Chapter 1

General Approach to Traumatic Injuries

Ryan O'Halloran and Kaushal Shah

Introduction

Trauma is the fourth leading cause of death overall in the United States and the number one cause of death for ages 1 to 44 – second only to heart disease and cancer in those older than 45 (CDC).[1] As the disease burden from infectious diseases declines and secondary prevention of chronic conditions improves, the relative importance of the practice of trauma care becomes even more apparent. Though safety engineering has improved across many industries (one need only consider examples such as crosswalk and bike lane planning, football helmet technology, and motor vehicle computerized improvements), trauma remains a significant threat to life and limb in emergency medicine.

The Trauma Team

The American College of Surgeons, the governing body for credentialing trauma centers, has provided guidelines for optimal resources necessary for a coordinated response to a critically injured trauma patient. Box 1.1 demonstrates the players suggested for an optimal response.

While response teams may vary, several principles are key to the functioning of a good, interdisciplinary team. These include clearly establishing roles for members of the team, following policy and protocols established in advance, briefing prior to the arrival of the patient, and debriefing after the event, whether immediately after the event or through quality case review. Successful team dynamics include the ability to be fluid, adaptable, and communicative.

Team leaders must focus on the big picture: overall physiologic status of the patient, triage of resources available in the trauma room, assigning tasks to individuals or groups of

Box 1.1 Human Resource Response to Trauma Activations

- Emergency Physician
- Emergency/Trauma Nurses
- Trauma Surgeon
- Anesthesiologist
- Radiology Tech (and radiologist)
- Blood Bank, Laboratory Support Staff
- Respiratory Therapist
- Social Worker
- Security

Table 1.1 Adapted in part from ALiEM article by Arlene Chung, an effective team debriefing checklist[2]

✔ Set ground rules (purpose, safe environment) and time expectations (5–10 minutes)	
✔ Present facts of the case (avoid excessive detail)	*Can you give us an overview about what happened from your viewpoint?*
✔ Elicit thoughts	*What was your first thought or most prominent thought?*
✔ Discuss reactions (emotions)	*How did that go? What were you feeling?*
✔ Discuss the facts of the case, medicine, and teamwork	*What was the worst? What was the best?*
✔ Teaching and learning	*What could have gone better?*
✔ Re-entry and closure (validate emotions, highlight learning points)	

Box 1.2 Trauma Teams That Are Successful at Helping Patients Work Together Well

- Institutionally organized policy and plans for interdepartmental cooperation
- Designated team leader
- “Pre-briefing” prior to arrival of trauma patients
- Debriefing and/or quality clinical reviews, of trauma resuscitations
- Closed-loop, concise, out-loud communication
- Systematic, reproducible approach to every trauma patient
- Ability to be fluid, adaptable, and communicative

individuals, and planning for the next series of actions for the patient and team. A systematic approach to the patient is important (discussed in Box 1.2), as is a systematic approach to directing the team. Critical actions, while they may be pre-designated to a member of the team by policy, must be verbalized and confirmed. Intravenous access, for example, is crucial for a sick trauma patient. Direct, closed-loop communication among team members is essential in trauma management. This call-and-response principle can be extrapolated to all critical tasks in the trauma room.

Trauma team members are often exposed to high stress, highly emotional situations. Team debriefing is critical for emotional well-being, education, and resolution of deficiencies, demonstrated in Table 1.1. It is ideal that a formal debriefing, even if only a few minutes, be completed after every trauma team activation. These meetings may be delayed based on the circumstances of the patient (e.g., going immediately to the operating room), but should be attempted as often as is practical, with as many of the team members as possible.

Emergency Medical Services (EMS)

The first step in the series of steps that can optimize outcome in trauma is accurate triage (with overtriage preferred over undertriage), rapid care that addresses immediate life

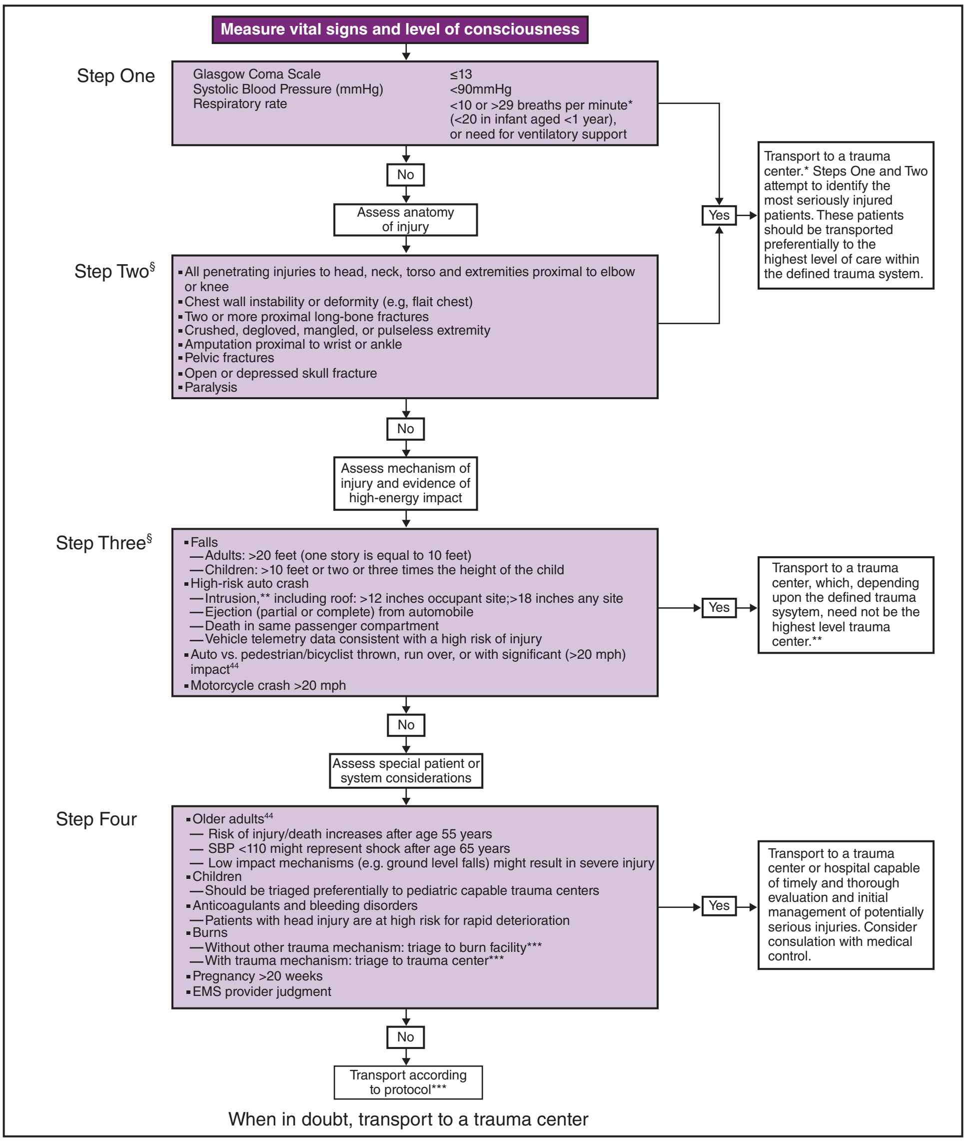

Figure 1.1 CDC guidelines for field triage of injured victims[3] (courtesy of the Centers for Disease Control, USA)

threats, and prompt transport to the appropriate level trauma center (see CDC guidelines chart, Figure 1.1) by EMS personnel.[3]

EMS professionals perform an abridged version of the hospital team's primary and secondary surveys. Many EMS systems rely on basic-level Emergency Medical Technicians (EMTs) to respond to calls for traumatic injuries. Modern EMT-staffed Basic Life Support ambulances carry equipment more advanced than simple standard first aid, such as tourniquets and hemostatic dressings for severe hemorrhage, and supraglottic airway devices. Paramedics, the highest trained pre-hospital providers, are capable of intubation, needle decompression, and IV and IO access. Regardless of the level of skill, or equipment available, rapid transport to the appropriate hospital is key to survival. Some controversial studies have suggested that police officers ought not to wait for EMS to transport victims – inferring that speed, rather than care provided in the interim of transport, is most important.[4–9]

EMS notification to the receiving hospital allows for the trauma team to assemble, prepare equipment, and "pre-brief," as described earlier, in anticipation of their arrival. In some urban systems this may be a quick "heads-up" that the ambulance is around the corner. In rural settings, the patient may be coming by air or ground from hours away. In extreme circumstances, notification may provide time for the calling-in backup personnel (such as in multiple or mass casualty incidents) or setup of decontamination equipment.

Upon entering the trauma room, the team leader ought to obtain a brief history from EMS about the mechanism of injury, vital signs, interventions started, and IV or IO access already obtained. This information, while easily ignored in haste to begin assessment and treatment, may be invaluable. A brief period of time should be set aside (30–60 seconds) where the EMS personnel can convey the critical data points or "bullet" to the team leader, discussed in Table 1.2.

Primary Survey

The primary survey is a rapid (less than two minutes), focused, and requisitely thorough process of identifying immediate threats to life, shown in Table 1.3. It should be completed

Table 1.2 Critical information to obtain from EMS during transition of care

EMS Bullet Information	
Critical Information	**Additional Information (if possible to obtain)**
Mechanism of Injury Latest Vital Signs (and trends) Mental Status (and trend) IV/IO Access (if already obtained) Interventions	Details of the mechanism (e.g., size of knife, type of gun, passenger space intrusion) Number of additional anticipated victims Past medical or surgical history, medications, allergies

Table 1.3 Immediately life-threatening conditions that must be identified during the primary survey

A – Airway	B – Breathing	C – Circulation	D – Disability	E – Exposure
• Swelling	• Pneumothorax	• Uncontrolled bleeding	• Herniation	• Any hiding injury
• Excessive fluid	• Hemothorax	• Hypotension	• Neurologic deficit suggestive of SCI	
• Burns	• Hypoxia			
• Tracheal injury	• Respiratory failure			

by a physician at the head-of-the-bed and start with a brief introduction: "my name is Dr. Smith, focus on me and my voice; lots of people are here to help and will be doing lots of things around you."

In the era of terrorism, high-power gunfire on city streets, and improvised explosive devices, it is important to immediately consider significant, life-threatening bleeding. Major uncontrolled external bleeding should be addressed before proceeding with the traditional "ABCDE" primary assessment; first with direct pressure, then consideration given to applying a tourniquet to the proximal extremity (or the "CABCDE" assessment).

At the end of the primary survey, while there is still more work to be done, the team leader has enough information to start considering the anticipated next steps, for example, the CT scanner, the intensive care unit, the operating room, or an operating room alternative such as interventional radiology.

A – Airway (Key Question: Do We Need to Take Control of the Airway Right Now?)

In many patients, a thorough assessment of the airway can be completed by asking one question: "what is your name?" A speaking patient, answering a question directly, typically has a patent and self-maintained airway. Changes in voice, gurgling, stridor, or the inability to speak in full sentences should be noted as clues to impending airway problems. Ultimately the decision must be made if it is necessary to immediately take control of the airway. Box 1.3 lists the most important things to consider when deciding to intubate a trauma patient.[10,11]

If the patient must be intubated, it is critical to mentally and physically prepare for an anatomically and physiologically difficult airway. Anatomy may be severely distorted by the trauma or simply difficult to visualize due to a cervical collar in place, swelling, or bleeding. The need for a backup plan should always be anticipated; before intubating, have a gum elastic bougie, supraglottic airway, video laryngoscope, and/or scalpel for cricothyrotomy available. As with any other anticipated difficult airway, a verbalized plan for front-of-the-neck access should be in place should a cricothyrotomy be required.

The already-physiologically-stressed trauma patient may respond profoundly to induction and paralytic agents – as many are already reliant on a sympathetic surge to maintain their cardiac output. Consider medication selection in the context of the patient's physiology. For example, ketamine[12–18] or etomidate[19–23] are better choices for induction in the context of hypotension, as they are less likely to cause a drop in blood pressure. Relative contraindications for paralytic agents should also be considered.[24–26] Likewise, consider

Box 1.3 Indications For Early or Immediate Intubation in the Trauma Room[10,11]

- Severe head injury, with significantly decreased mental status (GCS <8, mGCS <6)
- Penetrating neck trauma (such as gunshot wounds, or poorly visualized stab wounds)
- Severe burns (especially involving inhalation injury to the airway)
- Significant blunt or penetrating chest trauma impairing breathing efforts
- Severely intoxicated or agitated patients prohibiting assessment of life-threatening injuries
- Anticipated course (such as transport to another facility, or immediate surgery)
- Severely ill, unresponsive, or otherwise in extremis

adjusting the dosages of medications for hypotension; lower doses of sedatives and higher doses of paralytics may be required.[27] Attention should be given to beginning pre-oxygenation and optimization of the patient's physiology (mean arterial pressure, oxygen saturations, etc.). If the mental status allows, insert a supraglottic airway, place a nasal cannula, apply a bag valve mask, and/or utilize noninvasive ventilation to pre-oxygenate as would be expected with any non-trauma patient.

B – Breathing (Key Questions: Are Chest Tubes Required? Is There Bleeding in the Chest?)

Assessment of breathing is a look (ensure equal chest rise, quantify the respiratory rate, check for wounds), listen (auscultate bilaterally), and feel (press on the chest wall to assess for crepitus or flail rib segments) process. Glance at the monitor and note the oxygen saturation. Pneumothorax can be more subtle than anticipated. Careful attention to asymmetric breath sounds (as referred sounds from one side of the chest could be heard on the collapsed-lung side), neck veins, and tracheal deviation could be crucial to picking up a pneumothorax or hemothorax before it develops tension physiology.

If there is concern for pneumothorax or hemothorax in a hemodynamically unstable patient, needle decompression of the chest or placement of a chest tube should be completed immediately. This is both a diagnostic and therapeutic procedure in critically ill trauma patients, especially those with penetrating trauma to the chest.

C – Circulation (Key Question: Where Are They Bleeding and Do They Need Blood?)

Coagulopathy, acidosis, and hypothermia – the trauma triad of death –all primarily stem from shock in trauma. Finding and promptly methodically stopping major hemorrhage is paramount. The trauma adage is that blood can be found in six major places: the chest, the abdomen, the pelvis, the retroperitoneum, the thighs (or areas around other long bones), and the street.

External hemorrhage may be obvious or discovered when exposing the patient. Internal hemorrhage may be more subtle and requires considering the patient's heart rate, blood pressure, and appearance. Obtain a complete set of vital signs and assess peripheral circulation. Weak pulses and cool extremities imply a shock state, as does a more objective rise in the shock index (heart rate divided by systolic blood pressure). While cutoffs for tachycardia and blood pressure are more poorly defined in the literature, a shock index <0.7 or >1.3 is correlated with poorer outcomes,[28] and a shock index >0.95 is correlated with the need for massive transfusion.[29]

Ensure that good intravenous access has been obtained – at least two large-bore (i.e., at least 18-gauge) IVs in most trauma patients. While short, 18-gauge peripheral IVs are excellent methods for volume resuscitation, consideration should be given to placement of an intraosseous or central venous line if peripheral access is limited or difficult. While obtaining IV access, lab work should be sent, including a typical trauma panel of labs: complete blood count, venous blood gas (serum lactate), basic chemistry, coagulation studies, and type-and-screen for potential transfusion. Additional labs may be obtained, but they usually do not guide initial management. Initial hemoglobin and hematocrit levels may be falsely reassuring, as it takes time for blood concentrations of heme to equilibrate to rapid blood loss. Patients known to be on anticoagulants, or with elevated coagulation times, ought to be reversed in the context of active hemorrhage.

Hypotension/Shock

Classically taught "classes of shock" based on various vital sign cutoffs is important to appreciate; however, the literature demonstrates that they are not entirely reliable and often insensitive predictors of shock.[30,31] Normotensive elderly patients might be in shock. Children and healthy adults might compensate very well, leading to deceptively normal vital signs. The trajectory in tachycardia, mean arterial pressure, and mental status must be considered in any trauma patient with the potential for active bleeding.

If the patient is hypotensive, blood loss must be at the top of the differential for the cause, but also consider non-bleeding causes of hypotension in trauma; namely, tension pneumothorax, cardiac tamponade, spinal cord injury, myocardial dysfunction (from contusion, underlying heart disease, arrhythmia, or infarction), and toxic ingestions. Box 1.4 discusses causes of hypotension in trauma.

External bleeding should be stopped with direct pressure. Consider that holes in the skin are not always lined up with where blood originates. Attempts to apply pressure at potentially retracted vascular structures, or over proximal pressure points, may be reasonable additional measures. If blood loss from an extremity cannot be stopped with direct pressure, consider placing hemostatic stitches (e.g., a figure-of-eight or whip stitch) or staples if the wound is small enough. If bleeding cannot be controlled from a larger wound, such as an amputation, utilize a tourniquet (preferably a commercially available product or manual blood pressure cuff).

Blood loss from the pelvis is often associated with pelvic fractures, which may be stabilized with binding (either with a commercially available device or properly placed and secured bedsheet). While there are various types of pelvic fractures – some of which do not benefit from binding – a hypotensive patient with suspected active bleeding in the pelvis might benefit from empiric binding as a temporary measure.

Box 1.4 Differential for Hypotension in the Trauma Patient

Hemorrhagic Shock
- Bleeding (chest, abdomen, pelvis, retroperitoneum, long bones, street)

Obstructive Shock
- Tension pneumothorax
- Cardiac tamponade

Neurogenic Shock
- Spinal cord injury

Cardiogenic Shock
- Myocardial dysfunction (contusion, underlying heart disease, arrhythmia, infarction)

Distributive Shock (or other mechanisms)
- Toxic ingestion (poisoning, substance use)

Whether suffering from internal or external bleeding, a hemodynamically unstable patient needs to have replaced what has been lost: whole blood. Transfusion with packed red blood cells alone may not be adequate. Consider initiating a massive transfusion protocol. Protocols vary by institution but should include a mix of products containing packed fresh frozen plasma (FFP), platelets, and red blood cells (PRBC). The PROPPR and PROMMTT trials have demonstrated that overall transfusion in a ratio of 1:1:1 of FFP: Platelets:PRBCs is optimal.[32,33] Prothrombin Complex Concentrate (PCC) can be considered as an alternative to FFP, as it does not require thawing and is often more readily available. Consider supplemental calcium, as citrate in blood products can chelate body stores of calcium, potentiating hypotension. The CRASH-2 trial also demonstrated the efficacy of tranexamic acid (TXA), if given within the first three hours, to improve mortality in patients in hemorrhagic shock from trauma.[34] While IV fluids can temporarily elevate the circulating blood volume, they dilute clotting factors and perhaps unnecessarily increase the mean arterial pressure affecting hemostasis. They should be used sparingly and only as a bridge to blood products. Vasopressors have no role in hemorrhagic shock from trauma. Target resuscitation to a MAP of 65 mm Hg typically – and increase this goal to 80 mm Hg in any patient suspected of head injury or spinal cord injury.[35–37] This strategy of allowing penetrating trauma patients to remain slightly hypotensive is sometimes referred to as "permissive hypotension," and, although it has been demonstrated to be effective in one randomized trial, subsequent human trials have not been able to validate the benefit; therefore, the strategy remains controversial.[38]

Lastly, consideration may be given to more invasive hemostasis options such as a resuscitative thoracotomy[39–41] or placement of a Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA),[42–44] in select patients nearing death.

D – Disability (Key Question: Is There a Major Neurologic Deficit?)

During the primary survey the neurological assessment should include Glasgow Coma Scale (GCS),[45] pupillary exam, and gross motor/sensory assessment of all four extremities. Mental status is a key assessment in the overall status of the trauma patient. GCS can help assess the trajectory of the patient over time. Studies have indicated that simply assessing the motor component of the GCS can be a simplified, binary assessment (can the patient follow simple commands?) and is equally predictive of the need for airway management and mortality, discussed in Table 1.4.[46] Localized neurologic (or vascular) deficits in the context

Table 1.4 Glasgow Coma Scale GCS score[45] is used to stratify mental status in trauma patients[46]

Eye		Verbal		Motor	
4	Spontaneous opening	5	Oriented	6	Obeys commands
3	Opens to voice	4	Confused	5	Localizes pain
2	Opens to pain	3	Inappropriate	4	Withdraws from pain
1	No eye opening	2	Incomprehensible	3	Flexes to pain
		1	No verbal response	2	Extends to pain
				1	No motor response

Table 1.5 Key questions to consider in each portion of the primary survey

Airway	*Do we need to take control of the airway right now?*
Breathing	*Are chest tubes required? Is there bleeding in the chest?*
Circulation	*Where are they bleeding and do they need blood?*
Disability	*Is there a major neurologic deficit?*
Exposure	*What injuries haven't been found yet?*

of a mangled or deformed extremity may prompt a rapid bone or joint reduction and improve the likelihood of limb salvage.

All trauma patients with a significant mechanism of injury should be placed in a cervical collar until it is demonstrated they do not have an injury to the cervical spine, whether by clinical decision rules (in highly assessable patients, such as NEXUS or the Canadian C-Spine Rule) or by imaging and exam.[47,48]

If using induction or paralytic agents for intubation, the next possible neurologic exam will likely be significantly delayed. Consider performing a thorough baseline exam, if possible, prior to intubation.

If there is clinical evidence of brain herniation from head trauma, hyperosmolar therapy should be started to partially abate rises in intracerebral pressure (and subsequent losses in cerebral perfusion pressure).[49–56] Any intubation performed in this context should be completed by an experienced provider, as first-pass success minimizes hypotension and hypoxia.[55,57,58] Definitive therapy will require neurosurgical intervention.

E – Expose (Key Question: What Injuries Haven't Been Found Yet?)

Norman McSwain, a trauma surgeon and developer of the initial Advanced Trauma Life Support (ATLS) program, noted that "paranoia prevents disasters: the most severe injury is under the unremoved clothes." Every trauma patient should be exposed from head-to-toe in order to be examined thoroughly for injuries. Careful attention must be paid to areas that hide injuries, such as the axilla, skin folds, and the perineum. All patients must be rolled to examine the back. Key questions to consider in the primary survey are listed in Table 1.5.

Secondary Survey

As a continuation of the exposure portion of the primary survey, start from the head and work inferiorly, visualizing every square inch of the trauma patient. Descriptions of wounds ought to be as objective as possible and documented either with drawings of the body or precise anatomical locations. For example, "exit wound on the right flank" may be better stated as "1 cm ballistic wound in the R flank at the level of T5, 4 cm to the right of the midline." Excess qualifiers ("exit wound") serve to define the mechanism of injury in ways not typically known to the trauma team and do not provide additional, useful medical information. Remember these statements in the medical record may have criminal or legal implications for the patient or assailant.

A complete head-to-toe secondary survey, including rolling the patient and checking the posterior anatomy, should take no more than three to four minutes. Decisions should be

Table 1.6 General overview of the process of the trauma assessment

Primary Survey	Secondary Survey
• Massive Bleeding/Circulation	• Head-to-toe exam, including the back
• Airway	• Medications and allergies
• Breathing	• Past medical and surgical history
• Circulation	• Last oral intake
• Disability	• Discuss events leading to the trauma
• Expose	• Consider imaging

made at this point about what imaging needs to be completed in the trauma bay, i.e. what imaging is pivotal to deciding the next steps for the patient. While rolling the patient, consider placing plain film radiology plates underneath the patient's chest and pelvis.

Lastly, the secondary survey includes asking about the patient's past medical and surgical history, current medications (paying special attention to those immediately relevant to the trauma resuscitation, such as anticoagulant or antiplatelet agents), allergies, last oral intake, tetanus status, and any other details of the incident that led to the trauma in the first place. The general overview of the trauma assessment is listed in Table 1.6.

Imaging

Trauma Bay Imaging

A chest x-ray has long been the tradition for the trauma bay imaging of choice to evaluate for pneumothorax. In reality, a chest x-ray is poor at identifying this pathology, with sensitivity of 28–75%, especially if performed supine. The alternative is the eFAST (Extended Focused Assessment with Sonography in Trauma). This ultrasound exam is more sensitive (86–98%) than chest x-ray, and equally specific. It can be performed faster (no pun intended), and synergize better with the next steps.[59] If the patient is unstable with traumatic mechanism and there is clinical evidence to suggest pneumothorax (especially tension pneumothorax), a chest tube should be placed empirically without waiting for imaging.

The eFAST is a six-part study that assesses for abdominal free fluid, pericardial effusion, and pneumothorax. The prominent role for this procedure was largely designed to replace the need for diagnostic peritoneal lavage (DPL) to rule-out or rule-in abdominal sources of bleeding in blunt trauma patients with unstable vital signs, primarily as a means to guide operative therapy. In practice, the eFAST exam is also performed routinely on stable trauma patients, looking to identify the same abdominal and pericardial pathology early, and to identify pneumothoraces without the need for a chest x-ray. Positioning of the patient is key to enhancing the sensitivity of the exam. Brief periods in Trendelenburg (for the right and left upper quadrant views), reverse-Trendelenburg (for the suprapubic view), and supine (for the subxiphoid and lung views) will help position organ tissue, fluid, and air to improve diagnostics. Serial eFAST exams are not unreasonable in a stable patient, or one in whom the clinical picture has changed (sudden hypoxia or hypotension). Ultrasound has been