Initial management of the trauma patient

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The management of severely injured patients can be complex and requires a familiarity with a large body of clinical information that encompasses several specialties. Thus, organized trauma systems with designated trauma centers and trauma specialists have proven valuable for managing the multiply injured patient [1,2]. Unfortunately, only 35 states have formal trauma systems [3]. Critical care of the severely injured patient may therefore, at many centers, fall to other critical care physicians. This article discusses the prehospital and initial management steps of the multiply injured patient, focusing on established principles of therapy with which a critical care specialist should be familiar.

Epidemiology

Trauma is one of the leading causes of critical illness and death in the United States. In 2001, injury trailed only heart disease and deliveries as the most common first-listed discharge diagnosis category at nonfederal hospitals (over 2.4 million patients) [4]. In 2000, unintentional injury was the fifth leading cause of death (97,900 people) [5]. The leading cause of injury in the United States is the motor vehicle crash (MVC), which resulted in 3,033,000 injuries and 42,116 fatalities in 2001 [6]. About one third of trauma patients evaluated at a level 1 trauma center will be admitted to a critical care unit, with a mean length of stay of 5 days [7]. Several reports have documented a trend toward increased age and comorbidities...
among trauma patients, both of which are known to increase the risk of trauma morbidity and death [8].

**Prehospital care**

Regionalized trauma systems have a mandated ambulance destination policy that instructs prehospital personnel to transport seriously injured patients to a designated trauma center. Nontrauma designated medical facilities are bypassed even when they are closer in proximity to the scene of the injury. Prehospital personnel use well-defined mechanistic, anatomic, and physiologic criteria for trauma system entry (Table 1). Most trauma systems allow paramedics considerable discretion to overtriage. Scoring systems such as the revised trauma score (RTS) and the injury severity score (ISS) have not always been shown to be superior to paramedic judgment [9]. Trauma systems use quality assurance programs to periodically re-evaluate their entry criteria with the goal of minimizing undertriage. Trauma systems have been shown to decrease morbidity and mortality in urban areas, but the benefits have been harder to describe in rural areas [10].

The scope of care that paramedics deliver at the scene of the injury is controversial. Mainstays of prehospital care include airway management, control of external bleeding, immobilization of the spine, needle decompression of suspected tension pneumothorax, and splinting of major extremity fractures. On-scene delay usually is discouraged for interventions of unproven benefit [11–15].

Table 1

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<th>Oregon Health and Science University trauma activation criteria</th>
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<tr>
<td><strong>Full trauma team</strong>&lt;sup&gt;a&lt;/sup&gt; response</td>
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<tr>
<td>Snnty problems (intubated or attempted intubation)</td>
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<tr>
<td>Breathing difficulty (RR &lt; 10 or &gt; 29)</td>
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<tr>
<td>Systolic BP &lt; 90</td>
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<td>GCS &lt; 11</td>
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<tr>
<td>Penetrating injury to the head, neck or torso</td>
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<td>Flail chest</td>
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<tr>
<td>Paralysis</td>
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<tr>
<td>Pelvic instability</td>
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<tr>
<td>Amputation proximal to the wrist or ankle</td>
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<tr>
<td>Major crush injury to torso or upper thigh</td>
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<tr>
<td>Paramedic discretion</td>
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<tr>
<td>Significant intrusion/impact</td>
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<tr>
<td>Hostile environment (cold, heat)</td>
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<td>Presence of intoxicants</td>
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Abbreviations: ATV, all terrain vehicle crash; MCC, motorcycle crash; RR, respiratory rate.

<sup>a</sup> The full trauma team includes the trauma surgeon, emergency medicine physician, critical response nurse, anesthesiologist, and respiratory therapist.

<sup>b</sup> The modified trauma team excludes the anesthesiologist and the respiratory therapist.
For example, the application of military antishock trousers (MAST) by paramedics, once a standard component of prehospital care, did not prove beneficial in randomized trial [16]. Many, but not all, trauma systems encourage endotracheal intubation of the comatose trauma patient. Although more study is needed, recent prospective studies of field intubation of patients with severe traumatic brain injury, however, have uncovered a potentially harmful effect [17,18]. Prehospital intravenous (IV) crystalloid resuscitation of bluntly injured patients is recommended, but aggressive IV fluid administration is discouraged in patients with penetrating injury unless the patient manifests severe shock, or prolonged transport (more than 30 minutes) is expected [19].

Initial management

Optimal care of multiply injured patients includes a preplanned emergency department (ED) phase. Predetermined response teams with defined roles and expectations are necessary so that multiple therapeutic and diagnostic procedures can be performed simultaneously. A physician team leader assesses the patient, orders and interprets diagnostic studies, and prioritizes diagnostic and therapeutic concerns. The team leader helps the team focus on the injuries that are immediately life-threatening and formulates the plan for the evaluation of less threatening injuries in sequence. Dividing the ED phase into the Advanced Trauma Life Support (ATLS) recommended stages of the primary survey, initial imaging tests, secondary survey, and transfer to definitive care is a well-tested means of determining these priorities [20].

The primary survey

The primary survey is defined by the mnemonic ABCDE: Airway, Breathing, Circulation, Disability and Exposure/Environment [20]. Although these components are described sequentially, some components may be performed simultaneously. Problems identified during this portion of the evaluation are managed immediately.

Airway

The airway always is assessed immediately for patency, protective reflexes, foreign body, secretions, and injury. This assessment may range from asking the patient to open the mouth and phonate to suctioning secretions and assessing the stability of midface, mandible, or dental injuries. Suction or manual clearing of foreign bodies or vomitus is followed by careful inspection and palpation of the facial structures, oropharynx, and neck. The patient’s level of consciousness is also a primary indicator of airway stability. Patients with a Glasgow Coma Score (GCS) of 8 or less are at risk for aspiration and hypoventilation.
If for any reason the clinician is not convinced of the patient’s ability to maintain his or her own airway, the clinician proceeds to artificial airway control. The appropriate method of establishing an airway depends upon the specific situation, but some general rules apply. All trauma patients need manual cervical immobilization during airway management to prevent movement of a potentially unstable cervical spine injury. Rapid sequence induction is preferred in all but the most moribund patients and oro–tracheal intubation is the preferred route. Naso–tracheal intubation no longer is encouraged because of its difficulty to performance and higher complication rate [21]. The concern that clinicians have had that oro–tracheal intubation is potentially harmful in patients with potential cervical spine fractures has been refuted by prospective studies [22–24]. Urgent or emergent intubation should not be delayed to obtain radiographs of the cervical spine.

Stridor, hoarseness, or neck subcutaneous emphysema are signs of a possible laryngo–tracheal injury. Although many of these patients can be managed without an airway, they all demand close observation in an ICU. If intubation is required and time allows, a physician experienced in difficult intubations should be chosen. Unsuccessful endotracheal intubation of a partial laryngo–tracheal tear may transform it to a complete transection. Fiberoptic nasotracheal intubation should be attempted only by experienced clinicians with the necessary equipment immediately available. Even in this ideal situation, blood and secretions often render fiberoptic intubation difficult or impossible.

Surgical airway management is indicated when either the oral route has failed or is in the situation of massive facial injury. Percutaneous transtracheal ventilation can be a temporizing measure before performance of tracheostomy or cricothyrotomy. Cricothyrotomy is easier to perform and is preferred over tracheostomy in most situations; however, if there is a suspicion of a laryngeal fracture or tracheal transection, tracheostomy is the method of choice [25–27].

**Breathing**

Breathing is assessed by determining the patient’s respiratory rate and by subjectively quantifying the depth and effort of inspiration. Breath sounds should be carefully auscultated bilaterally. Pulse oximetry is a mandatory adjunct and end–tidal carbon dioxide monitoring is becoming a useful adjunct. Rapid respiratory effort, the use of accessory muscles of respiration, hypoxia, hypercapnia, asymmetric chest wall excursions, and diminished or absent breath sounds all require treatment before proceeding. Needle decompression of tension pneumothorax can be completed quickly at this stage with definitive tube thoracostomy performed after completion of the primary survey.

**Circulation**

Assessment of the circulation begins with a quick evaluation of the patient’s mental status, skin color, and skin temperature. Patients in significant hemorrhagic shock will progress from anxiety to agitation and finally coma if their blood loss is not abated. Because one of the immediate responses of the body to hemorrhage is
the activation of the sympathetic nervous system, the peripheral skin of a bleeding patient will become pale, cool, and sweaty. Cyanotic or mottled peripheral skin is a sign of severe hemorrhagic shock. Sluggish capillary refill of the toes and the absence of blood in the superficial veins of the feet and hands also may be apparent. Unfortunately, the traditional vital signs, heart rate, blood pressure, and respiratory rate, are neither sensitive nor specific for hemorrhagic shock [28]. Young, healthy patients in compensated shock may not be significantly tachycardic or hypotensive until they have lost up to 30% of their blood volume. In addition, because of the pain and anxiety that many injured patients experience, tachycardia and tachypnea are common regardless of whether there is significant hemorrhage.

Direct pressure should be applied to external bleeding. Physicians should resist the urge to clamp bleeding vessels, since significant additional damage can result, and direct pressure is usually effective. A tourniquet will be required only in cases of near or complete amputation with massive external bleeding.

The primary survey of circulation is not complete until adequate venous access is obtained. If two large bore (16–14 gauge) IV lines cannot be obtained within several minutes, a femoral venous central line should be inserted. If the patient is in shock, an 8 French single lumen catheter should be placed, but the smaller diameter triple lumen catheter is adequate for more stable patients. Because of the risk of lower extremity deep venous thrombosis and central line infection, femoral venous catheters placed in the ED should be removed within 24 hours.

Choices of fluids for resuscitation include crystalloid, colloid, and blood products. Initial fluids should be crystalloids, either normal saline or Ringers lactate. Ringers lactate is preferred when large volumes are required, as acidosis can result from large volumes of normal saline [29]. Ringers lactate, however, is hypotonic and hyponatremic compared with plasma and therefore may be contraindicated in cases of brain injury. Hypertonic saline (7.5% salt in 6% Dextran) in small volumes has been used and shown to improve survival in hypotensive trauma patients [30,31]; however, its use is not common.

Patients who do not respond to 1 to 2 L of crystalloid resuscitation or who appear moribund should be transfused with type O uncross-matched blood. O-positive blood can be used for most patients so that O-negative blood can be reserved for use in women of child-bearing age. Because of the time delay, type-specific or fully cross-matched blood is only indicated in less urgent situations.

Once therapy for shock has been initiated and external bleeding control initiated, the search for sources of internal hemorrhage must begin. The three body regions that will hide significant amounts of blood in cases of blunt injury include the chest, abdomen, and pelvis. Chest and pelvic radiographs and a focused assessment with sonography for trauma (FAST) or a diagnostic peritoneal lavage (DPL) are mandatory screening studies for patients in shock. Computed tomography (CT) scanning of patients in hemorrhagic shock is discouraged. Long bone fractures can cause bleeding, but absent open fractures with significant external blood loss rarely result in shock. Neurogenic shock is entertained as a diagnosis only after causes of hemorrhagic shock have been eliminated. Patients with torso-penetrating injury and shock should be taken urgently to the operating room by a qualified surgeon.
Selected patients with hypovolemic shock with circulatory collapse that is unresponsive to fluid resuscitation can be considered for ED thoracotomy. This procedure should be performed only by a qualified and experienced emergency physician or surgeon. Only patients with a penetrating mechanism of injury and loss of vital signs en route or after arrival should be considered. Patients with stab wounds, gunshot wounds, and blunt mechanisms of injury have 16.8%, 4.3%, and 1.4% survival rates, respectively [32].

Disability

Disability should be assessed early so as to document neurologic deficits before giving IV sedation or paralytics. The GCS and the gross motor and sensory status of all four extremities should be determined and recorded. The physician also should recognize the need for cerebro-protection measures in cases of brain injury. Brain injured patients who are intubated should be sedated with a rapidly reversible agent such as midazolam or propofol. Aggressive hyperventilation is not indicated, but it is the most rapid method of transiently lowering the intracranial pressure (ICP) in patients suspected of near-herniation [33]. Mannitol in a dose of 1.0 g/kg IV is indicated in patients with low GCS and asymmetric pupils who are not in shock [34,35].

Exposure/environment

The final portion of the primary survey is exposure and environmental control. Exposure is particularly important in the patient with a traumatic mechanism of injury where failure to identify a second or third injury may result in mis-assessment of the clinical picture. Environmental control involves assessing the core body temperature and preventing hypothermia. At a minimum, the room should be maintained at a temperature as warm as possible and the patient covered with blankets. Rapid infusion of blood products and crystalloid solutions should be accomplished by way of a Level 1 (Level 1, Inc., Rockland, Massachusetts) fluid warmer. Patients in shock may be normothermic initially, but nevertheless, they will require active warming during the resuscitation phase.

Initial radiographs and procedures

Depending upon findings during the primary survey, initial portable radiographs and indicated procedures should be performed immediately and not be delayed for the secondary survey. A portable chest film is usually the only radiograph necessary in cases of penetrating torso trauma. The placement of a chest tube on the side of the penetrating wound before chest film is routine if the patient has of shortness of breath, diminished breath sounds, or shock. Relatively routine emergent radiographs in bluntly injured patients are the lateral cervical spine, chest, and pelvis. The FAST exam can be used as a substitute for the DPL in a
patient who is in shock, but it should not be routine, as it has a low sensitivity in hemodynamically stable patients [36].

**Secondary survey**

The secondary survey is a complete re-assessment of the patient and injuries. A more complete and traditional history and physical exam is performed. Multiple sources (friends, relatives, law enforcement, and emergency services personnel) often are required to obtain a complete history. Much can be learned from the mechanism of injury. The type and magnitude of the potential energy transfer provides many clues to potential injury patterns. Patients with a history of high energy transfer (eg, high speed crashes, falls from great heights) are at higher risk for occult injury regardless of their initial clinical presentation. Single vehicle crashes, unexplained falls, or potentially self-inflicted injuries will require assessment of the patient’s underlying mental state and potential for further self-harm. The physical examination commences at the head of the patient and proceeds toward the toes. The experienced trauma specialist realizes that painful, distracting injuries and a less than precise examination may leave some injuries unidentified.

Throughout this portion of the evaluation, the patient should be monitored with continuous cardiac rhythm with pulse oximetry, frequent blood pressure measurements, mental status exam, and clinical assessments of peripheral perfusion. End–tidal carbon dioxide monitoring can be useful also. Invasive monitoring by means of pulmonary artery catheters is rarely feasible in an ED setting. If at any time during the secondary survey the patient’s clinical status deteriorates, the examiner should return to the elements of the primary survey.

Once the secondary survey is completed, more specific imaging and diagnostic studies can be obtained. If the patient is hemodynamically stable, and the physician has a low concern for life-threatening injury, transport to the radiology department or CT scanner for more accurate diagnostic testing is reasonable. The patient should be accompanied and monitored by a nurse at all times until the initial evaluation is complete.

**Geriatric trauma**

Because the general population of the United States is continuing to age, and more Americans are remaining active for many years after they retire, trauma centers are expected to admit increasing numbers of elderly patients. Most trauma systems recognize that advanced age should lower the threshold for field triage directly to a trauma center. The age cut-off for geriatric trauma has not been standardized, but it generally ranges from age 55 or certainly beyond age 65. Age, and especially comorbid medical conditions, are well-recognized risk factors for adverse outcomes following trauma [8]. In spite of the risk of increased morbidity, however, advanced age should not be used as the sole criteria for limiting trauma.
resuscitation and procedures. Most elderly trauma patients admitted to trauma centers will return to independent function.

Whether geriatric trauma patients should receive more aggressive invasive monitoring in the ICU than younger, similarly injured patients is not clear. There are insufficient data to support a level 1 evidence-based medicine recommendation for the use or nonuse of a pulmonary artery catheter during resuscitation based on age alone [8]. If the older patient has evidence of shock associated with a significant injury, however, a pulmonary artery catheter-directed resuscitation is probably wise, especially when chronic cardiovascular or renal disease is present. Older patients with blunt thoracic trauma are certainly at risk for pulmonary deterioration even if they initially appear compensated [37]. Pain control with an epidural catheter and ICU-monitored pulmonary toilet for the first 48 hours is recommended for any patient older than 65 years of age with multiple rib fractures [38].

Tertiary survey

Performing a tertiary survey on injured patients admitted to the ICU is necessary to completely identify all of the potentially multiple injuries. [39] Injuries that have not yet been detected or that have been set aside while more life-threatening issues are managed are common, especially in blunt trauma. In addition, patients who are intoxicated with alcohol or other chemicals and are unable to cooperate with the diagnosis and management of their potential injuries may require rapid sequence induction and endotracheal intubation just to facilitate their secondary survey and diagnostic imaging. The tertiary survey consists of yet another head to toe physical examination, an assessment of the patient’s response to resuscitation thus far, a review of current radiographic studies with radiologist interpretation, a review of all laboratory studies, and a effort if necessary to obtain a pre-injury medical history from family and friends who by this time should be arriving. Typically this would be performed upon the patient’s arrival to the ICU. It is reasonable at this point to order a new panel of labs that in the case of a multiply injured patient that would at the least consist of a complete blood count, coagulation panel, arterial blood gas, and serum lactate. The trauma specialist or intensive care specialist then decides what invasive monitoring and IV access and what further radiographic studies are necessary. A plan for sedation and analgesia is formulated.

Because delays in detecting all injuries are common in multiply injured patients, the injury should not be considered significantly delayed or missed if found within the first 24 hours. The experienced trauma specialist will suspect fractures that are hidden easily from view (eg, in the cervical, thoracic, or lumber spine). The authors’ routine practice is to obtain a cervical spine CT scan during the patient’s second trip to the CT scanner (eg, during the second serial head CT scan for patients with brain injury). A low threshold for a chest CT scan will detect occult pneumothoraces, pulmonary contusion, and even aortic injury. The potential development of extremity compartment syndrome should be considered around all extremity fractures or soft-tissue injuries. Intra-abdominal pressure
should be measured on admission to the ICU and every 6 hours in the critically ill trauma patient regardless of whether there is a known abdominal injury. The aggressive fluid resuscitation associated with traumatic shock will lead to total body edema and even ascites [40].

Two complications that will occur simultaneously and synergistically and that should be expected during the tertiary survey are hypothermia and coagulopathy. Hypothermia as the result of environmental exposure or shock complicates resuscitation and treatment of trauma patients and increases morbidity and mortality [41]. Iatrogenic causes of hypothermia include massive fluid resuscitation and prolonged surgical procedures. Hypothermia exacerbates acidosis, increases blood viscosity, decreases microvascular blood flow, and reduces platelet aggregation. IV fluids should be warmed with a Level 1 transfuser (Level 1, Inc., Rockland, Massachusetts) beginning in the ED, and the patient should be covered with a Bair Hugger (Arizant Health Care, Inc., Eden Prairie, Minnesota) and blankets as much as possible. The combination of hypothermia and massive transfusion may result in an uncorrectable coagulopathy unless both of these problems are anticipated and treated. Most trauma centers initiate a massive transfusion protocol as soon as it is predicted that more than ten units of packed red cells will be transfused [42,43]. A clinical pathologist should come to the patient’s bedside and directly assist the surgeon and intensive care specialist with the ordering and delivering of procoagulation products.

**Summary**

Critical care specialists should be familiar with the initial management of injured patients. Dividing the evaluation and treatment of the patient into the primary, secondary, and tertiary surveys ensures that the multiply injured patient will be managed expeditiously. The primary survey identifies the acute life-threatening problems that must be managed immediately. The secondary survey identifies the remaining major injuries and sets priorities for definitive management. The tertiary survey identifies occult injuries before they become missed injuries.

**References**


