCI‡	ADP/O	Time (hr)	State III* $nAO_2/min/mg$	State IV† $nAO_2/min/mg$	RCI‡	ADP/O
0	87.29	15.38	5.76	2.41	0	87.11	13.21	6.59	2.21
1	32.99	11.94	2.76	2.33	1	21.78	9.32	2.34	2.66
2	42.17	30.08	1.40	2.19	2	21.78	13.93	1.56	2.51
3	39.63	39.63	1.00	0.00	3	22.49	14.28	1.57	1.57

After the anoxic period, portions of the mitochondrial suspensions were re-oxygenated, and their function determined polarographically. The control consisted of a suspension of mitochondria which was continuously exposed to the atmosphere.

*State III–rate of oxidation in the presence of ADP and substrate
†State IV–rate of oxidation in the presence of substrate after the exhaustion of added ADP
‡RCI-----respiratory control index; the ratio of State III to State IV rates.

TABLE 2: Concentration of Free Fatty Acids Under Various Conditions*

Free fatty acid	Control (0 time)	One hr Anoxia	Two hr Anoxia	Three hr Anoxia	Three hr Control†
C16:0	1.68	3.25	5.09	5.19	0.76
C18:0	1.15	4.09	6.91	3.74	0.32
C18:1	0.85	1.28	1.68	3.23	0.29
C18:2	0.44	1.23	2.10	2.22	0.05
C20:2	0.22	0.08	0.15	0.25	0.06
C20:4	0.08	0.55	1.39	1.87	0.02
C20:5	0.00	0.16	0.35	0.25	0.00
C22:6	0.00	0.11	0.21	0.19	0.00
Total	4.42	10.75	17.88	16.94	1.50

FFAs were extracted and quantified by GLC.
*Expressed as nmol of free acid per milligram of mitochondrial protein.
†FFAs recovered after 3 hr under aerated conditions.

function. The initial rise in FFAs was largely due to saturated FFAs even though these saturated fatty acids account for only 33 percent of the total mitochondrial fatty acids. Of more interest is the proportionately greater increase in the polyunsaturated FFAs C20:4, C20:5 and C22:6. Also, the fatty acids, C20:2, C20:5 and C22:6 which were found in mitochondria rendered anoxic for one to three hours were not previously reported in mitochondria isolated from ischemic liver. These longer chain polyunsaturated fatty acids are known precursors of prostaglandins of the E and F series. As the liver has been shown to possess the enxymatic complement needed for prostaglandin synthesis, the accumulation of these known prostaglandin precursors may represent the penultimate step for synthesis of prostaglandins.

The synthesis and release of prostaglandins may represent a mechanism by which the cell deals with the deleterious effect of anoxia. Support for this hypothesis comes from studies demonstrating increased levels of prostaglandin released from tissues rendered ischemic. Furthermore, unpublished observations in this laboratory have shown an increase with time in endogenous FFAs in various organs rendered anoxic that parallel the organs' susceptibility to ischemic damage.

That mitochondria may be the regulators of the levels of prostaglandins during ischemic episodes in intact cells is an intriguing concept.

Normal cellular function is dependent upon a continuous supply of utilizable chemical energy. The major source of this cellular energy is ATP derived from oxidative phosphorylation in mitochondria. We suggest that prostaglandin synthesis is initiated in response to intracellular conditions which indicate an actual or potential deficit in the capability for maintaining cellular levels of ATP. A critical factor for the continuous function of oxidative phosphorylation is the steady supply of oxygen to the cell. The vasodilatory effects of E and A prostaglandins elaborated as a consequence of cell injury would enhance the local availability of O_2 and ensure continuous supply of substrates to the cell. If, however, cellular homeostasis is not readily restored, deteriorating cellular conditions could favor the synthesis of PGF. The local effects of PGF, namely, vasoconstriction, would function to decrease the availability of O_2 and metabolites to such cells. This would ensure that the limited local supply of O_2 and metabolites would be directed to cells elaborating vasodilatory prostaglandin, *i.e.*, cells with a greater potential for viability. Prostaglandin synthesis and the nature of the prostaglandin released thus serve as autoregulatory mechanisms which allow single cells to influence the functioning of the local microvasculature.

Prolonged noxious stimuli such as hemorrhagic shock, anaphylaxis or cold stress, intensify prostaglandin synthesis with concomitant elevations of prostaglandin levels in the systemic circulation. The systemic effects of the vasodilatory prostaglandins may also function to ensure the proper milieu for the viability of the cell. Among these effects would be an increase in hematopoietic stem cell proliferation, an increase in cardiac output, a relaxation of tracheal smooth muscle, and an increase in vascular permeability. In fact, many of the pharmacologic effects of these prostaglandins may be viewed as mechanisms to increase the delivery of oxygen and metabolites to cells.

If prostaglandins indeed function as modulators of the delivery of substrates and O_2 needed for the maintenance of cellular homeostasis, it is necessary to propose a mechanism by which perturbations in O_2 availability or ATP synthesis might lead to prostaglandin synthesis and release.

Rat liver mitochondria maintained under anoxic conditions elaborated medium chain free fatty acids and long chain prostaglandin precursors. Concomitant with this rise in mitochondrial free fatty acid concentration, the capacity to phosphorylate ADP fell, ultimately resulting in the uncoupling of oxidation and phosphorylation. On the basis of these observations, we proposed the following sequence: (a) as intracellular O_2 falls as the result of ischemia, oxidative phosphorylation capacity decreases; (b) the deterioration of mitochondrial function allows the release of sequestered Ca^{+2} which activates mitochondrial and microsomal phospholipases; (c) activated phospholipases liberate esterified free fatty acids by attacking membrane phospholipids (the availability of long chain free fatty acids has been considered the rate limiting step in prostaglandin synthesis); (d) concurrently, the inhibition of mitochondrial oxidation further permits the build-up of free fatty acids either directly, or by inhibition of the fatty acid activating system; (e) the available polyunsaturated C20 free fatty acids are converted to prostaglandins by microsomal prostaglandin synthetase; (f) the intracellular release of sequestered Ca^{+2} could also affect the release of nonrepinephrine which would enhance the synthesis of PGE, at least in nerve cells.

Other consequences of a diminished capacity for oxidative phosphorylation may also pay significant roles in increased prostaglandin synthesis. The adverse change in the ATP/ADP ratio would cause inhibition of the fatty acid activating system as well as inhibit the resequestration of Ca^{++}.

The accompanying increase in reduction potential may have multiple effects such as: (a) increasing the levels of reduced glutathione which is known to enhance vasodilatory-prostaglandin synthesis *in vitro;* (b) inhibiting prostaglandin dehydrogenase; (c) increasing the synthesis of PGF as well as PGE and PGA. The decreased capacity of mitochondrial oxidation would allow prostaglandins to accumulate, since their degradation via *beta*-oxidation would be inhibited. Finally, the metabolism of amino acids may be inhibited, thus increasing the cellular levels of these compounds. Amino acids, in the presence of other cofactors, have been shown to activate prostaglandin synthetase *in vitro*, selectively increasing PGE.

With the return of adequate tissue oxygenation, a reversal of the above mechanism would occur. Mitochondrial oxidation would be stimulated causing a resequestration of Ca^{+2}, an effect possibly mediated by the prostaglandins themselves. With the increase in ATP there would be enhanced fatty acid activation and oxidation, and a decrease in the reduction potential. Elaborated prostaglandins would be metabolized by *beta*-oxidation or by the prostaglandin dehydrogenase reaction. The restoration of energy would thus counter the role of prostaglandins.

The mechanism proposed here accounts for the enhanced efflux of prostaglandins in situations where there is an obvious decrement or cessation of oxygen delivery to cells or tissues. It is therefore a plausible explanation for enhanced prostaglandin content in experimental or pathological states involving hypoxia, anoxia, vasoconstriction, ischemia, severance of an organ from a continuous supply of oxygen, or extensive cellular trauma. Where endogenous or exogenous pharmacologically active agents provoke prostaglandin synthesis or release, the mechanism may hold if an additional postulate is invoked. This considers that agents such as catecholamines operate through their ability to constrict the local microvasculature, again resulting in a localized decrease in cellular oxygen content. It is possible that these agents have additional effects, such as the enhancement of adenyl cyclase activity, which in turn may transiently deplete cellular ATP. Although these vasoactive agents may presumably act to evoke prostaglandin synthesis and release through other mechanisms, we believe that their actions can also be attributed to their ability to produce localized decrements of oxygen and ATP. Finally, we consider the synthesis of prostaglandins in such situations as total organ ischemia as a magnification of rapid and transient mechanisms continuously operating in the microenvironment of the cell which insure an adequate supply of oxygen and metabolites.

To summarize, we propose that prostaglandin synthesis is integrally related to intracellular oxidative energy metabolism. When the oxygen supply to a tissue decreases or the energy metabolism is perturbed, leading to an increased utilization of ATP whether by ischemia, hypotension, embolism, severance from the blood supply, vasoconstriction, vascular pathology, exogenous pharmacologically-active agents, or endogenous compounds such as catecholamines, the resulting alteration in intracellular energy metabolism causes a deterioration of oxidative function leading to an increase in prostaglandin free fatty acid precursors. Concurrently, metabolic changes such as decrease in the ATP/ADP ratio, an increase in reduction potential, and an increased availability of certain amino acids promote the synthesis and decrease the breakdown of prostaglandins. The net effect is predomonantly the synthesis and release of the vasodilatory prostaglandins, E and A. This mechanism *in vivo* functions to enhance the delivery of 0_2 and metabolites to the cell. The destruction of this highly integrated response *in vitro* is seen as an elevation or release of prostaglandins. However, *in vivo*, the return of adequate tissue oxygenation allows a reversal of this mechanism, and prostaglandins are rapidly degraded as discussed above.

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Clinical Research—Urgent Solutions Needed

CLINICAL RESEARCH: DAMAGE TO THE CENTRAL NERVOUS SYSTEM

D. P. Byrnes, M.D. and T. B. Ducker, M.D.

Modern techniques and equipment have allowed us over the last 20 years to postpone or prevent death in the neurologically traumatized patient who prior to this time would have succumbed. However, our knowledge of the nature of central nervous system (CNS) trauma or even the physiology of the CNS itself, has not in our opinion, kept pace with our new powers. Therefore, we are presented with increasing onus the challenge to seek some of these answers.

What is the nature of injury at all levels even down to include the intracellular changes? How can we chart progress from that injury?

The oldest form of learning is observation. This, together with comparison and contrast, can increase our knowledge dramatically. The difficulty has been, and continues to be, that observation of the head or spinal injury is theoretically easy, but the significance of the observation has not been uniformly defined. Comparison has always been a problem because of the multiplicity of variables, such as age, type of injury, length of post-traumatic amnesia, and infinitum.

Two newer methods to help assess the condition of the patient are 1) the reduction of all possible clinical facts to numerical measurement and 2) the computer summation of those clinical facts. Clinical parameters such as pupillary size and reaction, consciousness level and degree of sensation are coded by number.

This paper is an attempt to rationalize various data in the brain or spinal injured patient so that the data are clear, weighted, repeatedly measurable and capable of reduction to a scoring system whereby comparison will be valid. The two basic CNS injuries, head injury and spinal injury, are discussed here, and two sets of data are treated in similar manner. The information gained from clinical examination and laboratory studies are grouped to the series of displays — five in the case of the head injury and eight in the spinal injury.

These displays are designed around use of a computer controlled 24-line cathode ray tube (CRT) display terminal. Each display shows four lines of identification — chart number, patient name, time and date of entry — followed by a set of related information, *e.g.*, muscle power of upper limbs or cerebral response to various stimuli. One display presents an overall summary.

All the clinical data, such as pupillar size response, consciousness level, degree of sensation, and motor power and, to a great extent, the lab and radiographic data, are reduced to numbers, with the highest number being the best conditions. In other words, the greater the number on any given score the more it approaches normality. Furthermore, these numbers are weighted in such a way as to emphasize those factors which, in our opinion, are important than others, *e.g.*, pain sensation in a spinal injury is of greater significance than joint position sense. In addition, the figures when added in various categories, such as motor power, sensory power, etc., have total possible aggregate of 100. Therefore, the figure 100 represents normality. Anything less than this figure of 100 implies a deficit or abnormality. Thus, the scoring system evolves, which is at the same time significant, easy to execute, and readily appreciated.

The CRTs are placed at the bedside or some convenient location close by. Thus, it will be possible to simply enter each day, or more often, any change in the patient's status. An attempt has been made to group the displays so factors that are likely to change the least are placed in the early displays, *e.g.*, CAT scan lesion size, as opposed to pupil size which may be changing all the time. This information would be stored by the computer system, a dedicated on-line computer system Dec. PDP 11/70, located in the Maryland Institute for Emergency Medicine (MIEM). This facility is specifically designated for critical care and constitutes a separate facility within the University of Maryland. Approximately 1,000 patients are admitted from throughout the state each year. These have mainly traumatic injuries and 50 to 60 percent have CNS injuries.

Following initial assessment, the information gained would be entered and the patient's clinical state scored. As the patient's condition changes so would his score, and the efficacy of treatment could be assessed, both in terms of a single patient and in the elucication of a pattern in many patients. For example, what effect would the reduction of steroids on the third day of a spinal injury as opposed to the fifth day have on patients' scores? New types of management and the effectiveness of established forms could be critically examined by removal of impressions and gut feelings. The MIEM and University of Maryland's Division of Neurosurgery will combine in this study to admit sufficient numbers of both spinal and head injuries per year to make such a study feasible. The data of the National Spinal Cord Injury Registry will be also a source of further comparison and information gain.

Head Injury

Display One is concerned with the CNS lesion as seen angiographically and on computerized axialtomography: size, density and enhancement, position, shift of midline structures, etc. Display Two is a display of intracranial pressure, blood gases and seizure type. Displays Four and Five attempt to score the patient's clinical state, *e.g.*, left pupil reaction is given a score of 0 to 2, 0 being no reaction, 1, a sluggish reaction, and 2, a

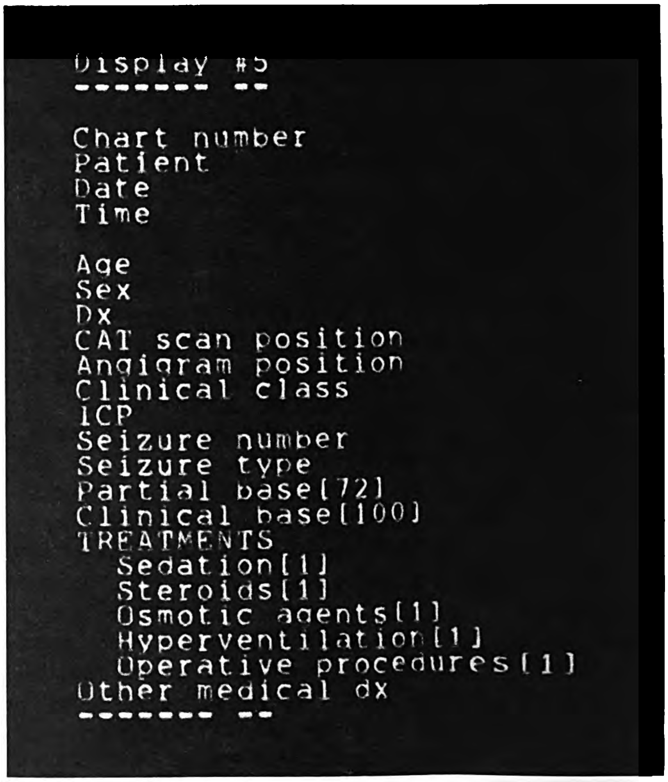

FIGURE 1

normal reaction. Motor power is graded 0 to 5 as is the conventional MRC scale, 0 being no power, 3 being weak but against gravity, 5 being normal, 2 and 4 being between these. Display Three aggregates to a subtotal partial base of 72. When this is added to the possible 28 score of Display Four, the total clinical base is 100. Display Five is a summary of Displays One through Four. (Figure 1) If the patient changes, be it in

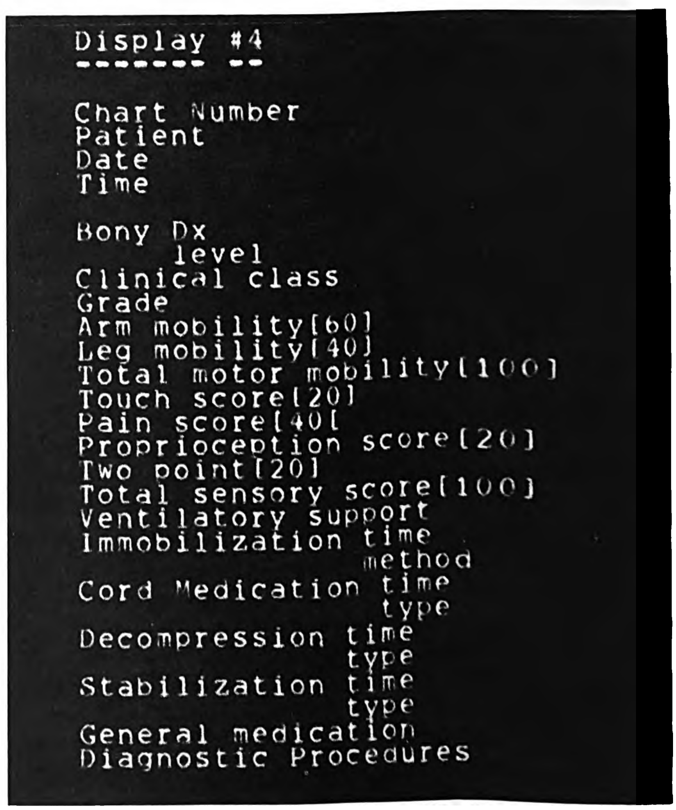

FIGURE 2

consciousness, pupil size or even visual field, his full change will be reflected in his clinical base total.

Spinal Injury

Similarly, with spinal injuries there are eight displays, mainly because the motor and sensory examination is necessarily more detailed. Display One is a summary of the patient's state on admission, the type of injury, the boney damage, etc. Display Two is an arm mobility scoring system adding up to 60 with Display Three scores leg mobility, adding up to 40. Thus, the total limb mobility score is 100. Displays Five, Six, Seven, and Eight are the various modalities of sensation which, in total, reach 100, with pain sensation being regarded as twice as important as the other sensory modalities. This is reflected in its total of 40 against the others of 20 each. Display Four (Figure 2) is a summary of all the information on the other displays. A spinal injury patient will thus have a muscle power and sensory score adding up to a possible normal 100 each.

The value of this project is that it will be readily implemented as the basic equipment and qualified personnel are already installed. Cost will be minimal. Input would probably require either a typing assistant or existing medical attendant who could be trained.

THE MEDICAL ASSESSMENT OF A NEW SOFT BODY ARMOR

Carl A. Soderstrom, M.D. and Andrew W. Carroll, M.D.

Since the 1960s, an increasing number of police officers have been assaulted by firearms. Attempts against the lives of public officials have also marred this period, including the assassinations of a president, a presidential candidate and a prominent civil rights leader.

The handgun represents the most commonly used weapon in assaults against police personnel. FBI statistics for the ten-year period from 1964 through 1973 showed:[18] 1) Seventy-four percent of police fatalities involved handguns. 2) The "common" handguns and "Saturday night specials" (.38, .380, .32, .25, .22 caliber) represented 81 percent of the handguns used in the fatal police assaults.

In 1973, a multi-institutional program, including the US Army Land Warfare Laboratory (LWL) and the Law Enforcement Assistance Administration (LEAA), was initiated to develop a new lightweight, inconspicuous, soft body armor. Armors then available were generally of the heavy, bulky military variety.

After ballistic tests using various materials, a lightweight synthetic fiber, Kevlar-29 (Dupont), was selected for use in body armor fabrication. Seven layers of this high tensile strength material consistently prevented penetration by a .38 caliber threat at 800 ft/sec and a .22 caliber threat at 1000 ft/sec.[14]

In addition to ballistic studies, biologic and mathematical methodologies assessing the protective qualities of a seven layer Kevlar soft body armor were developed at the US Army's Biophysics Division (Edgewood Arsenal).

Experimental Group

MATERIALS AND METHODS

Animal experiments were conducted in accordance with the *Guide for Laboratory Animal Facilities and Care.* These studies were carried out on anesthetised, intubated goats weighing approximately 40 kg. Goats protected with Kevlar armor were assaulted with .38 caliber 158 grain lead threats at velocities of approximately 800 ft/sec. Shots were targeted over various parts of the body, to assess the blunt trauma produced behind armor that defeats a missile, *i.e.*, prevents penetration. Threats to the lungs were targeted over the lateral chest in the sixth and seventh intercostal spaces. Cardiac threats were targeted on the "cardiac window" during end expiration. Intestinal threats were targeted on the mid-anterior abdominal wall; while hepatic and splenic threats were directed, respectively, to the right and left lower lateral thoracic cage in the eleventh intercostal space. In addition, strikes over the protected spinal column were carried out.

In each series of shots, various parameters were monitored depending upon the organ under study. In the cardiac shots, ECGs, cardiac outputs, arterial blood gases, and enzymes were monitored. In the pulmonary shots, arterial blood gases were measured. Neurologic assessments were made following the spinal shots. In all studies, the systemic blood pressure, and the parameters peculiar to each study were measured pre- and post-assault, one hour after assault, and prior to sacrifice, which was carried out at 24 hours. In the spinal shots sacrifice occurred at 48 hours. In all cases, immediate necropsy was performed.

Results

Typical skin wounds, behind the unpenetrated armor, consisted of an area of superficial laceration about 2–4 cm in diameter surrounded by an ecchymotic and erythematous area (Figure 1). Lacerations occasionally extended into the underlying thoracic and abdominal wall muscles, but penetration into these cavities was not seen.

Necropsy demonstrated the following injuries:

1) Four of eight assaults over dilated bowel resulted in perforations, while in 13 assaults over non-dilated bowel no per-

FIGURE 1: Typical skin lesion behind unpenetrated armor in experimental animal.

forations occurred. Minor serosal and omental contusions were seen in this second group.[9]

2) Assaults over the liver produced liver contusions or singular small fractures in 14 of 18 cases. Two associated, nondisplaced rib fractures were also noted. The amount of injured tissue averaged less than 50 cc. No more than 100 cc of blood was found in the abdominal cavity in each case. Although many of these injuries would have required laparotomy in humans, it was estimated that a marked reduction in morbidity and mortality would have been produced by armor protection, since the singular injuries were small and not associated with significant hemorrhage.

3) In 25 thoracic shots, small pulmonary contusions (20 cc or less) were seen in 20 cases. The largest lesion measured 96 cc of excised tissue. In addition, in six cases singular nondisplaced rib fractures were seen. In all cases, no significant changes in arterial oxygenation or systemic blood pressure were encountered.

4) In two of seven initial cardiac tests, a stiff, indwelling, left ventricular end-diastolic catheter was felt to be the iatrogenic source of aortic root injuries seen. In 15 subsequent tests (after removal of the catheter), one significant injury was noted, disruption of two aortic valves. This animal demonstrated moderate hypoxemia prior to sacrifice. One animal without evidence of a myocardial contusion, demonstrated transient PVCs prior to sacrifice. In all other cases, no conduction defects or arrhythmias were seen.

5) The spleen proved to be an elusive target. Three attempts were made to hit this small organ which has a variable orientation in the goat. In one case, a 2 cm contusion was demonstrated on the inferior edge of the spleen. In the two other cases, no damage was seen in one, and in the other there was poor targeting.

Since the spleen is a friable organ, it is expected that a hit over this organ in the human, could result in at least a contusion or subcapsular hematoma. Both of these injuries would eventually lead to laparotomy.

6) Seven of seven shots over the spinal column resulted in isolated spinous or transverse process fractures. In four shots demonstrating spinous process fractures, no neurologic deficits were noted. In three shots producing transverse process fractures, transient hind leg paresis was evident. In two cases, the

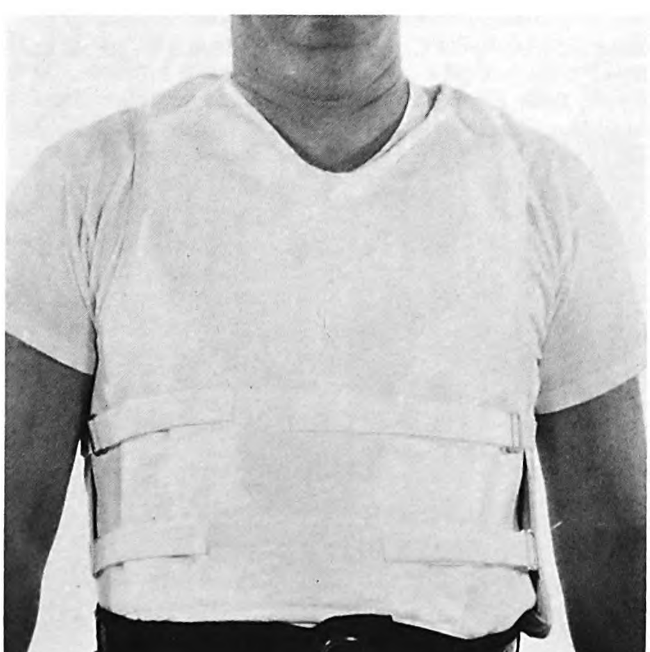

FIGURE 2: Sevel layer Kevlar soft body armor prototype.

weakness disappeared in about one hour, and in the third, resolved within 24 hours. In none of the spinal shots was morphologic or histologic evidence of spinal cord injury demonstrated.

Because of the relatively larger size of the spinous processes in goats compared to man, it is estimated that the goat is provided with better protection against blunt trauma injury. Hence, a shot over the human spinal column could possibly result in weakness or even contusion of the spinal column. To more accurately predict the results of a human spinal column impact, another species with similar spinal anatomy could be used in ballistic tests.

The innocuous appearance of typical skin lesions, occurring behind the armor did not correlate with the presence or absence of internal injury.

Clinical Correlation

In addition to the above studies, a mathematical methodology was developed relating surface areas of the body protected by the armor with the probability of injury to underlying organs, with and without protection. The probable necessity of surgical treatment was also calculated.

Results indicate:

Survival Probability	Percent
with armor	95–99
without armor	75–93
Surgery Probability	Percent
with armor	7–10
without armor	82–100

Since these calculations were based on pessimistic estimates of pathology, the protective qualities of the Kevlar armor are thought to be better than indicated.

Organs considered to be vulnerable in man were those organs which demonstrated injury in the goat ballistic studies. According to the experimental data, these included the heart, liver, spleen and spinal cord. A kidney impact may produce a small contusion requiring hospital observation, with negligible mortality. The lungs and non-dilated gastrointestinal tract were not considered vulnerable when protected by the Kevlar armor.

The Law Enforcement Assistance Administration (LEAA) began a field evaluation of the seven layer Kevlar armor in December of 1975. In 15 cities, selected on the basis of police assault rates and environmental factors, law enforcement personnel were issued Kevlar soft body armors (Figure 2).

To date, a medical and ballistic assessment team from the Edgewood Arsenal has investigated five assault incidents.

Case 1: A 33-year-old policeman was assaulted with a handgun upon interrupting a burglary in progress. Two .38 caliber, 158 grain lead bullets struck his chest without penetrating his seven layer LEAA garment. The assaults occurred at an estimated range of less than four feet. After impact, the officer was able to pursue his assailant. He experienced no loss of consciousness or dyspnea. Behind the armor, two wounds were noted: a 3 x 4 cm lesion located on the right chest slightly lateral to the mid-clavicular line at the level of the second intercostal space, and a 6 x 4 cm lesion noted over the left sternal border at the level of the fourth intercostal space. Both wounds showed areas of contusion, abrasion and superficial central laceration, similar to the lesions seen in the animal tests (Figure 2). Soon after hospital admission, an orthopedic procedure for an associated left hand wound was performed under regional anesthesia. No cardiac irregularities were noted during surgery or in subsequent 24 hour period of cardiac monitoring. An initial arterial blood gas, and subsequent serial ECGs, chest x-rays, and isoenzyme determinations revealed no

FIGURE 3: Skin lesions noted in emergency room soon after assault in Case I. (Courtesy of P. E. Besant-Matthews, M.D.)

evidence of cardiac or pulmonary injury. The patient was discharged on the third hospital day.

Case II: A 28-year-old policeman was assaulted with a handgun while investigating a burglary. A 40 grain, .22 caliber missile delivered at a range of about 6 feet, did not penetrate the officer's seven layer Kevlar armor. (Subsequent chronography of the weapon revealed a muzzle velocity of 1136 ft/sec). After the impact over the left chest, the officer, noting only slight wound discomfort, pursued his assailant. Hospitalization for observation of possible intrathoracic injury followed. A 2 x 3 cm wound exhibiting abrasion and central laceration was noted behind the armor one inch lateral to the left nipple (Figure 3). The patient was placed in a cardiac care unit for 24 hours of monitoring. No cardiac ectopy was seen. Vital signs remained stable. Serial ECGs, chest x-rays and an isoenzyme determination was within normal limits. The patient was discharged 48 hours after the ballistic assault.

Case III: A 46-year-old policeman was assaulted while searching for a gunman in a darkened restaurant. The officer's armor, composed of 14 layers of Kevlar and two of ballistic nylon, with front and back panels, lacked lateral torso protection. The officer was struck twice at a range of four to five feet. The first missile consisted of pellets from a .38 caliber "shot shell." A few of these pellets struck the left front panel resulting in no armor penetration or evidence of underlying tissue damage. A second .38 caliber bullet tunneled subcutaneously through the lateral right thorax and exited striking the edge of the back panel. Post-assault dyspnea did not occur, and the patient was unaware of his chest wound until hospitalized. Vital signs on admission were stable and remained as such. A groove-like 1 x 4 cm entrance wound was noted at the level of the fourth rib on the right lateral chest wall. The groove pointed to a 1 cm round exit wound posterior at the level of the tenth rib. The patient also sustained pellet wounds of the left arm, shoulder and face area. These missiles embedded subcutaneously, caused discomfort but no serious injury. Serial chest x-rays were within normal limits, and the patient was discharged on the second hospital day.

In addition to the three cases presented in the LEAA field evaluation program, two additional incidents of assault against commercial soft body armors were investigated.

Case IV: A 30-year-old policeman was shot over the lower sternal area while making a traffic investigation. The .38 caliber missile delivered at a close range became embedded in the officer's vest after penetrating two of its eighteen layers of ballistic nylon. A second missile struck the unprotected left shoulder and lodged in the musculature of the right posterior neck. After impact, the officer was able to take protective action. Hospitalization followed the assault. A 4 to 5 cm circular contusion with superficial laceration was noted over the right xiphoid margin. No radiographic or electrocardiographic evidence of intrathoracic trauma was noted. The patient was discharged on the third hospital day.

Case V: A 26-year-old policeman was shot with a handgun over the right thoracic cage, while wrestling with a criminal suspect. His 15 layer Kevlar armor was not penetrated. After the point blank assault, the officer continued the struggle and arrested the assailant. The missile, a 125 grain, jacketed hollow point .38 caliber bullet, produced a 5 x 5 cm area of contusion and abrasion on the right lateral chest wall over the sixth costal-chondral junction (Figure 4). Upon hospitalization, physical examination and serial radiographs revealed no evidence of intrathoracic injury. Discharge occurred on the second hospital day.

Discussion

In the defeat of a bullet by Kevlar armor, kinetic energy must be dissipated. Energy is expended in deformation of the missile, armor, and underlying body wall, transferred to the body and lost as heat. On impact, the armor is pushed against the body wall, forcing both inward. Studies were carried out at the Edgewood Arsenal, Biophysics Division to define the configuration of the deformed Kevlar armor. This deformation, defined as the "backface signature" of the armor, was studied using high speed photography. Motion pictures of backlighted 20 percent gelatin blocks, documented the deformation of the armor into the gelatin when impacted by a missile. Analysis revealed the depth and shape of the deformation, including the time required to reach maximal depth of penetration. These studies demonstrated a symmetric conical deformation of the armor into the gelatin when struck at0° obliquity.

With seven layers of Kevlar material: in 17 shots using 158 grain, .38 caliber bullets with an average velocity of 251 m/sec (822 ft/sec), kaving a kinetic energy of 32 joules (237 ft/lbs), a maximal "backface signature" deformation was reached in an average of 1.7 millisec (S. D. = 0.002).[18]

The deformed cone of armor, smashing into the body wall, over a discrete area in a short interval, describes a unique mechanism capable of producing trauma. This rapid jolting force focused on a small area, much like an "impulse," contrasts greatly with the usually encountered mechanisms producing blunt trauma injury, *i.e.*, those delivered by large objects, over large areas, with relatively prolonged periods of force application.

A host of methodologies have been described to produce

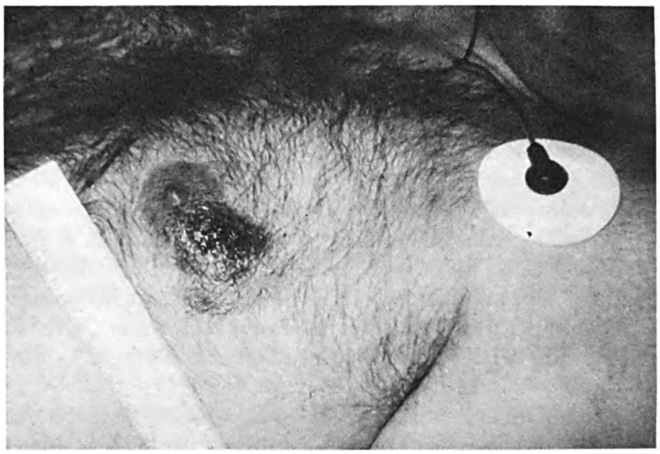

FIGURE 4: Skin lesion noted in emergency room soon after assault in Case II. (Courtesy of D. K. Wiecking, M.D.)

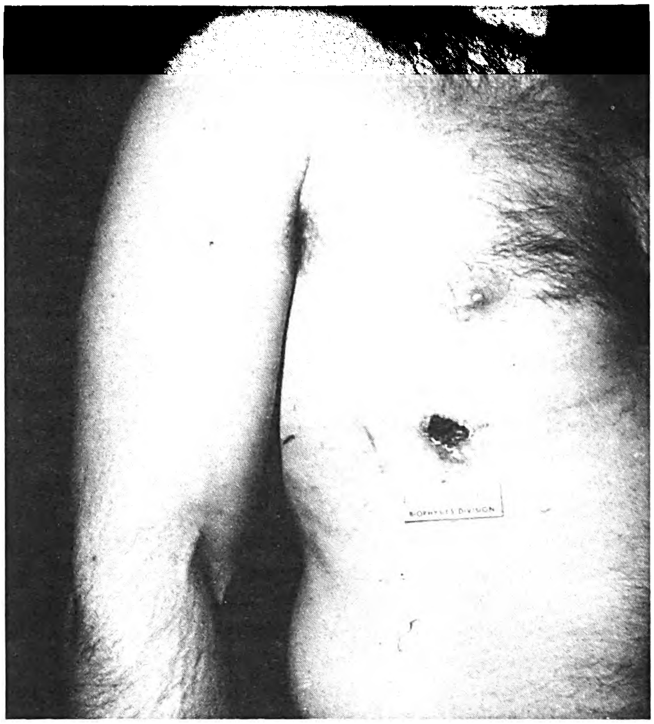

FIGURE 5: Healing skin wound in Case V, five days after assault.

experimental blunt trauma to the torso. Some methods have centered on explaining the pathophysiology of blast injury;[2,20] while others have addressed themselves to injuries produced when blunt objects strike the body. Much of this latter work has been directed at characterizing trauma seen in vehicular accidents, such as the steering column injury. These techniques include: striking the exposed heart *in vivo;*[3] the perfused liver;[19] strikes to the precordial area using a captive bolt gun apparatus;[6,7] ramming the abdomen of a stationary animal with a blunt object;[19] and propelling an animal into a blunt object.[8]

Thus, previous methods used to produce blunt trauma generally employed larger objects impacting larger surfaces. In addition, the application of force was generally over a long period of time relative to the 2 millisecond "impulse" in the ballistic studies.

Much of the blunt trauma experience in the clinical literature is not comparable to that seen behind a pliable body armor. Series presenting blunt trauma injuries of the heart;[5,10] aorta;[15] lungs;[1] liver;[12] and intestines[4] are heavily weighted by vehicular trauma. However, clinical and research experience in blunt trauma is not to be dismissed when considering blunt injury relative to soft body armor. This vast experience has documented the insidious nature of blunt trauma injury.

Although the assessment of the protective qualities of a shoft body armor prototype continues, the results of the cases presented in this report are most encouraging.

In cases I, II, and IV a projectile directed at or near the heart and great vessels, at close range, was easily defeated by the armor. Had penetration occurred, a serious chest wound necessitating emergency surgery would have resulted. A fatal outcome could have been postulated in each case. However, surgery was avoided (except for an associated hand wound) and hospitalization was short. In case V, the armor prevented penetration by a missile directed at an area occupied by both the lung and liver.

The injuries sustained by the policeman in Case III, although fortunately not serious, convinces the authors, that a torso encircling armor with lateral protection is the best protective design.

Summary

The development of a new lightweight soft body armor appears to lower the morbidity and mortality from certain ballistic threats. "Impulse" type blunt injuries have been produced in laboratory animals. The severity of underlying injury (if any) did not correlate with the seemingly innocent skin lesion seen behind the armor. Therefore, in the case of impact on a soft body armor, it is recommended that:

1) All victims of assault should be hospitalized for observation in spite of an apparent state of good health and a minimal skin lesion.

2) Strikes to the chest should be monitored with serial chest x-rays.

3) Strikes to the precordial region require cardiac monitoring and serial ECGs and enzyme determinations.

4) Strikes to the abdomen require frequent examination for signs of peritoneal irritation. Impacts over the liver should be viewed with great suspicion of underlying hepatic injury.

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THE RESEARCH VALUES OF QUANTITATION OF ACUTE INJURY AND CRITICAL ILLNESS

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I. Introduction

Quantitation of acute injury and critical illness is an important and complex problem. In this paper we will review quantitative models of injury and critical illness, introduce a methodology called PER which may be used to succinctly characterize the value of an index for a prospective user and as a standard method for comparing indices, and mention applications across the spectrum of emergency health care delivery and research.

II. Review of Quantitative Models

Anatomical disruption by external force was probably the first pathology recognized by man. Attempts to describe injury for the purpose of communication and comparison date from ancient Greek and Egyptian civilizations[1,2] through to the lively debate that introduced the "numerical method" to medicine in 1837[3].

Once inflicted, anatomical disruption is rarely progressive, and decay in the total organism is a result of the local and systemic responses to the injury. Thus, the anatomical trauma provides a static data base.

Factors which alter with time and influence the prognosis can be encompassed by the term, "physiological response" to injury, initially described by Cuthbertson[4], but here used to include all metabolic and physiological response to acute trauma. Such variables reflect not only the severity of the total trauma and the time elapsed since injury, but also the patient's age, and pre- or coexisting diseases, both of which may affect the response to injury and the eventual outcome.

Existing quantitative systems have employed the degree of anatomical injury, [5,6,7] elements of the physiological and biochemical response[8,9,10] combinations of the two[11], a clinical assessment,[12] and a therapeutic intervention score.[13] The anatomical approach usually involves the arbitrary assignment of numbers to a subjective evaluation of the severity of the injury. The Abbreviated Injury Sclae,[7] (AIS) is a ranking of injuries by their severity and is used internationally by researchers, including multidisciplinary accident investigation teams established by the United States Department of Transportation. The injury grades were based on an arbitrary scale developed by approximately fifty physicians, engineers and researchers. No verification has established that a "3" assigned to urethral or pericardial contusion is truly equivalent to the "3" attached to the hemothorax, or that the number is meaningfully relative to the "5" of a tracheal avulsion. The methodology has been extended to include the effect of multiple injuries by using an Injury Severity Scale (ISS) which correlates with actual mortality figures. This correlation has been validated in both England and the United States.[14,15] However, the ISS perpetuates the arbitrariness of the AIS scale. The quadratic expression reflects a composite of the three most severely injured areas of the body. The AIS values are squared and added to give the ISS rating. A particular weakness is that a patient may receive a lethal injury to one body "area" *e.g.*, decapitation or rupture of the heart, and only receive an ISS score of 25; a score that is exceeded by three moderate (AIS = 3) injuries in different areas which combine to give an ISS of 27. Such a combination might by no means have a fatal outcome.

The ISS provides some measure of severity of anatomical disruption, but does not account for a variety of other factors, *e.g.*, time between injury and therapy. For a given series of injuries, the data for the ISS score may not even include the injuries to which it is applied. Although numbers are produced from the AIS and ISS, and the latter correlates with mortality for patient groups, the system is arbitrary and does not account for the variations in pathological processes. The AIS has also been used to research the Comprehensive Injury Scale, which includes estimates of energy dissipated, degree of impairment, and other factors not previously included in injury quantitation. In brief, the AIS is an alternative total assessment to that based on clinical judgement and derives from a consensus subjective assessment of anatomical injury on an arbitrary scale. It is a useful, but limited tool for research. Its application to systems evaluation would, however, be tenuous.

Other attempts to quantify trauma have been specifically directed towards triage. The Trauma Index described by Kirkpatrick and Youmans[8] combines superficial anatomical assessment with some measure of physiological response in the form of pulse, blood pressure, cyanosis and consciousness level. Although the scoring system has not been validated, the Index has been tested in Japan[16], and in Pennsylvania, [17] with a good correlation between the Index rating and the clinical state of the injured patient one week later. The Index appears to be of value in triage by paramedical personnel or in the emergency room, but lacks the precision required to compare management. It requires instrumentation and is only slightly better than emergent/urgent/non-urgent.

The Therapeutic Intervention Scoring System (TISS)[13] is presented as an attempt to classify the severity of injury by quantifying the therapeutic intervention. The methodology consists of arbitrary assignment of the therapeutic intervention score based on a scale of one to four. It assumes that each patient who needs treatment got it, and that each patient who got treatment needed it. These are not valid assumptions on which to superimpose a totally arbitrary scoring system.

Although anatomical injury is more susceptible to objective quantitation than most disease processes, every system to date has employed a subjective value assignment to provide the "score." Other elements of quantitation of anatomical injury that remain problematic include an agreement on definitions for labeling, assignment of a scoring system and the synergistic effect of multiple injuries.

Characterization of interactions which are present in multiple trauma is complex. Our own data show surprisingly little overall effect in this context, while a separate study from the same center and affirmed by Baker,[15] found a marked increase in the mortality rate when a severely damaged organ from another body system was added to a spectrum of injuries, but little effect from minor injuries. Multiple injuries within one body system occur most frequently within the abdomen and musculoskeletal system. On the basis of relative frequency and severity, the additive effect of an intra-abdominal or musculoskeletal injury will thus, in general, be less than that of a thoracic or central nervous system injury. A comprehensive model for multiple trauma should account for the most critical injury, the number and relative importance of the other injuries, possible synergism and antisynergism, and would probably embody both progressive discounting and progressing enhancing. Although intellectually appealing the complexity of such a system would have to be weighted against its practical value. Thus, a system is also needed for comparing one scoring system with another. The framework for such a system of comparison, called PER, is introduced in the next section.

III. PER Methodology.

We believe that the recent proliferation of trauma indices tends to bewilder potential users. The concept of PER is meant to provide a succinct characterization of the value of an index for a prospective user, and a standard method for comparing indices.

In the PER methodology, each index, I, is characterized by a short prose description of the patient population (such as, acute trauma patients, surgical patients, general intensive care patients, emergency room patients, patients with renal dysfunction) and three descriptors P, E, and R. P is the priori probability of survival for the patient group studies, E is the expected misclassification rate associated with a Random Decision Rule (RDR) and R is the expected misclassification rate for the index, I, applied to the patient group studies. The RDR predicts survival for a patient if a random number, r, chosen from a uniform distribution of numbers on the unit interval is less than or equal to P; if r is greater than P, the RDR predicts death. The expected survival rate associated with the RDR is P, and the expected misclassification rate, E, is 2P(1-P). This latter quantity is obtained as follows:

E = probability that $r \leq P$ and the patients dies + probability that $r > P$ and the patients lives

$= P(1-P) + (1-P)P$

$= 2P(1-P)$.

To determine R, one needs P(I) which is the probability density function for the occurrence of values of the index I, P(S:I) which is the survival probability as a function of I, together with a decision rule which predicts survival if $P(S;I) \geq 0.5$ and predicts death otherwise. R is computed by

$$R = \int_A P(I)\, P(S{:}I)\, dI + \int_B P(I)[1-P(S{:}I)]dI$$

$$A = \{I{:}P(S{:}I) < 0.5\}$$

$$B = \{I{:}P(S{:}I) \geq 0.5\}$$

The quantity E-R which we call Information Gain is a measure of the prognostic value of an index applied to a patient group. The following examples may help to clarify the concept.

Example 1. Suppose P=0.70 for a major trauma center treating only severely injured patients, then E=2P (1-P) = 0.42, that is, the RDR is incorrect 42 percent of the time; hence there exists good potential for improving prognosis using an index. An index whose misclassification rate R = 0.35 would have an Information Gain (E-R) of 0.07. A perfect index (R=0) would have an Information Gain of 0.42 in this setting.

Example 2. An emergency service of a small hospital, treating a wide spectrum of injuries, has a P value of 0.95. Then E = 2P (1-P) = 0.095. So the RDR would be incorrect less than 10% of the time and hence, would provide formidable competition to a decision rule based on an index. (Of course, for large values of P, say $P \geq 0.95$, a decision rule which predicts survival for each patient has an associated misclassification rate of only 0.05. This rule is tantamount to a weather forecaster predicting no rain every day and reflects the fact that the value of an index diminishes the further P is from 0.5. In such a setting, we may prefer to apply an index to a subset T, of the patient population using a well-defined screening procedure which simply and objectively screens obvious noncritical patients; a concept which has triage overtones).

Example 3. An example of the use of screening a Renal Index[18] has been used to predict mortality for the total patient group at the Maryland Institute for Emergency Medicine. The PER values for this use are (.21, .33, .15). Also, it has been used to predict mortality for the subset, Q, of patients who experience "renal dysfunction", operationally defined as those patients whose Renal Index exceeds 1. Of the (N = 741), patients in this study N_Q = 166 belonged to Q of which 48 percent survived. We denote the PER values of the Renal Index for the subpopulation Q by using Q as a subscript. The succinct characterization then is (N, N_Q, P_Q, E_Q, R_Q) = (741, 166, .48, .50, .24) which can be interpreted: for the 741 patients of the study, 166 experienced renal dysfunction, 48 percent of those patients survived. The RDR applied to Q would have an expected misclassification rate of 50 percent. The expected misclassification rate for the Renal Index applied to Q is 24 percent, an Information Gain of 26 percent.

Indices developed to this degree of sophistication provide the most accurate means to date of "measuring" therapy. Although a therapy is usually directed at a single target organ, the direct and indirect effects are reflected throughout the body either beneficially or adversely. Two avenues of further investigation are apparent:

1) Derivation of therapy protocols based on the use of specified therapies for a given range of organ dysfunction or severity of illness.

2) Identification of organ specific effects of therapy together with general and non-target organ effects.

PER calculations for total patient groups and subgroups are being carried out by the authors of this paper for many existing indices.

IV. Applications of Indices.

The applications mentioned most frequently throughout the "index literature" are the use of indices in triage, prognosis, patient tracking, health care delivery evaluation, therapy protocols, identification of medical deficits, and definitions of tracer groups.

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COMPUTER MODELING OF PERSONNEL VULNERABILITY

Walter R. Cooper, M.B.A. and William Kokinakis, B.S.

General

For over a decade the thrust of the wound ballistics program at the Ballistic Research Laboratories (BRL) focused on criteria developed as the result of autopsy reports from animal experiments. Attempts to correlate the effects of wounds in animals with known effects of wounds in humans for a number of different physiological measures were generally unsuccessful. Consequently, in early 1974, a new and fresh approach, emphasizing the physical sciences, particularly physics and engineering, and making extensive use of computer simulation, was developed. The entire personnel vulnerability effort has in this manner been shifted to that of modeling the wounding process and simulating the dynamics of wounding with computers, using analytical techniques and sophisticated codes.

Methodology

The methodology is represented by the flow chart shown in Figure 1.

Inputs provided by a team of surgeons are combined with information obtained from cavities produced by firing projectiles of various mass and velocity combinations into a tissue simulant (gelatin) to obtain an estimate of physiological damage that would be caused by penetration into human muscle tissue. The present methdology is concerned with developing criteria related to two areas of interest: incapacitation to the extent that a soldier becomes non-combatant and unable to perform his duties, and human lethality. The nature of the medical inputs is different for each of these two issues, but the overall methodology is the same.

MEDICAL INPUTS

Incapacitation.

Because it is unreasonable to expect medical doctors to know the exact nature of the tasks soldiers perform in carrying out various duties, translation of typical soldier functions into scenarios with which the doctors might be more familiar was required. The incapacitation analysis was simplified into two basic areas —incapacitation to the extent that a soldier is unable to shoot his weapon, and incapacitation to the extent that the soldier is unable to run. With these simplifications in mind, two scenarios were presented to the surgeons, one relating to the immobilization of an armed assailant by a law enforcement officer, the second with the disarming of the assailant. The surgeons were then asked to consider lists of tissues and organs which, rendered nonfunctional by penetrating projectile, would produce some level of incapacitation with respect to the given scenario. Several time frames were stipulated: immediate incapacitation, incapacitation after 30 seconds, and incapacitation after five minutes. A quantitative index, numerically indicating estimates of human performance decrement, was used by the assessors in making their estimates. The surgeons used a scale of whole numbers from 1 through 10, with an entry of 1 representing minimum decrement and an entry of 10 representing maximum decrement. Table 1 presents a sample of the results for a portion of the list of organs and tissues considered.

In order to tie discrete tissue damage estimates to a model for assessing human vulnerability, a physical description of the "target" is necessary. A physical description of the human body is found in anatomy. In 1911, Drs. Eycleshymer and Schoemaker published *A Cross Section Anatomy*, in which they presented drawings of cross sections through human tissue. The text includes some 113 drawings, progressing consecutively from the top of the head through the thoracic and abdominal areas, followed by the arms and the legs. A grid system was superimposed on each cross section, producing a rectangular matrix. The contents of each grid cell was examined, and a code representing the tissue content was stored in that cell. By stacking the cross sections, and attaching and aligning the limbs in their respective configurations, a coded

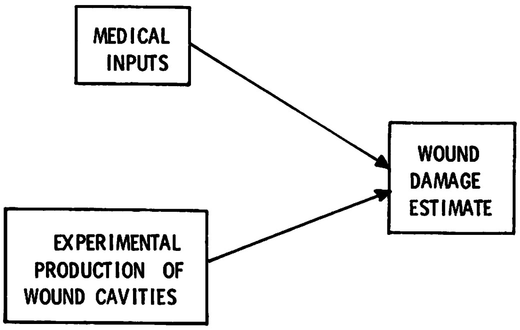

FIGURE 1: Flow Chart Representation of Methodology

INCAPACITATION ESTIMATES, IMMOBILIZATION SCENARIO

CRITICAL TISSUES	SCORES IMMED	30 SEC	5 MIN
SPINAL CORD	10.0	10.0	10.0
SACRAL PLEXUS	4.6	4.6	4.6
SHAFT OF FEMUR	10.0	9.7	9.7
FEMUR-TIBIA	9.4	9.2	8.6
SHAFT OF FIBULA, POINTS OF ARTICULATION	8.2	6.8	6.4
ACHILLES TENDON	7.4	6.2	6.0
TALUS	8.2	7.5	7.6
BRAIN	10.0	10.0	9.4

Table 1. Entries represent the average of five independent assessments.

representation of a man was created and stored in the memory of a computer at the Ballistic Research Laboratories. This particular code is called Computer Man. A pictorial representation of the Computer Man appears in Figure 2. By using this framework, critical tissues and organs can be located in a three-dimensional array, and the incapacitation estimates can be matched with the corresponding locations.

Lethality.

A somewhat different approach was used in obtaining the data relative to the lethality issue. Assessors were presented complete sets of drawings from Eycleshymer and Shoemaker with a grid system superimposed on them. The doctors were asked to independently assess the impact of the removal of the cells on human survivability, using a numerical scale of whole numbers from 1 through 10, where an entry of 1 signified a minimum impact and an entry of 10 indicated certainty on the part of the assessor that the cell's removal would cause death. Four time frames were stipulated relative to the availability of expert medical aid: treatment available 30 minutes after removal, one hour after removal, six hours after removal, and no treatment available at any time after removal.

Initially, three assessors were asked to make estimates on all of the grid cells throughout the body. Complete assessments from each of these surgeons were obtained for both the one hour time frame and the case where no treatment was available at any time; one complete assessment was received based on treatment after six hours. Subsequently, a different and larger group of assessors was asked to provide estimates, with each assessor's involvement limited to those areas in which he was a specialist. For this purpose, the body was divided into four areas: the head, assessed by a neurosurgeon, the thorax, the abdomen and the limbs. The specialists made assessments on the basis of all four time intervals.

Statistical Analysis.

Some basic statistical calculations were made based on the independent lethality estimates obtained. The mean for each cross section was calculated for each of the four time frames. These results show an almost constant upward shift in the mean values for scores in cross sections in the limb areas, while average scores in the head, thorax and abdominal areas produced a somewhat more pronounced increase when medical care is delayed.

Another way of looking at the way in which score values behave when the availability of medical aid is delayed is to examine the standard deviation of the scores by cross section. Calculations with respect to the standard deviation of scores show that dispersion of score values increases for all sections as medical care is delayed. Of interest is a pronounced increase in dispersion in the abdominal areas, suggesting the presence of organs whose score values increase dramatically with time, together with tissues that remain fairly low in value throughout the various time frames.

Of some interest, both from a purely statistical standpoint and from a medical standpoint, is the occurrence of differences in the scores the assessors provided. Throughout both the incapacitation and lethality assessment processes, the surgeons provided scores independently of one another, assuring the existence of differences. After examining all the scores, it was decided to identify those grid cells in which the doctors showed a pronounced disparity in scores and then request the assessors to work as a team to resolve the differences. The doctors then provided a value on which they all agreed.

Figure 3 presents the number of controversial cells as a percentage of the total number of cells for the cross sections in the head, thorax and abdomen. As already mentioned, a pronounced increase in difference percentage is observed as the availability of medical aid is delayed, particularly in the head, lower thoracic and upper abdominal areas.

Quantifying Medical Inputs.

The next step in the methodology was the derivation of a

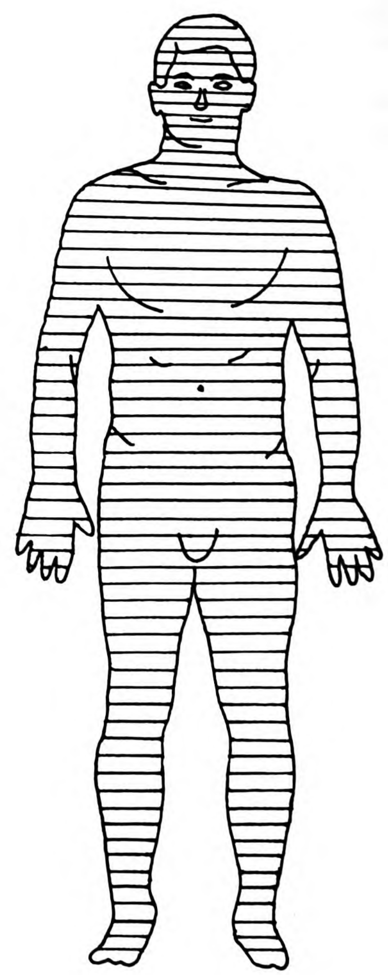

FIGURE 2: Graphic Representation of the Computer Man

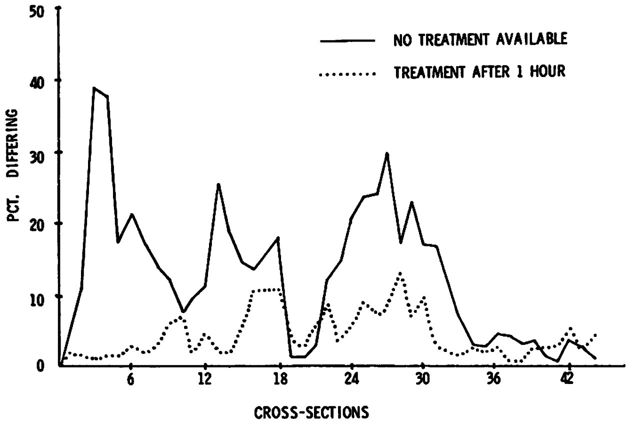

FIGURE 3: Number of Controversial Cells as a Percentage of Total Cells for Each Cross Section

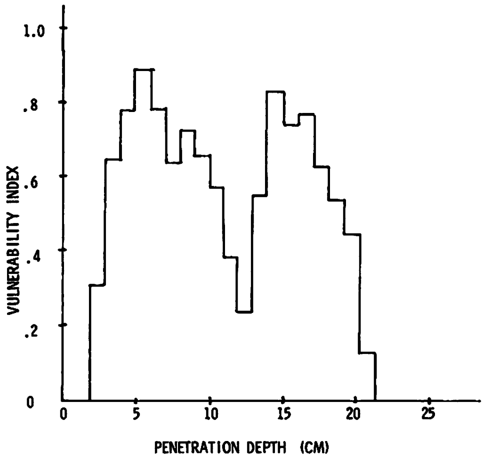

FIGURE 5: Vulnerability Curve, Averaging Technique, Lethality Scenario, Treatment After One Hour

relationship between penetration depth and the vulnerability assessments for both the incapacitation and the lethality cases. The aim of developing this relationship is to devise a medically based weighting function to apply to the experimentally obtained cavity profiles produced by firing projectiles into gelatin. Two opposing views have emerged with respect to the development of their weighting function; the basic issue revolves around whether or not the entire history of a trajectory should be considered in developing the weighting function.

Figure 4 shows rays passing through a typical cross section. The weighting function was originally developed by computing the average value of cell scores at various depths of penetration.

At each increment of penetration depth, the value of the cell is noted for each trajectory. After several thousand random rays have been traced through the Computer Man, the average cell value at each increment of depth is computed. A typical vulnerability curve using this technique maps a profile view of critical organs and tissue housed within the body (Figure 5).

A large average value occurs in the vicinity of 5 centimeters of penetration where the heart and other vital organs are located, followed by a decrease until approximately 15 to 18 centimeters, at which point the curve again begins to rise, reflecting the criticality of organs and tissues located at that depth, notably the spinal cord. This approach has been useful in studies related to comparing various handgun munitions where the depth at which energy is deposited by projectiles is important. One important feature of the relationship produced in this manner is the fact that preceding values encountered along a trajectory are not considered, *i.e.*, the cumulative effect of passing through more and more tissue is not incorporated into the calculation of a vulnerability index at a given depth of penetration.

Some users of the type of information being produced are interested in more than the optimal location of energy deposit. They are primarily concerned with vulnerability, that is, probability estimates of incapacitation and lethality given that a soldier has been hit with a penetrating projectile. It is apparent in these types of studies that the entire history of a trajectory is of major importance. Two alternatives have been developed to incorporate the history of values through which a trajectory passes. One approach keeps track of the maximum score encountered along a trajectory, and replaces smaller scores with the preceding maximum. A typical vulnerability curve constructed in this manner is represented by a nondecreasing function which shows that vulnerability increases as penetration depths increase. A pronounced increase in slope at smaller depths corresponds generally with depths at which

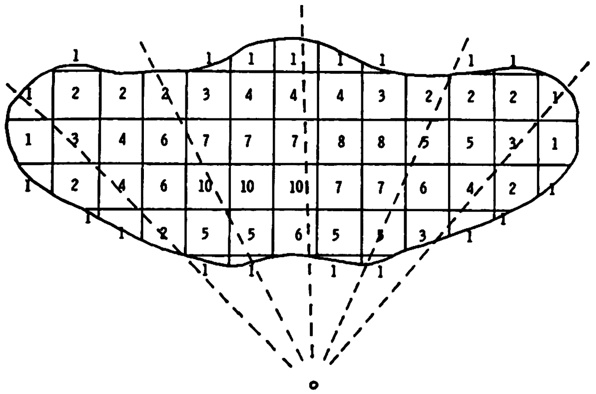

FIGURE 4: Random Trajectories Traced Through a Typical Cross Section

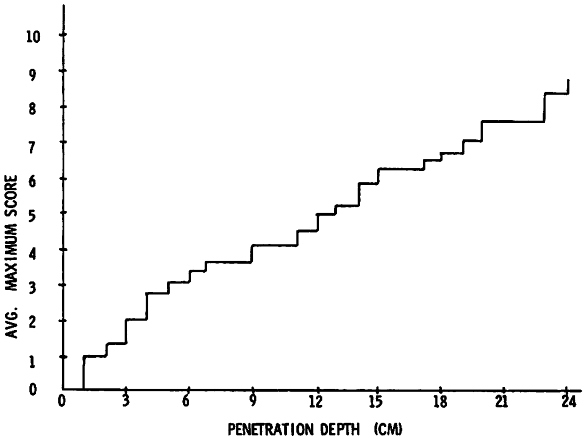

FIGURE 6: Vulnerability Curve, Maximum Score Technique, Lethality Scenario, Treatment After One Hour

EXPECTED FATALITIES COMPUTATION
FOR
SAMPLE TRAJECTORY

	GROUP SIZE	FATALITIES	SURVIVORS	TOTAL FATALITIES
START	10			
1 (.10)	10	1	9	1
2 (.20)	9	1.8	7.2	2.8
3 (.30)	7.2	2.16	5.04	4.96
2 (.20)	4.96	.992	3.968	6.032
1 (.10)	3.968	.3968	3.5712	6.4288

Table 2. Computations are based on starting group of 10 persons.

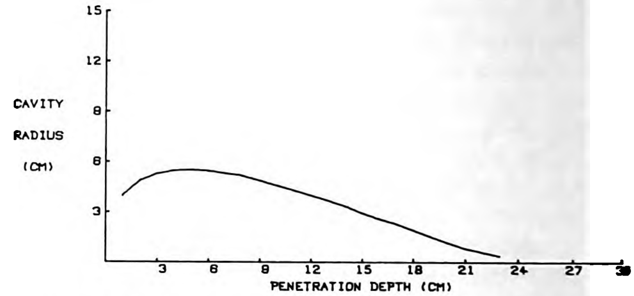

FIGURE 8: Typical Cavity Profile, 16 Grain Cube, Fired at 3000 ft/sec

the heart and other vital organs are located; another sharp increase exists at greater depths where the spinal area is located (Figure 6).

Another approach that incorporates the history of a trajectory uses a different interpretation of the lethality estimates. The estimates the doctors have provided may be considered as percentages: a "1" represents a 10 percent chance of lethality, for example, given a cell's removal. A "10" on the other hand represents certainty on the part of the assessor that death would occur given a cell's removal and this would translate to a 100 percent chance of lethality. Using this percentage approach, let us consider a sample trajectory and the impact that that trajectory's score content would have on a group of 10 men.

Consider a trajectory whose score appears as (1, 2, 3, 2, 1). The "1" represents an estimate that removal of that grid cell would result in a lethal wound of 10 percent of the population so affected; at that depth, one of ten men in the group might die, leaving 9 survivors. At the next increment of penetration, we observe a "2" meaning that 20 percent of the population remaining would receive a lethal wound, or 1.8 deaths. Adding 1.8 to the 1 obtained at the first increment produces a total of 2.8 deaths at a penetration depth of 2 units. At this point, the surviving population consists of 7.2. At the next increment a "3" is observed indicating a 30 percent lethality rate. Thirty percent of 7.2 is 2.16, which when added to 2.8 totals 4.96, which would be entered at a depth of penetration of 3 units. This sort of computational technique is carried forward for the entire trajectory, producing the expected number of deaths for the various depths of penetration. Table 2 shows the complete computation for the sample trajectory.

Figure 7 presents the vulnerability curve constructed after making the above described computation for a large number of trajectories. By tracing a large number of these trajectories through the body, and averaging the expected number of deaths at each depth of penetration, a functional relationship is produced that is nondecreasing, reflecting the fact that more and more deaths can be expected for a given group of men as penetration distance increases.

EXPERIMENTAL INPUT.

As mentioned earlier, the vulnerability curve, no matter how constructed, serves as a weighting function, to be applied to cavities produced by firing various projectiles into gelatin. For the experimental phase of our model development, projectiles of several masses were fired at different velocities into blocks of gelatin used to simulate human tissue. Using high speed photography, cavity profiles were created which reflected the behavior of the projectiles in the tissue simulant. Figure 8 presents a typical, graphical protrayal of cavity profile produced in this manner.

COMBINING MEDICAL AND EXPERIMENTAL INPUTS.

The final step in producing a measure of the effectiveness

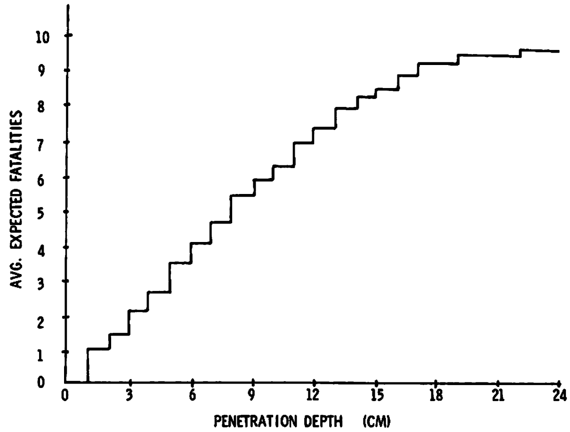

FIGURE 7: Vulnerability Curve, Expected Deaths Technique, Lethality Scenario Treatment After One Hour

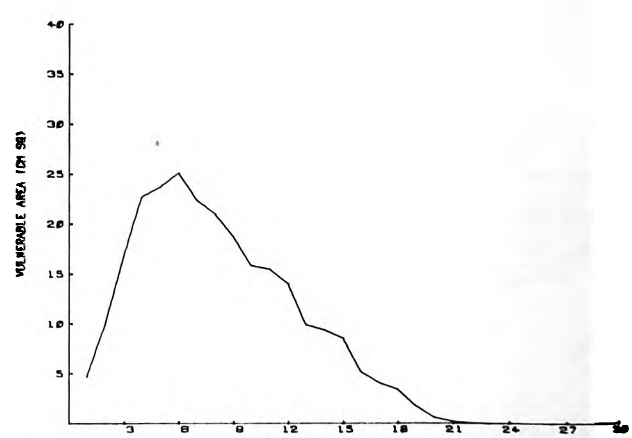

FIGURE 9: Vulnerable Area Contours, 16 Grain Cube, Fired at 3000 ft/sec, Lethality Scenario, Treatment After One Hour

of projectiles is to weight the experimentally produced cavities by the vulnerability functions discussed earlier. This process combines the inputs of experimentally derived cavities with the medical assessments, providing a meaningful estimate of the damage a given projectile can be expected to produce in human tissue. Figure 9 shows the result of combining a typical projectiles cavity with a vulnerability curve produced using the standard approach that does not consider trajectory history. The ordinates of the curve are produced by squaring the radius of the cavity (Figure 8) at each increment of depth, multiplying by π, and multiplying the result by the vulnerability index (Figure 5). The curves offer an indication of the physiological damage caused by the projectile in question at each increment of penetration.

Applicability of the Model.

Experiments conceived in a laboratory setting can be at best approximations to real world phenomena. Because the methodology simulates processes related to the wounding of human targets, caution must be taken in the claims made about the outputs of the model. Gelatin was chosen as a simulant of human tissue because it possesses characteristics similar to muscle in terms of density and elasticity, which has been proven experimentally. The cavities produced experimentally in blocks of homogeneous gelatin may not in fact be good approximations to cavities produced in all human tissue. Obviously, there is an infinite number of different cavities that could occur in human tissue, depending not only on the characteristics of the penetrating projectile, but also on the location of entry and the types of tissue the projectile encounters after penetration. The modeling of these countless cavities cannot be done in an efficient and economical manner.

Another real phenomena that has not been modeled in the methodology is the psychological effects of a wound. The estimates that the assessors have provided are limited to the physical domain. The physicians were simply asked to assess the impact of rendering various tissues and organs nonfunctional in relation to the things that a person can do from a purely physical standpoint. Perhaps in the future some appropriate technique can be developed to model the psychology of wounding, but at this point in time no such technique is known.

Great care must therefore be taken in discussing what it is that the model produces. The model is seen in its present form as a good analytical tool to be used in a wide range of both civil and military studies. Not only does the model give an indication of the effects that various penetrating projectiles might have on human performance and survivability, but it gives clues about where the body is most vulnerable with respect to various scenarios. For example, suppose there is an interest in developing protective clothing for law enforcement officers. By developing the programming necessary to input retardation data into the framework of the Computer Man, comparative statements can be made about the physiological effects of using protective clothing. By varying the amount, composition, and location of the protection, information can be obtained about the optimal configuration of the clothing as well.

In its present form, the model is limited to studies involving penetrating projectiles. The technique might be modified to accomodate studies related to other incapacitating phenomena. The assessors could be asked to produce lists of organs and tissues rendered nonfunctional by blunt trauma, for example. By devising appropriate laboratory experiements to simulate physical phenomena causing blunt trauma, medical inputs can again be combined with experimental inputs to produce a medically based estimate of the physiological damage. This information could prove useful in studies related to automobile passenger safety, for example.

In conclusion, the value of the Computer Man model lies in its potential as a solid analytical tool; at this stage of its development, it produces information useful in studies related to penetrating projectiles, but it is felt that by modifying inputs, it can be used to help solve problems in a wide range of areas where the protection of people is of paramount concern.

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Radiology — Practical Techniques in Evaluating the Trauma Patient

RUPTURE OF THE THORACIC AORTA DUE TO BLUNT TRAUMA — DIAGNOSTIC PROBLEMS

Robert L. Ayella, M.D., M. Sc. (Med.)

A rupture of the thoracic aorta due to blunt trauma is a common injury in our present day of high speed vehicular travel. Approximately, one out of six deaths due to automobile traffic accidents are due to ruptured thoracic aortas. The vast majority of these patients die rapidly and never have an opportunity to reach the hospital. Those who do reach a hospital still alive run the risk of another major problem, namely, a failure to detect the injury. In our present stage of thoracic surgery, if the rupture is detected early the vast majority of patients can be saved. The major problem in diagnosis is primarily the paradox that the chest rarely shows evidence of injury. Instead, these patients have severe head injuries, severe abdominal injuries, and multiple extremities injuries. Therefore unless there is an extremely high index of suspicion the imminently lethal ruptured aorta will be overlooked. At the Maryland Institute for Emergency Medicine we have instituted a system of radiology which has made it possible for us to detect hematomas of the mediastinum accurately. At the same time the over diagnosis of these hematomas is avoided.

In the past five years we have seen approximately 157 hematomas which were proven by angiography. Of these, 37 were due to ruptures of the thoracic aorta. To our knowledge no patient in this period of time has reached the autopsy table or has returned with evidence of a ruptured aorta which was not detected.

As the routine procedure at our institution, we initially obtain a lateral cervical spine immediately after the patient has been resuscitated. Following this, the patient is placed in what we describe as a true erect position. That is, the patient's

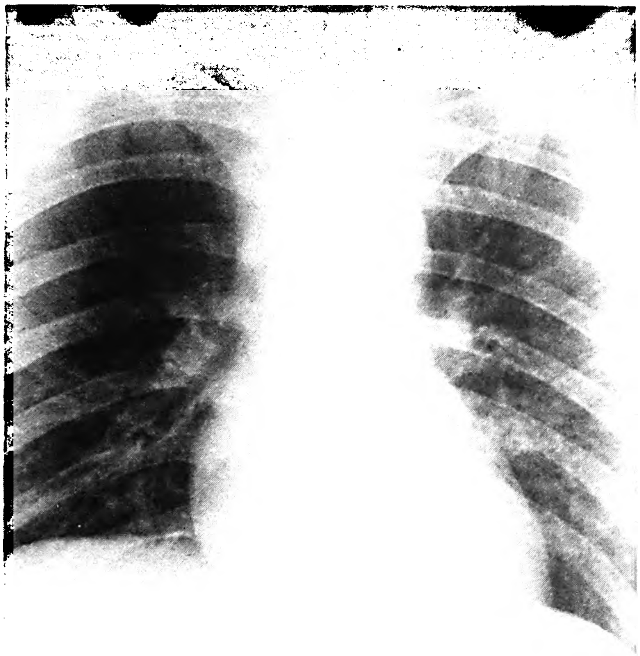


FIGURE 3A: Roentgenogram made in the supine position.

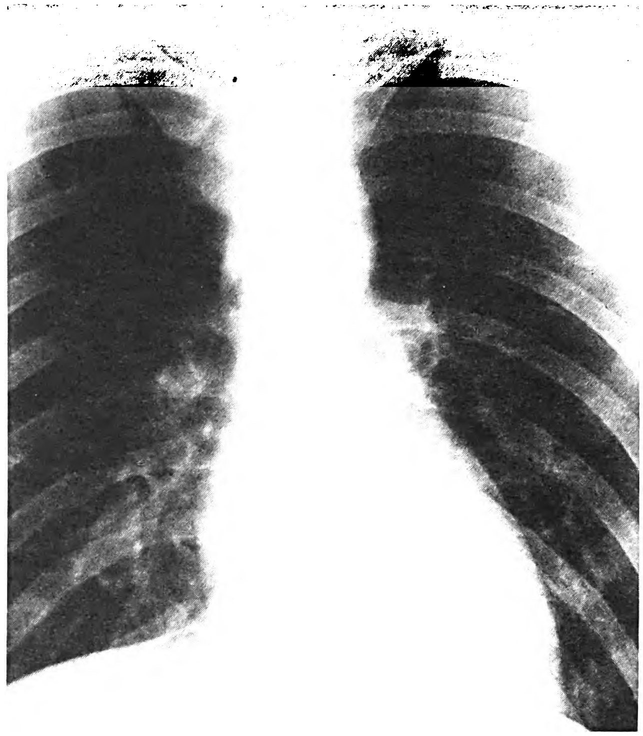


FIGURE 3C: An erect chest x-ray on the same patient shows a normal mediastinum.

mediastinum can be normally widened. Furthermore, we have seen very small mediastinums with an anatomical variation which cannot be identified and which represents a hematoma. The concept suggested in the past of the gradually widening mediastinum is not valid either. Changing erectness just a couple degrees will change the size of the mediastinum. We have actually seen mediastinums which appear to be getting smaller in a 30-minute period, when there was a hematoma with rupture of the aorta. (Figures 2 and 3) Furthermore if the increased widening is due to a rupture of the aorta, it means that the aorta is actively bleeding. In that case, the patient would be in profound shock and incapable of having serial films. Likewise, we consider that various other methods described to determine the presence of a ruptured aorta are based on a fallacy. The hematoma which is seen in the mediastinum in cases both with and without ruptured aorta is for the most part not due to bleeding from the aorta but rather to small vessels not requiring treatment, but which indicate

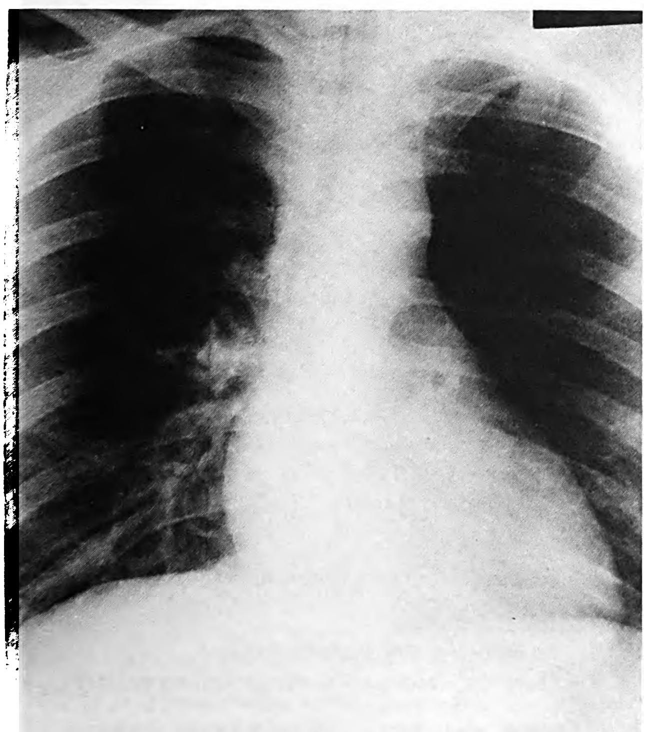


FIGURE 3B: Roentgenogram in the almost erect position of the same patient. The mediastinum has changed in shape.

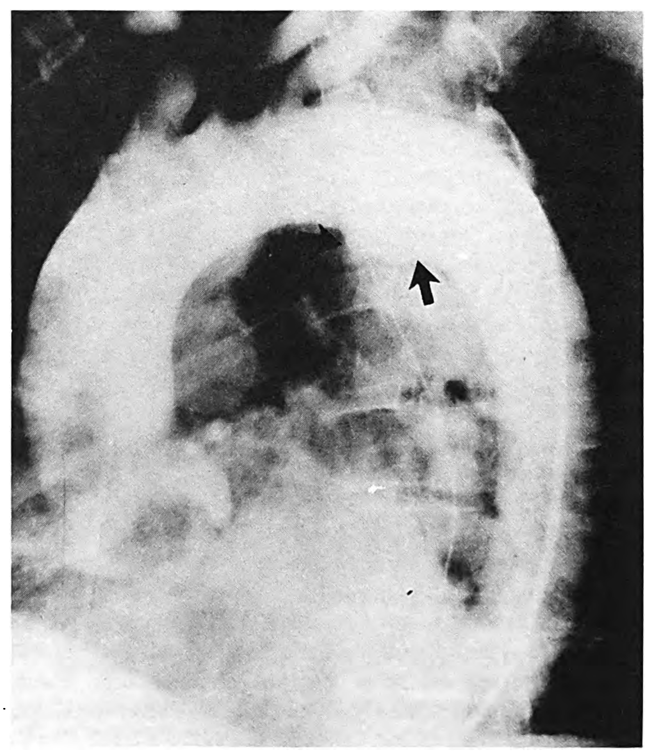


FIGURE 4: Bulge in the aorta due to a patent ductus. There is no flap of aortic wall.

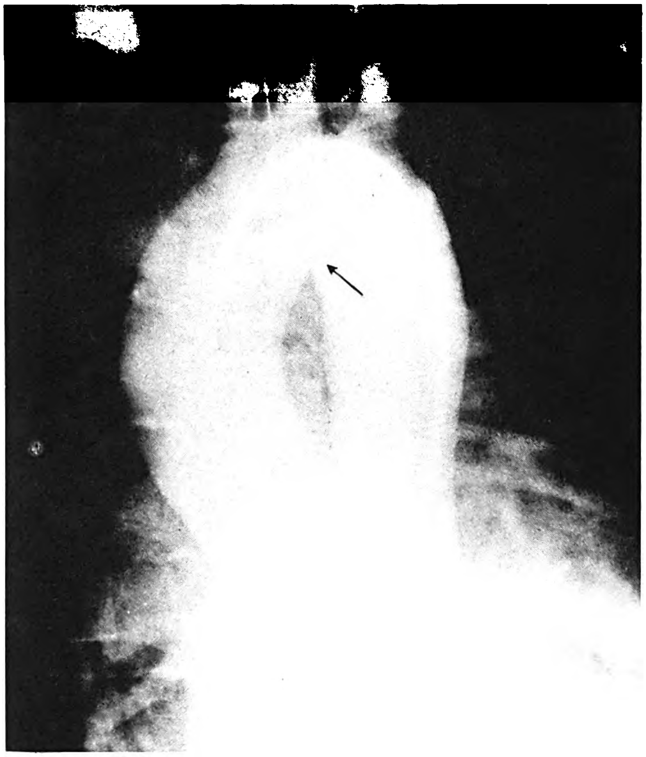


FIGURE 5: Arrow points to the flap of the aortic wall. This indicates a ruptured aorta and yet there is no localized bulge in the aorta.

that there has been a severe injury to the mediastinum. In over two-thirds of our cases only the intima and media have been lacerated and the adventitia is intact. If this is the case, then blood cannot leave the lumen of the aorta to get outside of the aorta and form a hematoma. Therefore, the shape or size of the hematoma has no bearing on whether the hematoma is due to a rupture of the aorta or to other causes.

The only method of definitively diagnosing a ruptured thoracic aorta is a thoracic aortogram. At present we used a 6 French teflon Pig-tail catheter. Renografin 76 is injected at a rate of 25 cc a second for two seconds. Films are made at a rate of two per second for three seconds and then one every other second for an additional four seconds.

The diagnosis of ruptured aorta consists of demonstrating a flap which represents the actual torn fragment of the aorta. Merely demonstrating a bulge is not diagnostic because bulges can be caused by a patent ductus arteriosus or could be due to changes secondary to atheromatous disease. (Figures 4 and 5) Using the method described we have been able to obtain a survival rate of 81 percent. This figure includes all patients who have reached the Institute and have been resuscitated sufficiently to have a chest x-ray. It includes also patients who have ruptured aortas, but who died of other injuries.

THE RADIOLOGICAL ASPECTS OF ACUTE TRAUMA TO THE CERVICAL SPINE

John H. Harris, Jr., M.D.

The initial management of the patient with acute cervical spine trauma is critical and is dependent upon recognition of the injury, radiographically, an understanding of the mechanism of injury, which may reasonably be inferred from the roentgen appearance of the injured segment(s), and the stability — or lack of stability — of the lesion.

No apology is offered for the simplicity of this approach to the radiologic aspects of cervical spine injuries. Rather, it is through such a process of simplification that this pragmatic concept of cervical spine injuries has evolved.

Cervical spine injuries are usually classified on the basis of the mechanism of injury, *i.e.*, flexion, flexion-rotation, vertical compression, and extension. The types of injuries produced by each of the mechanisms appear in Table 1.

The stability of acute cervical spine injuries is dependent upon the integrity of the posterior ligament complex (Holdsworth) (Figure 1) which consists of the supraspinous, interspinous, and posterior longitudinal ligaments and the thin capsule of the apophyseal (interfacetal) joint, and the effect of the force upon the cervical spin. A classification of cervical spine injuries, based upon stability, is found in Table 2.

The sequence of the radiographic examination of the cervical spine is important. If the patient is severely injured, unconscious, has neurologic signs related to the cervical spine, or has multiple system injuries, a horizontal-beam, lateral radiograph of the cervical spine must be obtained first. Every reasonable effort should be made to include all seven segments in this view. Additional radiographic projections should be obtained as seems appropriate.

When the patient is less severely injured, anteroposterior, open-mouth view of the atlantoaxial segments, lateral, and each oblique projection should be obtained and interpreted, before additional radiographic examinations are made. If lateral flexion and extension projections are indicated, the patient's head and neck manipulation must be done only by a physician.

TABLE 1: Types of Injury Produced by Various Mechanisms

A. Flexion
- 1—subluxation (Fig. 2)
- 2—bilateral interfacetal dislocation (Fig. 3)
- 3—simple compression fracture (Fig. 4)
- 4—clay-shoveler's fracture (Fig. 5)
- 5—acute flexion "tear-drop" fracture (Fig. 6)

B. Flexion-rotation
- 1—unilateral interfacetal dislocation (Fig. 7)

C. Vertical Compression
- 1—Jefferson bursting fracture of C_1
- 2—"bursting" fracture of lower cervical segments (Fig. 8)

D. Extension
- 1—extension "tear-drop" fracture (Fig. 9)
- 2—posterior element fracture (Fig. 10)
- 3—Hangman's fracture (Fig. 11)

Figures 2 and 8 from *The Radiology of Emergency Medicine*, Harris, JH Jr., Harris, WH, Williams & Wilkins Company, Baltimore, 1975. Reprinted with permission of the publisher.

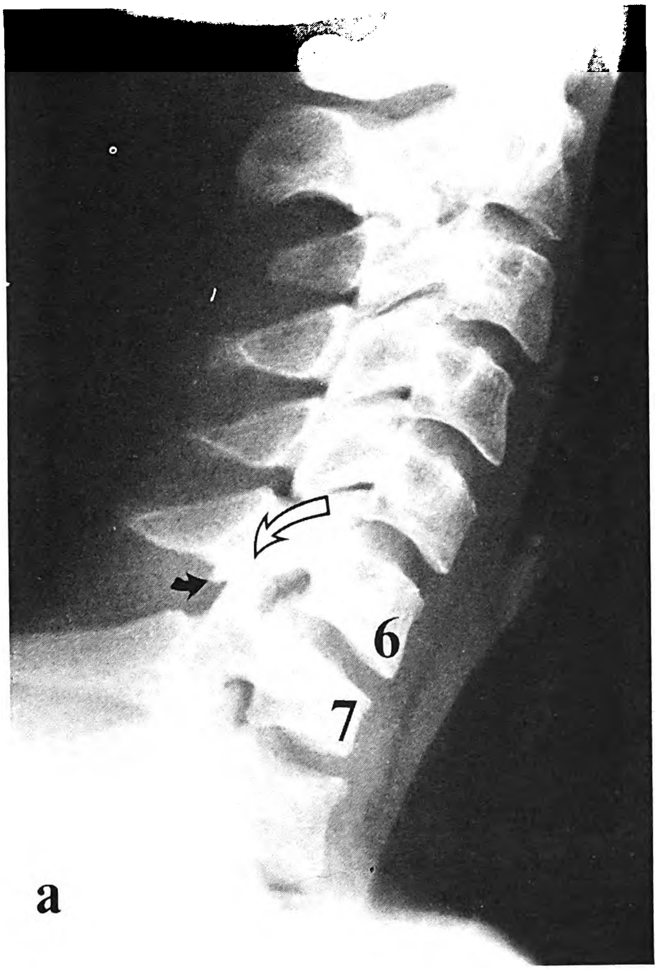
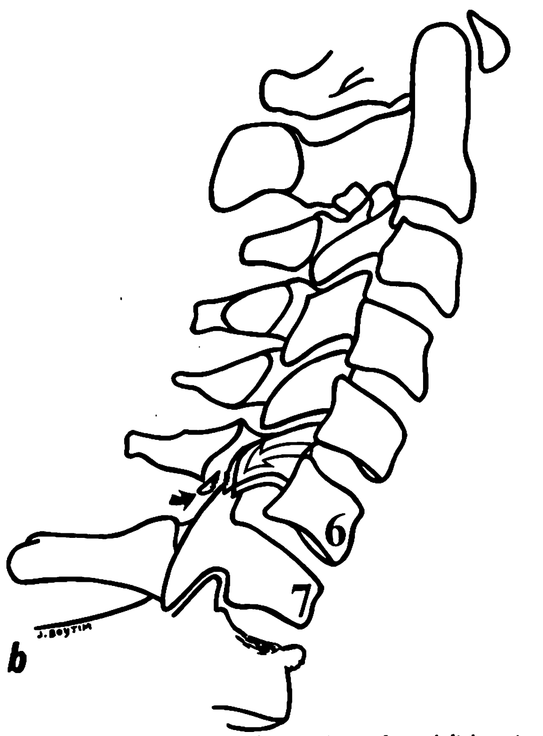
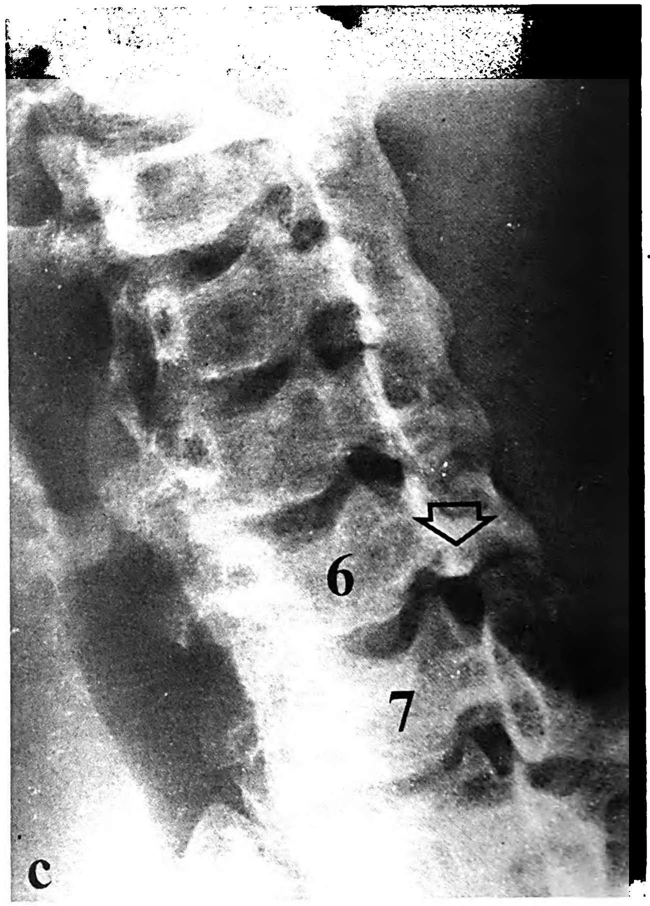
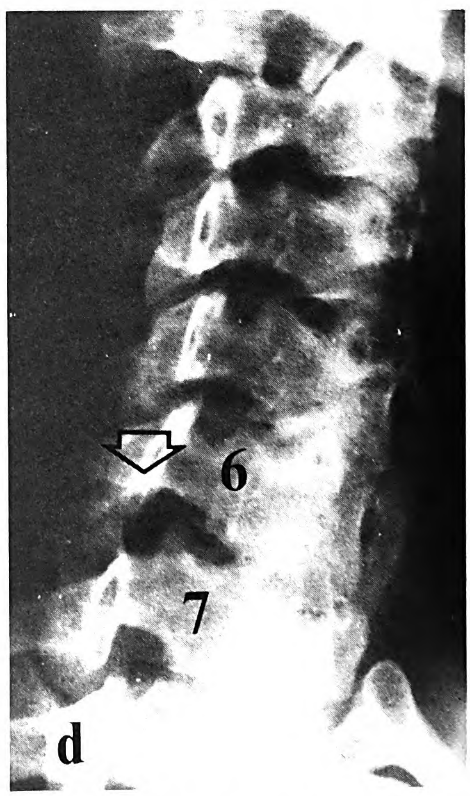


FIGURE 3: (a) Bilateral interfacetal dislocation of C_6 on C_7. The inferior articulating facets of C_6 lie within the intervertebral foramina, anterior to the superior facets of C_7 (open arrow). A small fracture fragment arising from the tip of one of the inferior facets of C_6 (solid arrow) remains posterior to the superior facet of C_7.



(b) Schematic representation of bilateral interfacetal dislocation.





(c and d) Each oblique projection demonstrating inferior facets of C_6 (arrows) dislocated anterior to the superior facets of C_7 and lying in the intervertebral foramen. Disruption of all soft tissue structures renders this dislocation unstable.

FIGURE 4: Wedge fracture of C_7.

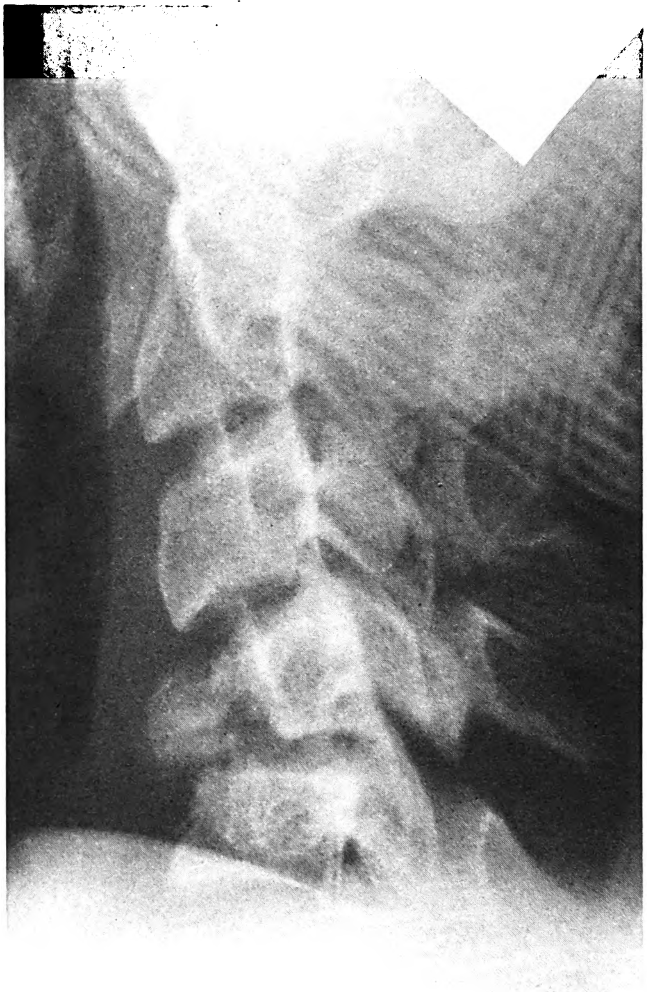


FIGURE 6: Flexion "tear-drop" fracture. This fracture, described by Schneider as the most unstable fracture of the cervical spine, is commonly associated with the acute anterior cerviacal cord syndrome, characterized by paralysis and loss of anterior column sensations but with retention of posterior column sensations, i.e., *position, motion, and vibration.*

FIGURE 5: Clay shoveler's fracture.

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FIGURE 9 (Left, top): Extension "tear-drop" fracture. This injury results when the anterior longitudinal ligament remains intact during an extension injury. In this circumstance, the inferior anterior corner of the vertebral body is pulled off by the intact anterior ligament. Therefore, this fracture is stable in flexion, but unstable in extension.

FIGURE 10 (Left, bottom): Fracture of the posterior neural arch caused by extension mechanism. This is a stable fracture.

FIGURE 11 (Above): Hangman's fracture is, by definition, a bilateral fracture through the pedicles of C_2. Because the neural ring is broken on each side, the fracture is unstable. Although the alignment of the vertebral bodies suggests a flexion injury, the fracture is caused by abrupt deceleration with the head and the upper two cervical segments (the cervico-cranium) in a position of extension.

A TAILORED APPROACH TO THE RADIOLOGICAL EVALUATION OF THE TRAUMA PATIENT

Jack W. Bowerman, M.D.

The emergency physician and radiologist facing the problem of x-ray interpretation in the trauma patient must be especially prepared from several standpoints. These include training in trauma and a heightened awareness of injury patterns. Ideally, the patient should be evaluated by the radiologist or trainee in radiology prior to the radiographic examination so that this examination is tailored to the problem at hand. Two views alone may be needed rather than four views for example. In another case, special views instead of conventional views may be needed. Special coverage or staffing of the emergency room must be arranged so that all hours of the day are covered. A system of senior coverage or a reserve system providing expertise in various disciplines is the best solution for the problem of extensive and acute injury or disease. These problems should not confront the junior resident or junior staff member alone.

In addition to a tailored approach to the evaluation of the patient and a tailored approach to staffing the x-ray area, a tailored approach must be applied to the equipment used in the emergency room. The equipment must be designed to deal specifically with the injured patient. The use of C-arm radiographic equipment in which the x-ray film is centered opposite the x-ray tube is the most functional and appealing design for the emergency room. The technologist does not then depend on adhesive tape and full cooperation of the patient to position a cassette. Views at all angles are possible and performed quickly without rotating the patient. Stretchers must be designed to fit within this framework and permit radiography without artifacts from the bed of the stretcher or its restraints. Tomography, fluoroscopy and arteriography are additional modalities needed to complement conventional radiography. Three-phase generators provide greater power than single-phase generators and allow shorter exposure times needed for patients who are acutely ill or injured and unable to fully cooperate in the emergency room. This generator system and a reliable automatic film processor, preferably with a reserve processor available, completes the equipment suggested for a useful emergency room.

As a future means of connecting the trauma patient with a team of diagnostic radiologists, a system of x-ray image transmission has been developed at the Applied Physics Laboratory and Radiology Department at Johns Hopkins. The x-ray image can be televised at a remote hospital site and sent to a central radiology staff or conversely the image may be generated at a central trauma facility and broadcast to physicians elsewhere to gain their opinion in the evaluation of the patient. A high resolution camera and fine line (1023) image tube are vital parts of the transmission system. Decisions regarding patient treatment and disposition would be influenced by this system.

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Rehabilitation—Why Wait?

REHABILITATION — WHY WAIT?

John E. Gessner, M.D.

History judges man and his civilization from many viewpoints, but the benchmark in any evaluation of society is how a man cares for his fellow man. This is the essence of almost all of our religions, and the Christian golden rule epitomizes the concept. The effects of technological development in our society are seen everywhere and have brought us far afield from those more pastoral days of the great philosophers, when man's relationship with individual men was, I suppose, clear and far easier to deal with. The Will Durant of 3076, when he writes his history of civilization, will document our technological revolution. He will describe the technocrat, and note that in 1976 there were men sitting in holes dug deep in the earth, who could press buttons and destroy civilization. The impact of technology on man in every aspect of his life will be a major thesis and the chapter on medicine will show its great benefit as well as the pain it produced.

The traumatologist has put technology to use in the treatment of his patients to the extent that the work he does is nothing short of miraculous when compared to the state of the art 25 years ago. But the more technological physicians become, the louder the cry from their patients to treat the "whole man." It is obviously unreasonable to expect every physician to be trained or to be prepared to treat the whole man, in spite of popular sentiment to the contrary. If the traumatologist can concentrate on a ruptured liver, a ruptured spleen, a lacerated thoracic aorta, hemothorax, cardiac tamponade, and cardiac arrest, pull all of these problems together and get a live patient as a result of his efforts, in my view he is redeemed, and his treatment of "disembodied organ systems" is legitimate. If the patient walks away from this trauma, all well and good. If he sustains ischemia to his cord and function of bowel, bladder and lower extremities is impaired, the obligation of the traumatologist to the whole man is to recognize that he needs further treatment so that his disability may be reduced.

Rehabilitation medicine is the specialty concerned with treating patients with impairment of function with the goal of reducing physical, social and economic disability to a minimum. It is, in my opinion, the quintessence of that civilized ethic expressed in the golden rule. It is a technique different from others in medicine. Controls and evaluation are sometimes difficult to come by. The process depends on the active participation of the patient himself. It should be prepared for and started by the primary physician. In order to do so, the primary physician must understand and utilize certain principles in his work.

Most frequently the basic impairment (for example, paraplegia) cannot be changed. It is of critical importance that those who refer their patients for rehabilitation understand the difference between impairment and disability. At the risk of overstating the problem I would like to offer the classical example used for the distinction of these terms. The medical impairment is the actual part or function that is lost. Every physician is able to quantitate this impairment. Severance of the left index finger at the metacarpophalangeal joint would be an example of a clearly identifiable medical impairment. The disability produced by this medical impairment, however, will be variable, depending upon who has the impairment. The vocational implications are easily seen in the cases of a carpenter and concert violinist. For the carpenter this impairment may be of little disability since he would be able to use the next finger and the thumb to hold nails in the process of hammering. The concert violinist would have a severe disability and might have to find some other kind of work. This is the concept most frequently misunderstood by my colleagues. Many of the therapies in rehabilitation tent to be equated with replacement therapy or a therapeutic drug. The fact is, we may use orthotic equipment in a sense as replacement therapy, but the fact remains that a severely damaged cerebral cortex may never recover sufficiently to be able to compute universal ideas in terms of words. Speech therapy will not help. Exercises to a hemiplegic arm and leg are not done to restore movement. This impairment may never improve. No one has devised therapy for homonomous hemianopsia. By and large all of these impairments depend upon spontaneous remission for return of function. Rehabilitation programs are based on helping the patient become functionally independent in spite of his impairment. They attempt to prevent the technologic triumph from becoming a defeat of the human spirit.

The role of the traumatologist or primary care physician is, to the extent that he can, to keep impairment at a minimum and to prevent the complications of the disability state. If he does his work with these concepts in mind he will have begun rehabilitation at the time of the initial treatment. A basic consideration is the metabolic effects of inactivity and injury. Original research in this area was done by Doctor R A. Cowley and his associates at the University of Maryland Hospital in the early days of the Shock Trauma Unit. The subject is summarized in the text, *Physiological Basis of Rehabilitation Medicine* in a chapter by Calvin L. Long and Lewis E. Bonella. I would like to quote several points which they make, including the statement that "inactivity causes alterations in the fluid compartments, in electrolyte balance, and circulation. It contributes to an increased nitrogen loss and muscular wasting, to change in mineral content in bone, and a decrease in resting metabolic expenditure." They point out that this decrease in metabolic expenditure is rarely adequate to conteract the increased energy requirement associated with any injury. Again, the supine posture produces a shift of a pint of blood into the thorax and cardiac work is increased by approximately 30 percent. They describe this "deconditioning syndrome" as being manifested by intolerance to the upright position and by an altered response to muscular exercise as seen in response to slight and moderate work load, and during tilting of the body from the supine to the upright position. These effects may be ameliorated by exercising in bed and by early mobilization including the use of the tilt table. Rehabilitation of spinal cord injured patients is completed at a much earlier date than even 10 years ago, and this is possible simply because the effects of deconditioning have been reduced by immediate mobilization of these patients. Anterior spinal fusion and external halo devices for stabilization of the spine play an important role. These principles have been well illustrated in other areas of medical treatment, and one can mention the rehabilitation of the cardiac patient as a striking example.

Active exercises in bed can be done by many patients with severe trauma. Patients with fractures of the lower extremities will be walking on their arms with canes and crutches, and should be made to strengthen the upper extremities in preparation for crutch ambulation. Those of you who have ambulated with crutches will know it is not as easy as it looks, and that energy expenditure is great. Patients who have neurological injury with paralysis should get passive range of motion exercise programs once or twice a day. This will maintain mobility of the joint, preventing contractures, especially in those patients who have upper motor neuron lesions with associated spasticity. We recommend splinting the wrist and hand early on and feel that this is particularly useful in the spinal cord injured patient in order to maintain the joint in a position of function and avoid stretching of the wrist muscles. Although the problem of foot drop can be controlled with footboards, it is easier to manufacture form fitting and well padded splints from materials such as "Orthoplast." The foot then remains continuously dorsiflexed and the position of the patient can be changed without reference to the fixed footboard. The loss of proteins through ulceration of the skin must be prevented at all cost. Nurses who are able to work with the severely injured patient are devoting the necessary time and getting the necessary experience so that skin care has improved by leaps and bounds during the past 10 years. Earlier involvement of the plastic surgeon in the treatment of decubitus ulcer is also contributing to earlier recovery.

The efforts which I have described above are particularly important to those patients with head injury, who may or may not have peripheral paralysis as a manifestation of this, but who have altered level of consciousness and affective disorders. It is amazing how much these patients do improve with time, and they may continue to improve slowly over a period of 18 months. The final improvement in speech and affect may continue over a period of four years.

Newer techniques in amputation surgery have included immediate post-operative fitting of the prosthesis and the use of rigid dressings. The traumatologist has a problem different from the vascular sugeon in that he may not be able to select a site for amputation which allows the best fitting of a prosthesis from the biomechanical standpoint. His site of amputation is frequently selected for him. Immediate post-operative fitting has not been widely adopted in this country. However, there has been considerable experience with rigid and semi-rigid dressings for the stump, the purpose of which is to prevent edema. Those patients who have had amputation for vascular disease can look forward to have complete healing of the amputation stump within two to three weeks and very early ambulation as a result. The Unna paste dressing is one which can be used to keep swelling from occurring and it can be changed frequently without difficulty. Wherever possible this type of dressing should be used.

Rehabilitation certainly starts on admission for the burn patient. The same principles apply and the prevention of contractures and further loss of viable skin by way of infection must be attended to. Well fitting splints should be applied to these patients immediately. They must be constantly revised as surgical procedures gain further range of motion and active exercises must be started in the burned extremities as soon as possible. The use of hydrotherapy in these patients and its beneficial effect is well known. The Hubbard tank or whirlpool not only debrides burned skin but keeps bacteria counts down and allows the patient to begin active exercises in an antigravity position.

So, there is no need to wait for rehabilitation. It can be started at the very beginning. Early mobilization and activity are the key factors. The traumatologist must also insist that his nursing staff assume the role of rehabilitation nurses, and understand the principles of early mobilization as clearly as he does. The physical therapist and occupational therapist should be on the scene to begin active and passive exercise programs as soon as possible, as well as mobilizing the patient on the tilt table. The moment the patient is medically stable he should be referred to rehabilitation medicine for the next stage of treatment which Rusk has called the "third phase of medicine." It is also the obligation of the traumatologist to clearly explain to the patient and his relatives the extent of his impairment, and to introduce his rehabilitation colleague by giving the patient hope that his disability can be lessened. He must be extremely careful not to feed into the denial which almost every severely impaired patient uses to keep his psychological equilibrium. He must also realize that this denial is just as strong in the patient's relatives and it is best to make as realistic a prognosis as is possible from the beginning. He must not expect his colleagues to be able to solve severe socioeconomic problems, because they cannot. Social problems are the usual sequelae of impairment, and often the degree to which the patient is able to adapt is insufficient to allow him to return to a previous life style. This is particularly so when his peers or family place unrealistic conditions on his reentering society. At this time recommendations for further rehabilitation training are appealing. Although they will postpone the day of reckoning, they are unrealistic and solve nothing.

There is no doubt that as ever increasing numbers of seriously impaired patients survive as a result of the efforts of the emergency medical system, identifiable rehabilitation programs and facilities must be developed in conjunction with Trauma Center.

Some type of comprehensive catastrophic health insurance program must be developed to provide the long term care that is required. The cost of these programs, particularly in spinal cord injury, is as spectacular as the treatment itself. Bernard M. Baruch said, "The investment in rehabilitation is an investment in the greatest and most valuable of our possessions, the conservation of human resources."

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REHABILITATION OF PERIPHERAL NERVE INJURIES

Paul F. Richardson, M.D.

The title of this workshop, "Rehabilitation—Why Wait?" is most appropriate for nerve injuries because the longer one waits to begin rehabilitation of an injured nerve, the less likely it will recover and the more likely a permanent impairment will result. In the early hours of treatment following trauma, primary concern, of course, must be directed to life threatening problems. However, too often very little attention is paid to nerve injuries since they are not perceived as emergency problems and are left for later management by secondary repair. Such delay significantly reduces the level of functional recovery. Whenever possible severed nerves should be repaired initially, because the proximal stump will begin to grow within a few days, and the axons can grow unimpeded by scar tissue which would otherwise soon fill the gap between the proximal and distal portions of the severed nerve.

In the event conditions at the time of the emergency care preclude primary repair, the disrupted nerve endings should be identified and if possible tied together by a suture for ease in identification and to prevent retraction of the ends. Certainly such a simple procedure is much easier at the time of the injury than it would be some weeks or months later when the nerve endings are buried in scar tissue. If the nerve ends cannot be tied together because of a large gap, the two ends should be tagged with metal clips for ease in later identification.

Physicians managing acute trauma should always suspect and look for nerve injuries whenever there is trauma to areas traversed by peripheral nerves. As elemental as this seems it is surprising how long some nerve injuries can remain undetected because the physician did not specifically look for them. Sometimes failure of the patient to move a portion of an extremity is attributed to pain, and significant paresis or even paralysis can be overlooked. This can occur in axillary nerve injuries associated with fractures or dislocations of the humerous where deltoid muscle paralysis is undiagnosed because of associated pain and the patient's ability to partially abduct the arm by scapular rotation. An aid in diagnosis here is the typical diminution or loss of sensation in the axillary nerve cutaneous distribution.

Peripheral nerves can be injured most obviously through direct laceration by a sharp object which may completely or partially sever the nerve trunk. This can occur anywhere along the course of the nerve or even more proximally in the plexus before the individual nerves have emerged. Nerves may be torn apart and segments may be missing. Traction injuries may stretch a nerve sufficiently to disrupt some or all of the axons while leaving the nerve trunk apparently intact. Hemorrhage or edema at the site of the trauma may cause a gradual increase in pressure which brings about delayed loss of nerve function. If the pressure is not great or prolonged, a temporary and reversible loss of function known as neurapraxia may result. With sufficient pressure and duration, death of some or all of the axons may occur with resulting degeneration of the distal segments. Retroperitoneal and intrapelvic bleeding may exert sufficient pressure on the lumbar or sacral plexuses or the nerves emerging therefrom to cause paralysis of the appropriate lower extremity muscles.

In diagnosing peripheral nerve injuries due to trauma, the history, especially the mechanism of the trauma, is very important since it provides clues as to the possibilities. As mentioned earlier, the likelihood of nerve injuries must always be entertained when there is trauma to an area through which a nerve passes. The site of damage is sometimes obvious by the mechanism of the injury, as when a laceration or wound is evident. Here the surgeon often has direct access to the nerve in order to assess the nature and severity of the injury. In blunt injuries localization and assessment of the nerve injury is not so easy. The occurrence of stretch injury must always be considered when the trauma mechanism is such that body segments are subjected to distractive forces. An example of this is the brachial plexus stretch injury or even cervical root avulsion which can occur when a shoulder is severely depressed with simultaneous lateral flexion of the cervical spine in the opposite direction. The development of slightly delayed or progressive signs of nerve injury is suggestive of pressure on the nerve due to hemorrhage or edema. If evidence of progressive nerve involvement occurs several weeks or months after injury, one would suspect the constricting or deforming effect of scar tissue or incorporation in callous formation when a fracture is associated.

In addition to the clinical observations of autonomic dysfunction, and assessment of sensory loss, manual testing of individual muscles is a very accurate clinical means of localizing nerve lesions by evaluating partial or complete loss of motor function. There are fewer aberrations in motor innervation than in sensory distribution. Thus an intimate knowledge of muscle function and innervation, including plexus configurations and root origins is a valuable asset in localizing and assessing peripheral nerve injuries.

Electromyography and nerve conduction studies are an important extension of the history and physical examination and provide information concerning the status of peripheral nerves that is not otherwise available. Electromyography, by reflecting in the electrical activity the functional state of the motor unit (anterior horn cell, axon, myoneural junction, and muscle fibers) allows the physician to delineate which muscles are denervated and whether the denervation is complete or not. A knowledge of the motor distribution of the plexuses and nerves will usually permit precise location of the site of nerve injury. Differentiation between plexus and root lesions is possible by examining muscles suppled by the posterior primary diversions of the motor nerve roots. Obviously, abnormalities found in the distribution of posterior primary division as well as the anterior must arise from a lesion at the root level. Electromyography is also useful when following the course of nerve regeneration as it will provide evidence of returning function before it can be seen clinically.

Motor nerve conduction studies allow one to differentiate between reversible neurapraxic lesions and those in which degeneration has or will take place. In neurapraxic lesions conduction delay or failure is confined to the temporarily compromised segment of the nerve, and conduction is normal above and below the lesion. One must keep in mind that the neurapraxic state may change with increased or prolonged pressure on the nerve and repeated conduction studies at intervals of a few days may alert one to the need for prompt surgical decompression in order to prevent axonal degeneration. Failure of a nerve to conduct in the segment below the lesion after several days is indicative of beginning axonal degeneration. Motor conduction studies, however, are not very helpful in assessing recovery of nerve function, because clinical recovery often precedes return of conductivity, as evidenced by the presence in muscle of evoked action potentials when stimulating above the lesion.

In making a prognosis for recovery of function following nerve injury, it is best to err on the conservative side since a patient will not be unhappy if recovery occurs sooner or to a greater extent than predicted. Naturally, the time for recovery or the degree to which function will return is related to the type of injury.

Mild injury resulting in a neurapraxia in which there is no loss of continuity or axonal degeneration, may permit return of motor function within a few days, weeks, or a month or two. The return of voluntary muscle control is relatively rapid in that all muscles innervated by that nerve tend to recover at the same time rather than sequentially as would be the case where degeneration had taken place and regrowth of the axons would be necessary.

More severe injury resulting in axonal degeneration but with preservation of the nerve sheaths will take longer to recover but usually will do so without undue delay since the axons can proceed distally, guided by the nerve sheaths. Axonal growth occurs at an average rate of approximately three millimeters per day following an initial delay of a few days. The growth rate is a little faster in the more proximal parts of the distal segment and slows as the muscle is neared. The unmyelinated axons reach the muscle first and myelination which proceeds at a later time must occur before functional maturation and reinnervation takes place. This takes a much longer time than would be expected by the growth rate of the unmyelinated axons and gives a recovery rate of approximately one millimeter per day.

In those nerves where trauma has completely disrupted or severed the nerve with separation of proximal and distal segments, recovery without surgical intervention is highly unlikely since the sprouting proximal axons grow off in all directions hindered by scar formation and unable to grow back along the neural tube. Neuroma formation is usually the result. If, however, the separated nerve can be sutured together, regrowth will usually occur. If the funiculi of the nerve can be appropriately aligned during suturing, the axons are much more likely to reach their original end organs. Under the best circumstances, however, nerves that have been severed rarely recover complete function.

Since it is often difficult to know the exact nature of the nerve injuries which are not assessed directly at surgery, prognosis must usually be guarded even when followed closely by clinical and electromyographic examination. In muscle that has been separated from its nerve supply, spontaneous activity of muscle fibers will develop usually after 14 to 21 days. These spontaneous potentials known as fibrillations, which can be detected by the electromyograph, will persist until the muscle is either reinnervated or atrophies completely and is replaced by connective tissue. Since the latter takes a very long time a reduction in the amount of fibrillation and its eventual disappearance usually is a favorable prognostic sign. Further indication of recovery is evidenced by the appearance of occasional complex potentials which at first are not under voluntary control but are produced by mechanical stimulation. These are soon followed by action potentials under voluntary control. All of this activity is noted by electromyography before any clinical evidence of voluntary muscle contraction can be seen. These findings are seen first in the most proximal muscles since they are the ones reached earliest, and the course of the regenerating nerve can be followed distally. The electromyographic evidence of returning function is reassuring to the surgeon who has approximated a severed nerve, and the calculated time for beginning clinical recovery has passed uneventfully.

Since nerve regeneration takes many months, what should be done to assure as complete a return to normal function as possible when reinnervation occurs? Inactivity of a body segment favors the development of soft tissue contractures, inadequate circulation and edema, and if the latter is allowed to remain, fibrosis and further limitation of motion will occur. Weak or paralyzed muscles will be stretched by the normal antagonists, improper positioning, and the ever present effect of gravity. Paralyzed muscles subjected to stretch do not recover full function and conversely, those which are allowed to shorten tend to remain so. The persistence of improper mechanical forces can also cause joint deformities. All of this adds up to a formidable array of forces acting to prevent the restoration of normal movement. However with the exception of the neurogenic atrophy which inevitably occurs in denervated muscle, the other adverse affects of denervation can be largely prevented.

Proper splinting of paralyzed extremity segments in a neutral position with removal at appropriate intervals, usually several times a day, to permit full passive movement of the involved joints will prevent contractures of muscle and joint capsules. If edema is a problem, massage in a proximal direction will aid in reducing it, as will elevation of the affected part. Additionally, intermittent compression applied by enclosing the part in a pressure sleeve connected to a motor driven pump can be used in stubborn cases.

The most important element in successful rehabilitation following denervation is the proper education of the patient in regard to the effects of immobility, improper positioning, and edema, and the necessary activity on his part to prevent adverse effects. He should also be cautioned regarding the protection of areas lacking sensation and the protection of the denervated part from exposure to cold. As recovery occurs or in cases of incomplete lesions, paresthesias and/or pain are frequent, and this phenomenon must be explained to the patient and if necessary, analgesics given. Every support, whether it be appropriate medication, encouragement or other assistance must be provided the patient since his cooperation is absolutely essential to successful rehabilitation.

As motor power begins to return, the patient must be taught reeducational exercises in the form of active assistive movements with progression to less and less assistance and eventually progressive resistance exercises to restore strength. A recent approach in the early phase is to provide biofeedback for the patient by placing percutaneous electrodes over the involved muscles to pick up the slight electrical activity caused by voluntary contraction. This electrical activity is then displayed on an ammeter or connected to an audio circuit to provide visual or auditory evidence of muscle function for the patient. Throughout the rehabilitation process the patient must be followed closely to see that conditions are optimal for recovery of nerve function and full mobility of the paralyzed parts. Most disabling complications are insidious in development and the physician must be aware of them in order to prevent their disabling effects.

At the Maryland Institute for Emergency Medicine which is contiguous with the University of Maryland Hospital, trauma patients are seen by a physiatrist from the hospital's Department of Rehabilitation Medicine soon after admission. The physiatrist actively participates in the medical management of appropriate cases so that unnecessary complications are prevented and a rehabilitation program begun as soon as possible. The patient is then followed until rehabilitation is completed, or if indicated, referred to another rehabilitation resource. If this is not done, the often miraculous feats performed by the trauma team results in much less than an optimal outcome.

In summary, the traumatologist can provide optimum care for his patient with a peripheral nerve injury by: suspecting its presence; accurately assessing its nature; repairing it promptly when possible; and providing rehabilitation as an integral part of the medical management.

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VOCATIONAL REHABILITATION, WHY WAIT?

Mark L. Stancil, M.S.

The other speakers have stressed the importance of medical rehabilitation; my presentation will focus on vocational rehabilitation and the need to involve patients (or clients, as we refer to them) in the programs at times when they are most receptive to rehabilitation measures. In doing this, I plan to review briefly the State/Federal Program of Vocational Rehabilitation, give a short history of its development in America and discuss the mandates of the Rehabilitation Act of 1973. In addition, I will discuss the vocational rehabilitation program in Maryland and the program of services at the Maryland Rehabilitation Center.

This conference on Traumatology has demonstrated that medicine has made tremendous advances in basic knowledge and new techniques which have resulted in improved medical care. One improvement is the development of emergency medical institutes for the treatment of trauma cases. Countless lives have been saved and returned to society who previously might have died or have become permanently disabled. Nevertheless, many of the individuals saved have sustained handicaps which prevent them from returning to occupations in which they previously worked. They need vocational rehabilitation services to return to productivity and self-support.

Vocational rehabilitation has been defined as a process of restoring the handicapped individual to the fullest physical, mental, social, vocational and economic usefulness of which he or she is capable. This definition envisions a process aimed at helping handicapped individuals obtain the highest employment level possible. It includes not only full-time competitive employment, but also provides services to persons who are capable of only part-time, sheltered, homebound or self-employment.

The rehabilitation process consists of a program of services planned jointly by a handicapped individual and a rehabilitation counselor to provide whatever services are necessary to assist the individual to achieve maximum vocational potential. To accomplish this vocational adjustment a wide range of services are available. They include:

1) Evaluation, including both medical diagnosis and vocational assessment and related services necessary to determine eligibility and rehabilitation potential.

2) Counseling and guidance services necessary for achieving adequate vocational adjustment.

3) Physical and mental restorative services including medical, surgical, psychiatric, hospital care and therapy to reduce or remove disability. Also, artificial limbs and other prosthetic orthotic devices.

4) Training, including vocational, prevocational and personal adjustment and remedial education.

5) Maintenance and transportation during the rehabilitation process.

6) Services to family members when necessary for the adjustment of the handicapped individual.

7) Interpreter services for the deaf and teaching, orientation and mobility services for the blind.

8) Telecommunication, sensory and other technological aides and devices.

9) Placement in suitable employment.

10) Postplacement services necessary for the individual's job adjustment.

11) Tools, equipment and licenses for work on a job or in establishing a small business.

12) Any other goods or services necessary to benefit a handicapped individual in terms of his employability.

These wide range of services may be purchased from any available resource depending on the individual need. Private physicians, public and private hospitals, specialized clinics, rehabilitation centers, workshops, public and private education facilities and employers are some of the resources drawn upon by the rehabilitation counselor in the provision of services.

On the national level the Rehabilitation Services Administration is located in the Department of Health, Education, and Welfare, Office of Human Development. Funds are provided to all states on a population and per capita income squared formula for the operation of vocational rehabilitation programs. These funds are provided for the most part on an 80 percent federal, 20 percent state matching basis. For the current year, Congress has authorized $740,000,000 and states must match this with $185,000,000 for a $925,000,000 nationwide program.

Vocational rehabilitation began when President Woodrow Wilson signed the Smith-Fess Act in 1920 and thus, is one of the oldest grant-in-aid programs for providing services to individuals. This act, which provided services to disabled civilians, grew out of the success of the Soldier's Rehabilitation Act of 1918 which was developed as a response to the returning disabled veterans of World War I. At that time the major emphasis of the program was career development, trade training and job placement. Through the years the rehabilitation movement has sustained periods of slow growth and periods of great expansion. The laws pertaining to rehabilitation have been extended, amended, and new laws passed which expanded the basic pattern of services for disabled individuals. The legislation has added sweeping changes in the financing provision, professional training and expansion of service resources. In the process, many more persons became eligible for rehabilitation services. In the 1940's, our nation began to recognize the needs of the mentally ill, and they were made eligible for services for the first time. During the Kennedy-Johnson era, the program encompassed the needs and began to deal more effectively and comprehensively with social problems.

The Rehabilitation Act of 1973, Public Law 93-112, specifically mandates that each state will place special emphasis and priority on services to those individuals with the most severe disabilities. In the *Federal Register*, a severely disabled individual is defined as one who has a physical or mental disability which seriously limits his functional capacities (mobility, communications, self-care, self-direction, work tolerance or work skills) in terms of employability, and whose vocational rehabilitation can be expected to require multiple services over an extended period of time. This signifies a redirection of priorities for services to disabled citizens. Many trauma victims sustaining disabilities are now eligible for services.

In past years vocational rehabilitation in most states was organizationally located in the state department of education. This relates back to the early laws when the major services were career planning and vocational training. Recently, approximately 17 states have reorganized vocational rehabilitation under an umbrella agency such as social services or human resources. In some states it comes under the department of labor. Four states have an independent agency and in many states, such as Maryland, it remains, a division in the department of education.

The Maryland Division of Vocational Rehabilitation comprises a staff of 860 persons and operates from a network of over 50 local, district and regional offices throughout the state. In addition to counselors who serve the general disabled population, the Division operates cooperative units in each of the local educational school systems, in five state mental hospital units and in a correctional rehabilitation unit in the prison system. The Division also operates the Disability Determination Service Program whose primary function is to determine eligibility for disability insurance benefits and Supplemental Security Income benefits for Social Security applicants. Finally, the Division operates the Maryland Rehabilitation Center, one of eight comprehensive vocational rehabilitation centers in the United States operated by a state rehabilitation agency.

The Center is located in northeast Baltimore at 2310 Argonne Drive and is physically attached to the Montebello Hospital Center by connecting ramps. The Center is a multistoried brick structure, architecturally barrier free, encompassing 246,500 square feet of floor space. The Center has a dormitory for 254 resident clients and a 50-bed rehabilitation nursing unit for a total resident capacity of 304 clients. In addition, the Center can accommodate 150 day or commuting clients for a total operating capacity of 454 clients at any given time.

The Maryland Rehabilitation Center is still relatively new. Construction was completed in late 1972, and the first group of clients was accepted for services on January 8, 1973. Last fiscal year, 1,013 clients received Center services, with a daily average census of 261 individuals in the program. The current daily census is approximately 300 clients. Efforts are currently underway to increase this capacity by adding the additional personnel, programs and financial resources necessary to operate the Center.

The program of services at the Center is varied and comprehensive in nature, depending upon the needs of the individual clients. Service programs include the following:

Counseling and Guidance

A counselor is assigned to each client on admission and is responsible for planning and coordinating the program of activities during the client's stay at the Center. The counselor also works closely with the referral source and recommends follow-up services indicated upon discharge of the client. The counseling department is also responsible for the operation of the admissions office and the supervision of dormitory house-parents stationed on each floor of the dormitory for general supervision and assistance to resident clients.

Vocational Evaluation

There are many individuals who need to be retrained as a result of their disability; others are young and have never worked. Many are not sure of their own vocational potential or have no idea of their ability and interests. Through medical evaluation, social, psychological, education and vocational assessment, the evaluation department assists the client in choosing the surest vocational routes to ultimate self-sufficiency. This program is conducted in three evaluation laboratories by social workers, psychologists and rehabilitation specialists (evaluators). In these laboratories more than 100 different work sample areas are available including components of the following evaluation systems: Tower, Jewish Evaluation Vocational System, Singer-Graflex and Valpar. The length of evaluation can range from one day to eighteen months, depending on the needs of the individual or the severity of his handicap. In our program, the average length of evaluation is usually three and one-half weeks. The evaluation for the blind, the deaf and the spinal cord injured is usually extended due to the nature of their disability.

Vocational Training

This program comprises a wide diversity of job opportunity courses ranging from accounting to woodworking. Staffed by 34 instructors and teachers utilizing shops, classrooms and learning centers, the program utilizes modern equipment and methods in teaching the respective trades. The programs are approved by the Maryland State Department of Education and the Veterans Administration which pays benefits to disabled veterans while they are enrolled in training at the Center. The program also offers remedial academic programs, high school equivalency, job preparation training and prescription training for specific job placement. All vocational courses have been developed on a self-instructional basis. This allows clients to progress in training at their own rate of speed. Training may extend from a few weeks to over one year depending on the course and the progress of the client.

Medical Services

All clients accepted in the Center are under medical supervision. Physicians are available 24 hours per day for an emergency that may arise. All clients receive a general medical examination to determine the nature and extent of disability and to establish the current state of health. Treatment may be prescribed within the Center or referred to a specialist within Baltimore City. Facilities at Montebello Hospital Center such as the x-ray department and the laboratory are used for diagnostic purposes on a contractual basis. Clients are also scheduled in the dental clinic and other specialty medical clinics at Montebello. The Center has a medical director, two internists, a physiatrist and four consulting psychiatrists. Other medical clinics may be scheduled as necessary for the health care and maintenance of Center clients. Other programs of services included in the medical program are:

REHABILITATION NURSING UNIT

The unit consists of 50 beds with a staff of full-time nurses. Clients housed in the unit are severely disabled or are multiply handicapped. They could not function in the Center dormitory because they are not independent in daily living activities. Emphasis in the unit is placed on independent living so the clients may realize their potential and transfer to the dormitory. The nursing department also staffs the health clinic and provides nursing assistance for medical problems arising in the dormitory.

Therapies

These services include: physical therapy, occupational therapy, speech therapy and audiological assessments in specially designed and staffed facilities. The services assist in providing treatment as prescribed by physicians and in evaluating individual physical capacities. The therapists also teach activities of daily living, transfer activities, muscle strengthening, gait training and other traditional activities carried on in therapy programs of this nature.

Recreation

A wide variety of leisure facilities staffed by recreational personnel are available to provide wholesome activities for the clients. Included are game rooms; an auditorium with stage for dramatics; 35mm movies; a swimming pool designed for the handicapped; an archery range; four bowling lanes; a gymnasium for basketball, shuffleboard, volleyball, dances and other activities; a library; a canteen and buses to enable clients to use community resources. These facilities operate until 11:00 p.m. each day, seven days a week.

Other Center Services

These include a chapel for religious services; special service units for the treatment and rehabilitation of clients who have suffered spinal cord injuries, as well as special facilities and programs for the deaf and the blind. Staff often assist with job placement. However, this is currently the responsibility of the referral source.

A wide range of disabilities are served by the Center. Last year, by primary disability, 28 percent were orthopedic and amputees; 26 percent mental and emotional disabilities; 8 percent mentally retarded; 7 percent deaf and hard of hearing; 7 percent spinal cord injured; 4 percent epileptic and smaller percentages with cardiac, speech and other disabilities.

Referrals are sent to the Maryland Rehabilitation Center by a counselor on the staff of the Division of Vocational Rehabilitation and come from all areas of the state. Some were injured on the job and are sponsored by Workmen's Compensation or insurance companies. Others are sponsored by Social Security Trust Funds or the Veterans Administration. A small number come from out of state and are sponsored by rehabilitation agencies in these states. The vast majority of clients are sponsored by the Division of Vocational Rehabilitation at no cost to the individual.

Referrals to the agency come from many sources including physicians, hospitals, schools, social agencies, Social Security, self-referral, etc. Referrals should be made early in the period of disablement; thus providing for contact with clients at a time when they are considered most receptive psychologically and physiologically to rehabilitation measures. The counselor should contact the client as soon as possible after the referral is made. The setting for the initial interview may be the counselor's office, in another agency, in a hospital or in the client's home. Early referral allows more time for planning effective services and reduces adjustment problems caused by continued psychological and physical stress and enforced dependency.

Timing in rehabilitation is very important and we often do too little, too late. Many persons who could profit from rehabilitation services do not know about them. Others refuse to seek or accept services for a variety of reasons. Some may not understand rehabilitation. Others fear the corrective surgery they know they need. Others do not want to change their dependent role. Some do not want to accept welfare and others too often get lost in institutions for one to ten years before they are referred for rehabilitation services.

Disability is one of the major causes of dependency. It is not known how many disabled persons are supporting themselves on savings, income from savings or investments, private or union pensions, private disability or other insurance payments, etc. Information is also not available as to the number of disabled persons supported wholly or in part by their families, relatives, friends or private social, charitable and religious agencies. However, more than 1.5 million persons under age 65 receive public assistance because of disability. This includes children who receive aid because of the disablement of their parents.

Rehabilitation, why wait? The nation cannot afford to wait. Disability reduced productivity and is a drain on the wealth of the state and the nation. It not only prevents people from working and receiving an income, but it requires taxes to carry on programs necessary to maintain disabled persons. There are many other effects of disability. The individual may lose self-confidence, develop feelings of dependency, inadequacy and not belonging. Disability also can affect the family unit when someone has to stop work to care for the disabled family member. This could mean constant supervision and care of the disabled individual. Also, the institutionalization breaks up the family unit. Finally, the public cost to provide maintenance, medical care and other services through public assistance is overwhelming.

Rehabilitation, why wait? The nation cannot afford to wait. served 25,000 disabled persons at a cost of $16,690,692. Of this, 8,114 were rehabilitated into gainful employment. These individuals will earn in excess of $34,201,908 in the first year of employment. This means in four and one half years they will pay back in taxes more than it cost to rehabilitate them. There are other values to rehabilitation which cannot be measured in dollars and cents. What the program means to the rehabilitated person himself by the enhancement of personal dignity through the ability to work or the ability to care for one's self is immeasurable. Again, from humanitarian, social and economic viewpoints, we cannot afford to wait to implement rehabilitation services. Every disabled individual has the right to have the opportunity to find his place in society.

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WHY WAIT? THOUGHTS PERTAINING TO SPINAL MAN

Arthur A. Siebens, M.D.

This is the country of the automobile, the jet engine, the computer, the touch tone telephone, the T.V. dinner, and instant coffee. Whether in penetrating space, probing the earth, winning on the athletic field, or planning emergency medical services, we want action. Patience and waiting are not prominent in much of our national heritage.

The topic can be interpreted, then, to suggest intolerance of inaction. Literally, however, "Why Wait?" is a request for an explanation, i.e., "Why should one wait?"

I have elected to look briefly at selected aspects of the early treatment of spinal man with both of these interpretations in mind.

Length of Stay

How quickly spinal man returns to a noninstitutional setting is one of the most dramatic changes that has occurred in his care. The uncomplicated first admission individual hospitalized in one of our leading institutions for care of the spinal cord injured can expect to return to the outside world within about 8 weeks if he is paraplegic and in about 11 weeks if he is quadriplegic. The comparable figures in 1960 were 13 weeks for paraplegics and 18 weeks for quadriplegics. Within 16 years, therefore, the length of hospitalization has been decreased by about 33 percent for paraplegics and by about 40 percent for quadriplegics in this center. The Director of the Spinal Cord Injury Service of the Veteran's Administration in a recent conversation estimated that length of hospitalization in this vast program now is about one third what it was ten years ago. Clearly, then, one can cite data indicating that spinal man is in fact waiting less in hospitals.

How much farther can this trend go? Is it possible to move too fast? Should one in fact advocate slowing down? Dr. Robert Jackson of the Craig Rehabilitation Center believes that it is possible indeed to push too hard. He estimates that reasonable figures for paraplegics are nearer 12 weeks rather than 8 and for quadriplegics nearer 16 weeks than 11. Perhaps we need to remind ourselves that although we can strengthen, manage incontinence, remobilize, equip and otherwise modify the flesh quickly, the spirit may move less rapidly.

Why wait? We now have the knowledge and means to deal with spinal man's medical problems more effectively and more quickly than ever. Do the needs of the total man justify a more deliberate pace than one set primarily by concern with body functions?

Instituting Bowel Care

Predictable bowel evacuation is one example of a practical area of care in which waiting is commonly too long. Evacuation of the bowel, mundane and uninspiring to the physician, is important physiologically and matters greatly to the patient. It is predicated, both in normal and spinal man, on an active contraction of the smooth muscle of the rectum coupled with a relaxation of the skeletal musculature comprising the anal sphincter. This is an active process which results in evacuation provided stool is of proper consistency. Eliciting this reaction is the first approach to managing the neurogenic bowel. This can be accomplished by the insertion of a suppository or by digital stimulation of the anus and rectum.

Patients referred for care of spinal cord dysfunction not infrequently are found to have been exposed to either no plan for bowel evacuation or to the use of enemas. The former may result in recurrent impaction and its abdominal concomitants. The latter results in prolonged periods of soiling as the enema is gradually eliminated. Neither approach is likely to achieve the predictable and relatively prompt experience which defecation should consist of in spinal man.

Concerning Ventilation and Speech

Individuals with cervical injuries in need of respiratory assistance usually find themselves attached to a source of positive pressure. Air is blown into the lungs and escapes from the lungs through a tube inserted below the larynx and sealed from it within the trachea. (Figure 1) The larynx is therefore bypassed and the individual is without voice despite consciousness and intact glossopharyngeal, vagus and hypoglossal innervation. His communication quandary is compounded by the inability to use his upper extremities for writing. At a time of extreme personal crisis, he finds himself incapable of reporting his observations, feelings and wants to those before whom he is literally prostrate.

An alternative is to unseal the tracheal cannula by deflating its cuff. (Figure 1) The conscious and waking individual will quickly learn to vary laryngeal resistance so as to achieve both alveolar ventilation and speech. The ventilator may need to be adjusted to compensate for the laryngeal leak. The staff may need to relax its preoccupation with the instrument's precision as it comes to recognize that the simple wisdom of the patient's body is a sure basis for the regulation of breathing.

Concerning Grasping Functions of the Hand

The patient with interruption of spinal cord function in the area of the sixth cervical segment has excellent positioning functions of the upper extremity when sitting. He lacks grasping functions, however, by virtue of paralysis of the muscles which provide stabilization and motion of the fingers. Nevertheless, he is able to achieve a measure of grasp because he can extend his wrist and because of the relationship between wrist motion and passive finger motion. (Figure 2) This relationship is such that when the wrist is flexed, as when the extensor carpi radialis relaxes, the dorsal tendons of the fingers are under greater tension then the volar tendons; the fingers therefore extend and the hand opens. When the wrist is extended, on the other hand, as during contraction of the extensor carpi radialis, the opposite occurs. The volar tendons are under greater tension than the dorsal tendons and the fingers therefore close weakly. This passive motion of the fingers secondary to wrist motion is the basis of "tenodesis grasp." Although this prehension is of great importance, it is nevertheless rudimentary for lack of force.

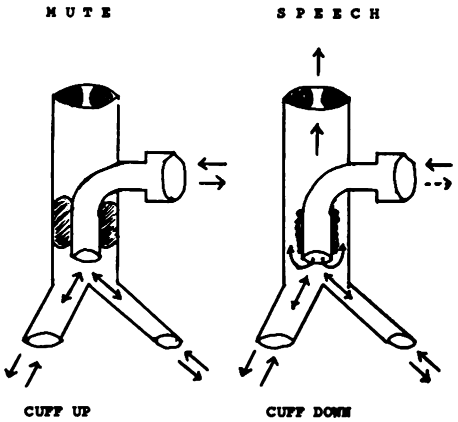

FIGURE 1: Early restoration of speech in patient ventilated by positive pressure delivered through cuffed tracheostomy tube.

There are four general approaches to improving this circumstance: 1) Allow the finger and thumb joints to stiffen somehwat and the hand to shape itself in a form which optimizes tenodesis grasp. 2) Equip the individual with an assortment of devices which fit onto the hand temporarily so as to assist grasp for certain specific functions such as writing. 3) Construct a functional brace (tenodesis splint) to be worn more or less continuously. This is designed to stabilize the fingers and to convert the power of the wrist extensors to useful finger strength for most forms of grasp. 4) Perform surgical procedures designed also to both stabilize thumb and fingers as well as to convert wrist and forearm strength to force for grasp.

Given these options, each of which currently finds its place, what are some of the variables which bear on selection? 1) The extent of neurologic recovery as *time* passes. 2) The increase in strength of the forearm muscles incident to their use over *time*. 3) The degree to which the finger joints do in fact stabilize with *time* in the absence of surgical procedures. 4) Whether or not the patient can learn in *time* techniques which are facilitated by simultaneous extension of fingers and wrist,

FIGURE 2: Double exposure of hand of patient with finger muscle paralysis but volitional control of extensor carpi radialis. See text for discusion of tenodesis action.

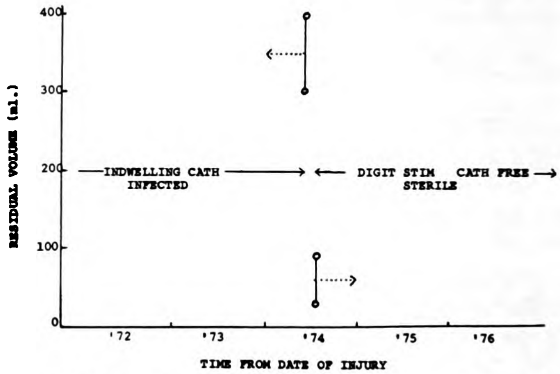

FIGURE 3: Care of the neurogenic bladder over a four and a half year period in a patient with low thoracic paraplegia. See text for explanation.

e.g., in bracing against bed or chair with the open hand while doing transfers. 5) What the patient intends doing, professionally, avocationally and in daily self-care as *time* passes and it dawns upon him that his quadriparesis is really permanent.

Although other considerations could be added to complete such a list, these five serve to emphasize that time for physiologic, anatomic, psychosocial, and vocational evolution is pivotal. Why wait? Because time is an essential ingredient for chosing wisely.

In Reference to the Paralyzed Bladder

Care of the neurogenic bladder has undergone a truly remarkable revolution. Whereas the indwelling catheter represented the hallmark of the paralyzed bladder for decades, this approach has been replaced in a few years by the intermittent drainage of the bladder or its total freedom from exposure to this tube. This change, probably more than any other single factor, is held responsible for shorter hospitalizations and the impression that spinal man is heir to fewer urinary complications.

When should intermittent catheterization begin in patients with upper motor neuron lesions of the bladder? Should this be begun immediately or after bladder tone and reflex contractility have returned? Assuming the latter, can the urine be sterilized after prolonged indwelling catheter care and infection of bladder urine? Can one wait and still achieve sterilization of the urine? Is the continued use of the indwelling catheter ever the best approach to the patient?

These interrelated questions are raised by the data represented on Figure 3. The patient became paraplegic with a low thoracic level in January, 1972, following which he was immediately catheterized. The Foley catheter remained in use through recovery from spinal shock and during a two-and-a-half year period. The urine was infected during this entire time. An effort was then made to eliminate the catheter. The postvoiding residual was found to be between 300 mls and 400 mls. Efforts to sterilize the urine failed. In mid 1974, he was instructed in the use of digital stimulation of the rectum in association with voiding. His residual with this technique fell to between 20 mls and 90 mls. Intermittent self catheterization was then discontinued and he was treated briefly with appropriate antimicrobials. His urine became sterile and has been sterile for approximately two and a half years. His IVP, BUN, and creatinine clearance are normal.

This, then, illustrates that intermittent catheterization need not begin immediately in order for renal health to be preserved and for urine to become sterile. Why wait? Because immediate intermittent sterile catheterization is time consuming, costly, and not uniformly necessary for continence and health. Perhaps all is not lost by picking the right time, therefore, taking proper care in the meantime.

Concluding Comments

In conclusion, there has been remarkable progress in the approaches to the physiologic deficits of spinal man, in reducing the period of obligatory institutionalization, in compensating for his deficits, and in assuring him access to health and longevity if he follows instructions.

One wonders if progress is as clear with regard to social, rather than physiologic, standards. Are there living-in quarters for the disabled? Is public housing suited to the needs of the disabled readily available? Where is the physically dependent healthy young person to live if he or she has no devoted spouse, parent, or friend prepared to make a lasting sacrifice? Is the American nursing home the environment of choice for disabled young people? What employment opportunities exist? These, and other questions, remain urgent reminders of continuing imperfections in addressing the total challenge of spinal man.

Why wait?

HAND — EMERGENCY CARE INCLUDING REPLANTATION

Raymond M. Curtis, M.D.

The emergency treatment of the acutely injured hand may determine whether the hand will regain usable function or is doomed to permanent disability.

During the next year it can be estimated that one million patients will require primary surgical treatment for upper extremity injuries, about one-third of these will involve the hand. The need for special centers to treat the injured hand was first established during World War II with the organization of the Hand Centers under the direction of Doctor Sterling Bunnell.

Those disabled by hand injuries suffer real psychological disturbances as well as functional loss. It is with his hands that each man plays out his life role in relation to society, his family and his personal self. Only by providing the highest quality of emergency care of the injured hand can we reduce the high cost of this disability to the individual and to society. The aim of treatment should be to return the patient to his previous occupation if possible and to reduce the cost of his rehabilitation.

Basic Principles

The general public must be educated in the proper care of hand injuries and their prevention.

The paramedical personnel who first splint, apply dressings and transport the patient to the nearest hospital emergency room must have formal instruction in caring for the minor as well as the most severe extremity injuries.

Hospital

A procedure of management so formalized that it may be followed by the emergency room nurse, as well as the emergency room physician, should be available in the emergency department of every hospital. The following is suggested as an optimal routine.

INITIAL WOUND MANAGEMENT

The wound is covered with a small sterile gauze dressing, following which the injured extremity is shaved properly and cleansed thoroughly with soap and water. This cleansing must be done carefully so that none of the solution enters the wound. The wound is irrigated with copious quantities of normal saline solution, or preferably, a buffered electrolyte such as Ringers Lactate, since experimental work has demonstrated that normal saline solution alters wound pH. Following completion of irrigation, the wound is again covered with a sterile dressing; and the hand and forearm are prepared with an antiseptic solution and placed on a sterile arm board for examination.

ASSESSMENT OF THE INJURY

Evaluation of total hand function is imperative. The examination must include a careful evaluation of flexor and extensor tendon function, an appraisal of sensation, an assessment of all the small muscle functions of the hand and a roentgenogram if bone injury is suspected.

DEFINITIVE TREATMENT

Suturing of hand lacerations in the accident room is permissible only if the examiner can be certain that there has been no tendon or nerve damage. The repair of injury to deep structures demands the following conditions: a well equipped operating room, adequate hand instruments, a sufficient number of assistants, complete anesthesia, a realization of the importance of the procedure, a bloodless operating field provided by a pneumatic tourniquet, and meticulous atraumatic surgical technique.

Recent advances in microsurgery make it possible to repair blood vessels as small as 1 to 2 mm. This makes it possible to restore the circulation to severely damaged hands and fingers which would previously have been useless due to inadequate circulation. It has made it possible to replant the amputated hand, thumb, or fingers. This meticulous surgery necessitates the establishment of replantation teams composed of surgeons, nurses and technicians trained in these new procedures. Time is an important factor in the success of such surgery, and for the future it calls for the development of regional referal centers in various parts of the United States to which such patients can be transported quickly. If much distance is involved, this would best be by helicopter or other type of air transport.

The Union Memorial Hospital Center was established in 1975 as a speciality referal center for the Maryland Emergency Medical Service and the Maryland Institute for Emergency Medicine. Its staff of specialists is capable of replanting severed and partially severed extremities and digits and reestablishing circulation to injured extremities. In addition to its acute trauma unit, the center operates a Microsurgical Laboratory and a special facility used by therapists for returning the injured extremity to useful function. The center is serviced by the Maryland State police Med-Evac helicopters.

It has developed a protocol which is to be used by the emergency room physician for the care of the amputated or partially amputated part.

Future Planning

Our future planning should include a standardized method of evaluating and reporting the end results of treatment of these injuries by a cooperative study among the centers so as to allow for a yearly review of end results. This will make it possible to improve the end results and to standardize the indications and contraindications for treatment, particularly in the care of replantation.

We must work toward reducing the numbers of these injuries by teaching prevention to both the individual and industry.

Organizations, such as the American Society for Surgery of the Hand, have developed programs of continuing education for physicians and allied health personnel. We must encourage these societies to expand their educational activities in this special area of trauma.

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EMERGENCY CARE OF THE SEVERELY INJURED HAND

E. F. Shaw Wilgis, M.D.

The purpose of this paper is to define the immediate emergency and operative treatment program for the crushed or partially amputated hand or digit which is ischemic.

The circulation of blood and tissue perfusion is essential for tissue survival. Intrinsic cellular damage from ischemia can be prevented or minimized by active, early management in these cases. In the crushed hand we shall illustrate how to prevent and treat ishcemia. In the partially amputated hand or digit we will illustrate methods to minimize ischemic changes and restore circulation to the damaged part.

When dealing with the crush injury, the single most important element to treat is edema or swelling. Edema is an inevitable product of the traumatic incident. Untreated, it causes increased pressure in closed fascial spaces thereby causing further circulatory embarrassment on the local cells.

The crush injury should be evaluated in the emergency department by close observation and radiography. This crushed hand should be immediately elevated and the wrist and hand splinted in neutral position.

Operative management is indicated when there are signs of circulatory embarrassment or open fractures and soft tissue injury. Intercompartmental tissue pressure can be used as a measurement of impending trouble. This method, devised by Whitesides, employs a single pressure monitoring system attached to a needle in the suspicious muscle compartment. A rising pressure or a tissue pressure approaching 40 mm Hg is an indication for decompressive fasciotomy. Fasciotomy should be employed in the crush injury early.

After the operative treatment of the underlying structures, skin closure can and should be delayed until the major edema has subsided. This may take five to eight days. Then secondary clsoure of skin grafting can be done.

In short, early and close observation, fasciotomy if needed, and delayed skin closure will enhance the recovery of the crushed hand.

The partially amputated hand or digit which is without circulation can be salvaged and restored to functional use. Again the immediate treatment is essential to its survival. In the partial amputation primary vascular repair in a facility with surgeons experienced in microvascular techniques must be done to ensure survival. A digit with a low flow status and circulatory embarrassment is doomed to thrombosis and eventual gangrene without microvascular repair.

This, then, may necessitate transfer to a Hand Treatment Center. Prior to transfer and during transport, the following procedures are recommended:

1) The wound should be flushed with lactated Ringers solution. Do not scrub or apply antiseptic solution to the wound. Apply dry sterile dressing, wrap in kling or kerlix for pressure and elevate.

2) After placing the severed part(s) in a functional position, apply dry sterile dressing, splint and elevate. Apply coolant bags to the outside of the dressing. If possible, control bleeding with pressure. If a tourniquet is necessary, place close to the amputated site.

Cooling the area of the injury and the partially amputated part is the most important element in treatment and preparing a patient for transport. Hypothemia prolongs the "safe" ischemia time and minimizes cellular damage.

The coolant bags are commercially available first aid devices as "instant ice" Placed outside the dressing, they provide the proper hypothemic environment.

Upon arrival at the Hand Treatment Center, the patient is evaluated and prepared for surgery. At surgery, after thorough irrigation and debridement, the usual order of repair is as follows:

1) The bone is stabilized by internal fixation.
2) The extensor and flexor tendons are repaired.
3) The microarterial repair is done and flow monitored.
4) The nerves are then joined.
5) Microvenous repair is then accomplished.
6) The wounds are closed loosely or skin grafted. As edema is inevitable, delayed skin closure is employed.
7) Aspirin, 5 gr. suppositories are given to prevent platelet agglutination. Heparin is rarely used systemically.

With proper immediate treatment, cooling and transfer to a facility with microvascular capabilities, one should expect to restore 80 percent of these partially amputated parts to useful use.

EMERGENCY ROOM ASSESSMENT AND CARE OF THE INJURED HAND

Gaylord Lee Clark, M.D.

The goal of caring for hand injuries is to restore to the hand as near normal function as possible, and to do this, an accurate diagnosis is imperative. The observation that the responsible physician or surgeon must have a live patient to treat may seem trite. However, one must recognize that life threatening emergency conditions must take precidence over the care of a hand injury.

The normal hand, when relaxed, assumes a characteristic posture than can easily be observed by allowing your own hand to lie on your lap in front of you. There is an increasing increment of flexion from the index finger to the little finger with the latter assuming the most flexed position and the former the least flexed. The thumb positions itself slightly anterior to the palm with its pulp barely touching the distal interphalangeal joint flexor crease of the index finger. The thumb nail lies at 90 degrees to the transverse plane of the index fingernail. This posture is so constant that any changes in the hand structure will upset the balance and focus the examiners attention to it.

The key to arriving at an accurate diagnosis is to carefully observe the hand. It must be free of all dressings and splints to do this. The examiner looks for: postural changes, skin injuries, skeletal deformities, skin color abnormalities, swelling of tissues, and temperature differences. It cannot be overemphasized that the initial care rendered the injured hand sets the stage for the end result. In the initial assessment *think logically; don't panic.*

The history of the injury must be known. When did it happen? Where did it happen? How did it happen? What treatment has already been rendered? Reflecting on each of these questions, their individual importance is quickly realized. It must also be known what, if any, other ailments the patient has that may affect his care, for instance, cardiopulmonary disease, renal disease, allergies, diabetes, seizures, alcoholism, etc.

The general direction of caring for the injured hand should be aimed at the prevention of infection, the restoration of skeletal alignment, the reestablishment of muscle and tendon continuity, the repair of nerves and blood vessels, and the provision of skin coverage.

Formulation of a plan for examination of the hand is paramount so nothing is overlooked. As mentioned before the entire hand and arm must be free of all dressings. The surgeon then examines the skin, tests for nerve continuity, tendon function, blood vessel patency and skeletal integrity. This may require the use of x-ray, radioisotope scanning, the Doppler flow meter and arteriogram, but these sophisticated modalities should only be used to confirm a diagnosis made on clinical grounds by careful examination and observation.

Nerve continuity is tested for by observing muscle action, quality of sensation and skin moisture. With musculotendonous integrity but a loss of muscle contactility, a nerve injury should be suspected. Loss of sensibility of the skin to touch, pain, or temperature sense will have the same meaning. Dryness of the skin in an area of special nerve distribution is evidence of damage to that particular nerve.

Examining for tendon continuity is performed by testing for each individual tendon where suspicion of injury exists. This requires a knowledge of the forearm and hand anatomy. The flexor tendons include the wrist flexors, the sublimus and profundus finger flexors and the flexor pollicis longus. The extensor group include the wrist extensors, the extensor pollicis longus, the extensor digitorum communis and the index and little finger proprius tendons. The intrinsic muscle contribution to finger flexion and extension cannot be overlooked.

The vascular tree is evaluated by skin color and temperature changes, by the color of the blood coming from a wound and its pressure, by the amount of distention of the soft tissues and by pain. More sophisticated methods of vascular assessment have already been mentioned. The alternate manual occlusion of the radial and ulnar arteries at the wrist (the Allen Test) is extremely useful in determining the patency of these arteries.

Skeletal injury is most reliably diagnosed by x-rays. It is imperative to obtain true A P and true lateral views of the areas of suspected injury, otherwise misdiagnosis is possible due to overlying skeletal shadows.

Frequently serious injuries may seem trivial on initial evaluation. The most common of these are injection injuries with grease, oil, paint and tear gas. These accidents are known to cause loss of fingers and long term disabilities. Lacerations with glass also falls into this category and can give partial injuries to nerves and tendons which will have late consequences that are difficult to repair.

Finally, the care of the amputated part: Control bleeding at the stump level with local pressure or a tourniquet as close to the wound as practical. Rinse the wound with physiologic solution then bandage. At the same time the amputated part should be placed in a clean plastic bag, then in a container. The container is then placed in an ice bath. Do not immerse the amputated part in ice without this protection.

In the situation of a partial amputation, the hand or digit should be bandaged with sterile gauze, splinted, and ice or coolant packs placed over it until definitive care can be rendered.

Accurate diagnosis, appropriate initial care, and precise definitive management will give the patient the best chance to reach the goal of restoration of nearly normal function to the injured hand.

MANAGEMENT OF ACUTE UPPER EXTREMITY THERMAL AND ELECTRICAL INJURIES

John A. Boswick, Jr., M.D.

Care of the upper extremity injured by electrical or thermal energy differs considerably from other types of injuries. An injury due to low voltage, electrical energy may vary from superficial or small punctate lesions to a diffuse tissue injury, usually of low magnitude. In the case of high voltage injuries where the current traverses all or most tissues, the injury is usually deceptive, as to the extent and depth, for several days after the accident. The delay in being able to recognize the magnitude of these injuries is usually due to progressive thrombosis of small vessels.

Cold injuries of the upper extremity are usually peripheral injuries. The majority are superficial in depth and heal without complication. When the exposure is long and the ambient temperature low, full thickness injuries may occur. In full thickness injuries, the separation of deviatalized from viable tissue is slow. Minimal daily debridement and late amputations are recommended to prevent the sacrifice of tissue that might survive.

The factors that determine the care of the burned upper extremity are numerous. They include the extent and depth of the injury to the extremity, associated injuries (especially other burns), age, and ability or desire of the patient to cooperate, as well as the location of the injury. Depending on these factors, it might be preferable to excise the necrotic tissue early or to allow it to separate slowly with spontaneous healing of the partially damaged tissue. Whatever method is chosen for treating the injured tissue, rehabilitative efforts should start the day of the injury. They should include active and passive exercises, splinting and hydrotherapy.

Renal Failure — Prevention, Recognition and Therapy

ACUTE POST TRAUMATIC RENAL INSUFFICIENCY: OVERALL PROGRESS AND PRESENT STATUS OF THE PROBLEM

John M. Howard, M.D.

The U. S. Army Surgical Research Team in Korea (1951 to 1953) demonstrated the feasibility of establishing an acute renal failure center and of transporting patients to such a center in the early hours after injury. This group achieved multidisciplinary care of these enormously complicated clinical problems. A dialysis center was established in an evacuation hospital, and all United Nations troops with acute renal failure were flown to the center by helicopter. Although excellent care was made possible under these difficult circumstances, the residual mortality remained in excess of 50 percent. A review of 61 consecutive patients treated in this center revealed the primary site of injury to involve the abdomen in the great majority of instances (Table 1). The prognosis was at its worst when the liver of kidney were injured. Seldom was the chest or head the site of major injury. A review of the background of these injuries revealed that the patient had received an average of 5.9 liters of blood (Table 2) but 41 other patients without acute renal failure had received an average of 12 liters. In these previously healthy young men, the average daily accumulation of non-protein nitrogen in the plasma was 50 mg%. In the same patients, the avareage daily plasma potassium increment was 0.7 mEq (Table 3).

The complications, in addition to acute renal failure, were frequent and sometimes fatal. These complications centered around the problems of infection, hemorrhage and wound healing. Special studies were undertaken to identify any defect in the resistance to infection, coagulation, or wound healing that were specific to the patient with acute renal failure. Although numerous abnormalities occurred in various patients, none of the defects appeared to be characteristic of the renal patient. Instead, they appeared to be the result of compromises made in the early care of the critically injured.

In an effort to identify the histologic defect in acute renal failure, a double blind study was undertaken in which the pathologists studied (by light microscopy) the kidneys from the patients dying of acute renal failure versus the kidneys from individuals killed in action. After several months of study, they concluded that they were unable to identify the kidney of one group from the kidney of the other group.

In an effort to define the physiological changes in renal function associated with severe injury, studies were undertaken of the battle casualties who did not develop oliguria. A study of the massively injured patients who did not develop oliguria revealed that 14 percent developed clinical evidence of acute renal failure and uremia, in spite of maintaining a urine output above 500 ml per day. Studying the relationship between glomerular filtration and renal blood flow in the patient immediately after resuscitation, Ladd revealed that the filtration fraction was depressed at low blood flows and rose as clearance increased. The investigator suggested that under conditions of relative renal ischemia, efferent arteriolar constriction (post-glomerular) occurred (Figure 1). During the phase of resuscitation, it was found that urine flow varied

TABLE 1: Acute Renal Failure — Oliguria

Korean War: 61 Patients	50%
Site of Major Wounds	26%
Abdomen	21%
Thoracoabdominal	23%
Liver	0
Kidney	0
Chest only	6%
Head only	-
Crush	
Other extremities	

TABLE 2: Blood & Expanders Transfused

61 Patients — Oliguria
Average 5.9 liters
Range 0.5 - 15.5 liters
(41 other non-oliguric patients received
an average of 12 liters)

TABLE 3: Acute Post-Traumatic Renal Insufficiency — Korea

Average accumulation of NPN in plasma
was 50 mg%/Day
Plasma K increment 0.7 mEq/L/Day

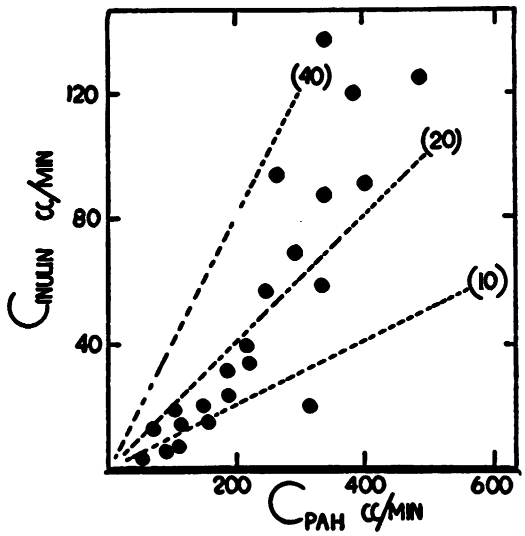

FIGURE 1: Relationship between C_{IN} and C_{PAH} during "shock." Filtration rate of inulin (C_{IN} in cc./min.) is plotted on the vertical scale against effective renal plasma flow (C_{PAH} in cc./min.). Each point represents one collection period obtained preoperatively, during the resuscitation of six casualties. In this and succeeding figures, clearance values are plotted on arithmetical scales. Diagonal dotted lines represent filtration fractions of 40, 20 and 10, respectively. The filtration fraction was depressed at low values for C_{PAH}, and rose as clearance values increased. This suggests reestablishment of glomerular filtration, under conditions of relative renal ischemia by efferent arteriolar constriction.

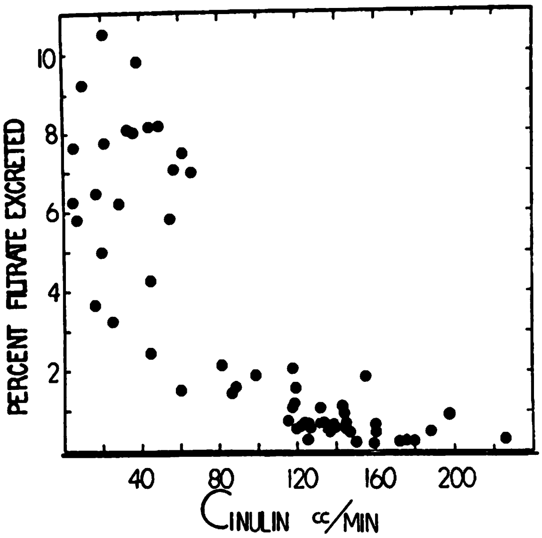

FIGURE 3: Urine flow and filtration rate during convalescence. Daily urine output is expressed on the vertical scale as percent of the prevailing filtration rate (C_{IN} in cc./min.). Unlike the pattern seen early after injury, tubular water reabsorption was depressed in casualties showing low filtration rates. Azotemia, consequent to increased catabolism, or decreased filtration, or both, presumably accounts for the osmotic diuresis approaching 10 percent of the filtration rate in nonoliguric post traumatic renal insufficiency.

directly with glomerular filtration, a relative increase in tubular reabsorption occurring at low values of inulin clearance (Figure 2). During convalescence in patients who developed azotemia without oliguria, it was found that urine flow approached 10 percent of glomerular filtration (Figure 3).

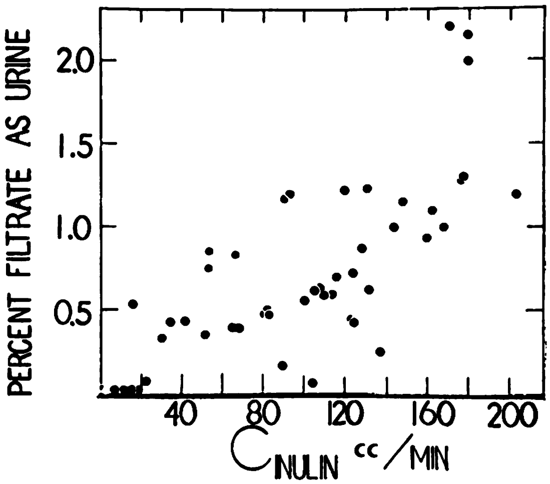

FIGURE 2: Urine flow and filtration rate during resuscitation. Urine flow (vertical scale), expressed as percent of the filtration rate, is related to the filtration rate itself (C_{IN} in cc/min). Each point represents one collection period, from one of six casualties examined during the interval between admission and reaction from anesthesia. During this phase, urine flow varied directly with glomerular filtration, a relative increase in tubular reabsorption occurring at low values for C_{IN}.

TABLE 4: Mortality Rates

Acute Traumatic Renal Insufficiency

World War II	91% oliguria 80-90%
Korea 1951	68% oliguria
1952	30% non-oliguria
Vietnam	63%

Reviewing the experiences of the U. S. military forces (Table 4), it is seen that little progress has been made in our understanding or care of these patients in the past 50 years. With the increasing magnitude of operative surgery and the steadily improving prehospital care of the civilian injured in this country, acute renal failure now probably ranks second only to acute head injuries as the major cause of delayed death after injury or operation.

Acute renal failure is a problem which should yield to targeted research at the present time.

Suggested Readings

Renal Sequelae of War Wounds in Man: Battle Casualties in Korea: Studies of the Surgical Research Team, Vol. 4, *Post-Traumatic Renal Insufficiency*. John M. Howard, M.D. and William H. Meroney, eds. Army Medical Service Graduate School, Walter Reed Army Medical Center, Washington, D.C., 1954.

Michael Ladd. Renal Sequelae of War Wounds in Man. Ibid.

ACUTE RENAL FAILURE: CORRELATION OF STRUCTURAL AND FUNCTIONAL ALTERATIONS

Elizabeth M. McDowell, Ph.D. and Walter Flamenbaum, M.D.

Introduction

The mechanism responsible for the pathogenesis of acute renal failure continues to be the subject of controversy. The maintained high morbidity and mortality of patients with acute renal failure, despite numerous clinical advances in its treatment as well as renewed scientific interest in its pathogenesis, suggests that a detailed knowledge of the responsible pathophysiologic mechanisms will be required before significant progress in the prevention and/or treatment of acute renal failure will be forthcoming. The controversy appears to have persisted, even though sophisticated investigative techniques are available, both because of the lack of a single experimental model or a single pathophysiologic mechanism accounting for the abnormal renal function and due to the lack of significant correlation of alterations in renal structure and function.

The approach we have utilized to study the pathophysiologic basis for acute renal failure has been to choose experimental models which approximate the functional abnormalities observed in clinical acute renal failure induced by $HgCl_2$ or uranyl nitrate. Based on our structural and physiologic investigations of heavy metal induced acute renal failure we propose that tubular epithelial dysfunction in nephron segments proximal to the macula densa results in activation of tubuloglomerular feedback, which, in turn, results in altered renal hemodynamics and diminished glomerular filtration rate (GFR).

Approach to the Problem

Acute renal failure has frequently been termed "acute tubular necrosis," a histopathologic diagnosis, because of the observation of epithelial necrosis in some biopsy or post-mortem samples of renal tissue. The imprecise correlation of structural and functional alterations in acute renal failure is well appreciated, and may result from a variety of factors. To limit differences due to duration of and severity of acute renal failure, experimental models resulting in a comparable and predictable degree of renal insufficiency were studied.

PHYSIOLOGIC STUDIES

The schema proposed to account for the pathophysiologic basis of acute renal failure is depicted in Figure 1. According to this proposed schema the following events would be predicted to occur and should be demonstrable: (1) the initial event is an alteration in tubule epithelial membrane function, characterized by decreased fluid and electrolyte absorption, as a direct effect of the heavy metals; this altered membrane function should correlate with ultrastructural and/or histochemical changes in proximal nephron segments; (2) as a result of this change in fluid absorption the composition of tubule fluid delivered to the macula densa is altered, as manifested by increased tubular fluid sodium concentration (or some associated change in electrolyte composition); (3) this altered tubule fluid composition is sensed by the macula densa resulting in increased renin-angiotensin system activity in the juxtaglomerular apparatus (JGA); (4) the increased angiotensin generation results in altered renal hemodynamics (increased afferent arteriolar tone), most marked in the outer cortex, and decreased renal and glomerular blood flow, resulting in diminished GFR in nephrons (SNGFR); and, (5) the negative feedback loop fails to operate and turn off this mechanism of tubuloglomerular feedback because of the persistent effect of heavy metals on membrane function. The physiologic approach to verifying the operation of the various components of this system has been accomplished using micropuncture, and other microtechniques. Although evidence is available detailing the pathophysiology of both $HgCl_2$ and uranyl nitrate induced acute renal failure the data to be presented are limited to the latter model. The model chosen was uranyl nitrate induced acute renal failure (10 mg/kg body wt, sc) and the experimental animal was the Sprague-Dawley rat, since more direct evidence concerning activation of the renin-angiotensin system is available from these studies.

The indications of abnormalities in fluid and electrolyte absorption in acute renal failure have been suggested by the numerous reports of increased urine sodium concentration and the diminished urine to plasma concentration ratios for osmolality, urea and creatinine. An initial site localization for this alteration was demonstrated during a micropuncture study six hours after uranyl nitrate induced acute renal failure (Figure 2). The significant decrease in absolute fluid absorption between sites of micropuncture in proximal and distal nephron tubules suggested that the most marked changes occurred in the late proximal tubule, including the pars recta, or loop of Henle. To further define this alteration additional studies of sodium excretion and distal tubule sodium concentration were obtained. As indicated in Figure 3, fractional sodium excretion increased from a control value of 0.7 ± 0.04

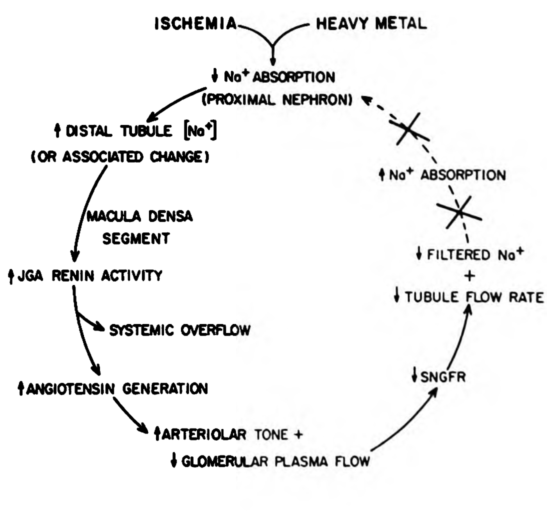

FIGURE 1: Schema depicting the initiation of acute renal failure.

The work described in this report was performed in association with Drs. B. Trump, R. Nagle, R. Hamburger, J. Kaufman and with Mr. R. Zalme and Mr. J. McNeil.

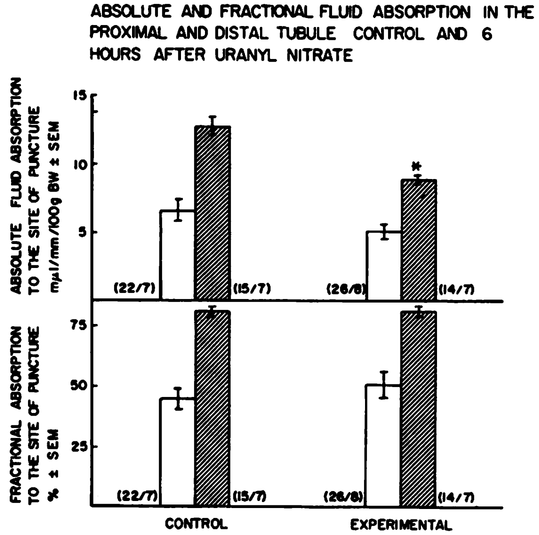

FIGURE 2: Alterations in fluid absorption after uranyl nitrate. Clear bars = proximal tubule; shaded bars = distal tubule. The numbers in parenthesis refer to the number of tubules studies over the number of animals studies. (= P < 0.05).*

(SEM) % to 1.8±0.09% and distal tubule sodium concentration rose from 53.7±1.2 mEg/l to 116.9±2.5 mEg/l six hours after uranyl nitrate. There was also an increase in the calculated distal delivered load of sodium delivered to the distal tubule.

During this same time interval, up to six hours after uranyl nitrate, marked increases in plasma and renal renin-angiotensin system activities were also observed in separate groups of rats (Figure 4). Plasma renin activity, determined by the radioimmunoassay of generated angiotensin I, increased from 1.5±0.3 ng/ml/hr to 2.9 ng/ml/hr. JGA renin activity, determined by the bioassay of generated angiotensin II in superficial (S) or deep (D) JGA's also increased markedly.

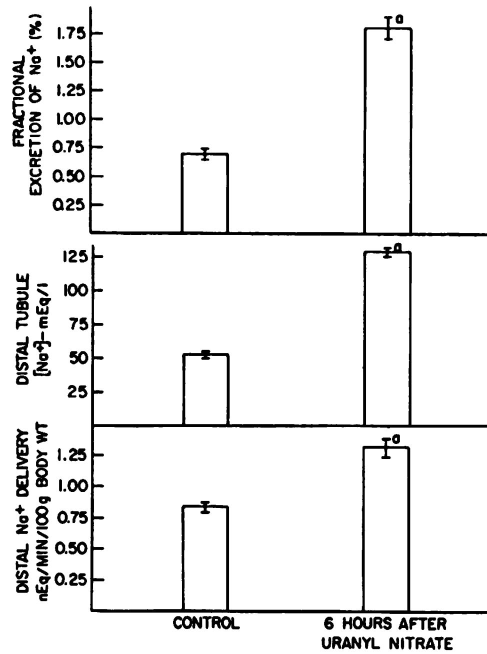

FIGURE 3: Alteration in sodium handling in uranyl nitrate induced acute renal failure. (a = P < 0.05, versus control).

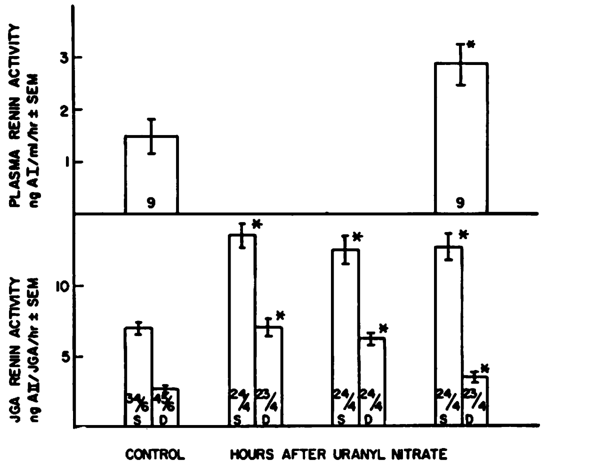

FIGURE 4: Activation of the renin angiotensin system in uranyl nitrate induced acute renal failure. The numbers within the bars refer to the number of animals studied or the number of JGA's over the number of rats studied. S = superficial, D = deep JGA's. (P = < 0.05, versus control.)*

In temporal association with these changes, there were parallel alterations in GFR (Figure 5). Whole kidney GFR fell from a mean control value of 1.07±0.06 ml/min/100g body wt to 0.62±0.18 ml/min/100g body wt. Single nephron GFR as measured in superficial distal segments, declined from a control value of 15.85±0.29 nl/min/100g body wt to 10.13±0.51 nl/min/100g body wt. Similar alterations were observed in a previous study in which, using radioxenon washout analyses and silicone rubber casts of the renovascular tree, marked decreases in outer cortical and total renal blood flow were demonstrated.

ULTRASTRUCTURAL/ HISTO-CHEMICAL STUDIES

The pathogenesis of acute renal failure is controversial and has been disputed for many years. In the 1950's and 1960's

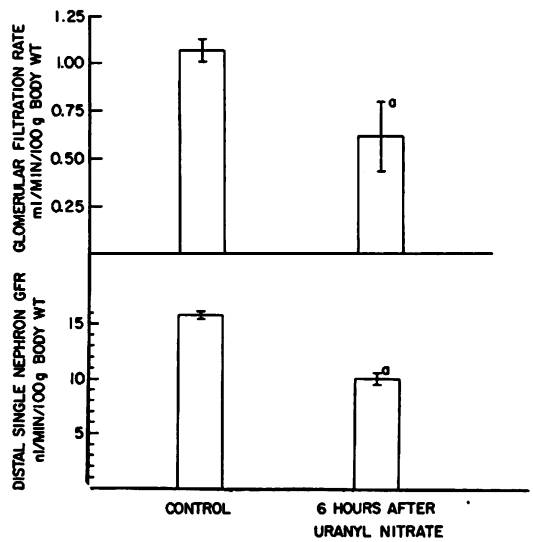

FIGURE 5: Alterations in whole kidney and single nephron GFR after uranyl nitrate injection.

the term "acute tubular necrosis" tended to be used synonymously with acute renal failure because tubular necrosis was seen in some of the fatal cases. However several investigators asserted that the functional changes of acute renal failure often existed in the absence of any demonstrable renal lesions detectable by light microscopy and, indeed, studies clearly showed that morphological changes were only occasionally pronounced in acute fatal cases. These observations suggested that the severe tubular lesions found in some patients with acute oliguric renal failure were not functionally related *per se* to the clinical syndrome. Thus, a striking paradox exists between the mild structural changes often noted and complete functional breakdown. It must be added that although renal failure may exist in the absence of demonstrable tubular pathology, patients with acute renal failure have, overall, a higher incidence of tubular necrosis than control groups. The correlation between structural and functional changes remains obscure.

In order to resolve this paradox it is necessary to study the initiation of acute renal failure using an experimental model. Rats injected with $HgCl_2$ provide a good experimental model for the study of acute renal failure. It has been shown the GFR decreases as early as 30 minutes after injection of $HgCl_2$. Fractional sodium excretion increases by 30 minutes after $HgCl_2$ and is maximally increased at 90 minutes after injection. It is well known that sublethal doses of $HgCl_2$ cause necrosis of pars recta of the proximal tubule (located in the outer stripe of the outer medulla) in kidneys of rats and mice within 24 hours, while pars convoluta tubules of the renal cortex remain viable. Ultrastructural studies of the renal effects of $HgCl_2$ toxicity have concentrated on the necrotic changes which occur in the pars recta tubules and little attention has been paid to subtle changes which may occur in cortical tubules. Emphasis has also been placed on the effects of $HgCl_2$ several hours to days after administration. Since reduction of GFR occurs early after $HgCl_2$ injection, very early changes are likely to be of great significance in the pathogenesis of acute renal failure.

Studies were undertaken to examine early structural, histochemical and functional changes which occur in the proximal tubules of rats poisoned with $HgCl_2$. A dose of $HgCl_2$ at 4 mg per kg body weight was chosen because this dose causes azotemia and necrosis of the pars recta and yet allows for 50 to 70 percent survival of the animals. Our experimental results show that early and similar subtle cellular alterations occur

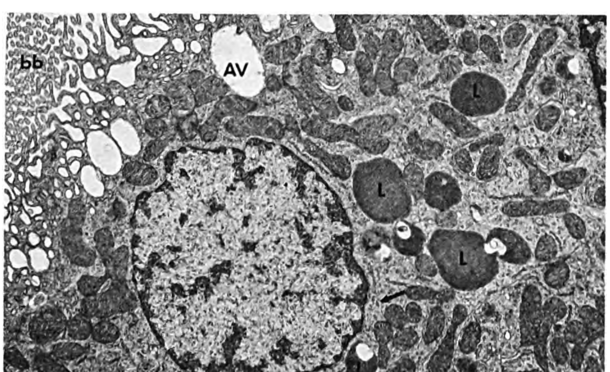

FIGURE 6: Ultrastructure of the proximal convoluted tubule in control rat. Note that cytoplasmic ribosomes are in polysome group (arrow). Abbreviations: bursh border (bb); apical vacuoles (AV); and, lysosomes (L).

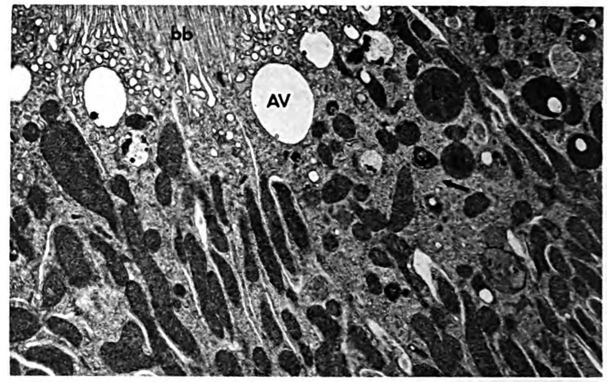

FIGURE 7: Ultrastructure of the proximal convoluted tubule 30 minutes after $HgCl_2$ injection. Cytoplasmic ribosomes are dispersed (arrow). No changes are noted in brush border (bb), apical vacuoles (AV) or lysosomes (L).

throughout the proximal tubule (i.e., in both pars convoluta and pars recta) but that in the pars convoluta these changes are reversible, while in the pars recta necrosis develops, beginning in the medullary rays. The dynamics of the development of the renal failure suggest that it precedes and is independent of the necrosis in pars recta, which develops relatively late.

Histochemical studies of $HgCl_2$ poisoning have previously concentrated on changes in activity of the enzyme succinic dehydrogenase. Often the doses of mercury used in earlier studies were very high and decreased enzyme activity was observed in morphologically changed, or even necrotic cells. The early stages of the interaction of mercury with the tubular epithelium were not examined. We chose to study the early effects of $HgCl_2$ on the ultrastructure of the proximal tubules and on soluble and bound exzymes known to be markers for various organelles and biochemical pathways.

Using routine light microscopical methods no changes were noted in the kidneys at three hours, and by six hours only relatively mild changes were observed in a few tubular segments located at the proximal end of the pars recta. Yet at this time acute renal failure had been initiated, as manifested by a significant azotemia, decreased GFR and increased fractional sodium and potassium excretion. Thus, this experimental model presents findings similar to the human clinical picture (*i.e.*, an apparent lack of structural and functional correlation). At 24 hours tubules of the entire pars recta were necrotic, yet the proximal convoluted tubules appeared as in controls.

Ultrastructural and histochemical analyses of the proximal tubules provided greater insight into the problem. The appearance of control proximal tubules is shown in Figure 6. As early as 30 minutes after injection of $HgCl_2$ cytoplasmic ribosomes were dispersed (Figure 7) and some mitochondria showed condensation of their matrices. Rarefaction of the cytoplasm was also observed in a few cells. It is probable that ionic imbalance occurs early in $HgCl_2$ induced acute renal failure and affects all segments of the proximal tubule. The brush border enzymes alkaline phosphatase (Figures 8, 9) and 5'-nucleotidase were severely inhibited at this early time interval. We propose that a decrease in the access of $Na+$ and $K+$ to the active transport site occurs as the direct result of binding of mercury to the cell membrane.

No morphological changes were noted in the microvilli of the brush border between one and three hours but evidence of increased endocytosis was observed and numerous

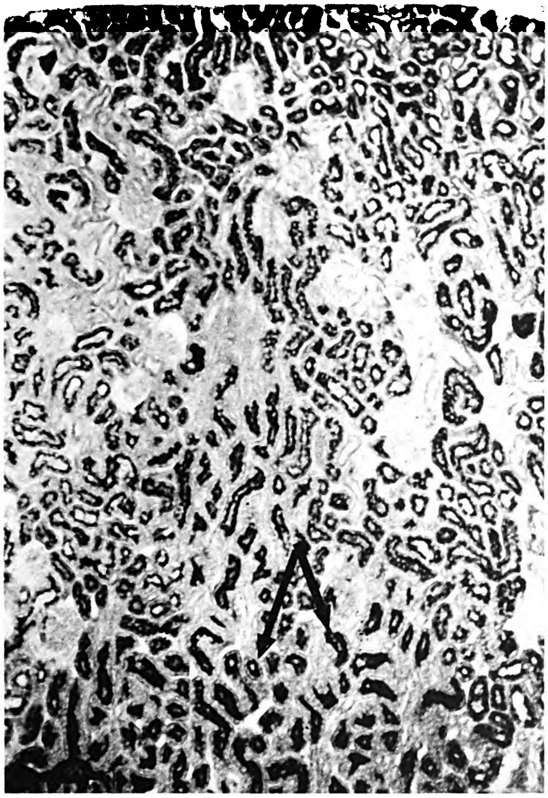

FIGURE 8: Alkaline phosphatase activity in control. The brush border of the pars recta (arrows) is more heavily stained than that of in cortical proximal tubules.

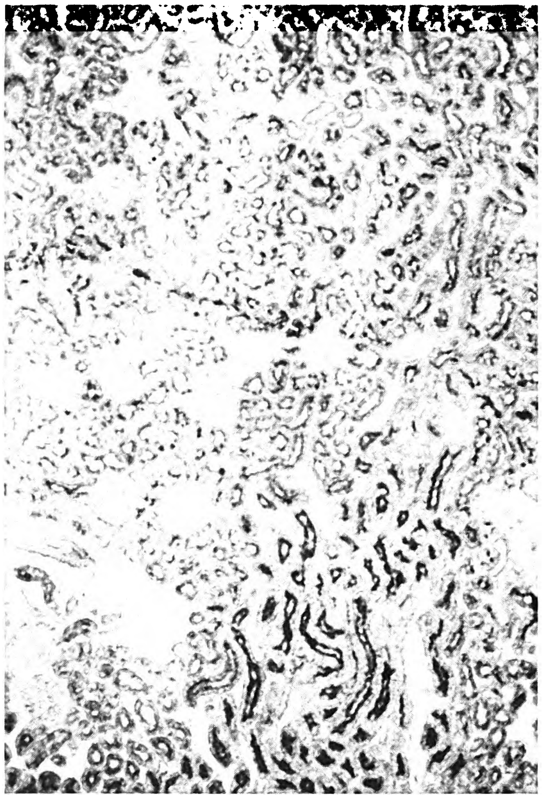

FIGURE 9: Alkaline phosphate activity 15 minutes after injection of $HgCl_2$. Enzyme activity is reduced especially in the cortical proximal tubules.

dense bodies accumulated, especially in the apices of the convoluted tubules. Cytophasmic ribosomes remained dispersed.

The changes in brush border enzyme activity were biphasic. Alkaline phosphatase and 5'-nucleotidase activity fell between 15 and 30 minutes but rose again by one hour to attain control values by three hours. We assume that mercury initially binds to enzymes in the brush border membrane, inhibiting enzyme activity and that the membrane together with bound mercury, is internalized by endocytotic activity. By one hour all membrane could be internalized. Within 30 minutes and at one hour, lysosomal acid phosphatase activity was inhibited, yet no morphological changes were seen in lysosomes. It is probably that apical vacuoles, with mercury bound to the inner aspect of their membranes, had fused with lysosomal membranes and that mercury, now bound to the inside of the lysosomal membrane, accounted for enzymic inihibition (since mercury is known to inhibit acid phosphatase activity).

At three hours, the activity of alkaline and acid phosphatases and 5'-nucleotidase had returned to control levels, suggesting that enzyme was available from a preformed pool, or had been newly synthesized and incorporated into the membranes of the microvilli. Mitochondrial matrix condensation was observed in some cells at 3 hours, as at earlier time intervals. The first changes in mitochondrial enzymes were noted at this time. Thus, the activity of malic dehydrogenase, a soluble enzyme of the mitochondrial matrix, had fallen in the proximal tubule and the activity of α-glycerophosphate dehydrogenase, an integral part of the inner mitochondrial membrane and an enzyme peculiar to the pars recta, was also lowered. These changes preceded any obvious mitochondrial swelling.

By six hours, at a time when acute renal failure was fully established, a widespread fall in enzyme activity of the brush border and lysosomes was noted throughout the proximal tubule, yet ultrastructural changes were not apparent in the microvilli of most of the proximal tubule, except for focal loss from some cells located proximally in the pars recta segment. Severe mitochondrial changes were also seen in cells of this segment. The mitochondria were rounded and swollen, and smudgy densities were seen in the cytoplasm. However, at this time severe morphological changes were not apparent elsewhere in the proximal tubule, yet the activities of the mitochondrial enzymes malic and succinic dehydrogenase were markedly decreased in all tubular segments, as were the activities of lactic and glucose-6-phosphate dehydrogenase, enzymes of the cytoplasm, and glucose-6-phosphatase, an integral part of the rough endoplasmic reticulum.

After 24 hours the entire pars recta was necrotic (Figure 10), accounting for low enzyme activity in this segment. However, in the proximal convoluted tubules microvilli were retained, pinocytotic activity appeared normal, polysome groups had returned, endoplasmic reticulum appeared normal and lysosomes were large and numerous. Yet, compared with control (Figure 11A) the enzyme activities of brush border, mitochondria, cytoplasm, endoplasmic reticulum and lysosomes were very low or even absent in the cortical tubules (Figure 11B). These observations indicate that destruction of cells and organelles does not account for reduced cortical enzyme activity and another mechanism must be responsible.

Synthesis

A dose of $HgCl_2$ which results in reproducible renal failure and necrosis involving the pars recta of every nephron, raises the question of the relationship between the two phenomena.

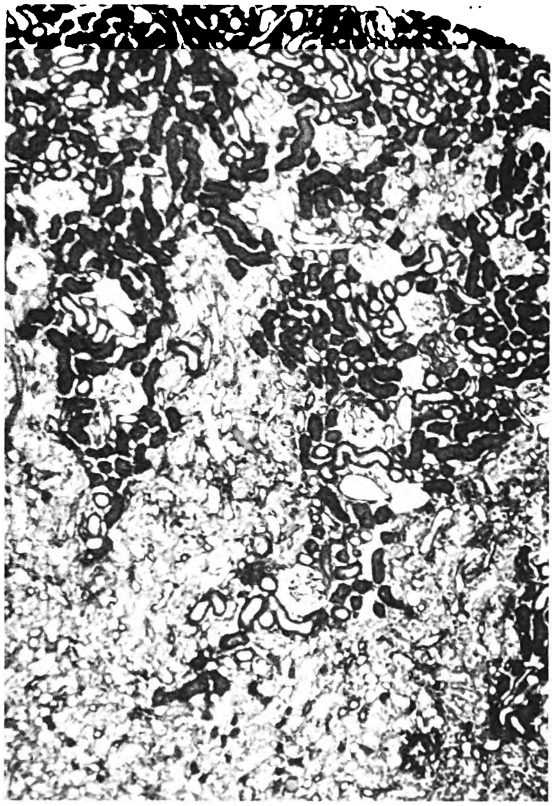

FIGURE 10: Cortex and outer stripe of outer medulla 24 hours after injection of $HgCl_2$. All pars recta tubules are necrotic, whereas cortical tubules appear as in controls. (Hematoxylin and eosin stain.)

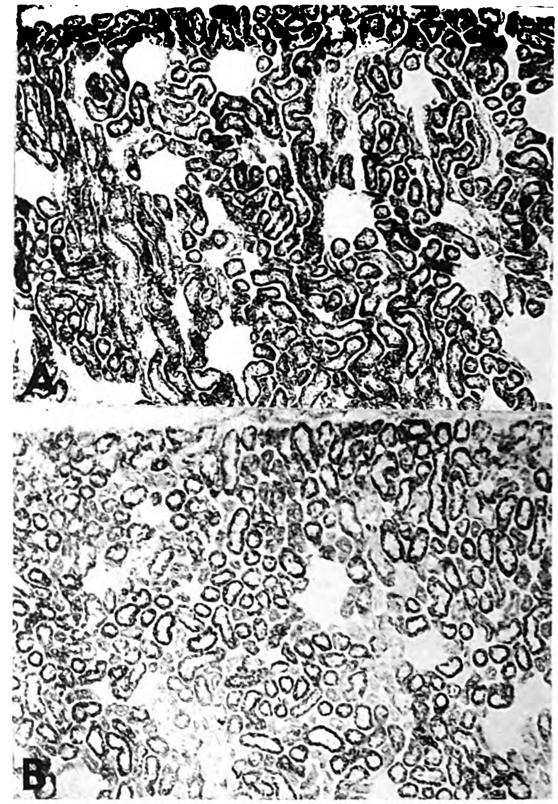

FIGURE 11: A. Succinic dehydrogenase activity demonstrated in the cortex of a control rat. B. Succinic dehydrogenase activity is greatly reduced in the cortex, 24 hours after $HgCl_2$ injection although morphologically the cortical tubules show no change (compare with Figure 10).

As stated earlier there are many reports pointing to a disparity and lack of correlation between necrosis and renal failure. Indeed, such was the case in the present study where tubular necrosis did not begin until after six hours, while acute renal failure was initiated much earlier. This can be explained by the following hypothesis. Mercury initially interacts with the entire proximal tubule and, although the injury is sublethal in the pars convoluta, it is responsible for greatly diminished sodium reabsorption and is related to the pathogenesis of the renal failure through feedback mechanisms involving the macula densa and release of renin (Figure 1). This results in renal hemodynamic alterations, decreased GFR and other functional disturbances associated with renal failure such as a diminution in urine osmolality. Although the immediate heavy metal-plasma membrane interaction may be overcome, the simultaneous intracellular accumulation of mercury in the pars recta leads to necrosis of that region. This occurs even as recovery from the event which initiates acute renal failure (in this case heavy metal-membrane interaction) is beginning.

Correlation of structure and function also appears to be possible in another important link in the hypothesis, namely that involving the JGA. This series of structures, believed to be critical in glomerular tubular balance, shows marked alterations in acute renal failure that can be correlated with changes in intrarenal renin content. Morphologically the initiation of acute renal failure is heralded by a dramatic increase in the number of granules, each of which is thought to contain renin. This response, overlooked in recent years, was forecast by Goormaghtigh in a pioneering series of studies on acute renal failure in human patients.

Further studies will obviously be needed but these experiments appear to shed much light on the structure-function relationships in acute renal failure and begin to explain the common disparity between renal failure and severity of tubular damage in humans.

Heavy metal induced alterations in renal function provide additional supportive evidence for this hypothesis concerning the initiation of acute renal failure. The increased distal tubular [Na+], increased renin-angiotensin system activity and diminished GFR and SNGFR after uranyl nitrate may be casually unrelated phenomena. The increased distal tubular [Na+] and decreased absolute fluid absorption up to the site of distal micropuncture (control = 12.55 ± 0.27 nl/min/100 g body wt; experimental = 8.32 ± 0.34 nl/min/100 g body wt) may be considered a direct effect of uranyl nitrate on tubule epithelium. The increase in [Na+] after uranyl nitrate occurred in association with a decrease in SNGFR. That uranyl nitrate may directly alter active sodium transport is evident from the marked decrease in net sodium transport, and parallel decreases in both active chloride transport and short-circuited current, which occurred when either uranyl nitrate or $HgCl_2$ solutions were added to the mucosal surface of the freshwater turtle bladder. Although the exact site of distal micropuncture was not determined, the selection of the earliest accessible distal segment for micropuncture in the present studies and the magnitude of the increase segment for micropuncture in the present studies and the magnitude of the increase in distal tubular [Na+] after uranyl nitrate is not consistent with a systematic selection of sites for micropuncture of distal tubules having a greater sodium concentration in rats receiving uranyl nitrate. Since the site of the macula densa in the early distal tubule is inaccessible to direct micropuncture, and the superficial distal tubule is anatomically close to this area, the observed [Na+] are considered representative of the [Na+] within the macula densa segment.

Increased renin-angiotensin system activity has been observed in both clinical and experimental acute renal failure. An increase in urine flow rate after uranyl nitrate has also been observed, and raises the possibility that volume depletion resulting from this relative diuresis may have resulted in increased JGA renin activity. Were the differences in urine volume to have persisted for seven hours, the maximum time interval of study after the administration of uranyl nitrate, the greatest predicted volume loss would have been less than one percent of body weight. In addition, the lack of markedly disparate body weights or increases in packed cell volume also mitigates against significant volume depletion.

Increases in distal tubule [Na+] of the magnitude observed in the present study have been demonstrated to result in similar increases in superficial JGA renin activity. That the macula densa may be spared heavy metal induced alterations in sodium transport is suggested by the refractoriness of this area to $HgCl_2$ and uranyl nitrate induced ultrastructural damage, suggesting that this area of the nephron may still be able to respond to heavy metal induced alterations in tubular fluid composition. A casual relationship between changes in renin-angiotensin system activity and alterations in glomerular filtration is more problematic. Heavy metal associated reductions in renal blood flow, mediated by a mechanism other than angiotensin generation, might be assumed to indirectly increase JGA renin activity and decrease SNGFR. The lack of a direct vasoconstrictor effect of uranyl nitrate, the marked protection against the development of acute renal failure afforded by renal renin depletion, and the effect of angiotensin on renal function and hemodynamics are consistent with a role for the renin-angiotensin system in the pathophysiology of acute renal failure.

The elements, on both a structure and a function basis, necessary to invoke tubuloglomerular feedback as a possible pathophysiologic mechanism responsible for the diminution in GFR after uranyl nitrate of $HgCl_2$ have been demonstrated. These observations suggest that increased activity of tubuloglomerular feedback as a result of heavy metal induced alterations in tubular function may be responsible for the renal hemodynamic abnormalities, decreased GFR and diminished SNGFR characteristic of the early, initiation phase of acute renal failure. The histologic results observed after $HgCl_2$ support a similar mechanism. Parallel increases in distal tubule [Na+] and decreases in GFR early after renal ischemia or hemorrhagic hypotension in the rat are findings consistent with this hypothesis. These observations do not preclude the participation of other pathophysiologic mechanisms at other times in the course of acute renal failure.

Diminished effective GFR, resulting in azotemia with or without oliguria, is the central renal function abnormality in clinical and experimental acute renal failure. The relative predominance of any single pathophysiologic mechanism may be related to the nature of the initiating event or its intensity. A more diffuse lesion is observed in nephrotoxic acute renal failure, while the changes after circulatory alterations may be spotty. The intensity of the initiating event may also telescope the development and course of acute renal failure resulting in a merging of the various phases. Regardless of these considerations, the net reduction in total kidney GFR is a reflection of the sum total of alterations in single nephron filtration rates. The changes in single nephron function are, characteristically, heterogeneous, and run the gamut from absent function to nearly normal function.

The results of our physiologic and ultrastructural/histochemical studies suggest that the "common denominator" in acute renal failure of diverse etiologies is an abnormality in tubular function characterized by alterations in the transport of sodium chloride and reabsorption of tubular fluid. This tubular dysfunction may result from either the effect of a nephrotoxin on the tubular epithelium or from circulatory alterations, with renal hypoperfusion. Regardless of the specific nature of the iniating event, the alterations in tubular fluid delivered to the distal nephron segments result in increased renin release from intrarenal sites, via stimulation of the macula densa. The subsequent local generation of angiotensin and glomerular arteriole vasomotion cause decreases in glomerular plasma flow and single nephron filtration rate. Thus, the mechanism of tubuloglomerular feedback interrelates changes in tubular function (which primarily depends on the integrity of actively metabolizing epithelial cells) to alterations in GFR (which primarily depends on the physical force contributed by the cardiovascular system), and may be considered the "final common pathway" in acute renal failure. The redistribution of intrarenal blood flow and diminished total blood flow, which is the "final common pathway" in acute renal failure, is a consequence of this physiologic response to tubular dysfunction. These changes are associated with subcellular and histochemical changes which precede the development of overt cell necrosis.

While tremendous strides have been made during the last 20 years in understanding the pathophysiology of acute renal failure, definitive modes of prevention or treatment are not yet available. Based on current research, efforts should be directed at defining and reversing the abnormalities responsible for tubular dysfunction, which is the "common denominator" in the pathophysiology of acute renal failure. Alternatively, therapy may be directed at abrogating tubuloglomerular feedback, which may be the "common mechanism" resulting in the pathophysiologic characteristics of acute renal failure. It is of more than passing interest that furosemide, an agent which blocks activation of tubuloglomerular feedback, has been reported to be of benefit in averting or ameliorating the course of acute renal failure. Whether this is a causal or casual set of events has yet to be determined.

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TRACK III
TRAUMA NURSING

SECTION I
Clinical Considerations

INITIAL ASSESSMENT OF TRAUMA

Carole A. Katsaros R.N., B.S.

Introduction

How do you utilize your skills of assessment for the multiple trauma patient who may be only minutes from death? The assessment must be rapid, encompassing the total patient. The priorities must be established quickly and life-saving support instituted immediately.

A planned, systemized approach to assessment and evaluation of the total patient is essential. A patient only minutes from death cannot wait while a decision is made on what to do first and how to proceed. The moments of stark terror when an emergency multiple trauma patient arrives can be minimized if an organized approach to assessment and resuscitation is utilized.

First, determine rather quickly whether the patient is stable, potentially unstable, or unstable. A patient is considered stable if his vital signs are steady over a given period of time, there is no obvious deterioration, and he does not require rapid resuscitation. He is potentially unstable if he is having fluctuations in vital signs, or if the number of injuries *i.e.*, fractures plus internal injuries, predict worsening of his condition. In an unstable condition, the patient shows obvious deterioration, the vital signs are fluctuating over a given period and he requires continuous support. Patients in the last two categories will require rapid assessment and resuscitation. Do not be distracted by some of the more obvious injuries, because the most obvious may not always be the most lethal. Many times a high degree of suspicion helps in detecting the less apparent problem areas.

The initial goal in managing the multiple trauma patient is to stabilize him. The areas of major concern are: (1) airway control and (2) circulatory control. Once a stable airway and circulatory control have been established, proceed with the assessment. At the same time the medical team will be performing a more specific diagnostic assessment to determine less obvious injuries the patient may have.

The guidelines for patient priorities and initial treatment are decided upon during the first two to three minutes after the patient's arrival. The initial rapid assessment uses the skills of keen observation, gross palpation, and ascultation. The following case presentation demonstrates those skills and shows how much information can be obtained within two to three minutes.

CASE PRESENTATION

Patient background: The patient was a 20 year old female involved in an automobile accident. She arrived directly from the scene of the accident. The transport time from the scene to the admission area was 10 minutes.

The patient had been a passenger in the car. Her condition was given as unstable, responding only to painful stimuli, several fractures and possible internal injuries.

Assessment: When the patient arrived, a rapid assessment was done by the physicians and nurse.

Airway

The airway was patent. Respirations were 36 and shallow. Breath sounds were present bilaterally with moderate bronchi in the upper lobes and minimal breath sounds in the bases.

Circulatory

The patient had no palpatable peripheral pulses. The skin was cool and clammy to touch. Cyanosis of the nail beds and lips was noted. The general color was very pale.

Chest

The chest expansion was equal. No open wounds or bruises were observed. Upon palpation, no subcutaneous emphysema or bony deformities were felt. There was no evidence of mediastinal shift.

If the chest expansion had been unequal, the patient could have sustained lung injury, pleural space injury, or fractures of the ribs or sternum. Many times chest injuries are sustained from the impact with steering wheels. However, since this patient was a passenger and did not have a steering wheel in front of her at the time of impact, the likelihood of chest injuries was reduced.

One of the most lethal dangers with chest injuries is that of a tension pneumothorax. If a tension pneumothorax develops, rapid intervention must be undertaken or the patient's condition may quickly deteriorate.

Conditions such as ruptured tracheobronchial tree, ruptured esophagus, ruptured diaphragm, ruptured aorta, pulmonary contusion and cardiac contusion may not be apparent during the initial two to three minute assessment.

Neurological

Upon arrival, the patient did not respond to verbal stimuli. The eyes were deviated to the left. Pupil reaction to light was equal but sluggish. Palpation of the skull revealed a small depressed area in the left parietal region. A large scalp laceration was found that extended from the parietal region to the temporal region on the left side. A small amount of blood was oozing from the left ear. When stimulated with pain, the patient responded with nonpurposeful movement of the upper extremities and rigidity of the lower extremities.

The primary key to the neurological assessment is observation. Alterations in the level of consciousness of a patient could be due to brain contusion, bleeding within the meningeal layers, alterations in bone continuity and even alcohol. With any patient who displays changes in level of consciousness, signs and symptoms of brain swelling or edema should be monitored carefully. The symptoms that must be carefully observed are decreased level of consciousness, pupillary changes, changes in motor ability, increasing blood pressure with a widening pulse pressure, decreased pulse rate and changes in respiratory pattern.

Abdomen

The patient's abdomen was not distended upon arrival. There were no bruises on the abdomen. Upon palpation, the abdomen was soft with no noticeable rigidity. Bowel sounds were absent.

In abdominal injuries, specific organ involvement cannot be diagnosed by inspection. The diagnosis is made at the time of surgery.

You can inspect the abdomen for open wounds, bruises, contusions, or distention. Ascites will give the abdomen a rather dull appearance while an acutely distended abdomen will appear to be shiny. Listen for bowel sounds although their presence does not mean that the patient has no abdominal trauma.

If the patient has lower rib fracture, he could have injured the spleen or liver. If lap belts have been worn, the patient may display the typical seat-belt contusion as well as damage to the bowel or mesentery and a possible fracture of lumbar vertebrae 2 or 3, usually the latter.

One of the best diagnostic procedures to determine abdominal bleeding is the mini-laparotomy or abdominal lavage. A blood return on the lavage would indicate more extensive exploratory surgery.

Skeletal

Palpation of the patient's extremities revealed a deformity of the upper one third of the left arm, edema of the upper one third of the left thigh with no deformity in the area and a moderate degree of abduction of the left leg. Based on past experience with multiple trauma patients, a fracture of the left femur and a fractured pelvis was suspected.

Most fractures are not life-threatening emergencies unless there has been disruption of blood flow, nerve involvement or fractures of the pelvis or femur with unseen hemorrhage.

When assessing the patient for skeletal injuries, examine for pain, swelling, tenderness, deformity, false motion, ecchymosis, crepitation, and muscle spasm. Check the pulses above and below the fracture site. Check for any paresthesia, paralysis, or pallor. Palpate gently but firmly.

TREATMENT AND EVALUATION

Past experience with multiple trauma patients at the Maryland Institute for Emergency Medicine has shown that life-saving support must be initiated immediately if the patient is to survive.

Following the priorities set during the two to three minute assessment, the patient was intubated with an endotracheal tube and put on a volume controlled ventilator. This was done to provide more adequate oxygen delivery and to decrease the workload of the patient. Secondly, because the patient had no palpable blood pressure and was vasoconstricted, three lines were inserted via saphenous vein cutdown and an anti-cubital cutdown. Initial central venous pressure reading was O. A volume challenge of 1200 cc of plasma was infused with minimal improvement of the patient's perfusion state. Packed cells replaced the plasma infusion and the patient's perfusion state improved. The blood pressure began to stabilize at 100/60 with a pulse rate of 110. The central venous pressure remained low.

A foley catheter was inserted which revealed a small amount of grossly hematuric urine. An intravenous pyelogram (I.V.P.) and pelvic films were ordered. The results obtained from the U.V.P. and pelvic films showed a ruptured bladder and a fractured pelvis.

The neurosurgeon, summoned because of the patient's altered level of consciousness and obvious injuries, ordered cervical spine films, skull films, and a carotid angiogram. The cervical spine films were negative for any fractures. The skull film showed a small depressed fracture in the left parietal region. The carotid angiogram revealed a small subdural hematoma in the left parietal region.

Meanwhile, the results of the mini-laparotomy showed a moderately positive abdomen. The mini-laparotomy is performed by making a two-inch incision just below the umbilicus and the dialysis catheter is inserted into the peritoneum through a purse string suture. The normal saline solution infuses in through the catheter by gravity and drains out. The blood content of the solution determines whether the patient will require an exploratory laparotomy.

An upright chest x-ray was made after the cervical spine x-ray revealed no injury. Both lung fields were fairly clear, lungs were expanded equally and there were no rib fractures.

The extremity x-rays showed a fracture of the mid-shaft of the left humerus and a fracture of the distal end of the femur.

Summary

The initial assessment should take two to three minutes to establish treatment priorities. This rapid assessment can reveal a considerable amount of information useful for the treatment of the patient.

First, maintain a patent airway and second, maintain adequate circulatory support. Then, proceed with a more refined assessment and specific diagnostic procedures such as; the mini-laparotomy, carotid angiogram and x-rays.

You must do an initial rapid assessment, set patient priorities, treat the specific priority areas, institute more specific diagnostic procedures and at the same time keep the total patient in prospective. This requires a planned approach and a preparedness by the staff. Your emergency will not be a crisis if you are prepared.

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BURNS: ASSESSMENT AND PITFALLS; CONTROVERSY IN FLUID MANAGEMENT

Florence Greenhouse Jacoby, R.N.

For some reason even highly trained medical and para-medical persons tend to feel overwhelmed when they become responsible for the care of a burn victim. There is no mystique. Actually, burn trauma can be one of the easiest types of trauma to treat.

Treatment and resuscitative measures needed can very often be anticipated. Pitfalls can be avoided if one can assess, with some degree of accuracy, the severity of the injury. The course of treatment needed will depend on the following factors: 1) circumstances under which injury occurred; 2) extent, apparent depth and location of wounds; 3) age of the victim; 4) intercurrent disease; and 5) concomitant injuries.

Priorities of care must be known. At the scene of the accident personnel must be trained to:

1) Stop the burning process in the most expedient way. (The severity of the wound depends upon the degree of temperature and the duration of contact with the heat source.)

2) Secure the airway.

3) Check for concomitant injuries and initiate appropriate treatment.

4) Cover patient with clean, dry sheet. Small areas can be treated with hypothermic packs or cool, wet dressings.

5) Transport to an appropriate care facility.

6) Report circumstances of accident to persons responsible for definitive care.

What is an appropriate care facility? At the present time there are about one hundred hospitals in the United States that have special burn care programs.

Some of these hospitals have a burn unit. This usually means that a special area has been designated. Ideally, the burn unit is autonomous. The burn unit has specially trained medical, nursing and ancillary staff. Within the unit there should be an operating room, hydrotherapy facilities and provision for intensive care treatment. Provisions for control of infection are made.

A burn institute is usually a burn unit where there is emphasis on teaching and research programs.

A burn referral center does not necessarily have to have a burn unit. The organization of a burn care program or service is essential if a hospital does not have a burn unit. In these programs burn patients are cared for in different areas of the hospital. In order to implement such programs written guidelines must be available. Physicians and nursing personnel should be responsible for developing them. Included should be emergency room care and specifics of treatment, for care on patient floors.

Hospital staff should be familiar with these procedures as part of their basic hospital orientation. For day to day care, the physician aided by a nursing supervisor, nurse clinician or coordinator, or a physicians assistant, can work with staff to give optimal care. In-service education classes are essential for keeping staff up-to-date.

Generally speaking, the severity of burn trauma and the type of care facility needed has been divided into three categories: minor, moderate uncomplicated, and major. These classifications were suggested at the April 1976 meeting of the American Burn Association in San Antonio, Texas:

1) The minor burn is second degree or partial thickness burn of less than 15 percent body surface area in adults (10 percent in children) with less than 2 percent third degree or full thickness burn; and not involving eyes, ears, face, hands, feet or perineum. This classification excludes electrical or inhalation injury, complicated injury (fractures) and the presence of intercurrent disease (cardiac problems, diabetes, etc.). This type of patient could be treated initially in a physician's office or hospital emergency room and followed on an outpatient care basis.

2) Moderate, uncomplicated burns are: second degree or partial thickness burns of 15 to 25 percent body surface area in adults (10% to 20% in children), with less than 10 percent third degree or full thickness burn, which does not involve eyes, ears, face, hands, feet or perineum. Excluded from this classification are electrical injury, complicated injury, inhalation injury and poor risk patients (extremes of age, intercurrent disease). These patients should be able to be treated at a general hospital that has a burn service type program, or, ideally, a burn unit.

3) A major burn injury is one that would involve second degree or partial thickness wounds of greater than 25 percent body surface area in adults (20 percent in children), and all third degree or full thickness burns of 10 percent body surface area or more. All burns involving hands, face, eyes, ears, feet, perineum, inhalation injury, electrical burns, complicated burn injury involving fractures or major trauma, and all poor risk patients, are in this category. If possible, these patients should be admitted to a hospital with a burn unit, or a highly developed burn service program.

Any hospital that has an emergency room should be able to provide initial resuscitation for even a major burn victim. Transfer for ongoing care can be effected once the patient is stabilized.

The priorities of care that should be followed in the hospital emergency room to help minimize future problems, and restore cardiopulmonary homeostasis include:

1) Establish the airway. If flame was involved, the patient should be started on humidified air. If the patient was trapped in an enclosed space, a blood carbon monoxide level should be obtained. The mode of administration and the amount of oxygen given will depend on this level. If the patient is stridorous in the emergency room, usually endotracheal intubation is required.

2) If affected parts still feel warm, apply cool, wet compresses. If acid or alkaline agents have caused the burn injury, flush the area with copious amounts of water, and wash the wound thoroughly with a nonirritating cleansing agent, until all evidence of chemical is removed. Phosphorus must be manually debrided.

3) Check for concomitant injuries.

4) Place secure intravenous line (obtain blood samples for serum chemistries and blood gases, if indicated.)

5) Administer intravenous fluids. Electrolyte, colloid, and 5 percent dextrose in water are usually used according to a formula in which extent of burn and body weight in kilograms are used to determine the type and amount of fluid given. The type and amount of fluid given is then modified according to the patient's response (urine volume, hematocrit, vital signs, mentation). One needs to know that when the principal intravenous fluid is electrolyte, the adequacy of therapy is principally gauged by urinary output; when colloidal solutions are given, treatment is gauged by changes in the hematocrit.

6) Insert nasogastric tube for moderate and major burns. Although bowel sounds may be present initially, many of these patients may develop gastric dilatation and ileus within a few hours. Aspiration can be prevented.

7) Insert Foley catheter. Urine should be checked hourly for volume, specific gravity, pH, presence of blood, sugar, and acetone. In deep burns and in electrical injuries, urine should be checked for myoglobin. If the perineum is burned, the Foley catheter should be inserted as soon as possible, before the meatus is occluded by edema.

8) Obtain history. This should include the circumstances of the injury, and prior medical problems, if any. Evidences of psychologic or sociologic factors that might be of influence should be noted.

9) Complete physical examination and obtain weight.

10) Estimate and record depth and extent of burn. It is very difficult for even the most experienced person to know initially if some wounds are partial thickness or full thickness. To figure fluid formulas for the initial assessment, the exact depth of injury is not important. The extent of the injury is, because it is used in determining initially the amount of fluids needed.

The extent of injury can be determined by the rule of nines. The head and arms are each figured at 9 percent body surface area. The chest and abdomen, the back and buttocks, and each leg, account for 18 percent body surface area each. The perineum is one percent. In children the head size varies according to age:

under 1	19%
1 - 4	17%
5 - 9	13%
10 - 14	11%

If one remembers that the hand, with fingers closed and extended, accounts for one percent of the body surface area, it is easy to do a quick estimate of body surface area and involvement. It is important to allow for differences in the size of your hand and that of the burn patient.

11) Evaluate wounds for possibility of constricting indurated tissue (eschar) which may interfere with the patient's breathing or obliterate circulation in a limb. An escharotomy (incision into eschar, which is relatively bloodless and painless) can avoid many problems. In the case of deep electrical injury a fasciotomy may be needed. Since this incision usually involves some viable tissue, there may be some blood and pain.

12) Analgesia should be given intravenously in small amounts, until patient's hypovolemia is corrected.

13) Give Tetanus immunization. Start with Hyper-Tet if the patient has never been immunized.

14) Course of prophylactic Penicillin for five to seven days is widely used.

15) Obtain a chest x-ray, and x-ray of suspicious areas.

16) Electrocardiogram on all electrical injuries, and when indicated by age or history.

17) Thoroughly cleanse wounds with nonirritating cleansing agent.

18) Institution of wound care: exposure; open, modified dressing; occlusive dressing methods. The open, modified dressing and occlusive mode of therapy usually incorporate the use of a topical antimicrobial agent. The most commonly used agents today are: Silver Nitrate solution, 0.5%; Silver Sulfadiazine (Silvadene), Marion Laboratories, Kansas City, Mo.); Povidone Iodine (Betadine, Purdue-Fredrick, Norwalk, Conn.).

19) Position patient with limbs elevated to minimize edema formation, and to minimize contracture of affected parts.

20) Keep accurate records: intake, output, vital signs, blood values, etc.

Many of the problems of assessing the severity of a burn injury are due to the fact that the signs may be latent. Given an accurate history, one can treat effectively, avoid some pitfalls, and not be discouraged by failures.

The controversy regarding fluid therapies used today to restore the body to homeostasis can be quite confusing. Dr. John Moncrief has told us that for years the success of a given fluid regimen was based on survival alone. We know that in a significant burn injury the capillary endothelium becomes permeable for approximately 24 hours. There is a loss of colloid oncotic pressure. Until the integrity of the capillary endothelium is restored, some fluids, including colloid, are lost from the intravascular space. Edema formation may be profound if large amounts of fluid are given; if colloid is given, it is felt that the problem of edema is prolonged.

The amount of sodium ion needed to achieve homeostasis on the first day of injury appears to be 0.5 to 0.7 milliequivalents times kilograms of body weight times percent of burn. One of the most commonly used formulas today, utilizes Ringers lactate solution on the first day postburn, and calls for 5 percent dextrose and water on the second day postburn. A colloid solution may be used as early as the 16th or 18th hour postburn, if the patient's clinical status warrants it.

Hypertonic solutions and colloid solutions allow for the replacement of the sodium ion, and for the most part, call for the use of free water in the form of oral fluids or 5 percent destrose in water. Today measurements of cardiac output, blood and plasma volume and extra-cellular fluid volume are leading to a better understanding of which types and what rates of fluid administration are optimal.

Infection is still the prime cause of death in burn trauma. Every effort must be made to control the number of organisms in the burn wound and in the patient's environment. Aseptic techniques to prevent the introduction of pathogens to the patient should be started from the beginning. Definitive, sometimes aggressive treatment of the burn wound is essential. Keeping the patient well hydrated, and staying abreast of his nutritional needs can aid and speed his recovery.

Above all, treating the burn victim as a person, is essential for his achieving optimum adjustment to the trials and tribulations of the burn treatment course, and the return of the patient to normal living patterns.

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HEAD INJURIES

Margaret Stevens, R.N.

In a 1970 study of accidental death, head injury presented as the fourth most common cause of death. Approximately 50 percent of the multiply injuried patients in Maryland Institute for Emergency Medicine have sustained some type of head injury, ranging from mild to severe.

The injuries seen are predominately of the closed head injury type or nonsurgical lesions. Nonsurgical cases vary in the amount of damage, depending on the area affected and the extent of secondary changes after the initial insult. Closed lesions may take the form of brief loss of consciousness or severe, extensive brain stem involvement. Many of these patients require rehabilitation.

Surgical lesions generally are subdural or epidural hematoma. Skull fractures requiring elevation of the depressed bone fragments are frequently seen. It is common to see postoperatively other effects of brain injury that have resulted either primarily or secondarily from the injury.

Since MIEM sees many head injuries, the Institute is provided with opportunities for improving the quality of the medical and nursing care given to the patients treated. We are continuously attempting to understand elevated intracranial pressure and how to deal with its consequences. Currently several studies are being prepared in the hope of finding better ways to assist patients.

Based on current trends in neurosurgery and findings of Institute work, a medical regime has been established. The primary treatment is rapid evacuation from the scene. As in any major injury, delays in treatment result in greater insult to the body, particularly with hypoxia. MIEM's second line of defense is hyperventilation with the Engstrom respirator. Patients are ventilated at 20 breaths/minute to give PCO2 of 20 to 30 mm. Continuation of hyperventilation is based on several parameters, *i.e.*, type of injury, level of consciousness, other injured systems, and the patient's general clinical picture. In addition to maintaining low arterial carbon dioxide levels, hyperventilation assures good to optimal oxygenation.

In conjunction with hyperventilation, intracranial monitoring via intraventricular catheter is utilized. Catheters are placed under regular operating room protocol in the O.R. and remain in the head no longer than five days. Daily cerebrospinal fluid (CSF) cultures are done to recognize any early signs of infection. With intracranial pressure (ICP) monitoring, pressure fluctuations are readily recognized and treated. More vigorous treatment of the chest for postural drainage can be undertaken sooner with the catheter placed. Antibiotics are not given prophylactically unless indicated.

As part of the MIEM research projects, the value of steriod therapy is being investigated in a double blind study. Regardless of type of head injury all head injuried patients receive the predetermined drug as prepared by the pharmacy. If it is known that the patient received steriods prior to admission, he is continued on regular protocol steriod dosage.

Diuretic of choice is mannitol. It is given either by intravenous drip or by IV push. Sedation is used often in the acute stages because of the extremely agitated states of some patients. Sublimze (fetanyl) and Thorazine are used with the dosage regulated to patient's needs. In some decerebrate states with high ICP, curare or the newer Pavulon is used, especially if the condition is complicated by chest injury.

The most important treatment used at MIEM is close observation. One of the best observers is the trained bedside nurse. She is the one who is most consistently with the patient. Through primary nursing at the Institute, we attempt to promote consistency and accountability for the patient.

Through training in basic assessment, each nurse can expand into her own role. Parameters of assessment used are level of consciousness (LOC) pupil light response, motor ability, respiratory pattern, vital signs and special devices (drains, shunts, etc.)

The LOC is vitally important, indicating grossly which area is affected. LOC is tested by the patient's response or lack of response to verbal stimuli. Hearing deficits, asphasia, etc. must also be considered. Ability to look to, examine, or follow the nurse around the room with his eyes can all be indications of a more wakeful state. Orientation to time and place can be deceptive if patient is unaware of how much time has passed since his injury or to what hospital he was admitted.

Pupillary light response can help identify specific areas of edema or damage. In trauma patients facial injuries can cause localizing eye signs. The ability to recognize doll's eye reflex is taught, but only those nurses who express interest need test the patient. Being aware of the terminology and understanding its implications are more important than being able to test for the reflex. Corneal checks are done only for those patients in states of deep coma and then only every eight hours.

Motor ability is another way of pinpointing areas of damage. Motor function is divided into two major areas: purposeful response to pain and nonpurposeful response to pain. From these two divisions, finer definitions of response are obtained, such as, decerebration, decortication, paralysis, and paresis. It must be remembered that the patient's apparent motor ability may vary from examiner to examiner. It is important that the stimulus be central and of maximal pain intensity.

If a patient is undergoing a neurological change, the vital signs are often the last indicators of an ongoing disease process. An acute brain stem swelling may not produce changes in the blood pressure until after the oculomotor nerve has been damaged. Also, respiratory changes may not occur early in edema, due to the center's location in the medulla. The nurse must be aware of the patient's baseline in order to note changes.

The key to a good neurological assessment is the establishing of a firm baseline. This must be done at the beginning of the nurse's shift. From the data she collects, hopefully, the nurse will be able to determine trends in the clinical picture. Early recognition of a developing trend, reported to the neurosurgeon, may allow for treatment that could possibly prevent acute brain changes. To sustantiate the findings, it is necessary to accurately record the assessment. During the acute phase (24 to 72 hours) neurological checks should be done every one to two hours, preferably every hour. Trends are more important than an isolated change. LOC, pupil changes, and motor movements all work with one another. A significant change is one that often brings changes in another area.

With the various treatment used at MIEM, the nurse caring for a head injury must be versatile. Treating a patient on hyperventilation, she must be able to recognize blood gas values and report abnormal findings. The nurse must be able to detect changes when the patient is receiving sedatives for control of agitation. She must know the complications of ICP monitoring and how to care for the catheter.

Even more important, the neurosurgical nurse must be able to render a certain type of nursing care that, at best, is underrated and totally mind- and body-consuming. An unconscious patient is a challenge, but coupled with incontinence, frequent moving, constant body odor and perspiration, a head injuried patient can easily be forgotten as a human being. At this point the truly dedicated nurse must be able to separate herself from the unpleasantness of care and treat the patient as a human being with respect and dignity.

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PHYSIOLOGICAL MONITORING: ARTERIAL AND INTRACRANIAL PRESSURE

Rae Nadine Smith, R.N., M.S.

In 1733, Reverend Stephen Hales connected a piece of brass pipe to the windpipe of a goose and then to a 12-foot, 9-inch glass tube. With this device attached to the left carotid artery of a horse, he measured direct blood pressure. Since then, various methods of indirect blood pressure measurement have been practiced. It was not until 1947, however, that the direct measurement of blood pressure was again reported, this time by Drs. Wood and Lambert of Mayo Clinic. Their study described the work they had done with Louis Statham on the development of a transducer for use in blood pressure measurement.

A transducer can be defined as a device used to change varying pressures into proportionately varying signals which can be displayed on a scope, meter, and/or recorder. Today's versions look considerably different from those used in 1947, but they continue to provide a means of obtaining direct pressure measurements.

In this presentation, the physiological monitoring of blood pressure (BP) and intracranial pressure (ICP) measurements by transducers will be discussed.

Such invasive or direct measurements provide a variety of advantages. For blood pressure measurements, the advantages of direct pressure measurement over indirect pressure include: 1) provision of a continual reading with an alarm system, 2) accuracy, 3) access for blood sampling, and 4) the saving of nursing time.

For intracranial pressure measurement, direct measurement usually provides knowledge of changes in intracranial pressure dynamics before such changes are clinically evident, thereby facilitating the initiation of measures to reduce increased intracranial pressure. In both intracranial pressure and blood pressure measurements, the transducer monitoring system provides continual feedback to assist the patient care team in determining the effectiveness of the therapeutic regime being utilized.

Blood Pressure Measurement

The basic system for blood pressure measurement consists of a transducer which is connected via a tubing system directly to a patient's artery, usually the radial, brachial, or femoral. The pressure from the artery is transmitted to the transducer by a column of fluid and converted to a pressure which can be read on a monitor. (Figure 1) To avoid the complication of clotting of the arterial cannula, a mildly heparinized flush solution, such as 5 percent dextrose and water, normal saline, or lactated Ringer's is administered at a continual rate of 3 to 6 cc per hour. To prevent the complication of bleeding back, the flush solution is maintained at a pressure higher than the patient's systolic arterial pressure. The complication of sepsis is eliminated by maintaining a sterile system between the transducer and the patient. With a system such as this, Gardner's study reported the risk to be 0.2 percent with a total of 4,500 direct arterial lines over 12,000 intensive care patient days. Other hospitals have published similar statistics.

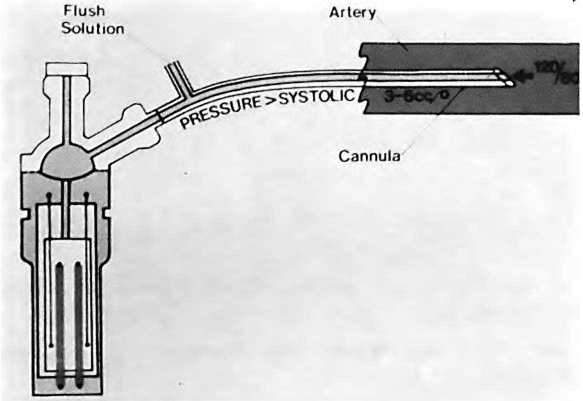

FIGURE 1: Basic principles of blood pressure measurement

The system provides a continual reading with an alarm system as the pressure from the artery is transmitted by the fluid column to the diaphragm of the transducer, where, in this particular example, the strain gauge wires are activated, converting the pulsating physiological pressure into an electrical signal that is displayed on a monitor. Direct pressures are particularly necessary during hypotensive episodes and shock status where indirect or cuff pressures are inaccurate because of decreased cardiac output and increased vascular resistance. A third advantage of direct pressure measurement is access for blood sampling. This is an advantage to the patient from the standpoint of increased patient safety and decreased patient discomfort, and it is an advantage to the nurse in that it saves nursing time. Frequent blood samples are routinely required in the critically ill patient. One example is the need for arterial blood gases of a patient with increased intracranial pressure or the tendency to develop such a pressure increase. It has been well-documented that an increased PCO_2 results in cerebral vasodilation, thereby increasing blood volume and intracranial pressure. Control of PCO_2 by a method such as hyperventilation has proven valuable in the reduction of increased intracranial pressure in selected patients.

Cerebral Perfusion Pressure

The measurement of direct blood pressure is routinely combined with the continual and simultaneous measurement of intracranial pressures in patients with clinical indications for intracranial pressure increases. The pressure value obtained by subtracting the mean intracranial pressure from the mean blood pressures is referred to as the cerebral perfusion pressure. A normal cerebral perfusion pressure is usually considered to be at least 50 mm Hg. Much of the work on such direct pressure measurement has involved the trauma patient. For example, an autopsy study on patients with head injuries revealed transtentorial herniation as the cause of death in 34 pecent of the automobile accident victims examined. Statistics in 1973 showed a mortality from head injuries alone to be 40 percent with 1,300,000 disabled. Fifty percent of all deaths related to motorcycle accidents are secondary to head injuries.

Mechanisms of Increased Intracranial Pressure

It has long been recognized that there are variations in intracranial dynamics. The standard Monro-Kellie hypothesis states that the volume of the intracranium is equal to the volume of the brain, plus the volume of the blood, plus the volume of the cerebrospinal fluid (CSF). Any alterations in the volume of any of these components of the cranial vault will lead to an increase in intracranial pressure, as will the addition of a lesion. Changes in the volume of the brain can occur with changes secondary to ischemia of the cerebral area. Increase in the volume of blood within the cranial vault can occur with cerebral vasodilation as well as the presence of subdural hematomas and aneurysms. An increase in CSF production or a decrease in CSF absorption would change the volume of cerebrospinal fluid.

Lesions such as brain abscesses and brain tumors also cause increases in intracranial pressure. With an injury to the head, as the intracranial pressure goes up, the cerebral blood flow declines leading to tissue hypoxia, a decrease in pH and increase in PCO_2, cerebral vasodilation and edema leading to increased intracranial pressure. The malignant cycle of brain swelling continues until herniation occurs. There are three major types of cerebral herniation: 1) herniation of the singulate gyrus under the falx, 2) herniation of the uncus of the temporal lobes beneath the free edge of the tentorium, and 3) downward displacement of the midbrain through the tentorial notch. Another form of herniation would be with an open head injury in which transcalvarial herniation occurs.

Many authorities in the field of trauma feel there could be significant reductions in death and disabling central nervous system damage by early detection of pressure changes. Between the onset of increased intracranial pressure and herniation is a stage where a wide variety of treatments are available to reduce intracranial pressure.

Intracranial Pressure Measurement

In 1952, the first report of the quantitative measurement of intraventricular pressure was published by Dr. Ryder. This was considered by many to initiate the era of modern neurosurgery. The technique got off to a relatively slow start, and it wasn't until the 1960's that work of men such as Lundberg and Langfitt generated a surge of interest in intracranial pressure measurement.

There are basically three techniques for measuring intracranial pressure: intraventricular, subarachnoid or subdural and epidural.

INTRAVENTRICULAR TECHNIQUE

The intraventricular technique of intracranial pressure measurement consists of placing a catheter into the lateral ventricle. A twist drill hold is placed lateral to the midline at the level of the coronal suture, usually on the nondominant side. A catheter is placed through the cerebrum into the anterior horn of the lateral ventricle. On occasion, the occipital horn is used. Connected to the ventricular catheter via stopcock and or pressure tubing is some type of a pressure transducer. (Figure 2) The transducer then records the intracranial pressure. A range of 0 to 10 mm Hg with an upper limit of 15 mm Hg is considered normal. Some patients have excursions to 100 mm Hg. Two primary disadvantages of this system are: 1) the risk of infection (Sundbarg and associates documented clinically apparent CNS infection of 1.1%), and 2) difficulty in locating the lateral ventricles in a patient who has had midline shifting of the ventricles or collapse of the ventricles as a natural compensatory mechanism for intracranial pressure.

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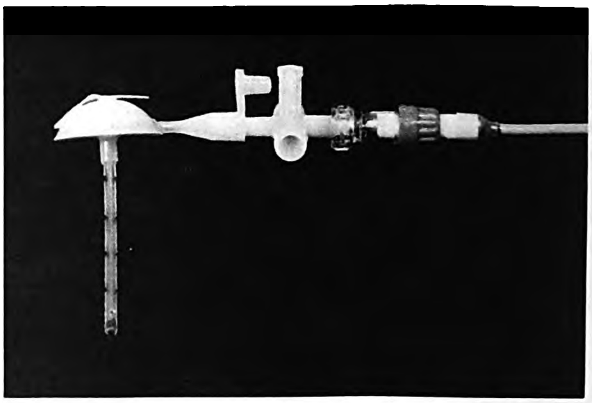

FIGURE 2: Intraventricular cannula with subminiature transducer

Volume Pressure Response

The brain can accommodate or compensate for minimal changes in volume by partial collapse of the cisterns, ventricles and vascular systems. During this compensatory period, the intracranial pressure remains fairly constant. When these compensatory mechanisms have been fully utilized, pressure increases rapidly until the blood supply to the medulla is cut off. These compensatory mechanisms can be evaluated by ICP monitoring. A technique utilized by Miller incorporates the injection of small amounts of fluid via an intraventricular catheter. If the ICP increases less than 2 mm Hg with a one milliliter injection given over an interval of one second, the patient is not undergoing compensatory changes. A response of at least 3 mm Hg per milliliter per second is considered a sign of altered compensation or compliance. In selected cases, ventricular fluid is withdrawn.

SUBARACHNOID TECHNIQUE

A second technique, first reported in 1973, is the use of a subarachnoid screw. The screw is inserted via a twist drill and extends into the subdural or subarachnoid space. Although the cerebrum is not penetrated, pressures, as with the intraventricular technique, are measured directly from the CSF. A transducer may be fastened via stopcock directly to the screw of via pressure tubing. (Figure 3) Volume pressure responses have been determined via the screw.

EPIDURAL TECHNIQUE

A third technique involves the use of an epidural device such as a balloon, radio transmitter or fiberoptic transducer. Such procedures are less invasive and considered by many to reduce the risk of infection. There is disagreement among medical researchers about the clinical correlations of epi-

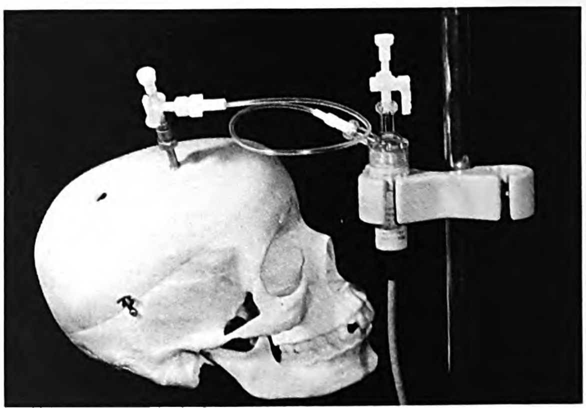

FIGURE 3: Subarachnoid screw with standard transducer

dural intracranial pressure measurements with those taken from the cerebrospinal fluid. Some researchers feel that dural depression and surface tension, as well as thickening of the dura during prolonged monitoring tend to cause inaccuracies in the pressure readings.

The patient's tolerance to changes of intracranial pressure varies with the acuteness of his pressure onset. Patients with a slower buildup of intracranial pressure are more tolerant of elevations in the ICP than patients with rapid development of pressure changes as with subdural hematomas.

PRESSURE WAVE FORMS

Pressure wave forms of varying form are displayed on the monitor. Hemodynamic and respiratory oscillations can be observed in the intracranial pressure traces. At times, the wave forms closely resemble arterial pressure wave forms, and other times resemble CVP wave forms. Certain patients exhibit a phenomenon known as plateau waves. Plateau waves, as defined by Lundberg, are spontaneous rapid increases of pressure to 50 to 100 mm Hg, usually occurring in patients with existing elevations of intracranial pressure. They last approximately 5 to 20 minutes and are usually accompanied by a temporary increase in neurologic deficits. Patients who sustain ICP's greater than 50 mm Hg for periods longer than 20 minutes usually have a poor prognosis. Although the mechanisms of plateau waves or A waves are not clear, they have been correlated with certain clinical conditions. A report by Nornes correlates an increased frequency of plateau waves in the patient with an aneurysm who has a tendency to re-bleed. Although B and C waves have been described, these do not have the clinical significance of the A wave or plateau wave.

Clinical Implications

Unfortunately, the classical Kocher-Cushing syndrone of increased pulse pressure, decreased pulse, and decreased respirations with pupillary changes usually occur only in posterior fossa lesions or transforaminal lesions. The lesions most often seen on trauma units are supratentorial lesions, such as subdural hematomas. With this type of lesion, the textbook symptoms of increased ICP usually appear only in the terminal state. Intracranial pressure monitoring can detect ICP changes before they become clinically symptomatic. Adjuncts to the surgical treatment of increased ICP such as the drainage of cerebral spinal fluid, hypothermia, hyperventilation, the use of corticosteriods and barbituates, and hypertonic solutions have proven to be most effective when given prior to the onset of clinical symptoms. Routine nursing measures, such as positioning, exercising, and sunctioning alter the patient's intracranial pressure. Cerebral perfusion pressures of zero have been recorded during such activities. Since 30 is the minimum perfusion pressure that can be tolerated by the brain, it is evident that significant central nervous system damage can occur during routine care in patients not being monitored.

In conclusion, invasive techniques of measuring intracranial pressure and blood pressure have proven valuable in helping to determine when medical and surgical intervention is necessary as well as to evaluate the effectiveness of the treatment being provided. Factors such as continuity, accuracy, patient safety and efficient utilization of staff time have made such procedures an integral part of the modern day treatment of the critically ill patient.

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CONTEMPORARY RESUSCITATION DEVICES USED IN EMERGENCY AND CRITICAL CARE

Judy Bobb, R.N.

Each year we find new equipment available to assist in the provision of emergency health care. Some of it will prove invaluable; some will gather dust in a forgotten closet. Two of the most recent devices in resuscitation are the Esophageal Obturator Airway and the Medical Anti-Shock Trousers.

Esophageal Obturator Airway

The first of these, the Esophageal Obturator Airway, is an adjunct to airway maintenance in situations where endotracheal intubation is unavailable. The most common use of the airway is by paramedical personnel in the field prior to and during transport to a medical facility. The device provides for ventilation, protects the patient from the hazard of aspiration of gastric contents, and prevents gastric distention.

The airway made its debut very recently. It was first described by Don Michael in 1968. Together with Archer Gordon are continuously attempting to understand elevated intracranial pressure and how to deal with its consequences. Currently several studies are being prepared in the hope of finding better ways to assist patients.

Based on current trends in neurosurgery and findings of Institute work, a medical regime has been established. The primary treatment is rapid evacuation from the scene. As in any major injury, delays in treatment result in greater insult to the body, particularly with hypoxia. MIEM's second line of defense is hyperventilation with the Engstrom respirator. Patients are ventilated at 20 breaths/minute to give PCO2 of 20 to 30 mm. Continuation of hyperventilation is based on several parameters, *i.e.*, type of injury, level of consciousness, other injured systems, and the patient's general clinical picture. In addition to maintaining low arterial carbon dioxide levels, hyperventilation assures good to optimal oxygenation.

In conjunction with hyperventilation, intracranial monitoring via intraventricular catheter is utilized. Catheters are placed under regular operating room protocol in the O.R. and remain in the head no longer than five days. Daily cerebrospinal fluid (CSF) cultures are done to recognize any early signs of infection. With intracranial pressure (ICP) monitoring, pressure fluctuations are readily recognized and treated. More vigorous treatment of the chest for postural drainage can be undertaken sooner with the catheter placed. Antibiotics are not given prophylactically unless indicated.

As part of the MIEM research projects, the value of steriod therapy is being investigated in a double blind study. Regardless of type of head injury all head injuried patients receive the predetermined drug as prepared by the pharmacy. If it is known that the patient received steriods prior to admission, he is continued on regular protocol steriod dosage.

Diuretic of choice is mannitol. It is given either by intravenous drip or by IV push. Sedation is used often in the acute stages because of the extremely agitated states of some patients. Sublimze (fetanyl) and Thorazine are used with the dosage regulated to patient's needs. In some decerebrate states with high ICP, curare or the newer Pavulon is used, especially if the condition is complicated by chest injury.

The most important treatment used at MIEM is close observation. One of the best observers is the trained bedside nurse. She is the one who is most consistently with the patient. Through primary nursing at the Institute, we attempt to promote consistency and accountability for the patient.

Through training in basic assessment, each nurse can expand into her own role. Parameters of assessment used are level of consciousness (LOC) pupil light response, motor ability, respiratory pattern, vital signs and special devices (drains, shunts, etc.)

The LOC is vitally important, indicating grossly which area is affected. LOC is tested by the patient's response or lack of response to verbal stimuli. Hearing deficits, asphasia, etc. must also be considered. Ability to look to, examine, or follow the nurse around the room with his eyes can all be indications of a more wakeful state. Orientation to time and place can be deceptive if patient is unaware of how much time has passed since his injury or to what hospital he was admitted.

Pupillary light response can help identify specific areas of edema or damage. In trauma patients facial injuries can cause localizing eye signs. The ability to recognize doll's eye reflex is taught, but only those nurses who express interest need test the patient. Being aware of the terminology and understanding its implications are more important than being able to test for the reflex. Corneal checks are done only for those patients in states of deep coma and then only every eight hours.

Motor ability is another way of pinpointing areas of damage. Motor function is divided into two major areas: purposeful response to pain and nonpurposeful response to pain. From these two divisions, finer definitions of response are obtained, such as, decerebration, decortication, paralysis, and paresis. It must be remembered that the patient's apparent motor ability may vary from examiner to examiner. It is important that the stimulus be central and of maximal pain intensity.

If a patient is undergoing a neurological change, the vital signs are often the last indicators of an ongoing disease process. An acute brain stem swelling may not produce changes in the blood pressure until after the oculomotor nerve has been damaged. Also, respiratory changes may not occur early in edema, due to the center's location in the medulla. The nurse must be aware of the patient's baseline in order to note changes.

The key to a good neurological assessment is the establishing of a firm baseline. This must be done at the beginning of the nurse's shift. From the data she collects, hopefully, the nurse will be able to determine trends in the clinical picture. Early recognition of a developing trend, reported to the neurosurgeon, may allow for treatment that could possibly prevent acute brain changes. To sustantiate the findings, it is necessary to accurately record the assessment. During the acute phase (24 to 72 hours) neurological checks should be done every one to two hours, preferably every hour. Trends are more important than an isolated change. LOC, pupil changes, and motor movements all work with one another. A significant change is one that often brings changes in another area.

With the various treatment used at MIEM, the nurse caring for a head injury must be versatile. Treating a patient on hyperventilation, she must be able to recognize blood gas values and report abnormal findings. The nurse must be able to detect changes when the patient is receiving sedatives for control of agitation. She must know the complications of ICP monitoring and how to care for the catheter.

Even more important, the neurosurgical nurse must be able to render a certain type of nursing care that, at best, is underrated and totally mind- and body-consuming. An unconscious patient is a challenge, but coupled with incontinence, frequent moving, constant body odor and perspiration, a head injuried patient can easily be forgotten as a human being. At this point the truly dedicated nurse must be able to separate herself from the unpleasantness of care and treat the patient as a human being with respect and dignity.

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PHYSIOLOGICAL MONITORING: ARTERIAL AND INTRACRANIAL PRESSURE

Rae Nadine Smith, R.N., M.S.

In 1733, Reverend Stephen Hales connected a piece of brass pipe to the windpipe of a goose and then to a 12-foot, 9-inch glass tube. With this device attached to the left carotid artery of a horse, he measured direct blood pressure. Since then, various methods of indirect blood pressure measurement have been practiced. It was not until 1947, however, that the direct measurement of blood pressure was again reported, this time by Drs. Wood and Lambert of Mayo Clinic. Their study described the work they had done with Louis Statham on the development of a transducer for use in blood pressure measurement.

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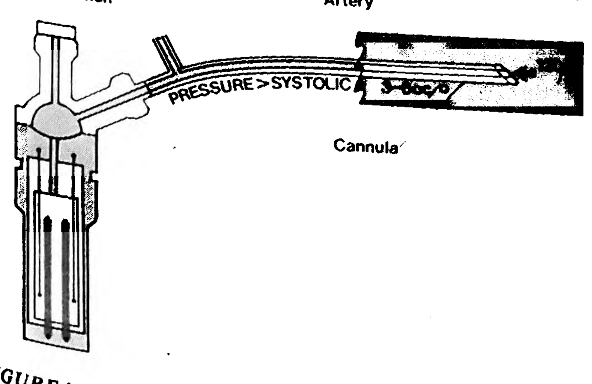

FIGURE 1: Basic principles of blood pressure measurement

The system provides a continual reading with an alarm system as the pressure from the artery is transmitted by the fluid column to the diaphragm of the transducer, where, in this particular example, the strain gauge wires are activated, converting the pulsating physiological pressure into an electrical signal that is displayed on a monitor. Direct pressures are particularly necessary during hypotensive episodes and shock status where indirect or cuff pressures are inaccurate because of decreased cardiac output and increased vascular resistance. A third advantage of direct pressure measurement is access for blood sampling. This is an advantage to the patient from the standpoint of increased patient safety and decreased patient discomfort, and it is an advantage to the nurse in that it saves nursing time. Frequent blood samples are routinely required in the critically ill patient. One example is the need for arterial blood gases of a patient with increased intracranial pressure or the tendency to develop such a pressure increase. It has been well-documented that an increased PCO_2 results in cerebral vasodilation, thereby increasing blood volume and intracranial pressure. Control of PCO_2 by a method such as hyperventilation has proven valuable in the reduction of increased intracranial pressure in selected patients.

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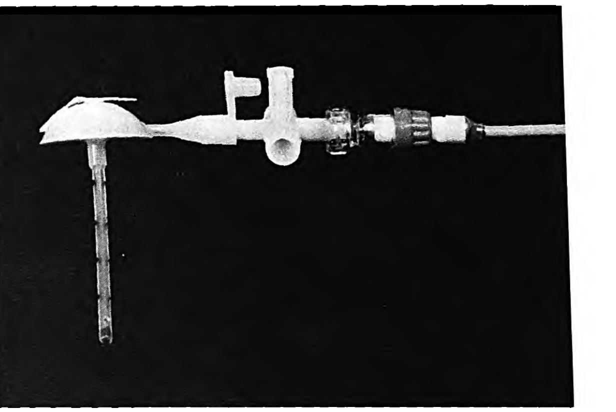

FIGURE 2: Intraventricular cannula with subminiature transducer

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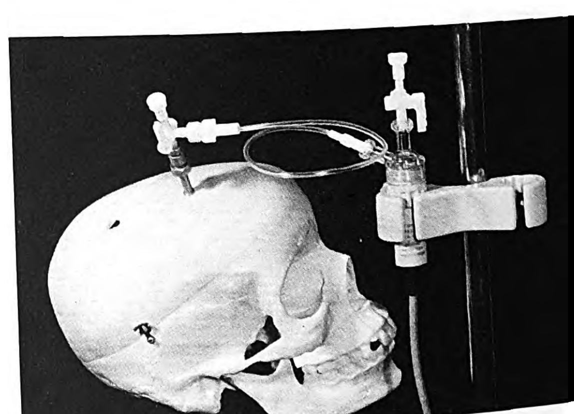

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Pressure wave forms of varying form are displayed on the monitor. Hemodynamic and respiratory oscillations can be observed in the intracranial pressure traces. At times, the wave forms closely resemble arterial pressure wave forms, and other times resemble CVP wave forms. Certain patients exhibit a phenomenon known as plateau waves. Plateau waves, as defined by Lundberg, are spontaneous rapid increases of pressure to 50 to 100 mm Hg, usually occurring in patients with existing elevations of intracranial pressure. They last approximately 5 to 20 minutes and are usually accompanied by a temporary increase in neurologic deficits. Patients who sustain ICP's greater than 50 mm Hg for periods longer than 20 minutes usually have a poor prognosis. Although the mechanisms of plateau waves or A waves are not clear, they have been correlated with certain clinical conditions. A report by Nornes correlates an increased frequency of plateau waves in the patient with an aneurysm who has a tendency to re-bleed. Although B and C waves have been described, these do not have the clinical significance of the A wave or plateau wave.

Clinical Implications

Unfortunately, the classical Kocher-Cushing syndrone of increased pulse pressure, decreased pulse, and decreased respirations with pupillary changes usually occur only in posterior fossa lesions or transforaminal lesions. The lesions most often seen on trauma units are supratentorial lesions, such as subdural hematomas. With this type of lesion, the textbook symptoms of increased ICP usually appear only in the terminal state. Intracranial pressure monitoring can detect ICP changes before they become clinically symptomatic. Adjuncts to the surgical treatment of increased ICP such as the drainage of cerebral spinal fluid, hypothermia, hyperventilation, the use of corticosteriods and barbituates, and hypertonic solutions have proven to be most effective when given prior to the onset of clinical symptoms. Routine nursing measures, such as positioning, exercising, and sunctioning alter the patient's intracranial pressure. Cerebral perfusion pressures of zero have been recorded during such activities. Since 30 is the minimum perfusion pressure that can be tolerated by the brain, it is evident that significant central nervous system damage can occur during routine care in patients not being monitored.

In conclusion, invasive techniques of measuring intracranial pressure and blood pressure have proven valuable in helping to determine when medical and surgical intervention is necessary as well as to evaluate the effectiveness of the treatment being provided. Factors such as continuity, accuracy, patient safety and efficient utilization of staff time have made such procedures an integral part of the modern day treatment of the critically ill patient.

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CONTEMPORARY RESUSCITATION DEVICES USED IN EMERGENCY AND CRITICAL CARE

Judy Bobb, R.N.

Each year we find new equipment available to assist in the provision of emergency health care. Some of it will prove invaluable; some will gather dust in a forgotten closet. Two of the most recent devices in resuscitation are the Esophageal Obturator Airway and the Medical Anti-Shock Trousers.

Esophageal Obturator Airway

The first of these, the Esophageal Obturator Airway, is an adjunct to airway maintenance in situations where endotracheal intubation is unavailable. The most common use of the airway is by paramedical personnel in the field prior to and during transport to a medical facility. The device provides for ventilation, protects the patient from the hazard of aspiration of gastric contents, and prevents gastric distention.

The airway made its debut very recently. It was first described by Don Michael in 1968. Together with Archer Gordon he developed a model in 1970. By 1971 the device was being used by Los Angeles County Paramedics. Acceptance was rapid, leading to recognition by the National Conference on Cardiopulmonary Resuscitation and Emergency Cardiac Care in May, 1973.

The airway itself is a flexible tube approximately 35 cm. in length. Occulsion of the esophagus is accomplished by a solid tip at the distal end, together with an inflatable cuff immediately above the tip. The proximal portion of the tube includes fenestration for the movement of air, a clear face mask, and the mouthpiece or adapter.

With proper positioning of the airway the tip and cuff will lie below the tracheal bifurcation to prevent excessive pressure on the trachea. The fenestrations are now located in the oral pharynx. The adapter passes through the face mask to complete the system.

Air delivered through the adapter exits the tube through the fenestrations and flows into the trachea and lungs. Once the rescuer is assured the tube is in proper position, he inflates the cuff with 35 cc of air, then continues ventilation.

INDICATIONS

The Esophageal Airway is indicated for use in unconscious patients who are unable to protect their own airways. That is, those patients who have absent cough and gag reflexes. At the present time no pediatric sizes are available, so use of the airway is limited to individuals of adult stature. We use 15 years of age to define adult stature.

Most often patients meeting these criteria have had either respiratory or cardiac arrest. However, the airway is also effective for the patient who is unconscious due to drug overdose or head trauma.

CONTRAINDICATIONS

There are few contraindications to the use of the Esophageal Airway. It should not be used if the patient has ingested any corrosive liquid. It is also contraindicated if the patient has a known esophageal disease or if esophageal injury is suspected. Until pediatric sizes are available, it should not be used in children under the age of fifteen years.

ADVANTAGES

There are a number of reasons for the popularity of the Esophageal Airway. Perhaps the major reason is the ease with which the device can be inserted and used. A trained individual, using the device preassembled, can usually insert it in less than ten seconds.

Also, the airway can be inserted blindly, without additional equipment, and without special positioning of the patient. Because the tube follows the path of least resistance into the esophagus, the rescuer need not visualize even the orophargnx in order to position the tube. He may be to the side of the patient, at the head, or even beneath the victim. The mouth piece is a standard 15 mm adapter which will accommodate standard ventilation equipment, therefore, no additional equipment is required. Mouth-to-mouth self-inflating bag, demand valve, even mechanical ventilators can be utilized.

The airway can be inserted when the patient is in most any position, including sitting. Neutral head position, or even slight flexion of the neck, is recommended. Gentle lifting of the mandible facilitates passage of the tube. Hyperextension of the neck is contraindicated as this would favor tracheal intubation. The airway, then, is ideal for the patient suspected of having cervical spinal injury.

A second advantage is that minimal training is required to achieve skill, as opposed to that required for endotracheal intubation. In Maryland, the State Police assigned to Med-Evac helicopters receive an average of two hours training, plus supervised manikin practice.

The Esophageal Airway is indicated primarily for field use by paramedics. It does not replace endotracheal intubation as the artificial airway of choice when this support is needed. But it does provide additional airway protection until tracheal intubation is completed. Note that it is recommended that the Esophageal Airway remains in place until the endotracheal tube is positioned.

Lastly, it appears that oxygenation, as evidenced by arterial oxygen tension, is satisfactory with this device. However, little data concerning blood gas results after Esophageal Airway use is available.

DISADVANTAGES

There appear to be few hazards associated with the Esophageal Airway, and these are easy to avoid.

It is possible to unintentionally intubate the trachea producing complete airway obstruction. To avoid this, the rescuer delivers a quick breath and observes for rise and fall of the chest prior to inflation of the cuff. If there is any question, the tube is removed and the patient ventilated in another manner before another attempt is made. One death due to tracheal intubation when the Esophageal Airway was inserted by a person untrained in its use has been reported.

Malposition of the tube is avoided by limiting its use to patients of adult stature, and assuring that it is completely inserted.

The risk of esophageal injury is apparent. Such injury could be tearing during insertion or rupture if a patient tries to vomit against the obstructed esophagus. To date, two cases of pharyngoesophageal tears have been reported from the University of California at Los Angeles. One patient died, but this was not felt to be due to the esophageal tear. The UCLA series included 1000 insertions. No cases of esophageal rupture have been reported. Paramedics are all instructed to remove the tube if the patient regains reflexes and begins to gag.

Gastric regurgitation as a complication of esophageal intubation would seem unlikely. However, perforation of the cuff by the patient's teeth as the tube is passed has occurred, and an occasional patient has regurgitated around an inflated cuff. Harbor General Hospital in Torrance, California reported six patients with gastric regurgitation in a series of 621 insertions. This complication can be easily corrected by replacement with a new tube.

The last potential hazard of Esophageal Airway use is ineffective ventilation. It is difficult to determine from the literature if this is a national problem since most data are merely of a pass/fail nature. As I noted previously, our experience has shown oxygenation to be generally acceptable upon admission, but the carbon dioxide levels to be considerably above normal indicating hypoventilation.

Two possible causes are: ineffective seal of the face mask; and, inadequate tidal volume delivered by the rescuer. The latter seems more likely since the Esophageal Airway increases dead space and increases resistance. We now recommend that the rescuer deliver approximately twice the normal tidal volume as well as verifying an air tight seal of the face mask.

The Esophageal Obturatory Airway, then, is a safe, effective tool for airway management of select patients.

Medical Anti-Shock Trousers

The second piece of equipment I would like to review is the Medical Anti-Shock Trousers (M.A.S.T.), sometimes known as the "G" Suit.

This is a one-piece pneumatic suit which encloses each lower extremity and the abdomen, extending to, but not including, the lower ribs. The patient is placed on the garment and wrapped within it. A foot pump inflates the garment to the desired pressure. It functions much as a large air splint.

The principle of venous compression to treat shock was first employed by Crile as early as 1903. When blood transfusion became readily available, the concept was abandoned. Interest was revived later with the advent of high altitude flying, hence the term "G" Suit, or "Anti-gravity Suit." Only recently has the M.A.S.T. been available for prehospital emergency care. The paramedics of Miami, Florida, were the first to actively employ the device in 1973.

When applied the suit exerts 88 to 120 mm Hg circumferential pressure which can provide an autologous transfusion of up to 1000 cc. This pressure also impedes venous return to the lower half of the body.

INDICATIONS

The device is designed to provide autotransfusion to patients in hemorrhagic shock, but has other benefits as well. It has been effective in slowing or stopping arterial bleeding, particularly from the lower extremities. The pressure application has also proved beneficial in retarding intra-abdominal bleeding, in crush injuries, and in postpartum hemorrhage.

ADVANTAGES

The combined effects of autologous transfusion and impeded venous return favor central perfusion of the brain and heart. Studies performed on dogs using single limb pneumatic compression indicate that arterial perfusion of the limb remains patent, even after several hours have elapsed. Further experience with the M.A.S.T. will be needed before data are available concerning the effects upon humans.

The garment has frequently been noted to lessen pain for many individuals. Since it also functions as a splint, it helps stabilize pelvic fractures.

The most striking clinical features of the M.A.S.T. are improvement in both blood pressure and level of consciousness. The improvement is usually rapid and often quite dramatic.

Lastly, the garment can be rapidly applied by trained paramedics. In the field two men will usually have the M.A.S.T. in place within one minute.

DISADVANTAGES

Although shown to be life-saving in many instances, the M.A.S.T. is not without some serious risks which could conceiveably complicate resuscitation.

Impaired venous return may produce or aggravate peripheral acidosis.

The device may precipitate acute pulmonary edema, congestive heart failure, incontinence or emesis.

The suit interferes with patient assessment to a degree in limiting inspection and palpation.

Respiration may be compromised if the device is applied too high, interfering with rib movement, or if diaphragmatic excursion is impeded.

There has been some concern expressed that impairment of lower extremity function may result from prolonged application, but no evidence to date that this has happened.

CONTRAINDICATIONS

The M.A.S.T. should not be used in patients with pulmonary edema or congestive heart failure, as noted above. It is, in addition, contraindicated in the presence of wounds of the upper body, intrathoracic bleeding or injury, and in the presence of intracranial injury.

RESULTS

The city of Miami has had the most extensive experience with M.A.S.T. They have reported a small series of 20 patients, 15 of whom survived. Patient injuries included vaginal hemorrhage, multiple trauma, gunshot wounds and gastrointestinal hemorrhage. Eighteen of twenty presented with systolic blood pressures below 100 mm Hg. Eight of these had no obtainable blood pressure. Only two patients did not benefit from the M.A.S.T. The first was pronounced dead on arrival in the emergency room, with fractured skull, crushed trachea, and left hemothorax. The second expired in the recovery room of injuries which included a fractured left leg, ruptured spleen and mesenteric tears.

The following case report demonstrates the effectiveness of the garment. A 67-year-old male was struck by an automobile sustaining a fractured femur and pelvis. In surgery a urethral tear and large retroperitoneal hematoma were found. The patient was initially hypotensive with a blood pressure of 80/60 mm Hg and became fully conscious. He went on to an uneventual recovery.

One last note of caution. Once the garment is in place, adequate fluid replacement must be initiated prior to its removal. Early or rapid removal of the unit without satisfactory treatment for shock may again result in acute hypotension.

Summary

In summary, both the Esophageal Obturator Airway and the Medical Anti-Shock Trousers seem to be promising new tools in pre-hospital airway management and treatment of shock. Both have proven effective and both seem safe and reliable. Only time and further experience will determine the final outcome.

SECTION II
Nursing in EMS Systems

EXPANDED ROLE OF THE NURSE: HOW TO IMPLEMENT THIS ROLE

Teresa Romano, R.N.

Over the past four or five years, significant advances have been made in the field of emergency medicine. Recognizing that life-threatening problems demand immediate skilled intervention, the medical community has taken steps to enhance the responsibilities and skills of most categories of emergency personnel with major impact on their roles and responsibilities. Yet, the actual practice of emergency nursing has stayed relatively the same.

The emergency medical technician, with a minimum 81 hours emergency medical training, has emerged as the national standard, replacing the poorly trained ambulance attendant of yesterday. The paramedic, a relatively new category of emergency care personnel, offers the ultimate in prehospital critical care by providing definitive treatment (i.e. defibrillation, intravenous medication and endotracheal intubation) at the scene of an injury or illness. Emergency medicine as a physician specialty is rapidly gaining nationwide acceptance and is preparing a large number of emergency physicians to provide 24-hour coverage in emergency departments.

What about nursing? In these past few years, with the climate ripe for across the board expansion of roles and responsibilities, nursing has made few significant or identifiable advances. Granted, most emergency department nurses have acquired a greater body of knowledge in the last few years, having made concerted efforts to attend every conference or seminar available.

As a result, nurses are better prepared to treat the emergency patient, but also more frustrated by their inability to initiate necessary definitive care because of hospital or physician policy. Unfortunately, if this educational effort has had any discernible effect on what nurses actually do in the emergency department, or what they are "allowed" to do, it has had little impact on emergency nursing as a whole. Not to be totally negative, nurses in several areas of the country have made considerable gains, but only in their own areas and only after much effort.

Why have we, as a profession and as a specialty, experienced only minimal change in an otherwise rapidly progressing field? Why have we been overlooked to fill critical emergency care gaps? Why have we sat by watching paramedics take on more responsibility than we have ever had without ever demanding, "Hey, what about me?"

As I meet emergency department nurses from across the country I hear repeatedly, "We'd like to be able to intubate and start treatment, but our doctors would never let us," or "How can we get our doctors to let us do these things?" Simply verbalizing these concerns to other nurses will not change the situation. Something must be done to provide nurses with a more satisfying, more challenging professional life.

Five years ago, when I first entered the field of emergency care, I was appalled at the lack of responsibility entrusted to nurses and the restrictions placed on necessary life-saving technical skills, even when no physician was present to immediately provide emergency care. Working with the Illinois EMS program I was able to implement nurse specialty courses that I naively hoped would help nurses to expand their limited scope of practice. A questionnaire was distributed to all graduates and their supervisors six months after completion of the course. Detailed questions were asked pertaining to expansion of role and increase in responsibilities as a result of the course.

Unfortunately the results were disappointing. The nurses gained considerable knowledge, confidence, and skills, but were rarely permitted to utilize this knowledge in actual practice once they returned to their own hospital. Isolated gains have been made. For example, a few hospitals have expanded nurse responsibilities to include intubation, but certainly not as many as was hoped.

Other states, besides Illinois, have allocated significant amounts of money to finance emergency nurse education programs. Surprisingly, we know very little about the tangible effects of these courses. We presume they increase nursing responsibilities and knowledge, but there is no documentation to support this assumption.

In contrast, over the past few years, paramedics have totally impressed the medical field with their enthusiasm, dedication and knowledge in emergency care. They are a revolutionary addition to the emergency health care team. Their widespread acceptance has opened a new era of emergency care, and has provided previously unthought-of care at the scene and during patient transport. Strangely, any resistance to paramedics defibrillating, intubating or starting IVs in the field is dissipating rapidly, and most physicians now welcome the patient care benefits paramedics can provide. Nurse involvement is lacking in many of these programs, and very few of the emergency department nurses have attempted to initiate similar role expansions to provide equal care capabilities within the emergency department.

In some existing EMS programs, an even newer category of emergency personnel is in the early stages of development — the emergency department physician assistant. Much like the paramedic, emergency department physician assistants, with anywhere from two to four years training, administer definitive emergency care in the absence of a physician. Unlike paramedics, they are stationed in the emergency department. When I asked a physician director of one of these programs if he had considered providing a year or two extra training to nurses to take on this role, he replied, to the wholehearted agreement of other physicians in the room, that nurses were not what they were looking for to fill this position. Nurses, he continued, are only interested in "giving care" and don't want to make a diagnosis or make independent judgments about care. This is an extreme, but it does illustrate one attitude confronting nursing.

What are the reasons for this particular slight and other obvious disregards of nursing potential? Why are nurses overlooked as potential manpower for more "complicated" undertakings?

First, as a traditionally female professional, nurses must contend with the full scope of female stereotypes, all of which become magnified when wrapped in a white "helpmate" uniform. Being female, nurses are considered less aggressive, less confident, less able to respond in time of crisis. This is only one of many reasons for the current situation. Most assuredly, nursing's own acceptance of the status quo has contributed to the lack of noticeable advancement.

Feminist or not, one cannot deny the tremendous effect that the female nurse/male physician tradition has had on the growth of nursing. It becomes painfully evident in emergency medicine when the responsibilities afforded the male paramedic are compared to those of the female nurse in the emergency department. Emergency department nurses should be defibrillating, intubating and starting IVs in the emergency department. As a nurse, she/he should have these skills, and the knowledge and judgment to initiate them.

Nurses have been accused of becoming angry or threatened by the prospect of paramedics functioning in their community. The basis of this is probably that paramedics are doing more, without question, than nurses would ever expect anyone to "let" them do. Many nurses have gone so far as to leave nursing to enter the paramedic field, a field offering obvious advantages as far as personal satisfaction, continuous challenge, and independent activity. What a sad commentary on nursing that we can't organize ourselves to provide similar advantages in the emergency department setting.

Even sadder is the growing impetus by nurses to develop a nurse-paramedic category and train nurses to work on rescue vehicles. I'm afraid this is a potentially harmful way to approach the real problem confronting us. Emergency department nurses should possess the skills and knowledge to provide the same crucial care in the emergency department that the paramedic provides in the field. If they don't, they should receive additional education and then attempt to implement changes within their hospitals or areas to bring the nurse's duties and responsibilities equal or above that of paramedics. Promoting a nurse paramedic category could seriously undermine efforts to upgrade nurse responsibilities in the emergency department itself. With the need for quality care in the emergency department so great, energies should be directed towards keeping nurses there and better utilizing their talents, rather than offering them the prospect of enhanced responsibilities as a paramedic.

Prehospital programs attempting to utilize physicians were found to be a waste of manpower, especially since paramedics could competently do any emergency procedures a physician could during the prehospital phase. Developing a nurse-paramedic would be tantamount to developing a physician-paramedic — in essence, taking a step backward while avoiding the real problem.

What is the answer? One route, obviously, is through continued improvement of not only postgraduate but undergraduate nurse education as well. All types of nurse undergraduate programs could benefit by a fresh approach to nurse education, one which strives for independence and confidence in its graduates and one which directs students towards specialty areas of interest.

Post graduate education must be developed with specialization in mind. Instead of exclusively degree programs for specialization, 6 months to one year post graduate programs in specific areas of medicine must be available for nurses.

I propose that one approach to nurse specialty education is the development of a nurse residency program. Specifically implemented in emergency medicine, this program mirrors physician residency programs by providing selected didactic information emphasizing the independent learning process, and the "on-the-job" clinical management and feedback central to physician residency programs. The nurse residency program includes experience in all critical care areas with emphasis on both the initial emergency and intensive care treatment. The multifaceted curriculum provides clinical experience in a burn unit, trauma unit, coronary care unit, neonatal unit, mobile intensive care unit and an emergency department, as well as management and coordination experience in the development of an EMS system. Experience also includes teaching and administrative responsibility along with much independent study.

It is appropriate and essential that a program such as this be integrated with efforts to train emergency residents. Besides the obvious advantage of dual use of scheduled educational opportunities, a program such as this could truly establish a team approach in emergency medicine, an approach where each member of the team functions at his/her optimum level.

The challenge and professional stimulation of specialty residency programs have, up to now, been unavailable to nurses, an oversight which may be partially responsible for the professional apathy and insecurity of many practicing nurses. Present nurse practitioner programs meet the needs of those nurses desiring an independent role in clinic-type, outpatient settings, but no existing programs provide nurses with the credentials and confidence to specialize in the field of their choice. Witness to this is the recent move of nursing organization to "certify," by national testing, nurses in emergency department or critical care areas. This appears to be the only avenue to identification as a "specialist."

I am presently developing a nurse residency program, such as the one described above, for the Philadelphia area. The one year program will accept four residents and will be affiliated with an active emergency residency program. An on-going evaluation component will monitor the effectiveness of the program.

Formal, ongoing postgraduate specialty programs are a priority need, if nurses are to keep pace with other health professionals in emergency medicine. However, education alone will not topple the existing barriers to full nurse participation in emergency care. It must be coupled with an organized attempt to upgrade the nurse's role in keeping with other emergency care professionals. Nursing must evaluate its role in the emergency department and develop a policy statement specifically outlining what nurses can and should be doing in the emergency department to provide optimal emergency care — diagnosis, clinical evaluation, defibrillation, intubation, and so forth. Education to prepare the nurse for these new responsibilities and skills should also be recommended. Perhaps, with this established, major national and state efforts can be directed towards making these standards the accepted norm.

The Emergency Department Nurses Association has a major responsibility for establishing standards, setting a national attitude, and assisting state and communities to initiate proposed changes. EDNA has fulfilled a major goal in gaining widespread acceptance as an emergency nursing professional organization. The organization's major objective, promoting ongoing educational opportunities for emergency department nurses, has been so well achieved that most areas of the country will continue efforts with minimal national encouragement. Much more important now is EDNA's role in achieving necessary changes in emergency nursing. Steps towards this end have already begun with ENDA now in the process of defining the role of the emergency department nurse and developing methods of certification. Even more aggressive approaches must accompany this, including soliciting the support and assistance of the American College of Emergency Physicians to achieve actual changes in practice.

The future of nursing in emergency care is dependent upon how successfully we utilize the strengths of our national organization to establish a meaningful place for nurses in emergency care. A major, full time commitment by the national organization is essential to meet this end. Just as important, however, is what individual nurses do to aggressively implement changes within their own hospitals.

EMS AND THE NURSE

Sally Sohr, R.N.

Our goal is to provide a holistic approach to the patient; to accomplish this the nurse cannot ignore what occurs on the other side of the emergency department door. She must involve herself intimately with the planning of a total system of emergency care for her patients.

The first question we must ask is: why an EMS system? To answer this we need to look at our society and how it has changed.

Whereas it used to take 100,000 years for the population to double, it now takes 35 years. Our growing complex society poses growing and complex problems. This population has exploded so fast that its methods for serving itself for optimal survival have been unable to grow at the same rate. What happens to a body that develops faster than its nervous system? It falters, becomes incoordinate, stumbles and falls!

In emergency treatment we are clearly stumbling. Our national statistics of deaths due to auto accidents alone, help to exemplify this. These accidents for the most part occur in the rural, high speed areas, but the sophisticated medical centers equipped to treat these multiple trauma victims are still located within the urban settings.

Trauma on the whole is increasing. Pick up any paper — homicide, suicide, child abuse — violence on every level is increasing. Are our emergency departments equipped with adequate numbers of trained staff to handle these emergencies? In 1970 only one medical institution in the country offered a residency in emergency medicine: today there are 28. Is this enough? The national death statistics and emergency audits say no. The traditional system of staffing emergency departments with rotating interns is still the norm. The least qualified doctors are taking care of the sickest patients.

In 1965, 28,700,000 patients received emergency department care. Ten years later this figure doubled to over 60,000,000 patients. What does this mean? The kinds of stresses Toffler described in ***Future Shock*** are evident in the types of patients increasingly seen in the emergency departments. For example, the number of drug and alcohol withdrawal and overdose-related problems account for a large number of emergency department patients.

Many patients are not emergencies, and their large numbers show that the public is using the emergency department for nonemergency problems because there is no other place to go. This dilutes the care to the true emergency patient, overtaxes the emergency facility and fosters inadequate care to all patients.

These are but a few of the obvious reasons for the necessity of the development of an Emergency Medical System — a sophisticated nervous system that can serve this large body of population.

The system is developing, utilizing fast effective transport systems, and communications systems with radio and telemetry between transport vehicles and emergency departments.

Professionals, paraprofessionals and laymen are being trained at all levles. Standards of emergency patient care are being suggested by EMS councils, which exist on regional, state and county levels throughout the country. Hundreds of thousands of people throughout the country are directly or indirectly involved in EMS. All of this activity has as its central goal the provision of services for the emergency patient.

Where is the nurse in all this? Is she aware of the EMS in her area? Is she fully represented on the EMS councils? In many hospitals the main stable force within an emergency department is the nurse, yet where is she when the decisions governing the emergency department patient care are made.

We need to wake up. It is time to look at ourselves as qualified people, not only clincally at the bedside, but also as the chief patient advocate. It is not enough that we address ourselves solely to bedside nursing. By doing so, we influence and provide only part of patient care. We cannot treat one system without realizing the interdependence of all systems within the body. The same is true with the EMS. We cannot address ourselves solely to treating the patient in the emergency department system without realizing the interdependence of all other systems within the emergency medical care plan.

Further, by addressing ourselves totally to the traditional clinical aspects of patient care, we are constantly placing ourselves in the position of having to react to, rather than influence, various aspects of the Emergency Medical System that directly or indirectly relate to nursing and patient care.

What can we as nurses do nonclinically to fulfill our goals of holistic patient care and patient advocacy?

First every emergency department nurse needs to familiarize herself with what the EMS is in her area, its goals, priorities and total functioning. Where are the EMS councils in your area, who is on the council? Is there emergency department nurse representation on the council? If not push to obtain this representation. Many times just having your local EDNA chapter write a letter requesting representation is all that is needed.

The council members are usually eager to have competent and enthusiastic members. Once on the council your representative needs to establish a two-way communication system where information on EMS decisions and functioning flows to the nurses working in the emergency department and where information concerning special problems and evaluation of the effect of EMS changes on the emergency department can flow back to the council. Also it is necessary for the emergency department nurse to obtain representation on medical audit, evaluation and standard committees within her own hospital for the EMS and patient care does not stop at the emergency room, but flows on to discharge and outpatient clinics. Only in this manner can a smooth and functioning EMS be obtained and only in this manner can nurses begin to fulfill their role as patient advocate providing holistic patient care.

POTENTIAL AREAS FOR RESEARCH IN TRAUMA NURSING

Nellie Kuhtik Abbott, R.N., Ph.D.

Introduction

Research in nursing can be viewed as a culminating and integrating experience which, in the short run, may be viewed as a refinement and not a necessity. In the long run, however, the health of the profession may depend upon it.

Philosophy of Nursing Research

Before launching into a discussion of the "what" and "hows" of trauma nursing research, I would like to establish a frame of reference by making some statements which might be labeled as my philsophy of nursing research:

1) Research is the primary force and vehicle which will move our profession into a higher plane of operation and will help us to achieve a fully professional state.

2) Research is both exciting and very demanding. In my opinion it permits an individual to reach that state of "self-actualization" that Maslow made so popular.

3) Research activity is almost always interdisciplinary in nature even though each participating discipline may approach it from a different focus and may wish to emphasize different elements.

4) One does not need to possess a doctoral degree to be involved in research as long as sound research principles are known and followed and expert help is obtained at certain critical points.

5) One should be aware that research today carries certain restrictions which regulate it. Careful attention must be paid to protecting human rights and meeting legal requirements by following patterns of approval established at each agency.

6) Even though nurses function in highly complex settings where it is very difficult to control and/or manipulate variables, it is still possible to design and implement "good" research.

7) A marriage of nursing education and nursing practice is the best way to design and implement nursing research.

Having made my position clear, I would not like us to turn our attention to some concrete areas in which research either can be, should be, or is being done.

Definition of Trauma

Depending upon your particular background both experientially and educationally, your concept of trauma nursing may be somewhat different from mine. Some prominent individuals view trauma as "cellular death." Others view it as a sudden accident or illness, usually associated with physical and/or chemical forces, in which multiple systems of the body are overwhelmingly affected. I tend to lean toward the latter definition. Therefore, there may be large segments of nurse/patient interaction in an emergency setting which would not fall into the category of trauma nursing. However, with all the stress and violence running through our society at large, much of what enters an emergency setting is classified as trauma. Very few institutions are equipped to handle only the severe trauma cases as we are at the Maryland Institute for Emergency Medicine. I shall attempt to make my remarks broad enough to be relevant to all.

Where does one go for a researchable idea? The idea for potential research is the most important element of research. We must turn to the trauma spectrum of events and the settings in which these occur to get our ideas.

Trauma Spectrum of Events

The trauma spectrum may be divided into definite time sequences which each offer ideas for research. These time sequences consist of:

1) *Pre-trauma* — that period during which stressful events or life styles seem to be leading individuals into potential trauma and/or death.

2) *The accident or injury itself.* Several broad categories of accident have been identified which need closer scrutiny: residential or home accidents, automobile/vehicular, industrial, and recreational.

3) *Transport period to health care facilities.* This may be accomplished by a variety of means: auto, ambulance, helicopter.

4) *Entrance into an emergency care setting.* This may range from a small country hospital to a highly sophisticated trauma center.

5) *Intensive Nursing care.* Today a wide variety of these exist with some subspecialization noted: medical, surgical, pediatric, burn, trauma, etc.

6) *Movement into extended care facilities.* Severe trauma usually necessitates varying levels of care over a period of time and is geared to articulate with extended care facilities and rehabilitation centers.

7) *Re-entry into society.* This is the desired end goal. The individual and family may be drastically altered by the traumatic event.

Researchable Ideas

What are some specific examples of potential research projects? Using the time sequence as a guide, some fruitful areas for research will be highlighted. These researchable ideas can often be posed as questions.

1) *Pre-trauma.* It may be necessary to carry out retrospective studies to determine: What type of individuals seem to be more prone to specific types of trauma? To what extent does life style contribute to trauma? To what degree can life style be modified for "repeaters"? What is the relevancy of "Life Stress Events" for trauma?

2) *The Accident.* Accident patterns change over time. They may be influenced by changes in society. Technology has the potential to modify accident patterns. Our approach to trauma research then might be:

a. Historical approach to accidents. Some examples of pertinent questions are: What forces in society are directly reflected in numbers of victims and types of trauma? What forces are undergoing change that predict changing patterns of trauma in the near future?

b. Epidemiological approach to accidents. This approach provides a more holistic viewpoint or framework for research on accidents. Accidents are viewed as a form of illness and the analysis of them can be categorized: Host - Individual; Agent - Cause of the accident or Trauma; and Environment - Circumstances surrounding the accident.

c. Statistical Approach. This approach has been used by the Employers Insurance of Wausau, Wisconsin (Schleuter, 1970) and employs the concept of "vital few." Applying it to our areas of interest we should ask: What "vital few" types of accidents account for our greatest nursing effort? What are the "vital few" nursing diagnoses we encounter in our particular area of practice? These critical areas highlighted by a statistical approach can give us a starting point for conducting significant research.

3) *Transport.* As a rule nurses are not involved with the transport system except perhaps to conduct classes for paramedical personnel. It is well known that proper triage, speed of transport and the services rendered enroute often make the difference between life and death, or full recovery and disability. Therefore, nurses should take more of an interest in this segment of the spectrum. Specific areas where more research is needed include:

a. Triage. How can decisions be made more accurately and quickly at the scene of an accident? Can simple trauma indices be validated which very early give a clue to the severity of injury and thus provide guidance concerning the most appropriate facility to care for this accident victim?

b. What is the best physical placement for equipment and supplies within transport vehicles which will facilitate the delivery of health care?

c. What specific crises are most frequently encountered during transportation for which paramedical personnel need specialized instruction?

Nurses who are interested in this aspect of trauma care might volunteer for ambulance service in their community to begin assessing the problems and potential.

4) *Admission*. The Emergency Department of a hospital today is probably one of the most challenging areas in which a nurse functions. If ever a well-prepared generalist is needed, it is here. This is also an area where the "expanded" role of the nurse is receiving much attention. This suggests one type of research, namely: the effectiveness of the expanded role of the emergency nurse. Expanded role will likely be defined differently by each institution or possibly in different regions of the country, but it needs to be evaluated systematically in a variety of settings. Since the nurses in an admitting area serve as the filter through which the mass of traumatized victims must pass, they need to be sensitized to those patterns of illness or behavior which are predictive of greater trauma down the road. For example: What specific complaints or presenting signs and symptoms should be viewed as "cries for help"? At what point may potential suicide victims be "turned around"? How may the psychological trauma of rape or assault and battery be minimized? What type of family therapy is called for when "battered children" or "battered spouses" arrive in the admitting area? What patterns of signs and symptoms suggest that a ruptured aorta may be present? One of our nurses is currently looking into this problem. Due to our very alert radiologist, Dr. Robert Ayella, our admitting area is particularly sensitized to this problem and has done an outstanding job of detecting and treating it in time to save many lives.

5) *Surgery*. The surgical area is another highly critical factor in the saving of lives and minimizing of disability. Well prepared, dedicated nurses in this area base their practice on a rapid, but thorough, assessment of the patient's condition and established protocol for the Operating Room. Some major research contributions which could be made here are: The effectiveness of standard protocols. How long do sterile items remain sterile?

6) *Intensive Care*. So much needs to be done within this large category of trauma care. At the moment this is where we are currently placing our emphasis at M.I.E.M. (but only because we have just really made a start) in nursing research. We have selected several broad areas within which "clusters" of studies are being developed. Nurses are being encouraged to identify with a broad area and develop special expertise as well as research skill. Some of these areas are:

a. *Infection*.

1) Catheter Line Infection Study. In this investigation of intravenous and intra-arterial catheter lines used for physiologic monitoring, analysis was made in terms of the congruence of bacteria found at four locations: stopcock, catheter insertion site, blood, and catheter tip upon withdrawal. Our findings are being reported elsewhere.

2) Steroid Infection Study. The relative risk of infection to head injured patients being treated with steriods versus those being treated by placebo is being investigated.

b. *Head Injuries*

We currently are studying the care of head injured pattients in terms of: how effective is hydrotherapy in moving a patient more rapidly through the stages of recovery? Does specific preparation of the family to receive a head injured patient into the home enable them to cope more effectively?

c. *Immobility*

We are attempting to determine: How can potential decubitus ulcer victims be more accurately identified? What scientific rationale for turning and positioning schedules can be developed? To what degree do special turning and pressure-relieving devices actually aid in nursing care?

d. *Nutrition*

This major area of care has received minimal attention from nurses and physicians. We need to pay more attention to: What are the patterns of nutritional intake in trauma victims? How might protein catabolism be minimized? What conditions interfere with retention and assimilation of food? What clinical problems are associated with hyperalimentation? How is vitamin intake related to wound healing and infection?

7) *Movement out into Society*

The movement of the patient into extended care facilities, rehabilitation centers, and home will be considered together. Some specific areas where nurses need to direct their attention are:

a. *Discharge Planning*.

In addition to specific family teaching alluded to above, there are many aspects of discharge planning which need to be identified and studied systematically.

b. *Rehabilitation*

What aspects of rehabilitation need to be started early and run as a thread throughout intensive care? What rehabilitation resources are available? What problems do patients have gaining access to them? Once access is gained, what major problems are encountered? If resources are available and not utilized, what are the reasons? What is the impact of trauma on an individual and the total family for certain major classes of trauma? How might the role of Trauma Nurse Practitioner or Critical Care Nurse Practitioner be developed and utilized to provide continuity of care?

These are just a few of the possibilities I see for discrete research projects under the broad umbrella of trauma nursing. Many areas have been completely overlooked. I hope this stimulates your thinking concerning possibilities in your setting.

Mobilizing for Research

How can you become involved in trauma nursing research? In conclusion, permit me to suggest come concrete ideas which I believe are realistic:

Identify potential research areas within your own agency or field of endeavors.

Identify another nurse or nurses in your area who are interested in research; form special interest groups.

Locate a nurse researcher (or some other type of reseacher) who can help you design, organize, and analyze research.

Put out feelers toward a sound nursing education program in your area where you may be able to obtain faculty consultation and possibly some assistance from nursing students.

Link up with local, state, regional, and national nursing research bodies where much help is available.

Identify members of other disciplines who are interested in and knowledgeable about research; establish collaborative relationships with them.

Consider the possibility of carrying out the same study in different parts of the country and in different types of settings. Model projects could be designed collaboratively and replicated, thus contributing greatly to the validity and relevance of these studies.

Research within nursing is well underway. It is high time we apply it to trauma nursing!

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Educational Opportunities for the Trauma Nurse

THE CRITICAL CARE EMERGENCY DEPARTMENT NURSE EDUCATION PROGRAM IN MASSACHUSETTS

Barbara R. Bennett, R.N.

The Office of Emergency Medical Services, Massachusetts Department of Public Health, provides overall coordination, direction and assistance for the identification of needs and the development of programs in each of the components of the emergency medical services system: hospital-medical, transportation, communications, public education and evaluation.

As emergency medical services system provides coordinated health care both prehospital and in the hospital for the emergently ill or injured person. The emergency patient has the need of immediate and organized intervention by many members of the health care team including physicians, nurses, emergency medical technicians and first responders.

The nursing process that is needed for critical care-emergency department nurses to meet the needs of patients is changing in current practice. Today ED nurses need to be skilled in the intergration of information gathered from the patient's condition, and the reports of the prehospital health care providers. Functioning as a team with the Emergency Department physician, the nurse must establish priorities with rapidity and precision to deal with critical situations. The nursing process is that process which the nurse defines to provide care. To arrive at this process, the nurse synthesizes her assessments, evaluations, judgements and knowledge to identify a nursing care plan for each emergency patient.

The essence of this process is for nurses to be educationally prepared for proper identification of patients' needs and appropriate decision-making with intervention. In order to meet the challenging role of nursing practice, it is essential that nurses continue their education. Continuing education increases knowledge and skills, as well as familiarizing nurses with new developments in the medical world.

The Critical Care Emergency Department Nurse Education Program (CEDNEP) is designed as a resource for continuing education to increase understanding of the pathophysiological concepts related to injury and illness and to provide a basis for team integration for comprehensive health care.

The Nurses Continuing Education Committee was formed in January, 1975, to advise OEMS on the approach and curriculum needed for an emergency department nurse continuing education program. This committee is composed of practicing nurses from around the state, including nurses from clinical specialities (burns, cardiovascular, psychiatry, etc.) and representatives from the professional nursing organizations, Massachusetts Nurses Association and the Emergency Department Nurses Association. With the assistance of the committee, OEMS developed a 137.5 hour curriculum entitled the Critical Care Emergency Department Nurse Education Program (CEDNEP). CEDNEP has been approved by the Massachusetts Nurses Association for 13.7 continuing education units.

The 137.5 hour month-long CEDNEP includes 97.5 hours of theory presentation and 40 hours of clinical experience (two eight-hour shifts in an emergency department and three eight-hour shifts with an ambulance service.

Course Goals and Objectives

The goal of the program is to ensure the high quality of emergency medical care through the development and implementation of continuing education for emergency department nurses. Its objectives:

1) To provide a basis for the understanding of the pathophysiological concepts related to the assessment and the therapy of the emergency patient.

2) To identify the psychological and behavioral aspects of stress related to the illness or injury of the patient and his family.

3) To provide new knowledge of observational acuity and evaluation assessment skills.

4) To promote and apply concepts of planning and providing for standards of comprehensive emergency health care through team approach of physicians, nurses, emergency medical technicians, and members of allied health disciplines.

5) To develop clinical skills in the procedures and techniques used for assessment, monitoring, and treatment of the critically ill or injured person.

6) To provide a basis for nursing interpretations and evaluations of a given outcome of nursing intervention.

7) To learn to establish priorities with rapidity and precision to deal with critical situations.

8) To define guidelines for identification of the nursing process of emergency department nurses.

9) To promote students to develop their own nursing assessment tools to care for emergency patients.

10) To develop teaching techniques for program participants to use for returning knowledge acquired to individual hospitals and medical communities.

Participants

The program is designed for the registered nurse currently practicing in an emergency department. Applicants must be registered nurses licensed in Massachusetts and employed in the Emergency Department of an acute care hospital.

The hospital from which the nurse is from should be participating and playing a key role in the development of an emergency medical services system.

Evaluation Mechanisms

Pre- and post-course tests will be administered. The test is a 100-question examination consisting of multiple choice, true/false completion and matching questions. Weekly quizes will be given, composed of questions from the content of the previous week's lectures. A written course evaluation will be completed by students at the end of the program.

Organization

The State EMS Nurse Coordinator works closely with the cosponsoring medical facility to arrange both medical and nursing staff members as faculty.

Graduates of the month-long CEDNEPs, with the support of their hospitals, are now forming nurse continuing education committees on a local basis. The CEDNEP graduates in each region, along with other interested persons from the area such as directors of nursing, in-service educators, hospital administrators, physicians and regional EMS staff, will comprise these committees, which have the advice, support and assistance of OEMS. These committees decide how best to offer CEDNEP in their area — it may be on a periodic modular basis in order to make it feasible for area nurses to attend. Several regions around the state have begun CEDNEP in a month-long design or a modular one. As long as the program is coordinated through the State EMS Nurse Coordinator and adheres to the 137.5 hour curriculum, it meets the requirements for program approval from the state.

EMERGENCY DEPARTMENT NURSES ASSOCIATION CONTINUING EDUCATION CURRICULUM

Mildred K. Fincke, R.N.

Background

The Emergency Department Nurses Association was formed in 1970 with the improvement of emergency health care delivery as its goal. Professional development through the development of standards and the provision of continuing education opportunities were viewed as primary vehicles to reach this goal. In the intervening years, the *Standards of Emergency Nursing Practice* has been published in conjunction with the American Nurses' Association, and the *EDNA Continuing Education Curriculum* has been prepared.

Philosophy

Emergency nurses are seeking specialty recognition and certification of competence in their specialty. The continuing education curriculum of 25 modules, represents an attempt to document, reinforce, and advance specialty status through serious efforts at defining the realm of emergency nursing and the establishment of a standardized educational program. With certification of competence by examination in the near future, this curriculum serves two roles. First, it provides the basis for the development of the exam by defining the competencies of the emergency nurse. Second, it makes available an educational program designed to prepare nurses for the examination. This strategy of developing the examination from the curriculum which defines the area of expertise in emergency nursing helps insure the development of a valid and fair certification process.

As a model curriculum, these materials are intended to guide course coordinators in the development of comprehensive and relevant educational opportunities for RNs practicing in the emergency department setting. Clinical and management content are included in 25 independent modules.

Each module is set up with objectives and an outline of the content needed to meet each objective. In addition, suggestions are made for teaching methods and possible learning experiences and for methods of evaluation. Any individual or organization truly motivated to sponsor a course in emergency nursing may purchase the Emergency Department Nurses Association Core Curriculum.

Emergency nurses are aware that their continued professional development must come through education. The Emergency Department Nurses Association Curriculum had been endorsed by the American Nurses' Association. With this formal approval, the Emergency Department Nurses Association Education Committee felt confident that they had developed a document that would help course coordinators meet the needs of their nurse learners.

AN EMERGENCY NURSE PRACTITIONER PROGRAM

Denise H. Geolot, R.N., M.S.

Before discussing the Emergency Nurse Practitioner program, it seems appropriate to look at some of the trends in emergency health care which have contributed to the need for this practitioner. In the last two decades there has been a tremendous increase in the utilization of Emergency Departments. This year DHEW estimates that approximately 50 million people will enter the emergency health care system which represents a 300 percent increase in the number of visits, compared to twenty years ago.

Associated with this trend is the large percentage of people seeking health care in emergency facilities for nonacute problems. In a Chicago study by Gibson in which he classified the patient population in emergency departments as emergent, urgent and non-urgent, over 50 percent of the patients seen were not considered clinical emergencies by the attending physician and did not need the specialized recources of a hospital emergency department. It seems that the Emergency Department is being used more and more as a primary health care facility by those who perceive that they need medical care but do not perceive that they have any other access into the health care system.

In addition to the increased utilization and large percentage of patients seeking primary care in emergency care facilities, the method of providing physician coverage in the smaller urban and rural facilities suggest the need for this type of program. In a study by Prybill and Clark, 36 percent of the Emergency Departments in Virginia did not have 24-hour physician coverage. In some facilities without physician coverage, the patient cannot receive any form of treatment until the physician is contacted and prescribes the treatment.

For these reasons and the apparent needs in this region for this type of program, the University of Virginia planned and implemented an Emergency Nurse Practitioner Program which is presented jointly by the Graduate Division of the School of Nursing and School of Medicine, Emergency Medical Services. The purpose of this program is to provide registered nurses with the additional knowledge and skills needed to deliver primary and emergency care services to patients in emergency care facilities. Some of the knowledge and skills include: interviewing techniques, history taking, physical examinations; triage techniques, managing adult and pediatric patients with non-emergent problems with physical consultation, collaboration, or under established protocols; providing basic and advanced life support; crisis intervention, patient/family teaching and counseling, and referral to other resources used to supplement and/or enhance emergency care services.

The ENP program is one of four practitioner programs at the School of Nursing. The entire program is one academic year in length and combines full-time study and clinical experience with a three-month preceptorship.

The first month of the program consists mainly of core material taken with the other practitioner students. The core component consists of lectures in anatomy and physiology, pharmacology, bacteriology, nursing process, communication skills, interviewing techniques, physical assessment and trends in health care delivery. Included in this component are clinical and laboratory experiences which correlate with the class content. As the ENP student progresses through the next three months of the program, less time is spent on core material and more time is spent on material specific to emergency care. Some of this content includes: the concept of the EMS system, the assessment and management of common nonacute health problems of the adult and child frequently seen in the Emergency Department; the emergency management of problems and injuries specific to each body system; therapeutic communication and crisis intervention; principles of screening and triage, and patient education. Some of the skills include: EKG interpretation, suturing, arterial punctures and other basic and advanced life support measures. During this period, students spend at least ten hours a week in the ambulatory and acute care areas practicing interviewing and physical assessment skills. At this time, each student must also successfully complete the American Heart Association Virginia affiliate CPR instructor's course.

The next three months of the program consists mainly of clinical rotations. Each clinical rotation is a three-week concentrated experience in a selected emergency department. At this time, seven emergency departments located throughout the state of Virginia in rural and urban facilities are clinical sites for this program. The student works 40 hours per week as an Emergency Nurse Practitioner under the direction of a physician preceptor. Each student is scheduled for three rotations in different settings to gain experience in both rural and urban emergency departments. After each concentrated experience, the student returns to the University for two more days of classes and then goes on to the next clinical site.

The final portion of the program, which the student is responsible for arranging, is a three-month preceptorship in an emergency care facility with a physician preceptor. During this period the student works as an ENP functioning independently when making decisions about nursing but functioning with physician supervision when making decisions about treatment and performing specific functions, traditionally associated with the physician's role. Throughout this period, the School of Nursing maintains contact with the student and physician to determine the student's evaluation and level of performance. At the end of the preceptor experience, the student must successfully complete a comprehensive examination and receive a satisfactory performance evaluation from the physician preceptor.

At the successful completion of the program, the student is awarded sixteen hours of graduate credit and a certificate. This program is an approved nurse practitioner program by the Virginia State Board of Nursing and Medicine. Graduates from approved programs are eligible for certification as Nurse Practitioners in the state of Virginia. Students enrolled in this program are considered special students in the Graduate Division of the School of Nursing. In the event the student wishes to apply the graduate credit toward a Master's degree, he/she must apply for admission and meet all requirements of the graduate school.

Prerequisites for admission to the Emergency Nurse Practitioner Program are: 1) minimum of at least two years of professional experience with at least one year in an emergency or acute care setting; 2) demonstration of academic potential by satisfactory scholastic achievement in the basic nursing program; 3) completed application with three letters or recommendation evaluating professional ability and potential for further professional development; and 4) personal interview with a faculty member from the program. Highest priority is given to applicants who have a position as a nurse practitioner awaiting them upon completion of the program.

In summary, this has been a brief overview of the Emergency Nurse Practitioner program at the University of Virginia. It is another example of a continuing education program which is now available for Emergency Department and Trauma nurses who are interested in improving their own knowledge and skills, thereby helping to upgrade the quality of emergency health care being delivered.

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THE WORKSHOP PROGRAM IN MARYLAND

Margaret Trimble, R.N.

The EMS Act states "an emergency medical services system shall provide for its personnel appropriate training and continuing education programs." Professional organizations concerned with critical care and emergency nursing, such as the American Association of Critical Care Nurses (AACN) and the Emergency Department Nurses Association (EDNA), have developed standards and curriculum guidelines for the specialties, but there exists no adequate implementation of programs to meet these standards.

The prehospital care in Maryland and many other states is becoming more sophisticated due to the heavy training emphasis and funding for ambulance attendants, that is, the Emergency Medical Technician (EMT), the Cardiac Respiratory Technician (CRT), and other paramedical personnel. But frequently the level of sophistication drops at the emergency department door, because the nurse and physician lack of the knowledge and management skills necessary for care of the critically ill or injured, and because the standards and policies of the hospital and emergency department may not have kept pace with the advances in emergency medicine.

To illustrate these contentions, consider the cardiac arrested patient who need the administration of a drug or the unconscious patient in need of an airway — either esophageal or endotracheal; consider the patient with a fractured femur who could benefit from application of a Hare traction splint; simpler and sadder yet, consider the patient in shock who merely needs an intravenous line started. There is no hospital in the State of Maryland which has nurses capable of or permitted to perform all of these life saving maneuvers even though the paramedic can perform any of them outside the emergency department door.

A last consideration in justifying the need for a continuing education program is the accepted fact that newly graduated nurses are generalists. Further education and training is necessary for these nurses to function at a minimum and safe level in the emergency department or critical care area.

In 1974, there were 12,056 nurses registered in the State of Maryland. There are 45 hospitals with emergency departments and nineteen schools of nursing. There is an established emergency medical system which includes nine specialty referral centers.

Patients are transferred into eight of these centers by Med-Evac helicopter and telemetry equipped ambulance from all of Maryland, and parts of Pennsylvania, Delaware, West Virginia, Virginia and the District of Columbia. With this rapid transportation system and early prehospital institution of life support techniques, patients who previously would have died at the scene or in transit are now reaching local hospitals. This establishes a need for ever increasing expertise in management of the critically ill and injured at the point of hospital arrival.

The specialty referral centers are located in the urban areas of Maryland, and although they are far advanced in patient care techniques, the standard of care in the rest of the hospital community frequently has not kept pace, due to the lack of information dissemination and the absence of any organized teaching programs for improved patient management concepts and techniques.

In the past year in Maryland, two nurse coordinator positions were established in the Division of Emergency Medical Services (D.E.M.S). One of the goals of the nursing program was to develop workshops for nurses involved in emergency and critical care. After preliminary meetings with nurses across the state, the following topics were defined as priority areas: 1) Medical Emergency: a. Cardiac, b. Respiratory, c. Diabetic; 2) Trauma Management; 3) Crisis Intervention; 4) Burn Management; and 5) Pediatric Emergencies. The two D.E.M.S. nurses were joined by two nurses from the Maryland Institute for Emergency Medicine and developed workshops for the above priority areas.

The workshops varied in length from one day to three days and were approved for continuing education units by the Maryland Nurses Association. Scheduling was done according to requests from hospitals, community colleges, and specialty groups (e.g., Industrial Nurses Association, EDNA, AACN). In ten months, 40 workshops were presented with a total attendance of 1,500. The target audience remained the nurse in emergency or critical care, but nurses from other areas, as well as paramedics and physicians, were accepted on space available basis.

For each of the workshops, specific behavioral objectives were defined, workbooks compiled, and audiovisual aids developed. Biographical data and baseline evaluation information was collected from each participant. For example, all participants were asked what continuing education they had received on the specified subject within the previous two years. (Table 1)

The participants were also asked the incidence of specific problems they encountered. Table 2 shows the response of 50 nurses who attended one Pediatric Emergency Workshop.

They reported an overwhelming number of pediatric problems, yet 68 percent of this group had no form of continuing education in the previous two years. In the Diabetic Emergency Workshop, 85 percent of those attending had no continuing education in the previous two years, yet the majority were faced with a diabetic emergency about ten times a week.

The need for upgrading the standard of care was reinforced by reports from the specialty centers. Problems were occurring in emergency management of patients on admission to the local hospital, in preparing the patient for transport to the specialty center, and in communication among the various members of the health care team about the continuing medical care needs of the patient. For example, the trauma patient frequently arrived without a secured airway; the burn patient had inaccurate assessment of wound area and was not being transported early enough to fully benefit from the specialty center; telemetry was bringing the arrhythmia into the emergency department, but the nurse on duty was unable to identify the life threatening pattern; and child abuse was going undiagnosed and unreported.

TABLE 1: Percent of workshop participants with no continuing education in past 2 years

Workshop Topic	Percent
Respiratory Emergency	86%
Diabetic Emergency	85%
Burn Management	82%
Trauma Management	68%
Pediatric Emergencies	68%
Cardiac Emergencies	57%
Crisis Intervention	79%

TABLE 2: Specific problems encountered by 50 nurses attending a Pediatric Emergency Workshop

Problem	Incidence in Previous 3 Months
Multiple trauma (peds)	389
Child Abuse	75
Poisonings	300
Respiratory distress	669
Cardiac	31
Seizure disorders	301

Although education is the primary goal of the workshop project, there are many secondary gains. The local community resource people are involved as instructors and have opportunity to be identified and given feedback; the encouraged exchange of information and feelings between participants helps to close the gap between the paramedic and the nurse, as well as serving as an opportunity for inter- and intrahospital problem solving; the knowledge gained serves as an inpetus in the expanding of the nurse's role and encourages her independent functioning wherever appropriate. Lastly, there have been workshops requested by schools of nursing so that the most current information on emergency and critical care nursing becomes part of their curriculum.

The State of Maryland is divided into five regions. Each region has an EMS Council which identifies needs of the region including nursing education needs. Nurses are represented on the councils. To insure adequate representation, an advisory nursing group composed of nurses from a variety of hospitals and specialties will be formulated within each region. A nurse coordinator of the workshop project will attend meetings of the advisory groups to insure responsiveness and pertinence of local continuing education workshop.

The basic plan will be to present each of the seven workshops at least once in each region — a minimum of 35 workshops in 10 months. It is anticipated that some regions will require two of each workshop due to the density of nursing population and large geographical area to be covered.

Additional requests for workshops are honored from schools are . nursing, community colleges, and professional organizations. In all, 60 workshops are presented each year.

Additional workshops are developed as needs and priorities are identified. The decision has been made to develop at least three additional workshops: neonatal emergency care, orthopedic emergencies and blood gas interpretation.

The anticipated changes in existing workshops will be an increased specificity and depth of topics and skills. The need and feasibility of an additional nurse training for longer periods in clinical settings also will be evaluated. The workshops will serve as the basis of prerequisite for any additional specialty training, so that there will be maximum use of personnel and resources and minimum of duplication and inconsistency.

The need for continuing education of the type represented by the workshop project is unending; therefore the division will incorporate into its state budget the cost associated with the project.

Advantages of Workshop Project

1) Availability of a minimum of 24 hours of continuing education is guaranteed to every nurse in emergency and critical care in the State of Maryland.

2) The program brings the training to the student's locale, rather than burdening the participants with traveling, lodging, and the attendant time away from work.

3) No charge to the participants is made by the State. Junior and community colleges may charge a fee to cover lunch, audiovisual technicians, or secretarial support for registration and recording of continuing education units.

4) Continuing education is offered to many rather than a select few as is found in longer, centrally located programs.

5) Each workshop reinforces the others but does not duplicate.

6) Information presented is the most current available and

is standardized.

7) Time is allotted for case discussions, problem solving, and information exchange between agencies, specialty areas, other professionals in the health field, and EMS representatives.

8) Nurses plan, coordinate and implement these continuing education programs for nurses.

Measuring Accomplishment of Aims

Methods of Evaluation

Status at the beginning of the project is measured by pretest administered to each participant on first day of workshop, and biographical data sheet including attitudes, procedures, facilities, and incidence of emergent problems, also filled out by each participant on the first day of each workshop.

Progress is measured by participation in case discussions, demonstration of skills, and post-testing on the last day of each workshop.

Follow-up evaluation is done six months after the workshop by head nurses and supervisors in the local hospitals. They know the quality of care delivered by workshop participants. Thus, they are in a position to assess changes by their nurses staffed in patient care and the degree to which that staff demonstrate the behavioral objectives outlined for each workshop.

An outcome audit is under development by the Program Evaluation Branch of the Division of Emergency Medical Services with consultation from the nurse coordinators. This audit will be conducted at yearly intervals and will reflect long term results of the workshop program, as well as the rest of the emergency medical services system. These audits will be conducted in the specialty referral center as well as in the local hospitals.

Personnel from the specialty referral centers provide consultation to the nurse coordinators and participate as instructors in the workshops. D.E.M.S. supplies audiovisual support (development and maintenance and publicity) through the Office of Public Education and Information. The Maryland State Police paramedics participate as consultants and instructors in the workshops. Regional coordinators of the Division of Emergency Medical Services manage the selection of workshop sites, registration of participants, and problem identification for specific regions. Specialty organizations, such as the Guild for Infant Survival and Burn Victim Aid Society, supply volunteers and booklets for the workshops.

Institutional Factors Which Affect The Success Of The Program

Attendance at workshops requires cooperation of hospital administration and nursing supervisors — particularly in scheduling the individual nurse who wishes to participate.

Maximum publicity of workshop project depends in part upon continuing education directors and head nurses within each hospital.

The implementation of new skills and knowledges may in part depend upon hospital policies.

Room size may occasionally limit registration.

Collaboration With Other Institutions or Agencies

Community colleges host the majority of workshops; the responsibility of content and organization remains with the nurse coordinators and DEMS. Curriculum of workshops employs the Core Curriculum of A.A.C.N. and the E.D.N.A. Modules, but is not rigidly bound by them. Specialty organizations may co-sponsor for annual meetings, etc. (e.g. Orthopedic Nurses Association, Industrial Nurses Association, Emergency Department Nurses Association). Success of the workshop program does not depend upon the above, but is designed to function independently.

In conclusion, the workshop program has proven effective in reaching over 1,500 nurses with approximately 50 workshops. Because of program flexibility, it is equally applicable for rural as well as urban areas.