Chapter 254: Trauma in Adults

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INTRODUCTION AND EPIDEMIOLOGY

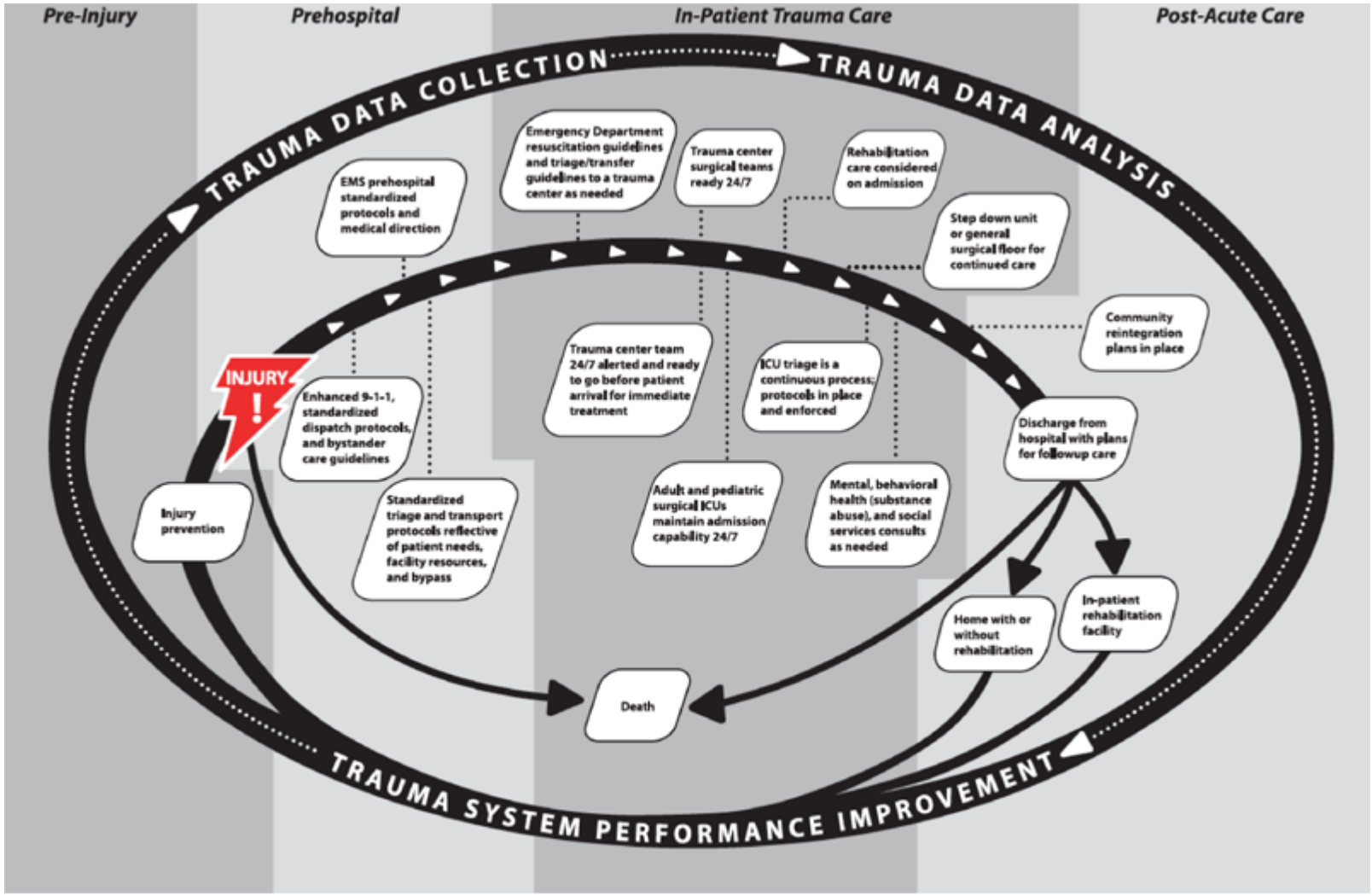
Trauma accounts for 41 million annual ED visits and 2.3 million hospital admissions across the United States. Trauma is the number one cause of death for Americans between age 1 and 44 years and is the number three cause of death overall.[1] In all countries, the incidence of death from injury increases more than threefold with increasing poverty. For the 90% of patients who survive the initial trauma, the burden of ongoing morbidity from traumatic brain injury, loss of limb function, and ongoing pain is even more significant.

The major causes of death following trauma are head injury, chest injury, and major vascular injury. Trauma care should be organized according to the concepts of rapid assessment, triage, resuscitation, diagnosis, and therapeutic intervention.[2] Worldwide, there are few countries or regions that have comprehensive systems of trauma care, from roadside to rehabilitation, and that incorporate effective injury prevention strategies.

TRAUMA SYSTEMS AND TIMELY TRIAGE

A systematic approach is required to reduce morbidity and mortality that occur after traumatic injury (**Figure 254-1**).

FIGURE 254-1.
Phases of a preplanned trauma care continuum. [From U.S. Department of Health and Human Services, Health Resources and Services Administration. Model Trauma System Planning and Evaluation. Rockville, MD: U.S. Department of Health and Human Services; 2006. Available at: www.facs.org/trauma/tsepc/pdfs/mtspe.pdf. Accessed June 17, 2014.]



Source: J.E. Tintinalli, J.S. Stapczynski, O.J. Ma, D.M. Yealy, G.D. Meckler, D.M. Cline: Tintinalli's Emergency Medicine: A Comprehensive Study Guide, 8th Edition
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Recognizing the need to establish a system to triage injured patients rapidly to the most appropriate setting and the importance of promoting collaboration among emergency medicine, trauma surgery, and trauma care subspecialists, the U.S. Congress passed the Trauma Care Systems Planning and Development Act of 1990.[3] This act provided for the development of a model trauma care system plan to serve as a reference document for each state in creating its own system. Each state must determine the appropriate facility for treatment of various types of injuries. Trauma centers are certified based on the institution's commitment of personnel and resources to maintain a condition of readiness for the treatment of critically injured patients. Some states rely on a verification process offered by the American College of Surgeons for the designation

of certain hospitals as trauma centers.[2] In a well-run trauma center, the critically injured patient undergoes a multidisciplinary evaluation, and diagnostic and therapeutic interventions are performed with smooth transitions between the ED, diagnostic radiology suite, operating room, and postoperative intensive care setting. **Table 254-1** details the requirements for designation as a Level 1 trauma center. A complete list of trauma center requirements is available at the American College of Surgeons website (http://www.facs.org/trauma/verificationhosp.html).

TABLE 254-1

Essential Characteristics of Level 1 Trauma Centers

24-h availability of surgeons in all subspecialties (including cardiac surgery/bypass capability)
24-h availability of neuroradiology and hemodialysis
Program that establishes and monitors effect of injury prevention and education efforts
Organized trauma research program

A well-functioning trauma system defines trauma centers with specific triage criteria, so that patients can be initially transported by EMS to these centers or transferred to trauma centers from other hospitals after stabilization (**Table 254-2 and Figure 254-2**). In accordance with the principles of advanced trauma life support, injured patients are assessed and treated based on their presenting vital signs, mental status, and mechanism of injury.[4]

TABLE 254-2

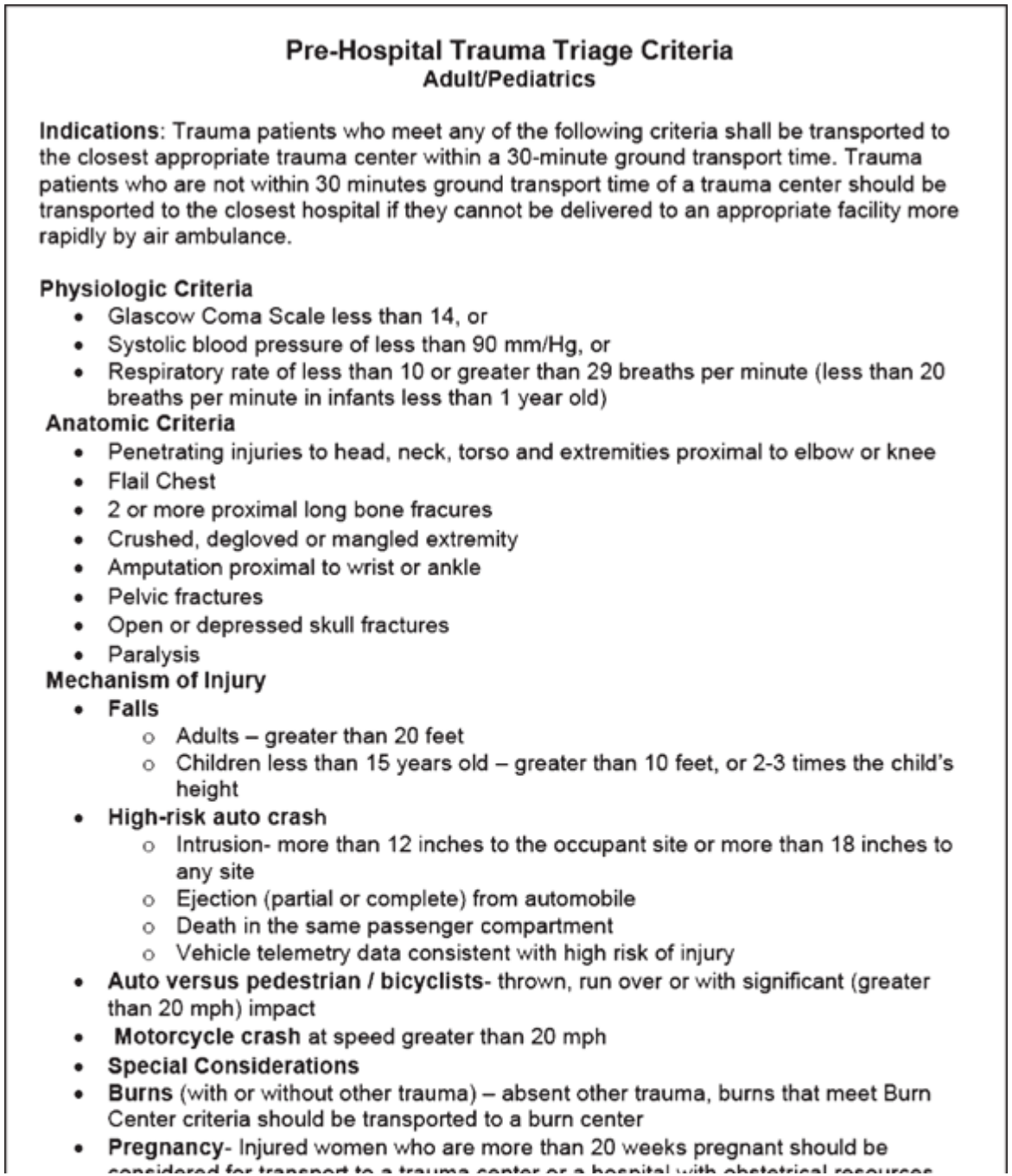
Triage and Trauma System Entry Criteria

Physiologic abnormalities
Systolic blood pressure <90 mm Hg
Glasgow coma scale score <14
Inadequate airway or need for immediate intubation
Injury pattern
Penetrating wound to head, neck, or torso
Gunshot wound to extremities proximal to elbow or knee
Extremity with neurovascular compromise
Amputation proximal to wrist or ankle
CNS injury or paralysis
Flail chest
Suspected pelvic fracture
Mechanism of injury
MVC with intrusion into passenger compartment >12 in
MVC with major vehicular deformity >20 in
Ejection from vehicle
MVC with entrapment or prolonged extrication of >20 min
Fall of >20 feet
MVC with fatality in same passenger compartment
Auto–pedestrian or auto–bicycle collision at >5 mph
Motorcycle crash >20 mph

Abbreviation: MVC = motor vehicle crash.

FIGURE 254-2.

Current Tidewater EMS (Norfolk, VA) prehospital trauma triage guidelines. [Photo contributed by Current Tidewater EMS (Norfolk, VA) Prehospital Trauma Triage Guidelines.]



Pre-Hospital Trauma Triage Criteria
Adult/Pediatrics

Indications: Trauma patients who meet any of the following criteria shall be transported to the closest appropriate trauma center within a 30-minute ground transport time. Trauma patients who are not within 30 minutes ground transport time of a trauma center should be transported to the closest hospital if they cannot be delivered to an appropriate facility more rapidly by air ambulance.

Physiologic Criteria

- Glascow Coma Scale less than 14, or
- Systolic blood pressure of less than 90 mm/Hg, or
- Respiratory rate of less than 10 or greater than 29 breaths per minute (less than 20 breaths per minute in infants less than 1 year old)

Anatomic Criteria

- Penetrating injuries to head, neck, torso and extremities proximal to elbow or knee
- Flail Chest
- 2 or more proximal long bone fracures
- Crushed, degloved or mangled extremity
- Amputation proximal to wrist or ankle
- Pelvic fractures
- Open or depressed skull fractures
- Paralysis

Mechanism of Injury

- **Falls**
  - Adults – greater than 20 feet
  - Children less than 15 years old – greater than 10 feet, or 2-3 times the child's height
- **High-risk auto crash**
  - Intrusion- more than 12 inches to the occupant site or more than 18 inches to any site
  - Ejection (partial or complete) from automobile
  - Death in the same passenger compartment
  - Vehicle telemetry data consistent with high risk of injury
- **Auto versus pedestrian / bicyclists**- thrown, run over or with significant (greater than 20 mph) impact
- **Motorcycle crash** at speed greater than 20 mph
- **Special Considerations**
- **Burns** (with or without other trauma) – absent other trauma, burns that meet Burn Center criteria should be transported to a burn center
- **Pregnancy**- Injured women who are more than 20 weeks pregnant should be considered for transport to a trauma center or a hospital with obstetrical resources

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- **Age** – greater than 55 years of age
- **Anticoagulation and Bleeding Disorders** – EMS should contact medical control and consider transport to trauma center
- **Time- Sensitive Extremity Injury** – open fracture(s) or fracture(s) with neurovascular compromise
- **EMS Provider Judgment** – EMS provides, based on experience and expertise, may always exercise clinical judgment regarding atypical patient presentations

Source: J.E. Tintinalli, J.S. Stapczynski, O.J. Ma, D.M. Yealy, G.D. Meckler, D.M. Cline: Tintinalli's Emergency Medicine: A Comprehensive Study Guide, 8th Edition
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PRIMARY SURVEY

Prior to the patient's arrival at the hospital, EMS providers should inform the receiving ED about the mechanism of trauma, suspected injuries, vital signs, clinical symptoms, examination findings, and treatments provided. In preparation for the patient's arrival, ED staff should assign tasks to team members, prepare resuscitation and procedural equipment, and ensure the presence of surgical consultants and other care team members. For patients transported to EDs that are not trauma centers, consider immediately whether transfer to a trauma center is appropriate and what resuscitation or stabilization can or should be performed prior to transfer.

A focused history obtained from the patient, family members, witnesses, or prehospital providers may provide important information regarding circumstances of the injury (e.g., single-vehicle crash, fall from height, environmental exposure, smoke inhalation), ingestion of intoxicants, preexisting medical conditions (e.g., diabetes, depression, cardiac disease, pregnancy), and medication use (e.g., steroids, β-blockers, anticoagulants) that may suggest certain patterns of injury or the physiologic response to injury.

ED care of the trauma patient begins with an initial assessment for potentially serious injuries. A primary survey is undertaken quickly to identify and treat immediately life-threatening conditions, with simultaneous resuscitation and treatment. Specific injuries that should be immediately identified and addressed during the primary survey include airway obstruction, tension pneumothorax, massive internal or external hemorrhage, open pneumothorax, flail chest, and cardiac tamponade. After assessing the patient's airway, breathing, and circulation, perform a more thorough head-to-toe examination (the **secondary survey**) (Table 254-3). Follow the secondary survey with appropriate diagnostic testing, further therapeutic interventions, and disposition. When derangements are identified in any of the systems assessed in the primary survey, undertake treatment immediately.

TABLE 254-3

Primary and Secondary Survey in Trauma Resuscitation

Primary Survey (rapid identification and management of immediately life-threatening injuries)

A. Airway and cervical spine

Assess, clear, and protect airway: jaw thrust/chin lift, suctioning.

Perform endotracheal intubation with in-line stabilization for patient with depressed level of consciousness or inability to protect airway.

Create surgical airway if there is significant bleeding or obstruction or laryngoscopy cannot be performed.

B. Breathing

Ventilate with 100% oxygen; monitor oxygen saturation.

Auscultate for breath sounds.

Inspect thorax and neck for deviated trachea, open chest wounds, abnormal chest wall motion, and crepitus at neck or chest.

Consider immediate needle thoracostomy for suspected tension pneumothorax.

Consider tube thoracostomy for suspected hemopneumothorax.

C. Circulation

Assess for blood volume status: skin color, capillary refill, radial/femoral/carotid pulse, and blood pressure.

Place two large-bore peripheral IV catheters.

Begin rapid infusion of warm crystalloid solution, if indicated.

Apply direct pressure to sites of brisk external bleeding.

Consider central venous or interosseous access if peripheral sites are unavailable.

Consider pericardiocentesis for suspected pericardial tamponade.

Consider left lateral decubitus position in late-trimester pregnancy.

D. Disability

Perform screening neurologic and mental status examination, assessing:

Pupil size and reactivity

Limb strength and movement, grip strength

Orientation, Glasgow coma scale score

Consider measurement of capillary blood glucose level in patients with altered mental status.

E. Exposure

Completely disrobe the patient, and inspect for burns and toxic exposures.

Logroll patient, maintaining neutral position and in-line neck stabilization, to inspect and palpate thoracic spine, flank, back, and buttocks.

Secondary Survey (head-to-toe examination for rapid identification and control of injuries or potential instability)

Identify and control scalp wound bleeding with direct pressure, sutures, or surgical clips.

Identify facial instability and potential for airway instability.

Identify hemotympanum.

Identify epistaxis or septal hematoma; consider tamponade or airway control if bleeding is profuse.

Identify avulsed teeth or jaw instability.

Evaluate for abdominal distention and tenderness.

Identify penetrating chest, back, flank, or abdominal injuries.

Assess for pelvic stability; consider pelvic wrap or sling.

Inspect perineum for laceration or hematoma.

Inspect urethral meatus for blood.

Consider rectal examination for sphincter tone and gross blood.

Assess peripheral pulses for vascular compromise.

Identify extremity deformities, and immobilize open and closed fractures and dislocations.

AIRWAY MANAGEMENT WITH CERVICAL SPINE CONTROL

Determine airway patency by inspecting for foreign bodies or maxillofacial fractures that may result in airway obstruction. Perform a jaw thrust maneuver (simultaneously with in-line stabilization of the head and neck) and insert an oral or nasal airway as part of the first response to a patient with inadequate respiratory effort. Insertion of an oral airway may be difficult in patients with an active gag reflex. Avoid nasal airway insertion in patients with suspected basilar skull fractures. **Whenever possible, use a two-person spinal stabilization technique in which one provider devotes undivided attention to maintaining in-line immobilization and preventing excessive movement of the cervical spine while the other manages the airway.** If the patient vomits, logroll the patient and provide pharyngeal suction to prevent aspiration. Perform endotracheal intubation in comatose patients (Glasgow coma scale score between 3 and 8) to protect the airway and to prevent secondary brain injury from hypoxemia. Agitated trauma patients with head injury, hypoxia, or drug- or alcohol-induced delirium may be at risk for self-injury. Trauma patients are frequently difficult to intubate due to the need for neck immobilization, the presence of blood or vomitus, or upper airway injury. Video laryngoscopy devices are beneficial because they aid in vocal cord visualization while minimizing cervical spine manipulation. If anatomy

or severe maxillofacial injury precludes endotracheal intubation, cricothyroidotomy may be needed. **Use a rapid-sequence intubation technique for intubation** (see chapter 29, "Intubation and Mechanical Ventilation").

Clearance of the cervical spine from serious injury involves careful clinical assessment, with or without radiologic imaging. Not all patients require cervical spine radiographs. The **National Emergency X-Radiography Utilization Study (NEXUS) criteria** (Table 254-4)[5] and the **Canadian cervical spine rule** (Table 254-5)[6] are useful only in awake and alert patients and are not a substitute for good clinical judgment. Patients meeting NEXUS or Canadian criteria for low risk of cervical spine injury should undergo full examination of the cervical spine, including active range-of-motion testing in all directions along with a thorough neurologic examination.

TABLE 254-4

NEXUS (National Emergency X-Radiography Utilization Study) Criteria for Omitting Cervical Spinal Imaging*

No posterior midline cervical spine tenderness
No evidence of intoxication
Alert mental status
No focal neurologic deficits
No painful distracting injuries

*Failure to meet any one criterion indicates need for cervical spine imaging.

TABLE 254-5

Canadian Cervical Spine Rule

Any high-risk factor that mandates radiography? (Age >64 y or dangerous mechanism or paresthesias in extremities) **No**	**If Yes, radiography indicated**
Any low-risk factor that allows safe assessment of range of motion? (Simple rear-end collision or sitting position in the ED or ambulatory at any time or delayed onset of neck pain or absence of midline cervical spine tenderness) **Yes**	**If No, radiography indicated**
Able to rotate neck actively? (45 degrees left and right) **Yes**	**If No, radiography indicated**
No radiography indicated	

If the patient is obtunded, assume a cervical spine injury until proven otherwise. Even when plain radiographs or CT images show normal findings, it is possible for a patient to have unstable ligamentous injuries. Therefore, maintain spinal immobilization during the resuscitation. Imaging of the spine should not delay urgent operative procedures because imaging results will not change the immediate management. CT of the cervical spine is the preferred initial imaging modality. For full discussion of cervical spine imaging and management in trauma, see chapter 258, "Spine Trauma."

BREATHING

Once the airway is controlled, inspect, auscultate, and palpate the thorax and neck to detect abnormalities such as a deviated trachea (tension pneumothorax); crepitus (pneumothorax); paradoxical movement of a chest wall segment (flail chest); sucking chest wound; fractured sternum; and absence of breath sounds on either side of the chest (simple or tension pneumothorax, massive hemothorax, or right mainstem intubation). Any of these findings warrants immediate intervention, including needle thoracostomy for tension pneumothorax (see the section "Needle

Decompression" in chapter 68, "Pneumothorax"); insertion of large-bore chest tubes (36-F) to relieve hemopneumothorax (see chapter 261, "Pulmonary Trauma"); and application of an occlusive dressing to a sucking chest wound. For asymmetric or absent breath sounds in the intubated patient, partially withdraw the endotracheal tube from the right mainstem bronchus or reintubate. If no breath sounds are heard, and if massive hemothorax or vascular injury is suspected (initial chest tube output of >1000 mL, or >200 mL/h), a thoracotomy or video-assisted thoracic surgery is indicated to identify and control the source of bleeding.

CIRCULATION AND HEMORRHAGE CONTROL

Assessment of the patient's overall hemodynamic status is critical. This assessment includes evaluation of level of consciousness, skin color, and presence and magnitude of peripheral pulses. Note the heart rate and pulse pressure (systolic minus diastolic blood pressure), particularly in young, previously healthy trauma patients.

As part of the primary survey in the prehospital and hospital settings, identify and control external hemorrhage. Apply direct pressure, a compression bandage, or a hemostatic dressing to control active external bleeding. QuikClot Combat Gauze is a kaolin-impregnated rayon and polyester hemostatic dressing that is safe and effective for arterial or venous bleeding.[2,7] For exsanguinating extremity injury, apply a tourniquet (see "Tourniquets"). Prehospital use of tourniquets on the battlefield has become commonplace. With aggressive tourniquet use, death rates from isolated limb exsanguination in Iraq dropped to 2% compared to 9% in the Vietnam War.[8]

Tourniquets

Robert L. Mabry

More than a decade of combat operations in Afghanistan and Iraq have provided the opportunity to evaluate methods for minimizing morbidity and mortality from traumatic injury. One of the greatest advances in the prevention of death on the modern battlefield is the rediscovery of the tourniquet.[9] During the war in Vietnam, tourniquet application was generally felt to be a technique of last resort.[10] The myth arguing against tourniquet use was primarily based on World War I and II experiences when evacuation to definitive care took many hours, and tourniquets were felt to increase ischemia in an already vulnerable extremity.

However, proper tourniquet application, coupled with rapid transport times to definitive care, can be life- and limb-saving in military and civilian settings.[7] Tourniquets saved lives at the Boston Marathon bombing, and as a result, the Boston Police Department and Boston EMS now carry tourniquets.[11,12,13]

Civilian tourniquet use is based on the military Tactical Combat Casualty Care guidelines for first responder care in the battlefield. Tourniquet use is a key component to Tactical Combat Casualty Care.

The Tactical Combat Casualty Care guidelines currently recommend three different tourniquets14: the Combat Application Tourniquet (C-A-T®), the SOF Tactical Tourniquet (SOF TT®), and the Emergency and Military Tourniquet (EMT®). The C-A-T® (**Figure 1**) is a lightweight windlass tourniquet, which can be applied with one hand. The SOF TT® (**Figure 2**) is another windlass tourniquet. The EMT® (**Figure 3**) is a pneumatic device, which carries the disadvantage of potential tourniquet failure if it were to be damaged or punctured by debris. Do not use narrow, elastic, or bungee-type tourniquets.[7]

If direct pressure is ineffective or impractical in controlling external bleeding, apply the tourniquet directly to the skin or over clothing, 2 to 3 inches above the wound. Tighten the tourniquet to eliminate the distal pulse. Do not release the tourniquet until the patient reaches definitive care and there is a positive response to resuscitation efforts.

The Tactical Combat Casualty Care guidelines recommend the application of a junctional tourniquet (SAM JT®) (**Figure 4**) if the bleeding site is appropriate (groin or axilla, where the torso meets the extremities) and the application of a hemostatic dressing with pressure has no effect.[14] However, as of this writing, the American College of Surgeons Committee on Trauma has not provided recommendations for the application of junctional tourniquets in the civilian environment.[7]

FIGURE 1.
C-A-T®.

FIGURE 2.

SOF TT®.

FIGURE 3.

EMT®.

FIGURE 4.

SAM-JT junctional tourniquet (internal view).

CIRCULATION

Any hypotensive trauma patient is at risk for development of hemorrhagic shock, a common cause of postinjury death. One system is commonly used for classifying the degree of hemorrhage (Table 254-6), although it has not been validated and there is wide variability in individual patient response to hypovolemia. Hemorrhage and shock are on a continuum, and some patients can compensate for significant blood loss better than others. Hemorrhage of up to 30% of total blood volume may be associated with only mild tachycardia and a decrease in pulse pressure, but may quickly progress to profound hypoperfusion and decompensated shock if not recognized early. Be aware that medications, such as β-blockers, can mask early hemodynamic indicators of shock.

TABLE 254-6

Classification of Hemorrhage Based on Estimated Blood Loss at Initial Presentation

	Class I	Class II	Class III	Class IV
Blood loss (mL)*	Up to 750	750–1500	1500–2000	>2000
Blood loss (% blood volume)	Up to 15	15–30	30–40	40
Pulse rate (beats/min)	<100	100–120	120–140	>140
Blood pressure	Normal	Normal	Decreased	Decreased
Pulse pressure	Normal or increased	Decreased	Decreased	Decreased

*Assumes a 70-kg patient with a preinjury circulating blood volume of 5 L.

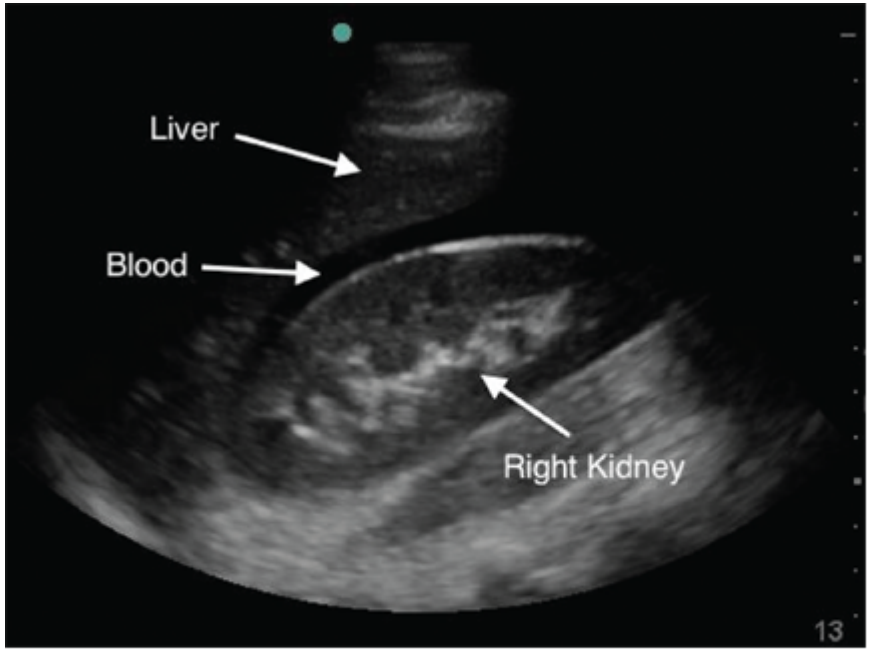
Establish two large-bore IV lines (18 gauge or larger), infuse lactated Ringer's or normal saline, and obtain blood samples or specimens for laboratory studies, particularly blood type and screen. In patients who are in unstable condition or in whom upper extremity peripheral veins are not easily cannulated, establish central venous access via the subclavian, internal jugular, or femoral vein. Avoid placement of a central venous line distal to a potential venous injury. Intraosseous access is an alternative technique for providing rapid vascular access in difficult clinical situations. Most medications including blood products can be administered through the interosseous route. Use a pressure bag to maximize flow rates. Decades of study have failed to demonstrate an advantage of colloid therapy over crystalloid infusion. Therefore, a balanced salt crystalloid (normal saline or lactated Ringer's) is the fluid of choice for initial resuscitation. There is some theoretical advantage of lactated Ringer's over saline when large volumes are given in order to avoid hyperchloremic acidosis, although this is unlikely to be significant for most patients during initial resuscitation.

Reassess hypotensive patients without an obvious indication for surgery after rapid infusion of 2 L of crystalloid solution (lactated Ringer's or normal saline). If there is no marked improvement, then transfuse type O blood (O-negative for females of childbearing age). Aggressive volume resuscitation is not a substitute for definitive hemorrhage control. A full discussion of the long-standing controversies over volume, timing, and

composition of fluid resuscitation is beyond the scope of this chapter. One major study demonstrated higher mortality in patients receiving immediate IV fluid resuscitation than in those from whom fluid was withheld until operative intervention. The study speculated that aggressive fluid resuscitation before operative control of bleeding was harmful.[15]

Patients requiring massive transfusions generally require urgent surgical intervention to control hemorrhage. A well-defined source of bleeding may be evident on external examination, assessment of chest tube output, extended FAST examination (**Figure 254-3**), or conventional or CT imaging of the chest or abdomen. There may also be considerable blood loss from blunt trauma to the pelvis and limbs without a discrete source. Immobilize open pelvic fractures in a pelvic wrap or sling and reduce and immobilize limb fractures to tamponade bleeding from fractured bone ends.

FIGURE 254-3.
Positive extended FAST exam with blood identified in Morison's pouch. [Photo contributed by Barry Knapp, MD.]



Major trauma patients may develop a bleeding diathesis almost from the time of injury, which results in defective clotting and platelet function. Data from both military and civilian experience reveal that patients receiving >10 units of packed red blood cells showed decreased mortality when they simultaneously receive fresh frozen plasma in a ratio of packed red blood cells to fresh frozen plasma of 1:1 rather than 1:4 (26% vs

87.5% mortality, respectively).[16] Another consensus article examining use of blood products worldwide supported the administration of platelets in massive transfusion protocol in a 1:1:1 ratio with packed red blood cells and fresh frozen plasma.[17] Both acidosis and hypothermia contribute to the coagulopathy and should be corrected as quickly as possible.

TRANEXAMIC ACID

Tranexamic acid is an antifibrinolytic agent that reduces blood loss after surgery and may reduce blood loss after traumatic injury. It prevents cleavage of plasmin and degradation of fibrin. It is on the World Health Organization list of essential medications affecting coagulation.[18] Studies involving >20,000 patients reported a risk reduction of death from bleeding of 10% to 15%. There was no reported difference in risk of death from myocardial infarction, vascular occlusion, stroke, pulmonary embolism, mutiorgan failure, or head injury.[19] Criticism of CRASH-2 was that the patient populations studied were heterogeneous in terms of injury and were in low- to middle-income countries with basic and very limited resources for major trauma management.[20] For these and other reasons, major Western nation trauma centers have not rushed to adopt the use of tranexamic acid in trauma management algorithms.[21] Nevertheless, the evidence to date indicates that tranexamic acid may reduce mortality without significant adverse side effects when given as early as possible after injury, with administration within 1 hour of injury reported to decrease the relative risk of death from bleeding by 32% and within 1 to 3 hours by 21%.[22] Administration of tranexamic acid more than 3 hours after injury is less effective and potentially harmful.[19] Tranexamic acid must be given before transfer/arrival to a trauma center in order to meet the time requirement of early administration.[20] The dose is 1 gram of tranexamic acid IV bolus over 10 minutes, followed by 1 gram IV over 8 hours.

DISABILITY

Once airway, breathing, and circulation have been addressed and stabilized, perform a focused neurologic evaluation to assess level of consciousness, pupillary size and reactivity, and motor function. Assess the Glasgow coma scale (see chapter 257, "Head Trauma"). A search for the cause of depressed level of consciousness should include measurement of capillary blood glucose level and consideration of possible intoxicants. Despite the concomitant use of drugs and alcohol in many trauma patients, do not simply attribute altered mental status in the setting of trauma to intoxication. Assume that a patient with an appropriate mechanism for head trauma and with altered mental status or a Glasgow coma scale score of <15 has a significant head injury until proven otherwise. **The Glasgow coma scale assessment can be insensitive in patients with normal or near-normal scores, and a Glasgow coma scale score of 15 does not completely exclude the presence of traumatic brain injury.** However, patients with a persistent Glasgow coma scale score of ≤8 generally have a graver prognosis; secure a definitive airway to protect against aspiration or asphyxia. Direct efforts toward resuscitating brain-injured patients in order to maintain normal cerebral perfusion. Monitor

serum glucose levels and maintain euglycemia. Mild hyperventilation may reduce intracranial pressure, although at the expense of cerebral vasoconstriction and hypoperfusion. Avoid hyperventilation during the first 24 hours after injury when cerebral blood flow is often critically reduced. **Prophylactic hyperventilation (partial pressure of arterial carbon dioxide of 25 mm Hg or less) is not recommended.**[23]

EXPOSURE

No primary survey is complete without completely disrobing the patient and examining carefully for occult bruising, lacerations, impaled foreign bodies, and open fractures. After completing the primary survey, logroll the patient, with one team member assigned to maintain in-line cervical stabilization. **Palpate the spinous processes of the thoracic and lumbar spine for tenderness or deformity, and then carefully logroll the patient back to a neutral position.** The utility of routine rectal examination is debated, but it is useful to identify gross rectal bleeding or loss of rectal tone in patients with suspected spinal injury. Examine the perineum for bruising, laceration, or bleeding. Cover the patient with warm blankets to prevent heat loss. Some have advocated the use of hypothermia in cases of severe brain injury. However, as of this writing, there is no conclusive evidence in favor of this therapy. Potential therapeutic benefits must be weighed against the coagulopathy and increased bleeding that hypothermia also causes in trauma patients.

SPECIFIC INJURIES OF IMPORTANCE

Place special emphasis on identifying the injuries described in the following sections during the primary survey, because they can be rapidly fatal if not recognized and treated.

SEVERE HEAD AND SPINAL TRAUMA

Rapidly assess neurologic status in patients with suspected traumatic brain injury. **To quickly identify patients with intracranial injuries who may benefit from operative treatment, defer any procedures that do not correct a specific problem discovered during the primary survey until after the head CT is performed.** In patients requiring intubation, provide in-line immobilization when the cervical collar is removed during intubation, and then reapply after intubation. Obtain a chest radiograph to assess endotracheal tube placement and exclude pneumothorax. The use of US to rapidly confirm endotracheal tube placement and exclude large pneumothorax is also an option.

TENSION PNEUMOTHORAX, OPEN PNEUMOTHORAX, AND MASSIVE HEMOTHORAX

Tension pneumothorax, open pneumothorax, and massive hemothorax all should be readily apparent during the primary survey. If tension pneumothorax is clinically suspected, immediately perform tube thoracostomy. If equipment is not immediately available, needle thoracostomy can be a temporizing measure. Delays in diagnosis and treatment (including awaiting confirmatory chest x-ray) can result in complete hemodynamic collapse. In equivocal cases, US can confirm the presence of pneumothorax and prompt emergent intervention. Perform tube thoracostomy in a timely manner in patients with a significant pneumo- or hemithorax, as determined by US, chest x-ray, or CT (see chapter 261).

PENETRATING ABDOMINAL TRAUMA

Abdominal tenderness or distention on palpation, coupled with hypotension, indicates the emergent need for exploratory laparotomy in a patient who has sustained a penetrating abdominal injury; this should prompt immediate transport to the operating room. Early operative intervention in patients experiencing penetrating trauma who are in shock results in better outcomes. Placement of nasogastric, urinary, and IV catheters may proceed in the ED only if they do not delay definitive operative intervention. Otherwise, these procedures should take place in the operating room as the patient is being prepared for general anesthesia. In the setting of a penetrating gunshot wound to the abdomen, diagnostic imaging (US, CT) is rarely indicated because almost all cases undergo emergent exploratory laparotomy.

IMPALED OBJECTS

Objects deeply impaled in the chest and abdomen should be left in place and the patient emergently transported to the operating room for surgical removal under direct visualization to ensure vascular control and hemostasis. The impaled object may be cut or shortened outside the skin to facilitate transport.[24]

TRAUMATIC CARDIAC ARREST

Unless obvious signs of death are present in the field, providers in most emergency medical systems continue to transport patients without pulse or respiration to a hospital once cardiopulmonary resuscitation has been initiated. For patients in traumatic arrest upon arrival to the ED, a critical decision must be made regarding the appropriate level of intervention and, specifically, the use of emergent thoracotomy. One study analyzing 862 patients undergoing ED thoracotomy at a regional trauma center showed that the proportion of neurologically intact survivors was 3.9%. The best outcomes were in patients with stab wounds to the chest. Further analysis revealed that the survival rate was 23% among thoracic stab wound victims who showed breathing or pulse in the field and 38% among those who were moribund but had some indication of respiration or pulse on arrival to the ED. Therefore, **the strongest recommendation for performing ED thoracotomy can be made for patients with penetrating chest trauma with witnessed signs of life during transport to or in the ED and at least cardiac electrical activity upon arrival.**[25,26,27] There were no

survivors among patients with blunt trauma and no respiration or pulse in the field. ED thoracotomy for this group is not indicated (including in the presence of myocardial electrical activity) (**Table 254-7**).[4]

TABLE 254-7

Indications for ED Thoracotomy upon Arrival to ED

Penetrating Thoracic Trauma	
CPR (pulseless) with signs of life (Signs of life include reactive pupils, spontaneous movement, or myocardial electrical activity)	Consider ED thoracotomy
CPR (pulseless) without signs of life	No further resuscitative efforts indicated
Blunt Trauma	
CPR (pulseless) with myocardial electrical activity	No further resuscitative efforts indicated

An extended FAST examination performed upon arrival can be useful in identifying cardiac tamponade or the absence of ongoing cardiac activity and can prevent an unnecessary ED thoracotomy.

SECONDARY SURVEY

The secondary survey is a rapid but thorough head-to-toe examination for injuries (Table 254-3). Do not start the secondary survey until basic functions have been corrected in conjunction with the primary survey (airway, breathing, circulation, disability, exposure) and resuscitation has been initiated. The secondary survey can help set priorities for ongoing evaluation and management. Frequent reassessment of the patient's blood pressure, pulse rate, and response to interventions should continue during this period.

Scalp lacerations can bleed profusely. Bleeding can be controlled with plastic Raney clips (see chapter 42, "Face and Scalp Lacerations") or staples that grasp the full thickness of the scalp. Inspect the tympanic membranes for hemotympanum and repeat the pupil examination. Repeat

the examination of the neck and thorax for any changes. When there is facial trauma or evidence of basilar skull fracture, insert the gastric tube through the mouth rather than the nose.

Inspect the urinary meatus, scrotum, and perineum for the presence of blood, hematoma, or laceration. Perform a rectal examination, noting sphincter tone, gross blood, and prostatic bogginess or displacement. The rectal examination is no longer routinely performed in alert patients without evidence of pelvic or spinal injury. If the prostate is normal and there is no blood at the urethral meatus, a urinary catheter can be placed in the bladder. **If meatal blood is present or the prostate is displaced, which suggests a urethral injury, perform retrograde urethrography before inserting a Foley catheter.** If there is vaginal bleeding, perform a manual and speculum examination to identify a possible vaginal laceration in the presence of a pelvic fracture. Evaluate the extremities for fracture and soft tissue injury, with attention to peripheral pulses. Perform a more thorough neurologic examination, carefully checking motor and sensory function.

Certain conditions are typically not evident during the secondary survey unless specifically sought. Injuries to the esophagus, diaphragm, and small bowel often remain undiagnosed, even with diligent examination, and further imaging and hospital observation for delayed presentation may be required. The most frequently missed conditions are orthopedic. Careful consideration of orthopedic extremity injuries is essential in patients with multisystem trauma. A tertiary survey has been recommended in patients with multisystem trauma within the first 24 hours to lessen the risk of missed injury.[28]

IMAGING AND LABORATORY TESTING

For patients who are not rapidly transported to the operating room or CT suite after the initial assessment, standard radiographic imaging may include cervical spine, chest, and pelvic radiographs. The chest and pelvic radiographs image regions outside the peritoneal cavity that can accommodate volumes of blood sufficient to produce hypotension and shock. In patients with gunshot wounds to the torso, a chest radiograph is required, with or without abdominal films, depending on the site of injury.

The **extended FAST** examination is a rapid and effective screening tool for the identification of major intraperitoneal bleeding, pericardial tamponade, pneumothorax, and hemothorax as the source of hypotension or shock.[29] It should be performed to identify causes of shock immediately after the primary survey (Figure 254-3). Perform a CT scan with IV contrast for definitive imaging of the abdomen. Obtain appropriate extremity radiographs to exclude fractures as directed by the physical examination findings.

In obtunded patients or those with multisystem trauma, consider imaging of the **entire spine** if the mechanism of injury warrants it. In patients undergoing head CT, most EDs perform cervical spine CT at the same time. If chest and abdominal CTs are performed, CT images of the thoracic

and lumbar spines can be reconstructed.

The liberal use of CT scanning in the setting of traumatic injury has the potential to detect injuries that are not clinically apparent. In one study of cooperative patients with no obvious signs of chest or abdominal injury, this "pan scan" method identified clinically significant abnormalities in 4% of head CT scans, 5% of cervical spine CT scans, 20% of chest CT scans, and 7% of abdominal CT scans. Overall treatment was changed in 19% of patients.[30] This approach should be balanced by the estimation that approximately 29,000 future cancers could be related to CT scans performed in the United States in 2007 alone.[31] Children represent a subgroup that deserve special consideration because exposure to radiation in childhood significantly increases the incidence of cancer later in life.[32] **In younger patients in whom the clinical indication for CT scan may be equivocal, avoid the use of ionizing radiation whenever possible.** In general, use clinical judgment to direct focused application of diagnostic imaging.

Routine laboratory studies often include blood type and screen, hemoglobin level, urine dipstick testing for blood, and ethanol level. In women of childbearing age, always perform a pregnancy test. Check capillary blood glucose level in patients with altered mental status or a history of diabetes mellitus. In patients older than 55 years, consider obtaining an ECG and measuring levels of markers for cardiac ischemia, such as troponin I.

DISPOSITION AND FOLLOW-UP

Expeditiously transport patients with hemodynamic instability and ongoing bleeding to the operating room or transfer the patient to another facility with appropriate surgical or critical care resources. Complete a rapid but thorough primary and secondary survey prior to transfer. In most urban Level 1 trauma centers, the trauma surgeon will have been present for the primary and secondary surveys. In rural hospitals that transfer the most severely injured trauma patients, the resuscitating physician should relate all the physical findings discovered during the primary and secondary surveys to the physician receiving the patient. Laboratory results, imaging studies, and the chronologic record of the patient's blood pressure, pulse, fluids infused, urine output, gastric output, and neurologic findings should accompany the patient. Personnel capable of performing ongoing resuscitation of the patient should accompany a patient transported to another facility.

Serial examinations are essential for patients without clear indications for surgery identified on initial assessment. Patients may be admitted to the hospital or an ED observation unit. Blunt abdominal injuries such as those involving the pancreas and bowel may not be readily apparent on initial CT. These injuries may become clinically apparent upon serial examinations. In addition, consider admission or observation for patients with closed head trauma who have normal levels of consciousness and require repeat neurologic examinations as well as patients at risk for delayed pneumothorax or pulmonary contusion that require repeat chest radiography.

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USEFUL WEB RESOURCES

American Trauma Society—http://www.amtrauma.org

Trauma programs, American College of Surgeons, Committee on Trauma—http://www.facs.org/trauma

Trauma.org—http://www.trauma.org