Elements of a comprehensive Emergency Medical Services system

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A "systems" approach to the provision of emergency medical services allows community leaders to plan and implement a comprehensive program to meet their specific needs. Development of an effective EMS system requires familiarity with the components of which the system is made up. Among the necessary components are recognition of an emergency situation, the provision of first aid, the ability to communicate with emergency treatment facilities, transportation in appropriate vehicles, the availability of well-trained emergency care personnel, categorization of emergency care facilities, and data collection and audit. It is imperative that dynamic, informed civic and professional leaders assume responsibility for making comprehensive emergency medical services a reality rather than a much-discussed but unfulfilled "plan."

The potential for survival following sudden catastrophic illness and injury is maximized when the incident is promptly recognized and the cry for help is answered rapidly. Those who respond to the incident must be well trained, properly equipped personnel who can immediately initiate life support actions and perform rescue and extrication procedures.

Establishment of a communication channel between the rescuer and a physician or medical advisor extends the capability of the system still further. It provides a means by which the administration of definitive treatment may be guided by medical personnel.

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Therapy, in the form of intravenous fluids, resuscitative drugs and defibrillation, may be needed to stabilize the patient's vital systems at the scene and during transport. Personnel at the receiving hospital should be able to continue life support activities. If necessary, arrangements for orderly transfer of the patient to a higher echelon facility—one offering extended critical care—should be routine.

All elements of such a sophisticated, multilevel, multifaceted response system must operate in an expeditious, coordinated manner, following a general prearranged plan of action. Yet each must retain sufficient flexibility to deal effectively with unforeseen contingencies.

The various phases of medical emergencies will be examined and methods suggested by which the community response in each phase might be optimized. General recommendations for the implementation of such an emergency medical response system, will be offered.

RECOGNITION

Before any of today's resuscitative measures can be applied, someone must recognize that an emergency exists. In some instances, such as motor vehicle accidents, recognizing the existence of an emergency is no problem; but in others, it can be very difficult. The middle-aged man experiencing moderate chest pain may dismiss it as "indigestion" or "heartburn." He may take a patent medicine and wait for the pain to pass, failing to realize that the pain may be the harbinger of acute myocardial infarction. Since 60% of myocardial infarction deaths occur within one hour after onset of symptoms,[1–3] the present median delay of 3½ hours in seeking help[4] renders many of our present life-saving procedures useless.

Clearly, there is need to improve the public's knowledge regarding acute myocardial infarction and other common emergencies. Educational programs which attempt to alleviate this potentially lethal ignorance should not only emphasize the need for promptly requesting assistance in cases of suspected heart attack but also the favorable outcomes resulting from early initiation of high quality care for heart attack patients.[5] This latter aspect is important in helping to alleviate the anxiety and reticence associated with admitting, especially to oneself, that a potentially lethal event has occurred.

Having recognized that an emergency exists, those on the scene must initiate appropriate action if an optimal outcome is to be realized.[6–8]

FIRST AID

By including courses in emergency care and resuscitation in high school curricula and as a prerequisite for obtaining a motor vehicle operator's license, the general public would be better equipped to provide immediate on-site measures essential for survival.

First-aid courses for the general public should provide training in airway control including head tilt, mouth-to-mouth and mouth-to-nose breathing, forward displacement of the mandible, removal of an obstructing foreign body, and positive pressure ventilation.[9] Training in methods of controlling hemorrhage and immobilization of fractures (including possible fractures of the spine) is equally essential.

External cardiac compression cannot be learned to proficiency without actual practice by the student. Therefore, programs of instruction in cardiopulmonary resuscitation must include instructor-guided practice on life-like resuscitation manikins. A new resuscitation manikin (Fig. 1) automatically provides the trainee with a printed record of his performance. Such a manikin can reduce the number of instructor hours required to train a population, thereby increasing the feasibility of training large numbers of people. In addition, it can provide the opportunity for controlled practice in privacy, thus eliminating the potentially embarrassing situations created when students are required to demonstrate their proficiency, or their lack of it, in the presence of others.[10]

COMMUNICATION

After an emergency has been recognized and immediate first aid has been started, help must be summoned. In many areas of the country, this may be a monumental problem. Bystanders may not know who to call for help. Should a call be placed to the police, the fire department, the telephone operator, the hospital emergency department, a private ambulance company or a special rescue

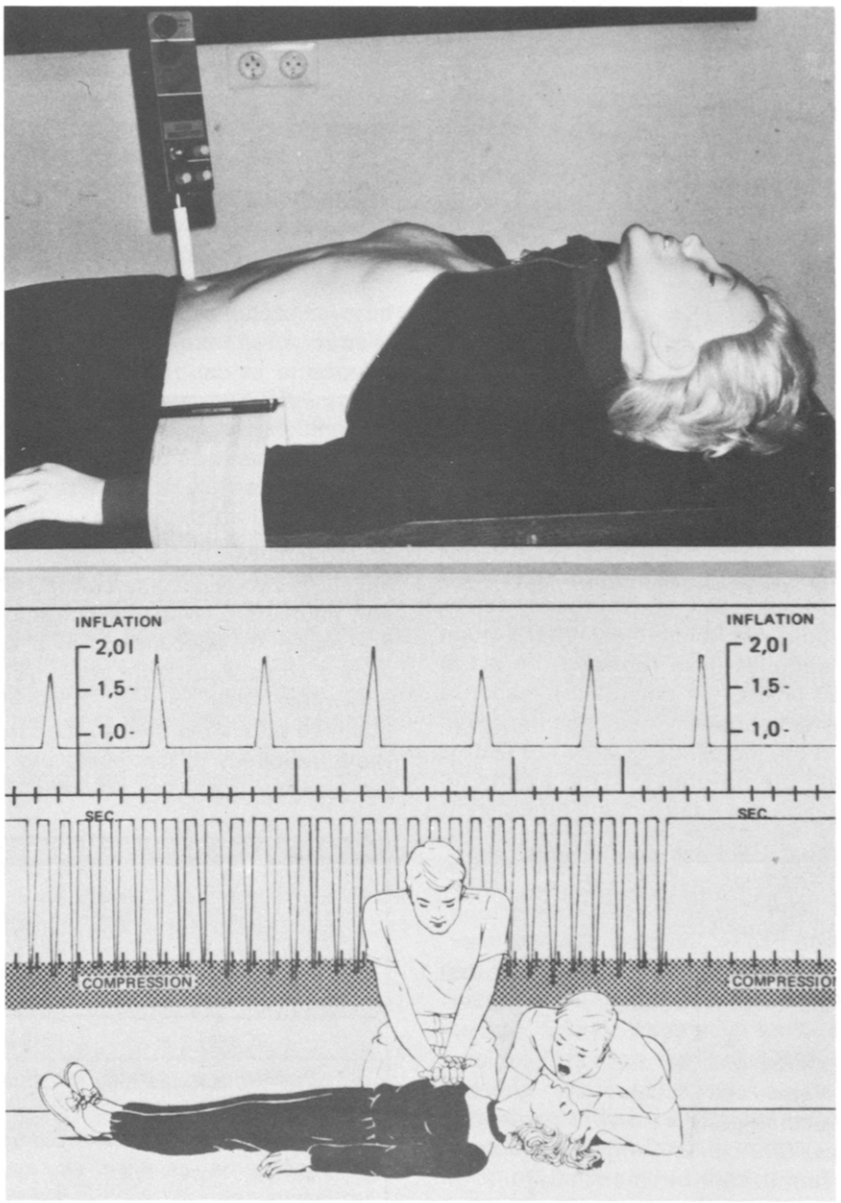

FIGURE 1. ***New Laerdal Resusci-Anne CPR recording manikin.*** *Top: battery-powered recorder in abdomen automatically delivers record from left flank. Pole on right hip with lights and metronome is for teaching correct rhythmic performance. Trainee learns by seeing correct ventilation performance (green light), correct external cardiac compression (ECC) performance (red light) and incorrect ECC hand position (yellow light). Instructor can control spontaneous pulse and pupillary constriction and dilation. Enclosed in manikin's suitcase are flip-chart pictures and tape-recorded coaching for manikin practice. Bottom: record of ventilation volumes and sternal compressions. Incorrect positioning of hands for compressions is also recorded.*

From: Kirimli, B and Safar, P: Ch. V/iv, Training Methods in Cardiopulmonary Resuscitation, pp. 453-477, in Meltzer, L.E. and Dunning, A.J. (Editors): Textbook of Coronary Care, The Charles Press, Philadelphia/Excerpta Medica, Amsterdam, 1972.

unit? Lack of a coin to place a call may delay communication with rescue personnel. Strangers in the community may be unable to determine the location from which they are calling. This can delay or prevent their providing direction of the rescue unit to the scene of the emergency.

Ideally, any person should be able to obtain access to the emergency medical services system by dialing the "universal" emergency telephone number from any telephone without inserting a coin.[11] In the United States, the number 911 is set aside and dedicated for use in emergencies. In areas where access to private or coin phones may be limited, such as beaches, expressways or crowded shopping plazas, two-way emergency telephones providing direct communication with an emergency center should be available. Where such telephones have replaced fire alarm pull boxes, the emergency response system capability has been improved and the incidence of false fire alarms has plummeted.[12] The ability to analyze the nature of the emergency, and dispatch the appropriate resources, has reduced cost as well as exposure to hazard for the public and rescue crews.

Where financial or technical limitations preclude prompt conversion to a 911 system, simple modifications of existing telephone systems can substantially enhance the community's ability to respond to a call for help. Existing coin telephone systems can be modified to allow access to the operator without first inserting a coin ("Dial tone first"). Posting the street address of each coin phone on the face of the instrument will enable callers unfamiliar with the neighborhood to identify their location when requesting help. Small adhesive telephone labels giving local emergency telephone numbers can be distributed throughout the community by enclosing them with the water or electricity bills.

The communication system component upon which all others depend is the Emergency Operations Center (EOC). EOC functions include receiving and analyzing emergency calls for assistance, dispatching and coordinating the response units (e.g., ambulance, rescue trucks, fire equipment), and issuing "what to do" instructions to the caller pending arrival of rescue vehicles.

Automatic EOC equipment should be capable of pinpointing the location of the caller. Reliable communication links must exist between the EOC and all organizations participating in the rescue response. Closed circuit telephone lines or two-way radio systems must be used to protect communications security under adverse conditions, such as civil disorder and mass disaster.

All units participating in the emergency rescue efforts should be linked by two-way voice communication equipment. When rescue efforts are made by specialized units with widely disparate functions (e.g., snowplow, fire rescue, and ambulance) all should share a common radio frequency so that plans and action can be directly coordinated.[13]

Like telephone systems, radio networks have limitations. Most commonly used two-way radio systems allow broadcasting of only one message at a time. Simultaneous broadcasting of two messages results in varying distortion of both. Since many potential users employ a single frequency, optimal use of available transmission time demands that all messages be brief and meaningful. Use of the communications code such as that shown in Figure 2 facilitates succinctness and also provides a modicum of privacy.[14]

TELEMETRY

Physiologic data requires interpretation by personnel specially trained in its evaluation. Telemetry is a communication technique which permits data to be collected and transmitted so that its interpretation may be accomplished at a distance. For example, the standard electrocardiograph signal can be broadcast (telemetered) to a physician with the proper receiving equipment permitting review and interpretation of the

FIGURE 2.
EMERGENCY COMMUNICATIONS CODE

Case	Region of Body	Ten Code
1. Breathing or Airway Disturbance	1. Head	10-4 OK
2. Bleeding or Open Wound	2. Face	10-5 What is the patient's condition
3. Bones, Poss. Fracture	3. Neck	10-8 Back in service, Available for call
4. CARDIAC ARREST	4. Chest	10-9 Repeat message
5. Burn	5. Abdomen	10-19 Return to station
6. Blunt or Closed Trauma	6. Perineum	10-20 What is your location
7. Heart Attack	7. Upper Extremity	10-23 Stand-by
8. Stupor or Coma	8. Lower Extremity	10-24 Police help needed
9. Dead at Scene	9. Multiple Regions Involved	10-30 Test count
12. Routine Case	11. Back	10-31 How are you receiving
13. O B Patient	12. No Specific Region Involved	10-96 Enroute to scene
14. Multiple Trauma Case	**Condition of Patient**	10-97 Arrived at scene
15. Pain in _____	2. Serious	10-98 Patient in amb. enroute to Hos.
18. Psychiatric Case	4. Life Threatening	
19. Intoxicated	12. Satisfactory	
20. Refused Service	13. Delivery Imminent	
21. No Patient		

ECG tracing at some distance from the scene.[15-17] Ambulance equipment should include devices which will permit telemetry of electrocardiogram.

VEHICLES

A comprehensive emergency medical services system requires that all ambulances be designed, equipped and manned to provide light rescue, life-support, extrication and transportation of the critically ill and injured. Minimal requirements for ambulance design and equipment have been published by the National Academy of Sciences Sub-Committee on Ambulance Services.[18] These requirements have been adopted, in part, by the U.S. Department of Transportation. The standards, written by an expert panel of physicians and non-physician emergency care specialists, describe the minimal spatial configuration of the vehicle and the essential fixed and portable life-support equipment to care for the critically ill and injured.

BASIC TRAINING OF PERSONNEL

Patient care attendants must have attained basic competency in emergency care procedures. These include, at a minimum, procedures required to sustain viability of essential organs until adequate spontaneous function can be restored by definitive care. They must further have knowledge of what and what not to do to prevent aggravation of the illness or injury.

Currently the standard basic training program for emergency medical technicians (EMT's) consists of 71 hours of seminars, demonstrations and practice conducted by physicians and lay professionals. The training course subject matter includes airway control, intermittent positive pressure ventilation, oxygenation, and cardiopulmonary resuscitation. Management of situations involving possible spine injuries, fractures, wounds, hemorrhage, emergency child birth, stroke and myocardial infarction, is presented. In addition, emergency vehicle operation, light rescue and extrication, and administrative aspects of ambulance services are included. The trainees must also spend ten hours observing patient care in hospital critical care areas such as the operating room, recovery room, intensive care unit and emergency department.[19]

Upon completion of this course, or its equivalent, the emergency medical technician is eligible to take the examination for the Registry of Emergency Medical Technicians — Ambulance.[20-21] Just as a nurse is "registered" at the state level, so also may ambulance personnel now be "registered" at the national level. After successfully completing written and practical examinations in emergency care methods, the emergency medical technician is issued a nationally recognized certificate of proficiency and is entitled to display the registry patch on his uniform. Registration is valid for a period of three years. Renewal is not automatic but requires submission for re-examination of competence.

MOBILE INTENSIVE CARE

Pilot projects in many areas of the country have demonstrated that mobile intensive care type ambulance services can substantially reduce prehospital mortality and morbidity.[6,12,23]

Mobile intensive care units (MICU's) are ambulances which meet national standards and carry equipment for the provision of definitive care as well as emergency care. Definitive care includes measures to prevent cardiac arrest and irreversible organ damage from anoxia, shock and other serious conditions. Diagnosis, defibrillation, drug therapy, and intravenous fluid therapy must be within the capability of the unit. Equipment and supplies for providing definitive care include an electrocardioscope, a defibrillator, intravenous infusion equipment, resuscitative drugs and equipment for emergency surgical procedures. The MICU may, in addition, carry equipment for telemetry of physiologic data from the site to an advising physician.[22]

HIGHER LEVEL TRAINING

Personnel on board the MICU should be trained to the intermediate emergency medical technician level.[24] The intermediate level, to be defined by the National Academy of Sciences/National Research Council Sub-committee on Cardiac Emergencies, will probably consist of 80 to 100 hours of training in addition to that required for the basic level EMT. The content of the intermediate level program will include medical observation and communication, review of airway control, oxygenation, ventilation, external cardiac compression, intravenous fluid therapy, defibrillation, telemetry-medical command systems, safe use of resuscitative drugs and maintenance of definitive care equipment.

In addition to the two levels of EMT training described above, a third program consisting of 480 hours of instruction is available.[25] This course reviews all the material presented in the basic and intermediate programs and provides the EMT with a more intensive education in emergency care, organization, and communication, which includes much clinical and administrative experience. The advanced EMT training is sometimes coupled with a physician's assistant program as in the program at Yale University.[26] Courses have also been provided through the junior colleges leading to the Associate of Arts or Associate of Science degrees.[27] Combinations of both these programs can be found.* Advanced programs of this type are designed to train EMT's for positions of responsibility in this field.

CONTINUING EDUCATION

A comprehensive emergency medical services system requires a program for continuing education of emergency care personnel. This program, delivered through annual or semi-annual meetings of professional associations as well as through

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professional journals[28] enables emergency medical technicians to maintain knowledge and learn improved methods of providing emergency health care.

Ambulance and mobile intensive care services should have a medical advisor who conducts frequent debriefing and practice sessions. At these meetings, which should be held at least monthly, the EMT's may present problems, discuss cases, or investigate innovations in emergency care. They may also practice skills learned earlier so that life-saving techniques, not utilized routinely, may be performed satisfactorily when they are required.

LEVELS OF CAPABILITY

Speed in getting the patient to the emergency facility is usually not crucial if rescue personnel are properly trained, adequately equipped and work in a well-designed vehicle. In fact, speed is frequently detrimental.[29] Far more important than speed en route is the level of capability of the receiving facility.[30]

Limitations in financing and manpower, as well as increasing demand for service, make it impractical and unreasonable for every hospital to offer a full spectrum of elaborate critical care services. While all hospitals which receive emergency patients should offer basic life-support services, not all hospitals should attempt to provide sophisticated care of the critically ill and injured. Instead, hospital capability should be inventoried and categorized according to the degree of sophistication available. Changes should be implemented as appropriate within the frame-work of a community plan to improve some and, perhaps, downgrade others.

The ultimate goal of hospital categorization is to offer critically ill patients the best possible care at the lowest cost. The immediate objectives of categorization should be two-fold: (1) to provide ambulance operators with a list, endorsed by both providers and consumers, of hospitals which should receive the critically ill patient; (2) to provide physicians attending the critically ill and injured with information on levels of critical care services available within the local referral region. Since less than 2% of present Emergency Department visits are for critical, life-threatening conditions, the present patterns of emergency department usage would be little changed. Instead, complex, expensive-to-manage patient problems would be selectively routed to the nearest appropriate emergency facility.

There are situations when terrain, weather or other circumstances make transportation to an emergency care facility impossible or impractical. Emergency receiving facilities, be they hospitals, industrial clinics or emergency care stations, should be capable of providing life-support functions and arranging for transportation via mobile intensive care unit to a definitive care facility.

CATEGORIZATION

Categories of emergency care offered by various types of hospitals[31] as well as methods for surveying and categorizing hospital emergency facilities[32,33] have been published. One categorization scheme has been proposed which divides medical facilities into four types.

The Type IV facility need not have a doctor available full time, but must be staffed by emergency medical technicians capable of sustaining the critically ill and arranging transportation, with on-going life support, to a more comprehensive facility.

A Type III facility is staffed 24-hours-a-day by a physician and has the capability of providing intensive nursing care and routine surgical care.

Type II facilities are staffed 24-hours-a-day by a physician as well as physician specialists of at least the resident level in those fields required for emergency life support, which includes anesthesia, surgery, internal medicine, pediatrics, obstetrics. The availability of nearby specialty hospitals may eliminate the need for pediatricians or obstetricians in the primary receiving hospital.

A Type I facility provides comprehensive medical care and is staffed 24-hours-a-day by physicians representing the major specialties required for life support. In addition, this facility should have advanced intensive care capability which includes a physician specialist exclusively committed to the care of the critically ill and injured. This facility should offer treatment for complex problems of patients with multiple organ failure.[34]

DATA COLLECTION AND AUDIT

A comprehensive emergency medical services system will include a mechanism for gathering data which describes the performance of all subsystem components such as bystanders, system-access ambulances, and referral hospitals. Such data should be processed by a central computer facility and should relate patient outcome to the performance of each subsystem component. This data should be used to improve the system and, hopefully, to decrease cost.

By installing computer terminals in accessible locations, physicians faced with difficult patient care problems may request information from the data bank on how such problems have been handled in the past and the outcomes that have been attained by various methods of management.[35]

COMMUNITY COUNCILS

Persons responsible for emergency medical system operations must seek input from health care consumers. Careful consideration of consumer comments may help to develop more efficient methods of dealing with patient problems. Where efficiency cannot be improved, or where consumer demands are unrealistic, the dialogue established between consumers and providers may alleviate much misunderstanding and hostility.

Since the emergency medical services system will undoubtedly be asked to accept new and improved treatment methods, a responsible group of providers and consumers

must be available to study and screen proposed alterations in the system. Such a group will ensure that responsible, humane, ethical, and medically sound practices prevail. Products and methods that are screened by such a committee and subsequently pass field tests, may then be introduced on a wide scale.

The tragedies in the operations of emergency medical services do not occur because knowledge and skills are lacking. The tragedies arise from failure to use existing knowledge and skills in a productive manner.

Since a comprehensive emergency medical service system impinges upon so many traditional lines of authority, interest and responsibility, the most effective way to plan and implement needed changes is through a Community Council on Emergency Medical Services. This local Council must have representatives from all parties concerned with local emergency medical services. Broad-based representation will encourage the discussion necessary to resolve conflicts and plan needed changes. Such a community council may be formed *de novo* or as an outgrowth of an existing organization such as a county medical society or a hospital council. Some areas of interest to community councils should be public education and training, communications, ambulance design and equipment, training for emergency medical technicians and allied health professionals, hospital categorization, regionalization of care, research and evaluation.

In summary, the development of an effective emergency medical services system that is responsive to the community's needs is a matter that should carry high priority with community planners. Although the difficulty of devising such a system may seem overwhelming, a concerted effort by consumers and providers joined in a community council can plan and implement an EMS system using technology that is currently available. It is doubtful if any other system can produce such widespread benefits to the community it serves. ◆

REFERENCES

1. Pantridge JF, Geddes JS: A mobile intensive care unit in management of myocardial infarction. *Lancet* 2:271-3, 1967.
2. Pyo YH, Watts RA: A mobile coronary care unit: an evaluation for its need. *Ann Intern Med* 73:61-6, 1970.
3. Gordon T, Kannel WB: Premature mortality from coronary heart disease: the Framingham study. *JAMA* 215:1617-25, 1971.
4. Moss AJ, Goldstein S: The prehospital phase of acute myocardial infarction. *Circulation* 41:737-42, 1970.
5. Early care for the acute coronary suspect: Six Bethesda Conference. *Am Cardiol* 23:603-18, 1969.
6. Rose LB, Press E: Cardiac defibrillation by ambulance attendants. *JAMA* 219:63-8, 1972.
7. *Accidental Death and Disability.* Washington DC, National Academy of Sciences/National Research Council, 1966.
8. Community-Wide Emergency Medical Services: Recommendations by the Committee on Acute Medicine of the American Society of Anesthesiologists. *JAMA* 204:595-602, 1968.
9. Safar P: Recognition and management of airway obstruction. *JAMA* 208:1008-11, 1969.
10. Winchell SW, Safar P: Teaching and testing lay and paramedical personnel in cardiopulmonary resuscitation. *Anesth Analg* 45:441-9, 1966.
11. Recommended Standards for Development of Emergency Medical Services Systems. US Public Health Service, Division of Emergency Health Services, Rockville, Maryland, 1971.
12. Waters JM: The Jacksonville EMS story. *The American County* 37:19-42, 1972.
13. Owens JC: Emergency health services require efficient communications system. *Hospitals* 43:71-2, 1969.
14. Nagel EL, Hirschman JC, Mayer P, et al: Telemetry of Physiologic data: an aid to fire-rescue personnel in a metropolitan area. *South Med J* 61:598-601, 1968.
15. Uhley HN: Electrocardiographic telemetry from ambulances. A practical approach to mobile coronary care units. *Am Heart J* 80:838-42, 1970.
16. Nagel EL, Hirschman JC, Nussenfeld SR, et al: Telemetry-medical command in coronary and other mobile emergency care systems. *JAMA* 214:332-8, 1970.
17. Benson DM: Emergency ambulance communications code. ParaMedical Journal. *Journal of the Pa Ambulance Assoc.* 4:6, 1972.
18. Division of Medical Sciences, Committee on Emergency Medical Services. *Medical Requirements for Ambulance Design and Equipment.* Washington DC National Academy of Sciences/National Research Council, 1968.
19. Dept. of Transportation/Highway Safety Bureau: Basic training program for emergency medical technicians-ambulance. US Govt. Printing Office.
20. Brandes RA: Registry of emergency medical technicians-ambulance. *The American County* 37:33, 1972.
21. Farrington JD: Emt-a registry certifies competence. *JACEP* 2:111-3, 1973.
22. Cobb LA, Conn RD, Samson WE, et al.: Early experiences in management of sudden death with a mobile intensive/coronary care unit. Suppl III: *Circulation* 144, 1970.
23. Safar P, Esposito G, Benson DM: Ambulance design and equipment for mobile intensive care. *Arch Surg* 102:163-71, 1971.
24. Division of Medical Sciences, Subcommittee on Cardiac Emergencies. National Academy of Sciences/National Research Council. Recommendations for the Early Care of the Acute Heart Disease Patient. In preparation.
25. Advanced Training Program for Emergency Medical Technicians-Ambulance, Washington DC National Academy of Sciences/National Research Council, 1970.
26. Yale University Physicians' Associate Program. Trauma Program, Dept. of Surgery, Yale University Sch. of Med.
27. The American Assoc. of Junior Colleges, National Center for Higher Education, Washington DC.
28. Paramedical Journal published bimonthly by the Pa Ambulance Assoc. Indiana, Pa.
29. Curry GJ, Little S: The speeding ambulance. *Am J Surg* 95:507-11, 1958.
30. Gertner HR, Baker S, Rutherford RB, et al: Evaluation of the management of vehicular fatalities secondary to abdominal injury. *J Trauma* 12:425-31, 1972.
31. Commission on Emergency Medical Services. Categorization of hospital emergency capabilities. The American Medical Association. Chicago, Illinois.
32. Benson D, Safar P: Categorization and regionalization of hospital emergency facilities. *The Public Health Considerations of Critical Care Medicine and Anesthesiology: The Clinical Anesthesia Series.* 1972.
33. Youmans RL, Brose RA: A basis for classifying hospital emergency services. *JAMA* 213:1647-51, 1970.
34. Benson D: Proceedings of the first Hawaii forum on emergency health services, 1971, Honolulu.
35. Boyd DR, Rappaport DM, Marbarger JP, et al.: Computerized trauma registry: a new method for categorizing physical injuries. *Aerosp Medi* 42:607-15, 1971.