Prehospital Assessment of Trauma

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KEYWORDS

• Prehospital • Emergency medical services • Trauma • Triage • Air medical
• Transport

KEY POINTS

- A significant amount of variability exists between the various prehospital trauma systems that provide early postinjury care in the United States.
- This variability includes differences in emergency medical services provided, types of transport available, protocols guiding care, and cooperation between hospitals and providers involved.
- Although advances have been made to prehospital care, more research is necessary to see how uniformly these advances are implemented.
- Further research on determining the best care practices and the development of uniform protocols is also necessary.

INTRODUCTION AND HISTORY OF PREHOSPITAL TRAUMA CARE

As with many of the advancements in trauma care, prehospital trauma care has evolved significantly with periods of military conflict. Most credit Baron Dominique Jean Larrey, Napoleon's surgeon, with the concept of the ambulance in 1792.[1] The genesis of an organized ambulance corps in the military, however, was not until the United States Civil War. This experience was furthered in World War II, when medical personnel were assigned to combat companies to provide care at the point of wounding, becoming the first combat medics. It was then during the Korean War and Vietnam conflict that en route care by medics for the wounded solider became the standard, alongside the rapid transport of patients to higher levels of care through air evacuation.[2]

Disclosure Statement: The authors have nothing to disclose.
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Surg Clin N Am 97 (2017) 961–983
http://dx.doi.org/10.1016/j.suc.2017.06.007 surgical.theclinics.com

In the United States, the National Academy of Sciences' 1966 white paper *Accidental Death and Disability: The Neglected Disease of Modern Society* is considered the birth of modern civilian emergency medical services (EMS) and prehospital trauma care. This landmark paper called for standardized training, funding, and organization of ambulance services.[3] Dr J.D. Farrington brought these issues to surgeons' attention when he published "Death in a Ditch" in the June 1967 *American College of Surgeons Bulletin*; in this piece, he outlines simple first aid techniques that he taught to local rescue volunteers.[4] The EMS Systems Act of 1973 identified key elements of an EMS service and provided funding and authorization for the Department of Health, Education, and Welfare to establish EMS systems throughout the United States. As trauma care and systems developed through the 1960s and 1970s, EMS systems continued to grow.

The advent of the Advanced Trauma Life Support course in 1978 was followed shortly by the first Prehospital Trauma Life Support course in 1984, aimed at training prehospital providers in the systematic approach to the injured patient.

PREHOSPITAL TRAUMA SYSTEMS

Since the early days of EMS and trauma systems, significant advancements in technology and medical practice have matured these services. In the United States, tremendous variation exists in prehospital trauma systems owing to differences in resource availability and varying levels of regional need. Regulatory authority for EMS systems, including treatment protocols and licensure of individual providers, is at the state level. Many states designate regional EMS councils to provider further local oversight. A recent survey demonstrated 38 states had either mandatory or model treatment protocols for EMS agencies, and the remainder allowed the development of protocols at the local level.[5]

Prehospital trauma care is provided by a variety of agencies. Some areas provide prehospital care and transport through the local fire department. EMS providers may comprise a separate division within the fire department or may be fully cross-trained as firefighters. Other areas may have separate standalone EMS agencies. These agencies exclusively provide prehospital medical care and often work with local fire departments, which then provide first response before the arrival of dedicated EMS personnel.

Another distinction is the EMS agency ownership. Many areas use municipal EMS agencies that fall under the jurisdiction of the city or town. In more rural areas, a county itself may provide EMS services. Municipal services are usually subsidized by taxes of the municipality residents. Other areas use private EMS agencies. Several large private EMS corporations exist throughout the United States that contract with municipalities directly to provide emergency prehospital care or supplement the local municipal EMS agency's response capacity.

Depending on the demand for service, EMS agencies may be composed of paid or volunteer providers. Larger services with a higher volume generally hire paid EMS personnel. More rural or less active services often employ volunteer members. These members may take block volunteer shifts or provide service on an on-call basis when the EMS agency is activated for a response. Finally, a number of agencies employ a core of paid providers with coverage supplemented by volunteers.

EMERGENCY MEDICAL SERVICES LEVEL OF CARE

Perhaps the greatest distinction of prehospital trauma care is the scope of practice. At the provider level, this ranges from the emergency medical technician (EMT) providing basic life support (BLS) care to the paramedic who provides advanced life support (ALS) care. BLS trauma care generally allows for vital sign measurement and patient assessment, noninvasive airway and ventilation techniques, oxygen administration, basic hemorrhage control, and splinting. ALS trauma care generally allows for more invasive airway methods including endotracheal intubation (ETI), chest decompression, intravenous (IV) access and fluid administration, as well as administration of cardiac and vasoactive medications.

Most states license providers for several levels of care between the EMT and paramedic. In 1996, the National Highway Traffic Safety Administration identified 44 different levels of EMS provider certification and 39 different state licensure levels between EMT and paramedic.[6] This has led to a national push by the National Highway Traffic Safety Administration and the National Registry of Emergency Medical Technicians to adopt a standardized scope of practice for a defined set of provider certification levels, including EMT, advanced EMT, and paramedic. The advanced EMT level is able to establish supraglottic airways as well as IV access with fluid administration. This standardization is intended to reduce variation in the scope of practice for EMS providers nationally.

Unlike many European and Asian countries, there is little direct physician participation in prehospital trauma care in the United States. Most physicians involved in prehospital systems are emergency medicine trained, serving as medical directors to provide administrative and educational support, develop protocols, and provide quality assurance. Some physicians, with various levels of training, staff aeromedical units as well.

PREHOSPITAL TRAUMA EDUCATION

Provider courses vary with state licensure requirements; however, a typical EMT course is composed of 120 to 150 hours of instruction including didactic and psychomotor skills. The advanced EMT course may require up to 300 hours to complete. Paramedic courses are typically conducted as a 2-year associate program.

Most initial and recertification courses contain a modular trauma education course. There are 2 main courses in the United States that focus on prehospital trauma care (**Table 1**). The first is the Prehospital Trauma Life Support course developed by the American College of Surgeons Committee on Trauma and the National Association of Emergency Medical Technicians. The course is framed around Advanced Trauma Life Support principles and approach. The second course is International Trauma Life Support. This course emphasizes a flexible, team-centered algorithmic approach and is endorsed by the American College of Emergency Physicians.

CHALLENGES OF THE PREHOSPITAL ENVIRONMENT

The prehospital environment presents several challenges that may be unfamiliar to the hospital-based provider. The most important issue EMS providers must constantly keep in mind is their own safety. The primary foundation taught to all prehospital providers is to first ensure scene safety before proceeding with any assessment or treatment. Threats to the EMS provider can come in many forms, including hostile patients or bystanders, unstable structures or vehicles, exposure to hazardous chemicals, or inattentive road traffic. Furthermore, prehospital providers are at a significantly increased risk of injury and death from ambulance crashes.[7,8]

The prehospital setting also poses environmental hazards and access to injured patients may be challenging owing to difficult terrain and patient entrapment. Depending on geography, providers must endure temperature extremes, as well as be prepared

Table 1
Similarities and differences in prehospital trauma care education

	Prehospital Trauma Life Support[a]	International Trauma Life Support[b]
Society endorsement	American College of Surgeons Committee on Trauma	American College of Emergency Physicians
Global reach	59 countries	35 countries
Types of courses offered	Provider, refresher, instructor	Provider, refresher, instructor
Special courses offered	First Responders, for care before EMS arrival	Military, Pediatric, Motor Vehicle Collision Access
Duration of provider course	16 h (instruction and skills training)	16 h (instruction and skills training)
Basic content	Scene assessment, patient assessment/management, organ system or region of injury, mechanism of injury, special populations: pediatric, geriatric, burns	
Additional content	Disaster management, mass casualties, wilderness medicine, role of civilians	Trauma in pregnancy, trauma arrest

[a] *Data from* National Association of Emergency Medical Technicians. Available at: http://www.naemt.org/education/PHTLS/phtls.aspx.
[b] *Data from* International Trauma Life Support. Available at: https://www.itrauma.org/education/itls-provider/.

to treat their patients for these issues. EMS agencies are integral in the first response to natural disasters and providers are subject to the attendant hazards.

Finally, the prehospital environment is limited in the availability of resources. Prehospital providers must quickly assess and treat patients on presumptive findings, because there are few diagnostic modalities available to them. Supplies are limited to what can be carried to the patient initially and subsequently what can be stored in the ambulance. Environmental and temperature issues may further limit the supplies that can be stocked.

TRIAGE

Field triage is one of the most important aspects of prehospital trauma care, because EMS providers using limited data must decide whether an injured patient requires transport to a trauma center for specialized care. The ASCOT and the Centers for Disease Control and Prevention jointly developed the National Field Triage Guidelines, which are based on the stepwise identification of 4 aspects of clinical presentation that are readily identifiable to prehospital providers at the scene of injury (**Fig. 1**).[9] These include physiologic criteria, anatomic criteria, mechanism of injury criteria, and special considerations criteria that are evaluated in a sequential fashion to identify patients who should be transported to a trauma center. Physiologic and anatomic criteria should prompt providers to transport patients to the highest level of trauma care in the system, whereas patients with only mechanism or special consideration criteria may be taken to lower levels of care.

Performance of the field triage guidelines has demonstrated high specificity, particularly for physiologic and anatomic criteria, although the sensitivity is variable.[10–14] Some have shown that all sequential steps are necessary to prevent unacceptable rates of undertriage.[15,16] There is also increasing evidence that geriatric patients are often undertriaged,[17–20] leading to some to develop geriatric-specific criteria.[13,21–23] The most recent revision of the guidelines notes that a normal systolic blood pressure may represent hypotension in the geriatric population.[24] More objective criteria have shown promise, such as prehospital lactate and automatic crash notification data, and are subject to ongoing study.[25–29]

An increasingly relevant aspect of field triage is mass casualty triage. When the demand of patients overwhelms existing resources, a shift in focus is required. The philosophy of mass casualty triage is to do the greatest good for the greatest number of patients. This includes rapid identification of salvageable patients and prioritization for evacuation and transport. Resources are not expended on patients who have a low likelihood of survival. Several mass casualty triage systems exist. Multiple emergency medicine and trauma association endorse the SALT algorithm (Sort, Assess, Lifesaving interventions, Treatment/Transport).[30] This algorithm (**Fig. 2**) begins with global assessment of patients who can walk, have purposeful movement, and those who are not moving or have obvious life-threatening injuries. This is followed by individual assessment and provision of simple life-saving maneuvers, such as basic hemorrhage control and opening the airway. This allows the on-scene triage of patients into 4 categories of minimal, delayed, immediate, and dead/expectant to prioritize patients for treatment and transport. Commercially available triage tags are often used to designate patients during the triage process with color-coded tags: black for dead or expectant, red for immediate, yellow for delayed, and green for minimal.

PREHOSPITAL PROVIDER ASSESSMENT AND CARE

Even in the prehospital environment, a systematic approach to the injured patient is required. Most prehospital providers follow a familiar approach of the ABCDs. Prehospital providers perform their assessment with attention to cervical spine precautions and immobilization first. This is applied liberally; however, some states have introduced more selective cervical spine protocols for the injured patient.[31] Some have also moved away from use of long backboards and focus on cervical spine motion restriction only. A good example of patients who do not need to be immobilized are patients with penetrating trauma. In fact, in these patients, it could be detrimental.

Airway

Prehospital providers begin with an immediate assessment of the airway, often by attempting to communicate with the patient. In patients with airway concerns, the first step is to attempt simple maneuvers to open the airway. This is usually a jaw thrust in the trauma patient, owing to cervical spine precautions. Additional adjuncts include placement of an oral pharyngeal or nasal pharyngeal airway and can be performed by BLS providers.

ALS providers can perform ETI. Indications most commonly include failure to protect the airway followed by inadequate ventilation or oxygenation. Depending on state and local protocols, paramedics may be able to perform rapid sequence intubation using pharmacologic sedation and paralysis. Controversy exists as to the benefit of prehospital ETI in trauma patients. Several groups have demonstrated worse outcomes in trauma patients undergoing ETI,[32–38] whereas others have shown improved outcomes.[39–41] Episodes of hypoxia, bradycardia, and inadvertent hyperventilation, as well as procedural complications and errors have been postulated to contribute to worse outcomes,[34,36,38] suggesting the need for rigorous performance improvement and continual training to maintain skill levels.[42] An option with increasing popularity is the use of supraglottic airways in the trauma patient. These airways require

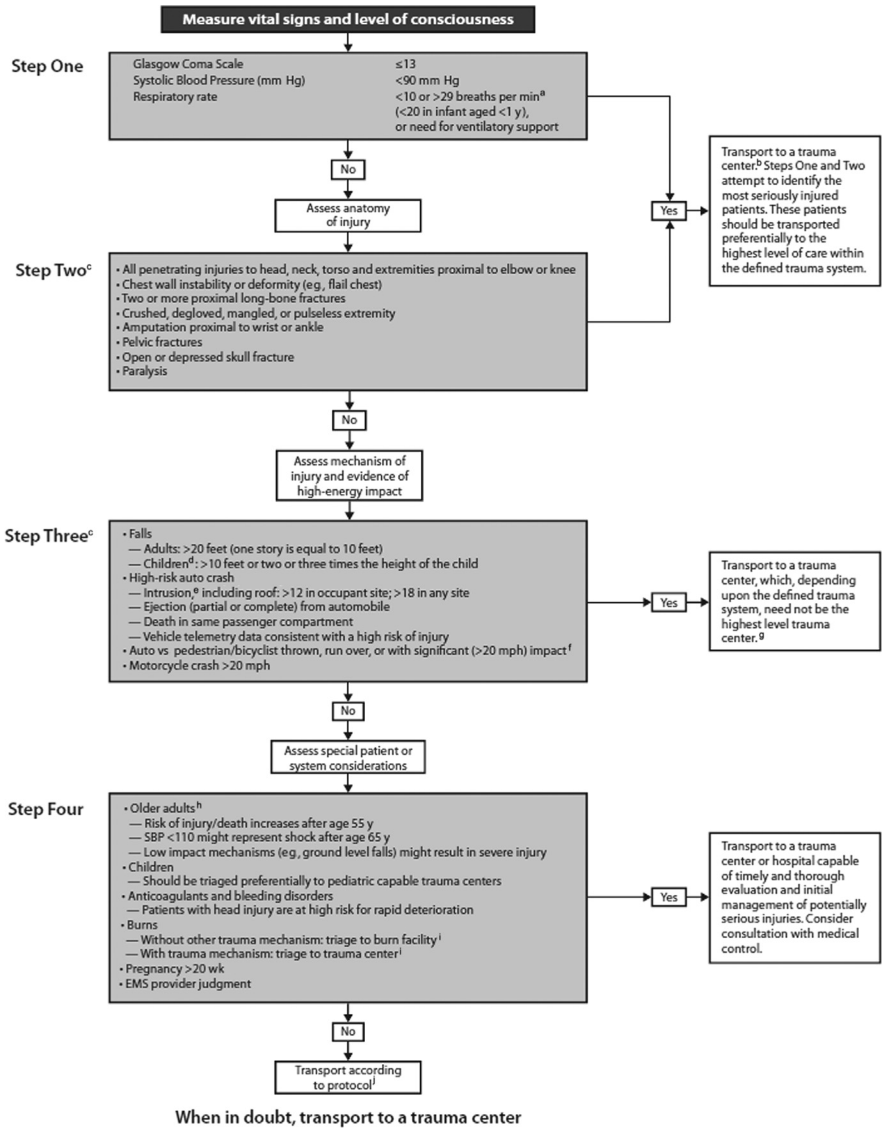

Fig. 1. American College of Surgeons Committee of Trauma and Centers for Disease Control National Trauma Triage Protocol, 2011. EMS, emergency medical services. [a] The upper limit of respiratory rate in infants is greater than 29 breaths per minute to maintain a higher level of overtriage for infants. [b] Trauma centers are designated levels I to IV. A level I center has the greatest amount of resources and personnel for care of the injured patient and provides regional leadership in education, research, and prevention programs. A level II facility offers similar resources to a level I facility, possibly differing only in continuous availability of certain subspecialties or sufficient prevention, education, and research activities for a level I designation; level II facilities are not required to be resident or fellow education centers. A level III center is capable of assessment, resuscitation, and emergency surgery, with severely injured patients being transferred to a level I or II facility. A level IV trauma center is capable of providing 24-hour physician coverage, resuscitation, and stabilization to injured patients before transfer to a facility that provides a higher level of trauma care. [c] Any injury noted in

less skill maintenance and may take less time in the field to place.[43,44] These are not, however, definitive airways and thus trauma personnel must be familiar with these devices and be prepared to replace it with a definitive airway when receiving a patient with this type of airway placed by EMS.

Many EMS systems also include protocols for surgical airway placement. This may take the form of needle cricothyrotomy or surgical cricothyrotomy. This skill is rarely used in the prehospital environment, but may be the only option to secure an airway in patients with severe maxillofacial or laryngeal trauma.[45]

Breathing

After confirming a patent airway or securing one, attention is turned to breathing. Most trauma patients are placed on supplemental oxygen. Options include nasal cannula or a nonrebreather mask for patients maintaining their own airway. Prehospital providers will also provide ventilations using a bag–valve mask for patients not adequately ventilating. BLS providers are trained to provide bag–valve mask respirations in conjunction with the oral or nasal airway adjuncts noted. For patients with an advanced airway placed in the field, respirations are provided using a bag–valve mask. Some agencies have access to transport ventilators that can be quite sophisticated, allowing for different volume or pressure control modes of ventilation and provide user-defined levels of positive end-expiratory pressure.

EMS providers are also trained to assess respirations with auscultation. In the trauma patient, they assess for signs of pneumothorax and signs of tension; however, subtle examination findings are difficult to appreciate in the prehospital environment. ALS providers are able to perform chest decompression for suspected tension pneumothorax. Patients with diminished breath sounds or signs of respiratory distress such as increased work of breathing, poor oxygen saturation, or signs of shock may be candidates for decompression.

Standard technique includes insertion of a 14-gauge angiocatheter in the second intercostal space in the midclavicular line. Several studies have shown that standard angiocatheters are not long enough to adequately decompress the pleural space.[46–48] This concern has led many agencies to use longer and stiffer commercial products designed specifically for chest decompression. Further, placement of the catheter or even finger thoracostomy in the fourth or fifth intercostal space anterior axillary line has become an acceptable alternative based on studies that the chest wall may be thinner in this location.[49,50]

step 2 or mechanism identified in step 3 triggers a "yes" response. [d] Age less than 15 years. [e] Intrusion refers to interior compartment intrusion, as opposed to deformation, which refers to exterior damage. [f] Includes pedestrians or bicyclists thrown or run over by a motor vehicle or those with estimated impact of greater than 20 mph with a motor vehicle. [g] Local or regional protocols should be used to determine the most appropriate level of trauma center within the defined trauma system; need not be the highest-level trauma center. [h] Age greater than 55 years. [i] Patients with both burns and concomitant trauma for whom the burn injury poses the greatest risk for morbidity and mortality should be transferred to a burn center. If the nonburn trauma presents a greater immediate risk, the patient may be stabilized in a trauma center and then transferred to a burn center. [j] Patients who do not meet any of the triage criteria in steps 1 through 4 should be transported to the most appropriate medical facility as outlined in local EMS protocols. (*From* Sasser SM, Hunt RC, Faul M, et al. Guidelines for field triage of injured patients: recommendations of the National Expert Panel on Field Triage, 2011. MMWR Recomm Rep 2012;61:1–20.)

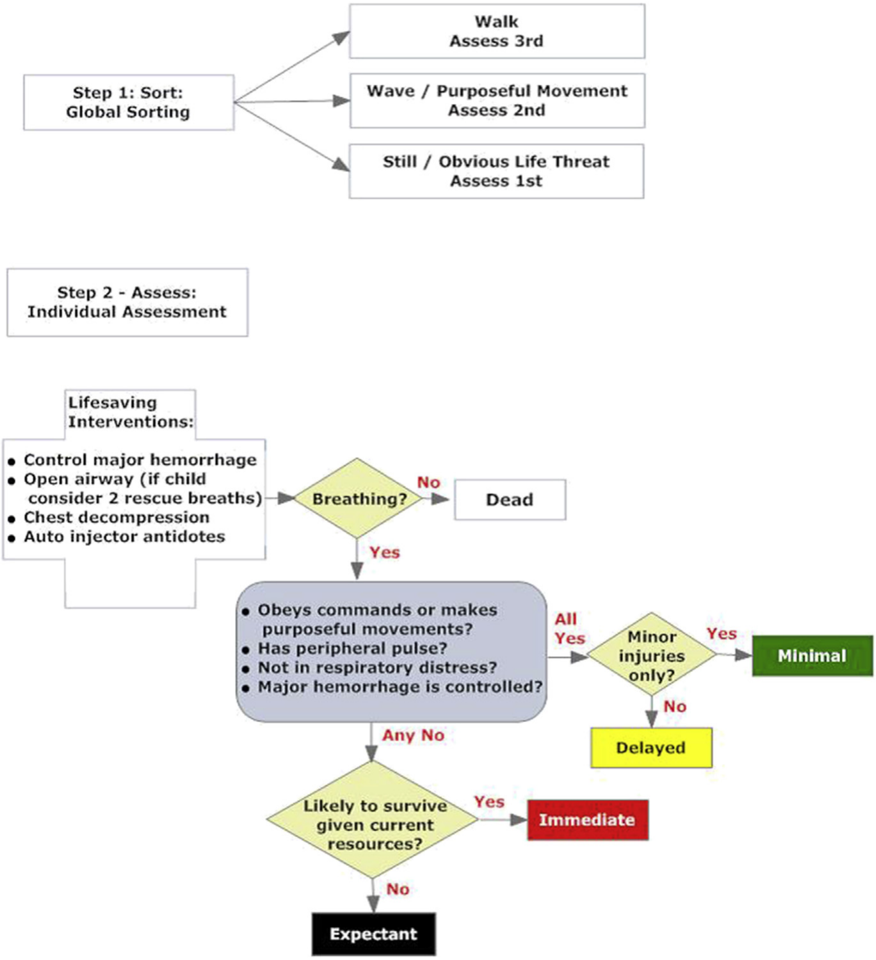

Fig. 2. Sort, Assess, Lifesaving interventions, Treatment/Transport (SALT) algorithm. (*From* SALT mass casualty triage: concept endorsed by the American College of Emergency Physicians, American College of Surgeons Committee on Trauma, American Trauma Society, National Association of EMS Physicians, National Disaster Life Support Education Consortium, and State and Territorial Injury Prevention Directors Association. Disaster Med Public Health Prep 2008;2(4):245; with permission.)

Circulation

Once the airway is secure and the patient is adequately ventilating, attention is turned to the patient's circulatory needs. Because it remains a major cause of morbidity and mortality, significant attention is given to active hemorrhage. A patient can bleed to death internally in the chest, abdomen, pelvis, or thigh. Furthermore, a patient can exsanguinate externally from many sites especially extremities and scalp. For life-threatening external hemorrhage, care can involve providing adequate fluid or blood products, if necessary and possible, and applying external hemorrhage control techniques.

Many of the current recommendations stem from the US military's recent experience in Iraq and Afghanistan, where there were increased rates of external hemorrhage.[51–56]

An increased focus on preparedness for active shooter scenarios[57,58] and awareness of the importance of early hemorrhage control in all trauma patients[54] has inspired specific guidelines for civilian settings as well. Several methods for external hemorrhage control exist today, including packing or pressure dressing, with or without hemostatic agents, as well as commercially available tourniquets. However, the most traditional method of curbing an active bleed and also the initial step in first aid is to apply direct manual pressure with or without gauze or cloth dressing to sites of hemorrhage until hemostasis is achieved.[59,60]

When direct pressure is not possible (eg, owing to limited staff or resources, unsafe scene of injury, or the need for complicated transportation of the patient) or when direct pressure alone is futile (eg, significant arterial bleed), tourniquets should be used for controlling external hemorrhage, especially at amenable extremity sites.[54,56,59,60] Commercially tested tourniquets are regarded as superior to improvised ones and should always be used first,[54,61–63] although improvised tourniquets may be beneficial in limited civilian settings when no commercial one is available.[64–66] Several types of commercial tourniquets exist, with windlass, pneumatic, or ratcheting types preferred by the American College of Surgeons Committee on Trauma, although this recommendation is based on limited data. Use of a narrow, elastic, or bungee-type device may worsen hemorrhage owing to venous occlusion without adequate arterial occlusion.[54]

Regardless of which tourniquet is selected, it is likely best to keep effective tourniquets in place until definitive treatment can be provided; however, exceptions may exist such as long transport times.[54] When placed properly, tourniquets have been shown to adequately control bleeding.[53,63–69] However, it is important to understand that this method of hemorrhage control is not without a risk of complications, for example, compartment syndrome, nerve damage, vascular damage, and amputation.[60] The rate of these complications, however, remains very low.[53,63–69] Despite well-documented evidence backing the early use of tourniquets, average prehospital care provider knowledge of this hemorrhage control technique may still be poor and highlights the need for further education and protocols.[70] Nonextremity tourniquets such as junctional tourniquets, designed for hemorrhage from the axilla or groin, have also shown some promise and there are multiple devices that have been approved by the US Food and Drug Administration,[59,71] although efficacy data are too sparse to make any recommendations on their use and this remains an open area for investigation.[54]

For anatomic regions that are not amenable to tourniquet use, such as neck, trunk, axillae, or groin wounds, and when direct pressure is simply not enough, topical hemostatic agents with packing or dressing may be useful.[54,56,60,72] Several agents have shown promise, including chitosan-based HemCon[73] and zeolite-based QuikClot.[74] Currently, the military uses kaolin-infused QuikClot Combat Gauze, which has some evidence backing its use,[75] as well as chitosan-based gauze products.[62] The ACS has recommended that regardless of which hemostatic agent is used, based on military experience, it should be used with gauze as the applicator; however, little evidence exists to make clear guidelines on the subject at this time.[54]

After assessing the patient for external bleeding and applying the appropriate hemorrhage control techniques, ALS providers will attempt to establish IV access when feasible; however, this should not delay transport, which can significantly increase prehospital time.[76,77] Attempts to establish peripheral IV access should be limited to 2 in the field, after which alternative routes should be attempted if necessary.[78] Intraosseous access has gained popularity among prehospital providers, owing to its technical ease and speed to obtain access for fluid and medication delivery.[79]

Crystalloid remains the de facto resuscitation fluid for prehospital care. It is inexpensive, widely available, and durable in the prehospital environment. Current practice has moved away from large crystalloid volumes in the prehospital setting as it has in hospital, starting with the landmark trial by Bickell and colleagues,[80] which demonstrated increased mortality in penetrating torso injury patients receiving prehospital crystalloid. Although several others have reported increased mortality with greater volumes of crystalloid, particularly in patients with normal blood pressure,[76,81,82] this has not been a universal finding and some report benefits in select populations, such as traumatic brain injury (TBI) and hypotensive patients.[78,81,83–89] Thus, a goal-directed protocol of judicious crystalloid use based on mental status and avoiding hypotension may be the best approach.[78]

The potential deleterious effects of crystalloid have led to an investigation of the use of prehospital blood products. United States and United Kingdom military have implemented prehospital transfusion of packed red blood cells for casualties at the point of wounding,[51,90] with promising results.[91–93] This practice has heightened interest in the civilian prehospital community, although generally limited to well-developed air medical transport programs.[94,95] However, initial evidence suggests that the use of packed red blood cells and plasma improves early outcomes in severely injured patients, including reductions in early mortality, indices of shock and coagulopathy, and need for in-hospital transfusion.[96–98]

Disability

Disability is, in essence, a neurologic evaluation. For EMS providers, assessing the patient's level of consciousness is of particular importance in evaluating TBI. Several scales exist to stratify deficits in consciousness; a classic scale for assessing consciousness is the AVPU or Alert, Responds to Voice, Responds to Pain, Unresponsive scale, which was initially a component of the primary survey by Advanced Trauma Life Support.[99] However, this scale has largely been replaced by the Glasgow Coma Scale (GCS) score. First devised in 1974, the GCS consists of 3 components based on the patient's arousal, awareness, and activity: eye opening (scored out of 4), verbal response (scored out of 5), and best motor response (scored out of 6). Patients receive a score out of 15, with a score of 3 being the lowest score possible and indicating significant deficits.[100]

Multiple studies have shown that the GCS collected in the field by prehospital providers is similar to that collected by the accepting emergency department with good interrater reliability[101,102]; however, as the GCS worsens, there may be more significant differences.[103,104] Also, it is important to note that for shorter response times, the GCS recorded in the field may be inaccurate if recorded during a "concussive" period after injury. Regardless, prehospital GCS[105,106] and delta, or change in GCS from field to arrival,[107] have both been shown to be predictive of outcome. More recently, the GCSm, or the motor subscale of the GCS, which can be measured even in intubated patients, has been shown to be a suitable replacement for predicting outcomes.[108,109] In the prehospital setting, a GCSm of 5 or less has been shown to be more specific and less sensitive compared to a GCS of 13 or less and may better predict trauma center need.[110]

In the context of TBI, serial GCS scores can be helpful in evaluating suspected increased intracranial pressure (ICP). If a patient begins to show signs of cerebral herniation (eg, asymmetric pupil sizes >1 mm, dilated and fixed pupils, extensor posturing, or a decline in GCS by 2 points from an initial score of $\leq$8), it is important that measures are taken in the field to lower ICP.[111,112] These may include hyperventilating the patient or providing pharmacologic or hyperosmolar agents; however, these interventions should not slow down transfer to definitive neurosurgical care.[111]

Although hyperventilation, with resultant hypocarbia, is a classic measure for reducing ICP in the setting of acute brainstem herniation in TBI, excessive hyperventilation may result in further damage owing to reduced cerebral blood flow.[111,113] The latest Brain Trauma Foundation guidelines on prehospital management recommend that hyperventilation, $ETCO_2$ of less than 35 mm Hg, only be used when there are clear signs of herniation; otherwise, the goal $ETCO_2$ of 35 to 40 mm Hg should be used to guide ventilation.[114] Failure to achieve these targets is an indicator of severe injury and has been shown to predict poor outcome.[115] Despite guidelines limiting the use of hyperventilation to those with clear signs of herniation, there seems to be a disparity between the guidelines and actual prehospital practice.[111] To avoid excessive use or even prophylactic use of hyperventilation, some have suggested either uniform normoventilation in the prehospital setting or stricter adherence of the Brain Trauma Foundation guidelines.[113] We strongly suggest that normoventilation should be the standard default practice in the field for the vast majority of cases.

With regard to hyperosmolar therapy, mannitol and hypertonic saline are both well-known methods of lowering ICP; however, there are very few efficacy data on their use in the prehospital setting.[114] The management of an increased ICP in the prehospital setting is still an emerging field and there is no clear consensus between the various guidelines that exist on which prehospital interventions to recommend.[116] In general, guidelines for managing TBI patients in the prehospital setting are sparse. However, the appropriate transfer and triage of these patients has been shown to have a positive effect on outcome.[117] In fact, some areas of the country have been able to demonstrate both improved short- and long-term outcomes in patients with TBI after the creation of a regional trauma system.[118,119]

TRANSPORT TO THE TRAUMA CENTER

A key function of the EMS system is to deliver the patient to the trauma center for further assessment and care. For trauma patients, controversy exists in the philosophical approach to this, often characterized as the "scoop and run" approach compared with the "stay and play" approach. Scoop and run postulates that time is the most important factor and EMS providers should transport the patient as rapidly as safely possible, providing minimal or no interventions in the prehospital setting. Several groups have reported no benefit to the use of ALS interventions among trauma patients.[77,120–122] Conversely, the stay and play approach advocates providing critical interventions to the injured patients in the field, proponents of which argue will occur much more quickly than if delayed to be performed in the hospital. Some investigators have demonstrated improved outcomes with prehospital interventions in select populations.[41]

Likely a balance between these approaches is necessary to provide optimal prehospital trauma care, avoiding a "one size fits all" approach. There is evidence that existing field triage criteria, including hypotension, penetrating injury, and flail chest can identify patients with truly time-sensitive injuries that may benefit from limited prehospital time.[123] For example, the Northern Ohio Trauma System developed and implemented both scene and interhospital transfer criteria with the philosophy of getting the "right patient to the right place at the right time." This policy was demonstrated to be an independent predictor of improved survival.[124] Regionalization and the appropriate transport of patients to an experienced level 1 center, has also been shown to reduce mortality in those requiring an exploratory trauma laparotomy[125] (**Fig. 3**).

Another issue prehospital providers must consider is the mode of transport to the trauma center. In general, this is a decision between ground and air transport. At

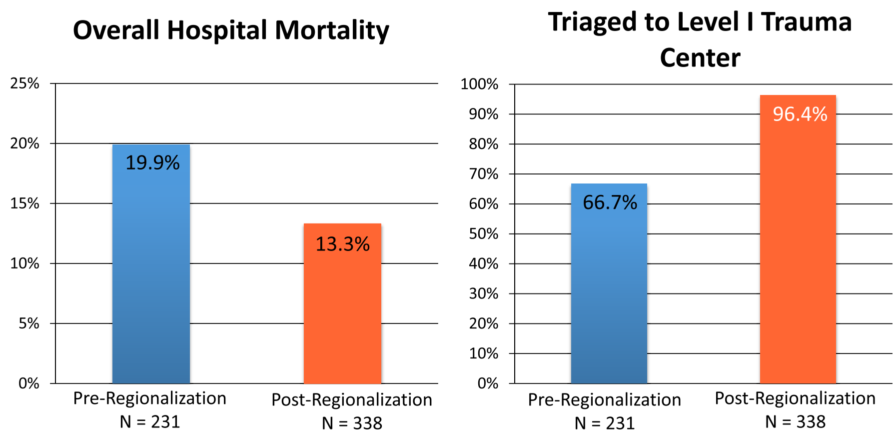

Fig. 3. Overall hospital mortality and triage rate to a level 1 trauma center before and after regionalization of a trauma network.

the individual patient level, this becomes a highly complex decision, because providers must consider physiologic and anatomic injury severity of the patient, distance to the trauma center, traffic and weather conditions, and the availability of EMS resources in the local area.

Patients may benefit from air medical transport for several reasons. First, it is widely accepted that air is faster than ground transport. Prehospital trauma care from air medical crews may also benefit patients, either owing to advanced capabilities or "regionalized" prehospital trauma care, because these providers are more familiar with caring for severely injured patients.[97,126] For example, several studies suggest airway management in the hands of air medical providers have better outcomes when compared with ground EMS providers.[36,37,40,42,123] Finally, air transport may expand access to trauma care for patients who otherwise would be taken to a nontrauma center.[127]

Again, there is conflicting evidence regarding the potential benefits of air medical transport. Several studies have found no survival benefit for patients undergoing transport,[128–132] whereas others report significant improvements in mortality among patients transported by air.[126,133–137] Additionally, some only report a benefit from air medical transport in selected groups of patients.[128,130,138,139] However, overtriage of patients to air medical transport is common, even among studies reporting benefits.[123,133,136] Given the costs of this trauma system resource and aviation risk, patient selection becomes paramount.[7,8,140,141] Few studies have examined the issue of air medical transport triage until recently.[142,143] The development of the Air Medical Prehospital Triage score (criteria for air transport displayed in **Table 2**) has been the first attempt at an evidence based approach to air medical triage; preliminary data have shown it to be successful in discriminating between patients who have a survival benefit from air medical transport and those who do not, based on a subset of field triage criteria.[144,145]

INTERFACILITY TRANSPORT

Although transport time from the scene of injury to an accepting facility is one component of prehospital care, another equally important aspect is the transport of patients to their appropriate final destination based on their needs. In an ideal world, EMS will

Table 2
Air AMPT criteria

Criterion	Points
Glasgow Coma Scale <14	1
Respiratory rate <10 or >29 breaths/min	1
Unstable chest wall fractures	1
Suspected hemothorax or pneumothorax	1
Paralysis	1
Multisystem trauma	1
Any 1 physiologic criterion[a] plus any 1 anatomic criterion[b] from the ACSCOT national field triage guidelines	2
Consider Helicopter Transport if AMPT Score ≥2 points	

Abbreviations: AMPT, Air medical prehospital transport; ACSCOT, American College of Surgeons Committee on Trauma.

[a] ACSCOT Physiologic Criterion: GCS of 13 or greater, systolic blood pressure of less than 90 mm Hg, respiratory rate of less than 10 or greater than 29 breaths per minute (<20 in infants aged <1 y), or need for ventilator support.

[b] ACSCOT anatomic criterion: All penetrating injuries to head, neck, torso, and extremities proximal to elbow or knee; chest wall instability or deformity (eg, flail chest); amputation proximal to wrist or ankle; 2 or more proximal long bone fractures (ie, femur and humerus); crushed, degloved, mangled, or pulseless extremity; pelvic fractures; open or depressed skull fracture; paralysis.

From Brown JB, Gestring ML, Guyette FX, et al. Development and validation of the air medical prehospital triage score for helicopter transport of trauma patients. Ann Surg 2016;264(2):382; with permission.

triage and directly transport the most severely injured patients to level 1 trauma centers. However, several situations may exist where interfacility transfers, from lower level centers or community hospitals to level 1 centers, are inevitable. In rural regions, as a consequence of the scarcity of trauma centers, patients may need to be stabilized at local community hospitals first. Studies have shown that, in such regions, this pattern of transport versus direct transport to a trauma center does not worsen mortality,[146] although in the rural setting this pattern may result in more transfers of minimally injured patients owing to inexperience or overtriage by the transferring hospital.[147]

In urban regions with more mature trauma systems, initial undertriage of patients, to ease the burden on level 1 trauma centers, may later result in increased interfacility transports. Although this pattern of transport uses significant resources at lower level centers and is overall more expensive, it has minimal impact on mortality.[148] The cost burden from inefficient triage and subsequent interfacility transfers may be due to repeat procedures and imaging at the final destination,[149] as well as an increased emergency department duration of stay.[150] Similar to the debate on air versus ground scene of injury transport, more research is needed on interfacility transport to find specific populations that may benefit from particular transportation modes. Although more severely injured patients, an Injury Severity Score of greater than 15, may benefit from helicopter transport in interfacility transfers,[139] when crew experience and ALS capabilities are controlled for there may also be no difference in outcomes.[151] However, distance between facilities may also play a role in this decision.

REGIONALIZATION OF SYSTEMS AND UNIFORM PROTOCOLS

The goal of our prehospital trauma systems is to essentially “get the right patient to the right place at the right time.”[152] However, the question of what is the right place for each patient may vary depending on the needs of the patient, the severity of injury, distance to each potential caregiving facility, and the capabilities of these accepting facilities to provide appropriate care. This question of what is the right place will vary region to region, because some urban corridors may have an abundance of trauma centers per capita, whereas other more rural areas may have almost none. In regions covered by multiple separate trauma systems and EMS or in regions that cross local or state borders, competition and differences in care pathways may further complicate this issue.

"Regionalization" and Regional Trauma Networks have evolved as 1 approach to standardizing and streamlining the prehospital care of the severely injured patient. By coordinating the effort and resources between all local EMS, hospitals, and hospital networks, the balance between optimal care, resource limitations and competition may be better addressed.[153,154] This may require Regional Trauma Networks to be inclusive, containing all trauma centers within a region regardless of affiliation or ownership, and also comprehensive, containing multiple lower level centers (level 2 or 3) in addition to level 1 trauma centers.[155] Many international studies on Regional Trauma Networks have shown that regionalization can reduce mortality, while improving functional outcomes.[156–161] Although data in the United States are scarcer, implementation of an inclusive and collaborative Regional Trauma Networks, with a uniform triage and transfer protocol and a single call center, has been shown to significantly improve mortality and outcomes.[118,119,125,152] These benefits may result from an increased use of lower level trauma centers for less severe injuries, less competition between centers allowing for adequate patient volume, and proper coordination between EMS and all trauma centers involved.[152,162–164]

SUMMARY

The prehospital period is an important phase in the care of all trauma patients. Because the effectiveness of early triage, interventions, and transport may be the only chance some patients have to survive, trauma providers and their networks must increasingly assess and improve this period of care. When the prehospital phase of care is implemented appropriately, it may have substantial impacts on the definitive management and long-term morbidity and mortality of trauma patients.

One particularly interesting development in prehospital care is the role of the public in providing early interventions. After the Sandy Hook Elementary School shooting that shocked the nation, a working group, later known as the Hartford Consensus, was convened to suggest national policy for enhancing survivability after intentional mass casualty and active shooter events.[58] Because uncontrolled hemorrhage remains a preventable prehospital cause of death and morbidity, a movement known as "Stop The Bleed" was created to make tourniquets more accessible to the public and to empower bystanders to act as first responders for such injuries.[165]

Although there has been much accomplished in the field of prehospital care since its genesis, there remain many open avenues for improvement and investigation. For instance, there is an incredible amount of variability in EMS prehospital provider training. Further, even more variability exists in how EMS prehospital systems are organized and function within a geographic area. Without clear, data-driven protocols guiding the appropriate triage and transfer of patients across a region, the use of local resources and facilities to care for the severely injured will be far from optimal. Achieving these goals will require more open cooperation from all stakeholders, local government, EMS providers, and hospital networks, as well as further research into best practices.

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