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Ultrasound for Trauma

Point-of-care ultrasound (POCUS) is a critical clinical tool that facilitates the early diagnosis of many life-threatening injuries. As with any test, clinicians need to fully appreciate indications and limitations of the diagnostic tool and integrate where advantageous to their practice. POCUS also is a valuable tool to enhance the speed, accuracy, and safety of several procedures that are frequently required in the trauma patient. The authors provide a synopsis of the state-of-the-art use of ultrasound for trauma patients.

— Ann M. Dietrich, MD, Editor

Introduction

Injury is a leading cause of death in the United States. In 2013, injured patients constituted 31 million emergency department (ED) visits and resulted in more than $406 billion in medical care and lost productivity. More people ages 1–44 died from injuries than from noncommunicable diseases and infectious diseases combined.[1] Given these staggering statistics, clinicians should have the proper skill sets to rapidly identify and treat injuries.

Ultrasonography is an ideal tool for the care of injured patients. It is rapid, noninvasive, portable, versatile, low cost, and easy to use. Discovered in the 1820s by Swiss physicist Jean-Daniel Colladon, it was first used as a diagnostic tool during World War II.[2] Since that time, ultrasound has gained tremendous popularity within the acute care specialties. German and Japanese physicians began using routine POCUS for trauma patients in the 1970s,[3] and emergency physicians in the United States followed in the 1980s.[4-5] POCUS is now also utilized in developing countries to direct patient care, as there is a scarcity of computer tomography (CT) scanners in many places.[6]

This issue of *Trauma Reports* will focus on the fundamental concepts of POCUS for the care of adult injured patients. This article begins with an overview of the important concepts in ultrasound physics, which serve as the foundation for better understanding of ultrasound techniques and image interpretations. Each subsequent section contains information on the indications, interpretations, and limitations of the specific ultrasound modality.

Ultrasound Physics

The source of the ultrasound wave is the piezoelectric crystal housed within the probe transducer. This crystal has the ability to transform an electrical current into mechanical pressure (ultrasound) waves and vice versa. Once the ultrasound wave is generated and travels through the medium, the crystal switches from "speaker" to "microphone" mode and awaits returning ultrasound echoes.

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STATEMENT OF FINANCIAL DISCLOSURE

To reveal any potential bias in this publication, and in accordance with Accreditation Council for Continuing Medical Education guidelines, Dr. Dietrich (editor in chief), Dr. Menaker (author), Dr. Hsu (author), Dr. Brader (peer reviewer), Ms. Behrens (nurse reviewer), Ms. Mark (executive editor), Ms. Leslie Coplin (executive editor), and Mr. Landenberger (continuing education and editorial director) report no relationships with companies related to this field of study.

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EXECUTIVE SUMMARY

- Ultrasonography is an ideal tool for the care of injured patients, since it is rapid, noninvasive, portable, versatile, low cost, and easy to use.
- The most important ultrasound mode is the "B-mode," or brightness mode. It provides structural information utilizing different shades of gray in a two-dimensional image.
- The goal of the FAST exam is to rapidly identify hemoperitoneum and hemopericardium.
- Thus, Morison's pouch has the highest sensitivity for the detection of intraperitoneal fluid.
- In most trauma management algorithms, if a patient is stable and needs further imaging, a CT scan is the highest sensitivity and specificity. It gives specific information about the hollow viscus and solid organs, as well as the retroperitoneum, which the FAST exam is unable to evaluate.
- If it is clear that the patient will require emergent surgical intervention (e.g., bowel evisceration from a penetrating injury), then the FAST exam should be bypassed to avoid delays to definitive treatment.

This cycle is repeated several million times per second during which "pulsed-echo" is generated.[7] Returning sound waves are then converted into images on the ultrasound monitor.

Diagnostic ultrasound uses frequencies between 2 and 10 million Hertz (Megahertz, MHz). Lower frequency ultrasound is able to penetrate deeper into tissue at the expense of less resolution. In contrast, higher frequency ultrasound will display more detail with a higher resolution in exchange for less depth penetration.[8] The commonly used ultrasound transducers are described in Table 1.

It is important to be familiar with the common ultrasound physics vocabulary to enhance the interpretation and communication of image findings with other clinicians. Table 2 lists some key terms, while Table 3 illustrates the relationships between the image medium, image echogenicity, and level of ultrasound wave attenuation.

The most important ultrasound mode is the "B-mode," or brightness-mode. It provides structural information utilizing different shades of gray in a two-dimensional image. M-mode, or "motion mode," captures returning echoes in only one line of the B-mode image and displays them over a time axis. Movement of structures positioned in that line can then be visualized. M-mode and B-mode both can be displayed simultaneously on the ultrasound monitor.

Table 1. Commonly Used Ultrasound Transducers

Curvilinear probe (2-5 MHz)

- This probe is low frequency and thus enables deeper penetration at the expense of lower resolution. It can be used for FAST or E-FAST and obstetric studies.

Linear probe (5-10 MHz)

- This probe is high frequency and thus enables high resolution at the expense of less penetration. It can be used for E-FAST, vascular access, ocular ultrasound, soft tissue imaging, and fractures.

Phased-array probe (2-4 MHz)

- This probe possesses similar frequency and level of penetration compared to the curvilinear probe but has a smaller footprint. It can be used for FAST or E-FAST to enable better cardiac imaging in between the intercostal spaces.

Table 2. Ultrasound Physics Terms

- **Attenuation:** Reduction in amplitude and intensity of the ultrasound wave as a function of distance through the imaging medium.
- **Anechoic:** Complete attenuation and thus complete absence of returning sound wave. The structure appears as a dark image.
- **Hypoechoic:** Large amount of attenuation and thus not much sound wave returned to the transducer. The structure will appear darker than surrounding tissue.
- **Isoechoic:** Produces ultrasound echoes equal to those of neighboring or of normal tissues.
- **Hyperechoic:** Opposite of hypoechoic due to poor propagation of sound wave through the medium. The structure will appear brighter than surrounding tissue.

Focused Assessment with Sonography for Trauma

The term Focused Abdominal Sonography for Trauma was first used in 1996 to describe a standard set of ultrasound examinations for the evaluation of injured patients. The meaning of the acronym was later changed to Focused Assessment with Sonography for Trauma (FAST) to reflect the applications outside the abdomen.[9] The goal of the FAST exam is to rapidly identify hemoperitoneum and hemopericardium.

The FAST exam is typically performed during the secondary survey according to the Advanced Trauma Life Support (ATLS) guidelines. However, in the appropriate clinical scenario, it may be performed during the primary survey to guide the decision for operative management of an unstable patient.

Table 3. Medium Type, Image Appearance, and Ultrasound Wave Attenuation

Medium	Image Appearance	Level of Attenuation
Air	Poor propagation	Low
Bone	Very echogenic (very bright)	
Muscle	Echogenic (bright)	
Liver/Kidney	Echogenic (less bright)	Middle
Fat	Hypoechoic (dark)	
Blood	Hypoechoic (darker)	High
Fluid	Hypoechoic (very dark)	

Figure 1. FAST Exam

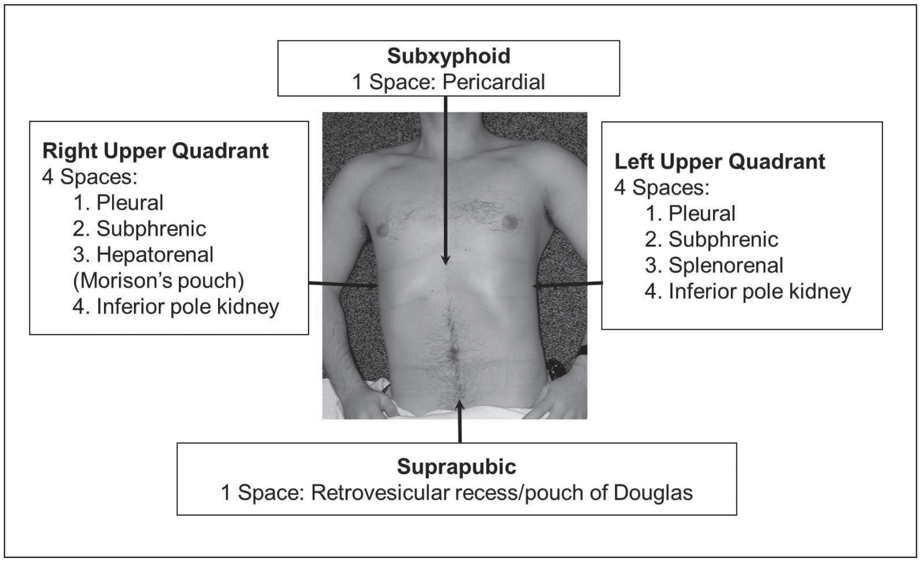


Figure 2A. Normal FAST Right Upper Quadrant View

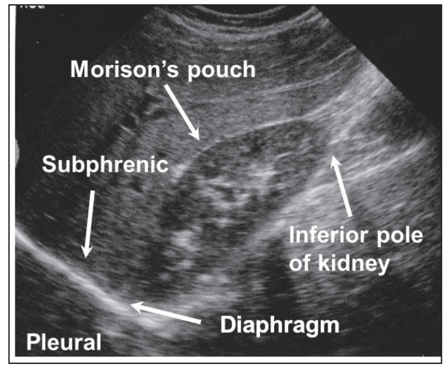


Figure 2B. FAST Free Fluid in Morison's Pouch

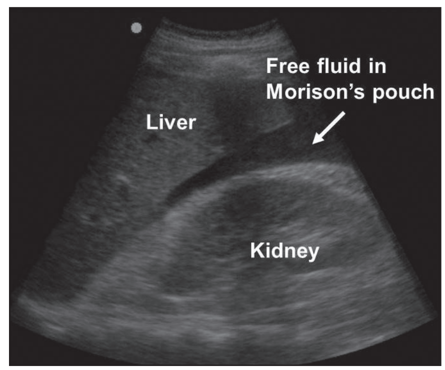
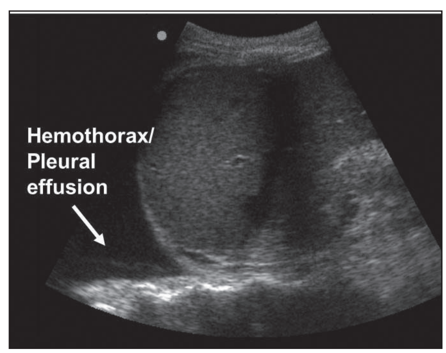


Figure 2C. Hemothorax/ Pleural Effusion



Compared to the FAST exam, a CT scan is more sensitive for the detection of intraperitoneal hemorrhage and solid injury and, thus, is the study of choice for stable patients.[10] However, CT scan warrants exposure to radiation and often requires patients to be transported out of the resuscitation area. Diagnostic peritoneal lavage (DPL), while highly sensitive for the detection of hemoperitoneum, carries a 1-2% complication rate and is now infrequently performed.[11]

The FAST exam consists of four views and 10 total spaces. (*See Figure 1.*) The curvilinear probe is often used for its larger footprint and excellent tissue penetration. However, the phased-array probe can also be used, as its smaller footprint enables easier cardiac imaging between the intercostal spaces. The probe indicator points toward the patient's head for the right upper quadrant and left upper quadrant views, and points toward the patient's right side for the subxiphoid and suprapubic views.

Right Upper Quadrant. This view consists of Morison's pouch (hepatorenal space), right subphrenic, inferior pole of the right kidney, and right pleural space (*see Figure 2A*). Free fluid will first accumulate at the inferior pole of the right kidney as an anechoic stripe then progress to Morison's pouch (*see Figure 2B*), the most dependent region in a supine patient. Thus, Morison's pouch has the highest sensitivity for the detection of intraperitoneal fluid. The placement of the patient in the Trendelenburg and right lateral decubitus positions can further increase the sensitivity of FAST exam. Care also should be taken to carefully isolate the area between the dome of the liver and diaphragm to identify free fluid that may accumulate there. Slight cephalad movement of the transducer allows imaging of the right pleural space for free fluid (*see Figure 2C*). Caudal probe movement allows visualization of the inferior pole of the right kidney as well as the right paracolic gutter for free

Figures 3A and 3B. Normal FAST LUQ

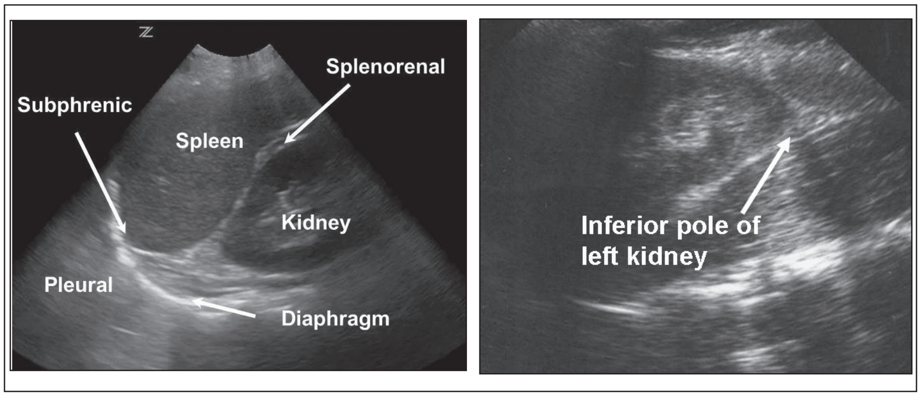
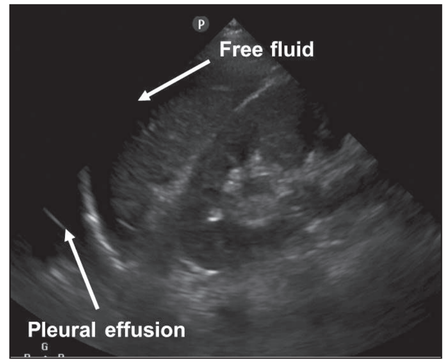


Figure 3C. Pleural Effusion and Free Fluid in Subphrenic Space



fluid assessment.[11] One study showed that a good quality FAST exam with multiple views can reliably detect as little as 200 to 250 mL of free intraperitoneal fluid,[3] while other studies showed up to 668 mL of fluid is required in supine and 443 mL in Trendelenburg patients.[12]

Left Upper Quadrant. This view consists of left subphrenic, inferior pole of the left kidney, splenorenal recess, and left pleural space (*see Figures 3A and 3B*). It is technically the most challenging view, as the splenorenal recess is more superior and posterior than the Morison's pouch. The view can be improved by placing the probe in the posterior axillary line with the operator's knuckles on the bed. The probe indicator can be rotated so that it is parallel to the rib spaces to minimize rib shadowing. The most dependent area of this view is the left subphrenic space and, thus, intraperitoneal fluid will first collect there (*see Figure 3C*).

Suprapubic. This view allows assessment of the most dependent space in the peritoneum for free fluid, which is the retrovesicular recess for males and the pouch of Douglas for females. (*See Figure 4A.*) Analysis through a fluid-filled bladder may help with the assessment of pelvic fluid. The bladder should be scanned in its entirety in both the sagittal and transverse planes. When free fluid is present, it is noted most often posterior or superior to the bladder and uterus. (*See Figure 4B.*) Free fluid from an isolated pelvic injury would accumulate first in the pelvis, then spread up to Morison's pouch, then the perisplenic area.[11]

Subxiphoid. This view uses the left lobe of the liver as an acoustic window for analysis of the heart. (*See Figure 5A.*) Sometimes, alternative cardiac windows such as the parasternal or apical 4-chamber views may be necessary if an adequate subxiphoid view cannot be obtained.[13] Fluid will appear as a dark anechoic stripe between the visceral and parietal pericardium. (*See Figure 5B.*) Epicardial fat pad may sometimes be mistaken for pericardial effusion. One can distinguish the two by noting that fat pads are attached to the heart and thus move with it during contractions; pericardial fluid or blood clots do not move with the heart.[11] The presence of cardiac tamponade (right ventricular collapse during diastole) and cardiac function abnormalities can also be assessed. The detection of posterior hemopericardium is not as sensitive as that of anterior hemopericardium, especially in the presence of concomitant left hemothorax.[11,14-17] The subxiphoid view should be repeated after the hemothorax has been evacuated by tube thoracostomy, although a false-negative remains possible if the hemopericardium continues to evacuate into the thoracic cavity.[11]

Utility of FAST Exam. The reported sensitivity of FAST for detection of free intraperitoneal fluid varies, ranging from 62% to 99%, with negative predictive values of 89% to 99%.[10,14,19] In most trauma management algorithms, if a patient is stable and needs further imaging, a CT scan is the highest sensitivity and specificity. It gives specific information about the hollow viscus and solid organs, as well as the retroperitoneum, which the FAST exam is unable to evaluate.[11,20,21]

The FAST exam has been shown to be most useful in unstable trauma patients, especially when the cause of hypotension is unclear.[20,22,23] When

Figure 4A. Normal Suprapubic

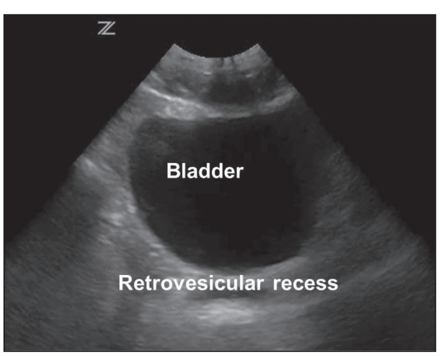


Figure 4B. Free Fluid Around Bladder

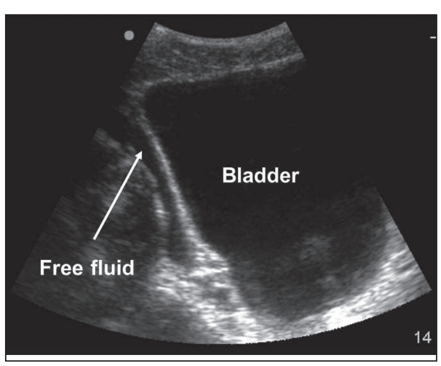


Figure 5A. Normal Subxiphoid View

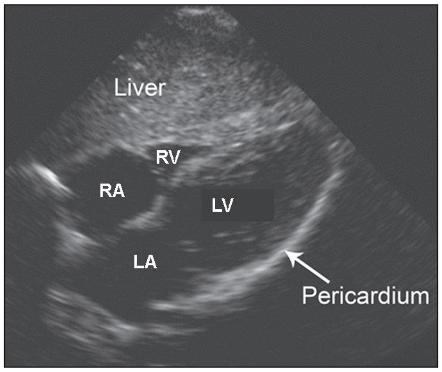


Figure 5B. Hemopericardium

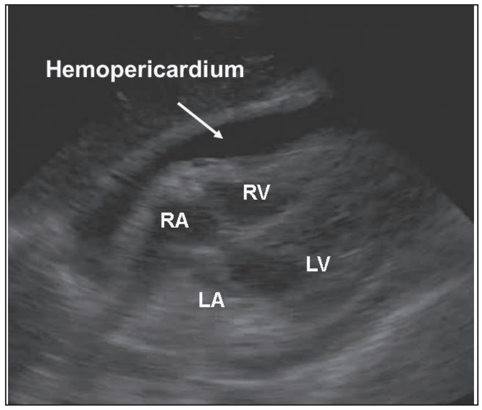


Table 4. Probe Positions for Lung Ultrasound of E-FAST

- Anterior second intercostal space at the midclavicular line
- Fourth intercostal space at the anterior axillary line
- Sixth intercostal space at the midaxillary line
- Sixth intercostal space at the posterior axillary line

transporting the patient to the CT scanner is not an option, FAST can be used for the initial evaluation and operative planning for an unstable patient. In addition, the detection of hemopericardium is also clinically useful for patients with penetrating trauma. The FAST exam can also be repeated during the patient's stay for routine reassessment or as a consequence of clinical decompensation.[11]

For the hemodynamically stable patients with penetrating injuries to the thoracoabdominal region, the sensitivity of the FAST exam for the detection of intraperitoneal fluid is variable. In a meta-analysis of eight prospective observational studies,[24] its sensitivity ranged from 24.2% to 100%, with a specificity of 94.1 to 100.0% and varied injury prevalence of 24.2% to 56.3%.[25-31] No patients with an initial negative FAST exam in these studies died. Thus, a negative FAST exam does not preclude significant intraperitoneal injury after penetrating torso trauma in a stable patient and should prompt further imaging in those with a concerning mechanism or exam. Patients without evidence of peritonitis, hemodynamic instability, or hollow viscus injuries on CT scan may undergo trial nonoperative management that involves serial clinical examinations and laboratory tests, delayed laparoscopic evaluation of the diaphragm for left thoracoabdominal injuries, or endovascular interventions for solid organ injuries.[32-33] Selective nonoperative management of both stab and gunshot injuries has been shown to be safe and can decrease the rate of unnecessary laparotomy, length of hospital stay, and management costs.[32-34]

For stable patients with blunt abdominal trauma, the FAST exam has been shown to lead to more accurate detection of intra-abdominal injury than physical examination,[21] as well as reduced time to surgery, CT use, hospital stay, complications, and cost.[35-36] Therefore, it is reasonable to use FAST as initial evaluation of blunt abdominal trauma, keeping in mind its limited sensitivity for intra-abdominal injuries.[37]

Limitations of FAST. The main limitation of the FAST examination is its limited sensitivity for the detection of injuries in the retroperitoneum, hollow viscus organs, diaphragm, or mesentery. Ultrasound may also be technically limited due to bowel gas, ascites, body habitus, subcutaneous emphysema, patient positioning, rate of bleeding, prior adhesions, and patient cooperation.[13] Patients with concerning mechanisms or abnormal hemodynamics warrant additional investigations such as

Figure 6A. Normal Lung

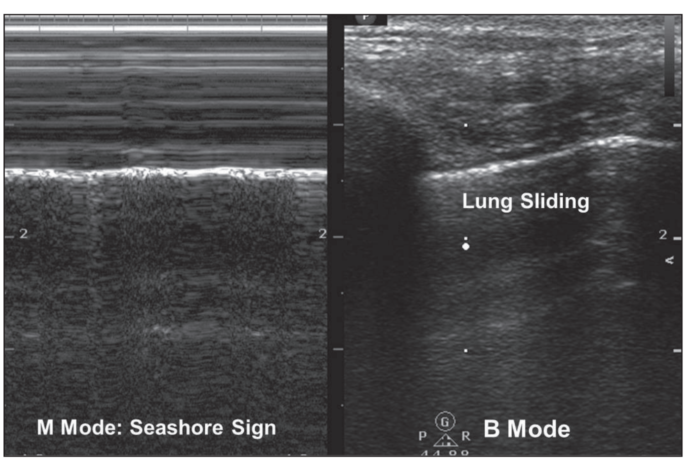


Figure 6B. Pneumothorax

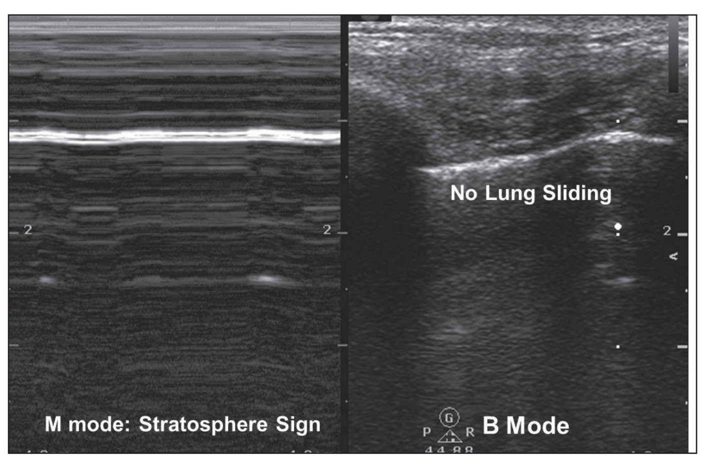
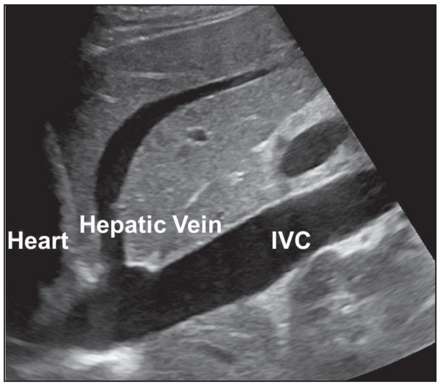


Figure 7. IVC Measurement for Volume Status



an exploratory laparotomy for unstable patients or additional CT imaging for stable patients. If it is clear that the patient will require emergent surgical intervention (e.g., bowel evisceration from a penetrating injury), then the FAST exam should be bypassed to avoid delays to definitive treatment. However, it may be necessary to exclude pericardial tamponade or pneumothorax before transferring a patient to the operating room for emergency laparotomy.[13]

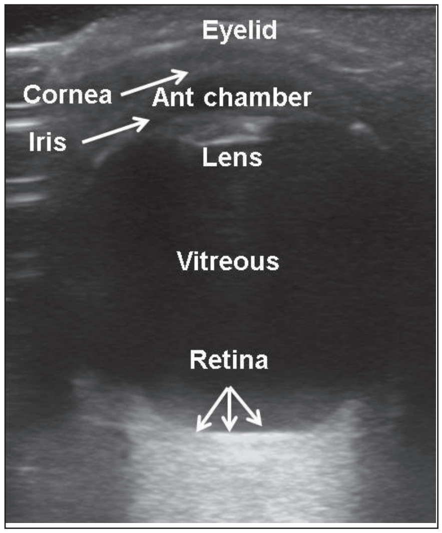
Extended FAST

Pneumothoraces are common in trauma, but more than half are missed on a supine chest radiograph.[38] POCUS has been shown to be equal or more sensitive than chest radiography, with high specificity for the diagnosis of pneumothorax in both blunt and penetrating trauma.[39-49] The expansion of the FAST exam to evaluate the lungs for the presence of pneumothorax led to the term Extended-FAST (E-FAST).

The high-frequency probe is preferred by some operators to evaluate the thoracic cavity because it provides better resolution and detail of the pleura. However, the curvilinear or phased-array probe can also be used to expedite completion of the examination. To perform the lung exam, the operator places the probe on four locations of each chest.[50] (*See Table 4.*)

Lung sliding and the presence of comet tails are evidence of movement of the visceral on the parietal pleura. Comet tails are vertical reverberation artifacts arising from the pleural line.

Figure 8A. Normal Eye



In M-mode, this lung sliding pattern is called the seashore sign.[47] (*See Figure 6A.*) Pneumothorax leads to loss of contact between the visceral and parietal pleura and the loss of lung sliding. This leads to a distinct pattern on M-mode called the stratosphere or bar code sign. (*See Figure 6B.*) Lung sliding may be absent in patients who are not spontaneously breathing, even in the absence of pneumothorax. If no lung sliding is present, subtle cardiac pulsation of the parietal pleura at the lung periphery, known as the lung pulse, may be detected. This finding is equivalent to lung sliding.[13,51] A lung point, or the transition between collapsed and normally expanded lung, is reportedly 100% specific for pneumothorax when present but may be difficult to detect.[48]

Vascular Access

POCUS has been utilized as an adjunct for central venous catheter (CVC) placement, traditionally used for internal jugular and femoral vein access. In addition, ultrasound reduces the time and number of attempts for peripheral line placement,[52] as well as the need for CVC placement due to difficult peripheral access.[53-54] The use of ultrasound has not been shown to increase infection rates compared to traditionally placed lines.[53-57] A linear probe is used with transverse and longitudinal views to optimize visualization for vascular

Figure 8B. Retinal Detachment

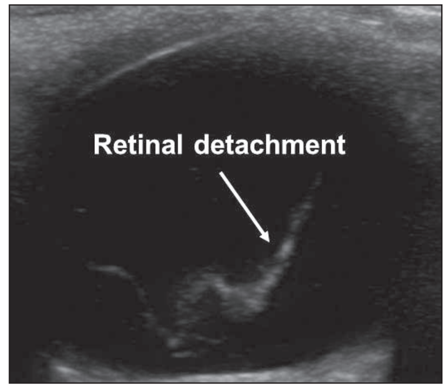
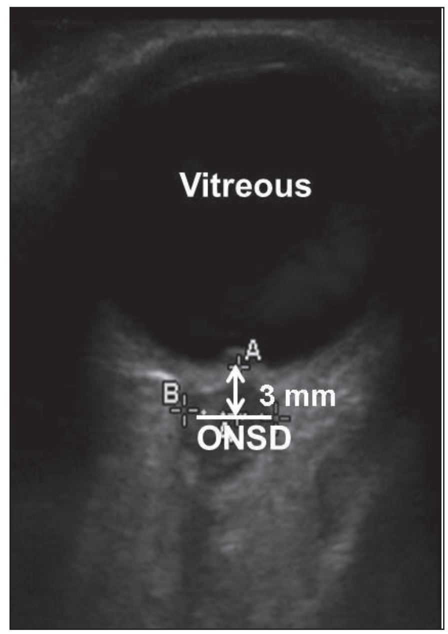


Figure 8C. ONSD for ICP



access. Color doppler can also be used to differentiate an artery from a vein.

There has been growing interest in achieving subclavian vein access through the axillary vein, which can be visualized using ultrasound just distal to the subclavian vein.[58] Ultrasound guidance resulted in faster access times and increased success at the first and second attempts for subclavian catheterization.[59] In a recent meta-analysis of 10 randomized controlled trials (total of 2168 participants) of ultrasound compared to landmark technique for subclavian catheterization, the overall complication rates were reduced with

Figure 9A. Normal Shoulder

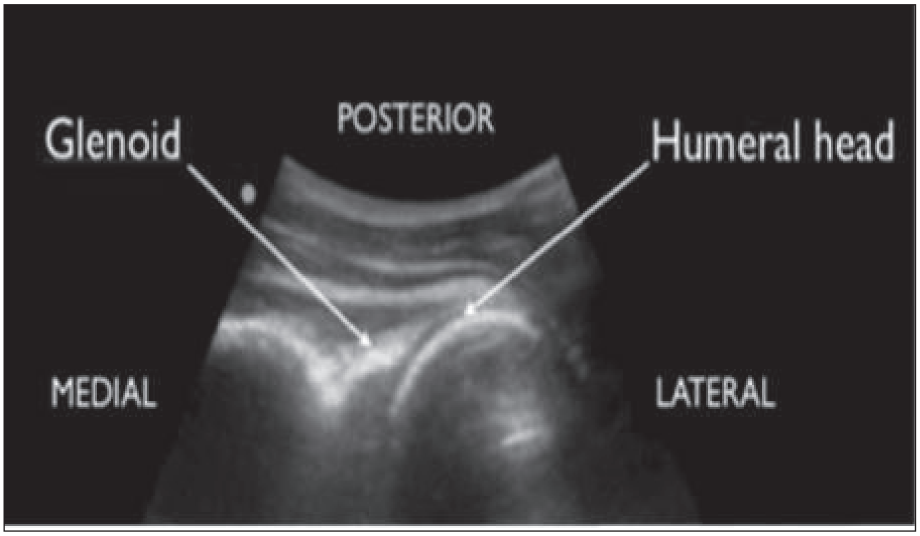
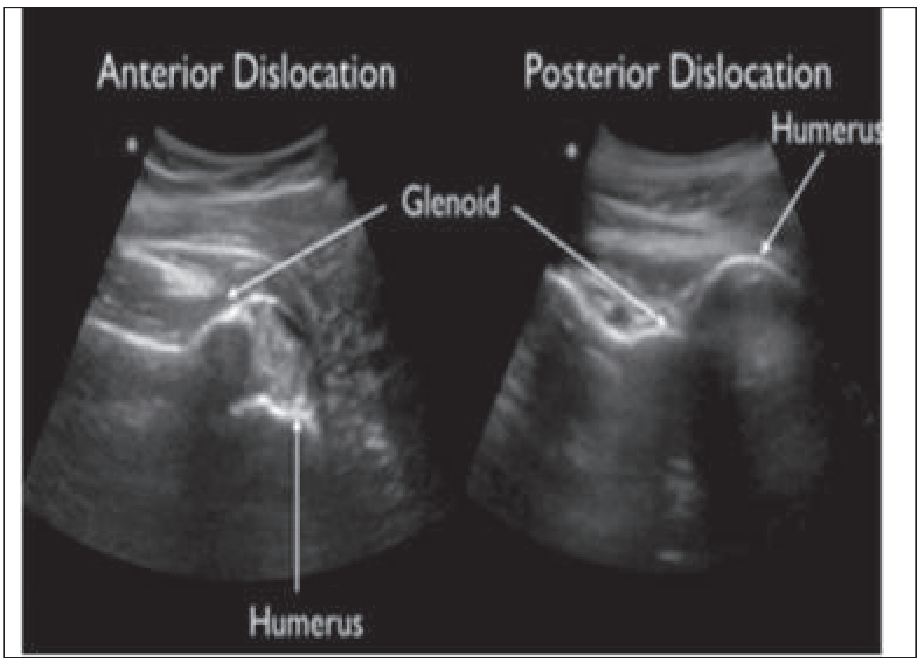


Figure 9B. Shoulder Dislocations



ultrasound use compared to the landmark group. Subgroup analysis also demonstrated that dynamic 2D ultrasound also reduced inadvertent arterial puncture, pneumothorax, and hematoma formation.[60]

Volume Status

The volume status of an injured patient can be assessed by examining the diameter of the inferior vena cava (IVC) at end expiration.[61-64] The curvilinear probe is positioned in the subxiphoid space with the indicator pointing toward the patient's head. The IVC can be seen in its long axis as it enters the right atrium. (*See Figure 7.*) The IVC diameter should be assessed 2 cm distal to the hepatic vein's entrance to the IVC.[11] A diameter of less than 2 cm at end expiration of greater than 50% collapsibility index correlates with intravascular volume depletion.[64-65]

Ocular Ultrasound

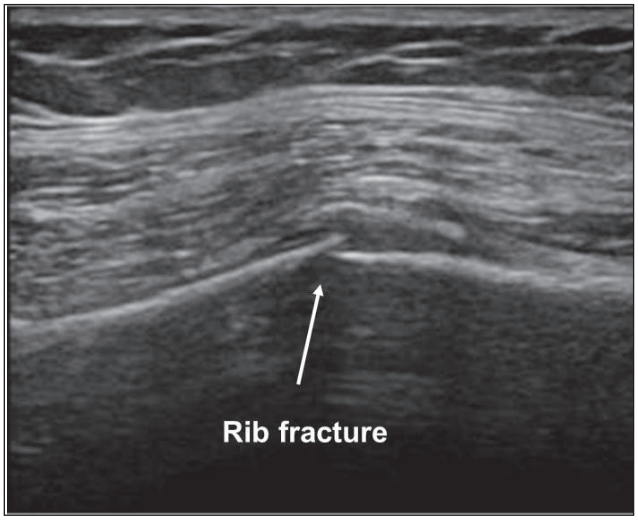
Normal Eye. Ocular ultrasound can expedite the diagnosis and management of several ocular emergencies, including globe perforation, retrobulbar hematoma, retinal detachment, lens subluxation, vitreous hemorrhage, and intraocular foreign body.[66-68] A linear transducer is most suitable for this examination. A large amount of water-soluble gel should be applied to the patient's closed eyelid so that the transducer does not touch the eyelid. The globe should be scanned in both sagittal and transverse planes through closed eyelids.

The normal eye appears as a circular hypoechoic structure. (*See Figure 8A.*) The cornea is seen as a thin hypoechoic layer parallel to the eyelid. The anterior chamber is filled with anechoic fluid and is bordered by the cornea, iris, and anterior reflection of the lens capsule. The iris and ciliary body are seen as echogenic linear structures extending from the peripheral globe toward the lens. The normal lens is anechoic. The normal vitreous chamber is filled with anechoic fluid. Vitreous is relatively echolucent in a young healthy eye. The optic nerve is visible posteriorly as a hypoechoic linear region radiating away from globe.[50,69,70]

Ocular Injuries. A retinal detachment appears as a linear opacity within the vitreous chamber that moves in conjunction with eye movements. (*See Figure 8B.*) Vitreous hemorrhage consists of wavy linear or curved strands connecting with the retina that sway as the eye moves from side to side. A vitreous detachment occurs when the vitreous humor detaches from the posterior retina, which results in a mobile "swaying seaweed" appearance on ultrasound, where the vitreous appears separated from the retina.[50,71]

Intracranial Pressure Measurement. Blaivas et al described the use of ocular ultrasound to detect elevated intracranial pressure (ICP) among adult ED patients. A normal optic nerve sheath measures up to 5.0 mm in diameter on ultrasound. The optic nerve sheath diameter (ONSD) is measured 3 mm posterior to the globe for both eyes (*see Figure 8C*) because the results are more reproducible at this location due to greatest ultrasound contrast. The operator should average two ONSD measurements. An average ONSD greater

Figure 10. Fracture on Ultrasound



than 5 mm is considered abnormal with suspected elevated ICP.[70,72,73]

Orthopedic and Soft Tissue Injuries

Shoulder Dislocation. Shoulder (glenohumeral) dislocation is a common orthopedic injury presenting to the ED, comprising about 50% of all major joint dislocations.[74] Recent literature has demonstrated the superiority of POCUS in detecting both anterior and posterior shoulder dislocations.[75-77] In addition, ultrasonography can increase the accuracy and efficacy of intra-articular anesthetic injections and, thus, eliminate the need for procedural sedation during shoulder reduction.[78]

While standing behind the affected shoulder, the operator should place the curvilinear probe parallel to and just below the scapular spine, with the indicator pointing laterally, at the level of the glenoid. Adjust the depth so that both the glenoid and humeral head are seen clearly. The humeral head will appear as a circular object located just lateral to the glenoid fossa.[79] (*See Figure 9A.*) With the more common anterior dislocation, the humeral head will be deep on the screen, while with a posterior dislocation, the humeral head will be closer to the probe and more superficial on the screen.[79-81] (*See Figure 9B.*)

Fractures. Rib fractures can also be diagnosed using ultrasound with higher sensitivity than radiographs. Fractures of the rib, costochondral junction, and costal cartilage appear as a disruption of the anterior echogenic margin of the rib. The costal cartilage normally appears relatively hypoechoic compared with the osseous rib.[50,82] Using a linear probe, a fracture is seen as a disruption of the bony contour as the rib is followed outward. (*See Figure 10.*) In addition, ultrasound has been used to diagnose other fractures, such as those of the clavicle, elbow, and distal forearm.[83-85] Ultrasound is an especially useful tool in children and pregnant women in whom minimizing radiation exposure is paramount.

Foreign Body Detection. Retained foreign body from a penetrating injury is a common problem. Although radiograph is the most often used method for detection, POCUS enables the real-time localization and extraction of the foreign body. A high-frequency linear probe is most suitable for this task. All foreign bodies appear hyperechoic but will display variable degrees of artifact. Metal and glass tend to produce reverberation artifact that is caused by the sound wave bouncing back and forth between tissue and foreign body boundaries. Wood, gravel, and plastic are hyperechoic with a trailing shadow.[86-87] Substances that have been present in the body longer than 24 hours typically have a small amount of surrounding inflammatory fluid, which appears as an anechoic halo surrounding the hyperechoic material.[88]

Nerve Blocks. Often, injured patients require anesthesia for painful procedures such as fracture reduction, incision and drainage, or complex laceration repairs. Ultrasound-guided nerve blocks can provide regional analgesia and minimize the need for large volumes of local anesthetic or procedural sedation. Nerve blocks targeting the femoral, posterior tibial, or popliteal nerves can facilitate lower extremity procedures,[89-90] while those that target the interscalene, supraclavicular, median, ulnar, or radial nerves can provide anesthesia for the upper extremities.[91-93] In addition, the elimination of procedural sedation by using nerve blocks can lead to decreased ED length-of-stay, shortened post-procedural observation periods, and high patient satisfaction.[89,91-93]

Pregnant Women

Trauma is the number one cause of pregnancy-associated maternal deaths in the United States.[94] FAST is a safe, rapid method to identify intra-abdominal free fluid in pregnant trauma patients.[95] In addition, ultrasound can assess gestational age, fetal viability, and fetal condition. Placental abruption after trauma occurs in 2% to 4% of minor accidents and in up to 50% of major injuries, and may occur without any external evidence of abdominal injury.[96] Clinical findings that indicate abruption include vaginal bleeding, abdominal cramps, uterine tenderness, amniotic fluid leakage, maternal hypovolemia, a uterus larger than normal for the gestational age, or a change in the fetal heart rate. The transabdominal ultrasound is a first-line diagnostic method to confirm the presence of abruption, but is not as sensitive as cardiotocographic monitoring.[96-98]

The left lateral decubitus position of the third trimester pregnant hypotensive patient theoretically relieves the pressure of the uterus on the IVC, thereby improving venous return. However, Fields et al found that while 76% of patients showed an increased IVC size in left lateral decubitus position, the remaining patients showed the largest IVC measurement in the supine position. The utilization of POCUS to evaluate the IVC diameter during resuscitation may help to appropriately manage the positioning for injured pregnant patients.[99]

Conclusion

POCUS enables the rapid diagnosis of critical injuries and disposition/operative management of injured patients, as well as expedites and improves the outcome of bedside procedures. This review serves as a practical guide for any clinician who wants to become more proficient with this critical clinical skill.

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CME/CNE Questions

1. FAST stands for:
   A. Fast Assessment of Sonography in Trauma
   B. Focused Abdominal Sonography in Trauma
   C. Focused Assessment with Sonography in Trauma
   D. Frequent Assessment with Sonography in Trauma
2. The four views of the FAST exam consist of:
   A. subxiphoid, right upper quadrant, Morison's pouch, suprapubic
   B. subxiphoid, right upper quadrant, left upper quadrant, left lower quadrant
   C. parasternal long, right upper quadrant, suprapubic, right anterior chest
   D. subxiphoid, right upper quadrant, left upper quadrant, suprapubic
3. What is the most dependent area of a supine patient?
   A. Morison's pouch
   B. pouch of Douglas
   C. subphrenic area
   D. splenorenal recess
4. How does fluid appear on ultrasound?
   A. hyperechoic
   B. anechoic
   C. isoechoic
   D. superechoic
5. A patient presents to the ED with a stab wound to the the left chest. His vital signs are: blood pressure 85/50, heart rate 130, respiratory rate 35. The FAST exam shows a large left pleural effusion but no pericardial effusion. Given these findings, one can assume that the patient does not have a cardiac injury.
   A. true
   B. false
6. What does lung sliding represent?
   A. the movement of the visceral pleura on the parietal pleura
   B. the interface between fluid and lung
   C. the interface between aerated and compressed lung
   D. the presence of blood in the pleural space
7. The order of sensitivity from least to greatest for pneumothorax detection is:
   A. CT scan, chest X-ray, chest ultrasound
   B. chest X-ray, CT scan, chest ultrasound
   C. chest ultrasound, chest X-ray, CT scan
   D. chest X-ray, chest ultrasound, CT scan
8. Where should the IVC diameter be assessed for volume status?
   A. 2 cm distal from hepatic vein's entrance to the IVC
   B. at the junction of the right atrium and IVC
   C. 2 cm distal from the suprarenal vein's entrance to the IVC
   D. anywhere on the IVC
9. On ultrasound, what is the normal optic nerve sheath diameter measurement, and at what distance posterior to the globe?
   A. 1 cm, 3 cm
   B. 1 mm, 3 mm
   C. 5 mm, 3 mm
   D. 5 cm, 3 cm
10. The best ultrasound probe for foreign body detection is:
   A. curvilinear probe
   B. phased-array probe
   C. linear probe
   D. endocavitary probe

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