**Chapter 26  
Trauma Systems of Care**

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**Introduction**

In its broadest sense, a trauma system consists of both an organized approach to managing patients who have suffered acute injury, across the continuum from initial medical care through rehabilitation, as well as injury prevention activities aimed at those at risk of suffering trauma. While the trauma system should be integrated with both public health and emergency management, there is significant overlap between trauma and EMS systems. This chapter will focus primarily on the close interaction between these two systems.

**Trauma system organization**

Trauma systems are typically organized on a state-wide basis, although some larger counties may have sophisticated systems (e.g. San Diego County, CA). In 1988, West and colleagues described the ideal criteria for a state-wide trauma care system ([Box 26.1](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c26.xhtml#c26-fea-0001)) [1]. State laws generally delegate the authority for designation of trauma centers to a state agency, such as a department of health, and describe the process by which hospitals may seek designation. Because of their close relationship, most state trauma offices are colocated with the state office of EMS.

**Box 26.1 Criteria for state-wide trauma systems**

* Legal authority for designation
* Formal process for designation
* Use of American College of Surgeons standards
* Use of non-biased survey teams (from out of area)
* Number of trauma centers based upon population or volume
* Triage criteria that permit direct transport to a trauma center
* Monitoring of system performance
* Full geographic coverage

While most states utilize the standards promulgated by the American College of Surgeons Committee on Trauma (ACS-COT) [2], some states (e.g. Florida) opt to draft their own trauma center criteria. The term “designation” refers to authorization from a state agency for an institution to represent itself to the public as a trauma center, while “verification” refers to the inspection by a non-biased team of experts (usually from outside the community) who have confirmed that all necessary services and processes are in place to meet the ACS-COT (or equivalent) standards.

In the ideal trauma system, the lead agency would have the authority to designate trauma centers based upon need, rather than simply approving any facility that desires designation in a competitive, free-market approach. Need for additional trauma centers should be based upon the population of a geographic area, the volume of trauma patients encountered, or proximity to other designated centers. Trauma centers that regularly see large numbers of patients are able to maintain readiness so that management becomes a matter of routine practice, while those that fail to see sufficient numbers of injured patients, especially the seriously injured, may find that their personnel struggle to maintain their organizational processes and procedural skills.

Like the trauma centers themselves, performance improvement is a key component of a trauma system. Data collected in trauma registries are pooled on a system-wide basis and analyzed. This information may provide insight for focusing injury prevention activities in addition to opportunities for improvement in system design or the need for education. Over the past few years, the ACS-COT has developed the Trauma Quality Improvement Project (TQIP) which conducts risk-adjusted analysis of outcomes at trauma centers that voluntarily participate. By presenting its data as observed-to-expected ratios, TQIP allows centers to voluntarily benchmark themselves to other centers across the country. When fully implemented, TQIP will allow high-performing trauma centers (low observed-to-expected ratios) to share best practices with lower performing facilities (high observed-to-expected ratios).

Most states have trauma advisory committees composed of individuals who represent stakeholder sectors involved in trauma care in that state. These committees provide oversight and advise the state trauma office on matters related to improvements in their trauma system. These committees often draft or approve a state trauma plan that serves as a strategic blueprint for enhancing the system over a period of time. Often the state trauma advisory committee also assists the state in determining how governmental funding, if available, will be distributed to stakeholders in the trauma system. This funding helps offset the expensive costs of maintaining trauma center readiness and data collection for trauma registries and aids with the uncompensated care delivered by these centers. State funding may also help provide education to individuals who care for trauma patients and may even purchase some needed equipment.

**Trauma care facilities**

Trauma centers represent one of the essential components of a trauma system. A trauma center is an institution committed to the care of injured patients across the spectrum of initial resuscitation through rehabilitation, including operative management and critical care. A trauma center is a unique blend of personnel (surgeons and other physician specialists, nurses, and allied health care workers), equipment, and processes (robust ongoing performance improvement program). The various physicians, nurses, therapists, and technologists must work together as a cohesive team, under the direction of the trauma surgeon.

The most widely accepted criteria for trauma center designation are those promulgated by the ACS-COT [2].

* **Level III trauma center**: the “basic” trauma care facility that possesses a 24-hour emergency department staffed by emergency physicians. General surgeons must be immediately available while orthopedic surgeons, plastic surgeons, radiologists, and anesthesia personnel must be on call.
* **Level II trauma center**: capable of managing more complex cases. Trauma surgeons must be available within 15 minutes of the arrival of the most critically injured patients. In addition to the criteria from Level III, a Level II center must include on-call physicians in the following specialties: neurosurgery, hand surgery, obstetrics/gynecology, ophthalmology, oral/maxillofacial surgery, thoracic surgery, and critical care medicine.
* **Level I trauma center**: the highest level trauma center. While medical capabilities are only slightly enhanced over the Level II facility (cardiac surgery with cardiopulmonary bypass capability and microvascular capability for replantation), a Level I center must have operating room personnel who are in-house around the clock as well as a surgically directed critical care service. In addition to providing the most comprehensive trauma care, a Level I facility serves as a regional referral resource. As part of its teaching responsibilities, a Level I center must participate in training of surgical residents and conduct Advanced Trauma Life Support courses. Level I facilities must also have an ongoing research program related to injury.

When first conceived, the system that included only Level I–III facilities was seen as an exclusive system, allowing only hospitals with certain minimal capabilities to participate. In response to this criticism, the ACS-COT added the Level IV trauma facility, which is a smaller hospital with limited capabilities that is viewed as a resuscitation point in a community that lacks Level I– II trauma centers. Following attempts at initial stabilization at a Level IV center, the injured patient would be transferred on to a higher level of care in a more distant location. The Level IV centers allowed for the creation of an inclusive trauma system and the ability to provide full geographic coverage for a regional system.

In additional to trauma centers, other facilities included in the trauma system are specialty hospitals, such as pediatric trauma centers or spinal cord injury facilities, and rehabilitation hospitals. In some communities, patients with isolated spinal cord injuries may be transported directly to an institution dedicated to managing spinal trauma and rehabilitation.

**Communications**

Communications are a key aspect of both the EMS and trauma systems. Traditional telephone (landline) and cellular phones are used by callers to access public safety answering points via 9-1-1 in order to report trauma victims. After obtaining essential information for EMS response, trained emergency medical dispatchers are capable of providing prearrival instructions of Basic Life Support measures that a lay bystander could provide while EMS is responding, such as direct pressure for hemorrhage control. Dispatchers also gather additional information from callers or first responders about the need for specialized personnel or equipment, such as extrication or hazardous materials experts.

For the most critically injured patients, rapid response and transport should result in a more expeditious arrival of the patient at the trauma center. Radio communications are used both between the dispatch center and the responding/transporting EMS unit, as well as between the EMS unit and the receiving facility. Prompt notification of the trauma center that a seriously injured patient is en route allows the facility to assemble its trauma team in the emergency department prior to patient arrival.

Some recent mass casualty events, such as the terrorist attacks of 11 September 2001, illustrated that many public safety agencies (law enforcement, fire, and EMS) were unable to communicate with each other. Since then, emergency management organizations have focused significant emphasis on increasing interoperability, resulting in enhanced communication between first responders in an effort to improve mass casualty response. Many state trauma and EMS agencies host a website for receiving facilities to post their current status (open versus on diversion, etc.). Some of these web-based systems are robust enough to indicate the number of available beds, permitting a rapid assessment of surge capacity in a disaster.

**Emergency response**

The greatest overlap between the trauma and EMS systems is seen with emergency response, from dispatch of EMS to patient arrival at the receiving facility. The adage of “getting the right patient to the right place in the right amount of time” truly describes the challenge faced by EMS providers when caring for trauma patients. “Field triage” represents the decision making for selecting which injured patients (“the right patient”) require transport to a trauma center (“the right place”). In 2006 and again in 2011, the Centers for Disease Control and Prevention assembled national expert panels to review evidence and revise the field triage algorithm originally developed by the ACS-COT (see Volume 1, [Chapter 45](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c45.xhtml)) [3].

“The right amount of time” includes decisions regarding both the interventions and time spent at the scene as well as determining the best mode of transport, namely ground EMS versus air medical service. While air medical transport can get an injured patient from a distant scene to a trauma center significantly faster than ground transport, ground transportation may be more expeditious when the patient is located closer to the trauma center (within 10 miles or so), because of the time required to set up a landing zone and power up and power down engines. Trauma surgeons should have input into regional protocols regarding transport modality of injured patients.

Emergency medical services personnel may also be called upon to transport a patient from initial receiving facility (perhaps a non-trauma center) to a trauma center. The care required en route (Basic Life Support versus Advanced Life Support) and need for rapid transfer are the major determinants of whether ground or air transport is utilized. In some jurisdictions, the transferring facility may need to send a nurse along with the patient if the patient requires care that exceeds the scope of practice of the EMS personnel (e.g. in many jurisdictions, an EMS provider may not transfuse blood unless also licensed as a nurse).

All ACS-COT verified trauma centers are required to participate in public and professional education. Several standardized trauma training courses for EMS personnel exist, including Prehospital Trauma Life Support (PHTLS) and International Trauma Life Support (ITLS). Many EMS systems require their personnel to maintain current certification in one of these programs. These courses provide an opportunity for nurses and physicians from trauma centers to share their expertise in managing trauma patients. Some trauma centers provide regularly scheduled case reviews for EMS personnel, offering follow-up on diagnostic procedures and management after arrival at the facility, in combination with reinforcement of basic trauma care principles.

**Medical oversight**

Medical oversight for EMS is divided into direct and indirect oversight. Direct oversight involves providing instructions to prehospital care providers via radio or telephone. In the early days of Advanced Life Support in the prehospital setting, this form of medical direction was heavily utilized with the thought that close communication between the receiving or base station physician and the EMS providers was essential for quality care in the field. Because of the time involved in contacting a physician, direct medical oversight may actually be associated with longer prehospital times. As years passed, focus has shifted more toward one form of indirect medical oversight, where EMS providers follow written protocols or treatment guidelines, each focused on a specific condition or chief complaint. Given the staffing of receiving emergency departments, direct oversight is virtually always provided by emergency physicians rather than trauma surgeons.

Another aspect of direct medical oversight involves a physician riding along with EMS personnel to monitor care and providing orders in those circumstances. Unlike emergency physicians who have mandatory rotations in EMS during their residencies, most trauma surgeons have limited exposure to prehospital care, unless they worked as EMS providers before medical school. As a result, trauma surgeons often have a poor understanding of how prehospital care is delivered and the unusual circumstances under which EMS providers must render care. One could argue that it would be beneficial for trauma surgeons to occasionally spend some time in the field observing the assessment and management delivered by both ground and air EMS personnel.

There are significant opportunities for trauma surgeons to participate in indirect medical oversight. In fact, trauma surgeons should have the opportunity to actively participate in the development of, or review and provide input to, written protocols utilized by the EMS providers in their trauma system. As a part of their performance improvement program, trauma centers should review the prehospital care provided to patients transported to their facilities. Most commonly, this is accomplished by review of the patient care reports for the most critical patients or those who died in the emergency department. Feedback should be provided to the transporting EMS agency, either through its performance improvement coordinator or the service medical director. Similarly, some trauma programs invite representatives from EMS services to participate in their monthly performance improvement meetings. Examples of audit filters for evaluating prehospital trauma care are listed in [Box 26.2](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c26.xhtml#c26-fea-0002) [4].

**Box 26.2 Audit filters for prehospital trauma care [4]**

* Lack of adequate airway
* Misplaced endotracheal tube
* Hypoxia (SpO2 <90%) upon patient arrival
* Inability to control external hemorrhage (e.g. no tourniquet applied to an extremity)
* Spinal immobilization performed for penetrating torso trauma
* Scene time >10 minutes for critical patient
* Appropriateness of needle decompression of pleural cavity
* Failure to transport a critically injured patient to the closest appropriate facility

Source: Salomone JP, Salomone JA [4]. Reproduced with permission of McGraw-Hill.

**Data collection**

Data collection is an essential component of the trauma system, and the data are utilized in many ways. All trauma centers are required to maintain trauma registries, databanks of key information regarding the trauma patients managed at their facilities. Data from these institutional trauma centers are then pooled on a system level, either regional or state-wide. Many centers also voluntarily submit data to the National Trauma Data Bank (NTDB). In some trauma systems, all hospitals, including those that are not trauma centers, are required to provide information about the injured patients for which they care, as not all injured patients require management at trauma centers. This allows the system to evaluate undertriage of trauma patients, which occurs when patients requiring trauma center capabilities are transported to hospitals that are not trauma centers. The ACS-COT believes a highly functioning trauma system has an undertriage rate of 5% or lower.

Data are the basis of a strong performance improvement project. By collecting data on complications or other issues, a trauma center or system may identify a problem that should be addressed. Such trends pose an opportunity for implementing a process change that is anticipated to result in improved care. In fact, progressive trauma systems have adopted a public health model that consists of three core phases: assessment, policy development, and assurance. In the trauma system, the assessment phase consists of data collection followed by data analysis. Once problems are identified, solutions are proposed and implemented in the policy development phase. Finally, in the assurance phase additional data are collected to confirm that the implemented intervention is producing the desired effect, e.g. lowering complications, etc. These three phases create a never-ending loop of performance improvement wherein the trauma center or system continually strives to provide better and better care.

Research is another important use of the trauma registry. As these registries include increasing numbers of patients, they provide a rich repository of data for retrospective studies comparing different management options and their respective outcomes. Linkages between databases of EMS records to hospital or system trauma registries allow for analysis of the relationship between the EMS system and trauma system. Efforts are currently under way to link the National EMS Information System to the NTDB. This linkage will permit robust analysis of how prehospital interventions and system design affect the outcome of trauma patients.

**Emergency management**

Emergency management is the discipline that focuses on the care of citizens affected by various disasters. Because there is significant overlap between the issues that arise from many different types of disasters, modern emergency management systems tend to utilize an all-hazards approach rather than developing different responses depending upon the type of the disaster. Because most disasters include some number of injured patients, there needs to be close cooperation and interaction between emergency management and trauma programs, both inside the trauma center as well as on the system level. Trauma centers should have internal strategies that open up extra beds, thereby creating surge capacity in the event of a disaster.

Preplanning is essential for successful disaster response. Along with their colleagues in emergency management, leaders in the trauma program should periodically test their trauma center’s readiness by conducting disaster drills. Ideally, drills should be held on different days and shifts to ensure all members are properly prepared. Similarly, trauma systems and their corresponding emergency management agencies should evaluate their system’s preparedness through drills that include numerous simulated patients, multiple EMS and first responder agencies, regional emergency management personnel, and multiple facilities. Such drills can uncover potential system weaknesses while emphasizing the need for system coordination and communication.

**Injury prevention**

Injury prevention represents another aspect of the integration between the public health model and the trauma system. In this model, trauma is viewed as a disease and efforts should be focused on preventing new cases. Trauma registry data, either from the trauma center or the trauma system, are analyzed to determine common causes of injury (e.g. motor vehicle crashes or falls) and at-risk groups (children or the elderly). Interventions aimed at preventing or ameliorating these injuries are conceived and implemented. Further analysis is used to monitor for the effect of these prevention strategies. In some EMS systems, EMS professionals routinely participate in injury prevention activities, such as distribution of car seats and educating parents on their use, or providing evaluations of homes for the elderly looking for conditions that may lead to falls, such as throw rugs or lack of anti-slip mats in bathtubs.

**Conclusion**

Trauma remains the leading cause of death for individuals between the age of 1 and 44 years. Significant overlap exists between the trauma and EMS systems, community public health, and emergency management. Although these systems each have somewhat different objectives, when these systems coordinate their activities related to injury and the injured patient, great strides can be accomplished toward achieving optimal care of the injured patients on a regional basis.