CHAPTER 33

Multiple Trauma

Eric A. Gross | Marc L. Martel

PRINCIPLES

Emergency clinicians play a vital role in the stabilization, diagnosis, and treatment of trauma patients. The management of trauma patients involves complex, decisive, leadership ability and technical skill. For the multiply or severely injured patient, a team approach is necessary, capitalizing on a strong clinical partnership between emergency medicine and surgery. An effective trauma response also requires timely consultation, access to other trauma-related specialties, especially neurosurgery and orthopedic surgery, and coordination with anesthesiology to ensure prompt and safe transfer to the operating room.

Epidemiology

Motor vehicle collisions (MVCs) are the leading cause of trauma-related mortality in people aged 1 to 44 years.[1] Firearm deaths are a significant concern unique to the United States (see Chapter e2). In 2012, there were almost 33,000 deaths by firearms.[1] The economic cost of traumatic injuries and death is estimated in the hundreds of trillions of dollars, which includes medical costs and lost productivity.[2] Between 2000 and 2012, primarily because of increased seat belt use, the motor vehicle fatality rate declined almost by one-third, to fewer than 11 deaths/100,000 population.[3]

ANATOMY AND PHYSIOLOGY

In contrast to penetrating trauma from knife wounds, in which injuries can be expected to occur only along the track of the weapon, injuries inflicted by gunshot wounds depend on several factors. The amount of tissue damage is related to the kinetic energy of the bullet, which is a factor of the bullet weight (caliber) and velocity. Gunshot wounds cause trauma to the surrounding tissue by direct laceration, crush injury, shock waves, and cavitation—the displacement of tissue forward and radially. Because of these dynamic forces, high-velocity weapons, such as rifles, cause more widespread injuries than low-velocity weapons, such as handguns. Similar to knives, handgun bullets and shotgun pellets (from long range) generally cause injury based on direct laceration and crush generated by the missile along its track. Shotgun wounds from close range are characterized by massive tissue injury.

Injury patterns can differ significantly between adults and children subjected to similar mechanisms of trauma. Pediatric trauma is discussed in Chapter 165.[4-7]

Older patients commonly sustain extremity, craniofacial, and closed head injuries. Most of these occur as the result of a fall or MVC. Unintentional injury was the fourth leading cause of death in 2013.[1] Older trauma patients typically have comorbid illnesses, may be taking relevant medications (especially anticoagulants) and also have normal, age-related changes in organ system function. These factors can increase susceptibility to injury, morbidity, and mortality.

Pathophysiology

In blunt trauma victims, the mechanism of injury can be associated with particular injury patterns. These are listed in Table 33.1. Knowledge of these associations can help the provider evaluate for injuries that may not be readily identified on the initial examination.

CLINICAL FEATURES

Primary Survey

The primary survey should be performed in a standardized fashion immediately after the patient arrives in the emergency department (ED). The goal of the primary survey is to diagnose critical, life-threatening injuries rapidly and begin treatment at the time of diagnosis. Figs. 33.1, 33.2, and 33.3 show the recommended algorithms for the evaluation of airway, breathing, and circulation. Fig. 33.4 describes special considerations between blunt and penetrating mechanisms that should be considered during the primary survey.

Traumatic causes of a compromised airway, such as by a neck or maxillofacial injury, are typically easily recognized. In the absence of obvious direct trauma involving the airway, airway management decisions are based on the overall patient condition and anticipated clinical course (see Chapter 1).

Inadequate ventilation, which may lead to respiratory acidosis, can be noted by the rate and quality of respirations. Pulse oximetry will detect inadequate oxygenation, which may manifest clinically as agitation and restlessness. Assessment for injuries that may compromise oxygenation, ventilation, or both requires careful inspection and auscultation of the chest. Signs of such compromising injury include increased work of breathing, tachypnea, penetrating wounds, subcutaneous emphysema, chest wall instability, flail segments, tracheal deviation, and distended neck veins. See Fig. 33.2.

Assessment of hemodynamic and circulatory status (see Fig. 33.3) follows evaluation of the airway and ventilation. Clinical indicators of adequate perfusion include normal mental status, skin color and temperature, heart rate, blood pressure, and capillary refill. However, a normal finding for any single sign does not rule out significant hemorrhage or even shock. Mental status changes associated with hypoperfusion can include anxiety, agitation, and depressed consciousness. Cool pale skin or extremities

TABLE 33.1

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 Hemothorax, pneumothorax
Dashboard involvement or damage		Pelvic and acetabular injuries Dislocated hip
Restraint or seat belt use		
Proper three-point restraint • Lap belt only • Shoulder belt only	Decreased morbidity	Sternal and rib fractures, pulmonary contusions Chance fractures, abdominal injuries, head and facial injuries and fractures Cervical spine injuries and fractures, "submarine" out of restraint devices (possible ejection)
Air bag deployment	Front end collisions Less severe head and upper torso injuries Not effective for lateral impacts More severe injuries in children (improper front seat placement)	Upper extremity soft tissue injuries and fractures Lower extremity injuries and fractures
PEDESTRIAN VERSUS AUTOMOBILE		
Low speed (braking automobile)		Tibia and fibula fractures, knee injuries
High speed		Waddel's triad—tibia and fibula or femur fractures, truncal injuries, craniofacial injuries Thrown pedestrians at risk for multisystem injuries
Bicycle • Automobile-related		Closed head injuries Handlebar injuries • Spleen or liver lacerations • Additional intra-abdominal injuries • Consider penetrating injuries
• Non–automobile-related		Extremity injuries Handlebar injuries

TABLE 33.1

Blunt Trauma Mechanisms and Associated Injuries—cont'd

MECHANISM OF INJURY	ADDITIONAL CONSIDERATIONS	POTENTIAL ASSOCIATED INJURIES
FALLS	LD_{50}, 36–60 ft	
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

LD_{50}, Height of fall that would be fatal for 50% of those falling.

with delayed capillary refill suggest inadequate perfusion and shock. A normal heart rate, blood pressure, or both can be present, despite significant hemorrhage. Conversely, tachycardia may be seen without significant volume loss.

Traditionally, direct pressure to external bleeding sites has been advocated, and the use of tourniquets has been discouraged. The use of direct pressure on the bleeding site remains first-line therapy, but there is good evidence to support the early use of tourniquets for massive extremity hemorrhage that is not otherwise easily controlled.[8-10] Similarly, studies of newer hemostatic agents have shown potential application in combat and out-of-hospital settings.[11,12]

Early intravenous (IV) access is required in the assessment of circulation. We recommend two large-bore (14- or 16-gauge) IV catheters. Routine IV access may be difficult or unobtainable in certain cases. Intraosseous vascular access can be obtained rapidly in pediatric and adult patients and allows the safe infusion of large amounts of fluid or blood products. Compact, battery-operated intraosseous drills are commonly available, and their use has been well established. Ultrasound-guided peripheral venous access by nurses and emergency clinicians should be considered in patients when blind peripheral attempts are unsuccessful. Central venous access may also be indicated in the appropriate clinical scenario or based on the emergency clinician's discretion. The use of ultrasound (US) has been shown to increase successful vein cannulation and decrease complications in the placement of central venous lines in pediatric patients and adults.[13-15] Central venous pressure measurements may be used to direct resuscitative efforts, but should not delay definitive care. Real-time US of the vena cava can be performed much more quickly by assessing its size and the degree of respiratory variation to determine adequacy of resuscitation.[16] We recommend that an extended, focused, abdominal sonography in trauma (eFAST) examination be performed on all patients at the transition point from the primary to secondary survey.

Secondary Survey

The goals of the secondary survey are to obtain pertinent historical data about the patient and injury and identify and manage all significant injuries by performing a systematic, complete examination. An AMPLE (***a***llergies, ***m***edications, ***p***ast medical history, ***l***ast meal, ***e***nvironments and events) history should be obtained. Trauma is a dynamic process, requiring frequent reassessment of the the patient's level of consciousness, airway, circulatory, and pain status throughout the ED phase of management. If deterioration occurs, a complete reevaluation of the primary survey should be initiated. Features of the secondary survey, with critical and emergent diagnoses, are listed in Table 33.2. Concurrently with the primary and secondary survey, oxygenation is enhanced as necessary, appropriate IV access is established, and volume resuscitation (as needed) commences. On completion of the secondary survey, laboratory and more extensive radiographic evaluations commence.

DIFFERENTIAL DIAGNOSES

The differential diagnosis of injuries to the airway or chest that might compromise the airway or breathing is finite. In contrast, circulation problems have a variety of potential causes. Figs. 33.2 and 33.3 outline the approach to emergent diagnoses in the critically ill trauma patient. The early assessment of a trauma patient's circulatory status is crucial and includes hemorrhage control. An algorithmic approach is designed to localize the cause, as well as direct intervention. In penetrating trauma, the bleeding site(s) and therefore the differential diagnosis of circulatory problems is relatively limited as compared to the patient who has sustained significant blunt trauma. In victims of blunt trauma, the goal of management often focuses on localizing the injury: (1) to obvious external hemorrhage; (2) to long bone fractures; (3) to pelvic fractures; or (4) to internal hemorrhage.

The goal of the initial assessment in the ED is to determine whether the patient is in shock. If so, the decision making process turns to an assessment of volume status. If the patient is hypovolemic, immediate resuscitation is initiated. Hemorrhagic shock prompts the emergency clinician to locate the source immediately and target interventions, with ongoing reassessment.

Although mechanisms of injury alone cannot be relied on to predict all injuries caused by blunt major trauma,[7] common patterns of injuries can be anticipated and specifically assessed in ED patients (see Table 33.1). Although these injuries may be present, there is frequently significant overlap between mechanism and injury. In this section, the differential diagnoses of various presentations are discussed.

Victims of trauma often present with altered mental status. Although acute neurologic injuries are the primary consideration, a variety of nontraumatic entities may also affect the patient's presentation or be present in isolation. These include acute intoxication with drugs or alcohol, preexisting medical conditions (eg, hypoglycemia, hyponatremia) and behavioral and mental health conditions. A breath alcohol test or serum alcohol level is indicated for the trauma patient with altered mental status, although waiting for the results should not delay emergent head

Text continued on p. 295

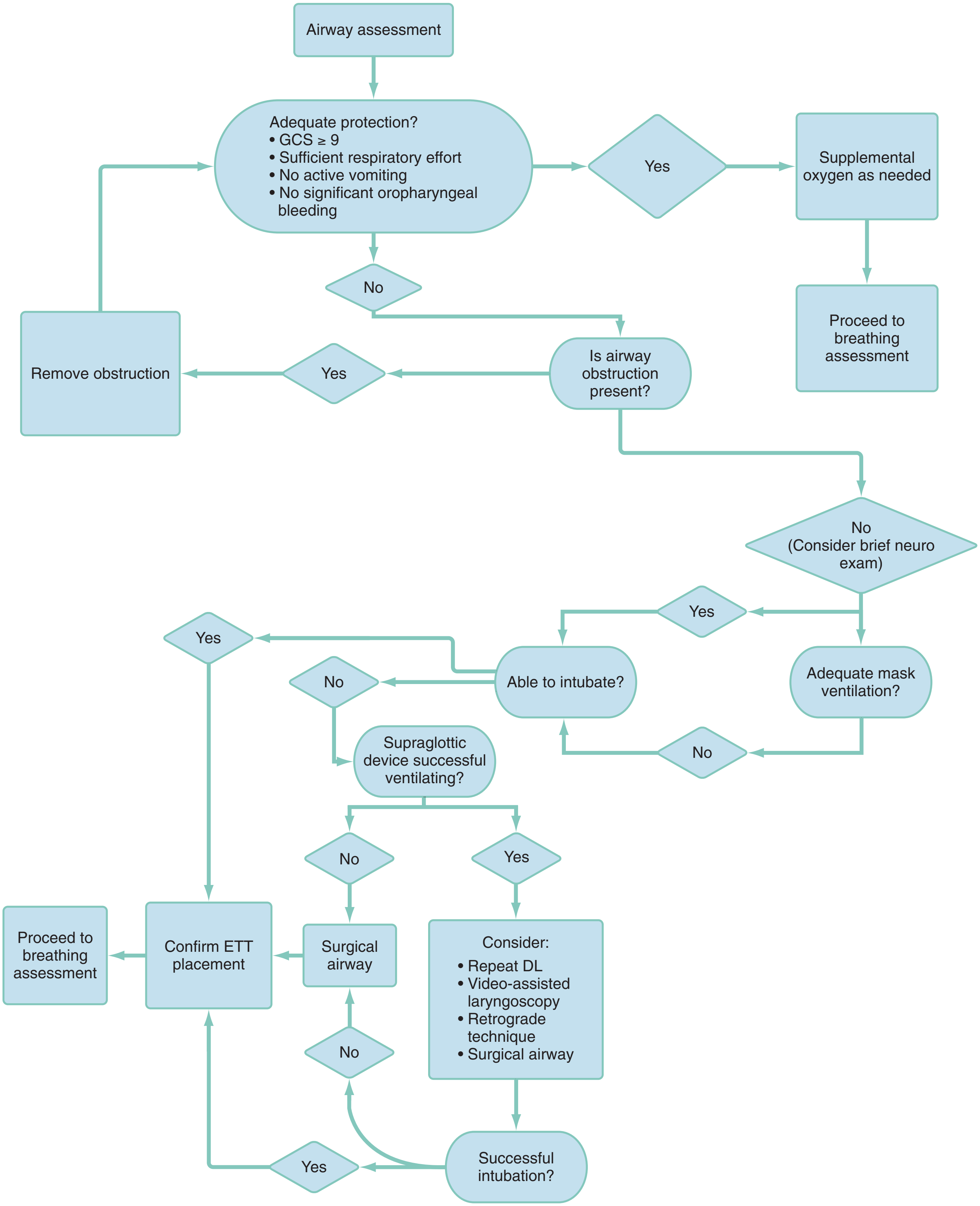

Fig. 33.1. Airway assessment algorithm. *DL,* Direct laryngoscopy; *ETT,* Endotracheal tube; *neuro,* neurologic.

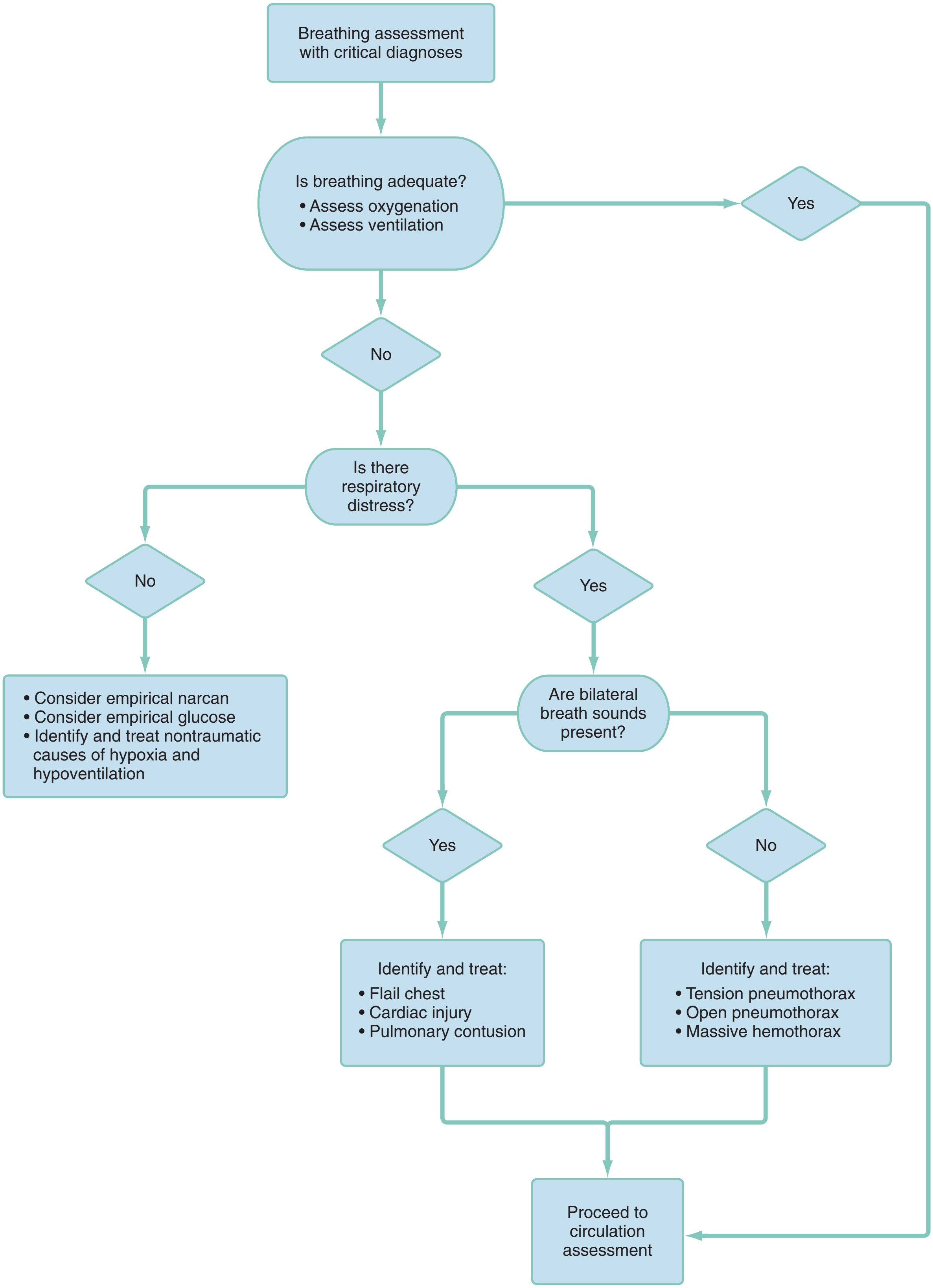

Fig. 33.2. Breathing assessment algorithm.

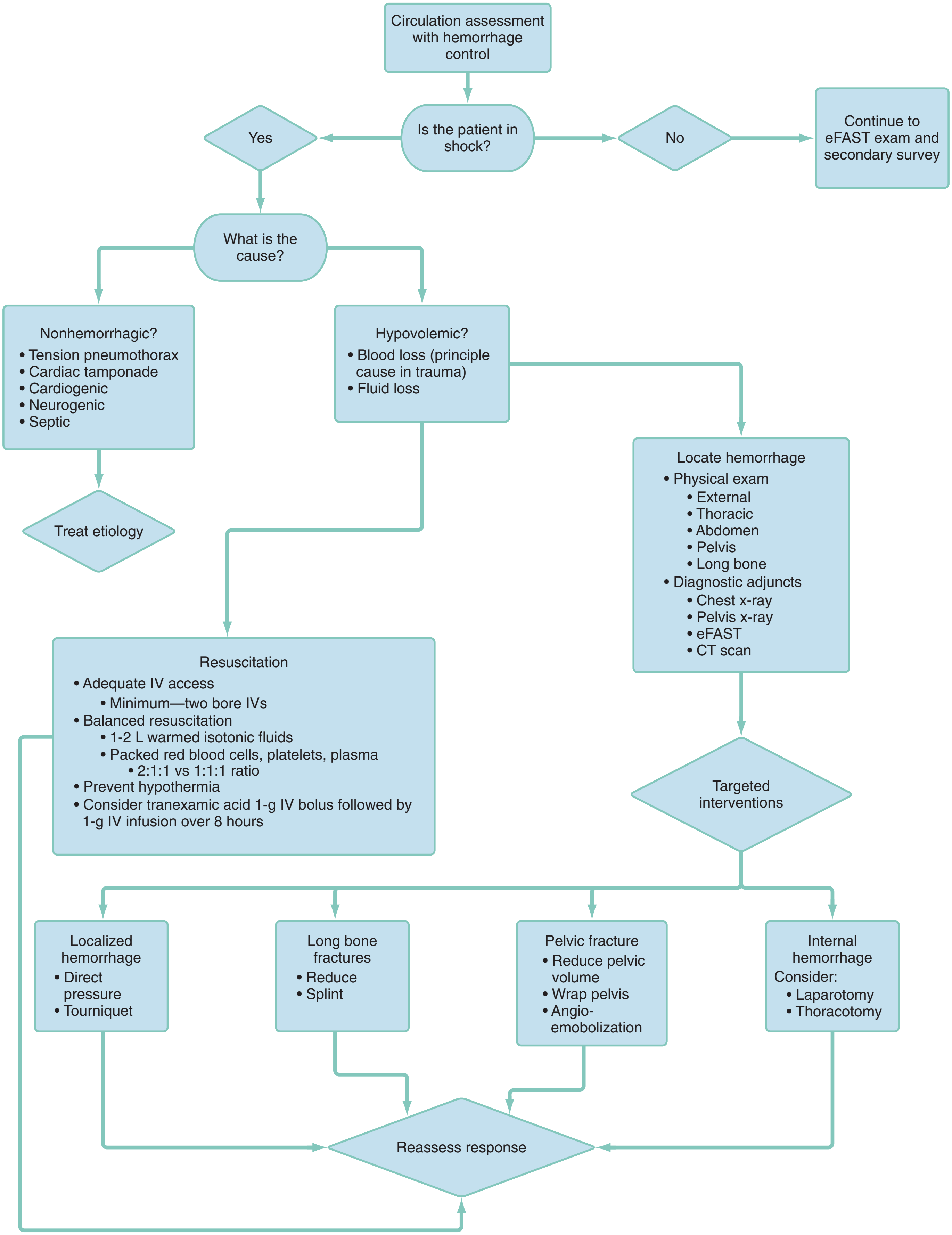

Fig. 33.3. Circulation with hemorrhage control algorithm. *CT,* Computed tomography; *eFAST,* extended, focused, abdominal sonography in trauma; *exam,* examination.

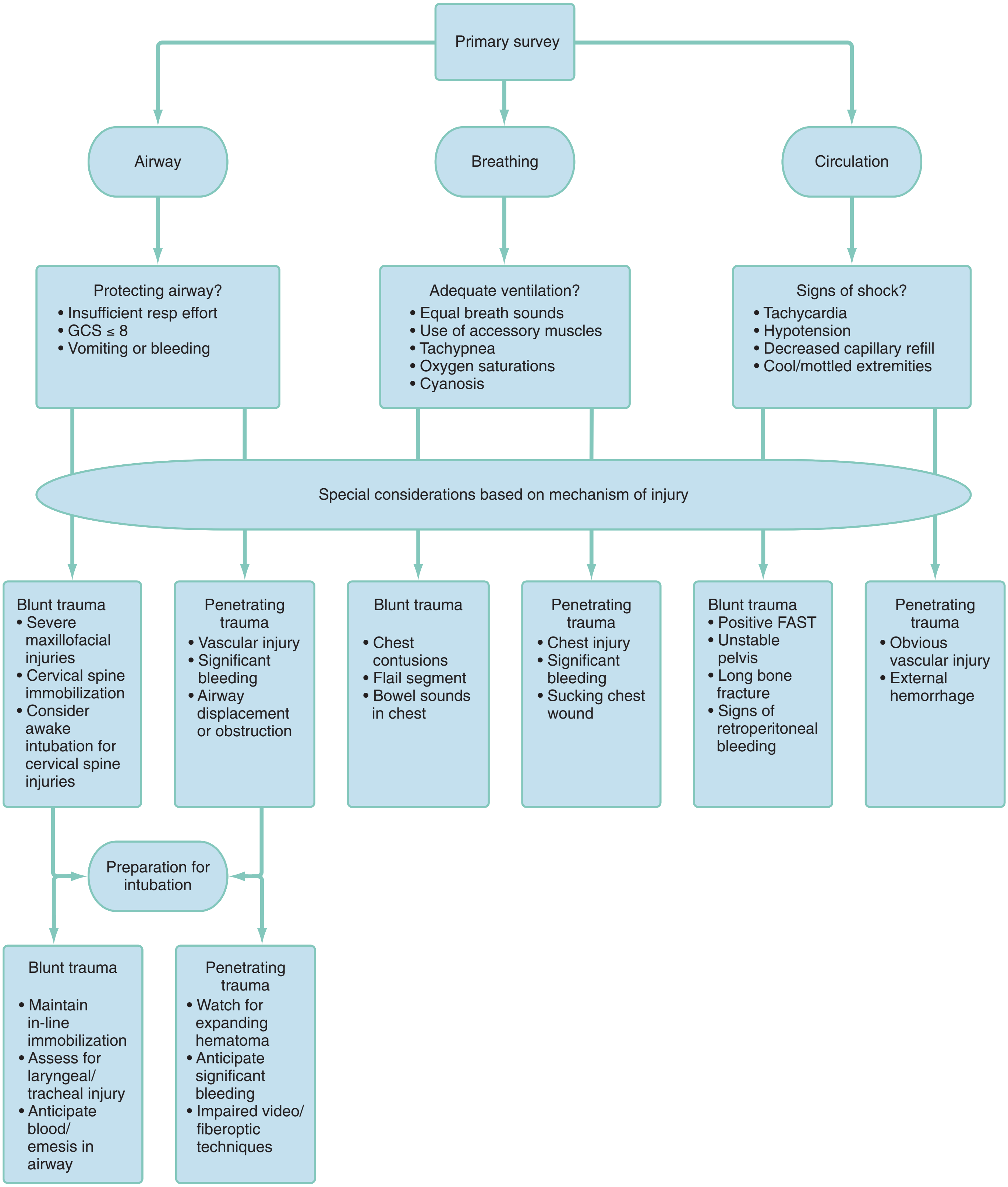

Fig. 33.4. Special considerations of the primary survey. *FAST,* Focused, abdominal sonography in trauma; *GCS,* Glasgow Coma Scale.

TABLE 33.2

Secondary Survey of Trauma Patients

REGION OR SYSTEM	ASSESSMENT OR EXAMINATION	CRITICAL DIAGNOSES	EMERGENT DIAGNOSES
General	Level of consciousness	GCS ≤ 8	
	Glasgow Coma Scale (GCS) score	Focal motor deficit	
	Specific complaints		
Head	Pupils (size, shape, reactivity, visual fields)	Herniation syndrome	Globe rupture
	Contusions		
	Lacerations		
	Evidence of skull fracture (hemotympanum, Battle's sign, raccoon eyes, palpable defects)		Open skull fracture Cerebrospinal fluid leak
Face	Contusions		
	Lacerations		
	Midface instability	Airway obstruction due to bleeding	Facial fractures
	Malocclusion		Mandible fracture
Neck (maintain cervical immobilization)	Penetrating injury, lacerations		
	Tracheal deviation	Carotid injury	
	Jugular venous distention	Pericardial tamponade	
	Subcutaneous emphysema	Tracheal, laryngeal fracture	
	Hematoma	Vascular injury	
	Midline cervical tenderness	Cervical fracture, dislocation	
Chest	Respiratory effort, excursion	Impending respiratory failure	
	Contusions		Cardiopulmonary injury
	Lacerations		Intrathoracic injury
	Focal tenderness, crepitus		Rib fractures
	Subcutaneous emphysema	Flail chest	Pneumothorax
	Heart tones (muffled)	Cardiac tamponade	
	Breath sounds (symmetric)	Tension pneumothorax	Pneumothorax Hemothorax
Abdomen, flank	Contusions		Solid, hollow viscous injury
	Penetrating injury, lacerations	Intra-abdominal hemorrhage	Solid, hollow viscous injury
	Tenderness	Intra-abdominal hemorrhage	Solid, hollow viscous injury
	Peritoneal signs	Abdominal catastrophe	
Pelvis, genitourinary	Contusions	Pelvic hemorrhage	
	Lacerations		Urogenital injury
	Stability, symphyseal tenderness	Unstable pelvic fracture Pelvic hemorrhage	
	Blood (urethral meatus, vaginal bleeding, hematuria)	Unstable pelvic fracture	Urethral injury
	Rectal examination	Colorectal injury (bleeding)	Urethral injury (high-riding prostate)
Neurologic, spinal cord	Midline bony spinal tenderness	Spinal fracture, dislocation	
	Mental status	Epidural hematoma Subdural hematoma	Cerebral contusions Shear injury
	Paresthesias		Spinal cord injury, contusion Nerve root injury
	Sensory level	Spinal fracture, dislocation	
	Motor function, including sphincter tone	Spinal fracture, dislocation	
Extremities	Contusions	Compartment syndrome	Rhabdomyolysis
	Lacerations	Vascular injury	
	Deformity	Neurovascular injury	Fracture
	Focal tenderness		Fracture
	Pulses	Arterial injury	
	Capillary refill	Hemorrhagic shock Arterial injury	
	Evaluation of compartments	Compartment syndrome	

computed tomography (CT) when serious head trauma is suspected. Hypoglycemia causes depression of mental status and can be an inciting factor in major trauma. Point of care glucose testing is commonly performed by prehospital providers, but normal glucose levels should be confirmed after arrival in the ED. Minor mechanisms of injury with significant mental status changes may be a clue to a concomitant nontraumatic cause of altered mental status in these patients. Chronic medication use and comorbidities may contribute to the incidence of traumatic injuries and complicate the ED management of these patients. In addition to oral or injectable agents used to control diabetes, medications used for hypertension may result in bradycardia or transient hypotension, with decreased levels of consciousness as the cause of trauma. Use of diuretics or anticholinergic medications or psychiatric illness may lead to hyponatremia. Seizures have a postictal state and also may result in (usually minor) injury, but major trauma can result from seizures occurring while driving or those causing a fall from heights or submersion in water. Anticoagulants present a high risk state for any patient sustaining trauma, and patients on warfarin or newer anticoagulants or antiplatelet agents should undergo neuroimaging with even minor mechanisms of injury.

Hypotension is a significant finding in the acute trauma patient, and all such patients warrant a thorough evaluation for acute hemorrhagic shock. If hypotension persists and no clear source of hemorrhage is identified, other causes of hypotension must be considered. Neurogenic shock, associated with a spinal cord injury, is the next most likely cause when paralysis is identified. Acute myocardial infarction and cardiogenic shock due to severe myocardial contusion or underlying cardiac abnormalities, or hypotension caused by preexisting sepsis or blood loss (eg, gastrointestinal [GI] bleed), are considered if hypotension is present and no clear cause has been identified.

Finally, a critical tenet of trauma management is to avoid distraction by what might appear as an obvious injury. Traumatic amputations, gaping wounds, complex open fracture dislocations, and combative patient behavior frequently distract providers from their structured trauma evaluation. Approaching patients in a systematic way, using the primary and secondary surveys, will help prevent overlooking significant acute injuries. Similarly, complete exposure and a head to toe examination of the trauma patient will identify otherwise occult injuries, which may be concealed on the back or may be in the axilla or perineum.

DIAGNOSTIC TESTING

Laboratory Evaluation

Laboratory testing in the trauma patient should be guided by clinical assessment and the needs of the individual patient. Used wisely, these studies may provide an objective measure of the adequacy of resuscitation, guide transfusion decisions, assess for coagulopathy, provide baseline information for ongoing assessment, and detect and aid in the management of comorbid conditions, such as renal insufficiency and diabetes. Electrolyte levels, liver function studies, international normalized ratio (INR), urinalysis, blood typing and screening (or crossmatching, depending on severity of injury) and lactate levels or base deficit should be determined in all critically ill trauma patients. A pregnancy test should be performed in all female trauma patients of childbearing age. Serum β-human chorionic gonadotropin (β-hCG) testing can avoid the delays in obtaining a urine specimen.

Lactate level, base deficit, and anion gap determinations can help identify subclinical hypoperfusion and track the adequacy of resuscitation. [17-20] Central venous oxygenation also has been used to assess adequacy of resuscitation.[21] Research into earlier markers of hypoperfusion continues.[22] We recommend determining the serum lactate level to evaluate for adequacy of resuscitation in trauma patients with abnormal vital signs suggestive of hypovolemia or altered mental status or other individuals for whom clinical assessment may be unreliable—older patients, those with comorbid conditions or medications that may affect vital signs (eg, beta blockers), or those with mechanisms with high risk for occult injury (see Table 33.1).

A type and screen are indicated for those patients with abnormal vital signs thought to be due to injury or mechanisms with risk for occult injury. A crossmatch should be ordered in those with persistently abnormal vital signs. If transfusion is needed prior to crossmatched blood being available, the provider can temporize with type-specific blood or type O-negative in women of childbearing age or type O-positive in other populations.

An INR should be ordered in all critically injured patients, those with ongoing hemorrhage requiring transfusion, and those on anticoagulants. The INR, however, does not provide a rapid comprehensive picture of the clotting process. In patients with extensive bleeding or undergoing massive transfusion, thromboelastrography (TEG) or thromboelastometry (ROTEM) testing is used to aid the early diagnosis of trauma coagulopathies and direct blood and blood product transfusion. These evaluations are most beneficial for patients undergoing massive transfusion.[23]

In the noncritical patient, determination of electrolyte levels can be reserved for those with underlying medical conditions for whom assessing or monitoring those values will be helpful. A complete blood count provides baseline information important for those at risk for ongoing bleeding or history of anemia. Liver function testing and serum lipase level determination should be carried out when blunt hepatic or pancreatic injury (eg, handlebar injury) is likely or comorbid conditions, including alcoholism, exist.

Radiographic Evaluation

Before the advent of CT scanning and advances in our understanding of the limitations of imaging, virtually all significantly injured patients underwent portable, plain radiographic imaging of their cervical spine, chest, and pelvis. This has now been largely supplanted by the selective use of portable plain radiography, bedside ultrasound (eFAST), and advanced imaging, usually CT scanning.

An eFAST examination should be performed on all patients with multisystem trauma or isolated trauma to the torso. Sonographic evidence of free intra-abdominal, intrathoracic, or pelvic hemorrhage, pneumothorax, and pericardial effusions or cardiac tamponade directs management of the patient. A positive abdominal scan for free fluid in hypotensive patients can identify those in need of emergent laparotomy, with good sensitivity.[24] The sensitivity for injury may not be as high in the pediatric population,[25] but in adult and pediatric populations, the absence of intraperitoneal blood on bedside US does not rule out intra-abdominal injury.[26,27] US evaluation of the inferior vena cava is useful for assessing volume status, but is not part of the eFAST examination.[16,28,29] Further discussion and suggested algorithms are found in Chapter 39.

Cervical spine imaging by plain radiographs in the trauma bay is of very limited value and has been largely supplanted by cervical spine imaging by CT. Patients with neurologic deficits are presumed to have spinal cord injury until proven otherwise, and a so-called normal cervical spine radiograph is not sufficient to rule out injury; spinal precautions should be continued.[30] We recommend using the NEXUS (***N***ational ***E***mergency ***X***-Radiography ***U***tilization ***S***tudy) criteria, which include absence of posterior midline tenderness, focal neurologic deficit, altered mental status, intoxication, or distracting injury.[31] When a patient is not cleared by the NEXUS criteria, a CT scan of the cervical spine should be obtained.[32] If the neurologic examination is normal, a normal CT scan of the cervical spine is sufficient to exclude injury; further imaging is not necessary.[33-36] Further diagnostic algorithms regarding spine imaging can be found in Chapter 36.

Imaging of the chest early in the evaluation of the multiple trauma patient can provide important information about potentially life-threatening injuries. US is superior to a supine portable chest x-ray as the initial screening tool for pneumothorax and hemothorax.[37-39] We recommend that thoracic US be used in the initial screening of the blunt trauma patient with a significant mechanism of injury to identify life-threatening pneumothorax or hemothorax. If US is not available, portable chest x-ray should be used as the initial screening modality. A normal chest x-ray does not exclude intrathoracic injury; sensitivity for intrathoracic injury is low.[40,41] Injuries not detected by chest x-ray, however, generally do not result in worse outcomes. Chest CT should be performed in those with significant chest pain, dyspnea, sternal tenderness, or abnormal thoracic US or chest x-ray findings. Chest CT is not required in asymptomatic blunt trauma victims with a normal chest x-ray.[42-45]

There is evidence that thoracic imaging can be avoided altogether in blunt trauma patients with very low risk of thoracic injury. The criteria for obtaining imaging in one large validation study are age older than 60 years, rapid deceleration mechanism, chest pain, intoxication, abnormal alertness and mental status, distracting painful injury, and tenderness to chest wall palpation. This rule has a sensitivity of 99.8% and negative predictive value of 98.5%.[46] However, these criteria have not been adopted on a wide scale. Adoption of these or modified criteria may occur by consensus among the key services involved (typically, emergency medicine, trauma surgery, radiology) at the local level as a way to decrease costs and radiation exposure.

In patients with a stab wound to the chest and an initial normal thoracic US or chest x-ray, routine use of chest CT is not indicated.[47,48] Asymptomatic patients can undergo a repeat chest x-ray in as little in 1 hour, rather than the traditional 6 hours after an initial normal chest x-ray, to exclude significant pathology.[47]

Pelvic fractures can cause significant hemorrhage, and early recognition of fracture and closure of the pelvic space can mitigate hypotension in these patients. In hemodynamically unstable patients, a portable pelvic x-ray should be obtained in the trauma bay. The sensitivity for an anteroposterior pelvic x-ray to identify all possible fractures is not high; however, an abnormal x-ray showing an open book fracture or vertical displacement of the posterior pelvis should alert the emergency clinician to the need for a pelvic binder and possible embolization or surgical fixation to control ongoing pelvic hemorrhage. Hemodynamically stable patients with pelvic tenderness or a distracting injury, or those with severe mechanisms of injury and altered mental status, should have their pelvis imaged. If the patient is undergoing CT of the abdomen and pelvis as part of the trauma assessment, we recommend using the bone windows of the CT scan rather than obtaining a pelvic x-ray.[49,50] Hemodynamically stable patients who are awake, alert, and asymptomatic, with a normal pelvic physical examination, do not require pelvic x-rays.[51,52] Similar studies have suggested the same for pediatric patients.[53,54] Further discussion of pelvic trauma can be found in Chapter 48.

In blunt multiple trauma victims, imaging with an abdominal-pelvic CT scan (AP-CT) is recommended for those with abdominal pain or tenderness, significant mechanism of injury (see Table 33.1), abnormal eFAST examination, gross hematuria, or unreliable examination (eg, altered mental status, distracting injury, head injury). The presence of a seat belt sign is associated with an internal abdominal injury (IAI) and should prompt a CT scan.[55] Blunt multiple trauma victims who have a Glasgow Coma Scale (GCS) score of 15, normal abdominal physical examination, negative eFAST, and normal laboratory results can forego a CT scan; however, they should have a period of observation, repeat eFAST examination, and repeat hemoglobin level determination.[55,56]

Indications for imaging of the head, spine, and extremities are covered in the respective chapters. Patients with moderate or severe head injury should have their head imaging completed as soon as possible after the primary survey, eFAST examination, and brief secondary survey. Imaging of the thoracic and lumbar spines and extremities can be delayed until other life-threatening injuries have been investigated and managed.

MANAGEMENT

Out-of-Hospital Management

Management of the trauma patient frequently begins before arrival in the ED by first responders. The goals of out-of-hospital care include intervention in immediately life-threatening injuries, prevention of additional injury, and rapid transport to trauma centers for definitive care.

Most life-threatening injuries that require intervention by out-of-hospital providers are related to airway, breathing, and circulation (the ABCs). Endotracheal intubation may be required for patients with severe trauma, particularly head trauma with coma, and for those with significant trauma when transport times may be prolonged. Tension pneumothorax compromises ventilation and perfusion and requires needle or other thoracostomy when suspected. Systemic hypotension with impaired end-organ perfusion necessitates restoration of intravascular volume to a level sufficient to provide perfusion, but not and attempt to restore normal blood pressure.

Preventing additional injury requires an awareness of not only clinically evident abnormalities but also potentially more serious injuries. Coordinated extrication and transport with cervical immobilization, spinal precautions, intensive hemodynamic monitoring, and stabilization of fractures to prevent neurovascular compromise are examples of assuming the most serious injuries exist in multiple trauma patients.

Emergency Department

Because multiple trauma patients have a variety of injuries from varying mechanisms, the initial focus is directed at overall resuscitative care, with emphasis on performing interventions in the optimal sequence.

For level 1 trauma centers, the American College of Surgeons (ACS) requires the presence of a board-certified general surgeon to be present in the hospital 24 hours each day. The trauma surgeon is expected to be present in the ED no later than 15 minutes after arrival of trauma patients to the ED (Box 33.1).[57] As the specialty of emergency medicine has evolved, and the number of residency-trained and board-certified emergency clinicians has increased, the need for a surgeon for all trauma patients has been increasingly debated; outcomes are equivalent when the trauma team is led by a surgeon or an emergency clinician.[58] Most trauma resuscitations in the community are performed by emergency clinicians, with consultation by a surgeon or surgical subspecialist based on identified injuries.

The priorities in the treatment of trauma patients are similar to those for any other life-threatening condition. Securing the airway, maintaining ventilation, controlling hemorrhage, and treating shock are the first priorities.

The goals of airway management are threefold—airway protection, adequate oxygenation, and adequate ventilation. The decision to intubate may go beyond these three tenets because the potential for deterioration in clinical status should be taken into account. Patients may have an obvious need for early intubation identified during the primary survey. Others will have serious

BOX 33.1

American College of Surgeons Requirements for the Presence of a Surgeon in Major Resuscitations

A surgeon should be present in the emergency department on trauma patient arrival or within 15 minutes if any of the following major criteria are found:

- Confirmed hypotension (systolic blood pressure < 90 mm Hg)
  - Gunshot wounds to the neck, chest, abdomen or proximal extremities
  - Intubated patients transferred from the scene
- Respiratory compromise requiring an emergent airway
- Penetrating gunshot wound to the neck, chest, abdomen, or pelvis
- Glasgow Coma Scale score < 8 attributed to trauma
  - At the discretion of the emergency clinician

injuries detected later in their evaluation or will have deteriorated and require intubation. Still others will require intubation based on their overall clinical course and constellation of injuries, rather than for any one clear indication.

Airway protection is necessary for many trauma patients. Airway obstruction necessitates immediate intervention. Obstruction from debris, blood, or vomitus may be removed with suction. Neck or facial trauma may cause more complicated problems. Swelling, distorted anatomy, and hematoma formation may all contribute to impending obstruction. Early airway control is safest because these conditions may rapidly worsen. The inability to protect the airway adequately, such as in patients with depressed levels of consciousness, is another indication for intubation. Airway control is recommended for patients with depression of consciousness sufficient to compromise airway protection (usually cited as a GCS score <9).[59] Alcohol intoxication can be an important confounder in the early neurologic assessment of these patients. In patients who do not immediately require airway protection, close observation over time for neurologic recovery to a normal state is necessary.

As a general rule, all trauma patients initially should be placed on supplemental oxygen. When oxygenation on room air is adequate, low-flow (3 L/min) nasal cannula oxygen is sufficient. When oxygenation is compromised, face mask oxygen at a high flow rate is required. Restoring adequate oxygenation has a direct effect on the outcome of many trauma patients, particularly head-injured patients. Maintenance of the arterial oxygen concentration (Pao_2) above 60 mm Hg has been recommended by the Brain Trauma Foundation, a recommendation that has not changed since 2007. Certain ventilatory problems, such as pneumothorax or hemothorax, may require tube thoracostomy in addition to intubation. Placement of the chest tube before undertaking intubation, if possible, may improve the patient's hemodynamic status and decrease the risk of serious deterioration related to the use of intubating medications and initiation of positive pressure ventilation.

If the patient's condition allows, a detailed neurologic examination is important before administering neuromuscular blocking agents, which may confound later evaluation. Correlation of head CT scan findings with neurologic status is critical to making any decisions regarding operative intervention for intracranial hemorrhage. Also, documentation of neurologic function or deficit is essential in the setting of a potential spine injury. Most patients will not have been cleared of cervical spine injury before intubation, so in-line spine stabilization and the most gentle possible technique are important. We recommend videolaryngoscopy with rapid sequence intubation as the primary method to secure the airway in the severely traumatized patient[60-62] (see Chapter 1). Videolaryngoscopy has been shown to reduce spine movement and generally achieves superior laryngeal views when compared with conventional direct laryngoscopy. When a potentially unstable spine injury has been identified, some emergency clinicians prefer to use a flexible bronchoscope for intubation. Overall, the choice of intubation technique will be based on the clinical scenario and emergency clinician's determination of what is most likely to accomplish the desired task in his or her hands. Blind nasotracheal intubation is undesirable in the trauma patient. Nasotracheal intubation using a flexible bronchoscope may be valuable in patients with a suspected airway or unstable cervical spine injury, performed as part of a prepared awake intubation (see Chapter 1).

A surgical airway is indicated in cases of failure of or contraindication to intubation. Cricothyrotomy is the preferred method, although it is performed in a small minority of all trauma cases requiring airway management, and the incidence has been decreasing because of the availability of better alternative rescue devices when intubation fails. When cricothyrotomy is required, we recommend the use of the four-step method or the no-drop cricothyrotomy technique, as described in Chapter 1. A variety of devices for percutaneous cricothyrotomy are also available, but only those using the Seldinger technique are sufficiently reliable and safe.

Control of external hemorrhage and rapidly establishing IV access are essential early steps in the management of the acute trauma patient. This has been discussed earlier (see "Primary Survey").

The choice of fluids for resuscitation includes crystalloid, colloid, and blood products. Fluid replacement is generally based on a 3 : 1 ratio of fluids to blood loss. There are few clinically significant differences between lactated Ringer's and normal saline solutions.[60,63] The debate regarding the choice of colloids versus crystalloids for resuscitation is ongoing. No indisputable advantages of colloids have been demonstrated.[64] Therefore, the less expensive and more readily available crystalloids are the mainstay of treatment. No clear benefit to the use of hypertonic saline has been established.[65] Current Advanced Trauma Life Support (ATLS) guidelines standardize the ratio of replacement fluids to loss and recommend 2 L of crystalloid be infused in all patients in shock, followed by blood products. O-positive blood should be used, except in women of childbearing age. Type-specific blood should be used when available, but emergent transfusion should not be delayed. Massive transfusion protocols are commonly used for patients with severe hemorrhagic shock. Recent data have suggested that the use of a 1 : 1 : 1 ratio of plasma, platelets, and red blood cells may result in earlier hemostasis, although no significant difference in mortality was noted.[66] We recommend the use of a 1 : 1 : 1 or 1 : 1 : 2 ratio of blood products based on specific institutional policies and procedures. Other transfusion ratios are less effective in resuscitation. The use of the antifibrinolytic agent tranexamic acid has been shown to decrease mortality in trauma patients at risk of major bleeding if given within the first hour following injury.[8-10] Any trauma patient with clinically significant hemorrhage, or those who present in shock, should receive 1 g of tranexamic acid over 10 minutes, followed by a 1-g infusion over 8 hours. Mortality benefits of tranexamic acid have been shown when administered up to 3 hours after trauma, but earlier administration (within 1 hour) is superior.

In the severely injured, hypotensive trauma patient, restoration of normal blood pressure may be undesirable. The concept of permissive hypotension is based on the premise that resuscitation to a normal blood pressure may increase bleeding from an uncontrolled hemorrhage site or even from a site that is tenuously contained and not actively hemorrhaging. In permissive

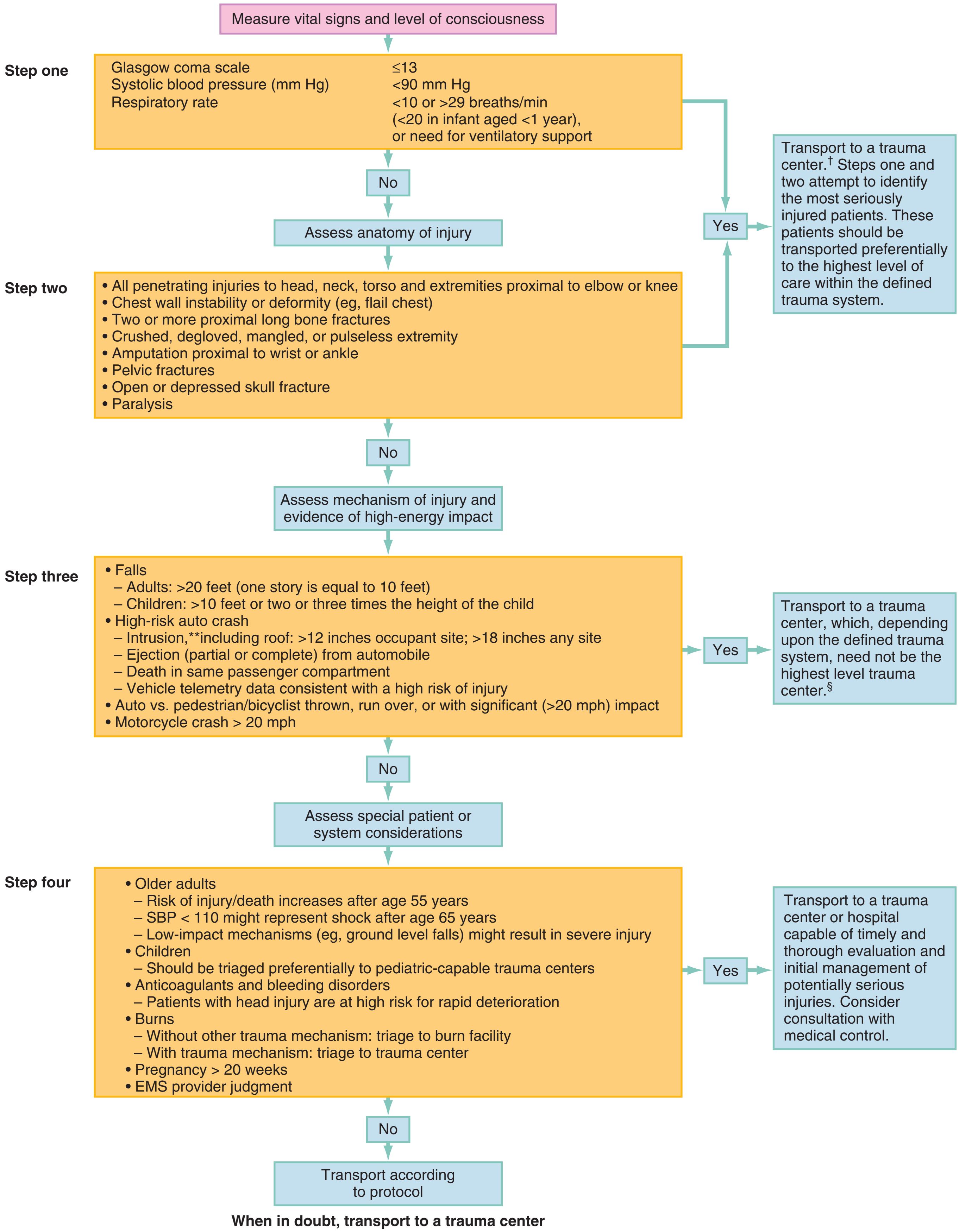

Fig. 33.5. Triage decision scheme. *EMS,* Emergency medical services. (Adapted from American College of Surgeons, Committee on Trauma: Resources for the optimal care of the injured patient, Chicago, 2012, American College of Surgeons.)

hypotension, mean arterial pressure (MAP) is restored to a goal of approximately 50 mm Hg. Data have shown that this strategy leads to less blood product use, less bleeding, and lower incidence of coagulopathy.[11,12] Permissive hypotension is contraindicated in the management of traumatic brain injury because of the risk of hypoperfusion.[13-15] Rather than any particular MAP target, restoration of adequate tissue perfusion, with normal mentation or, more importantly, normalization of tissue oxygen saturation (Sto_2) monitoring, is the clinically relevant endpoint in the resuscitation of the trauma patient.[67-69]

The role of ED thoracotomy (EDT) has become more selective to limit futile resuscitation efforts and minimize risk to providers. Patients with penetrating trauma who undergo cardiac arrest while in transport or in the ED are most likely to benefit from EDT. In contrast, cardiac arrest patients with blunt trauma, prolonged cardiopulmonary resuscitation (CPR), or delayed transport times generally have dismal outcomes that are not altered by EDT.[70] Most institutions have protocols in place outlining criteria regarding when EDT should be performed. The National Association of EMS Physicians and ACS Committee on Trauma have published guidelines for withholding or terminating resuscitation efforts in out-of-hospital traumatic cardiac arrest patients. As a result, these guidelines often limit the transport of patients who would not likely benefit from EDT. Patients who may not be transported include any blunt trauma patient without vital signs at the scene, apneic or pulseless penetrating trauma victims without other signs of life, patients undergoing more than 15 minutes of CPR, and patients with transport times of more than 15 minutes after arrest.[71-73] Suggested algorithms for the application of EDT are outlined in Figs. 33.5, 33.6, and 33.7. EDT is discussed further in Chapter 38. When EDT is performed, the goal is to manage rapidly correctable traumatic injuries and allow for transfer to the operating room for definitive intervention.

To assess disability, a rapid assessment of the patient's neurologic status is necessary early in the ED course. If intubation is necessary early in the patient's treatment, perform a brief neurologic examination, including level of consciousness, tone and motor ability for all four extremities (eg, spontaneous, purposeful, withdrawal to pain), anal sphincter tone (if obtunded or evidence of paralysis), and any lateralizing signs, prior to administration of the paralytic and induction agent.

DISPOSITION

The decision to admit the patient or transfer to a tertiary care facility should be coordinated based on available resources, consultation with the trauma surgeon, and consideration of institutional and regional guidelines. The ultimate disposition is dictated by a number of factors, including the patient's condition, nature of the injury, and availability of surgeons, subspecialists, and anesthesiologists. Possible dispositions include transfer to the operating room, admission to the surgical service, limited observation in the ED, and transfer to another hospital. The level of care and monitoring established in the ED should be maintained throughout transfer. All equipment and medications needed for resuscitation and maintenance of vital functions should be

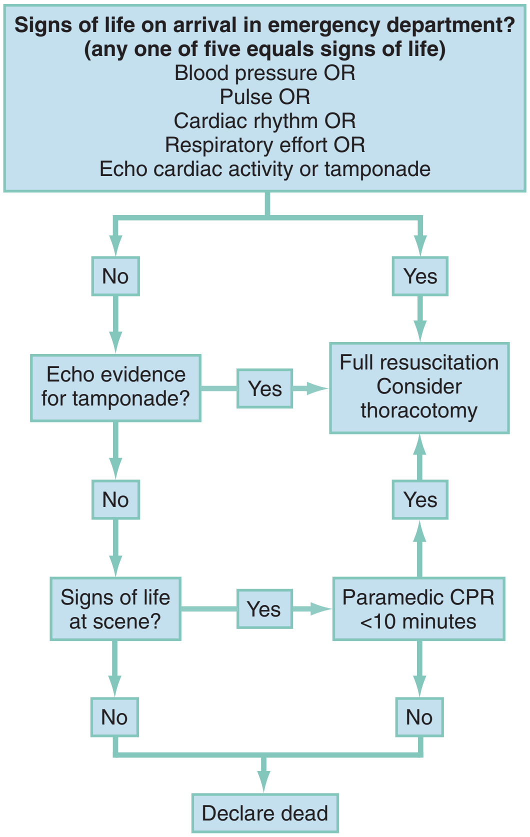

Fig. 33.6. Penetrating chest trauma—emergency department thoracotomy algorithm. *CPR,* Cardiopulmonary resuscitation; *Echo,* echocardiographic.

available during the transfer, as should qualified personnel to oversee the patient's care.

In cases of interhospital transfers, emergency clinicians at the two institutions should carefully coordinate all arrangements. Stabilizing measures are begun before the patient's transfer, but decompensation in transit should be anticipated. Qualified personnel and necessary resuscitative equipment should accompany the patient. The compelling reason for transferring a patient with life-threatening trauma is the lack of resources or personnel to care for a patient's particular injuries. Transfer should not be delayed for nonessential diagnostic procedures. All documentation and results of ancillary testing should accompany the patient in transfer.

In certain circumstances, the multiple trauma patient may not need admission or interhospital transfer. The decision to discharge these patients is evaluated carefully because many traumatic injuries may manifest in a delayed manner. When discharge is considered, thorough ED evaluation is necessary, with resources in place to ensure an optimal outcome—surgical consultation, where appropriate, attending radiologist support for image interpretation, and timely scheduled follow-up on an outpatient basis.

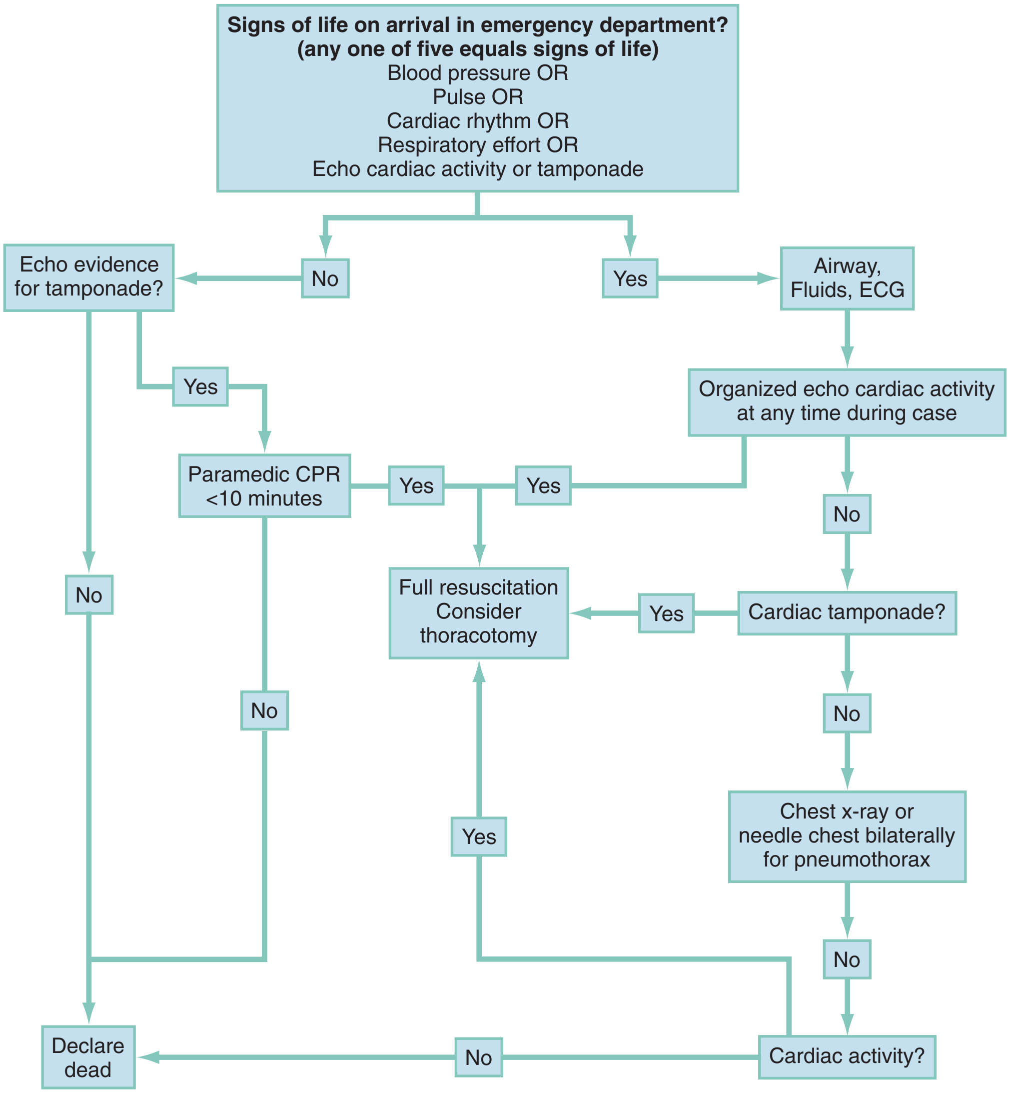

Fig. 33.7. Blunt chest trauma emergency department thoracotomy algorithm. *CPR,* Cardiopulmonary resuscitation; *ECG,* electrocardiogram; *Echo,* echocardiographic.

KEY CONCEPTS

- Immediately after a trauma patient arrives in the ED, the primary survey should be performed in a standardized fashion. The goal of the primary survey is to identify and initiate the treatment of critical, life-threatening injuries rapidly.
- The eFAST examination should take place early in the evaluation of the trauma patient, ideally as part of the primary survey. Thoracic examination of the trauma patient by ultrasound is more accurate than plain radiography.
- Any patient with potentially life-threatening injuries should have blood typing and screening performed. When transfusion is indicated, blood products should be transfused in a 1:1:1 or 1:1:2 ratio of plasma to platelets to packed red blood cells.
- Tranexamic acid is indicated for patients with evidence of significant hemorrhage or shock and is given as a 1-g bolus followed by a 1-g infusion over 8 hours. Results are best if started within 1 hour of injury but benefit may occur when it is given within 3 hours.

The references for this chapter can be found online by accessing the accompanying Expert Consult website.

REFERENCES

1. Centers for Disease Control and Prevention: Web-based Injury Statistics query and Reporting System (WISQARS). <www.cdc.gov/ncipc/wisqars>.
2. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control: Impaired driving. <www.cdc.gov/Motorvehiclesafety/Impaired_Driving/index.html>.
3. National Highway Traffic Safety Administration: Fatality Analysis Reporting System (FARS). <www.nhtsa.gov/FARS>.
4. Tracya ET, et al: Pediatric injury patterns by year of age. J Pediatr Surg 48:1384–1388, 2013.
5. Pinto PS, et al: The unique features of traumatic brain injury in children. Review of the Characteristics of the pediatric skull and brain, mechanisms of trauma, patterns of injury, complications, and their imaging findings—part 2. J Neuroimaging 22: e18–e41, 2012.
6. Ross M, McCormack J: Trauma and burns in children. Anaesth Intensive Care 15:570–576, 2014.
7. Brown JB, et al: Mechanism of injury and special consideration criteria still matter: an evaluation of the National Trauma Triage Protocol. J Trauma 70:38–45, 2011.
8. Kragh JF, Jr, et al: Military use of tourniquets from 2001 to 2010. Prehosp Emerg Care 19:184–190, 2015.
9. Passos E, et al: Tourniquet use for peripheral vascular injuries in the civilian setting. Injury 45:573–577, 2014.
10. Bulger EM, et al: An evidence-based prehospital guideline for external hemorrhage control: American College of Surgeons Committee on Trauma. Prehosp Emerg Care 18:163–173, 2014.
11. Achneck HE, et al: A comprehensive review of topical hemostatic agents: efficacy and recommendations for use. Ann Surg 251:217–228, 2010.
12. Granville-Chapman J, et al: Pre-hospital haemostatic dressings: a systematic review. Injury 42:447–459, 2011.
13. Stone MB, et al: Ultrasound detection of guidewire position during central venous catheterization. Am J Emerg Med 28:82–84, 2010.
14. Balls A, et al: Ultrasound guidance for central venous catheter placement: results from the central line emergency access registry database. Am J Emerg Med 28:561–567, 2010.
15. Gallagher RA, et al: Ultrasound assistance for central venous catheter placement in a pediatric emergency department improves placement success rates. Acad Emerg Med 21:981–986, 2014.
16. Dipti A, et al: Role of inferior vena cava diameter in assessment of volume status: a meta-analysis. Am J Emerg Med 30:1414–1419, 2012.
17. Galkova K, Vrabelova M: Normalization of blood lactate as early end-point of polytrauma treatment. Bratisl Lek Listy 114:637–641, 2013.
18. Leskovan JJ, et al: Anion gap as a predictor of trauma outcomes in the older trauma population: correlations with injury severity and mortality. Am Surg 79:1203–1206, 2013.
19. Cheddie S, et al: Base deficit as an early marker of coagulopathy in trauma. S Afr J Surg 51:88–90, 2013.
20. Bar-Or D, et al: Association between a geriatric trauma resuscitation protocol using venous lactate measurements and early trauma surgeon involvement and mortality risk. J Am Geriatr Soc 61:1358–1364, 2013.
21. Hosking C, et al: Low central venous oxygen saturation in haemodynamically stabilized trauma patients is associated with poor outcome. Acta Anaesthesiol Scand 55:713–721, 2011.
22. Bursa F, Pleva L: Anaerobic metabolism associated with traumatic hemorrhagic shock monitored by microdialysis of muscle tissue is dependent on the levels of hemoglobin and central venous oxygen saturation: a prospective, observational study. Scand J Trauma Resusc Emerg Med 22:11, 2014.
23. Tapia NM, et al: TEG-guided resuscitation is superior to standardized MTP resuscitation in massively transfused penetrating trauma patients. J Trauma Acute Care Surg 74:378–385, 2013.
24. Quinn AC, Sinert R: What is the utility of the Focused Assessment with Sonography in Trauma (FAST) exam in penetrating torso trauma? Injury 42:482–487, 2011.
25. Negusa S, et al: Paediatric trauma imaging: why do we need separate guidance? Clin Radiol 69:1209–1213, 2014.
26. Diercks DB, et al: Clinical policy: critical issues in the evaluation of adult patients presenting to the emergency department with acute blunt abdominal trauma. Ann Emerg Med 57:387–404, 2011.
27. Carter JW, et al: Do we really rely on FAST for decision-making in the management of blunt abdominal trauma? Injury 46:817–821, 2015.
28. Fields JM, et al: The interrater reliability of inferior vena cava ultrasound by bedside clinician sonographers in emergency department patients. Acad Emerg Med 18:98–101, 2011.
29. Prekker ME, et al: Ultrasound measurement of inferior vena caval diameter is more accurate than the internal jugular vein aspect ratio to estimate central venous pressure in ICU patients. Am J Respir Crit Care Med 181:A4580, 2010.
30. Theologis AA, et al: Cervical spine clearance protocols in level 1 trauma centers in the United States. Spine 39:356–361, 2014.
31. Hoffman JR, et al: Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. N Engl J Med 343:94–99, 2000.
32. American College of Radiology: Appropriateness criteria. <https://acsearch.acr.org/list>.
33. Vanguri P, et al: Computed tomographic scan: it's not just about the fracture. J Trauma Acute Care Surg 77:604–607, 2014.
34. Kanji HD, et al: Sixty-four-slice computed tomographic scanner to clear traumatic cervical spine injury: systematic review of the literature. J Crit Care 29:314, e9-e13, 2014.
35. Raza M, et al: Safe cervical spine clearance in adult obtunded blunt trauma patients on the basis of a normal multidetector CT scan—a meta-analysis and cohort study. Injury 4:1589–1595, 2013.
36. Patel MB, et al: Cervical spine collar clearance in the obtunded adult blunt trauma patient: a systematic review and practice management guideline from the Eastern Association for the Surgery of Trauma. J Trauma 78:430–441, 2015.
37. Abdulrahman Y, et al: Utility of Extended FAST in blunt chest trauma: is it the time to be used in the ATLS algorithm? World J Surg 39:172–178, 2015.
38. Ianniello S, et al: First-line sonographic diagnosis of pneumothorax in major trauma: accuracy of e-FAST and comparison with multidetector computed tomography. Radiol Med 119:674–680, 2014.
39. Chung JH, et al: ACR appropriateness creteria blunt trauma. J Am Coll Radiol 1:345–351, 2014.
40. Nafarsheth K, Kurek S: Ultrasound detection of pneumothorax compared with chest X-ray and computed tomography scan. Am Surg 77:480–484, 2011.
41. Gutierrez A, et al: The utility of chest X-ray as a screening tool for blunt thoracic aortic injury. Injury 47:32–36, 2016.
42. Yanchar NL, et al: Chest x-ray as a screening tool for blunt thoracic trauma in children. J Trauma Acute Care Surg 75:613–619, 2013.
43. Kea B, et al: What is the clinical significance of chest CT when the chest x-ray result is normal in patients with blunt trauma? Am J Emerg Med 31:1268–1273, 2013.
44. Kaiser M, et al: The clinical significance of occult thoracic injury in blunt trauma patients. Am Surg 76:1063–1066, 2010.
45. Lee LK, et al: Occult pneumothoraces in children with blunt torso trauma. Acad Emerg Med 21:440–448, 2014.
46. Rodriguez RM, et al: NEXUS chest: validation of a decision instrument for selective chest imaging in blunt trauma. JAMA Surg 148:940–946, 2013.
47. Berg RJ, et al: Prospective evaluation of early follow-up chest radiography after penetrating thoracic injury. World J Surg 37:1286–1290, 2013.
48. Mollberg NM, et al: Chest computed tomography for penetrating thoracic trauma after normal screening chest roentgenogram. Ann Thorac Surg 93:1830–1835, 2012.
49. Fu C, et al: The diminishing role of pelvic x-rays in the management of patients with major torso injuries. Am J Emerg Med 32:18–23, 2014.
50. Barleben A, et al: Implementation of a cost-saving algorithm for pelvic radiographs in blunt trauma patients. J Trauma 71:582–584, 2011.
51. Paydar S, et al: Role of routine pelvic radiography in initial evaluation of stable, high-energy, blunt trauma patients. Emerg Med J 30:724–727, 2013.
52. Holmes JF, Wisner DH: Indications and performance of pelvic radiography in patients with blunt trauma. Am J Emerg Med 30:1129–1133, 2012.
53. Wong AT, et al: Low-risk criteria for pelvic radiography in pediatric blunt trauma patients. Pediatr Emerg Care 27:92–96, 2011.
54. Lagisetty J, et al: Are routine pelvic radiographs in major pediatric blunt trauma necessary? Pediatr Radiol 42:853–858, 2012.
55. Borgialli DA, et al: Association between the seat belt sign and intra-abdominal injuries in children with blunt torso trauma in motor vehicle collisions. Acad Emerg Med 21:1240–1248, 2014.
56. Jones EL, et al: Intra-abdominal injury following blunt trauma becomes clinically apparent within 9 hours. J Trauma Acute Care Surg 76:1020–1023, 2014.
57. Committee on Trauma, American College of Surgeons: Resources for the optimal care of the injured patient, Chicago, 2014, American College of Surgeons.
58. Green SM: Trauma is occasionally a surgical disease: how can we best predict when? Ann Emerg Med 58:172–177, 2011.
59. Mayglothling J, et al: Emergency tracheal intubation immediately following traumatic injury. J Trauma 73:S333–S340, 2012.
60. Sakles JC, et al: A comparison of the C-MAC video laryngoscope to the Macintosh direct laryngoscope for intubation in the emergency department. Ann Emerg Med 60:739–748, 2012.
61. Aziz MF, et al: Comparative effectiveness of the C-MAC video laryngoscope versus direct laryngoscopy in the setting of the predicted difficult airway. Anesthesiology 116:629–636, 2012.
62. Mosier JM, et al: Difficult airway management in the emergency department: GlideScope videolaryngoscopy compared to direct laryngoscopy. J Emerg Med 42:629–634, 2012.
63. Silverberg MJ, et al: Comparison of video laryngoscopy versus direct laryngoscopy during urgent endotracheal intubation: a randomized controlled trial. Crit Care Med 43:636–641, 2015.
64. Jain S, Bhadani U: Lightwand: a useful aid in faciomaxillary trauma. J Anesth 25:291–293, 2011.
65. Quick JA, et al: Emergent surgical airway: comparison of the three-step method and conventional cricothyroidotomy utilizing high-fidelity simulation. J Emerg Med 46:304–307, 2014.
66. Langvad S, et al: Emergency cricothyrotomy—a systematic review. Scand J Trauma Resusc Emerg Med 21:43, 2013.
67. Myburgh JA, Mythen MG: Resuscitation fluids. N Engl J Med 369:1243–1251, 2013.
68. Carlile C, et al: Evaluation of StO2 tissue perfusion monitoring as a tool to predict the need for lifesaving interventions in trauma patients. Am J Surg 210:1070–1075, 2015.
69. Iyegha UP, et al: Low StO2 measurements in surgical intensive care unit patients is associated with poor outcomes. J Trauma Acute Care Surg 76:809–816, 2014.
70. Annane D, et al: Effects of fluid resuscitation with colloids vs crystalloids on mortality in critically ill patients presenting with hypovolemic shock: the CRISTAL randomized trial. JAMA 310:1809–1817, 2013.
71. Junger WG, et al: Resuscitation of traumatic hemorrhagic shock patients with hypertonic saline-without dextran-inhibits neutrophil and endothelial cell activation. Shock 38:341–350, 2012.
72. Lira A, Pinsky MR: Choices in fluid type and volume during resuscitation: impact on patient outcomes. Ann Intensive Care 4:38, 2014.
73. Kim H, Lee KH: The effectiveness of hypertonic saline and pentoxifylline (HSPTX) resuscitation in haemorrhagic shock or sepsis tissue injury; comparison with the LR, HES-HTS, LR-PTX treatments. Injury 43:1271–1276, 2012.

CHAPTER 33: QUESTIONS & ANSWERS

33.1. A 33-year-old mother and her 2-year-old-son are brought in by paramedics after they were both hit by a car moving at 15 mph. Although mother and child had an identical mechanism of injury, the son would be at greater risk for all the following injuries, with the following exception:
- **A.** Head injury
- **B.** Hypothermia
- **C.** Intra-abdominal injury
- **D.** Multisystem injury
- **E.** Posttraumatic stress disorder

Answer: E. Injury patterns can differ significantly between adults and children subjected to similar mechanisms of trauma. The major anatomic distinctions relate to the smaller size and surface area, larger head-to-body ratio, and less protected abdominal cavity of the child. As a result, children are more vulnerable to multisystem injury in blunt trauma, including significant head and intra-abdominal injuries, as well as being at greater risk for hypothermia.

33.2. Which of the following is the goal of the primary survey?
- **A.** Determine which consultations should be obtained.
- **B.** Do an AMPLE (***a***llergies, ***m***edications, ***p***ast medical history, ***l***ast meal, ***e***nvironments and events) history.
- **C.** Obtain pertinent historical data from the paramedics.
- **D.** Perform a radiographic evaluation.
- **E.** Rapidly identify critical life-threatening diagnoses and begin treatment at the time of the diagnosis.

Answer: E. The emergency clinician should use a standardized approach to the initial evaluation of these patients. Following the Advanced Trauma Life Support (ATLS) algorithm of ABCs in the primary survey allows the timely identification of critical diagnoses and intervention without delay. The primary survey should be performed in a standardized fashion immediately after the patient arrives in the emergency department. The goal of the primary survey is to identify critical, life-threatening diagnoses rapidly and begin treatment at the time of diagnosis. The goals of the secondary survey are to obtain pertinent historical data about the patient and injury as well as evaluate and treat injuries not found on the primary survey. An AMPLE history should be obtained.

33.3. An 89-year-old man who was a restrained front seat passenger with a history of hypertension, anxiety disorder, and dementia is being evaluated after a head-on collision. His home medications include an angiotensin-converting enzyme (ACE) inhibitor for the hypertension, lorazepam for the anxiety, and olanzapine (Zyprexa) for the dementia. The patient does not have any complaints but is noted to have a blood pressure of 80/50 mm Hg and heart rate of 100 beats/min. In evaluating the patient, you should suspect that the asymptomatic hypotension is most likely due to which of the following?
- **A.** Antihypertensive medication use
- **B.** Antipsychotic medication use
- **C.** Benzodiazepine use
- **D.** Blood loss

Answer: D. Lower extremity weakness, gait disturbances, decreased visual acuity, and the use of psychotropics, antihypertensives, and sedatives have been associated with falls in older adults, resulting in major injury. The use of these medications, particularly antihypertensives, should not be considered causative in trauma patients with hypotension until acute hemorrhage has been ruled out. In addition, anticoagulants, antiplatelet drugs, and aspirin are commonly prescribed, and their effects should be suspected and reversed, if warranted.

33.4. A critically injured, multisystem trauma patient has blood sent to the laboratory. The appropriate tests may determine the adequacy of resuscitation and need for blood transfusion. Hypoperfusion and inadequate resuscitation may be indicated by abnormalities in all except which of the following?
- **A.** Anion gap
- **B.** Base deficit
- **C.** Central venous oxygen saturation
- **D.** Lactate level
- **E.** Magnesium

Answer: E. Laboratory markers can help identify patients who may not appear acutely ill but do have hypoperfusion, as well as track the adequacy of resuscitation. Lactate level, base deficit, and anion gap also predict outcome in the trauma patient. Following changes in the central venous oxygen saturation may also be worthwhile; low values in hemodynamically stabilized trauma patients have been shown to worsen outcome.

33.5. A severely injured, hypotensive trauma patient is being considered for permissive hypotension because she has a contained retroperitoneal hematoma and is not actively hemorrhaging. In permissive hypotension, the mean arterial pressure is restored to a goal of 50 mm Hg. Which of the following should help you decide against using permissive hypotension?
- **A.** Age > 80 years
- **B.** Age < 10 years
- **C.** Associated traumatic brain injury
- **D.** Hemoglobin of 10 g/dL
- **E.** Intoxication

Answer: C. In the severely injured, hypotensive trauma patient, restoration of normal blood pressure may be undesirable. The concept of permissive hypotension is based on the concern that resuscitation to normal blood pressures may increase bleeding from a site that is contained and not actively hemorrhaging. In permissive hypotension, the mean arterial pressure (MAP) is restored to a goal of about 50 mm Hg. Studies have shown that this strategy leads to less blood product use, less bleeding, and lower incidence of coagulopathy. However, the provider should be aware that permissive hypotension is contraindicated in the management of traumatic brain injury because of the risk of hypoperfusion.