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Extended Focused Assessment with Sonography for Trauma (eFAST): A Comprehensive Strategy for Trauma Assessment

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Abstract

Trauma is the principal cause of mortality in individuals under 45 years old, with 80% being due to blunt trauma and most deaths arising from hypovolemic shock. Intraperitoneal bleeding occurs in 12% of these cases, making swift identification of trauma critical. The ideal diagnostic test should be fast, accurate, and non-invasive. The adoption of point-of-care ultrasound has profoundly influenced the management and evaluation of trauma patients. This discussion outlines the use of the Focused Assessment with Sonography in Trauma (FAST) protocol, which evaluates for hemoperitoneum and hemopericardium and has been shown to have sensitivities of 85% to 96% and specificities over 98%. In hypotensive trauma patients, FAST's sensitivity nears 100%. Performed in under 5 minutes by skilled clinicians, FAST reduces the time to surgical intervention, shortens hospital stays, and lowers the necessity for computed tomography scans and diagnostic peritoneal lavage. Currently, over 96% of level 1 trauma centers employ FAST in their protocols, aligned with the Advanced Trauma Life Support (ATLS) guidelines. Additionally, many centers have integrated the Extended FAST (eFAST) protocol, which additionally checks each hemithorax for hemothoraces and pneumothoraces, into their procedures.

Keywords: Focused Assessment with Sonography in Trauma (FAST), extended Focused Assessment with Sonography in Trauma (eFAST), right upper quadrant, left upper quadrant, hemoperitoneum, hemothorax, trauma, non-invasive

INTRODUCTION

In the rapid environment of emergency medicine, timing is crucial. Swift and precise evaluation of trauma patients is crucial for prompt and efficient intervention. Among the array of diagnostic instruments accessible to emergency physicians, Extended Focused Assessment with Sonography for Trauma (eFAST) stands out as a valuable diagnostic resource in the treatment of trauma patients. It offers a rapid and non-invasive method for assessing potential intra-abdominal injuries, allowing for timely interventions and improved patient outcomes. Originally developed in the 1990s, eFAST has become an integral part of trauma care protocols worldwide. eFAST combines various sonographic views to assess the presence of free fluid in specific body cavities, indicative of traumatic injury [1–5].

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ANATOMY AND PHYSIOLOGY

eFAST is a focused ultrasound examination performed by healthcare providers in the emergency

or trauma setting to rapidly assess for significant intra-abdominal or pericardial fluid indicative of injury. It consists of evaluating specific areas of the body for fluid collection using ultrasound. To understand the anatomy and physiology relevant to eFAST, let us break down the key structures and their significance [6]:

Heart

- *Anatomy:* The heart is located in the mediastinum, slightly to the left of the midline. It consists of four chambers: two atria and two ventricles. The pericardium is a protective sac surrounding the heart.
- *Physiology:* The heart pumps oxygenated blood to the body and deoxygenated blood to the lungs for oxygenation. Pericardial fluid may accumulate in cases of trauma, indicating potential cardiac injury.

Right Upper Quadrant

- *Anatomy:* The right upper quadrant (RUQ) contains the liver, gallbladder, part of the pancreas, and portions of the small and large intestines.
- *Physiology:* Trauma can cause hepatic injury leading to intra-abdominal bleeding, which may manifest as fluid accumulation in this region.

Left Upper Quadrant

- *Anatomy:* The left upper quadrant (LUQ) contains the spleen, stomach, pancreas, and portions of the large and small intestines.
- *Physiology:* Splenic injury can result from trauma, leading to intra-abdominal hemorrhage, which may present as fluid collection.

Pelvis

- *Anatomy:* The pelvis contains various structures including the bladder, uterus (in females), rectum, and pelvic bones.
- *Physiology:* Bladder rupture or pelvic fractures can result from trauma, causing intra-pelvic fluid accumulation.

Right Lower Quadrant

- *Anatomy:* The right lower quadrant (RLQ) contains the appendix, ascending colon, and portions of the small intestine.
- *Physiology:* Appendiceal rupture due to trauma can lead to intra-abdominal fluid accumulation.

Left Lower Quadrant

- *Anatomy:* The left lower quadrant (LLQ) contains the descending colon and portions of the small intestine.
- *Physiology:* Trauma to the descending colon or nearby structures can result in fluid collection in this area.

During an eFAST exam, each of these anatomical regions is systematically evaluated using ultrasound to detect free fluid indicative of trauma. In a normal situation, these spaces would appear sonographically anechoic (black) or contain minimal fluid. However, in the presence of injury, echogenic (bright) fluid may be visualized, suggesting internal bleeding or injury.

Understanding the anatomy and physiology of these regions is crucial for interpreting eFAST findings accurately and promptly, enabling rapid assessment and appropriate management of trauma patients.

INDICATION

eFAST is recommended for trauma patients who are hemodynamically unstable and have sustained blunt or penetrating injuries. It is particularly useful in identifying life-threatening conditions such as

hemoperitoneum, hemothorax, or pericardial effusion. Early detection of these injuries enables prompt intervention, reducing morbidity and mortality rates associated with trauma. eFAST is commonly conducted during the initial assessment stage as outlined in the Advanced Trauma Life Support (ATLS) protocol [7–9].

- Blunt abdominal trauma
- Penetrating abdominal trauma
- Blunt thoracic trauma
- Penetrating thoracic trauma
- Undifferentiated shock (low blood pressure)

eFAST is commonly employed in various clinical settings, including:

1. *Emergency Departments:* FAST is an integral component of the primary survey in trauma resuscitation, helping clinicians quickly identify critical injuries and prioritize treatment.
2. *Prehospital Care:* Some advanced medical teams, such as helicopter emergency medical services (HEMS) or specialized trauma units, utilize FAST in the field to expedite triage and streamline patient care upon arrival at the hospital.
3. *Mass Casualty Incidents:* In scenarios involving multiple casualties, FAST can facilitate rapid assessment and triage, enabling medical teams to allocate resources effectively and address the most urgent cases promptly.

CONTRAINDICATION

There are no definitive contraindications for performing an eFAST. However, in cases where immediate life-saving interventions take precedence, such as cardiac arrest or severe hypotension requiring immediate resuscitation, EFAST may be deferred until the patient stabilizes [10–13].

EQUIPMENT

To perform eFAST, the following equipment is required:

1. *Portable ultrasound machine*: Utilizing a low-frequency curved or phased array transducer ensures clear visualization of deeper anatomical structures. The eFAST examination employs a 2 MHz to 5 MHz curved probe, eliminating the need to switch between transducers and thereby streamlining the process. Additionally, the phased array probe is effective, particularly for evaluating parasternal windows. Similarly, the 5 MHz to 12 MHz linear probe is ideal for assessing pleural sliding.
2. *Sterile gel:* Applied to the skin to facilitate acoustic coupling and improve image quality.
3. *Personal protective equipment (PPE):* Including gloves and a gown to maintain a sterile environment and ensure operator safety.

Additionally, clinicians should possess adequate training in ultrasound physics and interpretation skills to perform eFAST effectively.

TECHNIQUE

The eFAST examination involves the following steps:

- *Patient positioning:* The patient reclines on the examination table, revealing the abdomen and chest area.
- *Transducer placement:* The ultrasound transducer is applied to specific regions of interest, including the pericardium, RUQ, LUQ, and suprapubic areas.
- *Image acquisition:* Images are obtained in multiple planes to assess for the presence of free fluid within the pericardial, pleural, and peritoneal cavities.
- *Systematic evaluation:* Each component of the examination is systematically evaluated for abnormalities, with attention to detail paid to any areas of suspected injury.

COMPONENTS OF THE EXAMINATION

The eFAST examination employs real-time B-mode imaging. With the patient positioned supine at the examiner's waist level, scanning begins from the right side of the patient. This setup allows the examiner's right hand to handle the probe while the left hand adjusts settings like gain and depth to enhance image quality. When capturing transverse images, position the probe so that the indicator faces the patient's right side. For sagittal views, the indicator aligns with the direction of the patient's head [14].

The eFAST examination typically encompasses four components:

1. *Pericardial View:* This involves evaluating the pericardial space for the presence of fluid, which could indicate potential cardiac injury. Place the probe just below the xiphoid process in a transverse orientation, ensuring to increase the depth to visualize the entire pericardium. Utilize the liver as an acoustic window to improve image clarity. Ensuring a shallow probe angle of less than 15° is frequently required to visualize the entire cardiac silhouette. Employing an overhand grip can facilitate this angle of approach. Note that the patient's body habitus may limit the subxiphoid window, in which case instructing the patient to inhale deeply or exploring parasternal windows may aid in assessing for pathologic pericardial fluid.
2. *Right Upper Quadrant View:* Assess the hepatorenal space for intraperitoneal fluid, indicative of hepatic or intra-abdominal injury. Position the curved probe from the back to the middle of the axillary line, between the 8th and 11th ribs, to generate a coronal perspective of Morrison's pouch. Sweep both anteriorly and posteriorly to assess the entire area, encompassing the liver tip and right paracolic gutter. Utilize the liver as an acoustic window to visualize the diaphragm and inferior hemithorax, adjusting for potential rib shadowing by rotating the probe obliquely. For improved visualization, instruct the patient to inhale deeply, displacing intra-abdominal contents below the ribs.
3. *Left Upper Quadrant View:* Examine the splenorenal space for free fluid, indicating splenic or intra-abdominal injury. Start by placing the transducer along the posterior axillary line, between the 6th and 9th rib spaces, in a sagittal orientation. Move the transducer both anteriorly and posteriorly to examine the splenorenal and perisplenic spaces. Then, move upwards to observe the subphrenic space and the left inferior hemithorax. Finally, shift the transducer downwards to visualize the left paracolic gutter.
4. *Suprapubic View:* Assess the pelvis for the presence of fluid accumulation, which may indicate genitourinary or pelvic injury. Locate the pubic symphysis and position the transversely oriented probe just above it. Adjust the depth to visualize the posterior bladder where free fluid tends to collect, moving the probe downwards and upwards to capture comprehensive views of the rectovesical space in men and the rectouterine and vesicouterine pouches in women. Rotate the probe 90° clockwise to obtain a sagittal orientation for a more thorough examination of the pouch of Douglas and vesico-uterine pouch in women.
5. *Anterior Thoracic:* With the patient lying on their back, position the probe lengthwise along the midclavicular line between the third and fourth rib spaces (or between the first and second rib spaces if the patient is standing). This area is crucial for detecting free air accumulation indicative of a pneumothorax. Assess lung sliding by observing the movement of the visceral and parietal pleurae against each other. Utilize M-mode if B-mode imaging is inconclusive, observing for distinct interfaces and artifacts such as the "sandy beach" or "barcode" sign, indicative of a pneumothorax (Figure 1).

ADVANTAGES

- *Rapid bedside evaluation:* eFAST can be performed quickly at the point of care, allowing for immediate assessment and intervention.
- *Non-invasive:* Unlike traditional imaging modalities such as computed tomography (CT) scans, eFAST does not involve exposure to ionizing radiation or the need for contrast agents, making it safe for repeated use, particularly in pregnant patients or children.

(a) The right upper quadrant, perihepatic area and hepatorenal recess or Morison pouch
(b) The left upper quadrant, the perisplenic view
(c) The suprapubic view (pouch of Douglas),
(d) A subxiphoid pericardial view
    - The preferred initial site - free fluid with FAST - right upper quadrant view, scanned by using a lower frequency (3.5-5 MHz).

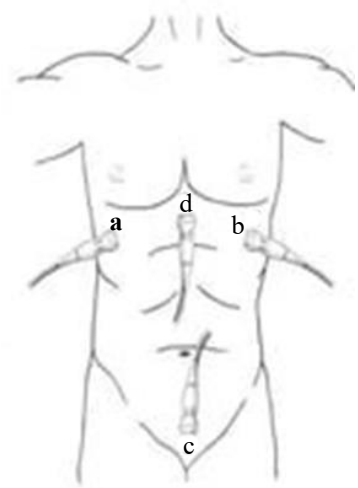

Figure 1. Extended Focused Assessment with Sonography for Trauma (eFAST) examination.

- *High sensitivity*: eFAST has demonstrated high sensitivity in detecting free fluid, aiding in the early identification of traumatic injuries.
- Helps accurately diagnose hemoperitoneum.
- Helps assess the degree of hemoperitoneum in blunt abdominal trauma.
- Can be integrated into the primary or secondary survey and can be performed quickly, without removing patients from the clinical arena.
- Can be repeated for serial examinations.
- Is safe for pregnant patients and children, as it requires less radiation than CT.
- This leads to fewer diagnostic peritoneal lavages; in the proper clinical setting, this can lead to fewer CT scans (patients admitted to the trauma service and receive serial abdominal examinations).

COMPLICATIONS

Complications from the eFAST exam are not documented; however, ultrasound does have several limitations. Its sensitivity is approximately 85%, necessitating the presence of more than 150 to 200 cm^3 of intra-peritoneal fluid for detection. To mitigate false-negative results, serial FAST exams can be conducted. False negatives may occur in patients with delayed presentations, where clotting of hemorrhage may alter the appearance of fluid, deviating from the typical anechoic or black appearance of fresh blood. False positives can occur due to conditions such as ascites, peritoneal dialysis fluid, ruptured ovarian cysts, and ruptured ectopic pregnancies. Additionally, ultrasound cannot differentiate between blood and urine in cases of severe pelvic trauma and cannot assess retroperitoneal hemorrhages.

Moreover, the ability to obtain and interpret point-of-care ultrasound images is influenced by factors such as the provider's expertise, the patient's body shape, and the presence of bowel gas, pneumoperitoneum, or pneumomediastinum. In these situations, conducting serial eFAST exams and considering advanced imaging may be necessary, depending on the patient's hemodynamic condition [15, 16].

ACCURACY OF eFAST AND CLINICAL DECISION-MAKING

- Sensitivity (69%–98%) for detection of free fluid and lower sensitivity (63%) for detection of solid organ injury.
- Underestimation of injuries and severity, especially in stable trauma patients without detectable free fluid.
- High specificity (94%–100%) for detection of free fluid and/or solid organ injury.
- Serial FAST examinations increase overall sensitivity (72%–93%).

LIMITATIONS

- *Operator-Dependent*: Skill and experience in ultrasound interpretation are crucial for accurate and reliable eFAST examinations. Inadequate training or proficiency may lead to false-negative or false-positive results, compromising patient care.
- *Limited Evaluation*: eFAST primarily focuses on identifying free fluid accumulation and may not detect all types of traumatic injuries, such as solid organ injuries or diaphragmatic injuries.
- *Diagnostic Accuracy:* Although eFAST is highly sensitive for detecting free fluid, it does not provide detailed anatomical information or differentiate between various types of fluid. In certain instances, additional imaging techniques like CT or diagnostic peritoneal lavage may be required for a thorough assessment.
- *Patient Factors:* Obesity, subcutaneous emphysema, bowel gas, and extensive trauma can obscure ultrasound images, limiting the utility of eFAST in certain patient populations or clinical scenarios.
- Identifying blunt trauma to the mesentery, bowel, diaphragm, and retroperitoneum, as well as isolated penetrating injuries to the peritoneum, can pose challenges.
- Scans may produce false-positive results, including the identification of ascites, peritoneal dialysate, ventricular peritoneal shunt outflow, ovarian hyperstimulation, and ovarian cyst rupture.
- Massive intravascular volume resuscitation false-positive eFAST examination – intravascular to intraperitoneal fluid transudation.

ENHANCING HEALTHCARE TEAM OUTCOMES

The management of trauma patients typically involves an interprofessional team that includes trauma nurses. Although FAST is a valuable tool in trauma care, it has inherent limitations. Healthcare professionals need to acknowledge that the ability to capture and analyze point-of-care ultrasound images can be affected by various factors, including the proficiency of the provider, the anatomical characteristics of the patient, and the presence of bowel gas, pneumoperitoneum, or pneumomediastinum. In cases where these limitations are evident or when there is uncertainty, clinicians should consider performing serial eFAST exams and obtaining advanced imaging, guided by the patient's hemodynamic status. If interpretation of the images proves challenging, consulting a radiologist is advisable. However, it is important to acknowledge that accessing a radiologist may not always be feasible, particularly during nighttime hours.

CONCLUSION

Extended Focused Assessment With Sonography in Trauma (eFAST) represents a valuable adjunctive tool in the management of trauma patients, offering rapid, non-invasive assessment of potential intra-abdominal injuries at the point of care. eFAST is indispensable during the primary evaluation of trauma patients, providing a swift and non-invasive approach to detect potential abdominal injuries. When performed by trained providers, eFAST can aid in timely decision-making and facilitate appropriate patient management, ultimately improving outcomes in trauma care.

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