

Diagnostic Accuracy of e-FAST in Stable Blunt Trauma Chest: A Prospective Analysis of 110 Cases at a Tertiary Care Center

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ABSTRACT

Background: Focused assessment with sonography in trauma (FAST) is an important adjunct and an extension of the clinical examination in an emergency setting for the last three decades. e-FAST visualizes the lung bases and injuries related to the lungs in addition to the intra-abdominal and pericardial bleed. In trauma patients, time is precious. Noncontrast computed tomography (NCCT) chest is the gold standard for the evaluation of blunt trauma chest. However, it is cumbersome and time-consuming and leads to increased morbidity and mortality. Therefore, evaluation of trauma patients at the trauma bay with e-FAST which is available at all times will not only save time but also the lives of trauma patients. Our endeavor is to find whether e-FAST can be substituted for NCCT for assessing injuries accurately in a stable blunt trauma patient.

Patient and methods: Prospective observational study was conducted in a tertiary care trauma center during the period of November 2017 to 2019. Of the 197 patients presenting to the trauma surgeon in the trauma center, 110 were included in the study after satisfying the inclusion criteria. Eighty-seven patients being hemodynamically unstable were excluded from the study.

Results: There was no statistical significance in the comparative data between the groups and all with “*p*” values more than 0.05. This accepts the null hypothesis and establishes the fact that there is no difference between NCCT chest which is the gold standard for chest blunt trauma and e-FAST.

Conclusion: We conclude that e-FAST is a better adjunct to the diagnosis and management of blunt trauma chest patients.

Keywords: e-FAST, Fractures, Hemothorax, NCCT, Pneumomediastinum, Pneumothorax, Surgical fixation.

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HIGHLIGHTS

A summary of the application of e-FAST for the evaluation of blunt chest trauma and comparing the results with the gold standard NCCT chest in a tertiary care center emergency room.

INTRODUCTION

Focused assessment with sonography in trauma (FAST) is an important adjunct and extension of the clinical examination in an emergency setting for the last three decades. The modality has gradually been considered as an important part of trauma management protocol replacing the old techniques of diagnostic peritoneal lavage and exploratory laparotomy. Today, the FAST expanded to involve the thoracic cavity and is called extended FAST or simply e-FAST. e-FAST visualizes the lung bases and injuries related to the lungs in addition to the intra-abdominal and pericardial bleed. In trauma patients, time is precious. Noncontrast computed tomography (NCCT) chest is the gold standard for the evaluation of blunt trauma chest. However, it is cumbersome and time-consuming. Shifting the patient to the CT scan center in a hemodynamically compromised state causes increased morbidity and mortality. Therefore, evaluation of trauma patients at the trauma bay with e-FAST which is available at all times will not only save time and but also the lives of trauma patients. Our endeavor is to find whether e-FAST can be substituted for NCCT for assessing injuries accurately in a stable blunt trauma patient.

PATIENTS AND METHODS

NCCT chest findings were considered the gold standard to evaluate the blunt trauma to the thoracoabdominal area. e-FAST is a relatively newer modality, and here, we are evaluating the

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sensitivity, specificity, and positive predictive value of e-FAST to NCCT.

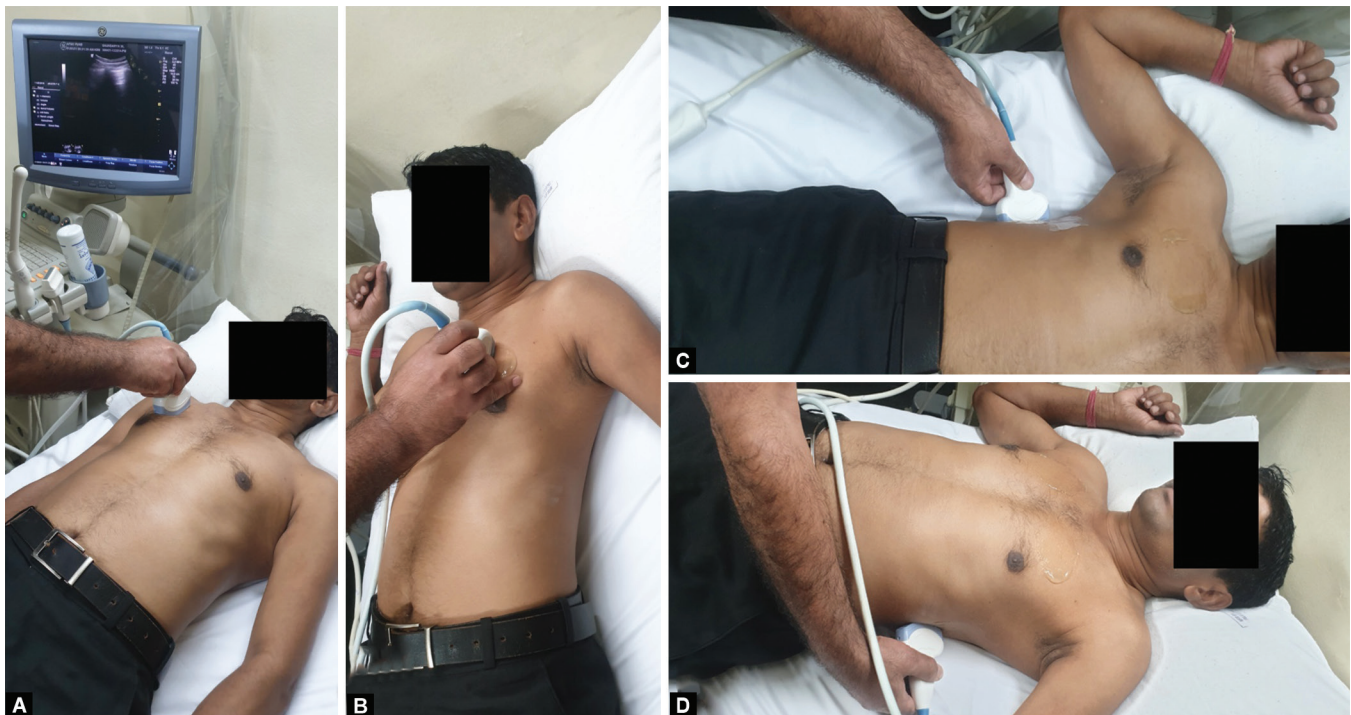
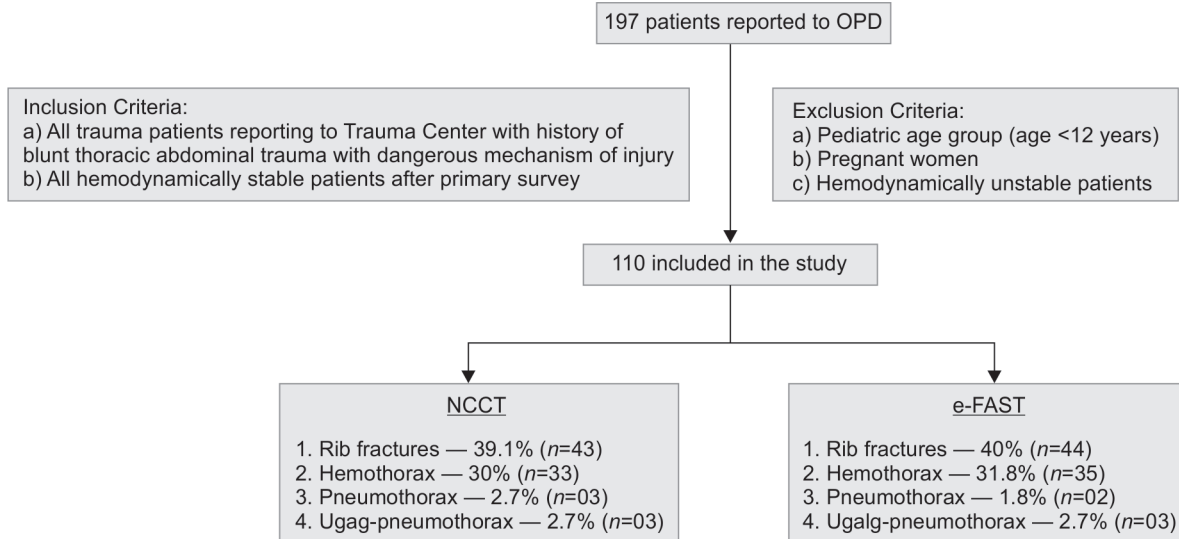
This is a prospective observational study conducted in a tertiary care trauma center in Northern India, during the period of November 2017 to November 2019. Ethical clearance for the study was obtained from the institutional ethical committee prior to the commencement of the study. The inclusion criteria were: (a) all trauma patients reporting to the trauma center with a history of blunt thoracic abdominal trauma with dangerous mechanism of injury and (b) all hemodynamically stable patients after primary survey. The exclusion criteria include: (a) pediatric age-group (age <12 years); (b) pregnant women; and (c) hemodynamically unstable patients (Flowchart 1). The null hypothesis was that there is no significant difference between NCCT chest and e-FAST in blunt thoracoabdominal trauma.

All patients admitted were subjected to the primary survey, brief relevant history, and a secondary survey by the trauma team. All patients underwent e-FAST by the trauma surgeon on duty.

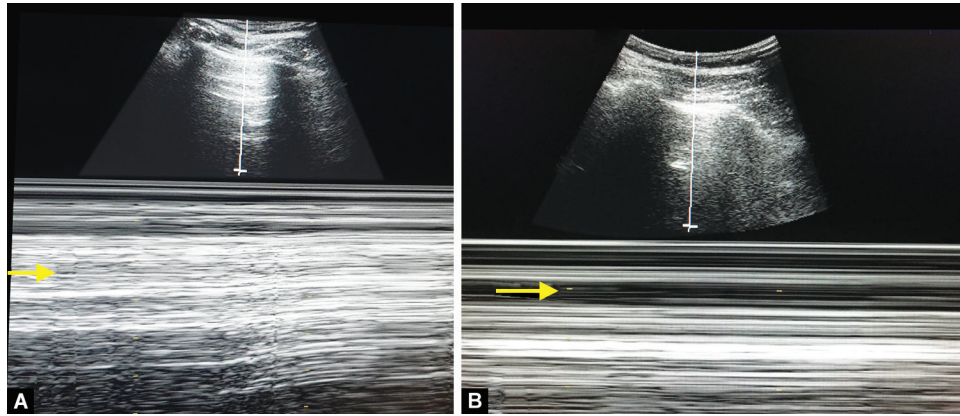
An ultrasound probe of 2–5 MHz was used for the evaluation of patients. All patients were placed in a supine position. Initial evaluation was done in both midclavicular lines bilaterally approximately at the level of 3–6 intercostal space. Normal lung sliding was checked. If there is no lung sliding, then the barcode sign and stratosphere sign are looked for in M-mode. If present, it is confirmatory of pneumothorax (PTX). Next, the probe was placed at the midaxillary line 5–8 intercostal space bilaterally. If there is free fluid above the diaphragm, it is suggestive of hemothorax (HTX). In both cases, e-FAST is considered to be positive (Figs 1 to 3 and Video 1, Video 2 and Flowchart 2).

Once the injuries were documented, the patients were segregated into hemodynamically stable and unstable patients. Hemodynamically unstable patients were admitted into the intensive care unit and were excluded from the study. Only the hemodynamically stable patients after basic resuscitation and initial documentation underwent NCCT chest. Abnormal findings of the NCCT chest were identified with the written report from the radiologist. The data were entered into Microsoft Excel for Mac (version 16.47). The data were analyzed using IBM SPSS version 24 and the results were tabulated. A two-by-two table was used to find the sensitivity, specificity, and positive predictive value with the level of significance at a “*p*” value of 0.05.

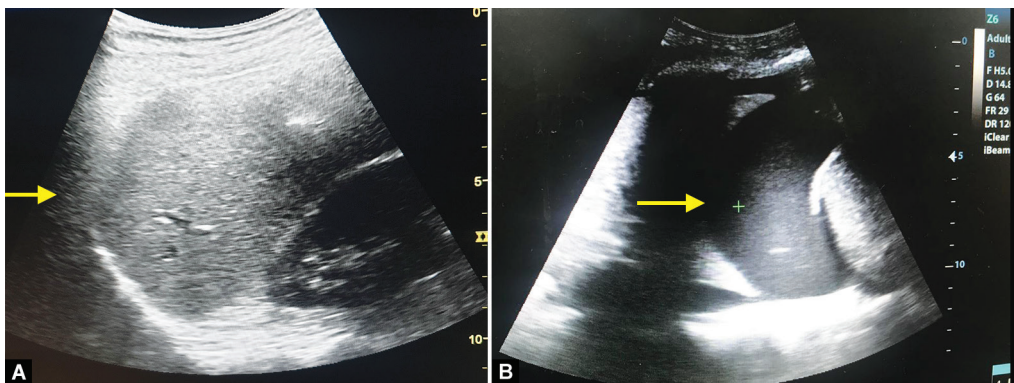
Flowchart 1: CONSORT diagram



Figs 1A to D: Different probe positions for e-FAST: (A) Right midclavicular line 3–5 intercostal space (ICS); (B) Left midclavicular line 3–5 ICS; (C) Right midaxillary line 6–8 ICS; (D) Left midaxillary line 5–7 ICS

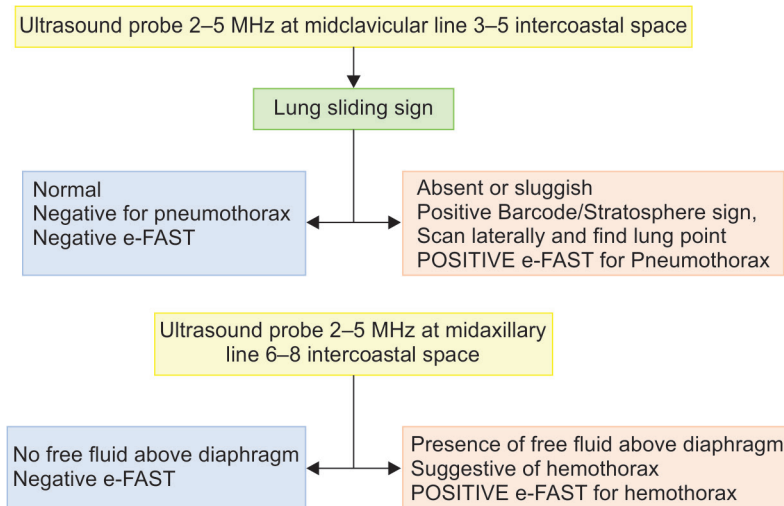


Figs 2A and B: (A) Seashore sign; (B) Barcode sign



Figs 3A and B: (A) Normal lung, diaphragm with liver and kidney in midaxillary probe; (B) Hemothorax demonstrated as fluid above the diaphragm and solid organs displaced inferiorly

Flowchart 2: Algorithm for performing e-FAST



RESULTS

A total of 197 patients were reported to the trauma center during the period of the study. One-hundred and ten patients were included after successfully meeting the inclusion criteria. The male-to-female ratio was 2:1. The majority of the patients 51.82% (n = 57) were in

the age-group of 21–30 and 26.4% (n = 24) were in the age-group of 30–40. On presentation to the emergency department, the majority of patients 62.72% (n = 69) had tachycardia with a pulse rate of more than 90 beats per minute and 28% of patients (n = 30) had tachypnea with a respiratory rate of more than 16/minute. The rest had a normal respiratory rate (12–16/minute). All patients were

maintaining percutaneous oxygen saturation above 94% on room air. Of the 110 patients, 73.6% ($n = 81$) of patients had decreased breath sounds on the side of trauma. The chest compression test was positive in all 110 patients.

All hemodynamically stable patients who were subjected to e-FAST at the trauma bay showed that 43 patients (39.1%) had rib fractures, 33 (30%) had HTX, 3 (2.7%) had PTX, and 3 (2.7%) had hemopneumothorax (HPTX). NCCT chest done at the department of radiology for these patients revealed rib fractures in 44 (40%) patients, HTX in 35 (31.8%), PTX in 2 (1.8%), and HPTX in 3 (2.7%) patients. NCCT chest was normal in 31.8% patients ($n = 35$) and e-FAST was normal in 30.8% ($n = 28$) patients. The result of the analysis of data is given in Table 1. It was found that there was no statistical significance in the comparative data with “ p ” values more than 0.05. This accepts the null hypothesis and establishes the fact that there is no difference between NCCT chest which is the gold standard for chest blunt trauma and e-FAST.

DISCUSSION

Trauma is the leading cause of death worldwide. The victims are mostly young adults, and road traffic accident is the leading cause of trauma death worldwide. Around 40% of trauma death is due to uncontrolled hemorrhage.¹⁻³ Diagnosing intra-abdominal and intrathoracic hemorrhage early is very much essential to save lives.

The widespread use of ultrasonography in diagnosing an internal bleed and incorporating it as a tool in trauma life support algorithm (ATLS) protocol became a game-changer in managing internal bleed. The use of sonography in the management of abdominal and thoracic trauma in diagnosing the life-threatening occult bleed was a saving grace in many situations. The reproducibility and accuracy of diagnosis both in emergency rooms and in prehospital settings made FAST an important tool in trauma management.³

The e-FAST protocol is aimed at diagnosing PTX, HTX, and HPTX in a simple bedside procedure. This helps the victim get early surgical management without the need for radiation exposure from NCCT or invasive diagnostic intraperitoneal lavage.⁴ Nunes et al. reported that serial FAST examinations decreased the false-negative rate by 50% and increased the sensitivity for abdominal free fluid detection from 69 to 85%.⁵ The airway, breathing, and circulation approach to trauma is suggested, starting by the airways (confirmation of patient airways and support of surgical airway), breathing (in which PTX and HTX are evaluated), and circulation, by bleeding as hemoperitoneum is investigated. One PTX was evidenced out of every five major traumas, which, if not identified, could lead to severe hemodynamic changes and death. The limitations of FAST are said to be a difficult assessment in pediatric traumas and patients with high injury-severity score (ISS).⁶ However, the use of FAST in the pediatric population also

demonstrated a sensitivity of 66% and a specificity of 98% with no exposure to radiation by a meta-analysis by Holmes et al.⁷ Natarajan et al. in their 7-year study of 2,130 patients demonstrated that only FAST without NCCT can result in missed intra-abdominal injuries.⁸

Becker et al. demonstrated in their study of 3,181 patients that patients with high ISS are at increased risk of having ultrasound occult injuries and have a lower accuracy of their ultrasound examination than patients with low and moderate ISS scores.⁹ Brooks et al. demonstrated the effectiveness of handheld FAST as a valuable technique for investigating chest and abdominal hemorrhage in single or multiple casualty events on operational military deployment.¹⁰ As per WINFOCUS (World Interactive Network Focused on Critical Ultrasound), currently developing the use of ultrasound for initial polytrauma patient evaluation, this protocol has been included in ultrasound trauma life support (US-ATLS) algorithm.¹¹ The reason for extending the FAST examination to assess the chest trauma was initially started in the United States by emergency physicians calling it e-FAST.

According to WHO global health observatory data May 2017, the leading cause of blunt trauma chest was a road traffic accident; of these, 20.9% of the cases was seen in the age-group of 31 to 40, with male predominance.¹² The mean age for trauma patients in our study was 48.5 ± 7.12 years. In our study, 72 (65.5%) were males, and the most common age-group involved was young adults, which corresponds well with the global data. Due to its reproducibility, the lack of radiation exposure, and bedside feasibility, this technology is being increasingly accepted.

A new protocol extension, the extended-FAST, provides valuable information for improved patient management, extending its availability from abdominal conditions to other diagnoses, such as HTX, pleural effusion, and PTX. We must underline that this technique is able to replace computed tomography and diagnostic peritoneal wash and does not delay the surgical procedure instead of performing this exam. Thus, its careful appraisal in connection with the clinical information should guide the therapeutic approaches, especially in inhospitable sites, such as intensive care units in war zones, rural or distant places, where other imaginary methods are not available. Blaivas et al. evaluated a chest X-ray (CXR) vs pulmonary ultrasound accuracy for occult PTX identification, found to have approximately 94% accuracy vs X-ray.¹³

In our study, out of 110 cases, on X-ray, there were 02 PTX detected, e-FAST showed 03 PTX; of which NCCT chest confirmed that there were 02 PTX. Of the 110 patients, 81 patients had decreased breath sounds, which constituted 73.6%; of which, e-FAST was turned to be abnormal in 87 patients (79%) and the NCCT which was taken as the gold standard was abnormal in 75 patients (68.2%). A recent systematic review showed moderate evidence supporting prehospital e-FAST use. It has been used successfully in air medical transport of injured patients. Press et al. reported moderate accuracy for helicopter paramedics performing

Table 1: Comparison between e-FAST and NCCT chest findings

Findings	e-FAST			NCCT chest			NCCT vs e-FAST	
	Number of patients (n)	Sensitivity (%)	Specificity (%)	Number of patients (n)	Sensitivity (%)	Specificity (%)	Z value	p value
Rib fractures	43 (39.1%)	97.7	100	44 (40%)	100	99.1	0.136	0.889
Hemothorax	33 (30%)	88.6	97.3	35 (31.8%)	99.1	98	0.289	0.772
Pneumothorax	3 (2.7%)	100	99.1	2 (1.8%)	98.9	100	0.450	0.653
Hemopneumothorax	3 (2.7%)	96.7	99.1	3 (2.7%)	99.1	98.2	0.000	1.000

e-FAST, with 46% sensitivity and 94.1% specificity for the detection of HTX and 18.7% sensitivity and 99.5% specificity for the detection of PTX. Desai and Harris also stressed the fact that e-FAST in prehospital areas and during transportation has improved the diagnostic and survival rate of casualties.¹⁴

In a study published in 2017 under the American College of Radiology, they have stated that ultrasound is increasingly being used for trauma patients to help, identify, and observe fracture, HTX, and PTX. According to a study published in the *Chinese Journal of Traumatology* 2017, out of 61 suspected patients, there were totally 38 rib fracture patients detected by ultrasound and 20 rib fracture patients detected by radiograph, with the sensitivity and specificity being 98.31 and 100% and the positive and negative predictive value of ultrasound in detecting rib fractures being 100% and 95.83%, respectively. In our study, out of 110 cases, 43 cases were identified to have rib fractures with a sensitivity and specificity of 97.7 and 100%, respectively. In our study, it was observed that 18.2% of patients, who had ISS >15, new injury severity score (NISS) >22, pH <7.35, Hb% <10 g/dL, and PCV <37%, required intubation. Also, NISS was found to be the good indicator of overall morbidity and mortality. ISS >50 was found to be a good indicator of mortality, but ISS lacked predicting morbidity. NISS on the other hand is the better indicator of major trauma and was able to detect significantly more major trauma patients as compared to ISS. NISS is also a better predictor of the need for intervention and the requirement of ICU care. As per our study, the accuracy of e-FAST for HTX is 94.55% with a sensitivity of 88.5% and a specificity of 97.33%. The accuracy of e-FAST for PTX is 99.09%, with a sensitivity of 100% and a specificity of 99.07%. As per our study, the accuracy of e-FAST for HPTX is 98.18%, with a sensitivity of 66.67% and a specificity of 99.07%. The accuracy of e-FAST for a rib fracture is 99.09%, with a sensitivity of 97.3% and a specificity of 100%.

However, an important challenge of e-FAST is the false positivities and false negativities. We must observe caution while analyzing the results of the same. The mistakes of identifying a double-line sign for free fluid, elongated left hepatic lobe for splenic hematoma, and missing PTX around the lung base and apices constitute significantly to the false-negative results.¹⁵ However, the long procedure time and hemodynamic instability in trauma patients might restrain the early use of a CT scan. It is important to detect PTX and HTX earlier as delayed diagnosis and treatment of PTX might affect the survival of patients with major trauma.

Two earlier studies have reported ultrasound as a reliable modality for diagnosing PTX and HTX in trauma patients with high sensitivity (94%) and specificity (99.7%).⁶ However, these investigators have used CXR as the reference for comparison with the e-FAST findings. Kirkpatrick et al.¹⁶ have investigated the diagnostic accuracy of e-FAST and CXR to detect PTX and HTX using CT scan as the reference. The authors reported that e-FAST had greater sensitivity than CXR (48.8 vs 20.9%). Consistently, Soldati et al.¹⁷ reported superiority of e-FAST over CXR (sensitivity; 92 vs 52%) for the diagnosis of occult PTX and HTX in trauma patients. Similarly, a recent study advocated that a transthoracic ultrasound is more reliable for the diagnosis of PTX and HTX than CXR.⁹ The e-FAST had a high positive and negative likelihood ratio compared to clinical examination and CXR. Moreover, consistent with earlier studies, e-FAST showed a high negative predictive value for the detection of PTX.¹⁸ The accuracy of e-FAST to rule out PTX and HTX is considerably high and it can potentially reduce the unnecessary chest tube insertion.

It was further demonstrated by Hamada et al. in 2016 that in a stable trauma patient, e-FAST associated with good clinical

examination provides all the necessary information about the trauma status of an injured patient that there is no requirement for even an X-ray in the emergency bay. The study was done in 430 patients who had fulfilled the stability criteria which resulted in a significant reduction in cost and radiation exposure with a “p” value of <0.0001. In a retrospective cohort study of 421 patients with blunt abdominal trauma, Dammers et al. in 2017 demonstrated that a positive FAST (positive likelihood ratio 34.3 [15.1–78.5]) had a stronger association with an adverse outcome compared to ISS or any clinicobiochemical variable. They also stressed that we should do an e-FAST examination in all patients with blunt abdominal thoracic trauma.¹⁹

The largest meta-analysis and systemic review of e-FAST were done by Netherton et al. in 2019. They analyzed 75 studies with 24,350 patients. Pooled calculation showed sensitivities and specificities of 69 and 99% for PTX, suggesting e-FAST as a valuable bedside tool for evaluating PTX.²⁰ Stengel et al. analyzed 34 studies with 8,635 patients that the use of e-FAST at a point of care was analyzed and compared to diagnostic reference standards revealed that in suspected blunt thoracoabdominal traumas ultrasonography was better helpful for guiding treatment decisions and showed a higher sensitivity for thoracic injuries.²¹ This also brings us the fact that e-FAST is operator-dependent and hence there will be operator-dependent variability. To ensure better quality control and standardized results, operator training is the most essential part before working in the emergency department.^{22,23}

Finally, in the prospective study by Basnet et al. in 2020 comprising 261 patients, the sensitivity was 94.8% and the specificity was 99.5%. The negative predictive value was 98.53% and the positive predictive value was 98.21% with an overall accuracy of 99.4%.²⁴ This corresponds to our study results. However, they also stress the fact that negative results need to be reassessed after 4 hours or need evaluation by NCCT.

CONCLUSION

e-FAST is a reliable and time-saving bedside test that had superior diagnostic accuracy over CXR and clinical examination. e-FAST can be used as an efficient triaging tool in blunt chest trauma patients that could be performed simultaneously along with resuscitation in the trauma room to explore life-threatening injuries without any delay or even interruption of resuscitation. Even though NCCT chest is the gold standard for diagnosing blunt trauma chest abdomen, the use of e-FAST is showing promising results. The overall diagnostic efficacy in terms of sensitivity and specificity of e-FAST is similar to NCCT chest. Moreover, e-FAST is a bedside procedure and less costly can be repeated many times, and there is no radiation hazard. There is no requirement for an additional specialist and additional infrastructure for e-FAST compared to NCCT. Hence, we can conclude that e-FAST is a better adjunct to the diagnosis and management of blunt trauma chest patients.

Ethical Approval

- Institutional ethical committee approval taken prior.
- Copy Attached

SUPPLEMENTARY VIDEOS

- Video 1: Normal Lung Scan
- Video 2: Hemothorax

Above mentioned supplementary videos are available online on the website of www.IJCCM.org

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