Review Article

Focused Assessment with Sonography for Trauma (FAST)

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Abstract

The main cause of death in traumas is hypovolemic shock. Physical examination is limited to detect hemopericardium, hemoperitoneum, and hemopneumothorax. Computed tomography (CT) is the gold standard for traumatic injury evaluation. However, CT is not always available, is more expensive, and there are transportation issues, especially in hemodynamically unstable patients. In this scenario, a rapid, reproducible, portable, and noninvasive method such as ultrasound emerged, directed for detecting hemopericardium, hemoperitoneum, and hemopneumothorax, in a "point of care" modality, known as the focused assessment with sonography for trauma (FAST) protocol. With decades of experience, spread worldwide, and recommended by the most prestigious trauma care guidelines, FAST is a bedside ultrasound to be performed when accessing circulation issues of trauma patients. It is indicated to hemodynamically unstable patients with blunt abdominal trauma, with penetrating trauma of the thoracoabdominal transition (where there is doubt of penetrating the abdominal cavity) and for any patient with the cause of the instability unknown. There are four regions to be examined in the traditional FAST protocol: pericardium (to detect cardiac tamponade), right upper abdominal quadrant, left upper abdominal quadrant, and pelvis (to detect hemoperitoneum). The called extended FAST (e-FAST) protocol also searches the pleural spaces for hemothorax and pneumothorax. It is important to know the false positives and false negatives of the protocol, as well as its limitations. FAST/e-FAST protocol is designed to provide a simple "yes or no" answer regarding the presence of bleeding. It is not intended to quantify the bleeding nor evaluate organ lesions due to its limited accuracy for these purposes. Moreover, the amount of bleeding and/or the identification of organ lesions will not change patient's management: Hemodynamically unstable patients with positive FAST must go to the operating room without delay. CT should be considered for hemodynamically stable patients.

Keywords: Emergency, FAST, point of care, trauma, ultrasound

Introduction

Trauma is an important cause of death, especially in younger people. Most trauma-related injuries are blunt, and the main cause of death is hypovolemic shock.[1-3] In this scenario, a method that could identify hemopericardium, hemoperitoneum, and hemothorax, mainly in hemodynamically unstable patients is of extremely relevance; once physical examination may be not so accurate, particularly regarding hemoperitoneum. Some decades ago, physicians worldwide used diagnostic peritoneal lavage (DPL) to identify hemoperitoneum; however, despite its good sensitivity and specificity, it is an invasive procedure with possible complications, besides, surgeons and emergency physicians experience with DPL has declined over the years due to the advent of new, noninvasive methods.[4-6]

Contrast-enhanced computed tomography (CT) is considered the gold standard for the evaluation of significant traumatic injuries, and above all, it is a noninvasive method. However, CT is not always available, more expensive, and there may be transportation issues, especially in hemodynamically unstable patients, wasting valuable time that could be used to save patients' lives.[7-9] CT may detect at least 100 mL of intraperitoneal fluid.[7] Ultrasound, however, achieves 85% sensitivity for intraperitoneal fluid detection only above 150–200 mL.[10]

In this context, trauma surgeons, emergency physicians, and radiologists started using ultrasound to detect hemopericardium, hemoperitoneum, and hemothorax in the last decades. Ultrasound is not invasive as DPL, usually more available and less expensive than CT, can be performed in the emergency room, and eliminates the transportation issues

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of hemodynamically unstable patients. And so the Focused Assessment with Sonography for Trauma (FAST) emerged, as a point-of-care ultrasound modality. It started in the 1970s to detect intraperitoneal fluid, mostly in Europe. The United States effectively adopted it later, in the 1990s. The traditional FAST protocol is directed to detect hemopericardium and hemoperitoneum with sensitivity of 85%–96% and specificity more than 98%.[11,12] The extended FAST (e-FAST) protocol, known as e-FAST, adds the detection of hemothorax and even pneumothorax.[7] The most used trauma care reference worldwide, the Advanced Trauma Life Support (ATLS), included e-FAST to evaluate trauma patients with systemic arterial hypotension in the last editions, with the goal of reducing laparotomies substantially.[1,4,8,13] The eastern association for the surgery of trauma and western trauma association also incorporated e-FAST in their guidelines.[1,7] Solid organ lesions and/or fractures are not typically part of the FAST protocol due to limited sensitivity.[14,15] However, in hemodynamically stable patients without access to CT, or in pregnant patients where CT risks are a concern,[13] additional findings may be evaluated.

Indications and Contraindications

There are three classical indications:

1. Blunt abdominal trauma, hemodynamically unstable
2. Penetrating trauma of the thoracoabdominal transition, in which there is doubt of penetration into the abdominal cavity, hemodynamically unstable. If you are certain of penetration into the abdominal cavity in a hemodynamically unstable patient, laparotomy is indicated and the FAST/e-FAST protocol must not delay it
3. Hemodynamically unstable patients with unknown causes.

There are no formal contraindications, unless if performing the protocol may delay life-saving procedures. For hemodynamically stable patients, CT may be performed, when available.

Where and When

FAST/e-FAST protocol is indicated mostly to hemodynamically unstable patients; therefore, it should be performed in the emergency room, bedside. The patient transportation should be avoided at most, and the use of small, portable ultrasound devices might be of high value.

It is indicated to be performed during the letter "C" (Circulation) of the ATLS systematized "Airway, Breathing, Circulation, Disability, and Exposure (ABCDE)" trauma care, after evaluating airways and breathing. It is when accessing circulation that eventual shock syndromes and tamponade should be addressed.

How

The FAST protocol is done mainly with B-mode images using a convex, low-frequency (3.5–5 or 1–5 MHz) probe. Four regions will be addressed in the traditional FAST protocol, in this order: (1) pericardium; (2) right upper abdominal quadrant; (3) left upper abdominal quadrant; and (4) Pelvis. e-FAST protocol will also include a 5th region: the pleural spaces [Figure 1]. Usually, the patient will be in the supine position. If possible, raising or spreading the patient's arms may help evaluate the upper abdominal quadrants. Physiological fluid precautions are required for the ultrasound operator and device once the contact with blood is common in these high-energy trauma scenarios. The examination should be performed in <5 min. In experienced hands, it takes <2 min.

Pericardium

This should be the first region examined because hemopericardium is potentially more life-threatening than hemoperitoneum or hemothorax. Cardiac tamponade is a cause of cardiac arrest in asystole or pulseless electrical activity. There are two main ways of accessing the pericardial space: subxiphoid and/or anterior left intercostal views. The first one might be limited in patients with higher body mass index, however you may ask for the patient to deeply inspirate and/or use the liver left lobe as an acoustic window, if possible. Negative FAST is considered the absence or a small amount of pericardial fluid, physiological, up to 5 mm wide [Figure 2a]. A typically positive FAST would be a significant amount of pericardial fluid, responsible to explain the patient shock syndrome [Figure 2b]. If positive, the hemopericardium should be immediately resolved before continuing to the next FAST protocol regions.

Right upper abdominal quadrant

This should be the second FAST protocol region examined after confirming there is no hemopericardium. In the abdomen, it must be the first region examined because small amounts of hemoperitoneum may accumulate in

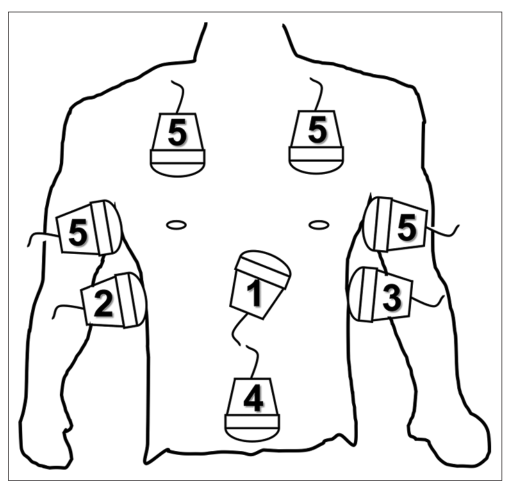

Figure 1: Schematic drawing showing the regions of the e-FAST protocol. The numbers indicate the order to be followed. (1) Pericardium; (2) upper right abdominal quadrant; (3) upper left abdominal quadrant; (4) pelvis; (5) pleural spaces – posterolateral views to search for hemothorax and anterior views to search for pneumothorax. e-FAST: Extended focused assessment with sonography for trauma

there. The hepatorenal space, known as Morrison's pouch, should be swept. Liquid in the perihepatic area should also be searched. Negative FAST is considered absolutely no fluid [Figure 3a]. Positive FAST is whether small or large amounts of fluid [Figure 3b]. If positive, you must stop the examination and send the patient to laparotomy immediately (if hemodynamically unstable).

Left upper abdominal quadrant

If the right upper abdominal quadrant is inaccessible due to traumatic lesions, subcutaneous emphysema, and arm position or without liquid, the examination must proceed to the left upper abdominal quadrant, to search for liquid in the splenorenal space and/or perisplenic. Just as in Region 2, negative FAST is considered absolutely no fluid. Positive FAST is whether small or large amounts of fluid [Figure 4]. If positive, you must stop the examination and send the patient to laparotomy immediately (if hemodynamically unstable).

Pelvis

If all regions above are FAST negative and/or inaccessible, the examination must proceed to the pelvis. One practical tip for examining this region is to perform the FAST protocol before bladder catheterization. ATLS recommends that the bladder should be catheterized also in the letter "C" of the systematized "ABCDE" trauma care. Performing FAST protocol before it might find the patients bladder full, to be used as an acoustic window for better evaluation of the pelvis. Negative FAST is the absence of fluid. The presence of any quantity of fluid in males constitutes a positive FAST exam. Conversely, females of reproductive age may exhibit physiologically small amounts of fluid in the pouch of Douglas (cul-de-sac). In such cases, a positive FAST result is only established when a large quantity of fluid is observed [Figure 5].

Pleural Spaces (extended focused assessment with sonography for trauma)

After ruling out hemopericardium and hemoperitoneum, pleural spaces should be evaluated in the e-FAST modality. There are many trauma centers, in which the extended protocol is routinely performed. This may be done in two steps: (1) examination of the posterolateral regions to search for significant pleural effusion (hemothorax) and (2) examination of the anterior thoracic regions to search for pneumothorax. Compared to plain radiographs, ultrasound presents higher sensitivity and similar specificity for detecting pleural effusion and pneumothorax.[16-20] Pneumothorax should be suspected whenever there is the absence of lung sliding once the gas in pleural space blocks the ultrasound beam and, therefore, the lung sliding movement underneath will not be able to be detected. However, there are some false positives, such as selective intubation of the contralateral lung and/or examining an area with known reduced lung sliding, for example, the anterosuperior lungs. To confirm the diagnosis of pneumothorax, it is necessary to demonstrate the "lung point," that is, the exact point of transition between normal and absent lung sliding, verifying the exact location where the pneumothorax starts.[21] Remember that a presence of a B-line excludes the possibility of pneumothorax in the examined location (once the B-line represents lung septal thickening, if the B-line can be seen, then the lung can be seen and, therefore, there is no pleural gas there to block the ultrasound beam).[22] It is important to consider that small amounts of pleural fluid and/or gas are less likely to be the cause of the patient's instability. Figure 6 shows examples of the absence and presence of a large hemothorax.

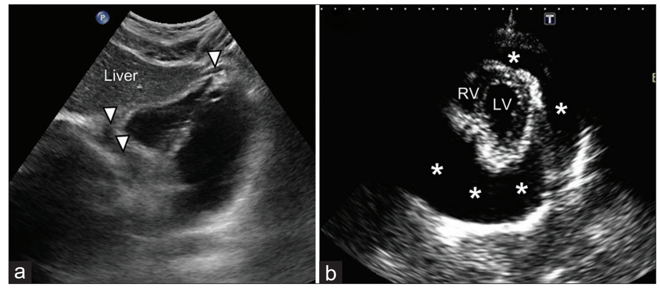

Figure 2: (a) Subxiphoid pericardium view showing physiological pericardial fluid (white arrowheads) – negative FAST, (b) anterior intercostal pericardium view showing large pericardial effusion (white asterisks), assumed to be hemopericardium in a significant trauma context – positive FAST. RV: Right ventricle; LV: Left ventricle, FAST: Focused assessment with sonography for trauma

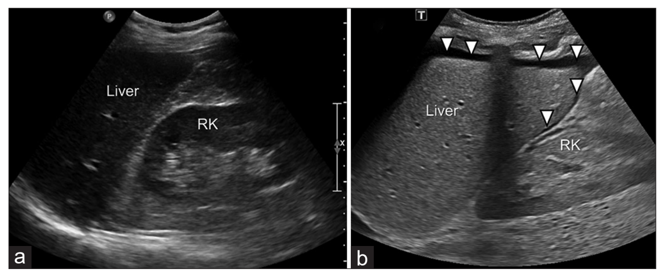

Figure 3: Upper right abdominal quadrant views with (a) absence of free fluid – negative FAST and (b) perihepatic and hepatorenal free fluid (white arrowheads), assumed to be blood in the trauma context – positive FAST. RK: Right kidney, FAST: Focused assessment with sonography for trauma

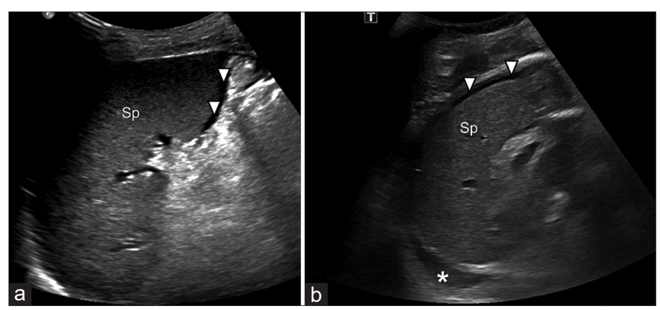

Figure 4: (a and b) Upper left abdominal quadrant views showing small amount of perisplenic fluid (white arrowheads) assumed to be blood in the trauma context. In B, it is also possible to identify a small amount of left pleural effusion (white asterisk), also assumed to be hemothorax, Sp: Spleen

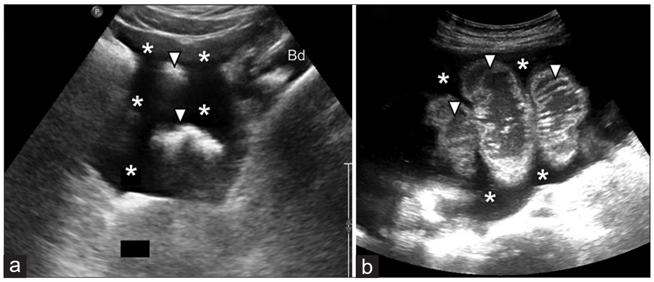

Figure 5: Positive FAST pelvis views of different patients (a: sagittal plane and b: axial plane). It is possible to see large amounts of peritoneal fluid (white asterisks), assumed to be blood in the trauma context, around bowel loops (white arrowheads). In A, the bladder is partially full (Bd). Bd: Bladder, FAST: Focused assessment with sonography for trauma

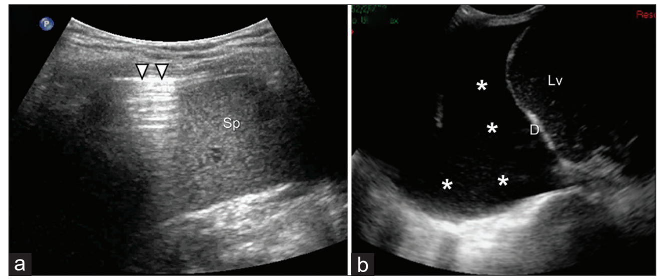

Figure 6: Posterolateral pleural views, in thoracoabdominal transition, different patients. (a) Absence of hemothorax. It is possible to see normal lung sliding through the left costophrenic recess (white arrowheads) and no pleural effusion, (b) large right pleural effusion (white asterisks), assumed to be blood in the trauma context. Sp: Spleen; D: Diaphragm; Lv: Liver

Discussion

FAST/e-FAST protocol has the main goal of detecting hemopericardium, hemoperitoneum, and/or hemopneumothorax. In the context of trauma, fluids in pericardial, peritoneum, or pleural spaces are assumed to be blood until proven otherwise. This logic may lead to false positives once there are situations where fluids other than blood may be present, and ultrasound will not be able to differentiate them, for example, pericarditis, pleural effusions from other conditions, ascites, peritoneal dialysate, ventriculoperitoneal shunt outflow, bladder rupture, ovarian hyperstimulation, ovarian cyst rupture, and massive intravascular volume resuscitation (intravascular-to-intraperitoneal fluid transudation – not rare in high-energy trauma patients who take a long time to arrive at the hospital). On the other hand, there are false-negative conditions, where the operator may not be able to detect the bleeding, such as superficial soft-tissue emphysema blocking the ultrasound beam; obese patients, which is a classical limitation for chest and abdominal sonographies; and isolated extraperitoneal injuries.[13,23,24] Ultrasound is limited to detect extraperitoneal bleedings, such as an aortic rupture, for example, once the aorta is a retroperitoneal structure. The same follows for renal lesions and pelvic fractures, although intraperitoneal fluid can be detected in cases where there is clinically significant extraperitoneal bleeding.[7,25] Once FAST/e-FAST protocol is not intended to detect extraperitoneal bleeding, strictly speaking, isolated extraperitoneal injuries are not supposed to be considered false negatives *per se*; however, it is important to remember this possibility. Clinical information such as hematuria and pelvic instability at physical examination should be taken into account to pursue further investigation in these scenarios.[26] Figure 7 shows an abdominal CT scan of a patient with a gunshot wound, hemodynamically stable, that had only retroperitoneal structures lesioned. FAST exam was negative. Table 1 shows the main causes of false positives and false negatives of the FAST/e-FAST protocol.

Another important topic to discuss is that FAST/e-FAST protocol is a "point-of-care" ultrasound modality; therefore, the conclusion must be FAST positive or FAST negative.

Table 1: Main false positives and false negatives

FAST/e-FAST protocol	
False positives	**False negatives**
Pericarditis	Superficial soft tissue emphysema
Pleural effusion from a nontrauma condition	
Ascites	Obese patients
Peritoneal dialysate	Isolated extraperitoneal injuries*
Ventriculoperitoneal shunt outflow	
Bladder rupture	
Ovarian hyperstimulation	
Ovarian cyst rupture	
Massive intravascular volume resuscitation (intravascular-to-intraperitoneal fluid transudation)	

*Once FAST/e-FAST protocol is not intended to detect extraperitoneal bleeding, strictly speaking isolated extraperitoneal injuries are not supposed to be considered false negatives *per se*, however, it is important to remember this possibility in abdominal traumas. FAST: Focused assessment with sonography for trauma, e-FAST: Extended FAST

In a positive FAST situation, trying to estimate the amount of peritoneal blood is not usually recommended for some reasons: (1) it is not going to change the medical conduct: if the patient is hemodynamically unstable, it does not matter the amount of blood, he or she must go immediately to the operating room; (2) the operator may waste precious time in a life-threatening situation trying to quantify it; and (3) there is no appropriate high accuracy way to estimate the amount of hemoperitoneum, hemothorax, or hemopericardium.

The same reasoning can be applied to searching for organ lesions. In the vast majority of cases, it is also not recommended because solid organ injuries are often underdiagnosed or not diagnosed by ultrasound (the numbers are even worse when there is no free fluid), the sensitivity is low, about 40%–63%, and again, the operator may waste precious time, and it will not change the medical conduct, driven by whether the patient is stable/unstable and FAST negative/positive.[3,15,27-29] Hemodynamically stable patients may benefit of undergoing CT, especially after a positive FAST examination. Exceptions could be made, of course, in cases where CT is not available

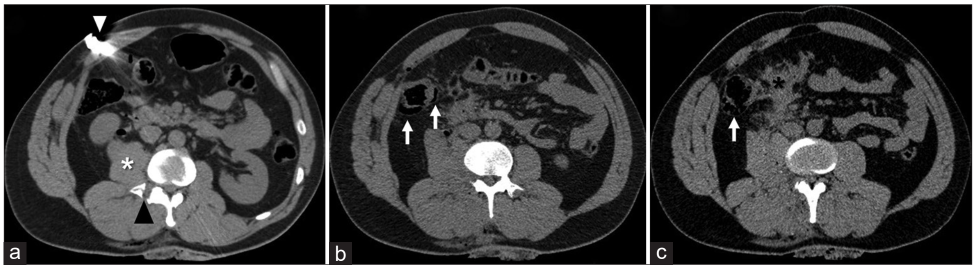

Figure 7: Without contrast CT. (a) gun projectile in the abdominal wall (white arrowhead). Entrance was posterior. There is a right transverse process fracture (black arrowhead) and enlarged right psoas, probably due to hematoma (white asterisk). (b and c) Lacerations of the right colon wall characterized by pneumatosis (white arrows) and (c) lesion of the second part of the duodenum (black asterisk). All injured structures were extraperitoneal, explaining why FAST protocol was negative (no hemoperitoneum). CT: Computed tomography, FAST: Focused assessment with sonography for trauma

or in pregnant patients because of the ionizing radiation and iodine contrast risks. For pregnant women, risks versus benefits of CT must always be considered.

Conclusion

FAST/e-FAST has achieved a widespread utilization worldwide over the past decades and revolutionized trauma care, reducing unnecessary laparotomies, and saving precious time in life-threatening trauma situations. It is important to know its indications, technique, interpretations, and limitations. Despite CT is considered the gold-standard for traumatic lesions' investigation, FAST is more accessible, quicker, cheaper, and with less risks, contributing significantly to trauma care and decision-making algorithms.

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Conflicts of interest

There are no conflicts of interest.

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