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DIAGNOSTIC ACCURACY OF ULTRASOUND IN THE DETECTION OF PNEUMOTHORAX IN CHEST TRAUMA PATIENTS WITH CT AS THE GOLD STANDARD

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Abstract

Background: To study the diagnostic accuracy of ultrasound in the detection of pneumothorax in chest trauma patients with CT as the Gold Standard

Methods: The present study was conducted from 31th July 2018 to 30th July 2019. A total of 36 patients were enrolled in the study.

Results: By chest ultrasound, pneumothorax was detected in 15 of 24 patients. The sensitivity of chest ultrasound for the diagnosis of pneumothorax was 62.5%, specificity was 100%, positive predictive value (PPV) was 100%, negative predictive value (NPV) was 54.14% and accuracy was 75%.

Conclusion: Chest ultrasound can play an important role in the emergency department aiding a physician for bedside rapid and accurate diagnosis of pneumothorax without interruption in the resuscitation process and without transferring the patient to the radiology section.

Keywords: Ultrasound, CT, Pneumothorax

Introduction

Generally, when a clinician suspects a pneumothorax, a chest radiograph is obtained. In general, ultrasound was not considered to be useful for diagnosing a pneumothorax. Furthermore, ultrasound was considered to be of little or no use in diagnosing most types of chest diseases as the ultrasound waves are hampered by the high acoustic impedance of the air-containing structures. The use of ultrasonography for thoracic injuries is fairly new compared to other accepted ultrasound applications and it is gaining more attention and acceptability. Thoracic Imaging with ultrasound was included along with FAST (Focussed Assessment with Sonography in Trauma) and is referred as Extended FAST (eFAST)[1]. 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. Ultrasound machines are readily available even at the peripheral centers.

Sonography to rule out pneumothorax is based on the principle that, without previous pleural disease, the visceral pleura slides to and fro against the parietal pleura lubricated by a small amount of pleural fluid during normal spontaneous breathing or mechanical ventilation called Lung Sliding Sign[2]. With the patient in supine position, 'Lung Sliding' can be seen all over the lung surface on the chest where visceral pleura is adherent to the parietal pleura. In case pneumothorax is present Lung Sliding will be absent.[2]

On M-Mode Doppler the normal to and fro movement of visceral pleura over the parietal pleura can be seen as horizontal lines representing the thoracic wall, and a sandy pattern representing the adherent normal ventilated lung known as 'seashore sign'. When pneumothorax is present, the normal seashore appearance will be absent, instead repeating horizontal linear lines will be seen, referred to as 'Stratosphere Sign'[3].

Another sonographic finding for ruling out pneumothorax are B- Lines. These lines are usually discrete laser-like vertical hyperechoic reverberation artefacts; they arise from the pleural line and extends to the bottom of the screen without fading and move synchronously with lung sliding[3].

Also, A Lines are horizontal echogenic long path reverberation artefacts that occurs beneath the pleural line. Absence of lung sliding associated with A-lines suggests pneumothorax[3].

Material and methods

Study design: Cross sectional analytical study.

Setting: Department of Radiodiagnosis, IGMC, Shimla, Himachal Pradesh, India.

Study period: 31st July 2018 to 30th July 2019

Methodology: This study was aimed to analyse the diagnostic accuracy of ultrasound for the diagnosis of pneumothorax in comparison and correlation with CT Scan as the Gold Standard on patients being referred to the Department of Radiodiagnosis from various clinical departments in Emergency Section of Indira Gandhi Medical College and Hospital, Shimla.

Inclusion Criteria:

1. Patients who presented with history of trauma to the chest.
2. Patients more than 10 years of age.

Exclusion Criteria:

1. Patients treated with open and tube thoracostomy prior to imaging.
2. Patients who were not willing to participate in the study.
3. Pregnant patients.
4. Very sick Patients.

Results

Table 1: Demographic data of the patients (n = 36)

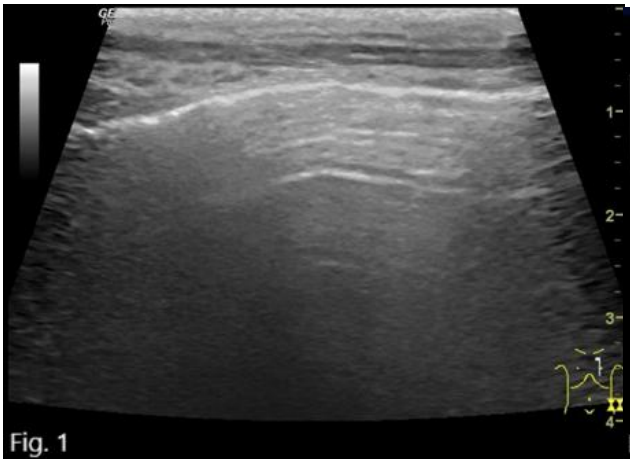
AGE(Years)	MEAN	43.56	
	RANGE	12-80	
SEX	MALE	21	58.3%
	FEMALE	15	41.7%
CAUSE OF TRAUMA	FALL FROM HEIGHT	20	55.6%
	ROAD TRAFFIC ACCIDENTS	16	44.4%

The age of patients in our study ranged from 12 years to 80 years. The mean age was 43.56 years. Most of the patients were in the range of 20-40 years (n=13) comprising 30.6% of total. Minimum number of patients were in the age group of <20 years (n=4).Out of the total 36 patients there were 21 male patients (58.3%) and female 15 patients (41.7%).

Table 2: Accuracy of *Ultrasound findings* in Pneumothorax, Gold Standard – CT Scan (n=36)

Ultrasound Pneumothorax	CT Scan Chest - Pneumothorax Disease Present	N	Absent	n	Total
Positive	True Positive	a= 15	False Positive	c= 0	a+c= 15
Negative	False Negative	b= 9	True Negative	d= 12	b+d= 21
Total	a+b= 24		c+d= 12		36
Statistic	Sensitivity	Specificity	PPV	NPV	Accuracy
	62.50%	100.00%	100.00%	54.14%	75.00%

By chest ultrasound, pneumothorax was detected in 15 of 24 patients. The sensitivity of chest ultrasound for the diagnosis of pneumothorax was 62.5%, specificity was 100%, positive predictive value (PPV) was 100%, negative predictive value (NPV) was 54.14% and accuracy was75%.



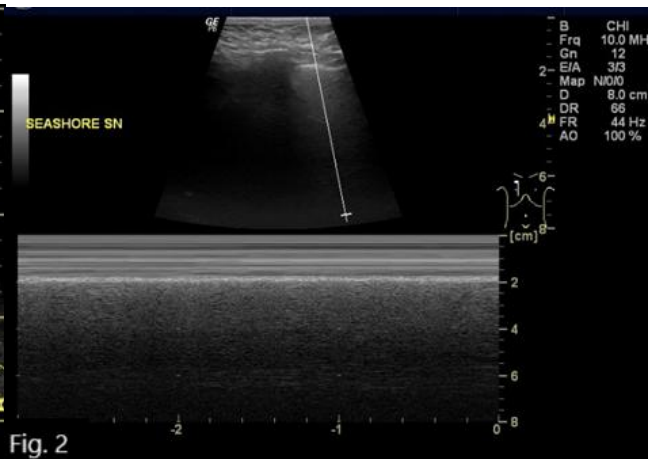
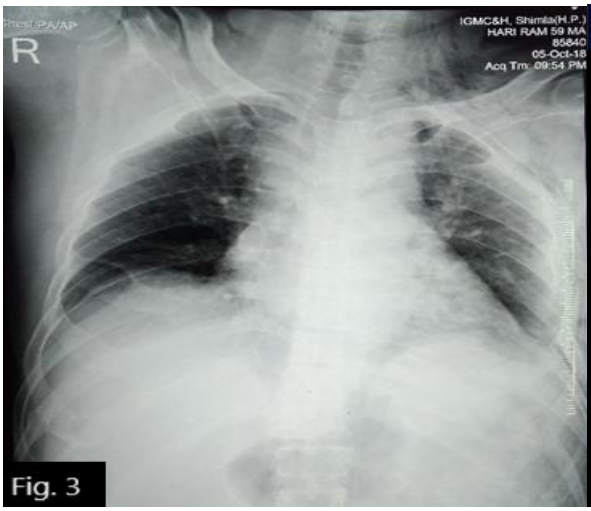


Fig 1: Lung Sliding Sign- the visceral pleura normally slides to and fro against the parietal pleura during normal breathing.

Fig 2: Seashore sign- On M-Mode Doppler- the normal lung sliding appears as horizontal lines representing the thoracic wall, and a sandy pattern representing the adherent normal ventilated lung known as 'seashore sign'.



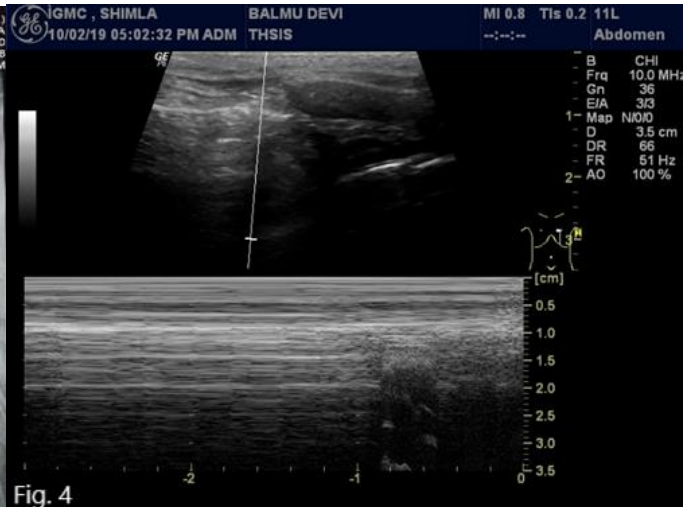


Fig 3: X-ray Supine Ap view of a 59 year old patient with history of fall from height showing haziness involving the left lung field with obliteration of the left Costophrenic angle. Subcutaneous emphysema seen involving the left lateral chest wall. No evidence of pneumothorax seen.

Fig 4: Chest ultrasound of left chest wall on anterior aspect showing the normal seashore appearance was absent, however repeating horizontal linear lines were seen, referred to as 'Stratosphere Sign' suggestive of presence of pneumothorax.

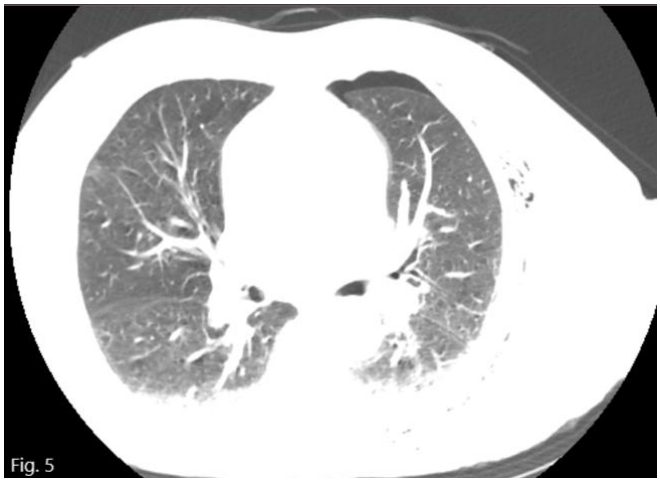


Fig 5: CT-Chest showing presence of left sided pneumothorax. Minimal hemothorax are also seen bilaterally. Minimal subcutaneous emphysema seen involving the left lateral chest wall.

Discussion

Matej Strnad et al.(2013)[3] opined that absent lung sliding associated with A-lines suggests pneumothorax. Lung sliding can be also shown by using M-mode Doppler. A normal image is called the "seashore sign", with the thoracic wall, represented as horizontal lines, and the adherent, ventilated lung generating a sandy pattern on M-mode. When a pneumothorax is present, the M-mode Doppler will show only repeating horizontal linear lines, identified as "stratosphere sign". Another sonographic finding, called B lines, rules out a pneumothorax as well. B- lines are defined as discrete laser-like vertical hyperechoic reverberation artefacts that arise from the pleural line, extend to the bottom of the screen without fading, and move synchronously with lung sliding. Presence of B lines alone had a sensitivity and negative predictive value for pneumothorax up to 100%. They concluded that lung sliding could rule out pneumothorax with a high degree of sensitivity and specificity.

S. Ianniello et al[4](2014) in their retrospective study involving 368 unstable adult patients(736 lung fields), 87 pneumothoraces were detected with thoracic CT scans (23.6 %). e-FAST detected 67/87 and missed 20 pneumothoraces(17 mild, 3 moderate). The diagnostic performance of ultrasound was: sensitivity 77 %, specificity 99.8 %, positive predictive value 98.5 %, negative predictive value 97 %, accuracy 97.2 %; 17 missed mild pneumothoraces were not immediately life-threatening (thickness less than 5 mm). They concluded that thoracic ultrasound (e-FAST) is a rapid and accurate first-line,

bedside diagnostic modality for the diagnosis of pneumothorax in unstable patients with major chest trauma during the primary treatment in the emergency room.

Şeyhmus Kaya et al(2015).[5] in their study on 210 patients to investigate the effectiveness of chest ultrasound for the diagnosis of pneumothorax in patients with blunt trauma to the chest showed that, for the detection of pneumothorax, the sensitivity of chest ultrasound was 88%, specificity 99.5%, positive predictive value (PPV) 95.7% and negative predictive value (NPV) 98.4%.

Khaled Morsy Salama et al.(2017)[6] performed a study to assess the accuracy of bedside chest ultrasound in detection of pneumothorax in chest trauma patients in which 50 patients were enrolled. All the patients underwent chest ultrasound, Chest X-Ray, and chest CT. The data from ultrasound and Chest X-Ray were compared with the gold standard CT. Then the accuracy of which were calculated. The specificity and sensitivity of chest ultrasound in diagnosing pneumothorax was 100% and 81% respectively, with overall accuracy 88%. The specificity is higher than sensitivity. Supine Chest X-Ray showed sensitivity (75%), specificity (88.9%) and accuracy (80%) which are good numbers but still lower than chest ultrasound. They concluded that Chest ultrasound is highly accurate tool for detection of pneumothorax in patients with chest trauma. It is a useful tool for the emergency physician for bedside rapid and accurate diagnosis without interruption of the resuscitation and without transferring the patient for the radiology unit.

Findings in our study are in concordance with the above mentioned study with chest ultrasound having good sensitivity, specificity and accuracy in the diagnosis of pneumothorax.

Ultrasound chest did not detect 9 (False Negative) of the 24 pneumothoraces that were present. 7 of these cases had minuscule pneumothoraces that were located in the para-cardiac region, the apical region of the upper lobes or just posterior to the sternum. The other 2 patients with pneumothoraces who were not detected on ultrasound were having marked subcutaneous emphysema due to which there was poor acoustic window.

Conclusion

Pneumothorax is a life-threatening clinical condition and early detection of pneumothorax in the emergency department in chest trauma patients is imperative to initiate early management of the condition. CT scan, which is the gold standard for diagnosis of pneumothorax, is time consuming and usually not available at all centers. In most cases, the diagnosis is confirmed by chest radiography, however small and miniscule pneumothorax are usually not detected on Chest X-Ray. Chest ultrasound is upcoming as an excellent bedside tool for non-invasive work-up of patients with blunt chest trauma for diagnosing and excluding pneumothorax. Chest ultrasound can become of great help to the emergency physician for bedside rapid and accurate diagnosis of pneumothorax without interruption of the resuscitation and without transferring the patient to the radiology section.

Thoracic ultrasound should be included as an extension of the standard focused assessment with sonography for trauma (FAST) protocol in all patients with multiple trauma. Although chest ultrasound has not been preferred as frequently as chest radiography for the diagnosis of pneumothorax yet, it is an important method for early bedside diagnosis of pneumothorax, particularly in cases of clinically unstable patients.

Limitations

This study has few limitations. This study included a smaller number of patients and in smaller hospital settings. The selected patients were more severely injured than patients who may only receive a chest radiograph without undergoing CT Scan which may have led to some selection bias. Presence of subcutaneous emphysema in certain patients also caused obscuration of the ultrasound waves leading to poor acoustic window. The CT scans were often performed more than 30 minutes after initial ultrasound, thus giving time for the pneumothorax to enlarge in some cases. And lastly, ultrasound is user dependent and opinions may different from one operator to another.

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