*Advanced Emergency Nursing Journal*
Vol. 41, No. 4, pp. 290–305


IMAGING

Column Editor: Denise R. Ramponi, DNP, FNP-C, ENP-BC, FAEN, FAANP, CEN

CE

# The Use of Ultrasonography in the Emergency Department to Screen Patients After Blunt and Penetrating Trauma: A Clinical Update for the Advanced Practice Provider

***Juan M. González, DNP***
***Johis Ortega, PhD***
***Nichole Crenshaw, DNP***
***Lila de Tantillo, PhD, MS, RN***

**ABSTRACT**
Use of bedside ultrasonography to identify life-threatening injuries for patients with blunt and penetrating trauma is the standard of care in the emergency department. The "FAST" examination—focused assessment with sonography for trauma—ultrasound scan of the chest and abdomen allows clinicians to assess critical regions for free fluid without use of invasive procedures as quickly and as often as needed. In addition, ultrasonography has a high degree of sensitivity and specificity and is safe during pregnancy. For patients requiring evaluation of the pleura, the "eFAST" (or extended FAST) may be conducted, which may serve to locate pleural effusions, hemothorax, and pneumothorax. However, ultrasound quality is operator dependent and is recommended with other diagnostic measures to provide a complete clinical picture of trauma patients. Ongoing development of ultrasound competency among established clinicians and nurse practitioner students is vital to maintain diagnostic accuracy and ensure quality care for trauma patients in the emergency department.
**Key words:** emergency department, standard of care, trauma, ultrasonography, ultrasound

***Author Affiliations:*** *University of Miami School of Nursing and Health Studies, Coral Gables, Florida. (Drs González, Ortega, Crenshaw, de Tantillo); and Jacksonville University, Keigwin School of Nursing, Jacksonville, Florida (Dr de Tantillo).*

*Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (http://www.aenjournal.com).*

***Disclosure:*** *The authors report no conflicts of interest.*

***Corresponding Author:*** *Juan M. González, DNP, University of Miami School of Nursing and Health Studies, 5030 Brunson Dr, Coral Gables, FL 33146 (j.gonzalez48@miami.edu).*

*DOI: 10.1097/TME.0000000000000267*

JACQUES AND PIERRE CURIE first described in 1880 the piezoelectric effect now used in ultrasonography (Manbachi & Cobbold, 2011). During subsequent years, the use of ultrasonography has broadened and evolved. In the 1970s, German and Japanese physicians initiated the use of ultrasonography for point-of-care sonography for evaluation in trauma (Hsu & Menaker, 2016). The Society of Point of Care Ultrasound (2017) defines point-of-care ultrasonography (or POCUS) as an ultrasound scan performed and interpreted by the clinician at the point of care to interrogate a clinical question or assist with a procedure. In this context, ultrasonic waves can be used as a diagnostic tool as well as a treatment modality incorporated in rehabilitation therapy (Wan, 2013). In 1984, Tiling, Schmid, Maurer, and Kaiser published one of the classic works in the ultrasound literature comparing ultrasonography with traditional diagnostic peritoneal lavage (DPL). According to Rozycki, Ochsner, Jaffin, and Champion (1993), ultrasonography was being used in treatment of trauma injuries in Germany but not adopted as the standard of care in the United States. The use of ultrasonography subsequently began to expand in the United States, especially in the emergency care setting (Hsu & Menaker, 2016; Rozycki et al., 1995).

Trauma is a leading cause of morbidity and mortality in the United States (Hsu & Menaker, 2016; Wongwaisayawan et al., 2015). In 2013, more than 31 million emergency department visits and $400 billion in medical expenses and loss of productivity resulted from patients affected by trauma (Hsu & Menaker, 2016). Point-of-care ultrasonography allows clinicians to rapidly identify life-threatening injuries without the use of invasive procedures (Hsu & Menaker, 2016; Montoya et al., 2016; Sue, 2015; Wongwaisayawan et al., 2015). Ultrasonography can be used extensively in the emergency department, allowing advanced practice providers to evaluate patients with blunt and penetrating trauma quickly. The use of ultrasonography for evaluation of patients with chest and abdominal trauma was introduced in the 1990s and has gained more popularity in the recent years as evidence has grown in support of the practice (Smith & Wood, 2014). Clinicians have been able to use ultrasonography to assist with invasive procedures such as central line placement, nerve block, and pericardiocentesis (American College of Emergency Physicians, 2017a). In 1997, the Advanced Trauma Life Support (ATLS) course began to include ultrasonography as an alternative to the traditional DPL (Catán, Villao, & Astudillo, 2011).

Previous research studies have been published describing the utility of ultrasonography as well as its moderate to high sensitivity and specificity compared with other modalities such as radiography, computed tomographic (CT) scan, and physical examination alone to identify hemoperitoneum, pericardial effusions, and pneumothoraces resulting from trauma (Sauter, Hoess, Lehmann, Exadaktylos, & Haider, 2017; Smith & Wood, 2014). When compared with radiography and physical examination alone, ultrasound modality is more sensitive and specific than radiography in identifying patients with a pneumothorax (Alrajhi, Woo, & Vaillancourt, 2012; Raimondi et al., 2016). Focused assessment with sonography in trauma (FAST) has been found to have a sensitivity of 92%–100% and a specificity of 94%–99% (Rippey & Royse, 2009). The sensitivity of the FAST has been found to be higher for blunt abdominal trauma than for penetrating abdominal trauma (Smith & Wood, 2014). Several factors may affect the sensitivity of the FAST, such as comorbidities and the clinician performing the examination. Importantly, ultrasonic waves are usually dispersed by air, which can affect the quality of the image and therefore the sensitivity of the test (Hoskins, 2010). Also, small amounts of bleeding in the cavity may not be picked up by the ultrasonography, also affecting its sensitivity (Rippey & Royse, 2009). In addition to its use with abdominal trauma, some studies have supported the use of a FAST examination in patients with other medical problems, such as hemodynamic instability and respiratory distress (Javedani, Oulton, Metzger, & Adhikari, 2016; Patel, Narasimhan, & Koenig, 2013). There has also been research supporting the use of ultrasonography in the prehospital setting to identify pneumothoraces as well as injuries in the abdomen and chest from blunt trauma (Ketelaars, Hoogerwerf, & Scheffer, 2013; MacDonald & Alqattan, 2017; O'Dochartaigh & Douma, 2015; Press et al., 2014). The American College of Emergency Physicians (2001, 2017a) recommends bedside ultrasonography for patients who have experienced blunt abdominal trauma, penetrating trauma, unexplained hypotension after trauma, and trauma during pregnancy.

There are several reasons why ultrasonography is an ideal initial test to perform during the evaluation of a patient with traumatic injuries to the chest and abdomen (Catán et al., 2011; Dinamarca, 2013; Montoya et al. 2016). Ultrasonography can help accurately identify patients who have free fluid in the abdominal or thoracic cavity and decrease the time it requires a clinician to achieve a diagnosis (Giraldo-Restrepo & Serna-Jiménez, 2015). It can be utilized repeatedly to assess the evolution of a patient's condition over time (Hsu & Menaker, 2016). This modality of imaging is considered safe for pregnancy and has also been found to decrease the number of less desirable procedures, such chest tubes, DPLs, and radiation modalities such as CT scanning (Montoya et al., 2016; Smith & Wood, 2014).

The FAST examination traditionally involves the pericardial, perihepatic, perisplenic, and pelvic views, often referred to as "the four Ps" (Montoya et al., 2016). Utilizing the ultrasound waves permits the practitioner to evaluate the patient and determine next steps based on findings such as the presence of blood in the peritoneal cavity, along with the patient's hemodynamic stability (Rippey & Royse, 2009). In 1995, Rozycki et al. published a prospective study that compared ultrasonography with DPL and CT scanning on patients who had experienced abdominal trauma. In that study, the utility of this four-view ultrasound modality was demonstrated to be helpful in disseminating its use in the United States. In this research study, 371 patients were scanned during a period of 20 months in a Level 1 trauma center, with ultrasonography as the main adjuvant modality in addition to the physical examination. Patients who were not hemodynamically stable and needed immediate surgery were excluded from the study. Examinations were performed by attending general surgeons, trauma fellows, or senior general surgical residents. Among the patients examined, 295 (79.5%) had suffered blunt trauma and the remaining 76 had penetrating injuries. The average examination time in this study was 2.5 minutes. Ultrasonography was found to have 81.5% sensitivity and 99.7% specificity detecting free fluid after a chest or abdominal trauma. Of the scans performed, 305 were true negatives, 53 true positives, 12 false negatives, and one false positive. From the 12 false-negative group, six had penetrating and six had blunt injuries. All the patients who had penetrating injuries had exploratory surgery without delay confirming the false-negative result. All six remaining patients with blunt trauma had exploratory surgery as well due to clinical change after the initial ultrasound scan. Patients with true-negative results had a repeat scan after 12–24 hr and patients with true-positive results had a repeat test after 2–12 hr to confirm the results (Rozycki et al., 1995).

The term FAST originally meant "Focused Abdominal Assessment for the Sonographic examination of the Trauma patient" (Han, Rozycki, Schmidt, & Feliciano, 1996). However, the FAST consensus conference changed the term to "Focused Assessment with Sonography for Trauma" to reflect an assessment more inclusive than the abdomen and includes areas such as the pericardium, considered particularly important during a chest trauma (Montoya et al., 2016). As the sonography field has evolved and expanded, so has the FAST ultrasonography. Among clinicians, it was apparent that many patients required visualization of the pleural space to look for fluid and air. Because pneumothoraces are common in traumas and frequently missed by radiography, ultrasonography began to play an important role in assessment of these abnormalities (Alrajhi et al., 2012). These developments led to the extended or eFAST protocol (Montoya et al., 2016). As this procedure has advanced, clinicians have been able to assess for pleural effusion, hemothorax, as well as pneumothorax, adding an additional component to the FAST ultrasonography (Montoya et al., 2016; Press et al., 2013). The term eFAST is therefore given when examination of the pleura is included in an extended study (Montoya et al., 2016; Rippey & Royse, 2009) (see Figure 1). An eFAST is considered positive if any fluid is identified in the abdomen or thorax and if there is lack of pleural movement, as in the case of a pneumothorax (Dammers, El Moumni, Hoogland, Veeger, & Ter Avest, 2017; Dinamarca, 2013; Hsu & Menaker, 2016; Montoya et al., 2016; Wongwaisayawan et al., 2015). A negative eFAST examination would be confirmed by the absence of fluid in those areas and the presence of pleural sliding (Dammers et al., 2017; Dinamarca, 2013; Montoya et al., 2016; Hsu & Menaker, 2016; Wongwaisayawan et al., 2015).

Emergency department clinicians using bedside ultrasonography when caring for patients with traumatic injuries should be aware of several limitations of this technology. This imaging technique should not be used as a stand-alone modality; ultrasonography should be confirmed with other modalities such as CT scan, especially among patients experiencing hemodynamic instability or high clinical suspicion (Dammers et al., 2017) (see Figure 2). Also, the quality of the eFAST ultrasonography is operator dependent (Kessler, 2017; Smith & Wood, 2014). In addition, this ultrasound modality may not be able to identify the precise location of an injury in cases when it does not appear hypoechoic. The recommendation for these patients would be to provide a CT scan or a comprehensive

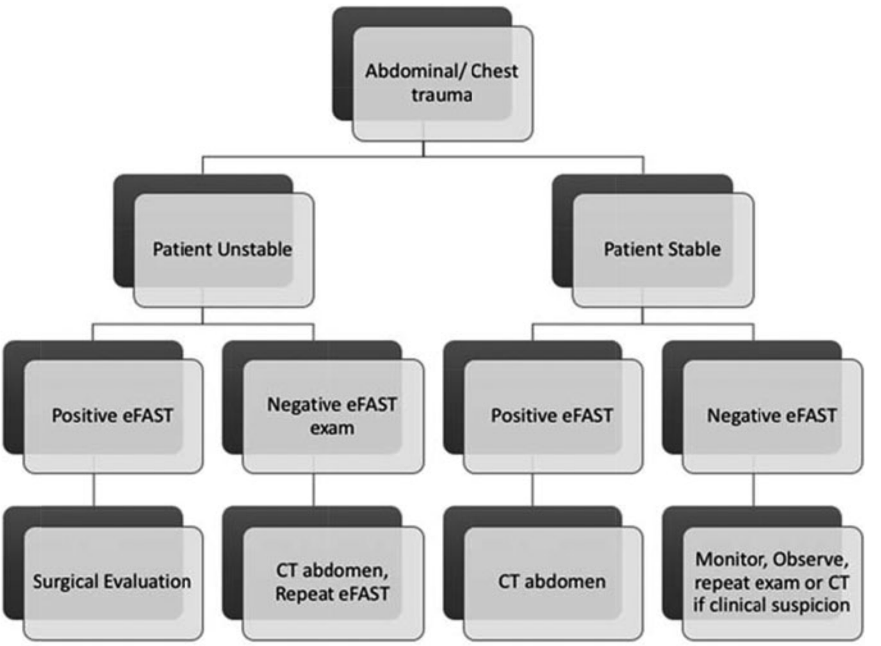


**Figure 1.** eFAST protocol for abdominal and chest trauma. CT = computed tomography. From "Ultrasound in Trauma," by J. C. R. Rippey and A. G. Royse, 2009, Best Practice & Research Clinical Anaesthesiology, *23*(3), pp. 343–362. Copyright 2009 by Elsevier Ltd. Adapted with permission.

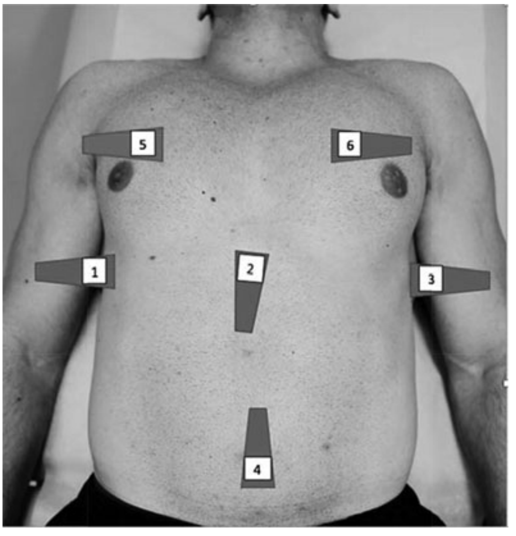


**Figure 2.** Windows of the eFAST examination. Original photograph courtesy of Juan M. Gonzalez.

ultrasonography for those who are not a candidate for CT scan (Rippey & Royse, 2009). In addition, some false-positive findings of hemorrhage have been documented with the use of eFAST ultrasonography. This is particularly the case when examining fluid-filled visceral organs such as the stomach or areas of the abdomen with excess fluid, for instance, ascites (Giraldo-Restrepo & Serna Jiménez, 2015; Sue, 2015). Another potential area of concern is that ultrasonography may miss bleeding in the retroperitoneal space and during very early evaluation of injuries (Montoya et al., 2016). Clinicians should also note that this imaging modality may have limitations evaluating patients with large body habitus, as excess fat can easily be confused for fluid or hematoma (Sue, 2015). Although the use of FAST ultrasonography has been increasing among the pediatric population, at this time there are few studies to support the sensitivity and specificity in this group (Kessler, 2017).

## FOUNDATIONS OF ULTRASOUND PHYSICS

The ability of the advanced practice provider to understand the essential components of ultrasonography will affect the use and application of the procedure. The principles of ultrasonography depend on the piezoelectric crystals found in the head of the transducer connected to the ultrasound machine (Hoskins, 2010). The provider should be conscious of the machine's pulse–echo, considered its ability to turn electricity to vibration with the use of these piezoelectric crystals and interpret the vibration that returns as a pixilated image on the screen (Hoskins, 2010). Pulse is the term that describes the waves formed by the transducer sent to the tissues, and echo refers to the vibrations that are produced by the tissues sent back to the transducer and the machine (Hoskins, 2010).

It is necessary to recognize that different mediums will transmit ultrasound waves differently. This is influenced by echogenicity, the ability of a structure to cause or produce an echo (Hoskins, 2010). Areas such as air will have the slowest velocity, distorting the image of the ultrasound, and bone will have the fastest velocity, allowing the vibrations to return to the transducer very quickly (Hoskins, 2010). These different velocities will also translate to different shades of gray, white, and black on the screen, producing different echogenic images.

Images that have no echo are considered to be anechoic. Fluids are known to be anechoic and typically look black in ultrasonography. Hypoechoic is when the structure produces less of an echo than surrounding tissues (Gunderman, 2014; Hoskins, 2010; Hsu & Menaker, 2016). This effect in the ultrasound image is shown as dark gray. Sometimes, hematomas may appear as hypoechoic (Gunderman, 2014; Hoskins, 2010; Hsu & Menaker, 2016). Isoechoic is when the image has the same level of echogenicity as surrounding tissues. In an ultrasound scan, normal tissues appear light gray in the ultrasound screen. Hyperechoic is when the structure or area has a higher echogenicity than surrounding tissues (Hoskins, 2010; Hsu & Menaker, 2016). A hyperechoic image typically appears to be white and stands out in comparison with surrounding structures (see Figures 3 and 4). An example would be stones inside the gallbladder.

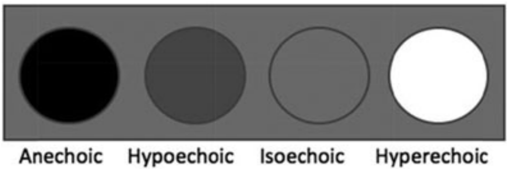


**Figure 3.** Levels of echogenicity. Illustration is the original artwork of Juan M. Gonzalez.

The transducer used for the procedure will provide not only different quality images but also different depths. It is essential for the clinician to be familiar with the primary transducers, also known as probes, utilized and which ones would be appropriate to conduct the eFAST examination. Transducers are equipped with different frequencies. As a general rule, the higher the frequency, the increased quality of the picture and also the reduced ability of its probe to penetrate into the deeper aspects of the body (Hsu & Menaker, 2016). These transducers are useful for vascular procedures or to observe structures located reasonably superficial such as the pleura (Hsu & Menaker, 2016). Low-frequency probes will be able to penetrate deeper, although the quality of the image is affected. Low-frequency ultrasounds range from 5 to 2 MHz and high-frequency ultrasounds range from 10 to 5 MHz (Hsu & Menaker, 2016; Sue, 2015).

The curvilinear (also known as curved array) and the phased array probes are two well-known low-frequency probes that are used for the eFAST examination in the evaluation of the abdominal and cardiac structures (Hsu & Menaker, 2016; Sue, 2015). Between the two probes, the phased array probe has a smaller dimension that allows it to obtain a better picture of the heart from the parasternal view (Hsu & Menaker, 2016). The parasternal view is typically used when the subxiphoid view is not optimal (Reardon, 2008). The linear sequential array is a high-frequency probe used for evaluation of the pleura during the eFAST examination (Hsu & Menaker, 2016; see Figure 5).

Ultrasound machines may have different settings. Typically, for advanced practice providers, the most important areas to review are the power button, gain, depth, brightness mode (B mode), time–motion mode (M mode), color flow or Doppler mode, and being able to freeze and save images when scanning patients. The gain will change the brightness of the picture, whereas the depth varies the amount of penetration seen on the screen. The B mode uses a grayscale to show a two-dimensional image (Hoskins, 2010; Hsu & Menaker, 2016; see Figure 6). The transducer will affect the depth depicted in the image. "M mode" or time–motion mode is a setting used for evaluation of the pleura (Gillman & Kirkpatrick, 2012; see Figure 7). The color flow or Doppler mode is utilized to assess

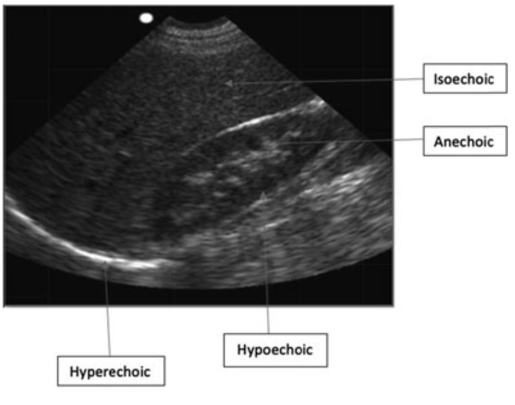


**Figure 4.** Levels of echogenicity in ultrasound image.

**Figure 5.** Curvilinear, phased array, and linear probes (from left to right). Photograph courtesy of Nichole Crenshaw.

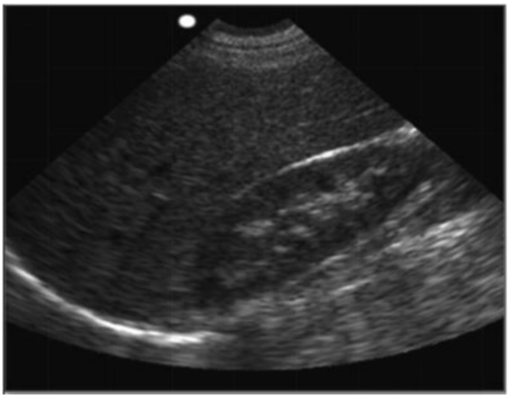

**Figure 6.** B mode image. Photograph reprinted with permission from SonoSim.


**Figure 8.** Color Doppler. Photograph courtesy of Nichole Crenshaw. (Color image is available as SDC at http://links.lww.com/AENJ/A42)

vascular structures. With the color setting, a clinician can display colors to differentiate fluid going toward and away from the transducer, the standard configuration being fluid going toward the transducer looks red and away from it is shown as blue. This setting may be changed by the user, so it is not absolute (Hoskins, 2010; McDicken & Hoskins, 2014; see Figure 8, Color image is available as SDC at http://links.lww.com/AENJ/A42).

When scanning patients with ultrasonography, the advanced practice provider should have a clear understanding of the different anatomical planes and the orientation of the transducer. The patient can be scanned using transverse, coronal, and sagittal planes (Gunderman, 2014). The transverse plane is also known as the cross-sectional plane, and the sagittal plane is also known as the longitudinal plane (Gunderman, 2014; see Figure 9). When scanning a patient from the sagittal plane, the transducer indicator should be facing the head of the patient (Sue, 2015). When scanning a patient from the transverse plane, the indicator should generally be facing the anatomical right of

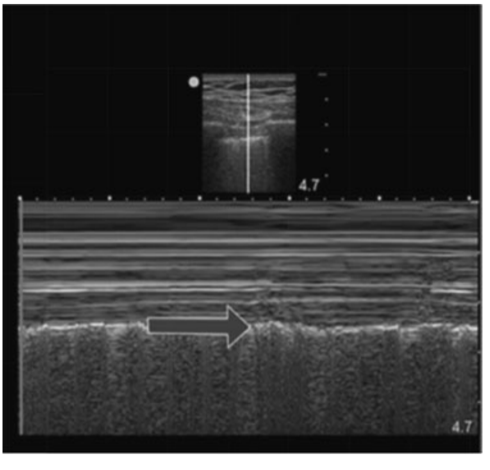


**Figure 7.** M mode image. Photograph reprinted with permission from SonoSim.

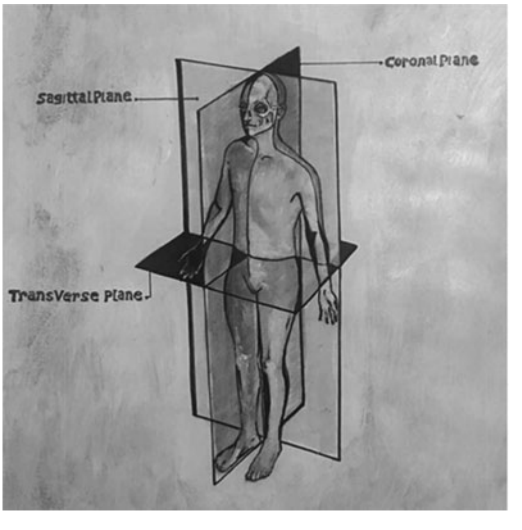


**Figure 9.** Different planes used for ultrasonography. Illustration is the original artwork of Yusmel Jimenez.

the patient (Sue, 2015). An exception to this rule is when completing the parasternal view of the heart, as the indicator would be facing the anatomical left of the patient. In the coronal plane, the indicator will face toward the patient's head (Sue, 2015).

When performing an ultrasound procedure, the advanced practice provider needs to be aware of the limitations of the image as well as some possible artifacts, or false images, that may occur while scanning a patient. Sometimes, these artifacts can be used to confirm and reject specific diagnoses (Catán et al., 2011; Gillman & Kirkpatrick, 2012; Hoskins, 2010; Raimondi et al., 2016).

One common form of artifact is a mirror image. This is a false image that forms as the sound travels at different velocities. An example of this mirror image is seen when scanning the right upper quadrant during the eFAST examination (Hoskins, 2010; Wongwaisayawan et al., 2015). In this portion of the examination, the reflection of the liver is seen in the area above the diaphragm. This artifact creating a mirror image is considered a normal finding. When this mirror image is not present, then there is a possibility of fluid in the chest cavity (Rippey & Royse, 2009; Wongwaisayawan et al., 2015).

Another common artifact during ultrasonography is acoustic shadowing (Hoskins, 2010; Wongwaisayawan et al., 2015). The artifact occurs because ultrasonic waves cannot penetrate bone, creating a shadow in the path of the wave. This artifact is experienced often when looking at the heart from the parasternal view or during the assessment of the lung pleura (see Figure 10). The ribs will produce a shadow seen on the screen as dark vertical lines. Acoustic shadowing is also considered to be a normal finding (Hoskins, 2010; Wongwaisayawan et al., 2015).

## EXTENDED FOCUSED ASSESSMENT WITH SONOGRAPHY FOR TRAUMA

### Right Upper Quadrant

Scanning of the right upper quadrant assesses the perihepatic space (Wongwaisayawan et al., 2015). For right upper quadrant scanning, the clinician will use either a phased array probe or a curvilinear probe. The transducer is placed in the midaxillary line in a coronal plane, and the marker would be facing the head of the patient. From this location, the practitioner would be scanning for the kidney and the connection of the kidney to the liver, known as the hepatorenal junction or Morrison's pouch (see Figure 11). To be able to find this location quickly, the clinician can draw an imaginary horizontal line from the subxiphoid area. This is known as the horizontal subxiphoid (HS) line. Where this HS line meets the midaxillary line is the H point where most individuals will

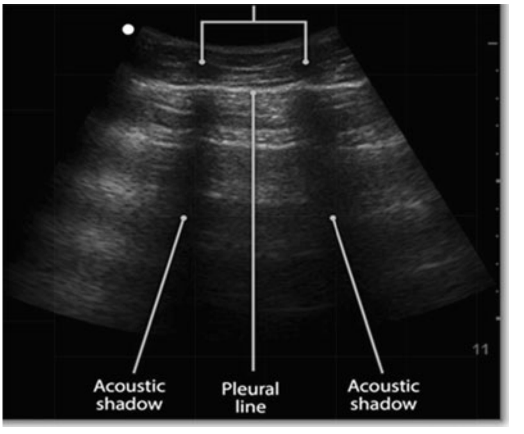


**Figure 10.** Acoustic shadowing artifact. Illustration reprinted with permission from SonoSim.

**Figure 11.** Right upper quadrant ultrasound probe position. Photograph courtesy of Nichole Crenshaw.

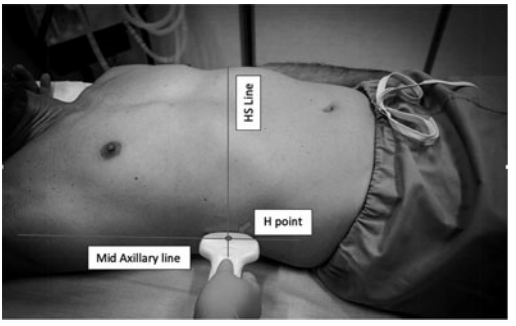


**Figure 12.** H point location. HS = horizontal subxiphoid. Photograph courtesy of Nichole Crenshaw.

**Figure 14.** Left upper quadrant ultrasound probe position. Photograph courtesy of Nichole Crenshaw.

have the window to the hepatorenal space (Wongwaisayawan et al., 2015; see Figure 12). The presence of any fluid in this area would be considered abnormal and warrant further evaluation by the advanced practice provider. In addition, the clinician would observe for the mirror effect of the liver to rule out the possibility of fluid in the pleural space (see Figure 13).

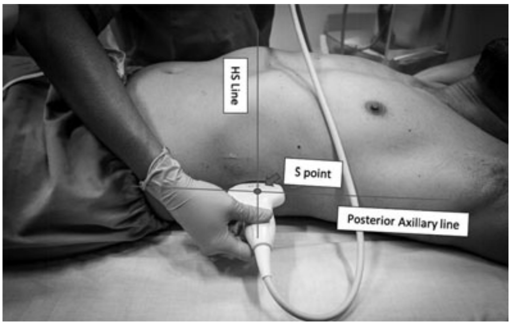


**Figure 15.** S point location. HS = horizontal subxiphoid. Photography courtesy of Nichole Crenshaw.

## Left Upper Quadrant

During the scanning of the left upper quadrant, the clinician evaluates the perisplenic view created by the spleen and the left kidney (see Figure 14). The HS line intersection with the posterior axillary line creates the "S point" where the splenorenal recess can be found (Wongwaisayawan et al., 2015; see Figure 15). In this area, the transducer would be placed in a coronal plane, with the transducer marker facing the head of the patient. The practitioner evaluates for fluid at the junction of the spleen and the left kidney or the splenorenal junction. Any fluid

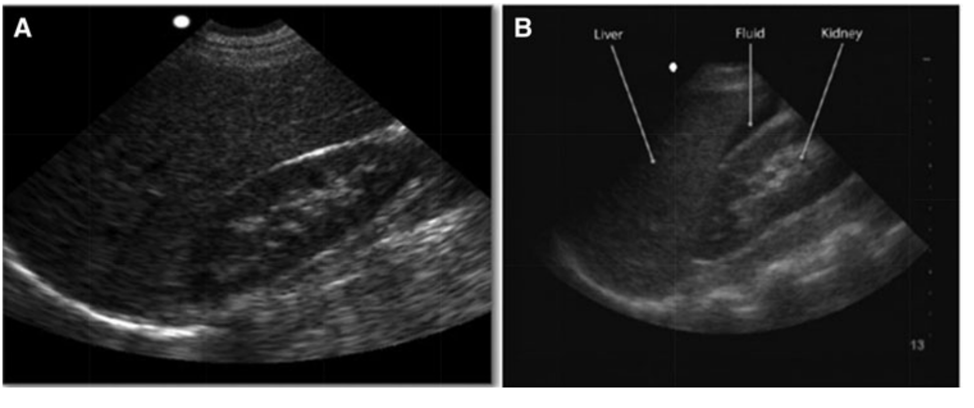


**Figure 13.** (A) Normal right upper quadrant window. (B) Abnormal right upper quadrant window with free fluid. Illustrations reprinted with permission from SonoSim.

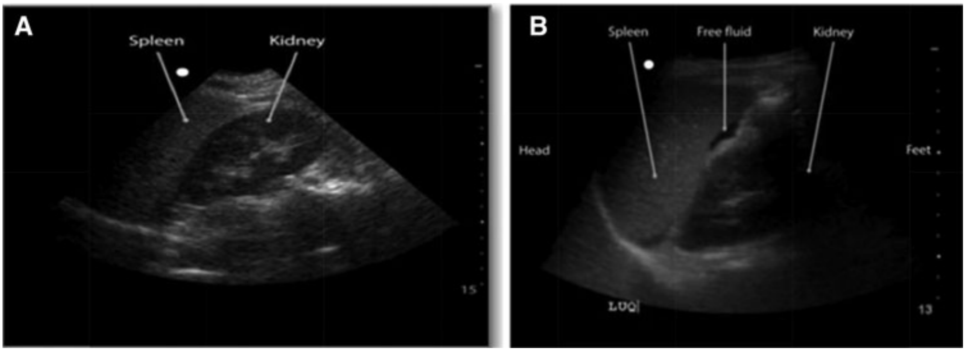


**Figure 16.** (A) Normal left upper quadrant window. (B) Abnormal left upper quadrant window with free fluid in the perisplenic area. Illustrations reprinted with permission from SonoSim.

in this area would be considered abnormal (Wongwaisayawan et al., 2015; see Figure 16).

### Pelvic Region

During this portion of the examination, the patient's bladder would be scanned using the longitudinal view, also known as sagittal view, and the transverse view. The clinician first places the transducer in the sagittal view, with the end of the probe near the pubic symphysis (see Figure 17). As the landmarks are identified, the practitioner rotates the probe to a transverse plane and continues to evaluate for free fluid around the bladder (see Figure 18). An empty bladder will reduce the accuracy of the FAST examination (Wongwaisayawan et al., 2015). It is important that the advanced practice provider should assess for free fluid in the rectovesical area in males and the rectouterine area in females.

### Pericardial Region

The pericardium can be assessed from two different views. The first is the subcostal view (also known as the subxiphoid view) and the second is the intercostal parasternal view (see Figure 19). Around the heart, there should be no more than 5 mm of space, as this distance represents the normal amount of pericardial fluid. Any greater area would be considered abnormal and regarded as a pericardial effusion. The advanced practice provider can quantify the size of the pericardial effusion by the measurements. A measurement of 5–10 mm would be a

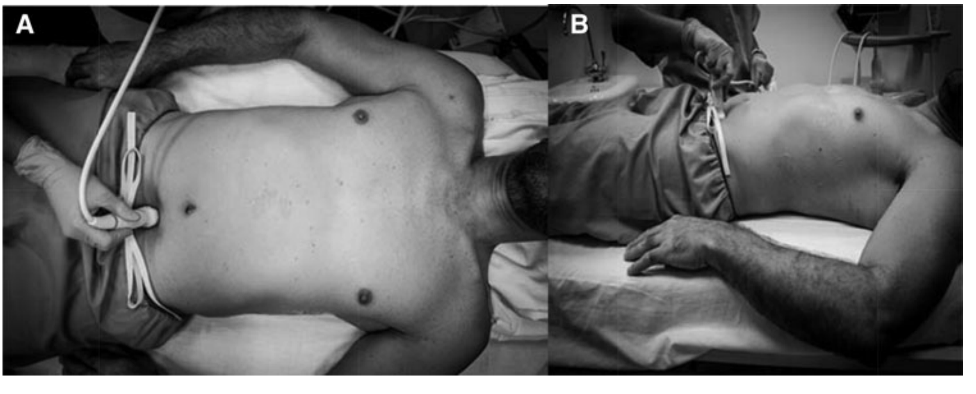


**Figure 17.** Suprapubic ultrasound probe: (A) sagittal position; (B) transverse position. Photographs courtesy of Nichole Crenshaw.

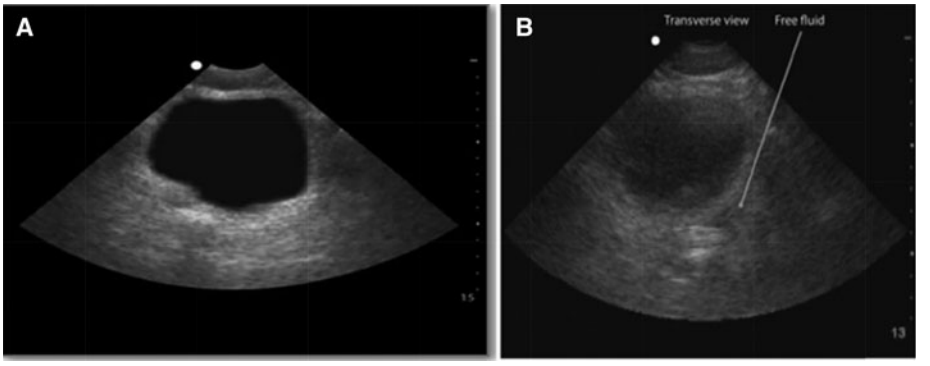


**Figure 18.** (A) Normal view of the bladder. (B) Abnormal view with free fluid around the bladder. Illustrations reprinted with permission from SonoSim.

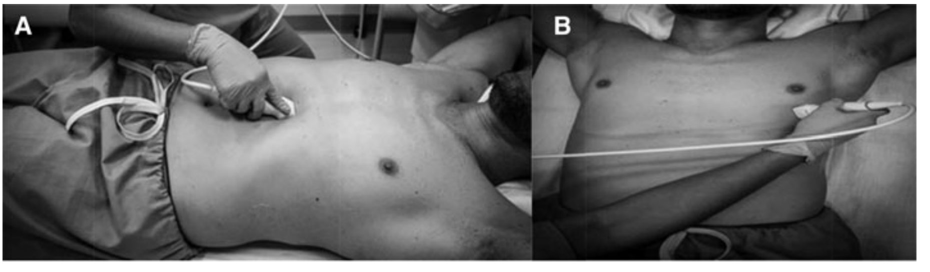


**Figure 19.** Cardiac view probe position: (A) subxiphoid; (B) parasternal long axis. Photograph courtesy of Nichole Crenshaw.

moderate effusion and greater than 10 mm would be considered severe (see Figures 20 and 21). In addition, the clinician would look for a collapsing of the right ventricle, the hallmark sign of cardiac tamponade.

### Extended Examination: Pleura

The extended portion of the ultrasonography is the evaluation of the pleura for hemothorax or pleural effusion. The clinician can evaluate pleural space for fluid while assessing

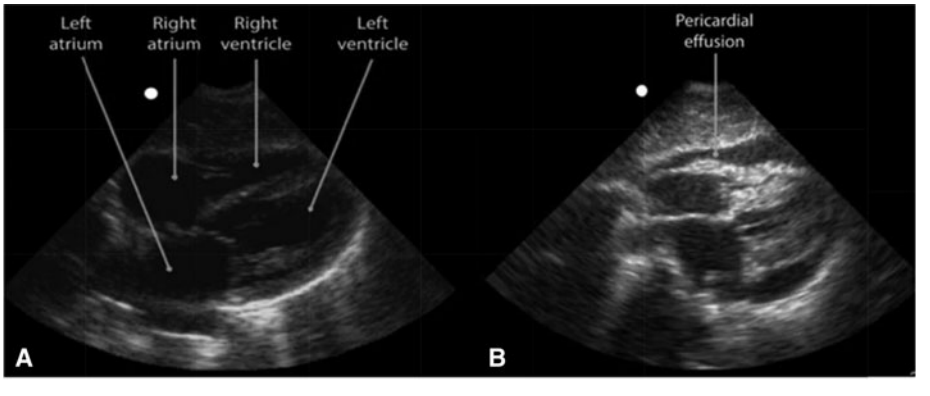


**Figure 20.** Subxiphoid view of the heart: (A) normal; (B) abnormal (fluid in the pericardium). Illustrations reprinted with permission from SonoSim.

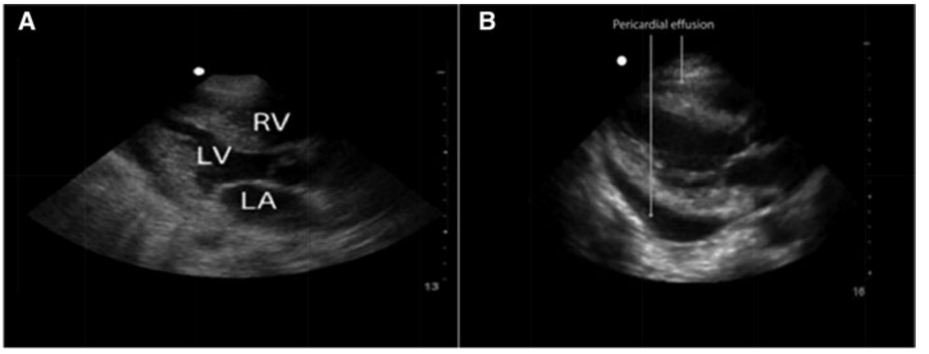


**Figure 21.** Parasternal long axis view of the heart: (A) normal; (B) abnormal (fluid in the pericardium). LA = left atrium; LV = left ventricle; RV = right ventricle. Illustrations reprinted with permission from SonoSim.

the right and left upper quadrants in the FAST examination with the transducer in the coronal plane. A mirror image artifact is frequently seen in these areas. This image forms when organs are located in front of strong reflecting structures such as the diaphragm. If the mirror image of the liver or spleen is absent, the clinician will suspect the presence of fluid, such as a pleural effusion or hemothorax, in the space where the mirror image would normally be located. In addition, because in this case the sound waves can be transmitted through that fluid, the spine may be visualized below the diaphragm (Ahmed, Martin, Saul, & Lewiss, 2014; Wongwaisayawan et al., 2015). This abnormal finding known as the "spine sign" helps confirm the presence of fluid in the thorax (Ahmed et al., 2014; see Figure 22).

## Extended Examination: Lung Field and Sliding

At this point, the linear array high-frequency probe is used to evaluate movement of the pleura as it will provide superior visualization for superficial structures (Wongwaisayawan et al., 2015). With the patient in the supine position, the probe is placed in the sagittal plane at the midclavicular line and also at the fourth or fifth intercostal space midaxillary line (Wongwaisayawan et al., 2015).

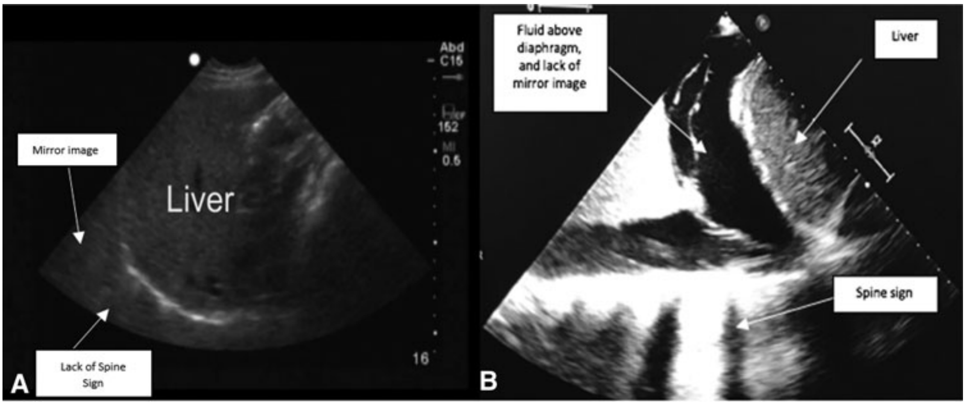


**Figure 22.** Right pleura. (A) Normal view, normal mirror image, and no spine sign. (B) Right pleura, abnormal view, positive anechoic with spine sign and lack of mirror image. Illustration (A) reprinted with permission from SonoSim. Illustration (B) is an original image courtesy of Nichole Crenshaw.

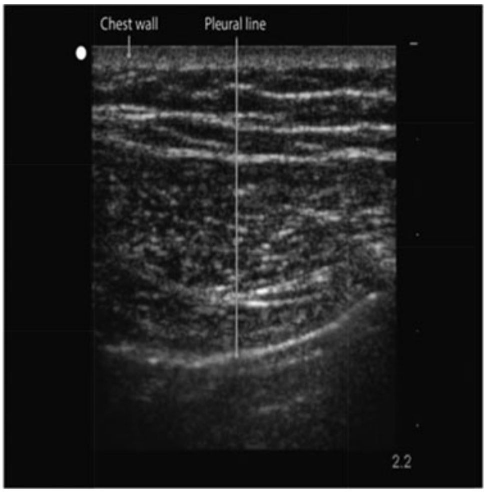


**Figure 23.** Assessment of pleural sliding while on B mode. Illustration reprinted with permission from SonoSim.

The practitioner will be assessing for pleural sliding in this location (see Figure 23). In addition, the clinician will be assessing for the presence of B lines or comet tails to support the absence of pneumothorax (see Figure 24). Once pleural sliding has been identified, it can be confirmed by changing the ultrasonography to "M mode." A pattern known as the seashore is observed in patients who do not have a pneumothorax. If the patient has a pneumothorax, no pleural sliding is seen, and the seashore pattern is not present in the M mode (Wongwaisayawan et al., 2015; see Figure 25).

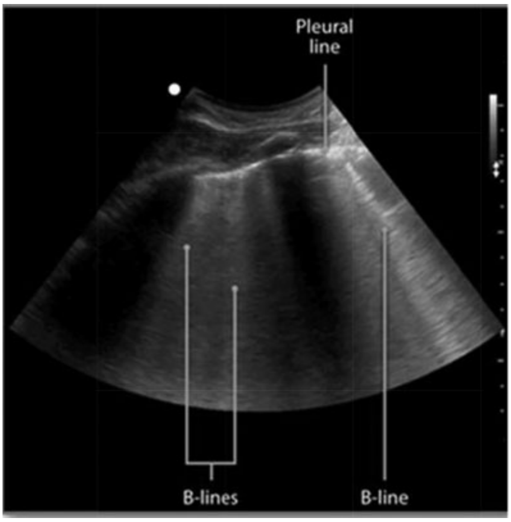


**Figure 24.** B lines or "comet tail" artifact support lack of pneumothorax. Illustration reprinted with permission from SonoSim.

## IMPLICATIONS FOR ADVANCED PRACTICE PROVIDERS AND NURSE PRACTITIONER STUDENTS

Developing competency of the eFAST examination as an advanced practice provider is increasingly important when working in the emergency department setting. The role of the ultrasonography has expanded considerably during the past 20 years, and nurse practitioners caring for patients with potential abdominal trauma must be prepared to utilize this diagnostic tool. Programs training nurse practitioner students should support ultrasound diagnostic courses to help practitioners achieve mastery of this skill before graduation. Of note, the American College Emergency of Physicians (2017a, 2017b) recently delineated the importance of training in ultrasound use and how to implement a combination of didactic courses and skills to help their residents achieve mastery of this content. There is variability in opinions regarding the necessary number of hours of training emergency clinicians should receive related to the use of POCUS. One recent study supports a 1-hr didactic training, followed by objective structured examination (OSCE), to improve the ability of students to complete the eFAST examination in under 6 min as well as increase diagnostic accuracy (Krause et al., 2017). In contrast, the American College of Emergency Physicians recommends a more formalized approach to educating clinicians about POCUS. The group describes a linear process that includes establishing ultrasound educational needs, educational goals, designing a curriculum for ultrasonography, implementing this curriculum, and assessing the educational outcome through competency (American College of Emergency Physicians, 2017b). In 2017, the American

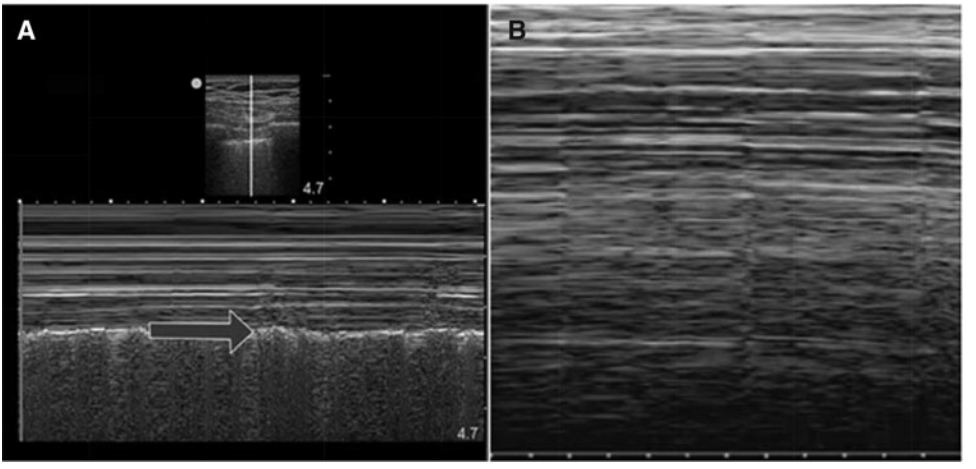


**Figure 25.** (A) Normal pleural sliding "seashore sign" on M mode. (B) Abnormal pleural sliding "stratosphere sign." Illustrations reprinted with permission from SonoSim.

College of Emergency Physicians also released a detailed policy statement delineating ultrasound guidelines for emergency point of care. Recommendations included that a trainee should generally complete 25–50 examinations per area and subsequent quality assurance (5%–10% of examinations) to ensure continued competency (American College of Emergency Physicians, 2017a). It is stressed how there is difference in the learning curve of clinicians training with POCUS and this should be considered during training.

Nursing schools can utilize a similar pedagogical approach to help nurse practitioner students develop this skill set. By providing ultrasound knowledge and training throughout the academic programs, nurse practitioners will be equipped with a core level of competence in this field upon entering the workplace setting. Being a user-dependent skill, the more students are exposed to these techniques and the greater feedback is given to them while performing this examination, the more likely they are to use ultrasonography in the future with enhanced diagnostic accuracy to the benefit of trauma patients in emergency settings. A combination of didactic training, simulation, objective testing, and feedback while training can help nurse practitioner students and those who have not received formalized training in ultrasonography achieve mastery of this important skill. At this time more than ever nurse practitioners and other advanced practice providers are in the forefront of health care and need to continue advancing the profession with clinical competence of technologically driven skills that improve patient outcomes and provide quality care.

## REFERENCES

Ahmed, A. A. R., Martin, J. A., Saul, T., & Lewiss, R. E. (2014). The thoracic spine sign in bedside ultrasound: Three cases report. *Medical Ultrasonography*, *16*(2), 179–181.

Alrajhi, K., Woo, M., & Vaillancourt, C. (2012). Test characteristics of ultrasonography for the detection of pneumothorax: A systematic review and meta-analysis. Chest, *141*(3), 703–708.

American College of Emergency Physicians. (2001). ACEP emergency ultrasound guidelines—2001. *Annals of Emergency Medicine*, *38*(4), 470.

American College of Emergency Physicians. (2017a). Ultrasound guidelines: Emergency, point-of-care and clinical ultrasound guidelines in medicine. *Annals of Emergency Medicine*, *69*(5), e27–e54.

American College of Emergency Physicians. (2017b). *Ultrasound training in CCM programs*. Retrieved from https://www.acep.org/how-we-serve/sections/critical-care-medicine/news/july-2017/ultrasound-training-in-ccm-programs/#sm.0000065v02mblfercwroja0cvmztk

Catán, G. F., Villao, M. D., & Astudillo, D. C. (2011). Ecografía FAST en la evaluación de pacientes traumatizados. *Revista Médica Clínica Las Condes*, *22*(5), 633–639.

Dammers, D., El Moumni, M., Hoogland, I. I., Veeger, N., & Ter Avest, E. (2017). Should we perform a FAST exam in haemodynamically stable patients presenting after blunt abdominal injury: A retrospective cohort study. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, *25*(1), 1.

Dinamarca, O. V. (2013). Ecografía abdominal dedicada al trauma (FAST). *Revista Médica Clínica Las Condes*, *24*(1), 63–67.

Gillman, L. M., & Kirkpatrick, A. W. (2012). Portable bedside ultrasound: The visual stethoscope of the 21 century. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, *20*, 18.

Giraldo-Restrepo, J., & Serna-Jiménez, T. J. (2015). Examen FAST y FAST extendido. *Revista Colombiana de Anestesiología*, *43*(4), 299–306.

Gunderman, R. B. (2014). Radiology 101. *Academic Radiology*, *21*(7), 945.

Han, D. C., Rozycki, G. S., Schmidt, J. A., & Feliciano, D. V. (1996). Ultrasound training during ATLS: An early start for surgical interns. *Journal of Trauma and Acute Care Surgery*, *41*(2), 208–213.

Hoskins, P. R. (2010). In P. Hoskins, K. Martin, & A. Thrush (Eds.), *Diagnostic ultrasound physics and equipment* (2nd ed.). Cambridge, England: Cambridge University Press.

Hsu, C. H., & Menaker, J. (2016). Ultrasound for trauma. *Trauma Reports*, *17*(1). Retrieved from http://access.library.miami.edu/login?url=https://search.proquest.com/docview/1992261055?accountid=14585

Javedani, P., Oulton, J., Metzger, G., & Adhikari, S. (2016). 358 Use of focused assessment with sonography for trauma examination skills in the evaluation of medical patients. *Annals of Emergency Medicine*, *68*(4), S137.

Kessler, D. O. (2017). Abdominal ultrasound for pediatric blunt trauma: FAST is not always better. *JAMA*, *317*(22), 2283.

Ketelaars, R., Hoogerwerf, N., & Scheffer, G. J. (2013). Prehospital chest ultrasound by a Dutch helicopter emergency medical service. *Journal of Emergency Medicine*, *44*(4), 811–817.

Krause, C., Krause, R., Krause, R., Gomez, N., Jafry, Z., & Dinh, V. A. (2017). Effectiveness of a 1-hour extended focused assessment with sonography in trauma session in the medical student surgery clerkship. *Journal of Surgical Education*, *74*(6), 968–974.

Macdonald, R. D., & Alqattan, S. (2017). Articles that may change your practice: Prehospital ultrasound. *Air Medical Journal*, *36*(1), 16–18.

Manbachi, A., & Cobbold, R. S. (2011). Development and application of piezoelectric materials for ultrasound generation and detection. *Ultrasound*, *19*(4), 187–196.

McDicken, W. N., & Hoskins, P. R. (2014). Physics: Principles, practice and artefacts. *Clinical doppler ultrasound* (3rd ed., pp. 1-25). Philadelphia, PA: Elsevier Health Sciences. Retrieved from https://www.clinicalkey.com/#!/content/book/3-s2.0-B9780702050152000010

Montoya, J., Stawicki, S. P., Evans, D. C., Bahner, D. P., Sparks, S., Sharpe, R. P., & Cipolla, J. (2016). From FAST to E-FAST: An overview of the evolution of ultrasound-based traumatic injury assessment. *European Journal of Trauma and Emergency Surgery*, *42*(2), 119–126.

O'Dochartaigh, D., & Douma, M. (2015). Prehospital ultrasound of the abdomen and thorax changes trauma patient management: A systematic review. *Injury*, *46*(11), 2093–2102.

Patel, P., Narasimhan, M., & Koenig, S. (2013). An 87-year-old woman with diabetes, hypertension, and liver cirrhosis in respiratory distress. *Chest*, *143*(6), e1–e4.

Press, G. M., Miller, S. K., Hassan, I. A., Alade, K. H., Camp, E., Junco, D. D., & Holcomb, J. B. (2014). Prospective evaluation of prehospital trauma ultrasound during aeromedical transport. *Journal of Emergency Medicine*, *47*(6), 638–645.

Press, G. M., Miller, S. K., Hassan, I. A., Blankenship, R., del Junco, D., Camp, E., & Holcomb, J. B. (2013). Evaluation of a training curriculum for prehospital trauma ultrasound. *Journal of Emergency Medicine*, *45*(6), 856–864.

Raimondi, F., Fanjul, J. R., Aversa, S., Chirico, G., Yousef, N., De Luca, D., …Migliaro, F. (2016). Lung ultrasound for diagnosing pneumothorax in the critically ill neonate. *The Journal of Pediatrics*, *175*, 74.e1–78.e1.

Rippey, J. C. R., & Royse, A. G. (2009). Ultrasound in trauma. *Best Practice & Research Clinical Anaesthesiology*, *23*(3), 343–362.

Rozycki, G. S., Ochsner, G. M., Jaffin, H. J., & Champion, R. H. (1993). Prospective evaluation of surgeons' use of ultrasound in the evaluation of trauma patients. *Journal of Trauma: Injury, Infection, and Critical Care*, *34*(4), 516–527.

Rozycki, G. S., Ochsner, M. G., Schmidt, J. A., Frankel, H. L., Davis, T. P., Wang, D., & Champion, H. R. (1995). A prospective study of surgeon-performed ultrasound as the primary adjuvant modality for injured patient assessment. *Journal of Trauma and Acute Care Surgery*, *39*(3), 492–500.

Sauter, T. C., Hoess, S., Lehmann, B., Exadaktylos, A. K., & Haider, D. G. (2017). Detection of pneumothoraces in patients with multiple blunt trauma: Use and limitations of eFAST. *Emergency Medicine Journal*, *34*(9), 568–572.

Smith, Z. A., & Wood, D. (2014). Emergency focussed assessment with sonography in trauma (FAST) and haemodynamic stability. *Emergency Medicine Journal*, *31*(4), 273–277.

Sue, K. (2015). The occasional ED ultrasound: Focused assessment with sonography for trauma (FAST). *Canadian Journal of Rural Medicine*, *20*(1), 33–39.

The Society of Point of Care Ultrasound. (2017). *Guidelines for point of care ultrasound utilization in clinical practice*. Retrieved from https://spocus.org/Practice-Guidelines

Tiling, T., Schmid, A., Maurer, J., & Kaiser, G. (1984). Wertigkeit der ultraschalldiagnostik beim stumpen bauchtrauma. *Hefte zur Unfallheilkunde*, *163*(79), 79–85.

Wan, T. (2013). Soft tissue pain and physical therapy. *Anaesthesia and Intensive Care Medicine*, *14*(11), 500–501.

Wongwaisayawan, S., Suwannanon, R., Prachanukool, T., Sricharoen, P., Saksobhavivat, N., & Kaewlai, R. (2015). Trauma ultrasound. *Ultrasound in Medicine and Biology*, *41*(10), 2543–2561.



### Test Instructions

Read the article. The test for this CE activity can only be taken online at http://www.nursingcenter.com/CE/AENJ. Tests can no longer be mailed or faxed.

You will need to create (its free!) and login to your personal CE Planner account before taking online tests. Your planner will keep track of all your Lippincott Professional Development online CE activities for you.

There is only one correct answer for each question. A passing score for this test is 13 correct answers. If you pass, you can print your certificate of earned contact hours and access the answer key. If you fail, you have the option of taking the test again at no additional cost.

For questions, contact Lippincott Professional Development: 1-800-787-8985.

- Registration deadline is September 3, 2021.

### Provider Accreditation

Lippincott Professional Development will award 1.5 contact hours for this continuing nursing education activity. This activity has been assigned 0 pharmacology credits.

Lippincott Professional Development is accredited as a provider of continuing nursing education by the American Nurses Credentialing Center's Commission on Accreditation.

This activity is also provider approved by the California Board of Registered Nursing, Provider Number CEP 11749 for 1.5 contact hours. LPD is also an approved provider of continuing nursing education by the District of Columbia, Georgia, and Florida CE Broker #50-1223.

The ANCC's accreditation status of Lippincott Professional Development refers only to its continuing nursing educational activities and does not imply Commission on Accreditation approval or endorsement of any commercial product.

Payment: The registration fee for this test is $17.95.

### Disclosure Statement

The authors and planners have disclosed that they have no significant relationship with or financial interest in any commercial companies that pertain to this educational activity.