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Utility of Extended FAST in Blunt Chest Trauma: Is it the Time to be Used in the ATLS Algorithm?

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Abstract

Introduction The clinical significance of extended Focused Assessment with Sonography for Trauma (EFAST) for diagnosis of pneumothorax is not well defined.

Objectives To investigate the utility of EFAST in blunt chest trauma (BCT) patients.

Study design A single blinded, prospective study. Participants: All patients admitted with BCT (2011–2013).

Settings Level 1 trauma center in Qatar.

Procedures and outcome measures Patients were screened by EFAST and results were compared to the clinical examination (CE) and chest X-ray (CXR). Chest-computed tomography (CT) scoring system was used to confirm and measure the pneumothorax. Diagnostic accuracy of diagnostic modalities of pneumothorax was measured using sensitivity, specificity, predictive values (PVs), and likelihood ratio.

Results A total of 305 BCT patients were included with median age of 34 (18–75). Chest CT was positive for pneumothorax in 75 (24.6 %) cases; of which 11 % had bilateral pneumothorax. Chest CT confirmed the diagnosis of pneumothorax in 43, 41, and 11 % of those who were initially diagnosed by EFAST, CE, and CXR, respectively. EFAST was positive in 42 hemithoraces and its sensitivity (43 %) was higher in comparison to CXR (11 %). Positive and negative PVs of EFAST were 76 and 92 %, respectively. The frequency of missed cases by CXR was higher in comparison to EFAST and CE. The lowest median score of missed pneumothorax was observed by EFAST.

Conclusion EFAST can be used as an efficient triaging tool in BCT patients to rule out pneumothorax. Based on our analysis, we would recommend EFAST as an adjunct in ATLS algorithm.

The present study has been accepted for presentation in part in The Trauma Association of Canada Annual Scientific Meeting, April 10–11, 2014 at the Centre Mont-Royal in Montreal, QC, Canada.

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Introduction

Since early 1970s, ultrasonography has been used as a diagnostic modality for trauma patients [1, 2]. Over the years, technological advancement made ultrasonography more portable to be used at the patient bedside in the emergency settings. Unlike radiographs or computerized tomography (CT) scans, ultrasonography could be done simultaneously along with resuscitation in trauma room to explore life-threatening injuries without any delay or even interruption in resuscitation. Rozycki et al. introduced the term Focused Assessment with Sonography for Trauma (FAST) in 1996 [3, 4] and it was accepted as an adjunct to the secondary survey by ATLS® since 1997 [5].

Pneumothorax (PTX), a common trauma complication, is found in more than 20 % of major blunt trauma cases [6]. The chest radiograph (CXR) is still accepted as the primary diagnostic tool to detect PTX, although it has been proven to be inadequate to detect traumatic PTX with low sensitivity (36–48 %) [7]. This is primarily because the CXR in trauma patients is always done in supine position to preserve cervical spine immobilization as recommended by ATLS [8]. Although chest CT scan imaging is considered as the gold standard for the detection of PTX, it also has some limitations such as the unavailability in some community hospitals, high cost, hazards of radiation (especially in children and pregnant females), the long procedure time, and the limited use in the vitally unstable patient [9]. This may potentially delay the diagnosis and treatment of PTX that might affect the survival of major trauma patients.

Of note, the use of ultrasonography for thoracic injuries is fairly new compared to other accepted ultrasound applications and it is gaining more attention and acceptability [10]. The FAST examination has been amended with thoracic imaging and is particularly referred as extended FAST (EFAST) which is included as part of assessment of trauma patient [10]. de Moya et al. [11] developed an objective scoring system for the detection of small (occult) PTX in trauma patients using chest CT scan findings. This system also predicts the need for chest tube drainage which avoids unnecessary chest tubes insertion among trauma patients. However, the use of EFAST for the diagnosis of post-traumatic PTX during initial resuscitation and to decide the need for tube thoracostomy is not yet considered as a standard of care [12, 13]. Moreover, the exact sensitivity and specificity of EFAST for measuring the size of PTX (detected/missed) and its comparison with the sensitivity of CXR and clinical examination remain unexplored. Herein, the present study intended to investigate the clinical implication and diagnostic accuracy of EFAST versus CXR and clinical examination and to compare the size of missed PTX by EFAST, CXR, and clinical examination of chest.

Methods

Study design

This is a single-blinded, prospective study.

Participants

All patients were admitted with blunt chest trauma (BCT) between July 2011 and January 2013.

Settings

This study was conducted in the setting of Level 1 trauma center in Qatar.

Hypothesis

We hypothesized that EFAST has higher sensitivity and specificity relative to thoracic radiographs and clinical examination for the diagnosis of PTX.

Inclusion criteria

The study included all adult BCT patients who undergone resuscitation and require further CT chest evaluation according to the ATLS® Guidelines.

Exclusion criteria

Patients in whom chest tube was inserted before CT chest examination or patients with penetrating chest trauma or cases with incomplete or inaccurate data were excluded from the study.

Data sources and measurements

During the secondary survey, all BCT patients underwent clinical examination followed by EFAST to look for PTX. The EFAST was performed by eight trauma surgeons after obtaining the hands-on training prior to initiation of the study. An ultrasonography machine with a 10 MHz linear transducer was used (GE LOGIQ P5, OH, USA). For saving time, the EFAST was performed immediately after routine FAST. EFAST involved examination of one anatomical position in the anterior chest wall on both sides and the third intercostal space at the mid-clavicular line. The whole procedure took less than 30 s for each side and did not interfere with the resuscitation process. Following EFAST, all patients underwent CXR and chest CT scan. Chest tube insertion (if needed) was based on the clinical and/or CT chest indications.

Data included demographic, mechanism of injury, clinical examination of chest (in terms of a combination of

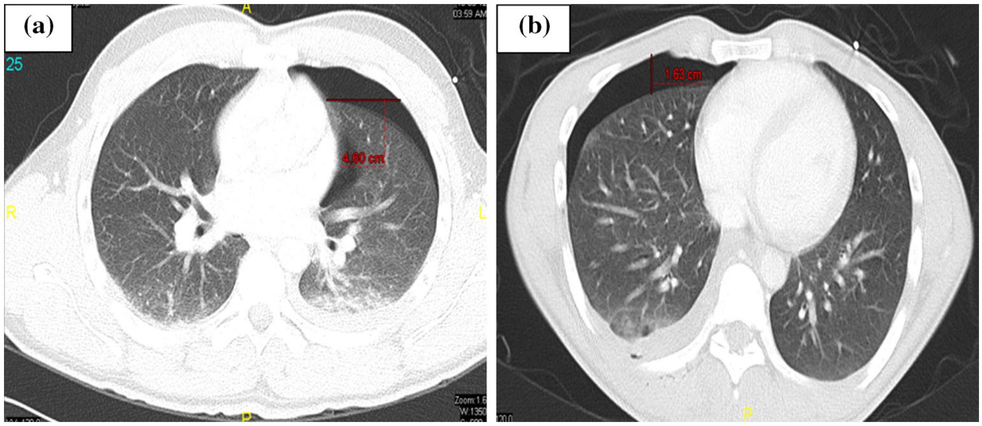

Fig. 1 Scoring based on CT findings **a** the lateral air pocket of 46 mm; (Score: 46 + 20 = 66); **b** The AP air pocket is 16 mm; (Score: 16 + 10 = 26)

decreased air entry with an increased resonance), and the EFAST findings for each hemithorax. If any sign of "pleural glistening" or "comet tail" is present through the real-time ultrasonography, this was documented as a negative EFAST (i.e., no PTX). The absence of both signs was documented as a positive EFAST.

The blinding of the study included EFAST performer and CXR reporter. Immediately, after documenting the EFAST and the clinical examination, the case report form (CRF) was kept in a closed envelope to ensure blinding from the results of the CXR and the CT scan. A consultant trauma radiologist reviewed CT chest images and had documented the findings on the CRF of each patient.

The size of PTX was measured and scored according to the chest CT findings as described earlier by de Moya et al. [11]. For measurement and scoring of PTX, we used the largest perpendicular distance (in millimeters) from the inner chest wall of the largest air pocket. A factor of 10 and 20 was added to the result, if the PTX was either antero-posterior or lateral, respectively. For instance, if a lateral PTX scores 66, it means that the actual largest perpendicular distance was 46 mm from the inner lateral chest wall (Fig. 1a). On the other hand, if an anterior PTX scores 26, it means it was 16 mm only (Fig. 1b). The decision of chest tube insertion was totally dependent on the CT chest finding and other clinical judgments such as occult PTX in an intubated patient.

Outcome measures

Diagnostic accuracy of different modalities such as EFAST, CXR, and clinical examination for identifying PTX in BCT patients was measured using sensitivity, specificity, predictive values, and likelihood ratio.

Ethical approval

The present study has been approved by the Medical Research Center (IRB# 9055/09) at Hamad Medical Corporation, Qatar.

Statistical analysis

Descriptive statistics were used to summarize the demographic and clinical characteristics of the patients. To evaluate the diagnostic accuracy of EFAST, CXR, and clinical examination, various parameters such as sensitivity, specificity, positive and negative predictive values, and positive and negative likelihood ratios were calculated along with corresponding 95 % confidence limits with reference to CT findings. Associations between two and more qualitative variables were assessed using Chi square test. For small cell frequencies, Chi square test with continuity correction factor was used. Comparison of quantitative variables was performed using student-*t* test. A two-sided *P* value <0.05 was considered to be statistically significant. All Statistical analyses were performed using statistical packages SPSS 19.0 (SPSS Inc. Chicago, IL) and Epi InfoTM 2000 (Centers for Disease Control and Prevention, Atlanta, GA).

Results

A total of 305 BCT patients were included in the study, of which majority were males (98 %) with median age of 34 (18–75) (Table 1). Motor vehicle crash (MVC) (46.6 %) and fall from height (22.6 %) were the most frequently associated injury mechanisms. The Chest CT scan was positive for PTX in 75 (24.6 %) patients, of which 8

Table 1 Demographics and diagnosis of pneumothorax in BCT patients

Number of cases	$N = 305$ (%)
Males	298 (98)
Age (median; range)	34 (18–75)
Mechanism of injury	
Motor vehicle crash	142 (46.6)
Fall from height	69 (22.6)
Pedestrian	44 (14.4)
Fall of heavy object	19 (6.2)
All terrain vehicle	9 (3)
Bicycle	6 (2)
Others	11 (3.6)
Total number of hemi thorax studies	610
Pneumothorax detected by	
Computed tomography (*Reference*)	75 (24.6)
EFAST	32 (43)
Clinical examination	31 (41)
Chest radiographs	8 (11)
Chest tubes insertion (based on CT finding)	27/75 (36)

BCT blunt chest trauma, *EFAST* extended focused assessment sonography in trauma

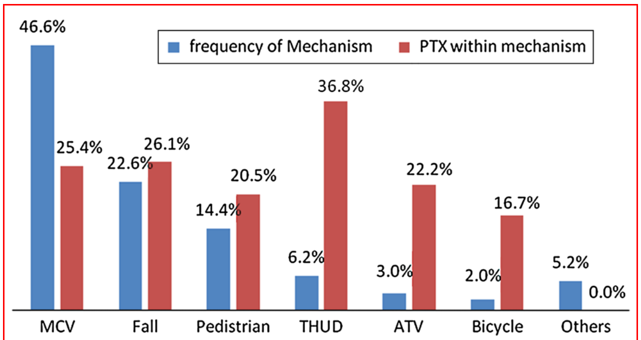

Fig. 2 Distribution of injury mechanism and detection of pneumothorax

(10.7 %) had bilateral PTX. Moreover, Chest CT examination confirmed the diagnosis of PTX in 43, 41, and 11 % of EFAST, clinical examination and CXR findings, respectively. The frequency of PTX according to the mechanism of injury is shown in Fig. 2. The highest frequency of PTX was observed in patients injured by fall of heavy object (36.8 %), followed by fall from height (26 %) and MVC (25.4 %).

Figure 3 demonstrates the overall study design and the frequency of positive and negative PTX findings by different modalities. By EFAST, PTX was suspected in 42 hemithoraces (the CT scan had confirmed 32 of them). The sensitivity was 42.7 % (95 % CI 31.3–54.6 %) and specificity was 98.1 % (95 % CI 96.6–99.1 %). This gives a positive predictive value of 76.2 % (95 % CI 60.6–87.9 %) and a high negative predictive value of 92.4 % (95 % CI 89.9–94.5 %) (Table 2).

The CXR reported by radiologist had detected only 14 PTX (the CT scan had confirmed eight of them) with a sensitivity of 10.7 % (95 % CI 4.7–19.9 %) and specificity of 98.9 % (95 % CI 97.7–99.6 %). The positive predictive value was 57.1 % (95 % CI 28.9–82.2 %) and negative predictive value was 88.7 % (95 % CI 86–91 %). Chest clinical examination revealed 78 PTX which was confirmed by CT scan in only 31 cases. The sensitivity was 41.3 % (30–53.3 %) and specificity of 91.2 % (88.5–93.5 %) with a positive predictive value of 39.7 % (95 % CI 28.8–51.5 %) and negative predictive value of 91.7 % (89–93 %).

The frequency of missed cases of PTX (false negative) by CXR was more ($n = 67$) in comparison to EFAST ($n = 43$) and clinical examination ($n = 44$) (Fig. 3). The median score of the missed PTX cases was 16 for EFAST and 22 for both clinical examination and CXR. Figure 4 represents the scatter chart which shows that the majority (71 %) of PTX that was missed by EFAST scored 20 or less.

There were a total of 27 chest tubes insertions for PTX after confirmation by chest CT scan. Nine (33 %) of those cases were missed by EFAST. None of these patients had a tension PTX at any time during assessment, resuscitation, or management.

Discussion

To the best of our knowledge, this is a unique study that assesses the utility of EFAST screening in BCT patients. Our study indicates that EFAST is a rapid test which could be performed at beside for the detection of PTX. Of note, PTX could be missed in a higher percentage of cases by clinical examination, CXR, or ultrasound examination. Furthermore, the diagnostic utility of EFAST is unclear, so the present study compared the clinical significance of the missed PTX by all these methods. This was evaluated by measuring the size of PTX using CT scan as described earlier by de Moya et al. [11]. The authors described an objective scoring system to detect small (occult) PTX by using chest CT scan. In our series, the median score for missed PTX by EFAST was the lowest compared to CXR and clinical examination. Our findings are supported by an earlier study in which the chance of missing PTX by CXR was quite high [14]. Moreover, the investigators reported that the initial CXR fails to detect 65 % of major chest injuries which mainly constituted pneumothoraces and hemopneumothoraces. Currently, CT scan is the modality of choice for diagnosing PTX in hemodynamically stable

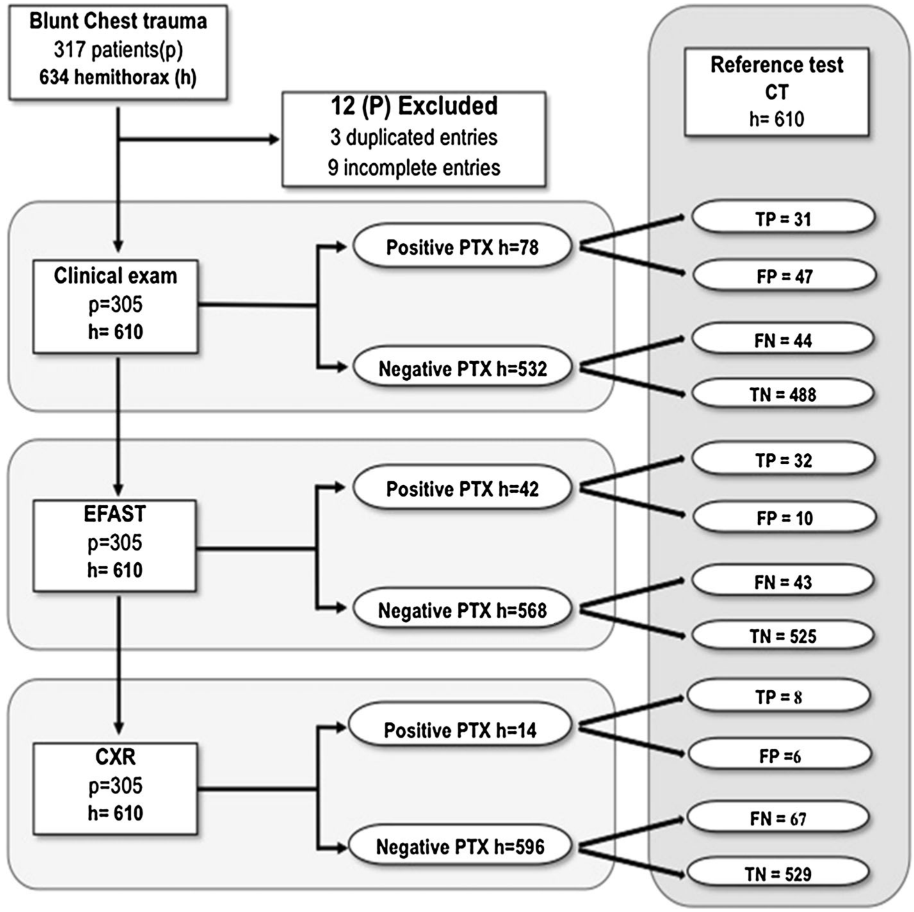

Fig. 3 Study design (*n* number of patients, *h* number of hemithoraces examined, *TP* true positive, *TN* true negative, *FP* false positive, *FN* false negative)

Table 2 Comparative analysis of pneumothorax detection using different modalities

	EFAST* (*n* = 42)	CXR*(*n* = 14)	Clinical Exam* (*n* = 78)
Sensitivity OR (95 % CI)	42.7 % (31.3–54.6 %)	10.7 % (4.7–19 %)	41.3 % (30–53.3 %)
Specificity OR (95 % CI)	98.1 % (96.6–99.1 %)	98.9 % (97.7–99.6 %)	91.2 % (88.5–93.5 %)
PPV OR (95 % CI)	76.2 % (60.6–87 %)	57.1 % (28.9–82.2 %)	39.7 % (28.8–51.5 % %)
NPV OR (95 % CI)	92.4 % (89–94.5 %)	88.7 % (86–91 %)	91.7 % (89–93 %)
LR+ (95 % CI)	22.83 (11.71–44.51)	9.46 (3.37–26.51)	4.7 (3.21–6.91)
LR− (95 % CI)	0.58 (0.48–0.71)	0.9 (0.84–0.98)	0.64 (0.53–0.78)

CXR chest X-ray, *EFAST* extended focused assessment sonography in trauma, *PPV* Positive predictive value, *NPV* Negative predictive value, *LR* likelihood ratio

*Calculation done with reference to the CT chest as a gold standard test

trauma patients. The Canadian Trauma Trials Collaborative reported incidental detection of occult PTX by CT examination in around 5 % of total trauma admissions [15]. However, the long procedure time and hemodynamic instability in trauma patients might restrain the early use of CT scan. It is important to detect PTX earlier as delayed diagnosis and treatment of PTX might affect the survival of patients with major trauma.

In our study, considering CT scan as a reference, the diagnostic accuracy of EFAST was higher than that of CXR. Particularly, we were able to reduce the EFAST time by using the ultrasound probe in a single anatomical position (the third intercostal space) on each side. It was estimated that the procedural time was less than 30 s for each side which is considerably lower than the average time (2.3 ± 2.9 min) reported earlier by Zhang et al. [12].

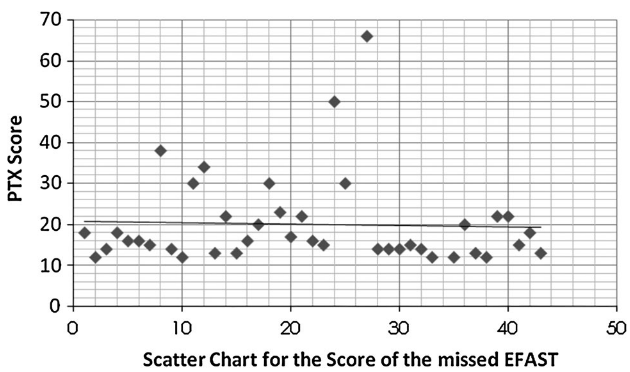

Fig. 4 The scatter chart of score of the missed pneumothorax by EFAST exam (*X* represents each patient who underwent EFAST with missed pneumothorax)

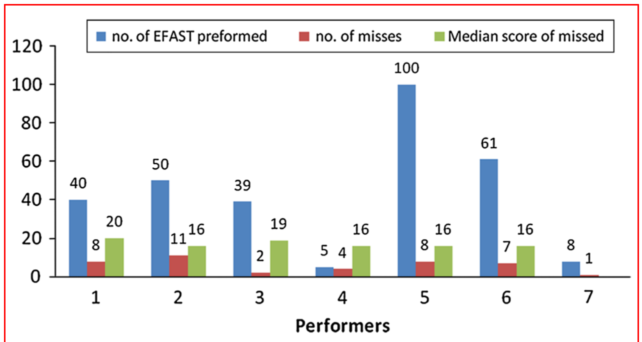

Fig. 5 Sub-analysis of the performance for each MD in relation to the missed EFASTS and the median score of the missed cases (median range 16–20)

Two earlier studies have reported ultrasound as a reliable modality for diagnosing PTX in trauma patients with a high sensitivity (94 %) and specificity (99.7 %) [16, 17]. However, these investigators have used CXR as the reference for comparison with the EFAST findings. Kirkpatrick et al. [18] have investigated the diagnostic accuracy of EFAST and CXR to detect PTX using CT scan as the reference. The authors reported that EFAST had greater sensitivity than CXR (48.8 vs. 20.9 %). Consistently, Soldati et al. [19] reported superiority of EFAST over CXR (sensitivity; 92 vs 52 %) for the diagnosis of occult PTX in trauma patients. Similarly, a recent study advocated that transthoracic ultrasound is more reliable for the diagnosis of PTX than CXR [20]. Our study demonstrated that EFAST had high positive and negative likelihood ratio compared to clinical examination and CXR. Moreover, consistent with earlier studies, EFAST showed high negative predictive value for the detection of PTX [20, 21]. The accuracy of EFAST to rule out PTX is considerably high and it can potentially reduce the unnecessary chest tube insertion.

The strength of this study includes the relatively high sample size in comparison to earlier published reports. Moreover, all the trauma surgeons who performed EFAST underwent the same hands-on training. The test performers were not biased by the nature of the injury as all cases had BCT. As EFAST is a performer dependent test, a sub-analysis was done to study the variability of EFAST interpretations for each performer. Figure 5 shows that the number of missed PTX by EFAST tests. Our findings addressed the value of the "learning curve" to reduce the number of misses.

An obvious limitation of this study is the male predominance (98 %) that cannot generalize our results. Another weakness to be addressed is the use of single anatomical site in each hemithorax, not using the M-Mode and looking only for two signs in EFAST rather than three (the sand–see–sky sign), this would have an impact on the reported low sensitivity. However, this was intended to save time and not to delay the management.

In conclusion, EFAST is a reliable and time saving bedside test that had superior diagnostic accuracy over the CXR and clinical examination. EFAST can be used as an efficient triaging tool in BCT patients that could be performed simultaneously along with resuscitation in trauma room to explore life-threatening injuries without any delay or even interruption of resuscitation. Based on our analysis, we highly recommend EFAST to be introduced as an adjunct in ATLS trauma management algorithm.

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