ECRONICON OPEN ACCESS
EC MICROBIOLOGY
Review Article

Overview of Focused Assessment with Sonography in Trauma

Maher Abdulrahim M Ghazawi[1]*, Waseem Mohammed Alyamani[2], Mohammed Saad Alkhathami[3], Alaa Jamal Akbar[4], Hadi Safi Mujalid[2], Hassan Abdulwahab Aljiffri[2], Zayed Mohammedali Almughamisi[2], Muath Suwaileh Alsawat[5], Nawaf Hameed Almohammadi[6], Raad Hassan Baabdullah[6] and Abdulmajeed Nasser Algadi[7]

[1]*Body Imaging Consultant, Al Noor Specialist Hospital, Mecca, Saudi Arabia*

[2]*Umm Al-Qura University, Mecca, Saudi Arabia*

[3]*King Abdulaziz Hospital, Jeddah, Saudi Arabia*

[4]*Ajyad Hospital, Mecca, Saudi Arabia*

[5]*Taif University, Taif, Saudi Arabia*

[6]*King Abdulaziz University, Jeddah, Saudi Arabia*

[7]*King Khalid University, Abha, Saudi Arabia*

***Corresponding Author:** Maher Abdulrahim M Ghazawi, Body Imaging Consultant, Al Noor Specialist Hospital, Mecca, Saudi Arabia.

Received: September 07, 2019; **Published:** September 10, 2019

Abstract

Introduction: Traumatic injuries remain to be the most common cause of death among individuals aged younger than forty-five years old, with an estimated number of two hundred thousand deaths every year in the US alone. The introduction of focused assessment with sonography in trauma (FAST) thirty years ago made it possible for physicians to perform fast screening for traumatic injuries at the bedside of suspected patients, specifically those who are not hemodynamically stable to be transported to an area with computed tomography (CT) available.

Aim of Work: We will review these recent developments of ultrasound in traumatic patients and discuss those applications that are considered to be useful to radiologists.

Methodology: We did a systematic search for ultrasound use in trauma settings using PubMed search engine and Google Scholar search engine. All relevant studies were retrieved and discussed. We only included full articles.

Conclusion: Focused assessment with sonography in trauma (FAST) has been widely used and investigated in patients with blunt and penetrating trauma for the last thirty years. Before the introduction of FAST, invasive procedures like diagnostic peritoneal lavage and exploratory laparotomy were frequently used to diagnose the presence of intraabdominal injury. Today the FAST study has improved to become a more comprehensive evaluation of the abdomen, heart, chest, and inferior vena cava, and many variations in technique, protocols, and interpretation exist. Trauma treatment protocols like laparotomy, laparoscopy, endoscopy, computed tomographic angiography, angiographic intervention, serial imaging, and clinical observation have also developed over the recent years.

Keywords: *Trauma; Injuries; Ultrasound; FAST*

Introduction

Traumatic injuries remain to be the most common cause of death among individuals aged younger than forty-five years old, with an estimated number of two hundred thousand deaths every year in the US alone [1]. In the year 2013 alone, there were about twenty-seven million patients who were treated in different emergency departments, with about three million being hospitalized later as a result of their injuries [1]. A significant percentage of these patients acquired their injuries following blunt abdominal and/or chest trauma. The introduction of focused assessment with sonography in trauma (FAST) thirty years ago made it possible for physicians to perform fast screening for traumatic injuries at the bedside of suspected patients, specifically those who are not hemodynamically stable to be transported to an area with computed tomography (CT) available.

The detection of free fluid within the pericardium, peritoneal cavity, and the pleural spaces could be done immediately at the arrival of the patient to the hospital. Other applications of focused assessment with sonography in trauma include assessment of the presence of possible solid organ trauma, pneumothorax, any fractures, serial examinations, as well as usage during pre-hospital transport and multiple casualty settings including a triage tool. On the other hand, there has been general reluctance by radiologists to encourage the use of ultrasonography in trauma, as there is more reliability associated with computed tomography. Much of this is because of the fact that the use of focused assessment with sonography in trauma has migrated to first responders and includes use of focused assessment with sonography in trauma in the field or during the transport of the patient. focused assessment with sonography in trauma is also classically used as the patient's first imaging modality for examination at arrival to the hospital. Since the original description of the use of ultrasound in patients with traumatic injuries, there have been multiple new applications of the use of ultrasound for these patients. We will review these recent developments of ultrasound in traumatic patients and discuss those applications that are considered to be useful to radiologists.

Methodology

We did a systematic search for ultrasound use in trauma settings using PubMed search engine (http://www.ncbi.nlm.nih.gov/) and Google Scholar search engine (https://scholar.google.com). All relevant studies were retrieved and discussed. We only included full articles.

The terms used in the search were: trauma, injuries, ultrasound, FAST.

The evolution of FAST

Ultrasound was initially used to examine patients with trauma in the 1970s in European countries. However, it was not generally used in the US until the 1990s. During that time the FAST acronym was defined as "focused abdominal sonography for trauma". As FAST improved to perform more complicated examinations, the acronym was modified to become "focused assessment with sonography for trauma". Since then, FAST has become the standard primary screening imaging technique to be used in most trauma centers in the US and around the world, and it is included in the Advanced Trauma Life Support protocol for assessment of the hypotensive trauma patients [2]. A special aspect of FAST is that it can be routinely used by radiologists, emergency doctors, and surgeons with different background education and experiences.

Accuracy of FAST and clinical decision making

In the year 1976, Asher and colleagues concluded that the sensitivity of ultrasound for the discovery of splenic injury following blunt abdominal trauma was estimated to be about eighty percent (four of five patients with splenic injury following blunt abdominal trauma will be detected). During the 1990s, several studies were published demonstrating sensitivities of ultrasound that ranged between sixty-nine percent (eleven out of sixteen patients) to ninety-eight percent (fifty-two out of fifty-three patients) and specificities that ranged between ninety-five percent (eighteen out of nineteen patients) to one-hundred percent (all patients) for the detection of the presence of a hemoperitoneum [3]. Much of this primary enthusiasm for the use of FAST and its high detected sensitivity were because of the fact that FAST results were primarily compared with the outcomes of patients rather than CT findings. One of the first studies that compared the use of FAST to the use of CT scanning demonstrated a significantly lower sensitivity of sixty-three percent (twenty-four out of thirty-eight patients will be detected) for FAST in discovering injuries of solid organ. This relatively lower sensitivity was mainly because of the fact that there was a case of isolated solid organ injury that lacked free fluid. Since that study, more recent critical assessments of FAST have been published, emphasizing on its high relatively false-negative rate in patients who have stable trauma [4]. In fact, Carter., *et al*. published a retrospective study where they studied over 1,671 patients with blunt abdominal trauma. In their study, they concluded a sensitivity of twenty-two percent (only twenty-five patients out of one-hundred and fourteen will be detected) in patients who are hemodynamically stable and twenty-eight percent (nine out of thirty-two patients) in patients who are unstable, and they demonstrated that a negative FAST test without performing a follow-up with CT imaging is likely to miss the presence of an intraabdominal injury [5]. The possibility of underdiagnosis of intraabdominal injury when using FAST is now well observed [6].

In a previous prospective study of more than seven hundred patients, Chiu., *et al*. demonstrated that as many as twenty-nine percent (fifteen out of fifty-two) of patients with negative FAST testing had in fact intraabdominal injury. The presence of a clinical suspicion, injury mechanism, and alterations in physical examination or hemodynamic status of patients must always be included when determining on whether further diagnostic investigations are needed in a patient who have a negative initial FAST test. For patients who get a negative FAST study, monitoring, serial later FAST studies, CT imaging, or contrast material-enhanced ultrasound might be performed. Through time, a new task for FAST has become important, in which its use in the assessment of patients who have unstable, hypotensive trauma [7]. The most efficient usage of FAST imaging has been fast triage of patients with hemodynamically unstable trauma to definitive management [7], causing significantly less time to achieve appropriate management, decreased hospital admissions, and less costs of treatment [8]. The FAST study has also been demonstrated to decrease the need for performing diagnostic peritoneal lavage (DPL), with one prospective study of about two hundred patients concluding a decrease from nine percent (seventeen of 194) to one percent (two of 194) [9].

FAST technique and interpretation

The selection of the probe during the assessment of patients with trauma is usually based on what the main emphasis of the examination is. A sector probe (3 - 5 MHz) is considered to be the best to use as a multi-purpose probe. It is ideal to use when examining solid organs and determining the presence of free fluid within the abdomen or the pelvis. A sector scanner, on the other hand, could be used to assess the heart for the presence of a pericardial effusion or a hemorrhage. A sector scanner can also be beneficial to check between the ribs for the possible presence of a pneumothorax. A curved-array transducer might be used in the abdomen to achieve better resolution but is not considered to be ideal for imaging of the heart or the lungs, specifically when performing scanning in the intercostal spaces. Linear-array transducers are not considered to be ideal as their larger footprint in the abdomen and chest and usually are of relatively higher frequency with limited depth penetration. The linear-array transducer probe is placed parallel to the ribs in the intercostal space to detect the presence of pneumothorax. The original FAST study included views of (1) the right upper quadrant, that included the perihepatic area and hepatorenal recess or Morison pouch, (2) the left upper quadrant, that encompasses the peri-splenic view, (3) the suprapubic view (pouch of Douglas), and then (4) a sub-xiphoid pericardial view. The preferred primary site to detect free fluid with FAST is the right upper quadrant view, which is scanned by using a lower frequency (three to five MHz) sector or curved-array transducer. A sector transducer with far field optimized is considered to be ideal for best penetration when used for examining the hepatorenal fossa or the deep pelvis. A curved-array transducer might also be optimized to achieve deep penetration. Nevertheless, linear-array transducers are rarely used in abdomen. The liver acts as a convenient acoustic window to interrogate the hepatorenal space and liver parenchyma. Hemoperitoneum often looks anechoic or hypoechoic when compared to adjacent solid organs. Long durations of hemorrhage might organize and become more echogenic. For the left upper quadrant view, the spleen is usually targeted for examination of the splenorenal fossa and peri-splenic area. Cephalad scanning allows the visualization of the left pleural space. The peri-splenic area might be insufficiently scanned because of the challenging physical access. Rolling the patient to his right side is beneficial when assessing this area, because small amounts of free fluid might collect superior to the spleen. The suprapubic view enables evaluation of the most dependent space in the peritoneal cavity. The transducer is put upper to the pubic symphysis in a sagittal plane and moved from a side to a side then rotated transversely and repeated. Reverse Trendelenburg positioning might improve discovery of the presence of free fluid in pelvis. In women during their reproductive age, small amounts of free fluid of up to fifty milliliters in the pouch of Douglas can be normally found and amounts that exceed fifty milliliters must be considered to be pathologic in the setting of trauma [10]. Therefore, given the absence of an injury or any other pathologic condition present, free fluid must not be detected at the recto-vesicular space in males, and only small amounts of fluid must be found in the recto-uterine space in females during their childbearing age [11].

The detection of the presence of free fluid in the pelvic area is helped when there is a fluid-filled bladder. When free fluid is present in the bladder, it is most commonly present in an area that is posterior or superior to the bladder and/or the uterus. The presence of free fluid in the pelvic area could be missed when a foley catheter is put to empty the urinary bladder, as the acoustic window for assessing the pelvic area is not present anymore, making it possible to only detect relatively large amounts of free fluid in the pelvis. The ideal study to achieve detection of significantly smaller amounts of pelvic free fluid needs a much more distended bladder [7].

There are, however, significant limitations to the use of FAST study despite which protocol is used. When examining the abdomen, the discovery of blunt mesenteric, diaphragmatic, bowel, and retroperitoneal injuries could be challenging, as well as the presence of isolated penetrating injury to the peritoneum. False-positive studies might be caused by the detection of ascites, ventriculoperitoneal shunt outflow, peritoneal dialysate, ovarian hyperstimulation, and ovarian cyst rupture. The presence of a massive intravascular volume resuscitation might result in a false-positive FAST study from the intra-vascular-to- intraperitoneal fluid transudation [12].

Despite that free fluid that is detected with FAST in patients with trauma is thought to be hemoperitoneum, it could also represent injury-related bile, urine, and/or bowel contents. Bowel gas, subcutaneous emphysema, and obesity also represent frequent obstacles to full ultrasound visualization. Patients who have delayed presentation following trauma might have hemoperitoneum that contains clots, that could have mixed echogenicity and be missed in the study. Peri-nephric fat, that widens the hepato-renal and spleno-renal areas, might be misinterpreted as free fluid or subcapsular hematoma, also known as “double-line” sign [13]. Comparison views for each kidney might be beneficial in these cases. The volume of free fluid that is required to allow the detection with FAST represents an important limitation of the use FAST.

In their study, Branney and colleagues demonstrated that the mean least detectable free-fluid volume during a FAST study in one hundred patients who underwent Diagnostic peritoneal lavage was 619 milliliters in the Morison pouch. The application of the Trendelenburg position might enhance the visualization of free fluid within the spleno-renal and hepato-renal areas. Abrams and coworkers showed that FAST done in the Trendelenburg position enhanced the detection of relatively smaller amounts of hepato-renal free fluid when compared to the supine position (median, 400 milliliters versus 700 milliliters) [25]. In another Diagnostic peritoneal lavage study, Von Kuenssberg., *et al*. concluded that even smaller volumes were needed for detection in the pelvic views of FAST, with median minimum volume of fluid of 100 milliliters [14]. nevertheless, several other studies have demonstrated relatively limited ability of FAST in the detection of smaller amounts of free pelvic fluid using the transabdominal approach following bladder decompression using foley catheterization. Scoring systems that are used to record the approximate amount of free fluid detected with ultrasound and clinical associations with prognosis have also been assessed. Previous studies included protocols to determine scores according to the anatomic site, number of free fluid areas, or vertical height of free fluid [15,16]. A common theme among these different studies is the relatively large the amount and frequency of sites with free fluid, the higher the probability of injury or requirement for further surgical intervention. These scoring systems give some standardization of fluid quantification but do not consider other clinical variables which are involved in surgical decision making and can potentially have significant impact on outcomes.

Newer protocols

During the mid-2000s, the addition of ultrasound assessment of the thorax for the detection of the possible presence of pneumothorax to the traditional FAST study caused the development of what is currently known as the extended FAST (eFAST) study [17]. There are different other protocols that were developed for the assessment of respiratory distress, shock and cardiac arrest, some of which characteristic echocardiography [18-20]. Other protocols for the assessment of dyspnea included the BLUE (bedside lung ultrasound in emergency) protocol and the RADIUS (rapid assessment of dyspnea with ultrasound). The BLUE protocol includes only lung ultrasound for checking for the presence of any pneumothorax, along with pulmonary edema, consolidation, and effusion [21]. The RADIUS protocol, on the other hand, is somewhat similar but also includes assessment of both the heart and the inferior vena cava (IVC) [22].

Other protocols include the RUSH (rapid ultrasound for shock and hypotension) protocol whose authors simplified its concept as an assessment of the (1) pump, (2) tank, and (3) pipes [19]. The "pump" assessment includes parasternal long and short axis of the heart, plus sub-xiphoid and apical views. The "tank" assessment involves interrogation of the inferior vena cava, FAST study of the abdomen including pleural views, and ultrasound of the lung. Finally, the "pipes" part of the RUSH protocol involves scanning the suprasternal, parasternal, epigastric, and supraumbilical aorta, with additional scans of the femoral and popliteal veins for deep venous thrombosis. To our knowledge, currently there are not any published studies that specifically evaluated the RUSH protocol for patients with hypotensive trauma [22]. Ghane., *et al*. in their reported, found a one-hundred percent sensitivity (sixteen out of sixteen) for RUSH protocol for the diagnosis of hypovolemic shock in sixteen patients, of which five pattients had solid organ damage that was secondary to blunt abdominal trauma [23].

The selective use of eFAST and RUSH protocols specifically for certain settings of trauma will discussed below.

Heart

Subxiphoid imaging of the heart is usually done by putting the transducer on the upper abdomen and targeting superiorly toward the left shoulder. Fluid that surrounds the heart is observed as an anechoic space that surrounds the myocardium. The liver usually acts as an acoustic window. If there is a challenge in obtaining the subxiphoid view, parasternal, apical four-chamber, and subcostal methods could be performed. If a significant amount of hemopericardium is present, cardiac tamponade is high likely to be present if a diastolic collapse of the right atrium and/or ventricle is heard. Fluid in the posterior pericardial space, on the other hand, might be hard to know from fluid that is present in the posteromedial pleural cavity. Distinguishing them can be achieved by visualizing the descending thoracic aorta, as pericardial fluid is present anterior to the aorta while the pleural fluid is present posteriorly. False-positive outcomes for hemopericardium include the presence of a pericardial cyst, fat pad, and pre-existing effusion. The sub-xiphoid pericardial area might be insufficiently scanned because of a sub-optimal acoustic window. Increasing the depth for this view or performing a left parasternal longitudinal scan for pericardial fluid aids in overcome these potential limitations.

Pneumothorax

As the eFAST protocol is considered to be a relatively recent protocol, there are less studies assessing its accuracy in the detection of pneumothorax. The diagnosis of small-to-moderate size pneumothorax cases with physical examination and supine chest radiography is considered to be relatively difficult, and these occult injuries might be missed in up to seventy-six percent of cases (eighty-one out of one-hundred and seven cases) of patients with blunt trauma patients [24].

In studies that used CT imaging as a control, the sensitivity of the eFAST protocol was found to be significantly better than that of the supine chest radiography. Kirkpatrick and colleagues performed a prospective study of more than two hundred patients with trauma using the eFAST protocol and concluded a sensitivity of eFAST that was about forty-nine percent (twenty-one out of forty-three) for chest ultrasound versus twenty-one percent (nine of forty-three) for chest radiography [17]. Ianniello., *et al*. also evaluated more than three hundred patients with unstable trauma using the eFAST protocol and concluded a sensitivity that reached seventy-seven percent (sixty-seven out of eighty-seven cases) for detecting the presence of pneumothorax [25]. Another study of about three hundred patients with trauma demonstrated that the eFAST protocol had a sensitivity that was only forty-three percent (thirty-two out of seventy-five cases) when compared to the use of chest radiography (a sensitivity of eleven percent; eight out of seventy-five cases) [26].

FAST scan by use outside the hospital

Generally emergency medicine physicians, surgeons, and radiologists are trained to perform FAST scans, however new trends in United States emphasize training of medical students, nurses and emergency medical technicians (EMT). Intraperitoneal fluid, for example, can be diagnosed by EMT using a FAST scan with a sensitivity and specificity of 61.3% and 96.3% respectively and with a physical examination time of only 3 - 4 minutes outside a hospital setting. FAST scan use by non-physicians in trauma setting can greatly enhance pre-hospital care by reducing time of diagnosis, early accurate management, as well as help the physicians in further management in the hospital. Flight nurses, pilots, and paramedics can also learn to perform FAST scan to ensure better handling of emergent situations, mainly hemoperitoneum, pneumothorax, and pericardial effusion. It also serves a major role during war time with regards to injured soldiers. Although FAST san trainings are widespread, a standardized training curriculum is lacking internationally [27].

Conclusion

Focused assessment with sonography in trauma (FAST) has been widely used and investigated in patients with blunt and penetrating trauma for the last thirty years. Before the introduction of FAST, invasive procedures like diagnostic peritoneal lavage and exploratory laparotomy were frequently used to diagnose the presence of intraabdominal injury. Today the FAST study has improved to become a more comprehensive evaluation of the abdomen, heart, chest, and inferior vena cava, and many variations in technique, protocols, and interpretation exist. Trauma treatment protocols like laparotomy, laparoscopy, endoscopy, computed tomographic angiography, angiographic intervention, serial imaging, and clinical observation have also developed over the recent years. This review discussed the evolution of the FAST examination to its current state in 2019 and assess its developing role in the acute management of the trauma patient.

Bibliography

1. Centers for Disease Control and Prevention. “National Center for Injury Prevention and Control” (2015).
2. Kool DR and Blickman JG. “Advanced Trauma Life Support. ABCDE from a radiological point of view”. *Emergency Radiology* 14.3 (2007): 135-141.
3. Pearl WS and Todd KH. “Ultrasonography for the initial evaluation of blunt abdominal trauma: A review of prospective trials”. *Annals of Emergency Medicine* 27.3 (1996): 353-361.
4. Miller MT., *et al*. “Not so FAST”. *Journal of Trauma* 54.1 (2003): 52-60.
5. Carter JW., *et al*. “Do we really rely on fast for decision-making in the management of blunt abdominal trauma?” *Injury* 46.5 (2015): 817-821.
6. Kornezos I., *et al*. “Findings and limitations of focused ultrasound as a possible screening test in stable adult patients with blunt abdominal trauma: a Greek study”. *European Radiology* 20.1 (2010): 234-238.
7. McGahan JP., *et al*. “The focused abdominal sonography for trauma scan: pearls and pitfalls”. *Journal of Ultrasound in Medicine* 21.7 (2002): 789-800.
8. Melniker LA., *et al*. “Randomized controlled clinical trial of point-of care, limited ultrasonography for trauma in the emergency department: the first sonography outcomes assessment program trial”. *Annals of Emergency Medicine* 48.3 (2006): 227-235.
9. Ollerton JE., *et al*. “Prospective study to evaluate the influence of FAST on trauma patient management”. *Journal of Trauma* 60.4 (2006): 785-791.
10. Ormsby EL., *et al*. “Pelvic free fluid: clinical importance for reproductive age women with blunt abdominal trauma”. *Ultrasound in Obstetrics and Gynecology* 26.3 (2005): 271-278.

11. Sirlin CB., *et al*. "Us of blunt abdominal trauma: importance of free pelvic fluid in women of reproductive age". *Radiology* 219.1 (2001): 229-235.

12. Slutzman JE., *et al*. "Positive FAST without hemoperitoneum due to fluid resuscitation in blunt trauma". *Journal of Emergency Medicine* 47.4 (2014): 427-429.

13. Sierzenski PR., *et al*. "The double-line sign: a false positive finding on the Focused Assessment with Sonography for Trauma (FAST) examination". *Journal of Emergency Medicine* 40.2 (2011): 188-189.

14. Von Kuenssberg Jehle D., *et al*. "Sensitivity in detecting free intraperitoneal fluid with the pelvic views of the FAST exam". *American Journal of Emergency Medicine* 21.6 (2003): 476-478.

15. Sirlin CB., *et al*. "Quantification of fluid on screening ultrasonography for blunt abdominal trauma: a simple scoring system to predict severity of injury". *Journal of Ultrasound in Medicine* 20.4 (2001): 359-364.

16. McKenney KL., *et al*. "Hemoperitoneum score helps determine need for therapeutic laparotomy". *Journal of Trauma* 50.4 (2001): 650-656.

17. Kirkpatrick AW., *et al*. "Hand-held thoracic sonography for detecting post-traumatic pneumothoraces: the Extended Focused Assessment with Sonography for Trauma (EFAST)". *Journal of Trauma* 57.2 (2004): 288-295.

18. Lanctôt YF., *et al*. "EGLS: echo guided life support. An algorithmic approach to undifferentiated shock". *Critical Ultrasound Journal* 3.3 (2011): 123-129.

19. Liteplo A., *et al*. "My patient has no blood pressure: point of care ultrasound in the hypotensive patient-FAST and RELIABLE". *Ultrasound* 20.1 (2012): 64-68.

20. Wu TS. "The CORE scan: concentrated overview of resuscitative efforts". *Critical Care Clinics* 30.1 (2014): 151-175, vi.

21. Lichtenstein DA and Mezière GA. "Relevance of lung ultrasound in the diagnosis of acute respiratory failure: the BLUE protocol". *Chest* 134.1 (2008): 117-125.

22. Manson W and Hafez NM. "The rapid assessment of dyspnea with ultrasound: RADiUS". *Ultrasound Clinics* 6.2 (2011): 261-276.

23. Ghane MR., *et al*. "Accuracy of rapid ultrasound in shock (RUSH) exam for diagnosis of shock in critically ill patients". *Trauma Monthly* 20.1 (2015): e20095.

24. Ball CG., *et al*. "Clinical predictors of occult pneumothoraces in severely injured blunt polytrauma patients: A prospective observational study". *Injury* 40.1 (2009): 44-47.

25. Ianniello S., *et al*. "First-line sonographic diagnosis of pneumothorax in major trauma: accuracy of e- FAST and comparison with multidetector computed tomography". *La Radiologia Medica* 119.9 (2014): 674-680.

26. Abdulrahman Y., *et al*. "Utility of extended FAST in blunt chest trauma: is it the time to be used in the ATLS algorithm?" *World Journal of Surgery* 39.1 (2015): 172-178.

27. Sorravit S., *et al*. "Focused assessment with sonography for trauma: current perspectives". *Emergency Medicine* 9 (2017): 57-62.

Volume 15 Issue 10 October 2019