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Research Article

DIAGNOSTIC ACCURACY OF E-FAST IN DETECTING PNEUMOTHORAX IN TRAUMA PATIENTS AND ITS COMPARISON WITH MULTIDETECTOR COMPUTED TOMOGRAPHY

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Abstract

Background: Traumatic pneumothorax is a common and potentially life-threatening consequence of chest trauma that requires prompt diagnosis and management to prevent respiratory compromise and progression to tension pneumothorax. Although multidetector computed tomography (MDCT) is considered the gold standard for diagnosing pneumothorax, it is expensive, time-consuming, involves ionizing radiation, and may not be immediately available during the initial trauma assessment. Extended Focused Assessment with Sonography in Trauma (E-FAST) has emerged as a rapid, bedside, radiation-free imaging modality capable of detecting pneumothorax during the primary survey of trauma patients. The present study evaluated the diagnostic accuracy of E-FAST in detecting traumatic pneumothorax using MDCT as the reference standard.

Objectives: To evaluate the diagnostic accuracy of E-FAST in detecting pneumothorax among patients with chest trauma and to compare its diagnostic performance with multi detector computed tomography.

Materials and Methods: A hospital-based cross-sectional study was conducted at Tertiary care Teaching Hospital, Tamilnadu, India over a one-year period (December 2024 to December 2025). A total of 739 consecutive stable trauma patients with suspected chest injury were enrolled using non-probability consecutive sampling. E-FAST examination was performed before CT by the principal investigator using a high-frequency linear probe. Sonographic findings including absent lung sliding, absent B-lines, barcode sign, and lung point were recorded. MDCT served as the reference standard. Statistical analysis was performed using IBM SPSS version 19.

Results: Among the 739 patients, MDCT confirmed pneumothorax in 165 (22.3%) patients, whereas E-FAST diagnosed pneumothorax in 175 (23.7%) patients. E-FAST demonstrated a sensitivity of 81.8%, specificity of 93.0%, PPV of 77.1%, NPV of 94.7%, and overall diagnostic accuracy of 90.5% (AUC = 0.874, $p < 0.001$). The barcode sign demonstrated the highest specificity (97.4%) with an accuracy of 92.6%, while absent lung sliding showed a specificity of 97.4% and accuracy of 91.9%. The lung point sign exhibited 100% specificity but relatively low sensitivity (24.2%). Tachypnea, tachycardia, and rib fractures were significantly associated with CT-confirmed pneumothorax ($p < 0.001$).

Conclusion: E-FAST is a rapid, reliable, highly accurate, and radiation-free bedside imaging modality for the early diagnosis of traumatic pneumothorax. Its high specificity and negative predictive value make it an excellent screening tool during the primary survey of trauma patients, allowing timely intervention while reducing dependence on CT in appropriately selected patients.

Keywords: E-FAST, Pneumothorax, Chest trauma, Thoracic ultrasound, Multidetector computed tomography, Diagnostic accuracy.

INTRODUCTION

Pneumothorax is defined as the presence of air within the pleural cavity resulting in partial or complete collapse of the lung. It is a common and potentially life-threatening complication of blunt or penetrating chest trauma, accounting for significant morbidity and mortality among trauma patients worldwide (1). Trauma remains one of the leading causes of death in the younger population, and thoracic injuries contribute to approximately one-fourth of all trauma-related deaths. Prompt recognition and treatment of pneumothorax are therefore crucial to prevent respiratory compromise, progression to tension pneumothorax, and cardiovascular collapse (2).

The diagnosis of traumatic pneumothorax is often challenging because clinical signs such as chest pain, dyspnea, tachypnea, diminished breath sounds, and hyper resonance may be subtle or absent, particularly in patients with multiple injuries (3). Conventional chest radiography has traditionally been used as the initial imaging modality in trauma evaluation; however, its sensitivity is limited, especially in supine trauma patients where occult pneumothoraces may be easily overlooked (4). Multidetector computed tomography (MDCT) has emerged as the gold standard for diagnosing pneumothorax owing to its excellent spatial resolution and ability to detect even minimal collections of pleural air. Nevertheless, CT has several limitations, including radiation exposure, higher cost, limited availability in resource-constrained settings, and the need to transport critically injured patients away from the resuscitation area (5).

Point-of-care ultrasonography has revolutionized emergency and trauma imaging over the past two decades. The Extended Focused Assessment with Sonography in Trauma (E-FAST) protocol extends the conventional FAST examination by incorporating thoracic ultrasound for rapid identification of pneumothorax and hemothorax during the primary trauma survey (6). Thoracic ultrasound is portable, repeatable, radiation-free, inexpensive, and can be performed at the bedside without interrupting resuscitation. The technique relies on characteristic sonographic signs such as lung sliding, B-lines, lung pulse, lung point, and M-mode findings including the seashore and barcode signs for accurate diagnosis of pneumothorax (7).

Several studies have demonstrated that E-FAST possesses high sensitivity and excellent specificity for detecting traumatic pneumothorax when compared with CT. Meta-analyses have reported sensitivities ranging from 78% to 90% and specificities exceeding 95%, making thoracic ultrasound a valuable first-line diagnostic modality in emergency departments and trauma centres (8,9). The absence of lung sliding and B-lines, together with the presence of the barcode sign or lung point, significantly improves diagnostic confidence and enables early therapeutic intervention before clinical deterioration occurs (10).

Despite increasing worldwide acceptance of E-FAST, variations in operator expertise, equipment availability, and institutional trauma protocols continue to influence its diagnostic performance. Moreover, data from Indian tertiary care centres remain relatively limited. Therefore, the present study was undertaken to evaluate the diagnostic accuracy of E-FAST in detecting pneumothorax among patients presenting with chest trauma and to compare its performance with multidetector computed tomography, which served as the reference standard. Establishing the reliability of E-FAST may support its routine incorporation into trauma management protocols, facilitating rapid diagnosis, timely intervention, and improved patient outcomes while minimizing unnecessary radiation exposure.

METHODOLOGY

Study Design

This was a hospital-based cross-sectional diagnostic accuracy study conducted to evaluate the diagnostic performance of Extended Focused Assessment with Sonography in Trauma (E-FAST) for the detection of pneumothorax in trauma patients using multidetector computed tomography (MDCT) as the reference standard.

The study was conducted at tertiary care referral and Level I trauma centre with 24-hour emergency, radiology, and trauma care facilities in Tamil Nadu, India. The study was carried out over a period of one year, from December 2024 to December 2025, following approval from the Institutional Ethics Committee.

Study Population

The study population consisted of patients presenting with blunt or penetrating chest trauma who were admitted to the trauma ward and fulfilled the eligibility criteria. A total of 739 consecutive patients with chest trauma were included in the study. Non-probability consecutive sampling was employed. All eligible patients presenting during the study period were enrolled consecutively until completion of the study.

Inclusion Criteria

- Patients aged 18 years and above presenting with blunt or penetrating chest trauma.
- Hemodynamically stable trauma patients with suspected chest injury.

- Patients undergoing both E-FAST examination and multi detector CT scan before any pleural intervention.
- Patients who provided written informed consent or whose legally authorized representatives provided consent.

Exclusion Criteria

- Patients who had undergone intercostal drainage (ICD) tube insertion before E-FAST examination.
- Previously diagnosed pneumothorax confirmed on CT before enrolment.
- Hemodynamically unstable patients requiring immediate life-saving intervention, including clinically diagnosed tension pneumothorax.
- Patients with incomplete imaging data or poor-quality ultrasound examination.
- Patients who declined to participate in the study.

Study Procedure

After initial stabilization according to Advanced Trauma Life Support (ATLS) guidelines, all eligible patients underwent a standardized clinical assessment, including recording of demographic characteristics, mechanism of injury, respiratory rate, heart rate, oxygen saturation, and physical examination findings.

Immediately after the primary survey, E-FAST examination was performed at the bedside by the principal investigator using a MINDRAY ultrasound machine equipped with a high-frequency linear transducer (5–12 MHz). The sonologist was aware of the patient's clinical condition but was blinded to the CT findings.

Thoracic ultrasonography was performed with the patient in the supine position. Both hemithoraces were systematically scanned at the second to fourth intercostal spaces along the mid-clavicular line and the anterior axillary line. Additional scanning was performed whenever necessary.

The following sonographic signs were evaluated:

- Presence or absence of lung sliding
- Presence or absence of B-lines
- Presence of lung pulse
- Presence of lung point
- M-mode appearance (Seashore sign or Barcode/Stratosphere sign)

The diagnosis of pneumothorax on E-FAST was established when absent lung sliding and absent B-lines were associated with the barcode sign and/or identification of the lung point.

Following E-FAST, all patients underwent 16-slice multi detector computed tomography (Toshiba CT scanner) of the chest according to the institutional trauma imaging protocol. CT scans were interpreted independently by experienced consultant radiologists who were blinded to the E-FAST findings.

MDCT served as the reference (gold) standard for confirming or excluding pneumothorax. A pneumothorax on CT was defined as the presence of free air within the pleural cavity causing partial or complete separation of the visceral and parietal pleura.

Clinical findings, E-FAST observations, CT findings, and associated thoracic injuries such as rib fractures were recorded in a predesigned case record proforma.

Statistical Analysis

The collected data were entered into Microsoft Excel and analysed using IBM SPSS Statistics for Windows, Version 23.0 (IBM Corp., Armonk, NY, USA). Categorical variables were summarized as frequency and percentage, whereas continuous variables were expressed as mean ± standard deviation (SD).Associations between categorical variables were evaluated using the Chi-square test or Fisher's exact test, wherever appropriate. Continuous variables were analysed using the Student's t-test. The diagnostic performance of E-FAST was assessed by calculating Sensitivity , Specificity and Receiver Operating Characteristic (ROC) curve and Area Under the Curve (AUC) with 95% confidence intervals A p-value <0.05 was considered statistically significant.

RESULTS

Baseline Characteristics:

The study included 739 patients with chest trauma. The majority were aged 31–40 years (31.1%), followed by 41–50 years (23.0%) and 51–60 years (20.2%). Most participants were male (81.1%), while females constituted 18.9% of the study population. **(Table 1)**

Tachypnea was the most common clinical finding, present in 87.3% of patients. Breathlessness was observed in 37.2%, tachycardia in 29.8%, and rib fractures in 28.3% of patients. **(Table 2)**

The barcode sign was identified in 18.9% of patients, absent lung sliding in 18.3%, absent B-lines in 17.6%, and the lung point sign in 5.4%. Preserved lung sliding and B-lines were observed in most patients. **(Table 3)**

E-FAST detected pneumothorax in 175 patients (23.7%), while CT confirmed pneumothorax in 165 patients (22.3%), demonstrating close agreement between the two modalities. **(Table 4)**

Tachypnea (χ^2=30.959), tachycardia (χ^2=78.557), and rib fractures (χ^2=89.877) were all significantly associated with CT-confirmed pneumothorax (p<0.001 for all). **(Table 5)**

The ROC curve for overall E-FAST demonstrated excellent diagnostic performance with an AUC of 0.874 (95% CI: 0.838–0.911; p<0.001), indicating high accuracy in detecting traumatic pneumothorax. **(Figure 1)**

Among the individual ultrasound signs, the barcode sign showed the highest diagnostic accuracy (Sensitivity: 75.8%, Specificity: 97.4%, Accuracy: 92.6%, AUC: 0.866), followed by absent lung sliding (AUC: 0.851). Absent B-lines showed good performance (AUC: 0.777), whereas the lung point sign had the lowest sensitivity despite 100% specificity (AUC: 0.621). **(Table 7)**

The barcode sign demonstrated excellent diagnostic accuracy with an AUC of 0.866 (95% CI: 0.826–0.906; p<0.001). **(Figure 2)**

Absent lung sliding showed excellent diagnostic performance with an AUC of 0.851 (95% CI: 0.809–0.892; p<0.001). **(Figure 3)**Absent B-lines demonstrated good diagnostic accuracy with an AUC of 0.777 (95% CI: 0.729–0.824; p<0.001). **(Figure 4)**The lung point sign demonstrated modest diagnostic performance with an AUC of 0.621 (95% CI: 0.568–0.675; p<0.001). **(Figure 5)**Overall E-FAST had the highest AUC (0.874), followed by the barcode sign (0.866), absent lung sliding (0.851), absent B-lines (0.777), and lung point (0.621). All ROC analyses were statistically significant (p<0.001). **(Table 10)**

Table 1. Baseline Demographic Characteristics of Patients with Chest Trauma (n = 739)

Variable	Frequency	Percentage (%)
Age Group (years)		
≤20	30	4.1

21–30	125	16.9
31–40	230	31.1
41–50	170	23.0
51–60	149	20.2
61–70	30	4.1
71–80	5	0.7
Gender		
Male	599	81.1
Female	140	18.9

Table 2. Clinical Presentation of Patients

Variable	Present n (%)	Absent n (%)
Breathlessness	275 (37.2)	464 (62.8)
Tachypnea	645 (87.3)	94 (12.7)
Tachycardia	220 (29.8)	519 (70.2)
Rib fracture	209 (28.3)	530 (71.7)

Table 3. E-FAST Sonographic Findings

Sonographic Sign	Present n (%)	Absent n (%)
Barcode sign	140 (18.9)	599 (81.1)
Lung sliding	604 (81.7)	135 (18.3)
B-lines	609 (82.4)	130 (17.6)
Lung point	40 (5.4)	699 (94.6)

Table 4. Comparison of Pneumothorax Detection by E-FAST and CT

Investigation	Pneumothorax n (%)	No Pneumothorax n (%)
E-FAST	175 (23.7)	564 (76.3)
CT Chest	165 (22.3)	574 (77.7)

Table 5. Association between Clinical Variables and CT-confirmed Pneumothorax

Variable	χ^2	p-value
Tachypnea	30.959	<0.001
Tachycardia	78.557	<0.001
Rib fracture	89.877	<0.001

*p value <0.05 significant using Chi square Test

Figure 1. Receiver Operating Characteristic (ROC) Curve of Overall E-FAST for Detection of Pneumothorax

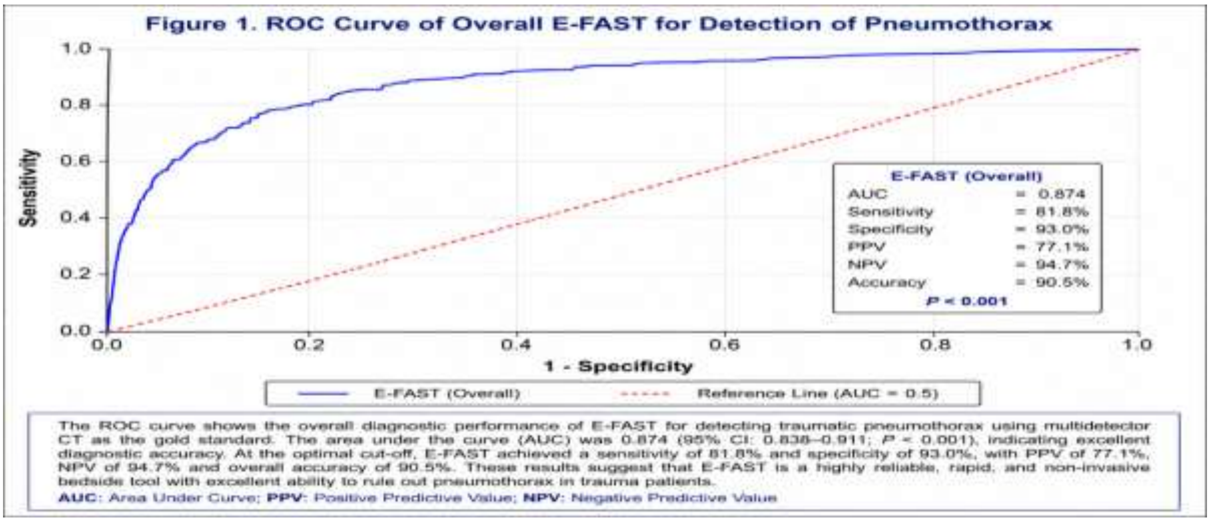

Table 7. Diagnostic Performance of Individual Sonographic Signs

Sonographic Sign	Sensitivity (%)	Specificity (%)	Accuracy (%)	AUC
Barcode sign	75.8	97.4	92.6	0.866
Absent lung sliding	72.7	97.4	91.9	0.851

Absent B-lines	60.6	94.8	87.1	0.777
Lung point	24.2	100.0	83.1	0.621

Figure 2. ROC Curve of Barcode Sign for Detection of Pneumothorax

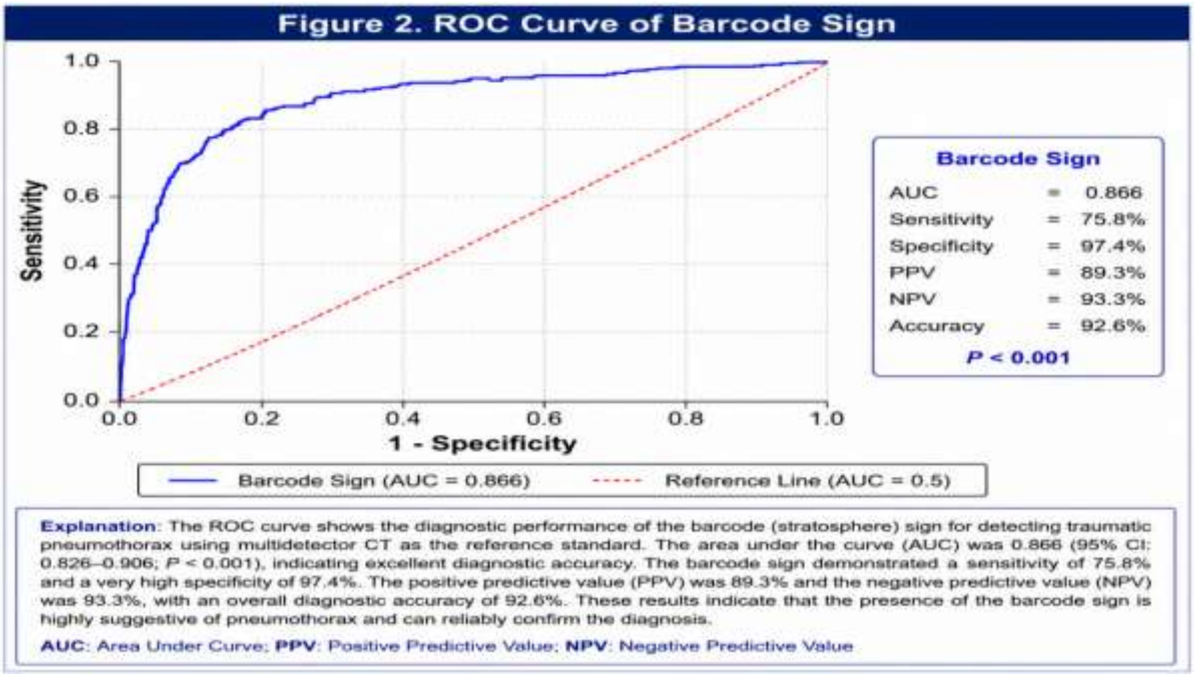

Figure 3. ROC Curve of Absent Lung Sliding

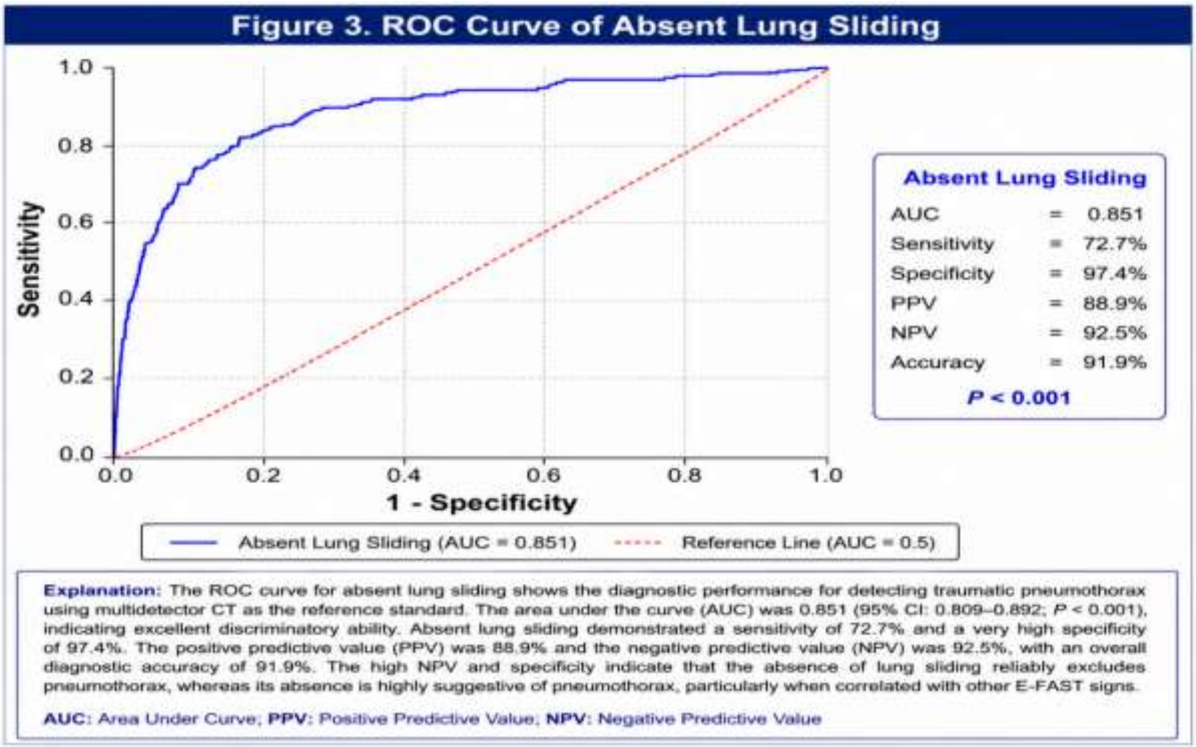

Figure 4. ROC Curve of Absent B-Lines

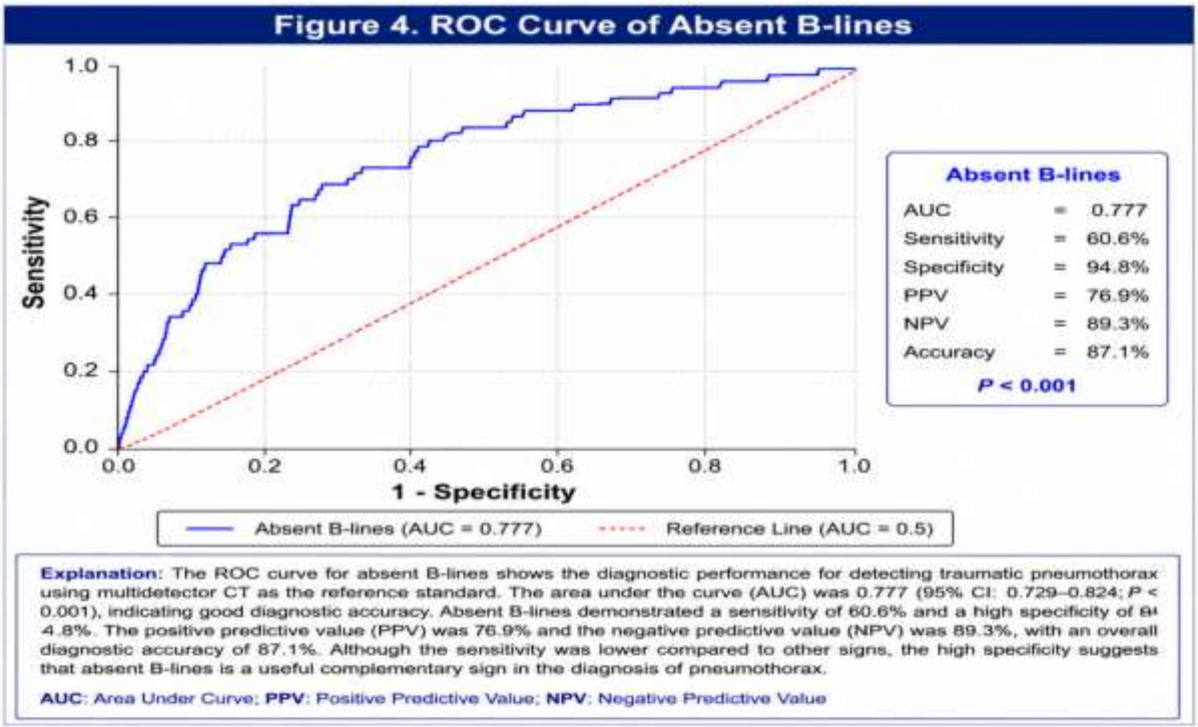

Figure 5. ROC Curve of Lung Point

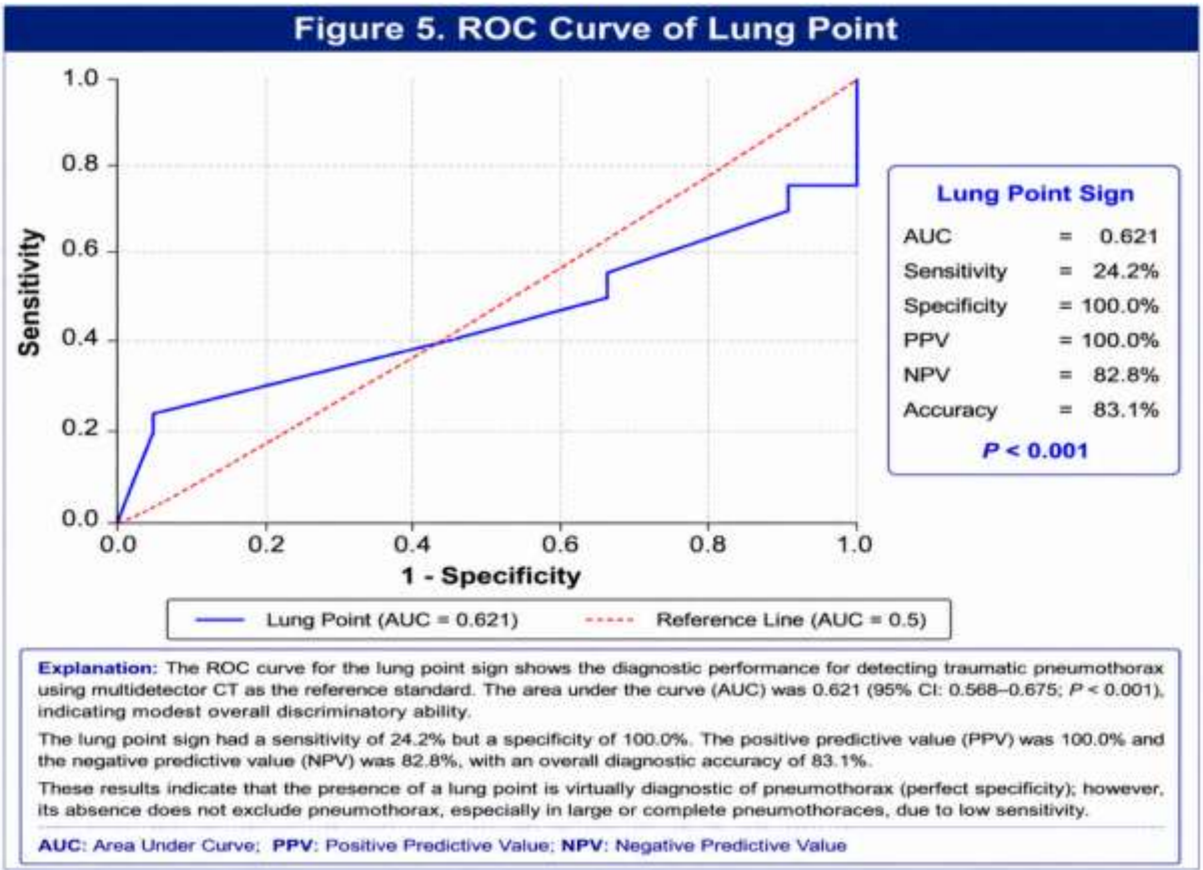

Table 8. Receiver Operating Characteristic (ROC) Analysis

Test	AUC	95% CI	p-value
Overall E-FAST	0.874	0.838–0.911	<0.001
Barcode sign	0.866	0.826–0.906	<0.001
Absent lung sliding	0.851	0.809–0.892	<0.001
Absent B-lines	0.777	0.729–0.824	<0.001
Lung point	0.621	0.568–0.675	<0.001

***p value <0.05 significant**

DISCUSSION

The present study evaluated the diagnostic accuracy of Extended Focused Assessment with Sonography in Trauma (E-FAST) for detecting traumatic pneumothorax using multi detector computed tomography (MDCT) as the reference standard. Among the 739 patients presenting with chest trauma, CT confirmed pneumothorax in 165 patients (22.3%), whereas E-FAST identified 175 patients (23.7%). The overall diagnostic performance of E-FAST demonstrated a sensitivity of 81.8%, specificity of 93.0%, positive predictive value of 77.1%, negative predictive value of 94.7%, and overall diagnostic accuracy of 90.5%. These findings indicate that E-FAST is a highly reliable bedside imaging modality for the early diagnosis of traumatic pneumothorax. Similar observations were first described by Kirkpatrick et al., who introduced the Extended FAST examination and demonstrated its effectiveness in rapidly identifying thoracic injuries during the primary trauma survey, thereby reducing delays in diagnosis and treatment **(10)**.

The demographic characteristics observed in the present study are consistent with previous epidemiological studies of thoracic trauma. Most patients belonged to the 31–50-year age group, and more than 80% were males. Young adult males are more frequently involved in road traffic accidents because of greater occupational exposure, outdoor activities, and high-risk behaviour. Ball et al. similarly reported that traumatic pneumothorax predominantly affects young male patients and emphasized that occult pneumothoraces are commonly encountered following blunt chest trauma, especially after high-energy injuries **(11)**.

Clinical findings including tachypnea, tachycardia, breathlessness, and rib fractures showed significant association with CT-confirmed pneumothorax in the present study. Although these findings increase clinical suspicion, physical examination alone cannot reliably diagnose or exclude pneumothorax, particularly in polytrauma patients. Soldati et al. demonstrated that a considerable proportion of traumatic pneumothoraces remain clinically occult and can only be identified through thoracic ultrasonography or CT imaging **(12)**. Similarly, Rowan et al. reported that conventional clinical examination and chest radiography frequently fail to identify occult pneumothorax, whereas bedside thoracic ultrasound provides substantially higher diagnostic sensitivity during the initial trauma evaluation **(13)**.

The diagnostic performance observed in the present study compares favourably with previous investigations evaluating thoracic ultrasonography. Ianniello et al. demonstrated excellent agreement between E-FAST and multidetector CT in diagnosing traumatic pneumothorax and concluded that ultrasound provides rapid and accurate bedside assessment in emergency departments **(14)**. The sensitivity and specificity reported in their study closely resemble the findings of the present investigation, further supporting the role of E-FAST as an effective first-line imaging modality during trauma resuscitation.

Among the various sonographic findings assessed, absent lung sliding and the barcode (stratosphere) sign demonstrated excellent specificity and diagnostic accuracy. In the present study, absent lung sliding showed a specificity of 97.4% and diagnostic accuracy of 91.9%, while the barcode sign achieved a specificity of 97.4% and accuracy of 92.6%. These observations are consistent with the landmark work of Lichtenstein and Menu, who first established lung sliding as a reliable sonographic sign for excluding pneumothorax in critically ill patients **(15)**. Subsequently, Lichtenstein et al. further validated thoracic ultrasonography by demonstrating the diagnostic utility of absent lung sliding and M-mode findings for identifying occult pneumothorax in emergency and intensive care settings **(16)**.

The absence of B-lines demonstrated lower sensitivity (60.6%) but maintained excellent specificity (94.8%) in the present study. These findings indicate that although isolated absence of B-lines cannot confidently exclude pneumothorax, the presence of B-lines effectively rules out clinically significant pleural air in most patients. Volpicelli emphasized that B-lines represent normal pleural apposition and therefore their presence virtually excludes pneumothorax at the examined intercostal space, making this sign an important component of lung ultrasound interpretation **(17)**.

The lung point sign exhibited the highest specificity and positive predictive value, both reaching 100%, confirming that whenever visualized it is virtually diagnostic of pneumothorax. However, the relatively low sensitivity (24.2%) observed in the present study reflects its absence in large or complete pneumothoraces where the collapsed lung no longer contacts the chest wall. Lichtenstein et al. originally described the lung point as a pathognomonic sonographic sign with absolute specificity for pneumothorax while acknowledging its limited sensitivity in extensive disease **(18)**.

Several systematic reviews and meta-analyses have consistently demonstrated that lung ultrasound is superior to supine chest radiography for detecting traumatic pneumothorax. Wilkerson and Stone reported that bedside ultrasound has substantially greater sensitivity than chest radiography during the initial trauma evaluation **(19)**. Likewise, Alrajab et al. concluded that pleural ultrasonography offers significantly higher diagnostic accuracy than chest radiography and should be considered the preferred initial imaging modality in emergency settings **(20)**. Ding et al. further confirmed through meta-analysis that thoracic ultrasonography possesses excellent pooled sensitivity and specificity for diagnosing pneumothorax **(21)**.

The findings of the present study also closely resemble those reported by Muhammad Imran et al., who documented sensitivity, specificity, and diagnostic accuracy values of 78.3%, 96.8%, and 95.3%, respectively, for thoracic ultrasound using CT as the reference standard **(22)**. Similarly, Zhang et al. demonstrated sensitivity and specificity values of 86.2% and 97.2%, respectively, among polytrauma patients undergoing bedside ultrasonography **(23)**. Abdalla et al. further validated the high diagnostic accuracy of lung ultrasound for traumatic pneumothorax, particularly regarding absent lung sliding, when compared with CT imaging **(24)**.

Overall, the present study confirms that E-FAST is a rapid, portable, radiation-free, and highly accurate bedside investigation for detecting traumatic pneumothorax. Its excellent specificity and negative predictive value make it particularly valuable during the primary survey of trauma patients, allowing early diagnosis, prompt intervention, and reduced dependence on CT in haemodynamically unstable patients. The findings strongly support incorporating E-FAST into routine trauma management protocols to improve patient outcomes and optimize emergency care.

CONCLUSION AND RECOMMENDATIONS

The present study demonstrates that Extended Focused Assessment with Sonography in Trauma (E-FAST) is a rapid, reliable, and highly accurate bedside imaging modality for the diagnosis of traumatic pneumothorax in patients with chest injury following road traffic accidents, using multidetector computed tomography (MDCT)as the reference standard. E-FAST achieved a sensitivity of 81.8%, specificity of 93.0%, positive predictive value of 77.1%, negative predictive value of 94.7%, an overall diagnostic accuracy of 90.5%, and an area under the ROC curve (AUC) of 0.874, confirming its excellent diagnostic performance. Among the individual sonographic findings, the barcode (stratosphere) sign demonstrated the highest overall diagnostic accuracy, while the lung point sign exhibited 100% specificity, making it a highly reliable confirmatory sign of pneumothorax.

Compared with computed tomography, E-FAST offers several important clinical advantages. It is rapid, portable, non-invasive, radiation-free, repeatable, cost-effective, and can be performed at the bedside without delaying definitive management. These characteristics make it particularly valuable during the golden hour of trauma care, where early diagnosis and prompt intervention are critical for improving patient outcomes and survival. Furthermore, the widespread availability of portable ultrasound systems, even in peripheral hospitals and primary healthcare centres, allows early identification and timely management of pneumothorax, reducing unnecessary referrals and facilitating prompt stabilization before transfer to higher-level trauma centres.

Although MDCT remains the gold standard for comprehensive evaluation of thoracic injuries and should be performed whenever clinically indicated, E-FAST serves as an excellent first-line screening tool for the rapid assessment of suspected traumatic pneumothorax, especially in haemodynamically stable patients and emergency settings. Its routine incorporation into trauma protocols can expedite clinical decision-making, decrease dependence on immediate CT imaging, and optimize emergency resource utilization.

In conclusion, E-FAST should be integrated into the standard initial assessment of patients with blunt chest trauma. Continued training of emergency physicians, trauma surgeons, and critical care specialists in thoracic ultrasonography, along with wider availability of portable ultrasound equipment and further large-scale multicentre prospective studies, will enhance the diagnostic accuracy, implementation, and overall clinical utility of E-FAST in modern trauma care.

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