Initial management of trauma in adults

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INTRODUCTION — Trauma is regularly encountered in the emergency department (ED). While injuries can range from isolated extremity wounds to complex injuries involving multiple organ systems, all trauma patients require a systematic approach to management in order to maximize outcomes and reduce the risk of undiscovered injuries.

This review will discuss the initial management of adult trauma patients. The management of pediatric trauma patients and specific injuries are reviewed separately. (See "Trauma management: Approach to the unstable child" and "Trauma management: Unique pediatric considerations" and "Initial evaluation and management of shock in adult trauma".)

EPIDEMIOLOGY — Trauma is a leading cause of mortality globally [1]. In the United States, it is the leading cause of death for those under the age of 35 and accounts for 10 percent of all deaths among men and women [2]. In addition, injuries from accidental trauma worldwide leave over 45 million people each year with moderate to severe disability [1]. In the United States, more than 50 million patients receive medical care for trauma annually, and trauma accounts for approximately 30 percent of all intensive care unit admissions [3,4].

According to the World Health Organization (WHO), motor vehicle collisions account for 1.3 million deaths annually, were the ninth leading cause of disability in 2004, and will rise to the third leading cause of disability worldwide by 2030 [1]. Outside areas of armed conflict, penetrating injuries are responsible for fewer than 15 percent of traumatic deaths worldwide [5], but these rates vary by country. As examples, while homicide accounts for as many as 45 percent of deaths in Los Angeles, penetrating injuries account for only 13 percent of deaths in Norway [6]. Approximately half of traumatic deaths result from central nervous system (CNS) injury, while another third stem from exsanguination [7].

Patients with traumatic injuries have a significantly lower likelihood of mortality or morbidity (10.4 versus 13.8 percent; relative risk [RR] 0.75, 95% CI 0.60-0.95) when treated at a designated trauma center [8]. Older age, obesity, and major comorbidities are associated with worse outcomes following trauma [9-15]. In trauma patients with significant hemorrhage, a lower Glasgow coma score and older age are both independently associated with increased mortality, according to multivariable logistic regression analysis of two large databases [16]. In addition, according to a large retrospective study from the United States National Trauma Databank, warfarin use is associated with an approximately 70 percent increased risk of mortality following trauma, after adjusting for other important risk factors (odds ratio [OR] 1.72; 95% CI 1.63-1.81) [17].

While the most common preventable causes of mortality from trauma are hemorrhage, multiple organ dysfunction syndrome, and cardiopulmonary arrest [18], the most common preventable causes of morbidity are unintended extubation, technical surgical failures, missed injuries, and intravascular catheter-related complications [19].

Early studies of trauma described a trimodal distribution of mortality: death at the scene; death one to four hours following injury; and death weeks after injury—typically in an intensive care setting [20]. However, subsequent studies report that relatively few patients die after the first 24 hours following injury and suggest that a bimodal mortality distribution is more accurate [21,22]. According to these later studies, the majority of deaths occurs either at the scene or within the first four hours after the patient reaches a trauma center.

The "golden hour" concept, which emphasizes the increased risk of death and the need for rapid intervention during the first hour of care following major trauma, was described in early trauma studies and has been promulgated in textbooks and instructional courses [23]. Undoubtedly there are instances when rapid intervention improves the outcome of injured patients (eg, obstructed airway, tension pneumothorax, severe hemorrhage). However, the relationship between timing and mortality may be more complex than once thought. In a large study using registries from multiple trauma centers across North America, no association between emergency medical services (EMS) intervals (eg, on scene and transport times) and trauma patient mortality was found [24].

MECHANISM — Particular mechanisms predispose patients to specific injuries. Common blunt trauma mechanisms and their most frequently associated injuries are described in the accompanying table (table 1). In addition, certain high-risk blunt mechanisms, including pedestrians struck by automobiles, motorcycle accidents, severe motor vehicle accidents (eg, extensive damage leading to prolonged extrication time), and falls greater than 20 feet, have been associated with greater morbidity and mortality [25-28].

PREPARATION TIME

Prearrival preparation — Whenever possible, emergency medical services (EMS) should notify the receiving hospital that a trauma patient is en route. This provides the receiving hospital with information and time that can be crucial to the management of the severely injured patient.

Ideally, the information provided by EMS includes:

- Patient age and sex
- Mechanism of injury
- Vital signs (some clinicians ask for the lowest blood pressure and highest pulse)
- Apparent injuries

Early notification enables emergency department (ED) staff to perform the following:

- Notify additional services (eg, trauma surgery, obstetrics, orthopedics)
- Prepare for anticipated procedures (eg, tracheal intubation, chest tube)
- Prepare for blood transfusion

Information provided by EMS prior to arrival can help hospital-based clinicians focus on more likely injuries (table 1). As an example, a description of a feet first fall from great height raises suspicion for fractures of the calcaneus, lower extremity, and lumbar spine; similarly, report of a prolonged extrication due to collapse of the driver's side compartment raises concern for such injuries as rib fractures, pulmonary contusion, and lacerations of the spleen and kidney.

Universal precautions against blood and fluid borne diseases should be part of the trauma team's preparation. These include gloves, gowns, masks, and eye protection for all members of the team involved in the resuscitation.

Trauma team — In rural hospitals, the trauma team may be limited to one physician and a nurse. In such settings, the team might enlist help from EMS personnel or other clinicians to manage critically ill or multiple patients. On the other hand, teams at major trauma centers may include emergency physicians, trauma surgeons, subspecialist surgeons, emergency nurses, respiratory therapists, technicians, and social workers. Regardless of the setting, all teams must have a clearly designated leader who determines the overall management plan and assigns specific tasks. While leaders of smaller teams might find themselves having to perform procedures in order to care effectively for their patients, leaders of larger teams should avoid performing procedures. This allows the leader to remain focused on their supervisory responsibilities and on the patient and possible changes in their condition.

Regardless of setting or team composition, optimal care of a trauma patient requires effective and efficient communication and teamwork among all members [29,30]. Good care begins with a prearrival briefing and the assignment of general roles and specific tasks, and continues throughout the resuscitation as the team practices closed loop communication and maintains a common vision of the plan of care.

Breakdowns in the care plan and medical mismanagement typically occur due to one of four potential problems [30]:

- Communication breakdowns (eg, changes in the patient's physiologic state or critical test results are not effectively communicated, overall management plan is not outlined clearly by the team leader)
- Failures in situational awareness (eg, failure to recognize shock, failure to anticipate blood transfusion needs, failure to modify standard management for higher risk patients)
- Staffing or workload distribution problems (eg, insufficiently trained staff conducting a procedure, inadequate staff for patient volume)
- Unresolved conflicts (eg, unresolved hostility about other team members perceived to be performing inadequately, disagreement about overall management plan, disagreement among senior clinicians vying for team leadership)

PRIMARY EVALUATION AND MANAGEMENT

Overview — A clear, simple, and organized approach is needed when managing a severely injured patient. The primary survey promulgated in Advanced Trauma Life Support™ (ATLS™) provides such an approach [23]. The primary survey is organized according to the injuries that pose the most immediate threats to life and is performed in the order described immediately below. In settings with limited resources, the primary survey simplifies priorities and any problems identified should be managed immediately, in the order they are detected, before moving on to the next step of the survey. However, at major trauma centers, many capable clinicians may be present, allowing the team to address multiple problems simultaneously.

The primary survey consists of the following steps:

- **A**irway assessment and protection (maintain cervical spine stabilization when appropriate)
- **B**reathing and ventilation assessment (maintain adequate oxygenation)
- **C**irculation assessment (control hemorrhage and maintain adequate end-organ perfusion)
- **D**isability assessment (perform basic neurologic evaluation)
- **E**xposure, with environmental control (undress patient and search everywhere for possible injury, while preventing hypothermia)

Keep the following points in mind while performing the primary survey:

- Airway obstruction is a major cause of death immediately following trauma [24,29].
- Definitive guidelines for tracheal intubation in trauma do not exist. When in doubt, it is generally best to intubate early, particularly in patients with hemodynamic instability or significant injuries to the face or neck, which may lead to swelling and distortion of the airway.
- Once an airway has been established, it is important to secure it well and to ensure it is not dislodged any time the patient is moved. Unintended extubation is the most common preventable cause of morbidity in trauma patients [19].

- Unconscious patients with small pneumothoraces that are not visible or missed on the initial chest x-ray may develop tension physiology after tracheal intubation from positive pressure ventilation. It is important to reauscultate the lungs of trauma patients who develop hemodynamic instability after being intubated.
- Hemorrhage is the most common preventable cause of mortality in trauma [18]. Be alert for subtle signs of hemorrhagic shock, particularly in the elderly and young, healthy adults who may not present with obvious manifestations. Hypotension generally does not manifest until at least 30 percent of the patient's blood volume has been lost [31]. Such patients are at high risk of death. Elderly patients may be hypotensive relative to their baseline blood pressure but still have blood pressure measurements in the "normal" range. A single episode of hypotension substantially increases the likelihood that a serious injury has occurred [32,33]. (See "Initial evaluation and management of shock in adult trauma", section on 'Recognition' and "Geriatric trauma: Initial evaluation and management".)
- Brain injuries are common in patients who have sustained severe blunt trauma and even a single episode of hypotension increases their risk of death [31,34].

Airway — Severely injured patients can develop airway obstruction or inadequate ventilation leading to hypoxia and death within minutes. Observational studies suggest that airway obstruction is a major cause of preventable death among trauma patients [35,36]. Therefore, airway evaluation and management remain the critical first steps in the treatment of any severely injured patient [23].

Assessment — In a conscious patient, initial airway assessment can be performed as follows [37]:

- Begin by asking the patient a simple question (eg, "What is your name?"). A clear accurate response verifies the patient's ability to mentate, phonate, and to protect their airway, at least temporarily.
- Observe the face, neck, and chest for signs of respiratory difficulty, including tachypnea, accessory or asymmetric muscle use, abnormal patterns of respiration, and stridor.
- Inspect the oropharyngeal cavity for disruption; injuries to the teeth or tongue; blood, vomitus, or pooling secretions. Note if there are obstacles to the placement of a laryngoscope and endotracheal tube.
- Inspect and palpate the anterior neck for lacerations, hemorrhage, crepitus, swelling, or other signs of injury. Palpation of the neck also enables identification of the landmarks for cricothyrotomy.

In the unconscious patient, the airway must be protected immediately once any obstructions (eg, foreign body, vomitus, displaced tongue) are removed. Management of the airway generally and in a patient with direct airway trauma is discussed separately. (See "Emergency airway management in the adult with direct airway trauma" and "Initial evaluation and management of penetrating neck injuries" and "Advanced emergency airway management in adults" and "Rapid sequence intubation in adults".)

Airway management in a trauma patient unable to protect his or her airway is completed in an expedient yet controlled fashion. When possible, perform a brief preintubation assessment to gauge the potential difficulty of intubation. Methods and mnemonics to assess airway difficulty are reviewed separately, but the application of the LEMON mnemonic to trauma patients is described here. (See "The difficult airway in adults".)

- **L**: LOOK: Facial and neck injuries can distort external and internal structures making it difficult to visualize the glottis or insert an endotracheal tube.
- **E**: EVALUATE 3-3-2: This refers to the intraoral, mandibular, and hyoid-to-thyroid notch distances (picture 1). The cervical collar must be opened to make these assessments. The distances referred to can be narrowed by fracture, hematoma, or other anatomic distortions (eg, soft tissue swelling).

- **M**: MALLAMPATI: A standard calculation of the Mallampati score cannot be performed in many trauma patients; injured patients requiring emergent intubation often cannot open their mouths spontaneously (figure 1). Nevertheless, an effort should be made to determine how much of the retropharynx can be seen and whether injuries of the oropharynx or pooled blood, vomitus, or secretions are present.
- **O**: OBSTRUCTION/OBESITY: Either factor can interfere with visualization and management of the traumatized airway. Any number of injuries can obstruct the airway including internal or external hematomas or soft tissue edema from smoke inhalation. Obesity complicates performance of cricothyrotomy.
- **N**: NECK MOBILITY: In-line stabilization is necessary in most trauma patients. Once the cervical collar is removed by a second skilled provider, that provider should stabilize the spine while orotracheal intubation is performed. It is important to note that the risk of neurologic injury from hypoxemia is much greater than the risk of spinal injury due to neck extension during intubation. Judicious relaxation of immobilization may be necessary in some cases [37].

Difficult airway devices — Devices for difficult airway management are discussed separately. (See "Devices for difficult emergency airway management in adults".)

A number of airway tools and rescue airways can be helpful when managing a trauma patient. Devices that should be available at the bedside include:

- Suction (ie, multiple pumps and tips) may be needed.
- Bag-valve mask attached to high flow oxygen
- Oral and nasal airways
- Rescue airways (eg, Combitube™, Laryngeal mask airway)
- Endotracheal tube introducer (ie, gum elastic bougie)
- Video laryngoscope if available
- Cricothyrotomy kit
- Endotracheal tubes in a range of sizes
- Laryngoscopes
- Preferred adjunct intubating devices (eg, lightwand)

Direct laryngoscopy relies on direct visualization of the glottis, which is often difficult in the severely injured patient whose airway may be obstructed and whose neck cannot be manipulated. In contrast, video laryngoscopes provide an excellent view of the glottis with minimal movement of the cervical spine and appear to be well suited for airway management in the trauma patient [38-40]. Larger studies in trauma populations are needed to confirm these initial impressions.

The endotracheal tube introducer (or gum elastic bougie) is another invaluable tool for airway management in the trauma patient, particularly when the glottic view is limited. Its use is discussed separately. (See "Devices for difficult emergency airway management in adults", section on 'Endotracheal tube introducers (gum elastic bougie)'.)

Intubation — Tracheal intubation of the injured patient is often complicated by the need to maintain cervical immobilization, the presence of obstructions such as blood, vomitus, and debris, and possibly by direct trauma to the airway [41]. Nevertheless, many trauma patients require intubation for immediate airway protection or because of the projected disease course. Intubation improves oxygenation, thereby helping to meet increased physiologic demands, and allows for testing and procedures to be performed more easily and with less patient discomfort. (See "The decision to intubate".)

Ideally, airway managers should have a predetermined back-up plan with all necessary tools at the bedside, including rescue airways and a cricothyrotomy kit, before proceeding with intubation. In crash scenarios, this may not be possible.

The performance of rapid sequence intubation and direct laryngoscopy are discussed separately. (See "Rapid sequence intubation in adults" and "Direct laryngoscopy and tracheal intubation in adults".)

Cricothyrotomy — Clinicians who manage trauma must be prepared to perform a cricothyrotomy when orotracheal intubation cannot be accomplished. The performance of cricothyrotomy and the approach to the failed airway are discussed separately. (See "The failed airway in adults" and "Emergent surgical cricothyrotomy (cricothyroidotomy)".)

In trauma patients with a potentially difficult airway, a double set-up, in which simultaneous preparation is made to perform orotracheal intubation and cricothyrotomy, may be the best approach. This enables the clinician to transition immediately to a cricothyrotomy if attempts at oral intubation are unsuccessful.

Trauma patients may have sustained injuries to the neck that make cricothyrotomy difficult to perform and therefore it is important to optimize any attempt at orotracheal intubation.

Cervical spine immobilization — Assume that an injury to the cervical spine has occurred in all blunt trauma patients until proven otherwise. Conversely, patients with **isolated** penetrating trauma, no secondary blunt injury, and an intact neurologic examination typically do not have an unstable spinal column injury [37]. Spinal immobilization may be harmful to these patients in some circumstances and is unnecessary when managing their airway [42]. (See "Evaluation and acute management of cervical spinal column injuries in adults".)

The anterior portion of the cervical collar should be temporarily removed and manual in-line stabilization maintained for all patients with blunt traumatic injuries receiving airway interventions, including bag-mask ventilation [43,44]. Preintubation airway interventions are associated with as much spinal column subluxation as intubation [43,44].

Tracheal intubation should **not** be attempted with the anterior portion of the cervical collar in place. Intubations performed with the complete cervical collar in place are associated with greater spinal subluxation than those performed with the anterior portion removed and manual in-line stabilization maintained [45].

The safety of manual in-line stabilization for patients with blunt traumatic injuries needing intubation is well established. Few case reports describe spinal injury during intubation, and in all cases, the spine was not manually stabilized [46-48].

Breathing and ventilation — Once airway patency is ensured, assess the adequacy of oxygenation and ventilation [23]. Chest trauma accounts for 20 to 25 percent of trauma-related deaths, in large part due to its harmful effects on oxygenation and ventilation [22]. The management of blunt chest trauma is discussed separately. (See "Initial evaluation and management of blunt thoracic trauma in adults".)

Inspect the chest wall looking for signs of injury, including asymmetric or paradoxical movement (eg, flail chest), auscultate breath sounds at the apices and axillae, and palpate for crepitus and deformity. In unstable patients, obtain a portable chest x-ray. Tension pneumothorax, massive hemothorax, and cardiac tamponade are immediate threats to life that should be identified at this stage of the primary survey.

Presumptively treat patients exhibiting signs of tension pneumothorax, including hypotension, dyspnea, and ipsilateral decreased breath sounds, with needle decompression before obtaining imaging. Delays to obtain a portable chest x-ray can cause significant morbidity. Needle decompression is performed with a large bore (14 gauge or larger) angiocatheter, either in the second intercostal space in the midclavicular line or in the fifth intercostal space in the midaxillary line.

Of note, a standard 14 gauge angiocatheter cannot penetrate the chest wall and reach the pleural space in 10 to 33 percent of trauma patients [49]. A 10 gauge, 7.5 cm (3 inch) armored angiocatheter is able to penetrate the pleural space in most instances. Needle decompression is followed immediately by tube thoracostomy. (See "Initial evaluation and management of blunt thoracic trauma in adults", section on 'Initial management' and "Placement and management of thoracostomy tubes".)

Tube thoracostomy in an unstable trauma patient is placed in anticipation of both hemothorax and pneumothorax using a chest tube of at least 32 French in diameter. A generous skin incision should be made in the fifth intercostal space in the midaxillary line allowing for placement of the tube in the inferior portion of the interspace and digital guidance towards the posterior-apical portion of the hemithorax.

Circulation — Once the airway and breathing are stabilized, perform an initial evaluation of the patient's circulatory status by palpating central pulses. If a carotid or femoral pulse is verified and no obvious exsanguinating external injury is noted, circulation may momentarily be assumed to be intact; completion of the primary survey should not be delayed by the determination of an exact blood pressure.

While circulation is assessed, two large-bore (16 gauge or larger) intravenous (IV) catheters are placed, most often in the antecubital fossa of each arm, and blood is drawn for testing, particularly for blood typing and crossmatch. Intraosseous cannulation or central venous catheter placement (ideally under ultrasound guidance) can be performed if there is difficulty establishing peripheral IV access. (See "Intraosseous infusion".)

Life-threatening hemorrhage must be controlled. A combination of manual pressure, proximal compression with either a tourniquet or a manual blood pressure cuff, and elevation is typically sufficient to control external arterial hemorrhage. When these are unsuccessful, hemostatic agents may be needed, if available. Venous bleeding is controlled with direct pressure. (See "Initial evaluation and management of shock in adult trauma", section on 'Hemostatic agents'.)

Emergency thoracotomy may be needed for trauma patients without central pulses. The procedure is most effective for victims of stab wounds to the chest who have pulses or other witnessed signs of life (eg, voluntary movement) initially. It is rarely beneficial in patients with blunt trauma or when performed in facilities without ready access to appropriate surgical care. Emergency thoracotomy is discussed separately. (See "Initial evaluation and management of blunt thoracic trauma in adults", section on 'Emergent thoracotomy'.)

Most trauma patients with hypotension or signs of shock (eg, pale, cool, moist skin) are bleeding, and patients with severe hemorrhage have significantly higher mortality [50]. Initial fluid resuscitation for these patients often consists of a bolus of intravenous crystalloid (eg, 20 mL/kg isotonic saline). Patients with obvious severe or ongoing blood loss should be transfused immediately with type O blood; women of childbearing age are transfused with O negative blood. Mildly unstable patients may be treated with isotonic crystalloid in lieu of blood, although unnecessary infusion of crystalloid should be avoided [51]. Fluid resuscitation, including the appropriate use of delayed fluid resuscitation and transfusion of the trauma patient in shock are discussed separately. (See "Initial evaluation and management of shock in adult trauma".)

Patients with persistent hemodynamic instability despite an initial fluid bolus generally require blood transfusion and definitive control of the bleeding source. Significant hemorrhage occurs in any of five sites: external, intrathoracic, intraperitoneal, retroperitoneal, and pelvic or long bone fractures. Patients requiring transfusion may benefit from treatment with tranexamic acid if it is given within three hours of injury. (See "Initial evaluation and management of shock in adult trauma", section on 'Antifibrinolytic agents'.)

It is important to obtain manual blood pressure measurements in trauma patients with systolic blood pressures below 90 mmHg, as automated blood pressure cuffs often overestimate values significantly in these patients [52]. Furthermore, data suggest that the traditional threshold of a systolic blood pressure below 90 mmHg used to define shock is inaccurate [53-56]. A significant proportion of trauma patients with hemorrhagic shock have a higher blood pressure and using a cut-off of 110 mmHg is likely to be more appropriate, especially in the elderly. (See "Geriatric trauma: Initial evaluation and management".)

Nonhemorrhagic causes of shock include tension pneumothorax and cardiac tamponade. These injuries are best detected by physical examination or ultrasound assessment (ie, FAST). (See 'Ultrasound (FAST exam)' below and "Emergency ultrasound in adults with abdominal and thoracic trauma".)

Disability and neurologic evaluation — Once problems related to the airway, breathing, and circulation are addressed, perform a focused neurologic examination. This should include a description of the patient's level of consciousness using the Glasgow Coma Scale (GCS) score, and assessments of pupillary size and reactivity, gross motor function, and sensation (table 2). Also note any lateralizing signs and the level of sensation if a spinal cord injury is present. Acute neurologic injury, including imaging recommendations and medical and surgical management, is discussed in detail separately. (See "Management of acute severe traumatic brain injury" and "Acute traumatic spinal cord injury".)

The GCS score is widely used and can be employed by clinicians to follow the patient's neurologic status. Unfortunately, a number of studies suggest that the initial GCS score is not predictive of outcome in patients with severe brain injury, and both intubation and sedatives interfere with its application [57-59].

Maintain spinal precautions for all patients with the potential for spinal cord injury. The presence of a motor deficit or a spinal cord sensory level indicates the need for imaging of the brain and spinal cord.

Exposure and environmental control — Be certain that the trauma patient is completely undressed and that his or her entire body is examined for signs of injury during the primary survey. Missed injuries pose a grave threat [60]. Regions often neglected include the scalp, axillary folds, perineum, and in obese patients, abdominal folds. Penetrating wounds may be present anywhere. While maintaining cervical spine precautions, examine the patient's back; do not neglect examination of the gluteal fold and posterior scalp.

Hypothermia should be prevented if possible and treated immediately once identified. Hypothermia contributes to both coagulopathy [61] and the development of multiple organ dysfunction syndrome [62]. During winter months and whenever a hypothermic trauma patient is being treated, the resuscitation room should be heated; the United States Military Joint Theater Trauma System Clinical Practice Guideline on hypothermia prevention recommends emergency department (ED) and operating room (OR) temperatures of at least 29.4°C (85°F) during the treatment of these patients [63]. Make liberal use of warm blankets and active external warming devices. Warm IV fluids and blood. Treatments for hypothermia are discussed separately. (See "Accidental hypothermia in adults".)

Diagnostic studies

Portable x-rays — Plain radiographs play an important role in the primary evaluation of the unstable trauma patient. Screening x-rays should be obtained, either in the emergency department (ED) or the operating room (OR), even in hemodynamically compromised patients who are sent directly to the OR during or after their primary survey. Prompt imaging of the lateral cervical spine, chest, and pelvis can detect life threatening injuries that might otherwise be missed. However, the sensitivity of the lateral cervical spine radiograph is only 70 to 80 percent [64-66], and some sacral and iliac fractures can be missed on plain pelvic radiographs.

Patients found to be hemodynamically unstable during the primary survey should be aggressively resuscitated; the decision of whether to take an unstable patients directly to the OR or to the OR after emergent CT imaging depends upon their response to resuscitation, probable injuries, and the proximity of the computed tomography (CT) scanner to the resuscitation bay.

Clinical decision rules (eg, NEXUS) can be used to determine the need for cervical spine imaging in hemodynamically stable trauma patients. Assessment of the spinal column injuries in trauma, including the selection of imaging studies, is discussed separately. (See "Evaluation and acute management of cervical spinal column injuries in adults".)

Plain radiography of the chest and pelvis is often obtained for trauma patients not thought to require CT imaging. The decision to obtain these images should be made based upon the injury mechanism and clinical findings. The evaluation of patients with penetrating trauma often includes images of the region of penetration; even in stable patients, these radiographs can detect retained foreign bodies or fragments. On the other hand, patients with blunt trauma should undergo imaging with plain radiographs only if clinical findings suggest the presence of injury [67,68]. Plain radiographs can be omitted altogether if there is no clinical suspicion of injury and the studies are unlikely to alter emergent management. (See "Pelvic trauma: Initial evaluation and management", section on 'Plain radiograph'.)

A plain radiograph of the chest should be obtained in patients with penetrating injuries of the chest, back, or abdomen regardless of the need for CT. Plain films may reveal subdiaphragmatic free air, a foreign body, or a pneumothorax or hemothorax.

If the clinician determines that CT imaging is needed based upon the mechanism or clinical suspicion, there is no role for either a plain radiograph of the chest or pelvis in hemodynamically stable patients with blunt trauma [67,69-71].

Ultrasound (FAST exam) — Focused Abdominal Sonography for Trauma (FAST) is an essential part of the primary circulation survey for unstable patients, in whom it often determines management [72-76]. FAST is used primarily to detect pericardial and intraperitoneal blood, and it is more accurate than any physical examination finding for detecting intra-abdominal injury. In hemodynamically stable patients, FAST can be delayed until the secondary survey and is ideally performed by a second operator while the remainder of the secondary survey is completed. The performance of the FAST examination and evidence supporting its use are discussed separately. (See "Emergency ultrasound in adults with abdominal and thoracic trauma".)

The accuracy and role of FAST may be more limited in patients with significant pelvic fractures because it is less sensitive for detecting pelvic bleeding and cannot differentiate between blood and urine. The management of such patients is discussed separately. (See "Pelvic trauma: Initial evaluation and management", section on 'Initial management'.)

The Extended FAST (E-FAST) includes examinations of the thoracic cavity looking for pneumothoraces. Preliminary studies suggest the sensitivity of E-FAST is better than plain x-ray for this injury [77].

Diagnostic peritoneal tap or lavage — Diagnostic peritoneal tap or lavage has a role similar to FAST in the unstable patient in whom a source of bleeding has not been found [78]. It can be performed to detect intraperitoneal blood when FAST is unavailable, to determine the type of intraperitoneal fluid when it is important to do so (eg, blood versus urine in the setting of a pelvic fracture), or at physician discretion. (See "Initial evaluation and management of blunt abdominal trauma in adults", section on 'Diagnostic peritoneal lavage'.)

Electrocardiogram — An electrocardiogram (ECG) should be obtained for all patients injured by mechanisms with the potential for causing cardiac injury. Signs of blunt cardiac injury can include arrhythmias, significant conduction delays, or ST segment changes. Findings consistent with pericardial tamponade include tachycardia, low voltage, and electrical alternans. If ECG findings consistent with cardiac injury are present, formal echocardiography (in addition to the FAST examination) should be performed. (See "Cardiac injury from blunt trauma" and "Cardiac tamponade".)

Laboratory tests — The practice of obtaining "screening" laboratory tests on trauma patients is neither useful nor cost-effective [79,80]. Testing should be performed based upon clinical suspicion and should be limited to those tests that may alter management. As examples, a pregnancy test (eg, urine hCG) should always be performed on women of child-bearing age, and a blood type and screen or crossmatch should be obtained for patients with significant trauma who may reasonably be expected to require transfusion.

Clinical circumstances determine the need for further testing. As examples, patients taking warfarin likely need coagulation studies (eg, prothrombin time) and patients found on the ground for an undetermined time need studies (eg, creatine kinase) to determine if rhabdomyolysis is present. (See "Clinical features and diagnosis of heme pigment-induced acute kidney injury (acute renal failure)".)

Commonly obtained but rarely helpful tests include the metabolic panel (a fingerstick blood sugar will often suffice provided the patient is not exhibiting signs of electrolyte abnormality or acidosis), alcohol level in a patient who is clearly intoxicated, toxicologic screen when it is not relevant to clinical care, and cardiac biomarkers, unless cardiac contusion or ischemia is suspected [81]. (See "Cardiac injury from blunt trauma", section on 'Diagnostic tests'.)

Elevation of both the serum lactate concentration and base deficit correlates with increased mortality in trauma patients [82-84]. However, the base deficit is essentially a surrogate for lactate and an elevated base deficit in the absence of an elevated lactate is **not** predictive of increased mortality [85]. Furthermore, while elevated levels should heighten suspicion for severe injury, a normal lactate and base deficit do not ensure the absence of significant injury, especially in geriatric trauma patients [53]. In addition, laboratory values lag behind clinical improvement after aggressive resuscitation. Thus, the patient may no longer be in shock despite an elevated lactate suggesting otherwise [86,87].

The white blood cell (WBC) count is nonspecific and of little value during the initial evaluation of the trauma patient [80]. The positive and negative predictive value of, respectively, an elevated or normal WBC is poor. Epinephrine release from trauma can cause demargination and may elevate the WBC to 12,000 to 20,000/mm^3 with a moderate left shift. Solid or hollow viscus injury can cause comparable elevations [88].

PATIENT TRANSFER — Clinicians at smaller hospitals should consult the nearest trauma center as soon as it becomes apparent that a patient has sustained injuries beyond the management capacity of their hospital. Patients should be stabilized as well as possible without delaying transfer; delays are associated with increased mortality [89,90]. Criteria for transfer are based upon the patient's demographics, mechanism of injury, and clinical findings. It cannot be overemphasized that a complete workup is **not** a requirement for transfer; postponing transfer to obtain laboratory results or imaging studies only delays definitive treatment. Often such studies must be repeated at the receiving facility.

Computed tomography (CT) imaging should only be obtained in patients who might otherwise be appropriately treated at the initial facility. If a negative CT would allow the patient to be discharged, it should be performed, but if that patient requires transfer regardless of the results then transfer should not be delayed. Likewise, procedures and other interventions should only be performed to treat emergent conditions or prevent possible patient deterioration during transport. Endotracheal intubation, tube thoracostomy, and pelvis fracture stabilization are common examples of necessary interventions; laceration repair, unless it is performed to prevent exsanguination, is not.

The decision of when to transfer an unstable patient should ideally be made by the transferring and receiving physicians in collaboration. Clear communication is critical: the transmission of vital information allows receiving clinicians to mobilize needed resources while the inadvertent omission of such information can delay definitive care. Information should be conveyed in both verbal and written (via the patient record) form and should include the patient's identifying information, relevant medical history, prehospital course, and ED evaluation and treatment (including procedures performed and imaging obtained) [23]. The use of a transfer checklist can help to ensure that important information is not omitted.

SECONDARY EVALUATION — Definitive management of a hemodynamically unstable trauma patient must not be delayed to perform a more detailed secondary evaluation. Such patients are taken directly to the operating room (OR) or angiography suite, or transferred to a major trauma center.

A careful, head-to-toe secondary assessment (ie, secondary survey) is performed in all trauma patients determined to be stable upon completion of the primary survey. The secondary survey includes a detailed history, a thorough but efficient physical examination, and targeted diagnostic studies, and plays a crucial role in avoiding missed injuries. Commonly missed injuries include [91-93]:

- Blunt abdominal trauma: Hollow viscus injury, pancreatoduodenal injuries, diaphragmatic rupture
- Penetrating abdominal trauma: Rectal and ureteral injuries
- Thoracic trauma: Aortic injuries, pericardial tamponade, esophageal perforation

- Extremity trauma: Fractures (especially in distal extremities), vascular disruption, compartment syndrome

Delayed reevaluation of the trauma patient (ie, tertiary survey) is also useful for preventing missed injuries and for detecting injuries that present late [91]. It is most helpful if the patient is reevaluated when fully alert. Any member of the trauma team with advanced assessment skills can perform the tertiary survey; however, it is best if the same clinician performs all serial examinations for a given patient in order to detect subtle changes.

History — The mechanism of injury can increase suspicion for certain injuries. Prehospital personnel often know important information and should be queried regarding the mechanism and history of the injury. If this cannot be done immediately upon arrival because of the patient's status, ask the prehospital providers to remain in the emergency department (ED) until this can be accomplished. Often the history is conveyed while medics and hospital clinicians transfer the patient and important information may be forgotten or missed.

While listening to the history, keep in mind that the scenes of accidents can be chaotic and not all information will be reliable. As an example, a patient described as "found down" may have been assaulted or struck by a car.

Mechanism-related information to be obtained from prehospital personnel includes [94]:

- Blunt trauma
  - Seat belt use
  - Steering wheel deformation
  - Airbag deployment
  - Direction of impact
  - Damage to the automobile (especially intrusion into the passenger compartment)
  - Distance ejected from the vehicle
  - Height of fall
  - Body part landed upon
- Penetrating trauma
  - Type of firearm
  - Distance from firearm
  - Number of gunshots heard
  - Type of blade
  - Length of blade

Inquire also about the patient's medications, allergies, and medical and surgical history. If this information is unknown, it can be helpful to assign someone the task of contacting family members to obtain it. The use of anticoagulant and antiplatelet medications is steadily rising and increases the risk of internal bleeding in trauma patients, and therefore these agents should specifically be discussed [95-97].

As an example of the risks associated with anticoagulants, a retrospective study of 11,374 adult trauma patients reported that the use of antiplatelet drugs was associated with an increased risk of death (propensity adjusted outcome 9.4 versus 8 percent mortality) and major morbidity among the 1327 (11.7 percent) patients taking them at the time of their injury [95]. Patients taking multiple antiplatelet medications were at greater risk than those taking a single drug.

Physical examination — The goal of the secondary survey is to identify injuries. This includes the performance of a thorough but efficient physical examination. Use standard precautions against blood or fluid-borne infection.

Head and face — Inspect and palpate the entire bony structure of the head and face for tenderness, deformity (eg, step off), and bleeding. Scalp lacerations are easily missed visually but often found by palpation.

Note any signs suggesting basilar skull fracture (eg, hemotympanum). Retroauricular (Battle's sign) and periorbital ecchymosis (raccoon's eyes) are also indicative of basilar skull fracture but generally do not appear until at least 24 hours after an injury. Look for nasal septal hematomas. (See "Skull fractures in adults" and "Facial trauma in adults".)

Perform an ocular examination including an evaluation of pupillary size, shape, reactivity, and extraocular movement. Look for signs of globe rupture and intraocular hemorrhage. (See "Open globe injuries: Emergent evaluation and initial management" and "Orbital fractures" and "Retinal detachment" and "Traumatic hyphema: Clinical features and management".)

Patients with mild traumatic brain injury may not have external signs of trauma. However, a mechanism consistent with brain injury may warrant imaging with computed tomography (CT). (See "Concussion and mild traumatic brain injury".)

Neck — Assume that all patients with blunt trauma have sustained an injury to the cervical spine. This assumption can be disproved by appropriate application of clinical decision rules, such as NEXUS or the Canadian C-Spine Rule, or by radiologic evaluation using plain radiographs or CT. Assessment of the cervical spine following trauma is discussed separately. (See "Evaluation and acute management of cervical spinal column injuries in adults".)

Inspect and palpate the entire neck for signs of injury. The management of penetrating neck trauma is discussed separately. (See "Initial evaluation and management of penetrating neck injuries".)

Chest — Inspect and palpate the entire chest wall. Pay particular attention to the sternum and clavicles. Injuries at these sites are often missed, and fractures of these bones suggest the presence of further injury, including of intrathoracic structures. Careful auscultation can detect a previously missed small hemothorax, pneumothorax, or pericardial effusion not yet causing tamponade. (See "Initial evaluation and management of blunt thoracic trauma in adults".)

Abdomen — Perform and document a careful abdominal examination. Inspect the abdomen and flanks for lacerations, contusions (eg, seat belt sign), and ecchymosis; palpate for tenderness and rigidity. The presence of a seat belt sign, rebound tenderness, abdominal distension, or guarding all suggest intra-abdominal injury. Note that the absence of abdominal tenderness does **not** rule out such injury.

Keep in mind that the abdominal examination is often unreliable, particularly in the elderly and patients with distracting injuries or altered mental status, and can change dramatically over time. (See "Initial evaluation and management of blunt abdominal trauma in adults".)

Rectum and genitourinary — Inspect the perineum of all patients for signs of injury. (See "Straddle injuries".)

Traditionally, the digital rectal examination (DRE) was considered an essential part of the physical examination for all trauma patients. However, the sensitivity of the DRE for injuries of the spinal cord, pelvis, and bowel is poor, and false positive and negative results are common [94,98-100]. Thus, routine performance is unnecessary and generally unhelpful. The examination is warranted in cases where urethral injury or penetrating rectal injury is suspected. If the examination is performed, check for the presence of gross blood (sign of bowel injury), a high-riding prostate (sign of urethral injury), abnormal sphincter tone (sign of spinal cord injury), and bone fragments (sign of pelvic fracture). (See "Blunt genitourinary trauma" and "Penetrating trauma of the upper and lower genitourinary tract" and "Evaluation and acute management of cervical spinal column injuries in adults", section on 'Secondary survey' and "Pelvic trauma: Initial evaluation and management".)

Perform a vaginal examination on all patients at risk for vaginal injury (eg, those with lower abdominal pain, pelvic fracture, or perineal laceration) [23]. Take care to avoid injury from bone fragments if a pelvic fracture is known or suspected.

Musculoskeletal — Inspect and palpate the entire length of all four extremities looking for areas of tenderness, deformity, or decreased range of motion. Also assess and document the neurovascular status of each extremity. Manipulate all joints thought to be uninjured both passively and actively to verify their integrity; immobilize and obtain radiographs of any area with a suspected fracture.

Note all penetrating wounds, especially those overlying suspected fractures, suggesting an open injury. The treatment of open fractures includes irrigation and debridement, application of a clean dressing, and prophylactic antibiotics. Preliminary wound irrigation can be performed in the trauma bay, but definitive irrigation and debridement is performed in the operating room (OR). (See "Treatment and prevention of osteomyelitis following trauma".)

Post traumatic compartment syndrome is an important source of patient morbidity. Increasing pain, tense compartments, and pain with passive stretching of the muscles contained within the compartment should prompt immediate measurement of intracompartmental pressures. (See "Acute compartment syndrome of the extremities".)

Inspect and palpate the pelvis. Ecchymosis over the pelvis or tenderness along the pelvic ring warrants diagnostic imaging. Examination findings (eg, instability) or imaging studies consistent with pelvic ring disruption indicate the need for pelvic immobilization and emergent orthopedic evaluation. Repeat examinations to assess pelvic stability are unnecessary and likely to exacerbate bleeding. (See "Pelvic trauma: Initial evaluation and management".)

Neurologic — The trauma patient's neurologic status can change dramatically over time (eg, from the effects of an expanding subdural hematoma). Serial examinations should be performed and carefully documented. During the secondary survey, perform a detailed assessment of the sensorimotor function of the extremities and repeat an assessment of the patient's GCS score.

Skin — Examination of the skin may reveal lacerations, abrasions, ecchymosis, hematoma, or seroma formation. Look closely at areas where lesions may be missed, such as the scalp, axillary folds, perineum, and, particularly in obese patients, abdominal folds. Do not neglect examination of the back, gluteal fold, and posterior scalp. Penetrating wounds may be present anywhere. The management of skin wounds is discussed separately. (See "Clinical assessment of wounds" and "Basic principles of wound management".)

Additional imaging

Plain radiographs — Plain x-rays are used during the secondary survey primarily to evaluate the spine, pelvis, and extremities for fractures, dislocations, and foreign bodies.

Computed tomography — Multidetector computed tomography (MDCT) has become the modality of choice for imaging trauma patients because of its speed and accuracy. However, studies of comprehensive whole body CT scanning ("pan scan") for all patients with significant trauma are methodologically limited and have reached contradictory conclusions [101-108]. Pending further research, we do not advocate comprehensive CT scanning in patients without significant alterations in mental status and believe imaging studies should be performed selectively based upon clinical assessment and the mechanism of injury. While whole body CT scanning may improve outcomes following certain high-risk trauma, such as explosions, high speed motor vehicle collisions, and falls from great heights [76,109], we believe it should not be used indiscriminately given the short-term risk of contrast-related renal injury and the long-term risk of radiation-induced cancer, as well as the substantial costs [110]. (See "Pathogenesis, clinical features, and diagnosis of contrast-induced nephropathy" and "Radiation-related risks of imaging studies".)

Some authors advocate whole body CT for severely injured patients with alterations in mental status. In a retrospective database analysis of 5,208 patients in Japan with Glasgow Coma Score ranging from 3 to 12, decreased mortality was noted in patients who received whole body CT scans [111]. Although further study of the outcomes and cost effectiveness of whole body CT is needed, the approach may be beneficial in such patients, in whom examination findings are often limited or unclear.

It should be noted that CT has limited utility for evaluating the trajectory and effects of low velocity penetrating injury (eg, stab wounds) because of the lack of tissue disruption and gas dispersion (seen with high velocity injuries) [112], and because injuries to luminal structures are often difficult to detect [113]. Diagnostic laparoscopy may be useful in patients with penetrating injury and signs of peritoneal penetration despite negative CT imaging. The use of CT for specific injuries is discussed separately. (See "Management of acute severe traumatic brain injury" and "Acute traumatic spinal cord injury" and "Initial evaluation and management of blunt thoracic trauma in adults" and "Initial evaluation and management of blunt abdominal trauma in adults" and "Initial evaluation and management of abdominal stab wounds in adults" and "Initial evaluation and management of abdominal gunshot wounds in adults" and "Pelvic trauma: Initial evaluation and management".)

Most patients should be hemodynamically stable before CT imaging is performed, and resuscitation should be sufficient to minimize the risk of decompensation while the patient is in the CT scanner. If the patient is unstable, CT imaging should be deferred.

PITFALLS AND PEARLS — The systematic evaluation of the trauma patient outlined above is designed to help clinicians focus on life-threatening problems and minimize the risk of missed injuries. Nevertheless, one systematic review noted that up to 39 percent of trauma patients have injuries that are initially missed and up to 22 percent of these missed injuries are clinically significant (defined as injuries associated with increased mortality, requiring additional procedures or alterations in treatment, or resulting in significant pain, complications, or residual disability) [60].

Potential pitfalls in trauma management and ways to avoid them are discussed below:

Esophageal intubations — Between 0.5 and 6 percent of prehospital intubations are esophageal due to airway difficulty or displacement during transport. The position of all endotracheal tubes must be verified either by direct visualization or use of an end tidal CO2 detector. (See "Prehospital care of the adult trauma patient", section on 'Airway support'.)

Hemorrhagic shock — Approximately 30 percent of the circulating blood volume may be lost before the onset of hypotension [23]. A transient response to one or more fluid boluses means the patient likely has ongoing hemorrhage and is in a persistent state of shock. (See "Initial evaluation and management of shock in adult trauma".)

Cardiac tamponade — Assume that elevated jugular venous pressure (JVP) in a trauma patient is caused by pericardial tamponade. However, hypovolemic patients with tamponade may not have elevated JVP. Perform the FAST exam early in the circulation evaluation of the unstable patient and begin by looking at the heart. (See "Cardiac tamponade".)

Thoracoabdominal injury — Assume that any penetrating wound of the thorax or abdomen involves both compartments until proven otherwise.

Penetrating bowel injury — During the initial resuscitation, injuries caused by low velocity penetrating wounds are easily missed by both ultrasound, because there is too little intraperitoneal blood to be detected, and CT, because there is inadequate tissue destruction. High clinical suspicion warrants further evaluation by DPL or laparotomy, despite initially negative imaging studies. Alternatively, a trauma surgeon may opt to perform serial observations of patients with abdominal stab or gunshot wounds over a 12 to 24 hour period. (See "Initial evaluation and management of abdominal gunshot wounds in adults" and "Initial evaluation and management of abdominal stab wounds in adults".)

Open book pelvic fractures — The unstable pelvis should **not** be manipulated multiple times; additional manipulation exacerbates hemorrhage. Once suspected, open or unstable pelvic fractures should be stabilized using a pelvic binder, or a sheet if no binder is available. If the patient is hemodynamically stable, computed tomography (CT) imaging is obtained. The unstable patient requires either surgery or angiography. (See "Pelvic trauma: Initial evaluation and management".)

Ocular injuries — Periorbital swelling and ecchymosis does **not** preclude an ocular examination. Patients with such findings are at higher risk of ocular injury. (See "Open globe injuries: Emergent evaluation and initial management" and "Orbital fractures" and "Retinal detachment" and "Traumatic hyphema: Clinical features and management".)

Elder patients — Assume that older patients involved in trauma have sustained a significant injury, even if they appear well. The paradox of elder trauma patients is that their physiology and medical interventions can both mask and exacerbate the severity of injuries. Medications are but one example: beta blockers may mask the effects of shock by suppressing tachycardia, while warfarin increases the risk of severe hemorrhage. A table summarizing important considerations in the elder trauma patient is attached (table 3). (See "Geriatric trauma: Initial evaluation and management".)

Common cognitive errors — Several cognitive errors appear to be relatively common during the initial management of injured patients, particularly those who do not look sick initially. Among these are [30]:

- **Premature diagnosis** – The hemodynamic status of trauma patients is often dynamic and the results of their initial diagnostic studies preliminary. Avoid making premature assumptions about patients' injuries and stability.
- **Overreliance upon early negative results** – No study is perfect and initial studies may not reveal the full extent of a patient's injuries or indeed any injury. Reassess the patient.
- **Attributing abnormal findings to benign causes** – Trauma patients, particularly young healthy adults, may not immediately manifest signs of severe injury. When abnormal findings arise, assume they reflect injury.

Analgesia and sedation — Injured patients are in pain. Do not neglect to provide them with appropriate analgesia and sedation. Short-acting agents, such as fentanyl and midazolam, are generally preferred to avoid adverse hemodynamic effects.

SUMMARY AND RECOMMENDATIONS

- Trauma is a leading cause of mortality globally. All trauma patients require a systematic approach to management in order to maximize outcomes and reduce the risk of undiscovered injuries. Optimal care requires effective and efficient communication and teamwork among clinicians. Common breakdowns in team management are described in the text. (See 'Epidemiology' above and 'Trauma team' above.)
- Particular mechanisms predispose patients to specific injuries. Common blunt trauma mechanisms and their most frequently associated injuries are described in the accompanying table (table 1).
- The primary survey used in Advanced Trauma Life Support™ is organized according to the injuries that pose the most immediate threats to life. Problems are managed immediately in the order they are detected. The individual steps (including assessments of the airway, breathing, circulation, and neurologic injury) and important principles of the primary survey are described in the text. (See 'Primary evaluation and management' above.)
- Observational studies suggest that airway obstruction is a major cause of preventable death among trauma patients. Therefore, airway evaluation and management remain the critical first steps in the treatment of any severely injured patient. (See 'Airway' above and 'Breathing and ventilation' above.)
- Hemorrhage is the most common preventable cause of mortality in trauma. Most trauma patients with signs of

shock (eg, pale, cool, moist skin) are bleeding. Be alert for subtle signs of hemorrhagic shock, particularly in the elderly and young, healthy adults who may not present with obvious manifestations. Hypotension generally does not manifest until at least 30 percent of the patient's blood volume has been lost. (See 'Circulation' above.)

- Diagnostic testing plays an important role in trauma management. The appropriate use of studies is described in the text. (See 'Diagnostic studies' above.)
- Clinicians at smaller hospitals should consult the nearest trauma center as soon as it becomes apparent that a patient has sustained injuries beyond the management capacity of their hospital. It cannot be overemphasized that a complete workup is **not** a requirement for transfer. (See 'Patient transfer' above.)
- A secondary survey is performed in all trauma patients determined to be stable upon completion of the primary survey. The secondary survey includes a detailed history, a thorough but efficient physical examination, and targeted diagnostic studies, and plays a crucial role in avoiding missed injuries. The secondary survey is described in detail above. (See 'Secondary evaluation' above.)
- Up to 39 percent of trauma patients have injuries that are initially missed, and up to 22 percent of these are clinically significant. Common pitfalls and guidance for avoiding missed injuries are provided in the text. (See 'Pitfalls and pearls' above.)

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Topic 13854 Version 40.0

GRAPHICS

Blunt trauma mechanisms and associated injuries

Mechanism of injury	Additional considerations	Potential associated injuries
Motor vehicle collisions		
Head-on collision		Facial injuries Lower extremity injuries Aortic injuries
Rear-end collision		Hyperextension injuries of cervical spine Cervical spine fractures Central cord syndrome
Lateral (T-bone) collision		Thoracic injuries Abdominal injuries: spleen, liver Pelvic injuries Clavicle, humerus, rib fractures
Rollover	Greater chance of ejection Significant mechanism of injury	Crush injuries Compression fractures of spine
Ejected from vehicle	Likely unrestrained Significant mortality	Spinal injuries
Windshield damage	Likely unrestrained	Closed head injuries, coup and countercoup injuries Facial fractures Skull fractures Cervical spine fractures
Steering wheel damage	Likely unrestrained	Thoracic injuries ▪ Sternal and rib fractures, flail chest ▪ Cardiac contusion ▪ Aortic injuries ▪ Hemo/pneumothoraces

Dashboard involvement/damage		Pelvic and acetabular injuries Dislocated hip
Restraint/seat belt use		
Proper three-point restraint	Decreased morbidity	Sternal and rib fractures, pulmonary contusions
Lap belt only		Chance fractures, abdominal injuries, head and facial injuries/fractures
Shoulder belt only		Cervical spine injuries/fractures, "submarine" out of restraint devices (possible ejection)
Airbag deployment	Front-end collisions Less severe head/upper torso injuries Not effective for lateral impacts More severe injuries in children (improper front seat placement)	Upper extremity soft tissue injuries/fractures Lower extremity injuries/fractures
Pedestrian versus automobile		
Low speed (braking automobile)		Tibia and fibula fractures, knee injuries
High speed		Waddle's triad - tibia/fibula or femur fractures, truncal injuries, craniofacial injuries "Thrown" pedestrians at risk for multisystem injuries
Bicycle		
Automobile related		Closed head injuries "Handlebar" injuries ▪ Spleen/liver lacerations ▪ Additional intra-abdominal injuries ▪ Consider penetrating injuries
Nonautomobile related		Extremity injuries "Handlebar" injuries
Falls	LD_{50} 36 - 60 feet (11 - 18 meters)	

Vertical impact		Calcaneal and lower extremity fractures Pelvic fractures Closed head injuries Cervical spine fractures Renal and renal vascular injuries
Horizontal impact		Craniofacial fractures Hand and wrist fractures Abdominal and thoracic visceral injuries Aortic injuries

Gross E, Martel M. Multiple trauma. In: Rosen's Emergency Medicine: Concepts and Clinical Practice, 7th ed., Marx JA, Hockberger RS, Walls RM, et al. (Eds), Mosby Elsevier, Philadelphia 2010. Illustration used with the permission of Elsevier Inc.

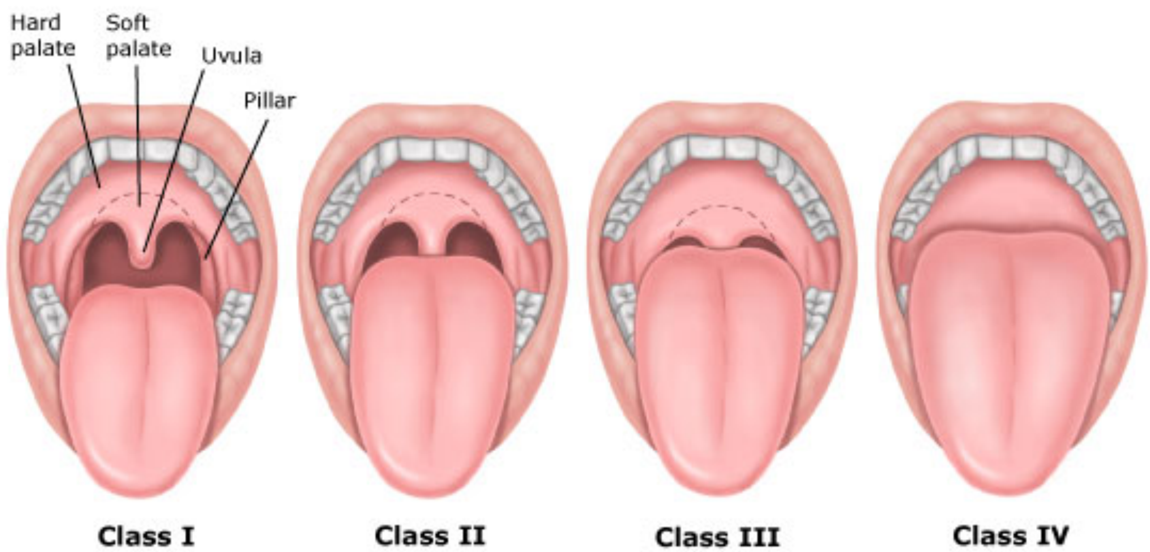
Graphic 50454 Version 4.0

The 3-3-2 rule for identifying a difficult airway

The spatial relationships depicted here are important determinants of successful direct laryngoscopy. A) The patient can open his/her mouth sufficiently to admit three of his/her own fingers. B) The distance between the mentum and the neck/mandible junction (near the hyoid bone) is the length of three of the patient's fingers. C) The space between the superior notch of the thyroid cartilage and the neck/mandible junction, near the hyoid bone, is the length of two of the patient's fingers.

Graphic 60507 Version 3.0

The modified Mallampati classification for difficult laryngoscopy and intubation



The modified Mallampati classification[1] is a simple scoring system that relates the amount of mouth opening to the size of the tongue, and provides an estimate of space available for oral intubation by direct laryngoscopy. According to the Mallampati scale, class one is present when the soft palate, uvula, and pillars are visible, class two when the soft palate and base of the uvula are visible, class three when only the soft palate is visible, and class four when only the hard palate is visible.

[1]Samsoon GL, Young JR. Difficult tracheal intubation: a retrospective study. Anaesthesia 1987; 42:487.

Graphic 75229 Version 3.0

Glasgow coma scale

	Score
Eye opening	
Spontaneous	4
Response to verbal command	3
Response to pain	2
No eye opening	1
Best verbal response	
Oriented	5
Confused	4
Inappropriate words	3
Incomprehensible sounds	2
No verbal response	1
Best motor response	
Obeys commands	6
Localizing response to pain	5
Withdrawal response to pain	4
Flexion to pain	3
Extension to pain	2
No motor response	1
Total	

The GCS is scored between 3 and 15, 3 being the worst, and 15 the best. It is composed of three parameters: best eye response (E), best verbal response (V), and best motor response (M). The components of the GCS should be recorded individually; for example, E2V3M4 results in a GCS score of 9. A score of 13 or higher correlates with mild brain injury; a score of 9 to 12 correlates with moderate injury; and a score of 8 or less represents severe brain injury.

Graphic 81854 Version 2.0

Potential pitfalls in the management of the elderly trauma patient

What the injured elderly would tell you (if they could)	Related physiology and rationale
"I can go from normotensive to hypotensive in a heartbeat."	Profound, life-threatening hypovolemia may occur in the setting of normal blood pressure. Physiologic reserve is minimal, and hemodynamic decompensation can occur quickly.
"I respond poorly to too much or too little fluid."	The therapeutic window for cardiac preload is narrow, and inadequate preload monitoring may lead to errors in volume resuscitation.
"My subdural hematoma hasn't expanded enough yet to really affect my level of consciousness."	Cortical atrophy, common in the elderly, may act to delay the clinical manifestations of serious intracranial hemorrhage. This hemorrhage may be clinically occult.
"Trauma is not really my major problem."	Stroke, myocardial infarction, and seizures may result from falls or motor vehicle crashes and delayed diagnosis of the principal underlying problem.
"I only look like I have adequate ventilatory reserve."	Ventilatory failure and respiratory arrest may occur suddenly in conjunction with chest or abdominal injuries despite a benign outward clinical appearance.
"I get demand ischemia if I have too much pain or my hematocrit drops below 29."	Myocardial (demand) ischemia may result from severe or prolonged pain or from transfusion thresholds that have not been appropriately liberalized in the setting of coronary artery disease.
"I can't stand even a little shock or hypoxia...and neither can my myocardium."	Even minor perturbations in perfusion, oxygenation, or vasoconstriction may lead to major cardiac complications.
"My connective tissue just ain't what it used to be..."	Decrease in connective tissue integrity with less "tamponade effect" for hemorrhage into soft tissues. Blood loss into soft tissue spaces, including subcutaneous loss, may be excessive and is often overlooked.
"The sensitivity of my abdominal examination is better than flipping a coin...but not much."	Clinical manifestations of serious abdominal injury in elderly patients are often minimal. Reliance on the abdominal examination often leads to missed abdominal injuries.
"My bones are brittle...my hip bone, my shin bone, and my aortic bone!"	BAI may occur in the elderly in the absence of conventional signs or symptoms. A low threshold for CT imaging should exist.
"A little medication goes a long way with me..."	Failure to adjust medication dosage, particularly sedative-hypnotics and analgesics, may result in serious complications.
"I just haven't been eating so	Chronic malnutrition is common and often undiagnosed.

well lately."	
"My injuries weren't accidental."	Elder abuse is common and often unreported and undiagnosed.
"Major trauma? Heck, I wouldn't even tolerate a brisk haircut..."	Underestimating and undermanaging comorbidities (eg, chronic obstructive pulmonary disease, coronary artery disease, smoking, ethyl alcohol [ETOH] consumption) may result in preventable morbidity/mortality.

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