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Radiology Section

Diagnostic Accuracy of Thoracic Ultrasound versus Supine Chest Radiography for Detecting Traumatic Pneumothorax using CT as a Reference Standard: A Cross-sectional Study

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ABSTRACT

Introduction: In trauma care, the prompt and accurate identification of pneumothorax is critical to prevent life-threatening complications. While Chest X-Ray (CXR) and Computed Tomography (CT) are conventional imaging options, Point-of-Care Ultrasound (POCUS) has emerged as a faster and potentially more reliable diagnostic method.

Aim: To compare the sensitivity and specificity of chest Ultrasonography (USG) and CXR in detecting pneumothorax in trauma patients, using CT as the definitive standard.

Materials and Methods: A cross-sectional study was conducted in the Department of Radiology, Mysuru Medical College and Research Institute, Mysuru District, Karnataka, India between October 2023 and June 2025. A total of 161 trauma patients were initially screened, of whom 109 patients who underwent thoracic ultrasound, supine chest radiography, and CT were included in the final analysis. Findings on thoracic ultrasound and supine chest radiography were compared with CT, which served as the reference (gold) standard. Diagnostic accuracy parameters were calculated, and statistical analysis was performed using Statistical Packages of Social Sciences (SPSS) version 16.0.

Results: Among the 109 patients included {mean age: 45.6±14.2 years; 84 males (77%), 25 females (23%)} underwent all three imaging modalities and were included in the final analysis, ultrasound showed a sensitivity of 93.3% and a specificity of 100%, whereas CXR demonstrated a sensitivity of 30% with the same specificity. The Negative Predictive Value (NPV) for ultrasound was 97.5%, compared to 79% for CXR. Ultrasound findings were not statistically different from CT ($p=0.125$), while CXR findings were significantly different ($p<0.001$).

Conclusion: Chest ultrasound outperformed CXR in detecting pneumothorax, particularly in terms of sensitivity. Its rapid diagnostic capability, absence of radiation, and ease of integration into existing trauma workflows support its broader adoption, especially as part of the Focused Assessment with Sonography for Trauma (FAST) examination protocol.

Keywords: Blunt thoracic trauma, Computed tomography, Emergency radiology, Lung point sign, Lung sliding, Occult pneumothorax, Point-of-care imaging

INTRODUCTION

Traumatic scenarios constitute a major proportion of emergency department presentations worldwide and are a significant cause of morbidity and mortality. Blunt and penetrating chest trauma frequently results in pleural and pulmonary injuries. Traumatic pneumothorax develops when air enters the pleural space due to disruption of the chest wall, visceral pleura, or alveolar rupture caused by sudden chest compression or deceleration forces [1].

Several imaging modalities are used for the detection of pneumothorax in trauma patients. Conventionally, supine CXR has been employed as the primary imaging modality because of its widespread availability and rapid acquisition. However, its sensitivity for detecting pneumothorax is limited, particularly in supine patients where pleural air accumulates anteriorly and may be radiographically occult. CT is regarded as the reference standard for pneumothorax detection owing to its high sensitivity and ability to identify occult pneumothoraces, but its routine use in acute trauma care is limited by radiation exposure, higher cost, restricted availability, and the need to transport potentially unstable patients [2,3].

Thoracic USG has emerged as an effective point-of-care imaging modality in trauma care. Foundational studies by Lichtenstein DA et al., described characteristic ultrasonographic signs of pneumothorax, including absence of lung sliding, absence of comet-tail artifacts, and the lung point sign, and demonstrated diagnostic superiority of ultrasound over chest radiography [4-6]. Subsequent studies further supported these findings; Zhang M et al., showed that POCUS enabled significantly faster diagnosis compared to portable chest radiography in trauma patients [7]. Additionally, two major meta-analyses systematically evaluated the diagnostic accuracy of thoracic ultrasound relative to chest radiography and concluded that ultrasound demonstrated markedly higher sensitivity with comparable specificity [8,9].

Despite this growing body of evidence, thoracic USG remains underutilised in routine trauma assessment in many clinical settings. Comparing thoracic ultrasound with supine chest radiography is therefore clinically relevant to determine whether ultrasound can reliably supplement or replace CXR during the initial evaluation of trauma patients.

The present study aimed to compare the diagnostic accuracy of thoracic ultrasound and supine chest radiography in detecting traumatic pneumothorax using CT as the reference standard.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Radiology, Mysuru Medical College and Research Institute, Mysuru District, Karnataka, India from October 2023 to June 2025. The study was approved by the Institutional Ethics Committee of Mysuru Medical College and Research Institute (Approval No. MMC EC 24.25-IS). Written informed consent was obtained from all participants prior to enrollment.

From October 2023 to June 2025, chest ultrasounds were conducted on 161 trauma patients. Of these, 109 patients who underwent thoracic ultrasound, supine chest radiography and CT imaging modalities were included in the final analysis.

Sample size: Of these, 109 patients who underwent all three imaging modalities were included in the final analysis. The convenience sampling technique was adopted.

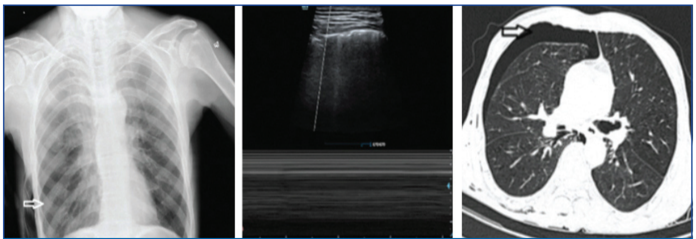
Inclusion and Exclusion criteria: Trauma patients who underwent thoracic ultrasound, supine chest radiography (anteroposterior view), and chest CT were included. Patients with a pre-existing chest tube, prior needle decompression, or extensive subcutaneous emphysema involving the chest or neck were excluded.

Study Procedure

Presence or absence of pneumothorax on USG, CXR, and CT; Sensitivity, specificity, PPV, and NPV of USG and CXR.

Ultrasound protocol: Thoracic ultrasound examinations were performed using a Mindray DC-80 ultrasound system with a 10 MHz linear array transducer. A low-frequency curvilinear transducer was used when required for deeper thoracic assessment. Scanning was performed in the supine position along the midclavicular line between the second and fourth intercostal spaces, followed by scanning along the anterior axillary line from the second to sixth intercostal spaces bilaterally. Pneumothorax was diagnosed based on the absence of lung sliding, absence of comet-tail (B-line) artifacts and the presence of the lung point sign when identifiable.

Reference standard: Chest CT was considered the reference standard for the diagnosis of pneumothorax. CT and chest radiography images were interpreted by a radiologist blinded to the ultrasound findings. Representative imaging findings of pneumothorax on chest radiograph, lung ultrasound, and CT are shown in [Table/Fig-1-3].



[Table/Fig-1]: Anteroposterior (AP) radiograph showing visible visceral pleural line along the lateral aspect of the right hemithorax (arrow) with absent peripheral lung markings. **[Table/Fig-2]:** Lung ultrasound demonstrates absence of lung sliding and comet-tail (B-line) artifacts with an M-mode "barcode/stratosphere" sign. **[Table/Fig-3]:** Axial CT chest image demonstrates a peripheral pleural air collection in the right hemithorax (arrow), consistent with a right-sided pneumothorax. (Images from left to right)

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS version 16.0 for Windows. Sensitivity, specificity, PPV, and NPV were calculated for thoracic ultrasound and chest radiography. McNemar's test was used to compare ultrasound and CXR findings with CT. A p-value< 0.05 was considered statistically significant.

RESULTS

The mean age of subjects was 45.6±14.2 years; 84 males (77%), 25 females (23%) . Among the 109 trauma patients included in the study, the majority sustained blunt chest trauma, while a smaller proportion had penetrating injuries [Table/Fig-4].

Thoracic ultrasound showed no statistically significant difference compared with CT (McNemar test, p=0.125), with no false-positive results and a low false-negative rate of 6.7% (2/30 CT-positive cases), as shown in [Table/Fig-5]. In contrast, supine chest radiography demonstrated a statistically significant difference compared with CT. Although no false positives were observed, 70% (21/30) of CT-confirmed pneumothoraces were missed on chest radiography (p <0.001), as shown in [Table/Fig-6]. A direct comparison between thoracic ultrasound and chest radiography also revealed a statistically significant difference in diagnostic performance (p=0.002).

Variables	Category	n (%)
Gender	Male	84 (77.1)
	Female	25 (22.9)
Age (years) (mean±SD)	Overall	45.6±14.2
Type of trauma	Blunt trauma	104 (95.4)
	Penetrating trauma	5 (4.6)
Mechanism of injury*	Assault (blunt)	3 (2.8)
	ATV	13 (11.9)
	Fall	30 (27.5)
	MVC	39 (35.8)
	MCC	18 (16.5)
	Other blunt mechanisms	1 (0.9)
	Stab injury	4 (3.7)
	Gunshot injury	1 (0.9)
	Total	109 (100)

[Table/Fig-4]: Study population demographics.
ATV: All-terrain vehicle; MVC: Motor vehicle crash; MCC: Motorcycle crash

Variables	CT negative	CT positive	Total
USG negative	79, Row%=97.5	2, Row%=2.5	81, Row%=100
USG positive	0, Row%=0	28, Row%=100	28, Row%=100
Total	79, Row%=72.5	30, Row%=27.5	109, Row%=100

[Table/Fig-5]: Cross tabulation of CT findings with ultrasound results.

Variables	CT negative	CT positive	Total
X-ray negative	79, Row%=79	21, Row%=21	100, Row%=100
X-ray positive	0, Row%=0	09, Row%=100	09, Row%=100
Total	79, Row%=72.5	30, Row%=27.5	109, Row%=100

[Table/Fig-6]: Cross tabulation of CT findings with X-ray results.

The sensitivity of chest radiography was 0.30, whereas thoracic ultrasound demonstrated a markedly higher sensitivity of 0.933 [Table/Fig-7].

Parameters	Ultrasound (95% CI)	Chest X-ray (CXR) (95% CI)
Sensitivity	0.933 (0.78-0.99)	0.30 (0.147-0.49)
Specificity	1.00 (0.95-1.00)	1.00 (0.95-1.00)
Positive Predictive Value (PPV)	1.00 (0.88-1.00)	1.00 (0.66-1.00)
Negative Predictive Value (NPV)	0.975 (0.91-0.99)	0.790 (0.70-0.87)

[Table/Fig-7]: Diagnostic performance of ultrasound and Chest X-ray (CXR) for detection of pneumothorax using CT as the reference standard (N=109).

DISCUSSION

In a supine patient, air trapped within the pleural space tends to accumulate in the paracardiac region and the anterior Costo-diaphragmatic recess, making it more visible on chest ultrasound. However, this air may be less detectable on portable CXR, where it could be obscured [2].

A recent study reported high accuracy in detecting pneumothorax with ultrasound within the first 24 hours following chest tube placement. However, it also found that sensitivity, specificity, PPV, and NPV all declined after 48 hours, and that ultrasound was no longer reliable for accurately monitoring a resolving pneumothorax in subsequent examinations [3]. The observed inaccuracies were attributed to local inflammatory responses and the formation of adhesions around the foreign body in the pleural space, which impeded proper lung sliding. Despite the decline in accuracy following chest tube insertion, the study still reported 100% sensitivity and specificity prior to the placement of the tube thoracostomy.

The present study revealed a significantly higher sensitivity for detecting pneumothorax using chest ultrasound compared to

Study (Year)	Study design	Study population	Sensitivity- USG	Sensitivity- CXR	Specificity-USG	Specificity-CXR	Reference standard
Tian H et al., (2023) [10]	Updated meta-analysis	Traumatic pneumothorax	91%	47%	99%	99%	CT
Chan KK et al., (2020) [11]	Systematic review (Cochrane)	Trauma patients (ED)	High (pooled >85%)	Low (pooled <50%)	High	High	CT
Alrajab S et al., (2013) [12]	Meta-analysis	Mixed (trauma and ICU)	90%	52%	98%	100%	CT
Abdalla W et al., (2016) [13]	Prospective, single-blind	Critically ill patients	94%	61%	100%	100%	CT
Nagarsheth K and Kurek S (2011) [14]	Prospective study	Trauma patients	95%	36%	100%	100%	CT
Blaivas M et al. (2005) [3]	Prospective comparative	Trauma patients	98%	75%	100%	100%	CT

[Table/Fig-8]: Summary of studies comparing thoracic ultrasound and supine chest radiography for pneumothorax detection with Computed Tomography (CT) as the gold standard [3,10-14].

portable CXR. The findings of the present study are consistent with previously published prospective studies and systematic reviews, including recent meta-analyses by Tian H et al., [10] and Chan KK et al., [11] (Cochrane Review), followed by earlier meta-analyses by Alrajab S et al., [12] and prospective studies by Abdalla W et al., [13], Nagarsheth K and Kurek S [14], and Blaivas M et al., [3], all of which demonstrate superior sensitivity of thoracic ultrasound compared with supine chest radiography, with comparable specificity when CT is used as the reference standard, as shown in [Table/Fig-8] [3, 10-14].

The authors utilised both a low-frequency curved transducer and a high-frequency linear array transducer, finding that the linear transducer produced clearer images, with both lung sliding and comet tails being more evident. These findings are consistent with conclusions from other research on the use of thoracic ultrasound for pneumothorax detection [14].

In the present analysis, each patient was treated as one subject rather than examining both hemithoraces, as both CXR and CT scans assessed both sides in a single study. Among the 109 patients in the present study, six had bilateral pneumothorax identified on both ultrasound and CT, although CXR missed one of their pneumothoraces.

Limitation(s)

The sample size was modest and convenience sampling was employed, which may limit the generalisability of the findings. Thoracic ultrasound is inherently operator-dependent, and diagnostic accuracy may be affected by the experience of the examiner. Additionally, factors such as pleural adhesions, extensive subcutaneous emphysema, or prior thoracic interventions may obscure sonographic signs and reduce sensitivity. Small posterior or apical pneumothoraces may also be missed on ultrasound, particularly in supine trauma patients.

CONCLUSION(S)

Thoracic ultrasound demonstrates significantly higher sensitivity than supine chest radiography and diagnostic accuracy comparable to CT for the detection of pneumothorax in trauma patients. Incorporation of thoracic ultrasound into standard trauma protocols, alongside the FAST, may facilitate earlier diagnosis and improve clinical decision-making.

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