

## Assessment and Initial Management in the Trauma Patient

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The initial assessment of a patient who comes to the emergency department after injury must be an overlapping series of evaluation steps. The goal is to identify all injuries in a stepwise fashion. These injuries must be identified in order of priority, starting with the injury most likely to directly threaten the life of the patient. The remaining injuries should then be identified, starting with potentially life-threatening injuries, followed by those that can cause long-term disability, and then to injuries of relatively minor significance. Immediately life-threatening injuries must, of course, be dealt with as they are identified.

Establishing a stepwise evaluation process is necessary to avoid missing the potentially important injuries. Injuries that are quite dramatic, such as a mangled lower extremity or facial trauma, may not pose the most immediate threat to life. The myriad of potential problems facing the resuscitation team precludes using a cookbook approach to trauma resuscitation. Clearly, the same resuscitation scheme will not suffice in all situations. There are, however, principles that should be used in all resuscitations.

It is also important to remember that trauma is an extremely dynamic process. A patient whose condition is initially hemodynamically stable may suddenly undergo decompensation. Conversely, a patient whose condition was thought to be unstable at the scene may stabilize en route

to the emergency department. Priorities must be adjusted as the evaluation process continues. If a seemingly stable condition suddenly becomes unstable, it is important to return to the first step in the evaluation algorithm to avoid missing an important new event.

In general, the evaluation process begins with the primary survey. This is a rapid evaluation that should identify all immediately life-threatening injuries. Although this involves several steps, a seasoned clinician should be able to perform the primary survey in less than 60 seconds. The primary survey is followed by the resuscitation phase. During resuscitation, an initial measure of hemodynamic stability should be performed. Patients in an unstable condition should undergo resuscitation, and a determination should be made as to whether the patient is responding. In addition, monitoring devices are placed during the resuscitation phase. After the resuscitation phase, the secondary survey is conducted. This is a head-to-toe physical examination that identifies all areas of potential injury. Hemodynamic stability should again be assessed. By the end of the secondary survey, all areas of defined or potential injury should have been determined. At this time, the attending physicians should construct a definitive plan that involves a series of diagnostic and therapeutic interventions that allow for a final diagnosis and therapy of all injuries.

These are obviously arbitrary classifications in what should be a dynamic process. For instance, if the resuscitation team consists of several physicians, the primary survey and initial resuscitation occur simultaneously. This is not possible in an emergency department where there is a single physician and one nurse. In addition, if a patient is in extremis, the evaluation algorithm must be

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truncated to control life-threatening injuries. The patient presents in a hemodynamically unstable condition may need to go directly to the operating room for control of life-threatening hemorrhage. In this patient, resuscitation and primary survey occur simultaneously in the operating room. A secondary survey is deferred, but it is important to remember to complete the evaluation process postoperatively to avoid missing a potentially disabling injury that was not obvious at the initial presentation.

### PRIMARY SURVEY

The primary survey involves the assessment of five components, which are abbreviated as A, B, C, D, and E.

#### Airway integrity

"A" stands for airway and designates the assessment of the integrity of the airway. The clinician must determine whether there is an anatomic and functionally patent airway. The chapter by Dr. Andrew Karlin in this issue of *Problems in Anesthesia* discusses methods of airway control, but some general comments are pertinent here. All patients with serious injuries should be examined for airway control. Any patient with a significant injury above the clavicle or who is unable to undergo a clinical assessment of the cervical spine should be presumed to have a cervical spine injury. If such a patient must have the airway controlled, it must be performed by means of in-line stabilization. Patients with obvious hemodynamic instability should also undergo early airway control. Peripheral oxygen delivery is compromised in these patients, and optimal oxygenation is important. Patients with traumatic brain injury should undergo airway control to avoid secondary brain injury that can occur from transient hypoxia (1). Finally, patients with multiple injuries, particularly bone injuries, should be carefully examined for early airway control. These patients often have significant pain. Clinicians are understandably reluctant to give high-dose narcotics without airway control. In addition, many of these patients will require early surgery

to stabilize their long bones and, therefore, will require airway control.

#### Breathing

"B" stands for breathing and refers to determining the adequacy of the mechanics of the chest wall. Functionally, this requires the clinician to identify the presence of any of the six immediately life-threatening conditions: airway obstruction, tension pneumothorax, massive hemothorax, flail chest, cardiac tamponade, and open pneumothorax. The potential for airway obstruction should be assessed in all patients. Foreign bodies must be removed.

An open pneumothorax is easily identified by the presence of a sucking chest wound. If this is associated with significant chest wall injury, operative stabilization and closure of the chest wall are required. This can be temporized by placing an occlusive dressing followed by tube thoracostomy. If a surgeon is not immediately available to place a chest tube, the occlusive dressing can be fastened on three sides only. This creates a flutter valve and allows the chest to decompress before a tension pneumothorax develops.

A flail chest is defined as two or more ribs broken in two or more places. Clinically, this is identified by paradoxical chest wall motion during inspiration. The flail segment moves independently. In the past, patients with a flail chest received airway control and positive pressure ventilation. More recently, however, physicians have realized that the chest wall instability is often of little physiologic importance. The underlying direct pulmonary contusion is usually responsible for the acute respiratory failure that often accompanies a flail chest (2). Therefore, the need for intubation can be individualized.

Tension pneumothorax, cardiac tamponade, and massive hemothorax are diagnoses that can often be made clinically (Table 1). It is important to remember, however, that these conditions often occur simultaneously and that relying on strict diagnostic criteria is often not possible. If a life-threatening condition is suspected clinically, it is prudent to simply assume that it exists and to decompress the chest or examine the patient for hemopericardium. A tension pneumothorax can be temporized by the insertion of a 14-

TABLE 1. Physical findings in thoracic trauma

	JVD	Resonance	Breath sounds	Tracheal position
Cardiac tamponade	Yes	Normal	Normal	Normal
Tension pneumothorax	Yes	Hyper	Decreased	Deviated away
Massive hemothorax	No	Hypo	Decreased	Normal

JVD, jugular venous distention

gauge needle in the second intercostal space of the midclavicular line.

### Circulation

The early detection of shock is the next highest priority and is termed "C" for circulation. Inadequate tissue perfusion is the underlying physiologic aberration (3). This is almost always caused by hypovolemia from blood loss or by fluid sequestration around areas of bony and soft tissue injury. Because of the body's inability to store oxygen, an oxygen debt can rapidly occur (4). The Advanced Trauma Life Support (5) course characterizes the various stages of shock, providing clinical correlates to the degree of loss of circulating blood volume (Table 2). Unfortunately, these findings are relatively nonspecific and occur late in the treatment process.

Response to blood loss is the function of several variables such as underlying compensatory mechanisms, the rapidity and magnitude of blood loss, and prehospital time and resuscitation. Vasoconstriction is one of the early mechanisms to compensate for blood loss and may maintain blood pressure at a normal level for a

long period of time (6). In young trauma patients with extremely compliant blood vessels, it has been estimated that a blood volume loss of 60% is necessary before hypotension suddenly occurs (7). Illicit drugs, such as cocaine, may also serve to mask hypovolemia after injury (8). Alcohol has been shown to be a significant myocardial depressant and may produce hypotension relatively early after injury (9).

It is not necessary to manually measure blood pressure to approximate perfusion. Assessment of the adequacy of peripheral pulses allows the clinician some degree of knowledge about the patient's blood pressure. A patient with a palpable radial pulse should have a blood pressure above 80 mmHg. If the patient has a palpable femoral but not radial pulse, the blood pressure is generally between 60 and 80 mmHg. A patient who has only palpable carotid pulses often has a blood pressure between 40 and 60 mmHg.

Blood pressure, pulse, and urine output often underestimate the degree of physiologic derangement (10). Tissue oxygen extraction, as measured by central or mixed venous oxygen saturation, has been shown to be the most sensitive measure of blood loss (11,12). This measure, however, re-

TABLE 2. Estimated fluid and blood requirements\*

	Class I	Class II	Class III	Class IV
Blood loss (mL)	Up to 750	750-1500	1500-2000	2000 or more
Blood loss (% BV)	Up to 15%	15%-30%	30%-40%	40% or more
Pulse rate	<100	>100	>120	140 or higher
Blood pressure	Normal	Normal	Decreased	Decreased
Pulse pressure (mmHg)	Normal or increased	Decreased	Decreased	Decreased
Respiratory rate (breaths/min)	14-20	20-30	30-40	>35
Urine output (mL/hr)	30 or more	20-30	5-15	Negligible
Mental status	Slightly anxious	Mildly anxious	Anxious and confused	Confused; lethargic
Fluid replacement (3:1 Rule)	Crystalloid	Crystalloid	Crystalloid + blood	Crystalloid + blood

\*Amounts are based on the patient's initial presentation. BV, blood volume. Modified from ACS Committee on Trauma (5), with permission of the publisher.

quires the insertion of invasive monitoring devices and may not always be appropriate. A good estimate of the depth of shock can be obtained by measuring arterial blood gas and examining the base deficit (13). This can be extremely useful, particularly in time-critical situations.

In patients who present with significant hemodynamic instability, it is important to rapidly identify the source of blood loss. In addition to external blood loss, there are four body cavities into which a patient can lose blood: the thorax, the abdomen, the retroperitoneum, and muscle compartments. It is important to remember that the cranium is a fairly small space and that acute neurologic symptoms may develop with a very small volume of blood loss. Bleeding into muscle compartments should be readily obvious on physical examination. External blood loss is best estimated by people present at the scene of the injury, but it is important to remember that these estimates may be grossly inaccurate. Ongoing external blood loss should be controlled with direct pressure.

This leaves the thorax, abdomen, and retroperitoneum as sources of blood loss in the patient with hemodynamic instability. A chest radiograph and a physical examination are sufficient to determine the presence of intrathoracic bleeding, whereas a physical examination and a pelvic radiograph should identify patients at risk for retroperitoneal hemorrhage. The abdomen is best evaluated with a focused ultrasound examination or diagnostic peritoneal lavage in cases requiring a rapid determination (14,15).

### Disability

"D" stands for disability, or a brief neurologic assessment to identify patients at high risk for traumatic brain injury or spinal cord injury. The best assessment of cerebral function is gained by a rapid calculation of the Glasgow Coma Score (Table 3). Patients with a Glasgow Coma Score under 8 should be presumed to have severe traumatic brain injury. Neurologic assessment should assume a high priority. The initial evaluation of spinal cord function is most rapidly determined by asking the patient to wiggle the toes. If the patient is able to accomplish this task, he or she is not likely to have a complete spinal cord lesion.

TABLE 3. *Glasgow Coma Scale*

Eye opening	
Spontaneous	4
To voice	3
To pain	2
None	1
Verbal response	
Oriented	5
Confused	4
Inappropriate words	3
Incomprehensible sounds	2
None	1
Motor response	
Obeys commands	6
Localizes to pain	5
Withdrawal to pain	4
Abnormal flexion	3
Abnormal extension	2
None	1

### Exposure

"E" stands for complete exposure of the patient, care being taken to observe environmental precautions. Complete exposure is necessary to assess the possibility of all injuries. Without this, it is easy to miss a subtle injury that may cause significant problems later. Despite the need for complete exposure, it is important to avoid hypothermia. In a completely disrobed patient in a 20°C resuscitation room, hypothermia may quickly develop and cause significant physiologic problems. Perhaps most importantly, the vasoconstriction that accompanies hypothermia maintains relative normotension in a hypovolemic patient. This is of particular concern because hypothermia also lowers cardiac output. In addition, the tubular insufficiency that accompanies hypothermia produces a "cold diuresis" (16). Therefore, an acutely hypovolemic patient remains normotensive and polyuric, which may mask significant volume deficits.

### RESUSCITATION

The resuscitation phase is the first formal assessment of the degree of the depth of shock, when the first true physiologic data are collected. Monitoring devices, such as those for continuous electrocardiogram monitoring, pulse oximetry, and capnography, should be placed at this time. Intravenous access should be obtained and vol-

ume loading begun. The amounts and types of resuscitation fluids to be used are dealt with elsewhere in this issue in the chapter by Dr. Donald Prough. In general, ideal intravenous access involves placing large-bore peripheral intravenous lines. In a patient with shock, however, this is often not possible. In the past, peripheral cutdowns were recommended if peripheral access was not available. Central access was avoided because of the perception that the complication rate would be excessive. More recent data, however, suggest that when the clinician is experienced, emergent central line placement for trauma resuscitation can be accomplished quickly and with a complication rate of less than 1% (17).

During the resuscitation phase, blood pressure should be determined formally. In addition, a decision should be made about the necessity and advisability of placing a Foley catheter and a nasogastric tube. In patients with significant midface fractures, nasogastric tubes should be avoided because the patients may have cribriform plate fractures. An attempt to place a nasogastric tube may cause disruption of the cribriform plate, and the nasogastric tube may be inadvertently placed intracranially. Foley catheter placement should be avoided in patients with urethral injuries because the catheter may be placed inadvertently into the retroperitoneum and not the bladder. This problem occurs most commonly in male patients with pelvic fractures. Physical findings such as blood at the urethral meatus, a scrotal hematoma, or a high-riding prostate on rectal examination should prompt investigation with a retrograde urethrogram before a Foley catheter is placed.

### SECONDARY SURVEY

The secondary survey is a head-to-toe physical examination of the patient to identify injuries that have been occult. It is important to take a careful history and emphasize physical examination in all areas where the patient has symptoms. The face must be carefully palpated to elicit tenderness that is suggestive of facial fractures. Pupils should be examined and extraocular motion tested. The tympanic membranes must be visualized, and the possibility of a cerebrospinal fluid leak from the ear or nose must be explored.

The area of the mastoid processes must also be examined. Battle's sign (ecchymosis over the mastoid area) is strongly suggestive of a basilar skull fracture.

The cervical spine should be examined to determine any area of tenderness. The neck should be palpated for subcutaneous air. The chest wall should then be examined for the presence of subcutaneous air or tenderness. The chest and abdomen should undergo inspection, auscultation, and palpation. Pelvic stability and tenderness should be gently determined. The patient should be carefully log-rolled and the thoracic and lumbar spine palpated for tenderness or step-off. A rectal examination should also be performed. The extremities should each be individually examined for tenderness, deformity, ligamentous stability, and the presence or absence of peripheral pulses.

During the secondary survey, another assessment of hemodynamic stability should be made. Patients whose conditions were unstable should now undergo stabilization, or urgent investigation must be undertaken to determine the site of bleeding. If a patient whose condition was initially stable has undergone decompensation, a directed search for bleeding, as identified previously, should immediately be undertaken. If a patient's condition was stable initially and has remained stable, a diagnostic and therapeutic plan should be made to identify and treat all injuries.

### DEFINITIVE CARE

Once the clinician has identified all areas of potential injury, plans should be made for further diagnostics. This almost always involves the use of radiographs. In general, the first three radiographs obtained are of the cervical spine (lateral view), the chest, and the pelvis. These are taken to identify areas of potentially life-threatening injury. For example, a lateral view of the cervical spine that shows a fracture or misalignment is important in planning further care. The cervical spine must be kept absolutely neutral to avoid further long-term neurologic disability. The chest radiograph will identify smaller pneumothoraces or hemothoraces and rib fractures. An indistinct mediastinum means that the possi-

bility of traumatic aortic injury must be considered and further diagnostics planned (18). A pelvic fracture seen on a plain radiograph is a marker for other, more serious injuries, because the force required to fracture the bony pelvis is substantial. In addition, a pelvic fracture raises concern about the possibility of retroperitoneal bleeding.

Patients whose mechanism of injury suggests spinal injury, such as a significant fall from a height, or who have back pain or tenderness on physical examination, should undergo complete imaging of the thoracic and lumbar spine. Patients must be log-rolled only until the spine can be determined to be free of injury clinically or radiographically. Areas of pain or tenderness in all extremities should be imaged at this time as well.

Decisions regarding further diagnostics must also be made at this time. Computed tomography scanning of the head is generally undertaken for a patient with significant loss of consciousness or one whose physical findings are consistent with neurologic injury. A patient with a significant headache or a Glasgow Coma Score under 15 should probably be considered for computed tomography scanning, even if there has not been a loss of consciousness. Although the yield of computed tomography scanning in these patients is relatively low, it is by no means zero (19). Relatively subtle traumatic brain injury can become symptomatic hours or days later, producing disastrous consequences.

All patients with a mechanism of injury consistent with the possibility of abdominal injury must be examined. Physical examination can be unreliable for identifying hemoperitoneum, especially if the patient is unreliable or has a neurologic injury (20). In addition, hollow viscous injuries may be initially asymptomatic. Therefore, patients with a significant mechanism of injury mandate investigation. Many techniques exist to aid in the investigation. Diagnostic peritoneal lavage and focused assessment with sonography for trauma allow rapid determination of the presence of hemoperitoneum. Both examinations, however, are tremendously nonspecific and do not reliably identify patients who require laparotomy. Abdominal computed tomography scanning, although more cumbersome, does allow for

investigation of the retroperitoneum and provides organ-specific diagnosis.

### SPECIAL CONSIDERATIONS

Pediatric and geriatric patients warrant special considerations in the assessment and management of trauma. Although the general priorities for these patients remain the same as for other patients, some special mention is appropriate.

In children, the larynx is located more anteriorly and cephalad than in adults, making airway control more difficult. In pediatric patients, the combination of placing the airway in the sniffing position and a jaw-thrust maneuver allows optimal airway positioning. Bag-mask ventilation is almost always successful in children, but normal vital signs, including respiratory rate, vary from those of adults (Table 4) (5). As a result, it is important to keep these facts in mind when ventilating a pediatric patient or assessing the patient's degree of hemodynamic stability.

In addition, clinical assessment is more difficult in children than in adults. Children are often anxious and upset after injury and are unwilling to provide a medical history. Children who cannot talk are obviously unable to provide a real history. Neurologic assessment using a modified Glasgow Coma Score can be useful, but this may not be possible in children who cannot or will not cooperate.

Until recently, trauma most commonly occurred in younger people. As lifespans increase, however, geriatric trauma has become much more common. Many elderly people have significant chronic diseases, such as coronary artery disease, hypertension, and diabetes, that limit their ability to meet the stress of injury. Common medications such as  $\beta$ -blockers, calcium channel blockers, and diuretics are often used to treat chronic diseases and may further limit the patient's ability to respond to injury.

Several factors affect the outcome after geriatric trauma. Milzman and colleagues (21) showed that the number of preexisting medical problems affects outcome and that outcome is inversely proportional to the number of preexisting diseases in a trauma patient. In addition, injury anatomy affects outcome. Elderly patients

TABLE 4. Normal pediatric vital signs

Age group	Weight (kg)	Heart rate (beats/min)	Blood pressure (mmHg)	Respiratory rate (breaths/min)	Urinary output (mL · kg <sup>-1</sup> · hr <sup>-1</sup> )
Birth to 6 months	3-6	180-160	60-80	60	2
Infant	12	160	80	40	1.5
Preschool	16	120	90	30	1
Adolescent	35	100	100	20	0.5

From Advanced Trauma Life Support Course (5), with permission of the publisher.

with significant traumatic brain injury or multiple fractures are much more likely to die than those with other injuries (22,23). Finally, a subgroup of elderly patients can be identified who have significant problems with cardiovascular performance despite seemingly normal vital signs (22,23). These high-risk patients (Table 5) have been statistically shown to have a significantly better survival when their initial evaluation process is truncated (23). In these patients, the initial evaluation should only identify immediately life-threatening injuries. Nonurgent studies should be delayed to allow for better assessment of cardiac performance. Most often, this involves the placement of a pulmonary artery catheter and resuscitation tailored to support cardiovascular performance.

Consideration should also be given to whether the patient would benefit from  $\beta$ -blockade. There are now good data showing that perioperative  $\beta$ -blockade in elderly patients reduces the incidence of acute cardiac insufficiency (24). Trauma and surgery are similar physiologic insults: blood loss and soft tissue injury are common to both. At present, there are no data to our knowledge that support the general use of  $\beta$ -blockade in elderly trauma patients. Therefore, care for these patients should be individualized.

### CONCLUSION

Trauma is a dynamic process, and injury can be initially occult. To avoid overlooking an injury,

TABLE 5. High-risk geriatric patients

Pedestrian struck by car
Traumatic brain injury
More than one long bone fracture
Initial systolic blood pressure <130 mmHg
Metabolic acidosis

it is important to establish a stepwise progression that identifies immediately life-threatening injury, assesses the degree of physiologic derangement, and allows for careful identification of other areas at risk. No single evaluation or resuscitation algorithm is correct for every patient, but the principles elucidated in this chapter constitute key components of an orderly evaluation process that must be interpreted and applied to each patient after injury.

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