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ORIGINAL RESEARCH ARTICLE

The utility of echofast in patients admitted to the emergency department with thoracic trauma

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ABSTRACT

Focused Assessment with Sonography for Trauma (FAST) has been widely used and studied in blunt and penetrating trauma for the past 3 decades. Prior to FAST, invasive procedures such as diagnostic peritoneal lavage and exploratory laparotomy were commonly used to diagnose intra-abdominal injuries. Today, the FAST examination has evolved into a more comprehensive study of the abdomen, heart, thorax, inferior vena cava, among others, with many variations in technique, protocols and interpretation. Trauma management strategies such as laparotomy, endoscopy, computed tomography angiography, angiographic intervention, serial imaging and clinical observation have also changed over the years. This technique, at times, has managed to replace computed tomography and peritoneal lavage diagnosis, without producing delays in the surgical procedure. As such, the relationship between the patient's clinical information and the results of the exam should be guided to guide therapeutic approaches in difficult to access settings such as intensive care units in war zones, rural or remote locations where other imaging methods are not available. This review will discuss the evolution of the FAST exam to its current status and evaluate its evolving role in the acute management of the trauma patient.

Keywords: Ultrasound Trauma; Intensive Care; Point-of-Care Systems

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1. Introduction

Traumatic injuries remain the leading cause of death among personnel aged 1–44 years. In 2013, there were 27 million patients treated in emergency departments, with 3 million hospitalized for their injuries in the U.S. alone[1]. A substantial proportion of these patients have blunt abdominal and/or chest trauma injuries.

The advent of focused assessment with sonography in trauma (FAST) 3 decades ago allowed physicians to quickly detect injuries at the bedside of patients, especially those patients too hemodynamically unstable to transport the computed tomography (CT) suite.

The identification of free fluid within the peritoneal cavity, pericardium and pleural spaces can be achieved immediately upon patient arrival at the hospital. Other applications of FAST include the detection of solid organ injuries, pneumothorax, fractures, serial examinations, as well as its use in prehospital transport and in multiple casualty settings as a triage tool[2].

However, there are conflicting opinions among radiologists to adopt the use of ultrasound in trauma, as there is a greater reliance on CT. Much of this is due to the fact that the use of FAST has migrated to first responders and includes the use of FAST in the field or during patient transport[3]. FAST is also typically used as an initial imaging exam of the patient upon arrival at the emergency department. Since the original description of the use of ultrasound in the trauma patient, several new applications of the use of ultrasound in these patients are found.

Ultrasound was first used for the examination of trauma patients in the 1970s in Europe. It was not widely adopted in North America until the 1990s, during which time the acronym FAST became defined as focused abdominal ultrasound for trauma[4].

As FAST evolved into a more comprehensive examination, the acronym was changed to “focused assessment with echography for trauma”. Since then, FAST has become the common initial screening modality in most trauma centers worldwide, and is included in the Advanced Trauma Life Support program for evaluation of the hypotensive trauma patient[3]. An unique aspect of FAST is that it is commonly used by radiologists, emergency physicians, and surgeons with varying training and experience.

2. Methodology

This research is focused on the study of the usefulness of echofast in patients with thoracic trauma admitted to the emergency room in order to show the benefits as well as the disadvantages that this type of procedure presents in a clinical situation.

The review focused on texts, documents and published scientific articles available on the web, considering that the legacy of globalization allows to access to more and better information through technological tools. The search engine has been academic web tools that specifically direct to archives with validity and scientific knowledge, discarding any information not confirmed or without the respective references.

3. Results

3.1 Interpretation of the FAST technique

Probe selection in the evaluation of the trauma patient depends on the primary focus of the examination. A sector probe (3–5 MHz) is best used as a multipurpose probe. It is appropriate for examining solid organs and determining the presence of free fluid in the abdomen or pelvis. A sector scanner can be used to examine the heart for pericardial effusion or hemorrhage[5]. A sector scanner is also useful for scanning between the ribs for pneumothorax.

A curved-array transducer can be used in the abdomen for better resolution, but is not ideal for imaging the heart or lungs, especially when scanning in the inter-costal spaces. Linear array transducers are not ideal due to their larger footprint in the abdomen and chest and are often higher frequency with limited depth penetration[5].

According to Ianniello & Di Giacomo[6], the original FAST scan included views of a) the right upper quadrant, included the perihepatic area and the hepatorenal recess or Morison’s pouch, b) left upper quadrant, encompasses perisplenic view, c) suprapubic projection (pouch of Douglas), and subsequently d) subxiphoid pericardial projection (**Figure 1**).

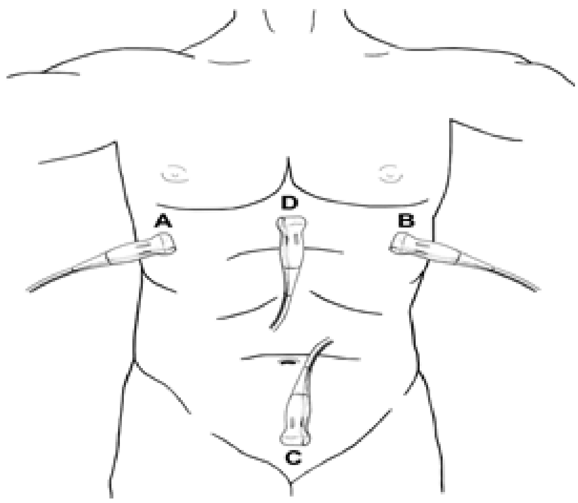

Figure 1. The four views for the original FAST scan: A = right upper quadrant, B = left upper quadrant, C = suprapubic view, D = subxiphoid view of the heart.
Source: Ianniello & Di Giacomo[6].

The preferred initial site for free fluid detection with FAST is the right upper quadrant view, scanned using a lower frequency sector (3.5–5 MHz) or curved array transducer. An optimized far-field sector transducer is ideal for better penetration when examining the hepatorenal fossa or deep pelvis[4]. A curved array transducer can also be optimized for deep penetration. However, linear array transducers are rarely used in the abdomen[6].

The liver serves as a convenient acoustic window to interrogate the hepatorenal space and liver parenchyma. Hemoperitoneum often appears anechoic or hypoechoic compared with adjacent solid organs. Prolonged hemorrhage may become organized and echogenic. For left upper quadrant view, the spleen is focused to examine the splenorenal fossa and peri-splenic area[3].

Cephalic exploration allows visualization of the left pleural space. By moving the probe caudally, the lower pole of the left kidney and the paracolic channel are visualized. The perisplenic area may be inadequately visualized due to difficult physical access. Turning the patient to the right side is useful to assess this area, as small amounts of free fluid may accumulate in the upper part of the spleen[7].

The suprapubic view allows evaluation of the most dependent space of the peritoneal cavity.

The transducer is placed above the pubic symphysis in a sagittal plane and displaced from side to side, then rotated transvertically and repeated. The reverse Trendelenburg position may improve the detection of free fluid in the pelvis. In female patients of reproductive age, small amounts of free fluid up to 50 ml in the pouch of Douglas are considered physiological and amounts greater than 50 ml should be considered pathological in the context of trauma[8].

Therefore, assuming there is no lesion or other pathologic condition present, free fluid should not be found in the rectovesicular space in men. Only small amounts of fluid should be found in the rectouterine space in women of childbearing age. The detection of free fluid in the pelvis is favored by the presence of a fluid-filled bladder. When free fluid is present, it is most often located posterior or superior to the bladder and/or uterus[8].

Free fluid in the pelvis may be lost when a Foley catheter is placed to empty the bladder, as the acoustic window for examining the pelvis is compromised, allowing detection of only large amounts of pelvic fluid. Optimal examination for detection of smaller amounts of free pelvic fluid requires a more distended bladder, allowing detection of only large amounts of pelvic fluid.

There are limitations to the FAST examination regardless of the protocol used. For abdominal examination, the detection of mesenteric, intestinal, diaphragmatic, and retroperitoneal blunt injuries can be difficult, as well as an isolated penetrating injury to the peritoneum[9].

False-positive scans may result from the detection of ascites, peritoneal dialysis, ventrio-culoperitoneal shunt leakage, ovarian hyperstimulation, and rupture of an ovarian cyst. Massive intravascular volume resuscitation can result in a false-positive FAST test of intravascular to intra-peritoneal fluid transudation[10].

Although free fluid detected with FAST in trauma patients is assumed to be hemoperitoneum, it may also represent injury-related urine, bile and intestinal contents. Intestinal gas, subcutaneous emphysema and obesity represent common obstacles to complete ultrasound visualization.

Patients presenting late after trauma may have clots containing hemoperitoneum that may have mixed echogenicity and go unnoticed. Perirenal fat, which widens the hepatorenal and splenorenal interface, may be misinterpreted as free fluid or subcapsular hematoma, also known as the “double line” sign[11].

The volume of free fluid necessary to allow detection with FAST represents a limitation of FAST. The authors Hernández & Gutiérrez[12] expressed that “the mean minimum detectable free fluid volume during FAST examination in 100 patients undergoing DPL was 619 ml in Morison’s pouch”. The Trendelenburg position may improve visualization of free fluid at the splenorenal and hepatorenal interface. However, Carter Falco & Chopko[5] demonstrated that FAST performed in the Trendelenburg position allowed detection of smaller amounts of hepatorenal free fluid than in supine (median, 400 ml vs. 700 mL).

In another DPL study, Von Kuenssberg Jehle, Stiller & Wagner[13] determined that even smaller volumes were required for detection in FAST pelvic views, with a median minimum fluid volume of 100 ml. However, other studies have shown limited ability to detect small amounts of free pelvic fluid with the transabdominal approach after Foley catheter bladder decompression.

3.2 Newer protocols

In the mid-2000s, the addition of US assessment of the chest for pneumothorax to the traditional FAST examination resulted in extended FAST (eFAST). There are several other protocols developed for the assessment of shock, respiratory distress and cardiac arrest, some of which include echocardiography. Other protocols for the evaluation of dyspnea include BLUE (bedside lung ultrasound in case of emergency) and RADIUS (rapid assessment of dyspnea with ultrasound). The BLUE protocol includes only lung ultrasound for the detection of pneumothorax, as well as pulmonary edema, consolidation and effusion. The RADIUS protocol is similar but includes cardiac and inferior vena cava (IVC) assessment[9].

A review of all protocols is not possible, but some deserve further review. Authors Manson & Hafez[9] of the RUSH protocol (an acronym for rapid ultrasound for shock and hypotension) simplified their conceptualization as an examination of (a) pump, (b) tank, and (c) tubing. The “pump” assessment includes the parasternal long and short axes of the heart, in addition to the subxiphoid and apical projections. The “tanque” evaluation involves interrogation of the IVC, a FAST examination of the abdomen including pleural views, and ultrasound of the lung.

The “conduit” portion of RUSH involves exploration of the suprasternal, parasternal, epigastric, and supraumbilical aorta, with additional explorations of the femoral and popliteal veins for deep vein thrombosis. The RUSH examination is not specifically aimed at traumatized patients, therefore, the “tube-rias” part of the protocol is generally not performed in the context of acute trauma[14]. To our knowledge, there are currently no published studies that specifically evaluate the RUSH test exclusively for hypotensive trauma patients.

Authors Ghane & Gharib[14] reported a sensitivity of 100% (16 out of 16) for RUSH in the diagnosis of hypovolemic shock in 16 patients, five of whom had solid organ injuries secondary to blunt abdominal trauma. The remaining patients in their study were diagnosed with shock from acute medical conditions, five of whom had solid organ injuries secondary to blunt abdominal trauma.

The number of different protocols for the evaluation of the critically ill patient is a source of confusion, especially as more and more protocols are developed with creative acronyms and abbreviations. It would be useful to establish a standardized examination protocol by consensus and based on large prospective studies and/or meta-analyses. Of these protocols, the eFAST exam, which includes assessment of pneumothorax, and parts of the RUSH exam, which includes a brief subcostal view of the heart and assessment of the IVC, seem more practical and time-efficient[9] (**Figure 2**).

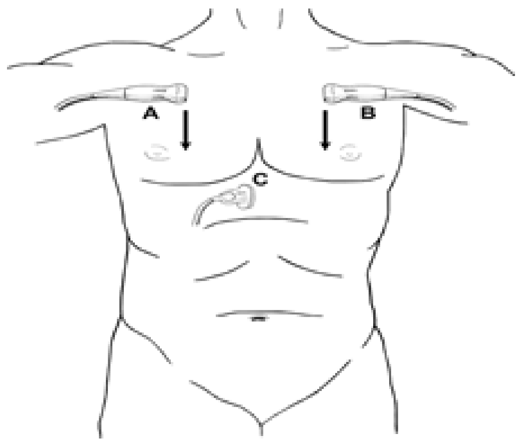

Figure 2. Additional views that may be useful in the trauma patient: A = right parasagittal view of the lung for pneumothorax, B = left parasagittal view of the lung for pneumothorax, C = longitudinal view of the IVC.
Source: Manson & Hafez[9].

3.3 Heart

Subxiphoid images of the heart are obtained by placing the transducer in the upper abdomen and pointing upward toward the left shoulder. The fluid surrounding the heart is seen as an anechoic space surrounding the myocardium. The liver acts as an acoustic window. If there are difficulties in obtaining the subxiphoid projection, parasternal, apical four-chamber and subcostal approaches can be attempted.

If a substantial amount of hemopericardium is detected, cardiac tamponade is likely to occur if there is diastolic collapse of the atrium and/or right atrium and/or ventricle. Fluid in the posterior pericardial space may be difficult to distinguish from fluid in the posteromedial pleural cavity. A distinction can be made by visualizing the descending thoracic aorta, as pericardial liquid is present anterior to the aorta while pleural fluid is posterior[14].

False-positive results for hemopericardium include pericardial cyst, fat pad, and preexisting effusion. The subxiphoid pericardial area may be inadequately scanned due to a suboptimal acoustic window.

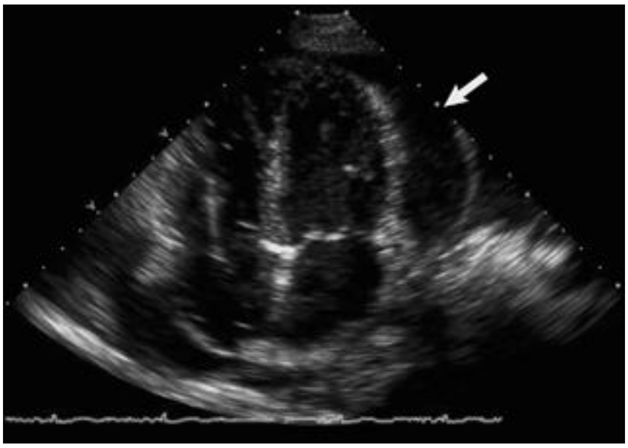

Figure 3. Pericardial effusion: four-chamber view of the heart shows a moderate-sized pericardial effusion (arrow).
Source: Ghane & Gharib[14].

3.4 Hemothorax or pleural effusion

At this point, the right pleural space can be explored for free fluid, as well as the interface between the dome of the liver and the diaphragm. This interface appears as a curvilinear echogenic line, and echoes similarities to liver parenchyma can be seen in the upper part. This mirror image artifact suggests the absence of pleural fluid. The normal lung can intermittently distort this interface during inspiration, which is known as the "curtain sign"[14].

Pleural fluid may be anechoic or have mixed echogenicity depending on its composition (e.g., hemorrhage, exudate, transudate, empyema). The atelectasis lung can also be seen with this view. The upright or inverted Trendelenburg position may improve the detection of pleural fluid.

3.5 Pneumotorax

Because eFAST is a relatively new protocol, there are fewer studies evaluating its accuracy in detecting pneumothorax. Diagnosing small to moderate-sized pneumothoraces with physical examination and supine chest radiograph is challenging, and these occult lesions may be missed in up to 76% (81 of 107) of patients with blunt trauma[1].

In studies using CT as the reference standard, the sensitivity of eFAST is better than that of supine chest radiography. Authors Kirkpatrick, Sirois & Laupland[15] conducted a prospective blinded study of 225 trauma patients with eFAST and reported a sensitivity of 48.8% (21 of 43) for chest ultrasound versus 20.9% (nine of 43) for chest radiography.

Additionally Ianniello & Di Giacomo[6] investigated 368 unstable traumatized patients with eFAST and reported a sensitivity of 77% (67 out of 87) for the detection of pneumothorax.

For pneumothorax detection, a high frequency (>5 MHz) linear transducer probe is preferred, but lower frequency sector transducers and even a curved transducer can also be used. The transducer is placed in the second or third intercostal space in the mid-clavicular line in a sagittal orientation, then moved downward. The probe can also be placed obliquely between the ribs to obtain a wider view of the lung[2]. The probe should be placed in different positions in the anterior part of the chest and compared to the opposite side to check for pneumothorax.

Subcutaneous emphysema may obstruct ultrasound attempts of the underlying pleural cavity and is frequently associated with pneumothorax. Disease severity may be a factor, as the positive predictive value of the absence of lung clearance for detecting pneumothorax is 87% in the general population, 56% in the critically ill and 27% in patients with respiratory failure[16].

A pneumothorax can only be detected directly below the probe, and smaller localized pneumothoraces may be missed. Apical pneumothoraces are more difficult to detect because there is less lung movement compared to the lower chest.

4. Conclusion

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 eFAST is recommended as the standard of care in trauma resuscitation protocols. It has been shown to reduce surgical intervention time; length of patients stay; cost; and rates of complications, CT and DPL performed. However, as with any imaging modality, its limitations are recognized and understood.

It is evident that the treatment of trauma patients is usually carried out by an interprofessional team that includes trauma nurses. Despite the questions and limitations, FAST is useful for trauma patients. However, physicians should be aware that the acquisition and interpretation of ultrasound images at the point of care are limited by the provider's experience; the patient's body habitus; and the presence of intestinal gas, pneumopneumothorax or pneumomediastinum. In these situations, serial eFAST examinations and advanced imaging are warranted based on the patient's hemodynamic status. Additionally, if necessary, a radiologist should be consulted if one cannot interpret the images.

Conflict of interest

The authors declare that they have no conflict of interest.

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