IMPORTANT TELEPHONE NUMBERS

Emergency Ambulance
Fire or Police 911

Maryland Poison Center
1-800-492-2414

National Capital
Poison Center 625-3333

Prince George's County
Fire Department

Office of the Fire Chief 925-5200

CPR Class Information 864-LIVE

Career Recruitment
Information 808-1795

Volunteer Recruitment
Information 699-JOIN

" The First County in the Nation to Require Sprinklers in all Residences "

A service of Prince George's County Fire Department
Parris N. Glendening, County Executive
M. H. (Jim) Estepp, Fire Chief

Fire Department Headquarters
9201 Basil Court, Fourth Floor East
Landover, Maryland 20785

PRINCE GEORGE'S COUNTY
FIRE DEPARTMENT

EMERGENCY MEDICAL SERVICES

Parris N. Glendening, County Executive
M. H. (Jim) Estepp, Fire Chief

PGFD

Prince George's County Fire Department Emergency Medical Services

The Prince George's County Fire Department is responsible for providing Emergency Medical Services (EMS) for all citizens in Prince George's County.

Last year, the Prince George's County Fire Department responded to over 63,000 medical emergencies. Paramedic Units responded to over 22,000 of these incidents.

The Department currently maintains 40 ambulances, which are staffed by career and volunteer personnel who have received training in Emergency Care. These personnel are responsible for initiating Basic Life Support (BLS) patient care. Their skills include: Cardiopulmonary Resuscitation (CPR), airway management, treatment for shock, and splinting fractures, as well as basic first aid.

Paramedic units, which are Advanced Life Support (ALS) units, are staffed by Cardiac Rescue Technicians (CRT) and/or Emergency Medical Technician-Paramedics (EMT-P). These "paramedics" have at least one year of experience as an Emergency Medical Technician (EMT) and over 240 hours of additional training. They function under the direction of a Control Physician. Their skills include: administering medications, interpreting EKG's, cardiac defibrillation, intravenous "lifelines", and advanced airway management. This allows the paramedic to provide advanced life saving procedures to patients who are severely ill or injured at the scene of the emergency.

What is an Emergency

An emergency is a situation in which immediate medical attention is needed. For example: chest pain, unconsciousness, severe bleeding, trouble breathing, choking, drowning, fractures, etc. In these and any other serious injury or illness, don't delay. Get immediate help!

In Case of an Emergency

CALL 911

To activate the EMS system, just dial 911. A dispatcher will answer the phone and gather some necessary information. Please be ready to answer a few important questions:

* What is the problem?
* What is the address of the emergency?
* What phone number are you calling from?
* Your name?

DO NOT hang up until the dispatcher tells you - some emergencies may require additional information. The dispatcher will send the closest available ambulance. (On occasion, a fire engine will arrive first - they are trained in Emergency Care and are well equipped to initiate patient care.) Certain severe emergency situations may warrant the dispatcher to send a paramedic unit.

The Fire Department asks that citizens not call for an emergency ambulance unnecessarily. Many minor illnesses and injuries (colds, small cuts, elective surgery, and follow up visits to a physician or clinic) do not require the services of an emergency ambulance. Cases not requiring the services of an emergency ambulance will be referred to other means of transportation.

Transportation to the Hospital

The crews of ambulances and paramedic units are trained to evaluate and begin treating a patient's condition. They then determine the appropriate mode of transportation.

Life-threatening emergencies such as: respiratory or cardiac arrest, severe bleeding, and unconsciousness are transported (using emergency lights and sirens) to the closet hospital capable of handling that emergency.

Non-life-threatening emergencies requiring medical attention such as: seizures, minor burns, or simple fractures will be transported to the hospital without emergency lights and sirens and abiding with all traffic regulations.

In special cases, the Maryland State Police, U.S. Park Police, and other medical helicopters are available for Med-Evac transportation to specialty treatment facilities, such as the Trauma Center at the Prince George's Hospital Center or Childrens Hospital National Medical Center, to name a few.

Fire Department Programs

CPR Training is offered to citizens at various times and locations throughout the County. All citizens are encouraged to take training in this life saving skill. For more information, Call 864-LIVE.

Project Identification is a program designed for the special needs of the disabled & handicapped citizen in the event of a Fire, Police, or Medical Emergency. For more information, Call 499-8120.

For additional information, or to arrange for a speaker for a civic group or organization regarding emergency medical services in Prince George's County, contact the Bureau of Advanced Emergency Medical Services at 772-9060.

Caused by

Chapter 1

Systems Organization

COMPONENTS

R Adams Cowley

INTRODUCTION

1 256

The success of any organization depends on three basic ingredients: the expertise of the individual base units, the comprehensiveness of the "umbrella" unit, and the effectiveness and coordination of the working interrelationships between the two. Like puzzle pieces, each of these ingredients can be viewed both as separate entities, *i.e.*, self-contained microcosms, and as part of an overall macrocosm.

This formula for success is especially applicable to the emergency medical systems (EMS) community. Although much research has established the validity of trauma centers and their vital contribution to emergency care for the critically ill or injured patient,[2,5,8] some debate still exists about the relative merits of statewide *versus* local trauma care systems. As the following discussion will show, the experience of the Maryland Institute for Emergency Medical Services Systems (MIEMSS), and in particular that of its Shock Trauma Center, supports the theory that a local trauma care system is better than none, but that a statewide (perhaps someday a national?) system provides the optimal treatment and care.

HISTORICAL BACKGROUND

To understand more fully the mechanisms of action used by today's various EMS systems, and how they work, it is necessary first to review how they developed

PRIOR TO 1960

Emergency medicine prior to 1960 was considered more or less the exclusive concern of the armed forces. Wartime activities generated lifesaving modifications,

delivered under less than optimal conditions, of existing surgical and medical techniques, as well as improved methods of rapid transport to medical aid. These advances resulted in decreases in overall mortality and morbidity from each military engagement regardless of the more numerous and sophisticated weapons used: from 8% in the First World War to 4.5% in the second, then to 2.0% and 2.5% in the Korean and Vietnam conflicts, respectively.[1]

In Korea and Vietnam, helicopters manned by trained paramedics brought EMS to the victim, saving time and increasing chances for survival. This mode of transport, combined with increased EMS field expertise, lowered the battlefield death rate but, ironically, increased that at the hospitals, because the helicopters delivered to the medical facilities alive, but dying, patients that formerly would have died in the field. Experience gained by military physicians, nurses, and paramedics in Mobile Army Surgical Hospital (MASH) units opened new horizons for improving care.

THE 1960s

Early Conditions. In the early 1960s, civilian trauma and emergency medical care received little attention. Prehospital care was rudimentary at best, and few cities had adequate ambulance service. Fifty-six percent of all emergency victims were transported to the hospital by hearse because those vehicles were the only ones capable of accommodating stretchers and extra equipment.[28] No standards existed for manufacturing ambulances or for converting existing vehicles to ambulance use. (Cowley, Baltimore City Fire Department Chief Marty McMahan, and others* collaborated to design the first modular ambulance; its first run occurred in 1963!)

Similarly, there were no standards for training ambulance attendants, and first responder training programs were unknown. A trauma victim was routinely delivered to the nearest hospital, regardless of its capability to handle the specific emergency.

Nearly all accredited hospitals claimed to have emergency facilities (a requirement in Maryland), but most were poorly equipped, inadequately staffed, and capable of providing only advanced first aid. Two-thirds of all emergency room visits were routine evening out-patient care, not actual emergencies.

NAS/NRC. In 1963, members of the National Academy of Sciences, National Research Council (NAS/NRC) Committees on Shock and Trauma joined with representatives from a wide variety of other organizations to study the existing EMS conditions and recommend improvements. For 4 years they reviewed, among other subjects, ambulance services, hospital emergency and intensive care units, shock research projects (and their results), and disaster planning efforts. In 1966, they published their findings and their blueprint for the improvement of these and other emergency medicine areas in the now classic white paper, "Accidental Death and Disability—the Neglected Disease of Modern Society" (see Table 1-1 for a summary of those existing conditions).[28] This document stressed the need for an overall organizational approach, rather than individual efforts, to solve the problem; it thus heralded the modern era of EMS systems and provided the impetus for national attention and federal involvement.

*The modular ambulance, an innovative concept in prehospital patient care, was developed, designed, and constructed by Dr. Cowley, Chief McMahon, Chief Warfield of the Baltimore City Fire Department, and Mike Margerum of the Schwab Coach Company, Pennsylvania.

TABLE 1-1. Existing Conditions in the Early 1960s and Recommendations for Change

Category	Condition
Accident facts	52 million accidental injuries 107,000 dead 2,000,000 hospitalized 10,000,000 disabled 400,000 permanently disabled Affects 1 of every 4 Americans
Public information	General public unaware of statistics and magnitude of problem Lack of general first aid knowledge
Training	No standard texts for EMS personnel Inadequate training in cardiopulmonary resuscitation (CPR) and other advanced lifesaving skills No standard requirements
Transport	Mortician-supplied hearses provided 50% of the "ambulance" force Incomplete and inadequate equipment and supplies Helicopters used for civilian transport No standard protocols
Communications	Rarely possible between ambulance and hospital
Emergency services	Overcrowded, outdated emergency rooms in most hospitals No standards for space, equipment, personnel No cooperation between health groups No support from local or federal government
Research	Inadequate funding and support No data/evaluation system
Category	**Recommendations**
Accident facts	Decrease accident morbidity and mortality rates by means of regionalized system of trauma care
Public information	Conduct national forums on all EMS subjects Stimulate public demand for accident prevention and adequate EMS Create active community EMS councils

(*Continued*)

TABLE 1-1. Existing Conditions in the Early 1960s and Recommendations for Change (*continued*)

Category	Condition
	Review and analyze safety acts pertaining to government departments with administrative responsibility in accident prevention
	Earmark funds for support of research in trauma therapy and related careers
Training	First aid: Extend training to lay population
	Prepare aids, texts, courses of instruction for rescue squad personnel, policemen, firemen, and ambulance personnel
Transport	Ambulance services: Implement recent traffic safety legislation to ensure compliance, and for qualification and supervision of ambulance personnel
	Adopt ways and means of providing services appropriate to locality, control, and surveillance of services, and coordination of services with health departments, hospitals, traffic authorities, and communication services
	Develop pilot program to study feasibility of physician-staffed ambulances
	Initiate pilot programs to evaluate automotive and helicopter ambulance services in sparsely populated areas and areas lacking adequate hospital facilities
Communications	Delineate radio frequency channels and equipment for voice communication between ambulances, EDs, and other local, regional, and national agencies
	Develop national pilot studies to evaluate models of radio/telephone installations to ensure effective communication facilities
	Promote daily use of voice communication facilities by agencies serving emergency medical needs
	Explore feasibility of designating a single nationwide telephone number to summon emergency assistance
Emergency services	Initiate surveys in selected cities, small communities, and rural areas to determine patterns, numbers, and types of EDs necessary for optimal care of emergency surgical and medical casualties
	Develop mechanism for continued inspection, categorization, and accreditation of EDs
	Solicit federal funds to design, construct, and operate model emergency facilities of each type
	Expand intensive care programs to ensure uninterrupted care beyond EDs
Research	Establish trauma registries locally and nationally
	Develop studies on the feasibility of designating selected injuries to be incorporated under Public Health Service control

TABLE 1-1. Existing Conditions in the Early 1960s and Recommendations for Change (*continued*)

Category	Condition
	Form hospital trauma committees
	Develop studies on degrees of disability and stages of convalescence with emphasis on earliest phases of treatment
	Develop judicial application for principle of seeking impartial medical advice in determining disability
	Replace lay coroners with medical examiners
	Institute routine, complete accident victim autopsies
	Develop center to study the necessary expansion of day-to-day services to cover mass disaster or national emergency
	Solicit increased financial support for trauma research
	Establish long-term financial support of specialized centers for clinical research
	Expand clinical research of war wounds
	Expand research in shock, trauma, and emergency medical conditions, with the goal of establishing a National Institute of Trauma

The Feds. In 1966, President Lyndon Johnson signed into law the Highway Safety Act of 1966 and the National Traffic and Motor Vehicle Safety Act of 1966; these two laws coordinated individual state efforts by requiring them (in order to receive federal funding) to make their regulations conform to national highway safety standards (including postaccident care) established by the Department of Transportation (DOT). A new governmental agency was established to supervise this national effort; it became known as the National Highway and Traffic Safety Agency (NHTSA). The systems and services thus generated were inherently concerned with the prehospital and transportation phase of EMS and did much to raise the public's level of consciousness about emergency care.[1]

In 1968, the Secretary's Advisory Committee on Traffic and Safety of the Department of Health, Education, and Welfare (DHEW) provided a checklist of specific recommendations to improve the EMS picture[2]:

- Develop leadership and support groups to provide heretofore unachieved sustained growth in environmental health and consumer protection services.
- Coordinate DHEW research and policies with that of the DOT to maximize effectiveness and accommodate increasing demands.
- Institute highway crash research in accordance with national goals.
- Enact a federal aid program for EMS as it relates to care for traffic accident victims in which DHEW would have responsibility for medical aspects and DOT would have responsibility for engineering aspects such as transportation, communications, education and skills for prehospital providers, and so forth.

- Establish research into driving behavior, how drivers learn, and what drivers should be taught in addition to machine operation.
- Initiate a massive federal program about the disease of alcoholism, especially as it affects motor vehicle operators.
- Establish a center for studying violent behavior, which contributes significantly to car crash statistics.
- Expand and intensify public education efforts about safety measures such as seat belt use.
- Establish a presidential commission to study ways and means of speeding up the various legal and judicial processes involved in highway crash litigation.

Unfortunately, many of these crucial objectives have yet to be accomplished.

Throughout much of the 1960s, the Division of Emergency Health Services (DEHS) of the DHEW was the only federal office that assumed significant responsibility for improving EMS. This office operated with limited funding and authority, and it focused its attention mostly on disaster preparedness and information dissemination.[1]

EMS Conferences. The first national EMS conference was held in 1969. While it established emergency medical technician (EMT) training curricula and certification programs, standards for EMS vehicles and equipment, and the American Trauma Society (among other accomplishments), it also provided intrinsic evidence that the microcosms of individual state and county efforts were starting to become part of a macrocosm—the overall effort on a national scale.[1]

THE 1970s

The decade of the 1970s saw increasing focus and emphasis on EMS activities.

When the NAS/NRC evaluated EMS resources again, they found that professional and community organizations had been more active than federal agencies in efforts to upgrade EMS. Their 1972 report described EMS as "one of the weakest links in the delivery of health care in the nation" and called for a coordinated federal effort to implement comprehensive emergency care:

- Regional EMS programs with centralized communications
- Continued DOT leadership in setting ambulance standards, providing subsidies for equipment purchases, and funding EMT training
- Standards for emergency nurses, physicians, and allied health personnel
- Categorization of hospital emergency capabilities
- Emergency facilities in industry, business, and public places
- A national center for disaster EMS

Action on these recommendations came relatively quickly with passage of the Emergency Medical Services Systems (EMSS) Acts of 1973 and 1975 (revised).[16] This "carrot and stick" legislation authorized federal funding for planning, establishing, and evaluating EMS systems that incorporated 15 required, basic components (Table 1-2).

TABLE 1-2. The 15 Basic EMS Components

Component	Requirements
1. Manpower	Adequate numbers of trained and experienced personnel to provide 24-hour-a-day care
	Personnel to include first responders (fire, police, *etc.*); communicators; EMS/resources dispatcher; EMTs, both ambulance and paramedics; ED and critical care unit registered nurses; ED physicians and specialists; EMS systems medical director, administrator, and coordinators
	Criteria for personnel to incorporate nationally accepted standards, standards negotiated through the Inter-Agency Committee on EMS, and standards from national professional organizations and registries
2. Training	Appropriate and continuing education programs for EMS personnel, police personnel, lifeguards, park rangers, and other public safety employees, to be coordinated within the system's service area
	Emphasis to be placed on recruiting armed forces veterans with health care experience
	Programs to include various educational experiences: Structured and nonstructured workshops, seminars, on-site observations, "hands-on" clinical exposure, videocassette lectures and demonstrations, and satellite-projected programs to reach remote or rural area personnel
3. Communications	Service to link personnel, facilities, and equipment
	Service to utilize emergency telephonic screening, universal emergency telephone number (911), and direct connections and interconnections in the system and to other service area systems
	Service to designate Control Center responsible for establishing channels and allocating necessary resources in an emergency situation
	Center to have equipment and facilities necessary to perform designated functions and information exchange
	Center to perform three essential functions: (1) receive *all* requests for system response within service area; (2) direct *all* system response; (3) coordinate *all* system liaison with other public safety and emergency mechanisms
	Center to address citizen access, central dispatch of resources, and medical control for basic and advanced life support (BLS and ALS) services
	Center to provide telecommunication interface for persons with auditory handicaps or for whom English is not first language

TABLE 1-2. The 15 Basic EMS Components *(continued)*

Component	Requirements
	Center to provide link between site, receiving hospital, and medical control hospital for maximal awareness of and preparation for patient's condition on arrival
4. Transportation	Adequate number of properly equipped ground, air, and water transportation vehicles to supply needs of system's service area
	Vehicles to meet national and federal standards for design, performance, and equipment
	Operators/attendants to meet national, federal training standards
	Elements of BLS ground transport to include ambulance meeting DOT, ACS, DHEW, and General Services Administration specifications; approved, 2-way voice communications for vehicle/medical control and consultation; at least two EMT-As in each ambulance; 5-min response time in 95% of metropolitan calls; 20-min response time in 95% of rural calls
	Elements of ALS ground transport to include all ground BLS requirements; personnel trained to paramedic (EMT-P) level; advanced biomedical telemetry equipment; extra medical equipment for critical care procedures
	Elements for air transportation to include helicopters for primary response to geographically determined areas (<30-mile radius) and for secondary response to areas within a 30- to 150-mile radius; fixed wing transport for areas greater than 150-mile radius
	Additional transport to include emergency boats and snowmobiles for response under specific geographic considerations
5. Facilities	Identification in each EMS region of each hospital's capability to receive, diagnose, and treat emergency (critically ill or injured) patients
	Categorization of above to ensure adequate number of appropriate EMS facilities which, collectively, provide 24-hour-a-day service—with no intrahospital duplication of services
	Utilization of critical care services plan to include personnel training and protocols for equipment, transportation, transfer, triage, and interhospital treatment
	Professional critical care advisory groups to ensure proper service utilization and interrelation across political boundaries
	Elements to include regional hospital categorization (by means of national criteria) with at least one AMA Category II hospital providing 24-hour ED physician coverage in each EMS region; regional advisory groups composed of personnel from all levels of care and planning to develop and carry out categorization plan; agreements for interregional assistance
6. Critical care units	CCUs to provide access to designated critical medical units for inter-or intraregional admissions
	Utilization plan to include personnel training; equipment provision; protocols for transportation, transfer, triage, and interhospital treatment; and delineation of responsibility for identifying and providing transfer for specified patients
	Advisory group to ensure proper utilization of CCUs
7. Public safety agencies	Agency personnel, equipment, *etc.*, to interface with standard regional EMS system, sharing equipment, personnel, training, *etc.*, to ensure maximal emergency or disaster response
	System to demonstrate appropriate coordination and mutual-aid plans for emergency and disaster response
8. Consumer participation	Nontrained/nonexperienced service area residents to participate in EMS policy making procedure
	"Reasonable representation" to be encouraged
	System to provide links to regional Health Systems Agency (HSA) for planning, consumer representation
9. Accessibility to care	Care to be provided without inquiry about or evidence of patient's ability to pay
	Lead agency monitoring to ensure care given to all without discrimination on any basis
10. Patient transfer	System to provide patient transfer to appropriate facility for follow-up and rehabilitation care (to ensure maximal recovery in addition to acute care)
	System physicians and facilities to have written transfer agreement to facilitate communication, cooperation
	Written agreements to document sign-off and sign-on medical responsibility, as well as mutual agreement on treatment, triage, and educational and evaluation protocols, especially in rural areas
	Expert physician panels to establish prehospital treatment and triage protocols for urban areas
	Physician groups within each specialty to develop protocols for patient selection, field identification, prehospital care, destination to designated facilities, and evaluation methods for EMS region

TABLE 1-2. The 15 Basic EMS Components *(continued)*

TABLE 1-2. The 15 Basic EMS Components (*continued*)

Component	Requirements
	Transfer protocols to incorporate all other components to provide continuum of care
11. Coordinated record keeping	Each EMS region to provide coordinated patient record keeping from initial entry to discharge from system Records to be used in system evaluation of care delivery
12. Public information and education	System to educate area residents and visitors about EMS regional system, how to access it, how to use it properly, and how to pay for it System to provide self-help, first aid, and CPR programs to help citizens understand EMS System to publish periodic status updates to secure continued support of its public
13. Review and evaluation	System to provide internal review of status, progress, and impact (EMSS Act of 1976 amended original 1973 requirement for external, independent review) Reviewer to supply description of beginning EMS resources, capability, and performance; description of alterations instituted (both clinical and system-related); description of EMS resources, capability, and performance during review period; and clinical evaluations (death and disability) for at least the seven clinical patient target groups (major accidental trauma, burn injuries, spinal cord injuries, acute coronary/heart attacks, poisonings, high-risk infants/mothers, and behavioral psychiatric emergencies)
14. Disaster linkage	Plan to assure the system's *capability* of providing EMS during mass casualties, natural disasters, or national emergencies Regional EMS system *not to be* the regional disaster organization Regional EMS system to link with local, regional, and state disaster organizations Regional EMS system to work with disaster organizations to ensure delivery of needed services and care Regional EMS system to participate at least biannually in disaster planning and exercises to test plans
15. Mutual aid	Each EMS region to establish arrangements with adjacent EMS systems to provide service to border areas on a reciprocal basis, regardless of state or county line divisions

TABLE 1-2. The 15 Basic EMS Components (*continued*)

Component	Requirements
	Arrangement to be in written agreement form, reviewed and reevaluated annually Agreements to ensure consistent, appropriate care regardless of patient location (rural, wilderness, or urban area)

APPLICATION

The federal impetus, combined with a growing public awareness and concern, generated increased interest and activity in EMS systems development during the early to mid-1970s. Communities and health organizations across the country started working together to establish "local" emergency services using the 15 basic components as building blocks, thereby receiving federal and state funding.[1]

The main development of the mid- to late 1970s, however, was the enhancement of such local services into regionalized systems of trauma care. The resulting larger units provided a more sophisticated level of care for the trauma patient through coordinated prehospital care, triage, and transportation, and through the concentrated but shared expense of equipment and personnel necessary for optimal care. Acceptance of the idea of regionalized care was neither immediate nor complete in spite of overwhelming evidence of its potential benefits; political as well as geographic barriers first had to be addressed and surmounted, and the process is still under way in most areas. Yet it is that same conceptual base of regionalized care that today makes trauma a potentially manageable disease.

REGIONAL RESPONSE

Effective response to any emergency, particularly a health-related one, requires a system (preplanned at the regional level) that rapidly deploys appropriate and properly trained and equipped personnel. To "beat the odds" and challenge the almost certainly fatal outcome of untreated or inappropriately treated injuries, victims of major trauma require sophisticated, definitive care provided *in a timely manner* through an integrated system of field, medical, and surgical personnel armed with state-of-the-art knowledge, skills, and equipment. Figure 1-1 shows the effect of variously timed interventions on the trauma mortality rate.

Because supplying such a service involves complex arrangements of essential personnel and equipment, a trauma/EMS system needs an EMS lead agency to provide the necessary focus and central direction for planning, implementing,

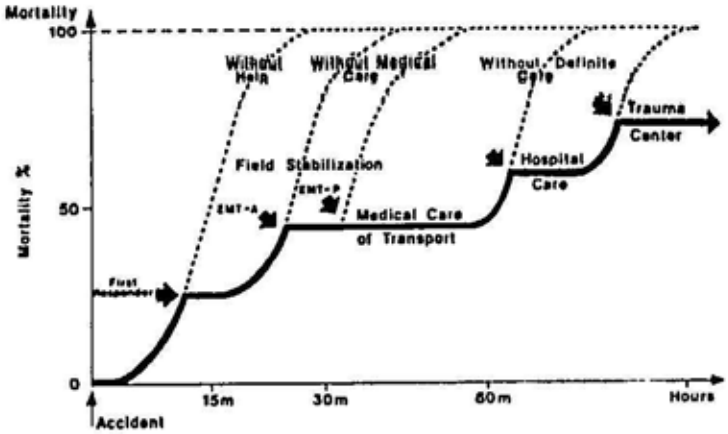


FIGURE 1-1. The effect on the mortality rate of an EMS systems approach to trauma care.

monitoring, and evaluating. In addition, this lead agency must represent the interests of both trauma victim and provider and also assume responsibility for all trauma patients in both the public and private sectors within the region. Uniform programs, guidelines, and protocols for patient care must be identified. The lead agency's traumatologist works with colleagues at various levels within the system to identify problems, develop practical solutions, and deploy operational protocols for prehospital, interhospital, and trauma center care, as well as for rehabilitation services. These protocols provide training and daily procedure guidelines, an evaluation basis, and a legal standard of care.

Critical trauma patient care, therefore, demands a regionalized system using a protocol approach for both systems operations and patient treatment throughout the various echelons of care.

Trauma incidence and patient distribution within any EMS regional system show that 85% of trauma patients can be managed at the local level, 10% need further care in standard and intensive care settings, and 5% need the special care available only at American College of Surgeons (ACS)-designated Level I trauma centers.[9] (These divisions correspond well with the ACS delineation of care levels; see Fig. 1-2.) The real impact in managing patients in that 5% category lies not in the importance of one treatment or a single phase of care (such as the prehospital phase) but in the conceptualization and implementation of each treatment and each care phase as parts of an organized regional trauma/EMS system of care.[18]

Maryland's EMS system, based on a five-region division of the state (Fig. 1-3),

evolved over a period of several years. MIEMSS is the overall, statewide organization. The EMS Division of MIEMSS, which is the field operations section, works to coordinate and improve treatment facilities, transportation and communications equipment, training of emergency medical personnel, and public education within each of the five EMS regions. Local EMS needs in each of these areas are determined by one or more professional regional coordinators and a volunteer EMS Advisory Council. Each council is composed of consumers, providers, institutional personnel, government representatives, and EMS professionals.

The Maryland EMS communications system, the first statewide system of its kind in the nation, ties the entire Maryland EMS system together. Ambulances, helicopters, hospitals, and central alarms that dispatch emergency medical teams are all linked with any EMS component in any region throughout the state.[11,14,20,25] The Systems Communication Center (SYSCOM) is operated 24 hours a day by trained MIEMSS communication dispatchers who are also EMTs.[20]

The communications system plays an important role in EMS by ensuring that any accident victim, coronary patient, or critically ill patient in Maryland will receive life-sustaining care within minutes as EMS personnel reach the scene, and that the patient will be transported to a treatment facility prepared to manage the problem (see also Vol I, Chap 2).

Ambulance and rescue companies in Maryland cooperate with the State Police Med-Evac helicopter system to provide extensive and rapid transport coverage throughout the state. At present, 240 paid and volunteer ambulance companies with well-equipped vehicles serve Maryland. In addition, State Police Med-Evac helicopters are on 24-hour-a-day priority call to transport patients to specialty referral centers either from the scene of the accident of from other hospitals. Two U.S. Park Police and several U.S. Army Med-Evac helicopters supplement the state police helicopter service.

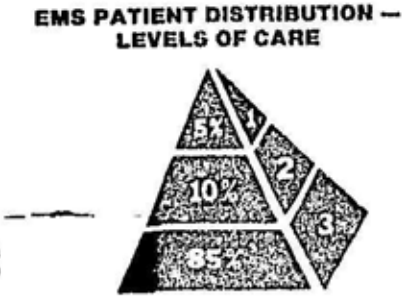


FIGURE 1-2. The correlation between trauma patient categorization and the ACS divisions of care.

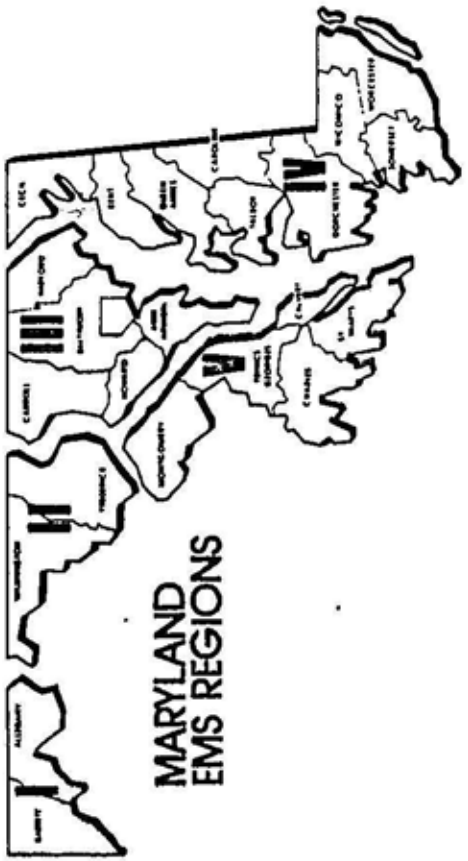


FIGURE 1-3. Maryland EMS regions and helicopter bases.

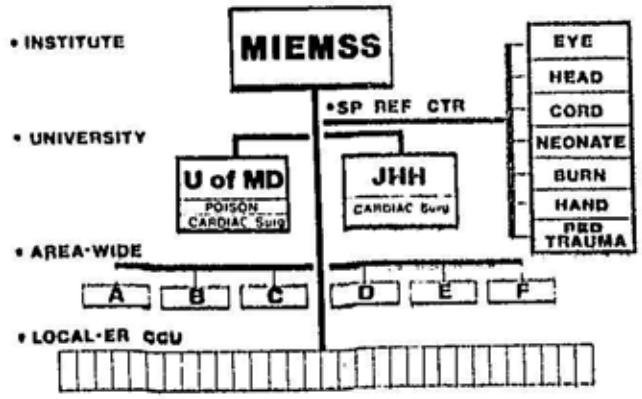
ECHELONS OF CARE

Maryland has a unique system for providing highly specialized care for critically ill or injured persons who require sophisticated medical management. The system, called the Maryland Echelons of Care System (Fig. 1-4), consists of the following[9]:

- The specialty referral centers, areawide trauma centers, and hospital emergency departments throughout the state
- The rapid transportation system (land, sea, and air)
- The EMS statewide communications system

Maryland's specialty referral centers serve the following patient populations: adult and pediatric trauma patients; high-risk infants; patients who need upper and lower extremity amputations; poison control patients; patients with eye trauma, spinal cord injuries, or burns; and patients who need hyperbaric oxygen for smoke or toxic substance inhalation, wound management, or decompression symptoms. Maryland also has nine areawide trauma centers, each of which has satisfied designation criteria including population, patient flow, quality of the facility, and geographic needs. Selection is based on the advice of the regional EMS Advisory Council. Each center is committed to accepting patients within the statewide system unless that facility is full (determined by preestablished guidelines and parameters), in which case the Shock Trauma Center serves as a back-up.

FIGURE 1-4. Echelons of Care in Maryland.



Training for medical personnel and other citizens dealing with emergencies is offered through the cooperation of various agencies.

Prehospital Personnel. Ambulance and helicopter crew members are trained to resuscitate and stabilize the patient at the scene of the accident and to maintain that stable condition *en route* to the hospital. Crew members are certified EMTs and many are also certified cardiac rescue technicians (CRTs). The CRT training instructs ambulance attendants how to use telemetry equipment, to begin intravenous solutions, to defibrillate, to administer drugs ordered by a physician, and to utilize other advanced life-support methods such as military/medical antishock trousers (MAST), endotracheal intubation, and establishment of the esophageal obturator airway. EMTs and CRTs thus become extensions of hospital emergency departments, and, like hospital personnel, must maintain and update their skills through accredited programs and workshops. All prehospital personnel and programs are under medical control.

Nurses and Physicians. Accredited programs also provide nurses and physicians with opportunities to update their skills. Nursing workshops are presented throughout the state on such topics as trauma, crisis intervention, child abuse, burns, cardiac emergencies, pediatric trauma, neonatal care, orthopedics, blood gases, diabetic emergencies, respiratory problems, mechanical ventilation, spinal cord injury, the nurse as a first responder, and principles of patient and family teaching. Various state and national seminars are presented on trauma and emergency medicine, along with intensive skills-oriented courses for emergency physicians.

The Public. CPR and first-aid courses are supported for the citizen. Through the cooperative efforts of the MIEMSS, the Maryland chapters of the American Heart Association, and the regional school systems, CPR training has been introduced into all high school curricula.

MERGING THE MICRO- AND MACROCOSM CONCEPTS

SUMMARY OF "LOCAL" EFFORTS

The concept of delivering sophisticated emergency care to critically ill and injured persons first became operational at the individual local community level in isolated areas around the country. As the care, and its delivery, improved and expanded, advantages in terms of response speed, efficiency, improved patient outcome, and cost-effectiveness developed from combining the efforts of several such contiguous communities into a regional system using shared resources. In Maryland, this regional approach has advanced one step further into a statewide system (see the next section in this chapter, Systems Evaluation, for an evaluation of the results of this program compared to national statistics).

Development and improvement of this country's overall EMS program, however, must not stop at the statewide system level; it must continue to grow. One promising recent development has been the establishment of an expanded, interstate EMS region.[12]

REGIONAL DEVELOPMENTS

Goals. As metropolitan areas merged and patient needs more frequently required transport across state boundaries, the need for interstate continuity of EMS care became more and more urgent. Based on Maryland's integrated EMS system, six Mid-Atlantic states, the Mid-Atlantic Emergency Medical Services Council, Inc., formed and incorporated to coordinate interstate EMS activities (evaluation, planning, reciprocity, implementation, and operation) to minimize duplication, increase cost-sharing benefits, and develop procedural recommendations for governmental and other involved organizations.[13] Thus, Delaware, the District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia banded together 10 years ago to provide maximal EMS care to any person anywhere within those six states.

Organization. The council is composed of not more than 18 governor-appointed representatives (a maximum of three from each state, all from the fields of health planning and/or EMS operation), and *ex officio* representatives from the U.S. Department of Transportation, the Appalachian Regional Commission, the EMS Division of DHEW, and the Region III Field Office of DHEW's Public Health Service. Additional regional interstate organizations are invited to participate in council activities. Since New Jersey has joined the Council, the name has been changed to the Atlantic Council.

The council's financial support rests on initial DHEW "seed" money (in 1976), which has been replaced by state budget allocations.

The council designated goal-specific committees to facilitate the accomplishment of its overall purpose. Table 1-3 lists each committee and its respective responsibilities.

Accomplishments. In spite of differing EMS laws and developmental stages, the council has accomplished the following:

- Developed and implemented a standard disaster triage tag
- Contributed significantly to national effort for mandatory passive restraints in all automobiles by 1984
- Developed compatible interstate communication systems
- Supported no-fault insurance through testimony before the U.S. Congress
- Developed and printed a council brochure;
- Obtained legal review of the region's medical practice acts and paramedic legislation and voiced suggestions for alleviating constraints found in existing legislation

TABLE 1-3. Mid-Atlantic EMS Council Committees

Committee	Responsibility
Interstate Disaster Triage Tag	Standardize triage tags to facilitate interstate EMS assistance
Hospital Capability	Establish council as reference center for EMS capability evaluations Define and standardize capability criteria
EMS Communications	Coordinate interstate communication systems
Legislation and Regulations	Identify minimal and optimal requirements for interstate EMS system based on existing and needed criteria and resources
Manpower Education	Seek gubernatorial support for interstate training standards and programs
Reimbursement for Services	Reduce financial loss for out-of-state patients
Reciprocity	Effect interstate reciprocity agreements through (1) EMT and paramedic reciprocity and (2) standard certification requirements and procedures combining National Registry and individual state criteria

- Developed a current inventory of existing and proposed legislation
- Established EMT reciprocity among five of the six states
- Supported states with little gubernatorial support
- Initiated steps to become an information resource center
- Established EMT and hospital interstate reciprocity programs.

Future Plans. Included in the Council's future plans are development of regional, and therefore cost-effective, research and legislation projects; development of regional EMS programs in other areas as a base for a strong national EMS council with DOT and DHEW funding; and development of public (and political) education projects to ensure institution and maintenance of a national system.

FUTURE VISIONS

A statewide or even an expanded regional program must not be considered the ultimate echelon of EMS care. To obtain maximal benefit from specialized medical authorities, transportation/communication linkages, as well as injury/treatment data, resources, and experience, must be pooled on a national level. Therefore, efforts toward establishing a national trauma institute (as the basis for a national program) must continue.[*]

Such a national institute would require at least two basic components to ensure success: (1) the allocation of adequate funding for continuing research into the etiology and effects of trauma, and (2) the establishment of a shared trauma registry to act as a nationwide clearinghouse for trauma data. This data would provide the means for evaluating the results of past actions and pinpointing areas needing revision or improvement (see the following section, Systems Evaluation). Only when the cumulative data can be centrally registered and evaluated on a national basis will efforts at fighting this disease become truly successful.

SYSTEMS EVALUATION

Belavadi S. Shankar

Any program worth trying is worth evaluating; and if it's not worth evaluating it's not worth trying.

—HENRIK BLUM[*]

INTRODUCTION

In this world of competing risks (demand) and limited resources, evaluation is one of the four most important ingredients of any program, whether it is national health services or a neighborhood recreational center (Fig. 1-5). In a large, ongoing program, the lessons learned by performing the activities of each of the elements are passed on to the next stage in a continuous fashion until the program attains its highest effectiveness (optimal state). Thus it is a *dynamic process*. For the sake of simplicity, "evaluation" is shown as a distinct element in Fig. 1-5, but, whether implicit or well-defined, evaluation is an essential step at every stage of the program. For example, at the planning stage one might ask such questions as, Are the objectives relevant and realistic? Are those objectives stated in measurable terms? Webster's Third New International Dictionary defines "evaluate" as "to examine and judge concerning the worth, quality, significance, amount, degree, or condition of."† Evaluation begins by examining the plan and judging whether the goals and objectives are appropriate for the program in question; in other phases, it examines the structure of the organization, the process prescribed for achieving the outcome, and finally, the outcome. Even the evaluation itself will be evaluated for the appropriateness of the methodology used, or for the cost. The evaluation should be *a built-in function* in the program operation.

A well-planned evaluation examines structure, process, and outcome of the

[*]Quoted as personal communication by Waller.[1]

†By permission. From Webster's Third New International Dictionary Unabridged, p 786. Springfield, Massachusetts, G & C Merriam Co, 1967. Copyright © 1967 by G & C Merriam Co.

FIGURE 1-5. Essential elements of a program.

system as described by Donabedian.[9] The basic criteria necessary for a successful evaluation include the following:

1. Objectives should be clearly stated in measurable terms, which are realistic and achievable within a defined time interval.
2. Evaluation methodology should be described in advance and included in the planning process.
3. Relevant data should be carefully collected at every level of activity, and one should make sure that such data are reliable and valid.
4. Evaluation should be conducted by an "objective" group of individuals.
5. The results of the evaluation should be considered seriously and resulting recommendations should be implemented whenever necessary. In other words, evaluation should be linked with the policy-making process as well.

In addition, in a complex system such as trauma care, where several organizations and several disciplines are involved, all participating groups should exhibit unqualified support and cooperation once they agree on the basic framework for evaluation. Fig. 1-6 displays some of the important components of a trauma system where evaluation should be carried out. An organized communication system of data feedback and "feedforward" among different participating groups needs to be established beforehand and should be carried out during the course of the operation of the program.

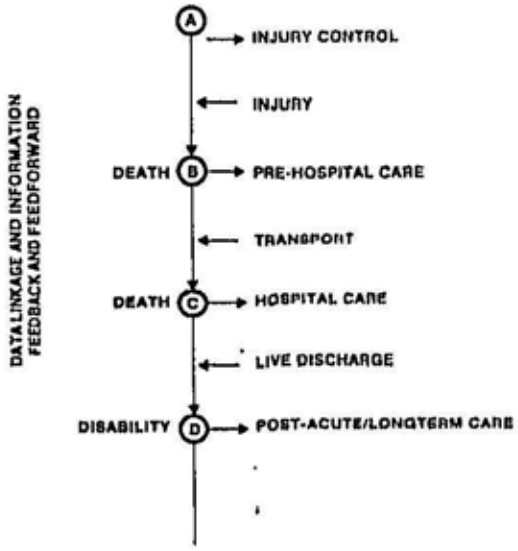
Systems evaluation should include both macro- and microlevel assessments of performance. For example, although it is important in a trauma care environment to ascertain whether the overall systems goals and mission of reducing death and disability have been met, it is equally important to examine if the objectives and subobjectives at various stages of the system operation have been achieved. Such an evaluation will help identify "disturbances," if any, within the system and make the systems operations more successful.

The application of a systems control theory, as described by Zelenock,[7] to evaluate trauma care systems may have some limitations in that a great many of the variables can become uncontrollable or even unrecognizable. Nevertheless, the salient features of the theory can be adopted in a trauma care program. Another problem that confronts the evaluator is the difficulty and complexity in quantifying some variables, such as the severity of an injury. Although indices are used to classify patients according to the severity of an injury (the injury severity score—ISS) or to assist in field triage (trauma score—TS), research to ascertain their validity and reliability under different circumstances is inadequate.

A critical aspect of the evaluation is the predetermination of the *markers* that are to be used in the evaluation of program implementation at various stages of the system, as well as the predetermination of the *outcomes* consistent with the overall goals and objectives. Once these measures are defined, a system of data collection should be put in place from the start of the program implementation to gather reliable and valid information so that the required measures can be computed accurately. Only then can the evaluation be performed reasonably.

Another critical factor in the evaluation process is the establishment of "baseline" data that operate *before* the implementation of the program; these baseline

FIGURE 1-6. Components of the system of trauma care.



data would then permit computation of "outcome" measures (such as mortality, morbidity), facilitating "before and after" comparisons for an assessment of the impact. If the evaluation strategy is to compare two regions, one that has implemented the program and one that has not, the baseline data should be collected in both regions in an identical manner.

INJURY CONTROL

The dictum "prevention is better than cure" is well known and should apply to almost all undesirable events. A necessary prerequisite to adopting this philosophy is to recognize that an episode is *preventable*. This seems to be the problem in prevention of injurious accidents. Although proposed 200 years ago, accident prevention did not find a place in the public health arena until recently. To many, the term *accident* implied an occurrence random in nature, which lead to the belief that it was due to bad luck, carelessness, or punishment by God for sins. Only after changing the term *accident prevention* to *injury control* did some skeptics begin to pay attention.[33] Yet, even today, not enough sustained support is given to injury control programs, to systematic evaluation, or to the study of the problems related to injury and its causation. This is a sad state of affairs, especially considering that mortality due to injury has numbered among the five leading causes of death in the United States for several decades, and that currently it ranks as the third leading cause, next only to heart diseases and cancer.

Recent studies (1980–1983) conducted in Maryland clearly indicate an increasing trend in the incidence of traumatic injuries requiring hospitalization among all age groups (Table 1-4). The data show a clear pattern in the incidence of serious injuries, which by no means can be considered random. The incidence peaks consistently during summer months and dips during the winter for children and

TABLE 1-4. Discharges from All Nonfederal Short-Stay Hospitals in Maryland

Data Set	Year				4-Year Total
	1980	*1981*	*1982*	*1983*	
All discharges	579,089	591,357	614,406	626,609	2,411,457
All trauma cases	31,183	33,301	33,718	33,466	131,668
Severe trauma cases (ISS ≥ 13)	4,182	4,649	4,572	4,745	18,148
Total population in the state	4,216,975	4,242,436	4,267,897	4,293,359	
Incidence rate/100,000 population	99.2	109.6	107.1	110.5	

(Health Services Cost Review Commission, State of Maryland)

young adults. And, just as consistently, the pattern is reversed for persons aged 65 years and older (Fig. 1-7). During the same period, the incidence of fatal and incapacitating injuries due to motor vehicle crashes also increased significantly. One explanation for the increasing trend in the incidence may come from state police automobile accident reports, which show that fatal and incapacitating injuries from vehicular crashes peak during the summer months and are the lowest during the winter months, and suggest an increasing trend over time.

Available data also show that about 55% of severe injuries resulting in hospitalization are related to vehicular accidents. In the words of Cooper, "Epidemiologic information is of great importance in the allocation of resources for treatment and in formulating policy designed to reduce the incidence, morbidity, and mortality [of head injury]."[7] He also noted that, "Because the automobile is responsible for one-half of all head injury deaths in the United States, trends in automobile fatality rates will have a significant influence on head injury mortality." Unfortunately, much-needed epidemiological data are not available, or what is available cannot be used owing to lack of specific definitions and standards. It is also known that fall- and fire-related injuries are most prevalent among older persons. It is not clear, however, why the incidence of severe injuries is the highest during winter months among older people. While it is recognized that vehicular accidents are a major cause of traumatic injuries, the full extent of the mechanism of such accidents is still unknown in spite of considerable research in this field. Although excess speed and alcohol are blamed for automobile accidents, one does not know how often such accidents are caused by a driver who lights up a cigarette, looks up at the mirror, has an argument with a passenger, or is simply negligent while driving. The point is, even in the "most understood" field, a lot is still unknown.

The question then becomes, If one cannot prevent an accident (because *how* it happens may be unknown), can one at least prevent the serious injuries such accidents can cause? For example, can the safety equipment in automobiles prevent serious injury when an accident occurs? Robertson examined the effect of federal motor vehicle safety standards on the occupant death rate from 1975 to 1978 in the United States and found a significant reduction in the number of deaths in federally regulated vehicles.[34] In a systems evaluation, one considers such other factors as speed limits, drunk driving, mix of vehicle size, and public awareness, in addition to the use of safety devices.

Hartunian and co-workers estimated the incidence-based costs of cancer, heart disease, motor vehicle injuries, and stroke.[22] According to their calculations, motor vehicle injuries generated $14.4 billion in present-value costs in 1975, next only to cancer. Watson and associates analyzed mortality data for motorcyclists from 1958 to 1979 in the United States and found a significant increase in the motorcyclist death rate in those states that repealed or weakened the helmet use law (Fig. 1-8).[35,36] Muller estimated that at least $61 million could be saved annually if all motorcyclists were to use helmets, and that repealing helmet use laws would result in $16 to $18 million worth of preventable medical care expenditures annually.[37]

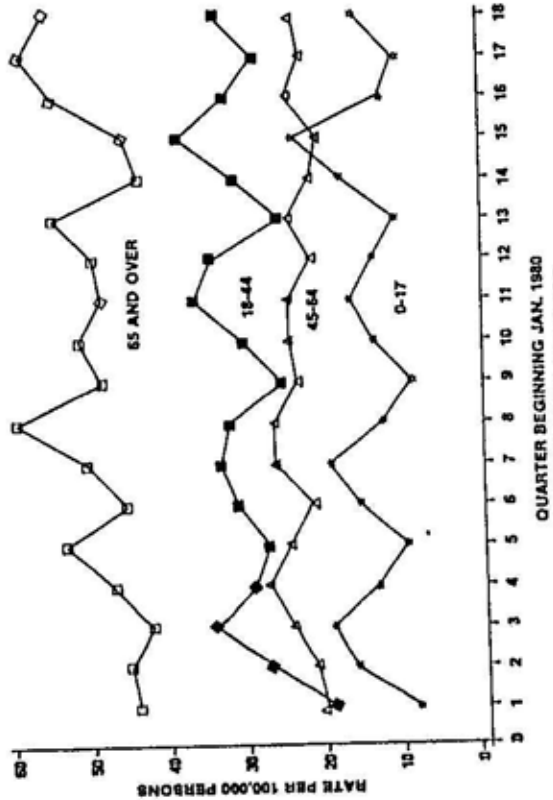


FIGURE 1-7. Age-specific incidence of hospital trauma (ISS ≥ 13) in Maryland.

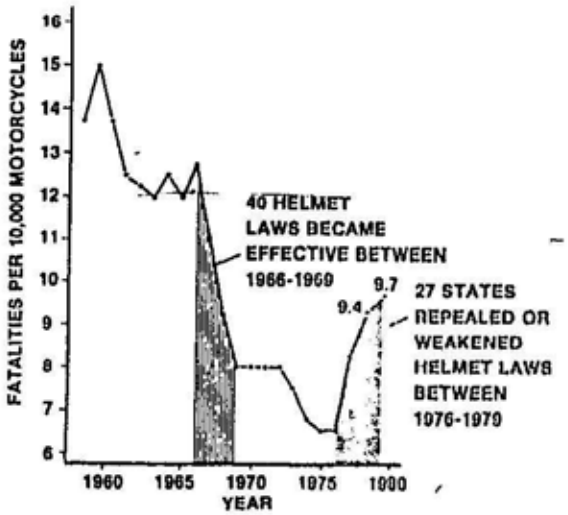


FIGURE 1-8. Motorcycle fatalities per 10,000 motorcycle accidents, 1958-1979. (Data from National Highway Traffic Safety Administration, 1979. Reproduced with permission from Watson GS, Zador PL, Wilks A: Helmet use, helmet use laws, and motorcyclist fatalities. Am J Pub Health 71: 297, 1981)

The debate over the effectiveness of driver education for teenagers goes on.[21,24,30] Although empirical evidence suggests that using safety equipment is effective in reducing vehicular injuries, most states have not passed mandatory seat belt laws, and many states have even weakened existing laws governing the use of motorcycle helmets. Such activity does not seem logical in the face of existing data and statistics; perhaps it is the result of political considerations outweighing the benefits derived from health regulations.[1] In the words of McLoughlin and co-workers, "...education for personal responsibility is not sufficient. Product modification (for safety) and environmental redesign must be instituted through education and legislation for successful control of an injury."[28] A systematic evaluation of injury control programs is critical to convince industry, legislators, and the public of the need for stricter safety measures. Systematic data collection under controlled conditions and replication of that methodology in different environments are necessary for an objective assessment of an injury prevention program's outcome.

Although automobile accidents are the major cause of injury among young adults, recreation-related accidents and falls seem to have been a frequent cause

of serious injuries among children over the past decade. However, considerable advances in accident prevention have been made by making toys safer and by using child-proof top on medicine bottles. Fisher and co-workers, for example, reported a 42% reduction in playground equipment hazards and a 22.4% reduction in playground-related injuries following a 1977 children's playground equipment injury prevention project conducted in New York State.[18]

An injury surveillance system is critical for the evaluation of an injury prevention program. A brief description of the elements of such a system can be found in *Injury in America*.[8] There may be several strategies to prevent an injury. The evaluation process should be able to assess the impact of each of these approaches in preventing or reducing the injury. This would permit comparison among various injury prevention programs for policy making and future program planning.

PREHOSPITAL CARE

When an injury occurs, the system should be able to respond swiftly and effectively to save the patient's life. According to Cowley's "Golden Hour" theory, a patient with a traumatic injury can be saved if the appropriate care is given within 60 minutes postinjury.[9] To ensure successful functioning, prehospital care must encompass thoroughly trained EMTs and paramedics; well-equipped and strategically located responder and rescue units; an efficient around-the-clock communication system; and "minute-man"-style trauma teams (at the appropriate hospitals) capable of mobilizing well before the patient arrives at the emergency department (ED). For an efficient use of hospital resources and optimal patient outcome, field triage and echelons of care should be clearly defined (see the first section of this chapter, Components). Maryland has a statewide system encompassing all of these aspects (see Vol I, Chap 2). An evaluation of this system is described below.

A comparison of the Maryland and United States figures for injury deaths occurring before the patients arrived at a medical facility (DOA) (Fig. 1-9) shows that the U.S. rate is 2.5 times that of Maryland. Although both the national and state DOA rates declined between 1980 and 1981, the rate of decline in Maryland (6.7%) was twice that of the national decline (3.3%). Maryland's well-organized training system for prehospital care providers, its centrally maintained communication system, and its coordinated transportation system probably contributed to the state's low DOA rate. In Maryland, the average time between injury and arrival at a hospital ED, whether by ambulance or helicopter, is less than 1 hour. With all the assumptions and simplifications, the observed differences in the magnitude and the percentage decline in DOA suggest a positive impact of the statewide system on Maryland's trauma scene.

It is difficult to ascertain whether every injured patient was appropriately triaged at the scene of the injury. According to the echelons of care in Maryland, critically injured persons are taken to a Level I center or to a specialty care center,

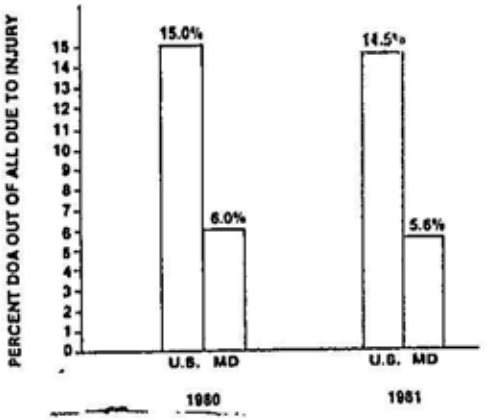


FIGURE 1-9. DOA statistics in Maryland and U.S.

severe multiply injured patients are sent to the Level II center in the region, and the others go to the nearest hospital. An analysis of hospital discharge records indicates that Maryland's field triage system may not only be working appropriately, but actually improving over time (Fig. 1-10). In 1983, for example, more than 70% of critically injured multiple trauma victims (ISS ≥ 20) and close to 40% of severely injured persons (ISS = 13 – 19) were taken to designated trauma centers. Based on the trend analysis, this "compliance" with the echelons of care is found to be increasing at an annual rate of 1.9% in Maryland.

One of the most important aspects of data gathering is to provide feedback to the originator of such documents, and both positive and negative findings of the analysis should be stressed. (Making the data collection instrument very simple and short will undoubtedly increase the accuracy.) The data so collected should be useful to those who provide it as well as to those who plan, manage, and evaluate the system. In Maryland, for example, every certified prehospital care provider is required to submit the "skills performed" report each year for recertification. Each prehospital care provider, therefore, should keep accurate records of his or her activities during the year. Such a record is produced on the computer for each individual, thus eliminating the need for additional paperwork as well as increasing the accuracy of the report.

The critical issues in prehospital care are the response time, the appropriateness of care given, and triage. To evaluate these functions, one needs accurate and complete data. Although the care providers are instructed to document relevant information on a prescribed form, their primary objectives at the scene of an accident are to stabilize and save the life of the injured person; naturally, paperwork becomes a secondary priority. They may complete the form after the

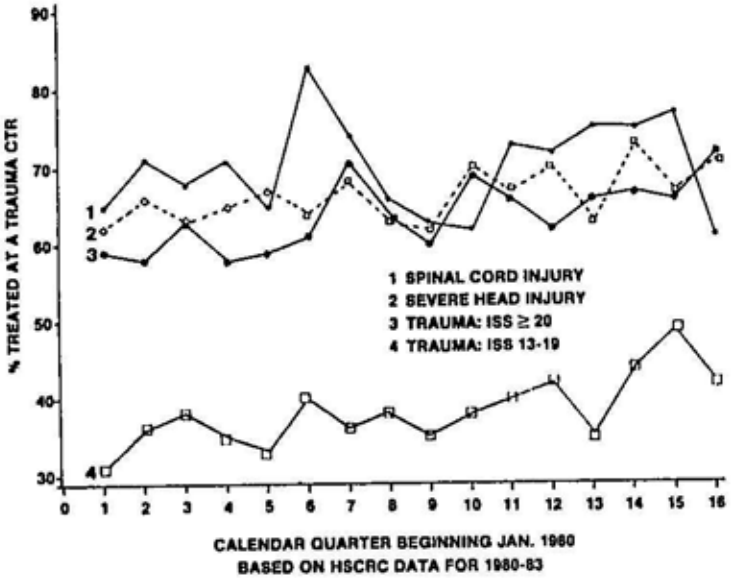


FIGURE 1-10. Compliance by type of trauma in Maryland: 1980 – 1983.

patient is delivered to the hospital, but by then the question of accuracy and completeness of the data based on memory (or even on partially written notes) arises. Thus, there has to be a constant reevaluation of the data collection instrument to make it simple and useful.

In Maryland, more than 300,000 ambulance responses are made each year; in the recent past, more than 70% of those annual calls have been "recorded" on a standardized runsheet, filled out by the responding field personnel and sent to central processing. A list of missing and incorrect data elements for each company is generated and sent to the state EMS director. The reports indicate a need for inclusion in the training curriculum, as well as in periodic refresher courses, orientation on the purpose and need for accurate data. Because the ambulance runsheet data are being used to provide annual summary reports, individuals do not have to keep track of their activities. In addition, management information by ambulance company is provided monthly, and a detailed tabulation of the data by ambulance units is sent to each company periodically, thus increasing the participation in the "voluntary" data collection system and, concomitantly, increasing the responders' level of efficiency and accuracy by "highlighting" both well- and poorly performed areas.

Accurate and complete prehospital care data are critical for systems evaluation. In addition, the information is extremely valuable to the medical staff at the ED in assessing the patient status more accurately and speedily. The ambulance runsheet should become a part of the medical record of the patient.

HOSPITAL CARE

When a patient is brought to the ED, appropriate resources should be available; patient outcome is a function of the quality and timeliness of prehospital and hospital care. Time is of the essence in critical injury situations; a good communication system will enable the trauma center to mobilize a full complement of the trauma team before the patient arrives.

It is more difficult to evaluate hospital care than any other type of patient care because the treatment criteria and standards of care vary widely, and the interpretations depend upon the attending physician. If the trauma team is not ready when the patient arrives, the ED surgeon will have to decide whether to manage the patient with his resources or to call in the trauma team. Thus, a second-level triage may take place in the ED.

In Maryland, ten hospitals have been designated Level II trauma centers.* All these hospitals also maintain general EDs. More often, the trauma center within such a hospital represents not a separate physical entity, but a concept based on the availability of resources and appropriately trained personnel within the ED. The evaluation of trauma patient care in the hospital should examine whether the patient was treated by the trauma team or by the general ED personnel (Fig. 1-11). In 1982 in Maryland, 69.3% of all critically injured patients (ISS ≥ 20) were triaged from the scene to one of ten trauma centers, yet less than half of them were treated by a "trauma team." An improvement in both primary and secondary triage was observed in 1983. Reliability and validity of these data notwithstanding, the observed change may be taken to indicate positive impact of the system. Each trauma center should institute an internal evaluation of patient outcome by comparing the complication rates, mortality figures, and lengths of stay of two groups of patients; the review should ascertain why a traumatically injured patient was not treated by the trauma team.

The concept of sensitivity and specificity can also be used in the evaluation of the triage system. Although this concept is frequently used to compare the results obtained from a new test against a "standard" test, the technique can be employed in a trauma care system to monitor the trends over time of adherence to and appropriateness of triaging.

Consider the outcome of performing a test on N number of subjects (Table 1-5). Suppose that, out of N subjects, N_1 have the disease (say diabetes) and N_2 do not have the disease. When a test is performed, four categories are obtained. Among the N_1 group, the test may show positive for some (true positive, T_p) and

*Although general guidelines for designation have been established, they are not fully adopted.

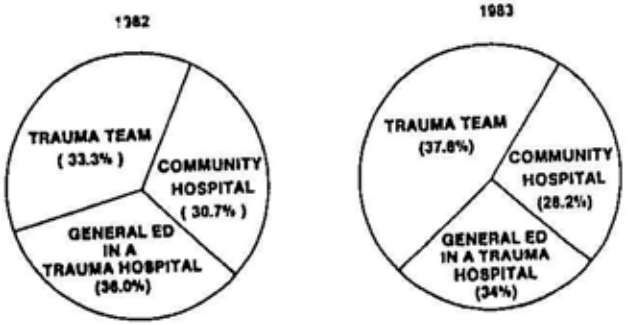


FIGURE 1-11. Distribution of trauma patients by levels of treatment in Maryland (ISS ≥ 20).

negative for others (false negative, F_n). Likewise, among the N_2 group, some may have positive test results (false positive, F_p) and the others show normal (true negative, T_n). Sensitivity and specificity of the test are computed as

$$\text{Sensitivity} = T_p/N_1$$
$$\text{Specificity} = T_n/N_2$$

One would like to have the test show positive results for *all* those who have the disease and negative results for *all* those who do not. In reality, owing to factors beyond one's control, it does not happen.

If the test is designed to make sure that very few subjects who have the disease are labeled "negative" by choosing a low threshold value, for example, for the blood sugar in the case of the diabetes test, then a high rate of false positives will result. On the other hand, a high threshold value will result in labeling a large number of diabetic patients as normal, who will then be left untreated. This concept is represented diagrammatically in Fig. 1-12 where "it is apparent that these two measures (sensitivity and specificity) are inversely related to one another."[19]

TABLE 1-5. Outcome of Performing a Test on *N* Subjects

Test	Disease		Total
	Present	*Absent*	
Positive	T_p	F_p	N_3
Negative	F_n	T_n	N_4
Total	N_1	N_2	N

The figures in Table 1-6 can be used as additional illustrations of this concept in trauma care. The two values are obtained as follows:

$$\text{Sensitivity} = 4000/6000 = 66.7\%$$
$$\text{Specificity} = 17{,}000/18{,}000 = 94.4\%$$

If one considers that seriously injured persons (ISS ≥ 13) should be treated in a designated (or well-equipped) trauma center, then the triage protocol should clearly describe the degree of injury severity for making the selection. The illustration shows that 67% of the seriously injured patients were taken to trauma centers (appropriate), while less than 6% of mildly injured patients went to trauma centers (inappropriate). Thus, among those treated in trauma centers, 20% could be considered false positive. Reduction of this percentage (false positive) can be done by proper changes in the triage protocol, but only at the expense of increasing the false negative rate (10.5%). Although it is expensive to treat a false positive patient in a trauma center, it is even more "costly" to send a critically injured person to an underequipped community hospital. Thus, a balance has to be reached. An acceptable equilibrium of false positive and false negative depends upon the maturity of the system in terms of standardization of triage protocol, training of prehospital care providers, professional and public education, and systematic evaluation.

The issue of false positive *versus* false negative prevails in many situations. The Committee on Medical Aspects of Automotive Safety made the following observations:

FIGURE 1-12. An illustration of the effects of shifting cutoff points on sensitivity and specificity. (Reprinted with permission from Friedman GD: Primer of Epidemiology. New York, McGraw-Hill, 1980)

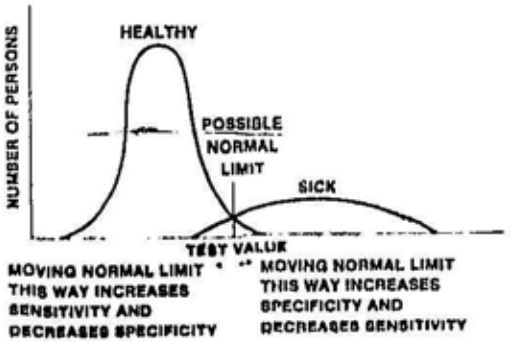


TABLE 1-6. Illustration for Sensitivity and Specificity Analysis in Trauma Care

Facility Type	Serious Injury (ISS ≥ 13)	Mild Injury (ISS = 1 – 12)	Total
Trauma center	4,000	1,000	5,000
Community hospital	2,000	17,000	19,000
Total	6,000	18,000	24,000

> It is difficult on these scales (abbreviated injury scales) to account for and compare multiple injuries. In addition, almost all of the scales base the severity of injury primarily on threat-to-life, a subjective judgment. . . . The committee on Medical Aspects of Automotive Safety fully realizes that it has not been able to eliminate completely the subjective from the Abbreviated Injury Scale, but it believes that it has reduced the error potential and has made a big step toward standardization of injury statistics.[4]

This statement means that a type of balance has been reached where the false positive and false negative may still exist. This balance is acceptable in many other medical and surgical situations, for example, surgical removal of the occasional healthy appendix (false positive) to ensure removal of *all* diseased appendices. Therefore, the existence of some false positives among the patient distribution pattern should *not* penalize the overall trauma system in terms of accreditation, financial recompense, and so forth. Again, it is better, both for the system and the population it serves, to have a few "inappropriate" admissions to a trauma center than not to admit a patient whose injuries require that special care. In any case, the length of stay of and the resource utilization by "false positives" should be evaluated periodically, and arrangements should be made to transfer such patients to appropriate care facilities as soon as possible.

Every trauma center, like any other "special care" unit, should fully comply with standards for its particular type of care. The Joint Commission on Accreditation of Hospitals sets forth the principles and standards for a special care unit as follows[23] (see also Vol II, Chap 1 and 2):

Standard 1. Special care units shall be properly organized, directed, and integrated with other departments or services of the hospital.
Standard 2. Special care unit personnel must be prepared for their responsibilities through appropriate training and educational programs.
Standard 3. The design of, and equipment for, special care units shall facilitate the effective care of the patient.
Standard 4. There shall be specific written policies and procedures for each unit, which supplement the basic hospital policies and procedures.

Thus, in addition to patient outcome, the structure of the trauma center as well as the process of trauma care should be included in the systems evaluation.

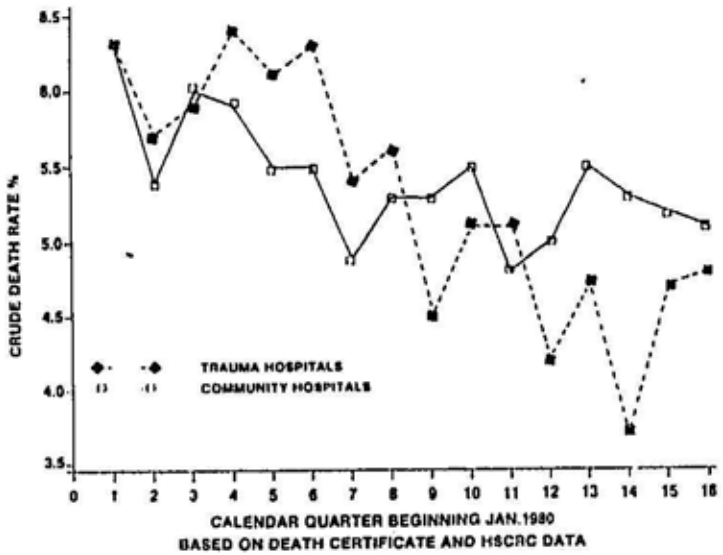


FIGURE 1-13. Trends in hospital death rate in Maryland.

The test of the trauma system lies in effecting a reduction in the patient death rate, thus increasing the probability of survival after injury. Hospital death rates and proportionate mortality ratios within the system provide measures with which to judge the performance of the trauma system. A comparison between trauma hospitals and the community hospitals with respect to trends in crude death rates among inpatients with injury diagnoses codes based on the ninth revision of the International Classification of Diseases—Clinical Modification (ICD-9:CM; 800-959) in Maryland indicates a statistically significant decline from 1980 to 1983 (Fig. 1-13). Such analyses should become a part of the surveillance of the system operation.

CRITICAL ISSUES IN TRAUMA SYSTEM EVALUATION

THE TEAM APPROACH

The success of any system depends on harmonious working relationships among all components. The success of a trauma system likewise depends on the working interrelationships of prehospital providers, clinical staff, administrators, re-

searchers, and so forth. Failure of any one component, or of the relationship between that component and another, can result in the failure of the total system. Therefore, intercomponent cooperation, coordination, and communication — in other words, teamwork — is mandatory; each individual component (see the first section of this chapter, Components) must be integrated with and linked to the previous and successive components to provide a maximally effective trauma system. The glory of success and the fault of failure of the system should be equally shared.

DATA

Collection. Documentation of all activities and findings is a time-consuming, often tedious, but necessary component. Saving a patient's life and caring for his or her injuries is, of course, the primary concern; however, data collection is necessary (1) to validate that what was done was both "necessary" and "sufficient" and (2) to facilitate feedback essential for making improvements. Therefore, documentation of each step of a patient's care provides a benefit not only to that individual patient (through checkpoints and as a control against possible errors), but also to the care givers (feedback on effectiveness of treatment), to the patients who come afterward (improved techniques), and to the overall system (review of strengths and weaknesses). For all these reasons, the trauma system depends on how diligently the individuals involved comply with the requirement for documentation and data collection.

Reliability/Validity. Mere compliance with data reporting, however, is not sufficient. Care givers must supply accurate and complete information — on a *timely* basis. As stated earlier, the longer the delay between event and record, the lower is the reliability (accuracy) index of that reported information. The goal, then, is to decrease the time lag and thereby increase the validity of the data.

One method for improving both compliance and accuracy is for a central registry (see below) to provide periodic review meetings and other feedback to the data suppliers; this feedback will point out areas needing improvement, will recognize those areas performed well, and will display the results of combined efforts. In short, it will generate interest in (and compliance with) the data collection system because it *involves* the collectors in the overall process, rather than isolating them as mere "drones" or "cogs in the wheel."

Processing/Linkage. The most efficient and economical way to process the raw data into meaningful information is through one central registry or agency. This agency can tabulate and correlate information from several different sources into standard terms and formats, facilitating efficient data storage and retrieval for speedy responses to inquiries and, most importantly, for effective evaluation; in fact, a system evaluation would be impossible without this link between data sources. The multiple records of a "typical" trauma patient provide a good example of how this link works.

A motor vehicle accident victim admitted to the Black Trauma Center for example, will have three basic record reports, each containing thousands of individual pieces of data. The police report describes the accident and various circumstances of injury. The prehospital report and[illegible] the patient's condition at the scene, the field care provided, any consultations and/or decisions made by way of telecommunications, the method of transport selected, the name of the receiving facility, and any other details of that transport. The hospital report provides a record of the patient's condition on arrival, the types and times of medical intervention, length of stay, outcome, and so forth. Unless all the data in all three reports are linked together, the patient profile and history will be incomplete, and the full extent of the problem and its outcome will never be known. Multiplying that amount of data for one patient by total patients per year produces an enormous amount of raw data, analysis of which requires tremendous computer resources (see Vol II, Chap 5, for a discussion of computer applications in the clinical setting). Although such a computer system may represent a hefty financial commitment, it is a mandatory requirement for the effective and efficient management and analysis of these data elements crucial to the success of any trauma system.

Access. As stated earlier, all components providing data input should have access to the system results. In some instances, however, extra-system agencies may provide data and may consequently request access to the computer information banks. Some arrangements should be made to provide this access, but it must occur under controlled conditions. Patient confidentiality must be formulated and rigidly enforced, and the types of data to be accessed, as well as the method of access, should be clearly defined. Collaborative research and data sharing should be encouraged, and research and program interests of individual participating agencies should be recognized; however, there must be an explicit understanding about the data sharing process and its limits *before* the process begins.

REHABILITATION

Most trauma victims are young with, under normal circumstances, many years of productive life ahead of them. Those who survive their critical injuries often have permanent disabilities that prevent them from resuming their normal activities and places in life. A successful trauma care system, therefore, will address not only the acute and immediately postacute phases of injury; it will also include a comprehensive rehabilitation services program for assisting the trauma victims to make the adjustments necessary to reestablish a functional role in society (e.g., see Vol I, Chap 15, and Vol II, Chap 9).

Again, data collection and evaluation play a significant role in the successful achievement of this goal. Such a program depends on accurate and adequate data and the interpretation of the results to determine the extent of need, to inventory available (and needed) resources and referral services, to plan maximal

use of said resources and services, and to evaluate the effectiveness of the program.

TRAUMA REGISTRY

Establishing a trauma registry has recently received increasing interest, both regionally and nationally. Such a registry can ideally function as an important tool in assessing the impact of a trauma system; however, considerable planning is required to accomplish that intended purpose.

A true trauma registry should include all data points in the total spectrum of the trauma care - from injury to long-term rehabilitation. Because establishing a trauma registry can involve considerable expense, the success of any trauma registry depends on its structure and format as well as on its content and usefulness. For example, in Maryland's statewide system, the developing central trauma registry consists of minimum information and registration of all trauma patients treated in the system. This registry facilitates linking (1) relevant prehospital care data from the ambulance runsheet, (2) circumstances of injury (from the state police file in the case of a vehicular accident), and (3) cost data from the cost review commission files. The trauma registry thus eliminates duplication of effort and minimizes the expenses. Each trauma center is encouraged to maintain detailed clinical data and follow-up information on the patients treated within that hospital.

One of the advantages of a central trauma registry is its research potentials. For example, the National Eye Trauma Registry (maintained at the MIEMSS evaluation office) can provide an acceptable sample size for a study of eye injury from BB guns. Without pooled data from many facilities, such rare injuries cannot be studied effectively as a group. A centrally maintained trauma registry uses computer and statistical resources more efficiently than would multiple (and probably duplicate) individual registries. Of course, such a registry will have some problems, too; for example, the question of confidentiality of patient records occurs quite frequently. Other concerns include unauthorized use of data and the lack of flexibility and specificity in the data processing to meet the needs of individual participants. Many of these problems can be avoided with proper planning.

Whether the trauma registry is established centrally in a region or it is maintained by each trauma center, *national* standards for the structure and content need to be established, along with some general guidelines for reporting and analyzing the results. Every trauma registry should consist of a minimum data set, and each data item should be defined uniformly; otherwise, comparisons between data sets will be inappropriate and conclusions therefrom will be invalid. A trauma registry should include at least the following information:

A. Circumstances of injury
   1. Cause
      a. Vehicular (driver, passenger, pedestrian)
      b. Fall
      c. Assault (blunt, penetrating)
      d. Fire
      e. Other
   2. Where
      a. Highway
      b. Farm
      c. Recreation
      d. Home
      e. Other
   3. Industrial/work-related: Yes/no
   4. Injury type
      a. Head
      b. Spinal
      c. Multiple fracture
      d. Burn
      e. Other
   5. If vehicular, safety equipment used
   6. Whether alcohol/drug used
   7. Time of day; day of week
B. Prehospital care
   1. Vital signs
   2. CPR
   3. MAST
   4. Drugs
   5. IV
   6. Transport information
C. Hospital data
   1. Vital signs
   2. Diagnostic/treatment data
   3. Disposition
   4. Length of stay/cost
   5. Attending
D. Posthospital data
   1. Patient's destination
   2. Functional status of 6-month interval for 5 years
   3. Health services utilization pattern
E. General
   1. Age
   2. Sex
   3. Race

This example may serve as a starting point. A national consensus on a minimum data set for a trauma registry is in order. Whenever applicable, ambulance runsheets and the police accident reports should become a part of the patient's med-

ical record. In addition, the trauma registry record should include the identification information as it appears on the runsheet and the accident report if these records are also computerized. Such a procedure will enhance the capability for capturing all relevant data in the trauma registry.

SUMMARY

A necessary prerequisite for a systems evaluation is the collection of complete and accurate data on the activities of all components of the system. The data also permit evaluation of these subsystems (components), which will have their own subobjectives. An effective functioning of the system depends upon achievement of these subobjectives at every level. A breakdown at any one stage will make the system suffer. For example, even if the prehospital care were successful (see Vol I, Chap 2), the system would be deemed a failure if resuscitation, stabilization, and evaluation of that patient in the admitting area were less than adequate.

Systems evaluation requires a reasonable and appropriate evaluation of all such activities. One of the most important tools for such an evaluation is a comprehensive trauma registry. Every care provider needs to be sensitized to the importance of accurate data and should receive the necessary training on data collection.

In this section of Chapter 1, patient features and general principles of systems evaluation were discussed. Within this framework, specific action steps appropriate to the given system need to be developed and incorporated in the planning documents. Such an evaluation should be an ongoing activity. The results of an evaluation should be carefully examined and the recommendations promptly implemented.

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Chapter 2

Prehospital Trauma Care

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INTRODUCTION

Abraham Lincoln once remarked that "to save a man's life is the most a person can do for another." Today, the right to life—and a healthy one—is regarded not only as a personal responsibility, but as a basic human right; therefore, it has become the task of modern society to ensure a full, healthy life for each of its members. In the United States, the last few decades have witnessed tangible evidence of society's acceptance of this task: increasing advocation of preventive medical programs, a growth in public awareness, health education for increasingly younger audiences, safety- and health-related legislation, and the development of sophisticated health care systems for the sick and injured.

This growth of emergency medical services (EMS) systems, coupled with lower speed limits and higher safety standards (developed by the U.S. Department of Transportation and the automotive industry), has led to a significant (30%) decrease in accidental death rates since 1974.[1,2] In recent years, for example, the Maryland Institute for Emergency Medical Services Systems (MIEMSS), a fully integrated system of communications, prehospital care, and sophisticated transport and medical intervention, has reduced early statewide accident mortality by 23% despite increasing numbers of accident victims.[3] Continued improvement depends on two major factors: (1) the community at large must become aware of this decline in deaths from traffic accidents and must come to understand how prehospital care can reduce it even further; and (2) community leaders—legislators, health planners, directors of emergency care programs—as well as health care providers must be educated about why and how people die, why and how people survive, and ways to improve the latter.

Understanding life and death processes helps legislators allocate funds and pass laws to protect their citizens, planners to recommend needed resources, program directors to allocate those resources, and providers to develop and de-

liver state-of-the-art medical care to those in need—even outside the environs of a medical facility.

HISTORICAL PERSPECTIVE AND DEFINITION

PRE-1800

Human concern with illness, injury, and death probably predates recorded history. Earliest accounts indicate that illness was believed to be the result of a god's anger, but that trauma, that is, bodily injury, was a natural and expected result of poor safety practices and necessary wartime activities. Early civilization's only antidotes were magic potions and religious incantations to drive the "devils" out of the victim's body; failure, of course, resulted in death.

According to the Edwin Smith papyrus, however, by 1500 BC distinct triage and surgical treatment protocols had been developed; the Babylonian Code of Hammurabi even regulated fees for trauma surgeons.[25] Later, the Romans followed a Greek tradition and required a physician to be present during battle; they also established a system of hospitals close to the battlefield. Many of today's prehospital treatment techniques are based on these same ancient concepts.

1800–1900[26]

Dominique Larry (1776–1842), considered by many the father of prehospital care, was Napoleon's chief physician. During the campaigns, he organized a system of prehospital transportation to carry the wounded from the scene of battle to a centralized location by a horse-drawn wagon called "the flying ambulance." He is also credited with performing more than 200 amputations in 24 hours during the Battle of Borodino. Florence Nightingale revolutionized hospital care of the injured during the Crimean War; by applying simple sanitary measures, she decreased the infection mortality rate from 42% to 2% in just 3 months.

The origin of the Red Cross may be traced back to 1859 and the Austrio-Serbian War. Henri Dunant, a Swiss banker and philanthropist, arrived in Solferino, Italy, the day after a 15-hour battle between Italian and French *versus* Austrian armies. He found 40,000 dead or wounded soliders abandoned on the battlefield. His book, *Un Souvenir de Solferino* (1862), brought international attention to the problem. He called for a world congress to organize societies of volunteers which, in time of war, would give aid to any wounded person regardless of nationality. As a result of his efforts, the first two Geneva conventions were held in 1863 and 1864, the Red Cross was established, and he shared the first Nobel Peace Prize in 1901.

During the American Civil War, Lewis C. Duncan, a young army captain, described the situation of the wounded: "A volunteer soldier offers his dearest possession to his country, his blood, his limbs, possibly his life. When that soldier is struck down, shall his country leave him on the field suffering from cold, pain, thirst, even hunger; to die perhaps without aid, unless he drags himself [illegible] by his own painful exertions? Certainly when he gives his dearest possession the country should not be niggardly when all it can give is dollars, but should apply an abundance of the best possible means for his succor."[14]

The Civil War experience supplied the impetus for Joseph K. Barnes, MD, Surgeon General of the Army, to establish a system of prehospital care. He designated medical corpsmen for on-the-scene management of patients as well as for transportation to the nearest mobile or fixed medical facility.[26]

THE MODERN ERA[4,5,26]

Both prehospital and hospital care among the U.S. armed services have improved after each war; the mortality rate among the wounded reaching medical facilities fell from 8% in World Wars I and II to 2.5% in the Vietnam conflict. During World War I, for example, corpsmen began using the Thomas splint to manage open or closed femoral fractures. In World War II, plasma, whole blood, and antibiotics were introduced. In fact, the lowest mortality rate (1.4%) occurred during the Italian campaign where Beecher's shock tents were available to resuscitate most of the wounded. In Korea, surgeons improved techniques for vascular surgery and developed the artificial kidney; both the Korean and the Vietnamese experiences proved the value of (1) expeditious field stabilization, (2) rapid air transportation for the severely wounded to appropriate medical facilities, and (3) protective body armor in reducing wound severity and mortality.

The medical "advances" developed and learned during one battle or war fell into disuse during peacetime. Much of what applied to the massively injured patient was felt to be out of place in civilian practice, and, even had the desire been present, there was no mechanism for implementing such procedures. This also meant that skills rusty from nonuse had to be relearned at great cost with the onset of each new war: the 70% risk of death early during the Korean conflict, for example, fell to 25% as both combatants and medical support teams gained experience. By the end of the conflict, the Marines had the lowest mortality rate (11% compared to the Army's 22%), a fact explained by the protective armor worn by the Marines and the close proximity of their medical support units to the battle sites.

Although the past several years have remained relatively war-free, lifesaving techniques learned during wars have come to be used in a new way: to fight trauma in the peacetime, or civilian, arena.

THE 1980s

Today, trauma is defined as a surgical disease. It is caused by excessive kinetic energy reacting on the body's systems, disrupting major vascular structures, organs, and tissues; if not treated quickly by skilled surgeons, it will cause death. "Civilian" trauma (accidental death, injury, or disability) has become a nationally recognized disease epidemic. Trauma kills more than 150,000 Americans each

year and permanently disables 400,000 others.[9] Trauma is the number-one killer of Americans between 1 and 44 years of age and the number-three killer (after arteriosclerotic heart disease and cancer) of all Americans. It is an indiscriminate killer; it does not differentiate between the young and the old, the rich and the poor, the healthy and the sick.

Most of this trauma results from road traffic accidents (RTAs), the majority of which are caused by two major factors: drinking while driving and failing to wear seat belts. Despite widespread public education campaigns and stricter laws, individual behavior patterns have remained largely unchanged. Each year, the cost in lives and money increases; 1984's cost was more than $90 billion.

WHY DO PEOPLE DIE?

The best way to treat trauma is to understand the primary causes of traumatic death. This chapter focuses on blunt trauma from RTAs, to the exclusion of penetrating and burn injuries. Analysis of RTA-related deaths forms a basis for developing ideal prehospital trauma care management protocols.

CAUSES OF DEATH

Trauma from RTAs "begins" as a *multiple organ disease* because of the reaction of the body to excessive kinetic energy being dissipated in a short distance and time:

$$\text{Gravity} = \frac{(\text{change in velocity})^2}{30 \times \text{stopping distance}} \qquad (1)$$

In a crash, the body's weight (G) can be multiplied many times and may exceed 100,000 foot pounds if stopping distance is minimal. Stapp's rocket sled tests have proved that man can survive enormous rapid deceleration forces: Stapp survived stops from greater than 600 miles per hour in 1.5 seconds by using a pioneering, five-point harness restraint system.[16] Such studies have led to the development and installation of modern protective devices in cars and airplanes, such as collapsible steering wheels, seat belts, air bags, and ejection seats, all of which should be considered as modifiers of deceleration. The most effective method today is the passive restraint air-bag system, which maximizes stopping distance and better distributes the energy transferred to the body.

When injury does occur, the interaction of three factors will determine if death will be the outcome: the injury (a manifestation of the amount of kinetic energy transferred to the body), the age of the injured, and the time lapse between injury and medical intervention. This interaction may be expressed in the nonlinear and obviously time-dependent Equation 2:

$$P(D) = K[(\text{age}) + (\text{vital organ or tissue injury})^3 + (\text{time})^3] \qquad (2)$$

where P(D) = probability of death with values between 0 and 1, and where K = kinetic energy.

REVIEW OF RTA DEATHS IN MARYLAND*

That trauma continues to be one of the leading causes of death in this country comes as no great surprise, nor does the fact that, despite continual development of advanced EMS systems, the same overall patterns persist. But this latter fact must be viewed closely in order for one to realize that some changes have evolved: *where* death occurs for this patient population is being shifted from the accident scene to hospital arrival/admission. Maryland's statewide system personnel, for example, can so quickly stabilize and evacuate a patient with wounds previously considered lethal that the patient survives to reach the hospital awake—often, however, only to die soon afterward in the operating room where frustrated surgeons wage desperate and sometimes futile battle against rarely encountered injuries (see Vol I, Chap 10). That patients who never used to leave the accident scene alive now survive to reach surgical intervention at the receiving facility is directly attributable to the advanced and integrated communications, stabilization, and helicopter transport system of prehospital care in Maryland.

To determine if mortality could be further reduced during the prehospital phase, MacKenzie and associates reviewed all RTA-related deaths that occurred within 24 hours of patient admission (by direct helicopter transport from the scene) to the Shock Trauma Center of MIEMSS.[23,24]

A total of 305 patients who died within 24 hours of admission were identified from a population of 2579 patients admitted over a 4-year period from 1976 to 1980. Of these 305 patients, 132 (43.3%) were dead on arrival (DOA) or declared dead within 30 minutes of admission after resuscitation was unsuccessful (Group I). The remaining 173 patients of the original 305 (56.7%) arrived alive but died within 24 hours of admission (Group II). Autopsies were performed on 98.3% of these patients; only 152 potentially reversible injuries were found. Many of these were not the primary causes of death, and there was an average of more than five injuries per person.

Of those injuries in Group II patients with any possibility of treatment, 52 (34.4%) were acute subdural hematomas, which carry a mortality of greater than 50% even when treated early. Only eight (6%) were airway/hypoxic problems, and 5 (3%) were cardiac arrhythmias. The greatest number of injuries in this group were pneumothoraces, 42 (45%), of which 14 were bilateral. All were di-

*The numbers discussed here should be viewed as applicable to accident victims anywhere.

agnosed and treated at the time of admission. It is not known whether any of these pneumothoraces was the primary cause of death, but this is not suspected.

Again, these facts underline the success of the MIEMSS-coordinated prehospital system: Patients who would have suffered cardiopulmonary arrest in another system arrive at a Maryland Trauma Center prior to this devastating event.

To be maximally effective, prehospital care protocols must focus on those injuries that cause the most damage: head and spinal cord injuries remain the number-one primary cause of death, are commonly associated with respiratory failure, and should be considered respiratory emergencies. The second most frequent cause of death is exsanguination from a major organ, or vessel disruption, especially from injuries to the abdomen, pelvis, and lower extremities. These two areas alone comprise 93% to 96% of deaths that occur in the first 24 hours postinjury. However, victims with even potentially lethal injuries can survive if they receive prompt, appropriate prehospital intervention and rapid transportation to a trauma care facility.

WHY DO THE INJURED SURVIVE?

STATISTICS

In the past 10 year, the risk of having an RTA has increased as more vehicles are registered, more miles are driven, and individual behavior patterns remain unchanged (drinking while driving, nonuse of seat belts or helmets)[1]; yet 30% more RTA victims survive today than did in previous years. This statistic may be explained by Equation 3; the probability of survival (P[s]) from RTAs may be quantified as a function of kinetic energy (KE), crashworthiness (cw), passive restraint measures (prm), and the sum of both prehospital and hospital components (K) interacting with the number of systems injured:

$$P(s) = KE[(cw)^3 + (prm)^3 + K(\text{organ/tissues injured})] \qquad (3)$$

where P(s) may obtain any value between 0 and 1. Thus, survival from RTAs depends on many factors, such as precautions against injury and care after injury, as well as the number of injuries and their severity.

PRECAUTIONS

During the past 15 years all components of Equation 3 have been improved significantly. The federal government has mandated a maximum speed limit of 55 mph throughout the country; the U.S. Department of Transportation (DOT) has provided vehicle manufacturers with crashworthy standards; and individual states are beginning to require mandatory seat belt use. The Department of Transportation, in conjunction with the Department of Health and Human Resources, has improved the total system of prehospital care by providing funding for standardizing training and system development throughout the country. (National legislation and funding became available through the EMS acts and others from the late 1960s and 1970s.) The American College of Surgeons has provided hospitals with the guidelines necessary to enable them to resuscitate and treat potentially lethal injuries in a consistent and qualified manner.[8,9,10]

If a further increase in the survival rate is to occur, resources must be expanded to legislate laws that incorporate mandatory air bags in all vehicles and to reinstate helmet laws for motorcycle operators. Research funds must be allocated for examining both prehospital and hospital resources capable of reducing morbidity and mortality. In addition, vehicles must be constructed so as to modify and attenuate crash forces. If the structural and passive design of a vehicle enables it to absorb and dissipate the forces of a crash, the occupant will not sustain lethal injuries to vital organs. Automobile production lines already incorporate much of this principle; however, increased emphasis must be placed on the use of passive restraint mechanisms (air bags, seat belts, *etc.*).[11]

If injuries do occur, skilled personnel must be brought to the scene in a timely manner to extricate the injured, perform lifesaving procedures, and stabilize and immobilize the injured for expeditious transport to designated facilities.

The major goal of prehospital care, then, is to deliver, in a maximally expedient manner, a viable patient to a facility where an experienced trauma team can perform resuscitative procedures.[12,20] The second goal in managing trauma victims is to do them no harm during the prehospital care phase.

THE IDEAL PREHOSPITAL SYSTEM

The knowledge of why people die and the components necessary for survival provides a foundation for an ideal management system for the trauma patient. But this knowledge alone is not enough. It must be understood that prehospital care can exist only as a *team effort* aimed at early identification of critically ill or injured patients, even when only minimal information is available. Each link in the system, from initial activation to trauma center delivery, is vital.

The prehospital phase may be broken down into four major components: (1) communications, (2) notification and urgency, (3) on-the-scene management, and (4) transportation.

COMMUNICATIONS

Central to any prehospital system is an advanced communications system that functions as an information exchange vehicle. From the first phone call to the final air-to-ground monitoring, it must serve not only to notify and dispatch but also to make available to all involved care personnel the following critical information: identification of the extent of injury and urgency status, basic safety and first aid instructions to the caller, manpower and skill levels required, and the

necessary mode of transportation. Of primary importance is the provision of (1) a link to remote specialists for consultation and (2) on-line medical control through all parts of the prehospital phase.

NOTIFICATION AND URGENCY

Both Cowley and co-workers[12] and Andrews[3] have provided reasons why critically injured or ill patients must be identified early and transported expeditiously to designated facilities. Survival in critically ill and critically injured patients remains both a time- and skill-dependent function: the level of urgency must be determined as early as possible to provide both the proper mode of transportation and the skill levels required at the scene of injury.

It should be possible to identify critical patients during the notification phase. The age of computers has allowed for a centralized notification system for police, fire, or health emergencies; once activated, the system automatically displays the location and telephone number of the caller. Identification of the emergency by a trained operator immediately dispatches a police, fire, or ambulance unit. With mobile police units, all locations should have a first responder on site within 3 to 5 minutes of the call. Simultaneously, functioning from a protocol, the operator will establish and dispatch the level of emergency care needed and may instruct the caller, if necessary, in basic first aid procedures and safety.

To incorporate criteria for urgency into the skills level of the operator, algorithms should be developed that can determine and recognize the level of urgency with a minimum amount of essential information. Algorithms would identify whether the situation is nonurgent, urgent, or critical (matching category levels of 3, 2, or 1, respectively). For example, if an RTA is reported, the operator would need to determine the following essential information:

- How many vehicles involved?
- Passenger or driver entrapment?
- Number of people involved? How many appear injured?
- Any of the injured unconscious or appearing dead?
- Any of the injured with gross injury to head, chest, or abdomen?

(During the call, and until first responders arrive on the scene, the operator may also have to instruct the caller in simple airway management and external bleeding control.)

If it is determined that

- Someone is trapped in any manner
- Anyone is unconscious or appears dead
- The passenger compartment is deformed
- Two or more systems of any one victim are involved

then a critical (Level 1) response is indicated. This level of response dictates the simultaneous dispatching of life-support units, paramedic supervisors, and a helicopter, as well as the notification of the appropriate trauma facility.

If no apparent injuries have occurred (nonurgent, Level 3), the additional manpower would be alerted. In all other situations, a basic life support unit with a minimum of two emergency medical technicians–ambulance (EMT Asn would be dispatched (urgent, Level 2).

The victims of all Level 1 accidents would be automatically triaged to the closest appropriate trauma facility for resuscitation.

ON-THE-SCENE MANAGEMENT

The First Responder. Regrettably, the term "first responder" has come to be understood as the first medical personnel to arrive at an accident scene. In an absolute sense, the first responder should be that citizen who first happens upon the scene, but it would be rather unrealistic to expect every member of the general public to know basic first aid and triage. Therefore, to supply the "middle ground" of a large number of responsible individuals, all police, fire, and certain other civil, state, or municipal personnel should be trained for these situations.

On arrival at the scene, the first responders must quickly assess both the accident scene and the patient's condition. The accident scene gives information as to the amount of energy transferred and levels of injuries to be expected. The patient assessment provides information on the status of the central nervous, respiratory, and cardiovascular systems, and in what order lifesaving modalities are to be applied. Both of these assessments can be accomplished in less than 30 seconds. System evaluation, such as monitoring vital signs, must be assessed after every procedure and repeated every 5 minutes.

All first responders would be trained not only in extrication but also in advanced first aid procedures such as airway control, oxygen administration, neck immobilization, and control of external bleeding. All providers must also be trained to recognize gross abnormalities in the central nervous, respiratory, and circulatory systems. They must be trained to monitor these systems using the simple techniques of inspection and palpation.

The central nervous system can be quickly evaluated: Is the patient alert? Is there any reaction to pain or voice? Is the patient completely unconscious with injury to the head or pupillary changes? These three states would be appropriately scored as 2, 1, and 0, respectively.

The respiratory system can be similarly assessed quite rapidly. Is the patient able to take a deep breath without pain? Is the patient breathing rapidly with pain, with some suspicion of thoracic pathology? Is there obvious thoracic pathology or respiratory arrest? Each state is then scored 2, 1, and 0, respectively.

The first responder would evaluate the cardiovascular system by checking peripheral pulses, most commonly the radial. The rate and strength of the pulse or its absence would be rated 2 (normal), 1 (abnormal), or 0 (none), respectively. The presence of gross limb deformity or external hemorrhage must also be considered.

After assessing the accident scene for mechanism of injury and safety, the first

responders' priorities are directed toward airway, cervical spine, and control of external bleeding. These personnel must be trained in the use of both oral and nasal airways, suction, hard collars, oxygen therapy, and external pressure dressing.

Hard cervical collars should be applied as soon as possible in both conscious and unconscious patients. When cervical pathology is suspected, this procedure not only provides stabilization to the cervical spine, but also prevents excessive pressure on the neck veins; poor head position may compress neck vessels and increase cerebral pressure. Before applying any cervical mobilization device, the responder should note whether or not the trachea is deviated.

All first responder assessments and procedures should be performed in a minimal amount of time (90 seconds); they can also be done during an extrication.

This system is developed around a tiered response. When the central operator has completed his or her inquiries and instructions, and, if necessary, dispatched advanced life support units and appropriate transportation, the first responder should expect the timely arrival (within 1 to 5 minutes) of both basic and advanced life units, followed by the appropriate paramedical supervision and helicopter transport (within 10 to 15 minutes). When these personnel arrive, the first responders are able to perform other duties to expedite the extrication, stabilization, immobilization, and, finally, transport of the patient.

Life-Support Personnel. At the scene of any accident requiring an ambulance, there would be at least two EMT–As providing a basic life support unit. Beyond this level, either by initial notification or by an upgrading of the urgency level by the trained first responder, advanced life support units would be dispatched and a paramedic supervisor might also be *en route* from a central location for the area.

At the scene, if the victim is unconscious and trapped, the paramedic supervisor or other skilled personnel may elect to stabilize the airway and enhance oxygenation by use of an endotracheal tube. Today, this modality is supplementing esophageal obturator airways (EOAs) as a treatment of choice (although there may be a "middle ground" with use of a pharyngolaryngeal-endotracheal tube). Only in extreme instances (and then only by appropriately trained personnel) may a needle cricothyroidotomy be performed to administer 100% O_2; during these procedures, a second EMT–A simultaneously places a large-bore IV in an accessible vein. The paramedic supervisor would continually assess the central nervous, respiratory, and circulatory systems using the method described above.

At the same time, assessment for, and management of, other life-threatening injuries (sucking chest wound, flail chest, external hemorrhage) must continue. Most of these injuries are obvious conditions and can be managed expeditiously by the majority of EMTs.

Extrication may greatly prolong evacuation, and the field personnel should notify the trauma facility of the delay. If necessary, a field team (comprised of a trauma surgeon, a nurse, and an anesthesiologist) will be dispatched immediately. When required, this team can perform full surgical procedures, such as amputation, in the field.

For immobilization during extrication, a short board or similar device is used for the patient whose neck is already stabilized in a rigid collar. The patient is then transferred to a long board where military/medical antishock trousers (MAST) are in place awaiting closure and inflation.

Internal bleeding must be suspected in every conscious or unconscious patient when the vehicle's occupant compartment is deformed or other blunt forces are suspected. Pelvic or multiple fractures and weak, rapid, or absent radial pulses indicate internal bleeding in the lower body regions with approximately 25% or more blood volume loss. External pressure devices must be rapidly applied and inflated in an attempt to modify and control this loss. These devices not only slow internal bleeding but also allow rapid immobilization of the lower half of the body. In addition, when inflated, they provide artificial peripheral resistance only to the lower half of the body, thereby supporting perfusion pressures needed for the heart and brain.

After inflating the MAST, EMTs must repeat the quick assessment, looking for external bleeding within the inguinal, femoral, or other areas where external pressures are not provided. As the MAST is applied, a vein may become accessible in the upper extremities for insertion of additional large-bore needles and infusion of Ringer's lactate. Time should not be wasted inserting lines; only two attempts should be made. Once the patient is stabilized and no longer in immediate danger, he or she is quickly immobilized on the long backboard and assessed for levels of consciousness, respiration, and pulses every 5 minutes; the patient then is moved to the appropriate mode of transportation. If a life-threatening condition does occur, it must be treated immediately.

The patient may be ready for transport in 6 minutes. At this time the field trauma team should move the patient to the awaiting transport helicopter or other vehicle and dispatch him or her to an appropriate specialty center. No time should be wasted performing a secondary survey. The total time necessary for the on-scene assessment, stabilization, and immobilization should not exceed 360 seconds, or 6 minutes (Table 2-1).

TABLE 2-1. Procedure Timing

Provider Group	Procedure	Time (sec)
First responders	Initial assessment	30
	Airway, cervical collar, suction, and oxygen application	30
	External bleeding controlled	30
	Subtotal	90
Basic/advanced life support	MAST and IV	180
	Immobilize	60
	Monitor	30
	Subtotal	270
Total time		360

TRANSPORTATION

With the arrival of the helicopter or other vehicle, additional personnel are added to the manpower pool. On-scene personnel are responsible for the primary assessment, stabilization, immobilization, and transportation. Time should not be wasted in the field performing secondary surveys of the critically injured. Once the patient is placed in either a ground or air ambulance, appropriate monitoring is continued, vital systems reassessed, and the secondary survey begun. Vehicle personnel must have additional skills of advanced airway and ventilation management.

On arrival at the trauma facility, the patient is met by a resuscitation team for immediate reassessment, ventilator support, and placement of additional large-bore infusion lines. The patient is further evaluated for life-threatening conditions, and emergency procedures are performed if necessary.

The maximum time from dispatch to a trauma center should not exceed 35 minutes for either helicopter or ground ambulances. Both ground and helicopter ambulances should be strategically located so that the time required to move to and from the scene is minimized. Ground personnel must be able to reach the scene of injury within 3 to 5 minutes; helicopter personnel, within 10 to 15 minutes. For the critically injured patient, basic stabilization procedures should begin within 3 to 5 minutes after notification, immobilization should be completed within an additional 5 to 6 minutes, and transportation to a trauma facility should not exceed 20 minutes for either ground or air transportation. Total time from notification to trauma center should not exceed 35 minutes, barring difficult extrication.

Trauma centers must be located strategically statewide with regional geography in mind. Along with the multiple trauma centers, centers for specialized management, such as care of burn victims, pediatric victims, and neonates, specialized hand care, and reimplantation, are also needed. These special centers may be located apart from or incorporated with a central Level 1 trauma facility.

THE MARYLAND SYSTEM

ORIGINS

Today there is no question that trauma systems save lives, but this was not always believed to be true. In the 1950s, highway deaths were a spectre to discuss, yet public concern was directed to the Department of Transportation and car manufacturers, with little belief that the trauma victim was of specific interest to the medical field. Unprotected by prehospital treatment or appropriate facilities, the trauma patient, albeit a source of excitement and medical bravado, was virtually predetermined to die—until 1963, that is.

Armed with a U.S. Army grant in 1963, Dr. R Adams Cowley finally convinced a few people that trauma deaths need not be so frequent, and that appropriate advanced and accelerated care and adequate treatment facilities could substantially reduce the mortality and morbidity of the injured patient. Cowley's revolutionary system began with just two beds at the University of Maryland Hospital in Baltimore. Central to his trauma treatment program was the concept of the "Golden Hour"—identifying the crucial period after the trauma incident when the mortality of the severely injured patient could be substantially reduced by advanced medical intervention.[1]

Nationally, laws were being passed for highway safety to subsidize emergency medical systems and to both study and improve the RTA statistics.

Along with such support arose a Maryland State commitment to continue financing and legislating a second phase of growth in Maryland's EMS system. State police helicopter services were used, and Department of Transportation funding was allocated for medical helicopter use. In 1969 the Maryland Center for the Study of Trauma opened.

In 1965, morticians supplied approximately 50% of the available ambulance service nationally because their vehicles were the only ones capable of carrying litters[2]; by 1970, however, Maryland had introduced successful ambulance service programs to educate ambulance personnel, establish emergency care standards, and develop the transportation and communications systems that are still used today.

In 1973, the Governor of Maryland and the state legislature mandated the creation of the Division of Emergency Medical Services (DEMS) and the Maryland Institute of Emergency Medicine Systems (MIEMS), formerly the Center for the Study of Trauma. The overall goal was to ensure that every citizen would receive the best emergency medical care regardless of type of illness or injury, severity, the citizen's personal circumstances, or the geographic location.

By 1976, regionalization in the Maryland system had been completed. Each region was presided over by an EMS Advisory Council and a Central Regional EMS Advisory Council, which included representatives of each Council, the Maryland Hospital Association, Maryland Department of Planning, Maryland State Police, Maryland Department of Transportation, Comprehensive Health Planning Agency, Maryland Department of Education, Maryland State Fireman's Association, Maryland State Ambulance & Rescue Association, and the Medical and Chirurgical Faculty of Maryland. The Emergency Medical Services Technical Advisory Council was established by the Department of Health and Mental Hygiene, and the Medical Management Consultant Group was formed to help determine medical needs in delivering emergency care. The Maryland system also allocated resources for training and continuing education, rapid evacuation and transportation, communications, and specialty referral centers.

In 1977 the Maryland legislature combined MIEMS and DEMS to create a single controlling body, MIEMSS, responsible for coordinating all emergency medical systems throughout the state.

HOW DOES THE SYSTEM WORK?

Communications. A major premise of the MIEMSS is the need to forewarn treatment facilities of each patient's condition and impending arrival. This communication decreases the time lapse from incident to advanced medical intervention. The statewide communications center is located at the MIEMSS administrative center in Baltimore; it coordinates all statewide helicopter medical transportations to the various specialty centers and hospitals. Phone lines link the central Emergency Medical Resources Center in Baltimore with all parts of Maryland. These two systems are directly linked and serve as the hub of the entire trauma system. They are frequently patched together to deliver proper communications from the field to an advanced medical facility or trauma specialist to obtain a radio consult. With the recently instituted statewide 911 emergency dialing system, police, fire, and EMS dispatchers are automatically linked as well.

Notification and Urgency. With the implementation of the 911 system throughout the state, a central operator can immediately notify the appropriate response group (police, fire, ambulance rescue unit). The determination of the level of urgency, including the request for a helicopter, is the first responsibility of the first official person on the scene.

On-the-Scene Management: The First Responder. It was obvious early in the development of the Maryland system that advanced life support could not arrive as a first responder in the vast majority of cases, and that, in the interim, any noninjured person at the scene not helping was a wasted resource. For this reason, in Maryland, *all* state police and fire personnel receive a minimum of 40 hours of training in triage and basic cardiopulmonary resuscitation (CPR). Thus, every hour, every day, there is a roving force of thousands around the state who are qualified to begin work at an accident scene before advanced trained medical personnel arrive. With the 911 system, a first reponder is no more than 3 to 5 minutes away from any accident site within the state.

The decision for a helicopter request is made by the first responder in response to any of the following three questions:

1. Does the crash scene indicate that a large energy transfer to the victim could have occurred? (*Translation:* It didn't look like anyone could have lived through that!)
2. Does anyone appear dead at the scene?
3. Is there a change in the victim's mental status, or is it probable that more than one organ system is injured in any victim?

On-the-Scene Management: Life-Support Personnel. In several counties, medic units and a paramedic supervisor are notified at the same time that a first responder receives notification of a severe crash. The paramedic supervisor has more than 5 years of experience in the field, and on arrival will direct scene stabilization. One major point that experience over the years has taught is the need to have, at the scene of major trauma, enough manpower for safe and rapid care of the patient. Thus, by the time a patient is transported, state police, fire, and ambulance personnel, a paramedic supervisor, and an aviation trauma technician may be present.

In 1976, there were 4000 certified EMT–As in Maryland, each a graduate of an 81-hour course. Today, there are more than 12,000 of these essential paraprofessionals, nearly all of whom are trained in the use of the MAST and the EOA. More than 1500 cardiac rescue technicians (CRTs) have each taken an additional 160 hours in advanced life support coursework, and 400 paramedics have each been trained with a minimum of 300 additional hours above the CRT level. A large portion of Maryland's educational and training programs include considerable clinical experience. In 1980 the Aviation Trauma Technicians Program began. Today there are 40 technicians in the system who have each received certification for completing an additional 160-hour course. All prehospital providers must be recertified in routine cycles: EMTs every 3 years, all others, every year. Continuing education for all these positions is mandatory.

Once set in motion, the modified "swoop and scoop" method can have a patient *en route* by air in 5 or 6 minutes with neck and body immobilized and with MAST and at least one IV in place. The MAST garment overlies the long spinal board so that its placement is not an additional step. IVs are started during extrication and can be inserted in less than 1 minute. If two attempts fail, no IV is begun and the patient is transported. Secondary survey and monitoring are completed during transportation to the treatment facility. The Maryland experience indicates that IVs and MASTs, coupled with proper attention to the airway, are essential management tools in the prehospital phase.

Revisions and modifications of the existing system occur on a continual basis to include any situational exception that may have occurred and to incorporate changes in state-of-the-art care standards. For example, on July 1, 1985, the use of EOAs for airway management in the field began to be replaced by endotracheal intubation; this change has required additional training of paramedic personnel prior to implementation.

Transportation. The Maryland State Police Medical Evacuation Helicopter Program, combined with the state's volunteer and paid ambulance and rescue companies, form a most efficient and successful shock trauma team. More than 450 ambulances are now in service in conjunction with six geographically distributed helicopters. There are no hospital-based ambulance rescue units or helicopters in the Maryland system, which serves 4.5 million people, covers 12,600 square miles of land, bay, and inland waterways, and receives more than 300,000 calls per year.

During a 5-month period in 1983, a review of more than 3000 statewide autopsy records identified 325 trauma deaths.[3] Record abstracts were studied in detail to determine if any of the deaths were preventable. In almost 80% of the cases, the EMS response was felt to be fast and appropriate; patients who had

died were either dead at the scene or had sustained life-threatening head injuries and had been transported to appropriate facilities. Only three deaths were even questioned as being preventable, an outstanding testimony to the high calibre of prehospital EMS care within Maryland.

This Maryland system is by no means perfect, but it can proudly claim a patient care and delivery system so rapid and efficient that patients with even lethal injuries arrive at treatment centers alive; and only 6% of trauma deaths occur outside of hospital facilities.

The final factor mentioned in the "ideal system" is destination. It is critical to deliver the patient to a center capable of delivering prompt treatment appropriate for the injury. Maryland has ten Level I trauma facilities around the state to care for the adult trauma victim. In addition, specialty centers have developed over the years to meet specific needs. The Maryland system now incorporates the MIEMSS Hyperbaric Center, the Johns Hopkins Pediatric Trauma Center, the Maryland Regional Neonatal Program (involving four hospitals), the Raymond M. Curtis Hand Center at the Union Memorial Hospital, the Wilmer Eye Clinic at the Johns Hopkins Hospital, the Georgetown Eye Center, the Neurotrauma Center, and the Francis Scott Key Burn Center.[1]

CONTROVERSIES

A number of reports have questioned the value of prehospital care for the critically injured; the authors of these reports feel that the only care that should be initiated is airway, neck stabilization, and control of external hemorrhage, especially if hospital facilities are only minutes away.[4,15,18,21,22,27,31] They cite as evidence the studies of McSwain and co-workers[27] and Gervin and Fischer[15] for prolonged times in placing intravenous lines, and those of Mackenzie and co-workers[23,24] as well as Bickell and co-workers[4] for noneffectiveness of external counter-pressure garments.

McSwain and co-workers conducted a retrospective study of 100 consecutive victims of cardiac pulmonary arrest during a 2-month period.[27] More than 80% of the arrests were cardiac in origin. At the time, the prehospital system had no telemetry or standing medical orders, and it did not use esophageal obturators, endotracheal intubation, or MAST. Paramedics had to depend on radio contact with the physician before advanced life support procedures could be initiated.

McSwain and co-workers found that a definite relationship existed between total trip time and successful hospital outcomes. Those victims who died (93) had an average prehospital time of 43 minutes, and those who survived (7) had an average prehospital time of 30.3 minutes, a difference of 12.7 minutes. Although some authors credit this time difference to time taken to insert IVs, this explanation seems to be a rather simplistic explanation. It is highly likely, as other reviewers assert, that the overall severity of injury was greater in the patient that died, therefore requiring more time at the scene for stabilization.[27]

The retrospective study of Gervin and Fischer of 13 trauma victims with penetrating injuries attempted to give credence to the report of Mcswain et al.[27] workers.[15] All the victims had been injured within 10 minutes and all had transport time to the nearest hospital. Of the six patients (three with gunshot wounds and three stabbing victims) who reached the hospital in less than 9 minutes with no field treatment, five survived. Each of the other seven patients reached the hospital in excess of 25 minutes owing to extensive in-field treatment; all seven died. The extrapolation of these facts creates the assumption that time in the field resulted from standard measures of stabilization; however, the corollary could be just as true: the extensive measures were undertaken because of the magnitude of the injuries.

Hunt and associates conducted further studies on patients with full cardiac pulmonary arrest in the same system McSwain and co-workers studied.[13,25] When all receiving hospitals were included, no differences were found in the average total transport times between those who survived and those who did not. Once the EMS system was further improved by the addition of standing medical orders and the incorporation of MAST and the esophageal gastric obturator, survival rates improved dramatically, even though transport times were identical or even exceeded those of McSwain and co-workers.

Mackenzie and co-workers[23,24] as well as Bickell and co-workers[4] found that MAST had no effect on the trauma score among those patients found hypotensive at the scene and taken to a trauma facility; however, a close examination of this data reveals that the MAST group had a higher probability of survival.

Jacobs and associates compared the effects of basic and advanced life support treatment using trauma and injury severity scores.[20] They found that, after adjustment of the original trauma score, advanced life support prehospital care did have a significant effect on survival when instituted more immediately after the traumatic event. Average prehospital time was 31 minutes; the time was somewhat shorter for patients with more severe trauma (25 minutes).

Experience from the MIEMSS Shock Trauma Center supports the work of both Hunt and co-workers and Jacobs and co-workers (see data given above).[13,20] In the study of Mackenzie and co-workers, the primary causes of death were neurologic injuries (head and spine, 63.7%) and hemorrhagic injuries (32%) associated with more than five injuries per death. As stated, of the deaths that occurred in the first 24 hours, not one was considered preventable. Moreover, as was mentioned under the Maryland System, the prehospital communication/stabilization/transportation system is so coordinated that patients who would have been dead at the scene are now arriving at the Shock Trauma Center with "fatal" injuries.

Examination of the hemorrhagic deaths showed them to be secondary to major liver and vessel injuries, massive retroperitoneal hemorrhage, and operational deaths during repair of ruptured thoracic aortas and cardiac injuries. It is a credit to the prehospital providers that all survived to reach the facility.

A case in point is a 34-year-old black man who arrived at the Shock Trauma Center facility within 20 minutes postinjury; he sustained injuries from a high-speed collision of his motorcycle with a parked car. He arrived conscious, with IVs inserted and MAST in place. Resuscitation procedures began with the place-

ment of large-bore lines and the insertion of an endotracheal tube. Peritoneal lavage was grossly bloody and the patient was rushed to the operating room. He died on the operating table secondary to lethal injuries from transection of the suprahepatic vena cava, a torn infrahepatic vena cava, torn hepatic veins, crushed kidney and spleen, and lacerated liver.

At-the-scene care in Maryland demonstrates the success and importance of resuscitative measures during, and as a part of, extrication, after which the patient is immobilized on the long board and transported quickly to the awaiting helicopter for a speedy trip to the appropriate trauma center. All procedures are accomplished in approximately 4 to 10 minutes.

First reponders bear the responsibility for triage and for deciding which mode of transportation is appropriate, based on mechanism of injury, number of systems injured (two or more), and whether or not a death has occurred at the scene.

Maryland procedures have reduced on-scene time to a minimum. A major question to be answered is whether or not additional advanced life support skills, other than endotracheal intubation, IVs, or MAST application, are required in the initial field stabilization of trauma patients. Although paramedics may be taught to use needles for cricothyroidotomy if and when required, it is not known if decompression of the chest (either by needle or chest tube thoracotomy) would be beneficial in multiply injured patients in the absence of acute tension pneumothorax.

To answer this question, the survey of 2579 admissions to MIEMSS noted earlier was analyzed. Of the 60 pertinent deaths in the first 24 hours, 42 victims had massive head injuries, 35 with massive chest injuries and 20 with accompanying C-spine injuries. There were 7 victims with thoracic aortic ruptures and 11 with cardiac injuries. Of these same 60 victims, only 4 were noted with respiratory/airway difficulty during stabilization and transport: 3 patients with facial fractures, 1 patient vomiting. Autopsies on all early deaths revealed 36 victims had rib fractures (24 bilateral), 21 had pneumothoraces (7 bilateral), 23 had hemothoraces (9 bilateral) and 14 had lung contusions. Although the exact cause of death in those listed as having chest injuries was not elucidated, it is difficult to propose that a pneumothorax was present as a lethal or potentially lethal injury and could not be treated appropriately at the receiving facility even with rapid transport. It should be pointed out that any massive hemothorax *should not* be decompressed in the field without the presence of multiple IVs and fluid/blood resuscitation in progress.

Only 3.7% of all patients who died (0.4% of admissions) did so with chest or airway problems. Five of these eleven patients had crushed chests. Trying to identify which patient might benefit from further field invasive procedures is difficult, but it does not seem practical to add chest tube placement to the armamentarium of field personnel when there is little, if any, evidence of need. The only situation in which such use might arise is an acute tension pneumothorax; this complication can be managed easily by a needle.

Therefore, there does not seem to be a justifiable need for tube thoracostomies in the field or for additional training, since possible use might only be 1 or 2 per 1000. With rapid transport, the Maryland system seems to handle space-occupying thoracic injuries adequately and appropriately. When prolonged transport times are anticipated (greater than 1 hour, such as in rural areas), physicians or flight nurses may contribute to the stabilization of the critically injured.

SUMMARY

A 30% reduction of deaths from RTAs has occurred in the United States over the past 10 years despite an increase in motor vehicle registration and miles driven. This statistic may be attributed to a combination of factors such as improved crashworthiness standards, use of passive restraint systems, a system of prehospital care, and the awareness of the medical community of the importance of timely surgical intervention at designated trauma centers.

The number of immediate lethal injuries is being reduced and modified to severe life-threatening injuries by ablation of the kinetic energy involved.

The mortality profile of patients with critical life-threatening injuries shifted from the field to the hospital environment, although the rate may remain high. The major improvements are seen is in the population of victims with severe life-threatening and non-life-threatening injuries who no longer die in the field or in admitting areas of hospitals.

Prehospital care in Maryland has been developed successfully. The majority of patients with severe life-threatening injuries are stabilized in the field and quickly transported to one of ten areawide trauma facilities where resources are available 24 hours a day.

Potentially lethal and severe life-threatening injuries are triaged by prehospital providers and transported to the nearest Level 1 trauma facility. In spite of a greater number of these types of patients, mortality in the first 24 hours postinjury has decreased more than 23% during the past 4 years.[3] The majority of those saved owe their lives to Maryland's fully integrated EMS system. This system includes communications, transportation, tiered response, and skilled, experienced paraprofessionals, all integrated and coordinated by MIEMSS, the central medical authority.

On-scene response times after notification average 3 to 5 minutes, and patients are appropriately stabilized and immobilized in less than 5 to 10 minutes by a team of first responders, basic and advanced EMTs, and skilled paramedics.

First responders have been delegated the responsibility for triage and notification of helicopter transportation. Their decisions are based on the mechanism of injury, number of systems injured, and whether or not a death has occurred on the scene. Airway control, neck stabilization, control of external bleeding, and intravenous support are begun during the extrication phase. MAST inflation and immobilization quickly follow. For the multiply injured patient, no time is wasted on second surveys or on the placement of traction. Further training to insert chest tubes has been found to be inappropriate in view of massive pneumothorax or

hemothorax. IV lines are inserted (on the average) in less than 1 minute; the success rates are above 90%. Patients may be fully stabilized and immobilized in 5 to 10 minutes at the scene; normally, by the completion of this phase, helicopter transportation is on the scene and patient responsibility is transferred to the aviation trauma technician for speedy delivery to the trauma center. The aviation trauma technician is responsible for monitoring the patient and for completing the second survey. EOAs are used only on adult, unconscious patients with no intraoral pathology or bleeding. Endotracheal intubation will replace this modality.

Patients are then transported to one of ten areawide trauma centers to be met by skilled teams of airway specialists for immediate insertion of endotracheal tubes and delivery to the admitting area, where a team of surgeons and nurses resuscitate and operate if necessary.

The lessons learned from wartime epidemics have been implemented successfully in the state of Maryland. The Maryland system has also been adopted *in toto* by other countries during the past several years.

In conclusion, the Maryland system closely approximates an ideal emergency medical system.

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