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Prospective evaluation of thoracic ultrasound to detect pneumothorax in emergency department (ED)

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Abstract
Introduction: Pneumothorax can be life threatening in patients with critical thoracic trauma and requires quick and accurate management. Ultrasonography is safe, quick to perform at bedside, efficient, accurate, readily available and cost-effective in ED and can help in prompt detection of pneumothorax.
Aims and objectives: We conducted the present study to compare and correlate the accuracy of bedside ultrasonography in patients with thoracic trauma, with Chest X ray and CT scanning.
Materials and methods: A single centred prospective observational study was done on 175 patients after ethical commitee approval in Department of Emergency Medicine at Civil hospital, Ahmedabad over a period of 18 months from May 2013 to November 2014 and after obtaining consent of patients/relatives, data was collected.
Observations and results: Out of 175 patients presenting to ED with thoracic trauma, pneumothorax was present in 24.6% (43) patients between May 2013 and November 2014 as diagnosed by Gold Standard (CT scan). EFAST examination was performed as an adjunct to primary survey in our patients and was positive in 41.1% (72) patients of whom 59.7% (43) patients had pneumothorax. EFAST was followed by Chest X ray and pneumothorax was confirmed by CT scan. In unstable patients, it was also confirmed initially by air bubbles on intercostal drainage, followed by CT scan. On EFAST, anterior "lung sliding" and comet-tail artifacts (B lines) were absent in 95.3% (41) patients, Barcode sign and Lung point sign was present in 95.3% (41) patients with pneumothorax and absent in 100% (132) cases without pneumothorax. (P value<0.05). In our study, Kappa index for ultrasonography was 0.969+/ 0.022 indicating ultrasound findings showed a very good correlation with CT scan findings.
Conclusion: Ultrasound is portable, simple, quick, and has higher sensitivity and accuracy compared to Chest X ray and may precede it in the evaluation of injured patients performed at any time, in any place, and on any patient. Hence, it is the ideal method for emergency conditions allowing immediate diagnosis and management of pneumothorax with better outcomes.

Keywords: Thoracic ultrasound, pneumothorax detection, EFAST, Chest X ray for pneumothorax, CT chest.

Introduction
Pneumothorax is a potentially dangerous complication of thoracic trauma requiring prompt and accurate management in ED to prevent mortality. We conducted this study to compare the accuracy of ultrasonography of thorax with chest X ray and CT scan as ultrasonography is safe, quick to perform at bedside, efficient, accurate, readily available and cost-effective in ED. Portable chest radiography (CXR) has been demonstrated to be an insensitive examination for the detection of pneumothorax that can miss over half of all post-traumatic pneumothoraces.
Computed tomography (CT) is considered as the gold standard for the detection of pneumothorax. However, it requires severely injured patients to be transported to the CT room, and is usually time-consuming, resulting in delayed diagnosis. Ultrasonography (US) can be easily performed at the bedside. With the advancement of technology, ultrasound devices have decreased in size, weight and cost, and have increased in image quality. US offers the possibility for clinicians to perform rapid evaluation of severely injured patients. The use of it to detect pneumothorax has been shown to have a higher sensitivity and specificity compared to CXR.

Time taken by an experienced person to detect pneumothorax by EFAST is 45 seconds to 1 min. reducing the time taken for bedside diagnosis of pneumothorax could allow the clinician to take early treatment measure s.

2) Aims

We conducted the present study to evaluate the accuracy (sensitivity and specificity) of bedside ultrasonography to rapidly detect pneumothorax in patients with thoracic trauma comparing with that of supine AP Chest X Ray and chest CT scanning and study the correlation of ultrasonography for pneumothorax with CT scan.

3) Materials

This was a single centred prospective observational study done on 175 patients in Department of Emergency Medicine in a tertiary care hospital over a period of 18 months from May 2013 to November 2014. Consent of patients/relatives and approval of the institutional Ethics committee was obtained prior to data collection. Patients of thoracic trauma receiving an EFAST exam, CXR and chest with or without abdominal CT were included in the study. All pregnant patients, patients resuscitated in other hospitals and referred to our hospital, patients who needed operative intervention, patients with chest wall injuries precluding ultrasound evaluation and patients who refused to give consent, were excluded from the study.

In lung Ultrasonography, the normal pleuro-pulmonary interface or the edge of the pneumothorax lies in the anterior, lateral or posterior chest, depending on the extension of the pneumothorax. At a point, normal lung-sliding and pneumothorax coexisted in a single view, forming 'partial lung-sliding'. This phenomenon was described as 'lung point', where lung-sliding and absent lung-sliding appeared alternately. The size of pneumothorax was inferred by ascertaining such points at different intercostal spaces. When these points are lined up, the contour of the pneumothorax is also outlined. Comet tail artefacts and bar code sign were also used in the study.

4) Observation

In our study, among the 175 patients with thoracic trauma, 144 patients were males and 31 were females, and pneumothorax was present in 24.6% (43) patients as confirmed by CT scan. 80% had a history of blunt trauma while 20% had penetrating trauma. The average age of our patients was 37.02+/-16.52 years. The commonest mode of injury was road traffic accidents (RTA) (23.4%). The commonest complaint was breathlessness. Tachycardia was the commonest sign. Limb injuries were the commonest associated injuries followed by facial injuries and head injury. Lacerations were the commonest thoracic wound.

E FAST examination was performed as an adjunct to primary survey in our patients and was positive in 41.1% (72) patients. 59.7% (43) patients had pneumothorax while hemothorax (with or without pneumothorax) was seen in 27.7% (20) patients, hemoperitoneum in 11.2% (8). EFAST was followed by Chest X ray and CT scan. In unstable patients, it was confirmed initially by air bubbles on intercostal drainage followed by CT scan.

On EFAST of pneumothorax patients, anterior “lung sliding” sign and comet-tail artifacts (B lines) were absent in 95.3% (41) patients, Barcode sign was present in 95.3% (41) cases and Lung point sign was present in 93% (40) patients with pneumothorax and absent in 100% (132) cases without pneumothorax.(P value<0.05). Initial diagnosis was based on these four US signs. In 2 patients, because of extensive subcutaneous emphysema finding of EFAST examination were not appreciable. Chest X ray findings of hyperlucency of lateral lung field and visible razor sharp border of lung were observed in 86% (37) and 88.4% (38) patients with pneumothorax respectively.

In our study, Kappa index for correlation of ultrasonography with CT scan was 0.969+/-0.022 indicating ultrasound findings showed a very good correlation.

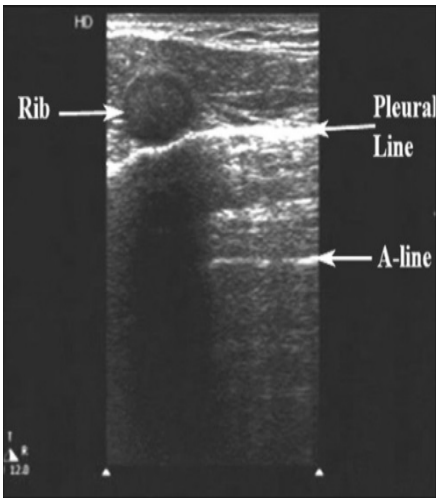
Patients were given oxygen through nasal prongs and face mask if SpO_2 was less than 94% initially. Advanced airway in the form of intubation was required in 32% (56) patients. 25.7% (45) patients required mechanical ventilation. Of the 67 patients requiring intercostal drainage tube, 19.4% (34) patients with pneumothorax were hemodynamically unstable. Intercostal drainage tube was inserted in ED. Air bubbles visible in ICD bag confirmed pneumothorax. CT scan also confirmed pneumothorax, which had partially resolved due to intercostal drainage tube insertion.

After stabilization, 68% patients were shifted to ward while 25.7% patients were shifted to ICU for mechanical ventilation. After inserting intercostal tube, SpO2 improved, Respiratory rate decreased and air entry improved. Despite resuscitative measures, mortality rate in ED was 4.6% (8). 1.7% (3) patients were sent home.

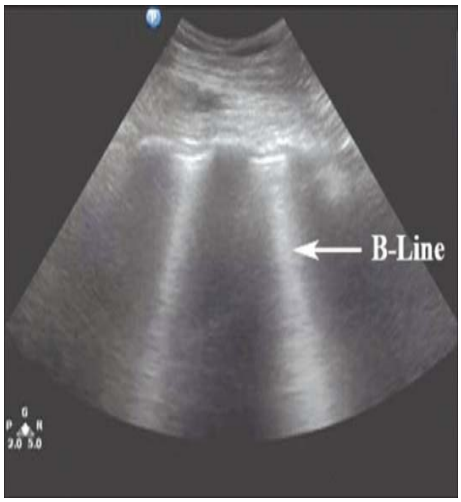
5) Discussion

Thoracic trauma contributes to a major number of trauma cases and severe cases usually present with pneumothorax. Pneumothorax can be life-threatening in ED. Hence quicker detection can improve survival of patients. Ultrasound can be that medium due to its positive features compared with Chest X ray.

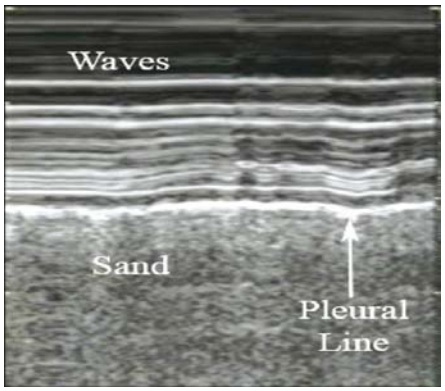
Ultrasound was first used to diagnose pneumothorax in humans in 1987. It was based on the principle that, without previous pleural disease, the visceral pleura moves against the parietal one during normal spontaneous breathing or mechanical ventilation. This physiological movement can be detected by ultrasound, forming lung-sliding in real-time and time-motion modes. Comet-tail artifacts are vertical reverberation artifacts arising from the visceral pleura, and caused by swollen septa surrounded by air. It is usually thought to be a pathological sign, and multiple comet-tail artifacts in one view can indicate alveolar or interstitial syndrome. When pneumothorax is present, the pleura is separated by air, which hampers the transmission of the ultrasound beam, so neither lung-sliding nor comet-tail artifacts can be observed. A higher diagnostic accuracy was obtained when both lung sliding and comet-tail artifacts were absent in previous studies.

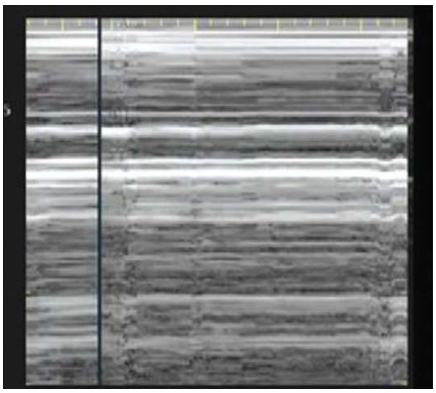


Lung sliding sign

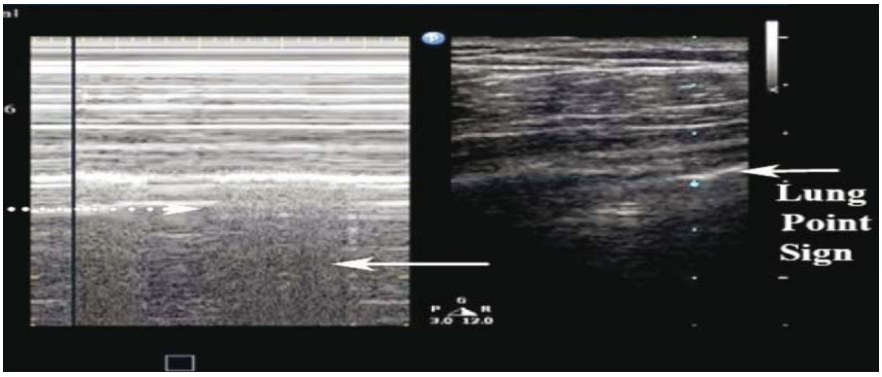


B lines on ultrasound





M mode view showing Seashore sign (left) and Barcode sign (right)



Lung point seen on M mode (left) and B mode (right) at site of pneumothorax

Kirkpatrick (2004) *et al.* [6] studied 225 patients of trauma (207 blunt, 18 penetrating) of which 65 (28.9%) had pneumothorax. While, we studied 175 patients of thoracic trauma (140 blunt trauma, 35 penetrating) of which 43 (24.6%) had pneumothorax. Satish (2014) *et al.* [10] had an overall male: female ratio of 5:1 while in our study, 82.2% (144) were males with 21.1% (37) having pneumothorax (4:1) and 17.7% (31) females with 3.4% (6) having pneumothorax with male: female ratio of 4.7:1. The difference between males and females in our study was statistically significant (P value<0.05). Satish (2014) *et al.* [10] in their study on patients presenting to ED with pneumothorax observed that the age distribution showed a biphasic pattern with 1st peak in the 3rd decade and 2nd peak in the 5th decade. While in our study, the most common age group affected with pneumothorax was 21-30 years, the average age of our patients was 37.02+/-16.52 years, 35.88+/-15.69 in males and 42.29+/-19.26 years in females and the peak was in 5th decade. The difference in age between males and females was statistically significant (P<0.01). In our study, 71.4% (125) patients came with breathlessness as the most common complaint followed by chest pain (19.4%), vomiting (14.3%), perspiration (12%), nausea (10.3%), altered sensorium (8.6%), facial and chest wall swelling (5.1%) which correlates with the findings of Satish (2014) *et al.* [10]. He also observed breathlessness (68%) as the commonest complaint followed by chest pain.

Table 1: Comparison of sensitivity (se) and specificity (sp) of USG signs of pneumothorax

Study	Lung sliding		B lines		Barcode sign		Lung point	
	Se	Sp	Se	Sp	Se	Sp	Se	Sp
Lichtenstein(1995)	95.3%	91.1%	-	-	-	-	-	-
Lichtenstein(2005)	100%	78%	95%	94%	-	-	79%	100%
Present study (2015)	95.3%	100%	95.3%	100%	95.3%	100%	95.3%	100%

In our study, sensitivity and specificity of lung sliding sign (95.3% and 100%), B lines sign (95.3% and 100%), Barcode sign (95.3% and 100%) and Lung point sign (95.3% and 100%) were obtained and were seen to be comparable to Lichtenstein (1995) *et al.* [2] with 95.3% sensitivity and 91.1% specificity for lung sliding sign, and Lichtenstein (2005)[9]{sensitivity and specificity of lung sliding (100% and 78%), B lines (95% and 94%) and lung point (79% and 100%). It was observed that due to subcutaneous emphysema, obesity and bowel gas, US signs could not be elicited in some patients.

Kappa index found in study by Zhang *et al.* [11] was comparable to our study (0.669 vs. 0.969).

6) Conclusion

The results of this study suggest that thoracic ultrasound when performed by Emergency physicians can enable definitive exclusion of pneumothorax with superior sensitivity and similar specificity as antero-posterior chest radiography for identification of pneumothorax in adults suffering with thoracic trauma. It has added benefits of portability, simplicity, rapidity, and higher sensitivity and accuracy allowing immediate diagnosis and management.

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