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StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-.

Focused Assessment with Sonography for Trauma (FAST)

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Last Update: June 1, 2019.

Introduction

Traumatic injury is the leading cause of death among individuals younger than 45 years old [1]. Eighty percent of traumatic injury is blunt with the majority of deaths secondary to hypovolemic shock [2]. In fact, intraperitoneal bleeds occur in 12% of blunt trauma [3]; therefore, it is essential to identify trauma quickly. The optimal test should be rapid, accurate, and non-invasive. Historically, providers performed diagnostic peritoneal lavage (DPL) to detect hemoperitoneum. While extremely sensitive (96% to 99%) and specific (98%), DPL is an invasive procedure with a complication rate of 1% [4],[5], [6]. CT remains the gold standard for diagnosing intra-abdominal injuries detecting as little as 100 cc of intraperitoneal fluid. However, time delays and transportation out of the emergency department confound the evaluation of hemodynamically unstable patients.

The implementation of point of care ultrasound has significantly impacted the evaluation and treatment of patients [7]. Ultrasound has considerable advantages, including its bedside availability, ease of use, and reproducibility. Furthermore, it is non-invasive, employs no radiation or contrast agents, and is inexpensive. The use of ultrasound to detect intraperitoneal fluid was first described in Europe during the 1970s. However, widespread adoption in the United States did not occur until the 1990s. The Focused Assessment with Sonography in Trauma (FAST) is an ultrasound protocol developed to assess for hemoperitoneum and hemopericardium. Numerous studies have demonstrated sensitivities between 85% to 96% and specificities exceeding 98% [8]. In the subset of hypotensive trauma patients, the sensitivity of the FAST exam approaches 100%. Experienced providers perform the FAST exam in less than 5 minutes [9], and its use decreases time to surgical intervention, patient length of stay, and rates of CT and DPL[1]. Presently, more than 96% of level 1 trauma centers incorporate FAST into their trauma algorithms as does Advanced Trauma Life Support (ATLS) [10].

Recently, many institutions have introduced the Extended FAST (eFAST) protocol into their trauma algorithms. The eFAST examines each hemithorax for the presence of hemothoraces and pneumothoraces.

Anatomy and Physiology

The FAST exam evaluates the pericardium and three potential spaces within the peritoneal cavity for pathologic fluid. The right upper quadrant (RUQ) visualizes the hepatorenal recess, also known as Morrison's pouch, the right paracolic gutter, the hepato-diaphragmatic area, and the caudal edge of the left liver lobe. Position the probe in the sagittal orientation along the patient's flank at the level of the 8 to 11 rib spaces. Start with your hand against the bed to ensure visualization of the retroperitoneal kidney. The RUQ view is the most likely to detect free fluid with an overall sensitivity of 66% [11] [12]. Recent retrospective evidence suggests the area along the caudal edge of the left lobe of the liver has the highest sensitivity, exceeding 93% [11]. Most importantly, remember to assess each of these areas while scanning the RUQ.

Next, obtain subxiphoid (or subcostal) views to evaluate the pericardial space. Ultrasound detects as little as 20 cc of pericardial fluid [13] and studies have shown excellent sensitivities and specificities approaching 100% [14]. Traumatic pericardial tamponade happens rapidly with as little as 50cc to 100 cc preventing the pericardial compliance from accommodating as it does with gradually accumulating effusions common in numerous chronic medical conditions. There are several sonographic findings of cardiac tamponade. Most are beyond the scope of this review. Right ventricular collapse during ventricular diastole and inferior vena cava (IVC) plethora are the easiest and most frequently observed. The subcostal view helps differentiate between pleural and pericardial effusions as well since there is no pleural reflection present.

Following the subxiphoid view, image the left upper quadrant (LUQ) to inspect the splenorenal recess, the subphrenic space, and the left paracolic gutter, as well as the left lower hemithorax when performing an Extended FAST exam (eFAST). Obtain similar views of the right hemithorax when scanning the RUQ. For each hemithorax view, simply slide the probe cranially above the diaphragm. The presence of the hyperechoic vertebral bodies, or "spine sign," aids in identifying pleural fluid. Sensitivities and specificities of ultrasound for the detection of hemothorax are 92% to 100% [15]. Finally, suprapubic images evaluate for free fluid in the rectovesical pouch in males and the rectouterine (Pouch of Douglas) and vesicouterine pouches in females.

In addition to the anatomy described above, the eFAST incorporates views of the right and left anterior hemithoraces to detect the presence of a pneumothorax. Typically, a small amount of pleural fluid lines the interface between the parietal and visceral pleurae, allowing for synchronized lung and chest wall expansion and contraction during inhalation and exhalation, respectively. The sonographic appearance is described as pleural lung sliding or the "ants marching" sign.

Indications

Indications for the eFAST exams include:

- Blunt and/or penetrating abdominal and/or thoracic trauma
- Undifferentiated shock and/or hypotension (as part of the Rapid Ultrasound for Shock and Hypotension (RUSH) exam).

Contraindications

There are no absolute contraindications to the eFAST. However, eFAST should not delay resuscitative efforts for patients in extremis.

Equipment

The 2 MHz to 5 MHz curvilinear (or abdominal) probe is used for the eFAST exam to eliminate delays when switching between transducers. However, the phased array (or cardiac) probe is effective as well, particularly with parasternal windows. Likewise, the 5 MHz to 12 MHz linear (or vascular) probe is ideal for assessing for pleural sliding.

Technique

The eFAST exam is done in real time B-mode imaging. With the patient in the supine position at [16] the level of the examiner's waist, scan from the patient's right. This will allow the provider's right hand to manipulate the probe while the left adjusts gain and depth to optimize image acquisition. For transverse images, position the probe with the indicator toward the patient's right. For sagittal views, the indicator points in the direction of the patient's head.

RUQ: Place the curvilinear probe along the posterior to the mid-axillary line between the 8 and 11 rib spaces to establish a coronal view of the interface between the liver and right kidney, known as Morrison's pouch. Sweep anteriorly and posteriorly to evaluate the entirety of this space. Slide the probe caudally to evaluate the liver tip and the right paracolic gutter. Move the probe cephalad to visualize the diaphragm and inferior hemithorax, utilizing the liver as an acoustic window. Rib shadowing may obscure imaging. Mitigate this complication by rotating the probe to an oblique position. Additionally, if the patient is alert and cooperative, have the patient inhale deeply and hold. This will displace intraabdominal contents inferiorly below the ribs, allowing for a more complete visualization of the dependent recesses.

Pericardium: Position the probe just below the xiphoid process in the transverse orientation. Increase the depth in order to view the entire pericardium. Use the liver as an acoustic window to enhance your image. Typically, a shallow probe angle of less than 15 degrees is necessary to see the entire cardiac silhouette. An overhand grip is ideal to achieve this angle of approach. Patient body habitus can limit the subxiphoid window. Have the patient inhale deeply or try parasternal windows to assess for pathologic pericardial fluid.

LUQ: Typically, the left upper quadrant dependent recesses are more posterior and cephalad since the spleen is generally smaller than the liver. Begin with the transducer along posterior axillary line between the 6 and 9 rib spaces in the sagittal orientation. Fan anteriorly and posteriorly to survey the splenorenal and perisplenic spaces. Move cephalad to view the subphrenic space and the left inferior hemithorax. Slide caudally to image the left paracolic gutter.

Suprapubic: Locate the pubic symphysis and place the transversely oriented probe immediately cephalad to it. A full bladder is preferable, however if the bladder is decompressed aim the probe caudally. Increase the depth to visualize posterior to the bladder where free fluid collects. Sweep caudally and cephalad to obtain complete views of the rectovesical space in men and the rectouterine and vesico-uterine pouches in women. These pouches are the most dependent recesses of the intraperitoneal cavity. In order to achieve greater sensitivity, rotate the probe 90 degrees clockwise into the sagittal orientation to best assess the pouch of Douglas and vesico-uterine pouch in women.

Anterior Thoracic: With the patient supine, position the probe in the longitudinal orientation along the midclavicular line at the third to fourth intercostal space (with an upright patient the first or second intercostal space is more sensitive). This is the most anterior portion of the thoracic cavity where free air accumulates as a pneumothorax. Normally, the visceral and parietal pleurae move against one another, creating a sliding artifact known as the “ants marching” sign. Absence of this movement is indicative of disruption between the serosal membranes by the presence of air. The presence of comet tail artifacts and B-lines indicate the absence of a pneumothorax, though. [17]

If B-mode imaging is equivocal for lung sliding, change to M-mode. The resulting grayscale heterogenous image will have a distinct interface at the level of the pleurae. Normal lung sliding creates a grainy artifact below the pleural line known as the “sandy beach” or “seashore” sign. In the setting of a pneumothorax, the resulting homogenous image lacks this grainy artifact, which is known as the “barcode” or “stratosphere” sign. Likewise, the presence of a lung-point sign is virtually pathognomonic of a pneumothorax. Numerous studies have demonstrated that ultrasound is far more sensitive than plain radiography and physical exam for diagnosing pneumothoraces with specificities of 99% [18] [16].

Complications

There are no known complications from the eFAST exam. However, ultrasound has several limitations. It is only 85% sensitive requiring the presence of more than 150 cc to 200 cc of intra-peritoneal fluid to detect [19]. Serial FAST exams can help prevent false-negative studies [7]. Other false negatives include patients with delayed presentations whose hemorrhage has clotted causing a mixed echogenicity rather than the anechoic or black appearance of fresh blood or fluid. False positives include ascites, peritoneal dialysate, ruptured ovarian cysts, and ruptured ectopic pregnancies. Additionally, ultrasound cannot distinguish between blood and urine in severe pelvic trauma and cannot evaluate retroperitoneal hemorrhages.

Most importantly, the point of care ultrasound image acquisition and interpretation is limited by the provider’s experience; the patient’s body habitus; and the presence of bowel gas, pneumoperitoneum, or pneumomediastinum. Serial eFAST exams and advanced imaging are warranted in these situations based on the patient’s hemodynamic status.

Clinical Significance

Ultrasound has revolutionized the care of traumatic injuries. Numerous studies, albeit mostly observational, have demonstrated that the eFAST protocol is a clinically significant adjunct in the evaluation and treatment of trauma patients. The EAST (Eastern Association for the Surgery of Trauma) guidelines, Western Trauma Association, and ATLS recommend the eFAST as the standard of care in trauma resuscitation protocols. The eFAST has been shown to decrease time to operative intervention; patient length of stay; cost; and the rates of complications, CTs, and DPLs performed [1]. As with any imaging modality though, recognize and understand its limitations.

Enhancing Healthcare Team Outcomes

The management of trauma patients is usually with an interprofessional team including trauma nurses. While FAST is useful in trauma patients, it has limitations. Clinicians should be aware that the point of care ultrasound image acquisition and interpretation is limited by the provider’s experience; the patient’s body habitus; and the presence of bowel gas, pneumoperitoneum, or pneumomediastinum. Serial eFAST exams and advanced imaging are warranted in these situations based on the patient’s hemodynamic status. A radiologist should be consulted if one is not able to interpret the images; unfortunately this may not always be possible in the middle of the night.[20][21]

Questions

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Bookshelf ID: NBK470479 PMID: 29261902