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CORRELATION OF CHEST ULTRASOUND WITH PLAIN X-RAYS FOR THE DETECTION OF PNEUMOTHORAX

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Abstract :

Background: Chest radiograph has been the standard initial imaging modality of choice to detect pneumothorax. Despite of moderate sensitivity in detection of pneumothorax, due to its wide range of geographical availability and less expenditure in our country, it has been widely advocated by all the physicians. Computed Tomography (CT) and Ultrasonography (USG) being the current point of care in most parts of the country and having no radiation risks, it can be utilized in early and safe detection of pneumothorax. In this study, we analyzed the diagnostic utility and efficacy of chest ultrasound in detecting pneumothorax on comparison to chest x ray.

Methods: Ethical committee clearance and informed consent was taken from all the patients. Total of 79 patients who were having clinical suspicion of pneumothorax were evaluated. Initial imaging evaluation was done using B-mode and M-mode chest ultrasonography and further subjected to chest radiography. Images were assessed by 2 experienced radiologists. Demographic, clinical and radiological data were documented and analyzed. In the cases of discrepancy in findings of USG vs. Radiograph, CT was considered the gold standard for obtaining the final diagnosis.

Results: We found that chest ultrasound had sensitivity of 98.43%, specificity of 100%, PPV of 100%, NPV of 93.75% and diagnostic accuracy of 98.73%. Chest radiograph had sensitivity of 73.43%, specificity of 83.33%, PPV of 94%, NPV of 46.9% and diagnostic accuracy of 78.9%

Conclusion: Chest USG is a useful and essential tool in detection of pneumothorax. Although chest radiograph being widely available and CT with its highest sensitivity & specificity, USG stand apart in providing good diagnostic value with no radiation risks.

Key words: USG; Chest radiograph; Pneumothorax

INTRODUCTION:

Pneumothorax is defined as presence of air in the pleural cavity. Pneumothorax is broadly classified into spontaneous and traumatic pneumothorax. Spontaneous pneumothorax occurs without trauma in normal healthy individuals. Spontaneous pneumothorax is further divided into primary and secondary spontaneous pneumothorax. Primary spontaneous pneumothorax

occurs without any underlying lung pathology. Secondary spontaneous pneumothorax is seen in patients who have underlying lung pathology [1].

Traumatic pneumothorax occurs due to various causes, like blunt or penetrating chest trauma or iatrogenic as a complication following post-procedure like biopsy or any medical/surgical interventions. Patients present with symptoms of sudden onset of chest pain and shortness of breath. Diagnosis of pneumothorax requires a chest X-ray or Computed Tomography (CT) scan. Small spontaneous pneumothorax typically resolves without treatment and require only monitoring[2].

Although a clinical diagnosis is simple to arrive, a multidisciplinary approach is required for definitive diagnosis and treatment [3]. The roles of cross-sectional imaging and conventional chest radiography have been well established in the literature. Chest radiography being widely available in most parts of our country; it has moderate sensitivity and specificity in diagnosis of pneumothorax. Despite of moderate sensitivity,due to its wide range of geographical availability and less expenditure in our country, it has been widely advocated by all the physicians [4].

Computed Tomography (CT) has been considered the gold standard imaging modality with highest sensitivity and specificity in detection of pneumothorax, but it may not be available in all the sectors of health care in our country [5]. Ultrasonography (USG) being currently widely available in many parts of our country, it can be utilized in the early and safe detection of pneumothorax. No radiation risk makes it as a well suitable and safe modality for pregnant women and newborn [6].

To the best of our knowledge, not many studies have been done in previous literature in comparing the diagnostic efficacy of USG vs. Chest Radiography in the detection of pneumothorax. In this study, we analyzed the diagnostic utility and efficacy of chest ultrasound in detecting pneumothorax on comparison to chest radiography.

Materials and Methods :

Study details

This study was a prospective comparative study conducted between January 2020 to June 2021 in Department of Radio-diagnosis, Vydehi Institute of Medical Sciences and Research Centre.

Inclusion and exclusion criteria

All patients presented with clinical suspicion of pneumothorax were included in the study. Patients who refused to undergo Chest radiography and/or CT following USG Patients who did not provide informed consent were excluded.

Study Protocol

Total of 79 patients with clinically suspected pneumothorax was included in our prospective comparative study. Institutional Ethical committee clearance was obtained. Informed consent was taken from all the patients. All these patients were subjected to initial USG evaluation followed by chest radiograph. Discrepancy in USG and radiographic findings were confirmed

by Computed Tomography. In addition, patients with clinical suspicion of pneumothorax but depicted normal USG and CXR appearances were confirmed on CT. Radiological evaluation was done by two experienced radiologists.

Method of evaluation

Anterior and posterior lung fields were examined both in transverse and sagittal planes. Lateral lung fields were examined both in transverse and coronal planes.

Region of interest and optimal patient position

Anterior lung fields - Patient sitting in erect position

Lateral lung fields - Patient in erect position with arms overhead. Posterior lung fields - Patient in prone position were followed.

Statistical analysis

Data was entered into Microsoft excel data sheet and was analyzed using SPSS 22 version software. Categorical variables were represented in the form of frequencies and proportions. Chi-square test was used as test of significance for qualitative data. Continuous data was represented as mean and standard deviation

Results :

Out of total 79 patients were included in our study, 76% were males [60/79] and 24% were females [19/79]. Age range of patients was <40 to >70 years.

Etiology of pneumothorax

Many patients included in our study hadunderlying lung disease. The most common cause of pneumothorax in this study was secondary spontaneous (48.1%) followed by trauma (27.8%), iatrogenic (22.8%) and primary spontaneous (1.3%).

USG detection of pneumothorax

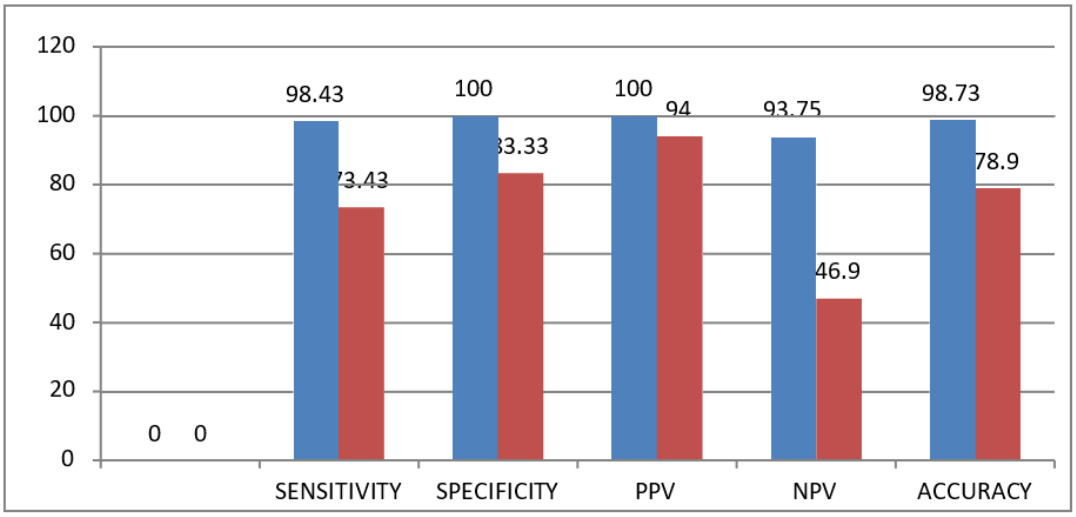
All the patients were first subjected to chest ultrasound; we observed that 64 patients had absent lung sliding sign (81%) and 15 patients had normal lung sliding sign(19%). In our study we observed that 64 patients had barcode sign (81%) and 15 patients did not show barcode sign(19%).

Other parameters

We observed that USG in 43 patients demonstrated lung point sign (54.4%) and USG of 36 patients did not demonstrate this sign (23.9%). We combined all the ultrasound signs of pneumothorax which resulted in USG detecting pneumothorax in 64 patients (81.1%) and could not detect pneumothorax in 15 patients (18.9%).In our study all patients underwent chest radiography, 47 patients showed pneumothorax as evidenced by the pleural line and absent lung markings (59.4%). 32 patients showed no signs of pneumothorax (40.6%). In 17 out of 79 patients, chest USG was able to detect signs of pneumothorax but chest radiography was normal. In these cases, CT was done to confirm the presence of pneumothorax. All 17 patients had pneumothorax on CT. In our study, USG detected pneumothorax 64 out of 79

and 15 patients did not show any signs of pneumothorax. Patients who had pneumothorax which was correlating with chest radiography. One patient had subcutaneous emphysema; showed presence of pneumothorax on USG, on chest radiography also did not show any signs of pneumothorax. But minimal pneumothorax was confirmed on CT.

Figure 1 - USG [blue] and Chest radiograph [red] pneumothorax correlation



Our study showed, on chest radiography 47 had pneumothorax and 17 did not show pneumothorax. Because of the discrepancy, CT was performed for these 17 cases and confirmed to have minimal pneumothorax. In this study, we observed USG had sensitivity of 98.43%, specificity of 100%, positive predictive value of 100%, negative predictive value of 93.75 and diagnostic accuracy of 98.73%. Chest radiography had sensitivity of 73.43%, specificity of 83.33%, positive predictive value of 94%, negative predictive value of 46.9 and diagnostic accuracy of 78.9%. By analyzing these values, we can say that chest USG is better imaging tool in detecting pneumothorax when compared to chest radiography.

Table 1 –

	No. of Patients	%
Gender		
Male	60	75.9
Female	19	24.1
Agein Years		
<40	44	55.7
40-50	6	7.6
50-60	14	17.7
60-70	9	11.4
>70	6	7.6
Etiologyofpneumothorax		
PRIMARY SPONTANEOUS [NO LUNG DISEASE]	1	1.3
SECONDARY SPONTANEOUS [LUNG DISEASE]	38	48.1
TRAUMA	22	27.8
IATROGENIC	18	22.8
USG findings: absent lung sliding sign		
ABSENT	15	19
PRESENT	64	81
USG findings: barcode sign		
ABSENT	15	23.9
PRESENT	64	76.1
USG findings: lung point sign		
ABSENT	36	45.6
PRESENT	43	54.4
Detection of pneumothorax by USG		
ABSENT	15	18.9
PRESENT	64	81.1
Detection of pneumothorax by chest radiograph		
NEGATIVE	32	40.6
POSITIVE	47	59.4
CT confirmation of pneumothorax in cases with non-concordant USG and Chest radiograph finding		
NEGATIVE	0	0
POSITIVE	17	100.0

Parameters recorded during the study

Discussion:

In our study,we analyzed the role of chest ultrasound in patients presenting with clinical suspicion of pneumothorax. In our study we included 79 patients who satisfied the inclusion

and exclusion criteria. There was significant male gender preponderance [males 76 % and females 24%]. Majority of the subjects were under the age of 40 years (55.7%). The most common clinical presentation was sudden onset of chest pain and breathlessness. Patients presented with reduction in oxygen saturation in cases of massive pneumothorax [7].

Our study included cases of secondary spontaneous pneumothorax (48.1 %), h/o trauma (27.8 %), iatrogenic (22.8%) and primary spontaneous pneumothorax (1.3 %). Ultrasound demonstrates presence of pneumothorax by these signs: absent lung sliding, barcode and lung point sign. Pneumothorax is rapidly detected by the absent sliding lung sign on USG as per our study findings. Our study showed absent lung sliding sign and barcode sign in 64(81.1%) patients out of 79 and lung point sign was present in 54.4% of cases. Dulchavsky et al. conducted a study with similar findings which demonstrated true negative rate of 100% for ruling out pneumothorax when compared with chest radiography [8].

In our study we included absent lung sliding sign, barcode sign and lung point sign. Michael In a previous study, included 176 patients; they detected pneumothorax [PTX] in 53 (30%) patients by ultrasound and 40 (23%) patients by chest x-ray. On ultrasound, they detected pneumothorax by absent lung sliding sign. They detected pneumothorax [PTX] in 53 (30%) patients by ultrasound and 40 (23%) patients by supine AP chest radiography. They found 53 (30%) true positives by CT or on chest tube placement. The sensitivity for the chest radiography was 75.5% and specificity of 100% [9,10]

In our study, we detected one occult pneumothorax which was confirmed by the CT. When chest radiography is contraindicated like in pregnant women, chest ultrasound can be an alternative tool for diagnosing pneumothorax. Though CT is considered as the gold standard due to its high accuracy rate and chest radiography as the initial investigation or screening tool for pneumothorax both can be avoided for diagnostic purpose owing to its risk of ionizing radiation to the patient. Chest ultrasound has more advantages over chest radiography; as it is non-invasive, inexpensive, radiation free, bedside, portable, rapid, allows better visualization of lung pathology. Most important advantage of USG is that it can be repeated without radiation risk to the patient [11,12]. In cases of discrepancy between chest radiography and chest USG, we incorporated CT as the gold standard. The results favoured chest ultrasound over chest radiograph. Chest radiography could be completely avoided and chest ultrasound can be used as an alternative investigation of choice for diagnosing pneumothorax at bedside and emergency conditions.

In our study chest ultrasound was performed first in all patients. USG was able to detect pneumothorax in 64 patients. We included absent lung sliding, barcode and lung point signs. In our study the sensitivity of chest ultrasound was found to be 98.43%, specificity of 100%, PPV of 100% and NPV 93.75 % which was comparable to the accuracy evaluated by various authors. Diagnostic accuracy was found to be 98.73%. Chest radiography was able to detect pneumothorax in 47 patients. In our study the sensitivity of chest radiograph was found to be 73.43%, specificity of 83.33%, PPV of 94% and NPV 46.9% which was comparable to the accuracy evaluated by various authors. Diagnostic accuracy of chest radiograph was found to be 78.9%.Our study had 22 patients with history of trauma. USG showed 1 false positive due to subcutaneous emphysema. Bon S. Ku et al conducted a study on traumaticpneumothorax [13].

Our study was a prospective study and we included patients who had undergone interventions also. We had included absent lung sliding sign, barcode sign and lung point sign. Absent lung sliding sign and barcode signs were detected in 64 out of 79 and 43 out of 64 patients showed lung point sign for the diagnosis of pneumothorax.From our study we could infer that overall, chest ultrasound has high sensitivity for pneumothorax; in cases with clinical suspicion of pneumothorax chest ultrasound examination is highly recommended for the detection of pneumothorax.

Conclusion:

From this study, we like to infer that USG chest may be employed as the first hand efficient and safe tool in detecting pneumothorax with high diagnostic accuracy. Contrary to CR and CT, USG with no risk of ionizing radiation is much safer tool in the clinical setting. USG being widely available in most geographic parts of our country and can be utilized in all patient population, it should be considered as stand-alone imaging modality of choice in fast and efficient way of diagnosing pneumothorax which hastens the management plan.

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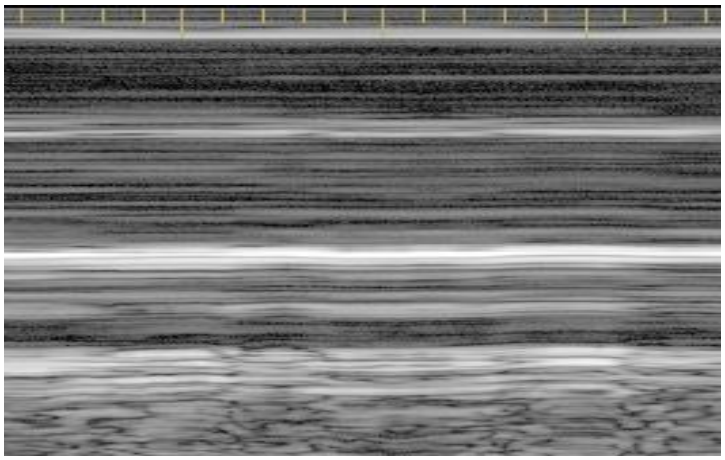
Supplementary data
Illustrative cases

Case 1- A 50 year old male patient with history of pulmonary tuberculosis presented withdifficulty in breathing and chest pain. Relevant chest USG, chest radiograph and CTimages are depicted below. USG showed findings of pneumothorax but in contrary chestradiograph didn't depict pneumothorax. USG findings were confirmed with CT.



USGshowed barcodesign onthe leftside

Onultrasound absent lungsliding and barcodesigns wereseen.

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Chestradiograph showednosignsofpneumothorax.