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Original Research Article

Role of ultrasound in diagnosis of pleural and parenchymal lung diseases in OPD patients

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ABSTRACT

Background & Objective: Thoracic CT is the most common imaging modality used after screening with chest x-ray in treatment of lung pathologies. But high cost, radiation, immobility & availability restrict its widespread use. For many years transthoracic ultrasound is being used in examination of pleural effusions in ICU patients. To study the role of chest ultrasonography in diagnosing pleural & parenchymal pathologies in OPD patients this study was carried out.
Materials and Methods: 32 adult patientswithdyspnoea, cough & other chest symptoms coming to OPD of pulmonary department of Santosh hospitals from January 2017 to July 2018 were enrolled in the study.
Results: In diagnosing pleural lung diseases- pleural effusion, pneumothorax, hydropneumothorax and pleural thickening, US showed a sensitivity, specificity, PPV & NPV all of 100% and accuracy of 1.00. But for parenchymal lesions taken all together (Consolidation, collapse, atelectasis, lung abscess, fibrocavitary lesion with necrosis, idiopathic pulmonary fibrosis, bleb/ bulla) it showed low accuracy of 0.62 with 42.86% sensitivity, 86.36% specificity, 80% positive and 54.29% negative predictive values respectively.
Conclusion: Thoracic US offers fast, cheap, safe, radiation free, widely available, easily reproducible and non-invasive diagnostic modality for evaluating pleural lung diseases in OPD patients. But low sensitivity in diagnosis of parenchymal diseases is not encouraging.

1. Introduction

Majority of chest diseases have been treated with chest x-ray as only imaging modality. With continuous advances in field of medicine, need for further imaging modalities after chest x-ray is being felt increasingly for better diagnosis. Thoracic CT is the most common imaging modality after chest x-ray being used. But it has many limitations ie cost, radiation, availability. Use of ultrasound for diagnosis of chest diseases has been restricted mostly to ICU settings, where patients are immobile and are on ventilators. However over the past few years USG of the pleural space and lung parenchyma is getting acceptability in different conditions in clinical practice.

1.1. Lung consolidation

Can be diagnosed by ultrasound as an echo-poor or tissue like image.

1.2. Pneumothorax

By ultrasound pneumothorax can be diagnosed by absent lung sliding, as presence of lung sliding and/or B lines rule out diagnosis of pneumothorax.

1.3. Pleural thickening

Pleural thickening is defined as a focal lesion arising from the visceral or parietal pleura that is greater than 3 mm in width with or without an irregular margin. These can be difficult to distinguish from small effusions as both

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may appear hypo-or anechoic on US. Pleural thickening neither displays movement relative to the chest wall during respiration nor contains movable strands or echo densities.[1] In a pleural effusion, transmitted motion during respiratory or cardiac cycles causes a colour signal known as the fluid colour sign. This sign, being both sensitive and specific, can be used to differentiate a small effusion from pleural thickening.[2] In case of pleural thickening no colored signals are detected as pleural thickening has no movable part.

1.4. Interstitial syndrome

Multiple B-lines play an important in diagnosis of diffuse interstitial pathology which is 7mm apart characterize subpleural inter-lobular septal oedema or thickening. If closely spaced (< /=3mm) and coalescent B-lines suggest subpleural fluid filled alveoli which correspond to ground-glass opacities in CT.

1.5. Neoplasms

Tumors in relation to the pleura can be assessed with ultrasound, lung tumors appear as predominantly hypoechoic masses. Different soft-tissue lesions arising from the chest wall can be easily detected by high-frequency US. Masses generally have variable echogenicity and US findings are too non-specific to differentiate between various etiologies.

2. Materials and Methods

The study was conducted from January 2017 till July 2018 in tertiary care hospital, Santosh Medical College & Hospital, Ghaziabad, U.P. Study population was the patients who visited pulmonology OPD in Santosh Hospital with complaints of dyspnoea, recurrent cough (dry or productive), hemoptysis or chest pain, fever and had findings on chest x-ray. Patients fulfilling the criteria were advised ultrasonography of chest.

2.1. Inclusion criteria

1. Patients equal to and above 18 years of age.
2. Patients with chief complaints of dyspnoea, cough & symptoms did not resolve after antibiotic therapy.
3. In patients where chest radiography showed pleural and peripheral lung diseases.

2.2. Exclusion criteria

1. Those patients who are bed ridden, critically ill, patients in intensive care unit and emergencies and with comorbidities.
2. Patients with obstructive and restrictive airway diseases.

A 2-5MHz curvilinear probe allows visualization of the deeper structures, and the sector scan field allows a wider field of view through a small acoustic window. The chest wall, pleura, and lungs may be quickly surveyed with the curvilinear probe. Another probe is phased array these probes have a useful footprint for getting in between the ribs. They can be used to demonstrate all the signs of lung ultrasound but the clarity of the images is not as good. Once an abnormality is detected a high-resolution 7.5-10MHz linear probe can be used to provide detailed depiction of any chest wall, pleural or peripheral lung abnormality. For data analysis each hemithorax was divided into six regions delineated by the anterior and posterior axillary lines, three in upper fields (anterior, posterior, lateral) and three in lower fields(anterior, posterior, lateral). Patients were studied in the supine position. The posterior chest is best scanned with the patient sitting in an upright position, whereas the lateral and anterior chest wall can be examined with the patient in either the lateral decubitus or supine position. The superior sulcus pathology can be apically visualized with the patient in the supine or sitting position. Color Doppler imaging was used for assessment of most of the thoracic lesions. M-mode (motion mode) was utilized as an adjunctive imaging modality in most of the cases. Ultrasound generates digital images by transmitting sound waves from a transducer to human tissues and recapturing the reflected sound waves (or echoes) that are then converted back into electrical impulses and processed into images. The frequency of diagnostic ultrasound is in the millions of Hertz (MHz) and ranges from 2 to 10 MHz for transthoracic US.[3–5] The distribution and intensity of the US image on the screen is determined by three characteristics: 1) the direction and 2) intensity of the captured echoes, and 3) the time elapsed from emission to capture.[3–5] Different tissues have different densities and therefore conduct these waves differently. Echogenicity is the ability to reflect an echo, and the echogenicity of any tissue or lesion is defined relative to that of the normal liver, which is arbitrarily considered isoechoic.[4] Sound waves propagate well through liquids (e.g., pleural effusions) and through tissues with a high fluid content (e.g., consolidated lung, tumors, and liver).[3,5,6] Tissues that have higher echogenicity are called “hyperechoic” and are usually represented with lighter colors. In contrast, tissues with lower echogenicity are called “hypoechoic” and are usually represented with darker colors. Areas that lack echogenicity are called “anechoic” and are usually displayed as completely dark (e.g., fluid). Solid organs have variable echogenicity depending on the content of fluid and fraction of reflected waves. However, when a significant difference in density between tissues is encountered, the sound waves are reflected in a phenomenon called “acoustic impedance.” This is readily seen when imaging gas (e.g., normal lung or a pneumothorax) or solid tissue (e.g., bone).[5,6] Thus, the anatomy beyond the visceral

pleura is not indiscernible in healthy individuals.

2.3. Ultrasound of the normal chest

Ribs are seen as convex structures with posterior shadowing on transverse (vertical) scanning, and when viewed longitudinally, the anterior cortex appears as a continuous echogenic line. The combined visceral and parietal pleura appear as a single highly echogenic pleural line approximately 5 mm deep in the rib cortex and no more than 2 mm in width, and they represent the pleuro-pulmonary interface.[3,4,7] On high resolution scanning, the parietal and visceral pleura can be seen as two distinct echogenic lines, with the former seemingly thinner and the latter more echogenic. These two layers glide over each other during normal respiration, giving rise to the so-called "lung sliding" sign, which is best seen on longitudinal (vertical) real-time scanning.[3,7] Because of the presence of air and major acoustic impedance, a normal lung cannot be visualized on US; however, the pleura–lung interface causes artifacts that can be described as "the ABC's" of thoracic US.[3,4,7] "A-lines" or reverberation artifacts are seen as a series of echogenic parallel horizontal lines equidistant from one another, and they diminish in intensity with increasing distance from the pleural surface.[3,7,8] "B-lines" are longer, vertical artifacts that obliterate A-lines, move synchronously with lung sliding. One B-line indicates contact of visceral pleura with parietal pleura. This represents a normal lung surface. Multiple B-lines are considered pathological.[3,7,9] A-line & B-line are not generally seen together. "Comet-tail" artifacts are short, vertical lines seen at the pleura-lung interface in normal individuals, particularly at the lung bases, and are possibly caused by fluid-filled subpleural interlobular septa.[3,4,7,9] The diaphragm is best studied in the supine position.[10] On the right, the liver is used as a window to view the diaphragm (the spleen is used on the left), and it appears as an echogenic curved line that is 1–2 mm thick which contracts with inspiration.[3,4,7] At the costophrenic angle, an aerated lung can variably obscure underlying structures, and this is termed the "curtain sign".[3,4] The characteristic appearance of two ribs and pleural line in between is appearance is called "Bat sign". In time motion M-mode), the structure till parietal pleura appear as horizontal lines and beyond this sandy pattern representing lung sliding. This characteristic appearance is called "Seashore sign. The presence of pleural line, lung sliding, A-lines in 2D and seashore in M-mode are characteristic of normal aerated lung.[11–13]

3. Results

This study was conducted on 32 OPD patients. 20 males and 12 females with a mean age of 47.2± 14.6 years for males and for females mean age was 36.1±16.6 years. All enrolled patients were between the age 18 to70 years. 12 patients (37.5% (n=12) were in the age group of less than 40 years, 13 patients (40.6%(n=13) were in the age group of 40 to 60 years and 7 patients (21.9%(n=7) were in the age group of > 60 years. In this study, out of 32 patients 34.4% patients (n=11) were undernourished (underweight), 59.4%(n=19) were having normal BMI and 2 patients 6.3%(n=2) were overweight. In this study, out of 32 patients, Dyspnoea was seen in 32 patients (100%), chest pain in 23 Patients (71.88%), anorexia in 22 patients (68.75%), fever in 18 patients (56.25%) & weight loss was seen in 18 patients (56.25%). 18 patients (56.25%) had productive cough while 14 patients (43.75%) presented with non-productive cough. Episodic dyspnea was a predominant symptom in 22 patients (69%), however, persistent dyspnea was a presenting feature in only 10 patients (31).

In regard to location of the diseases, the frequency distribution among all the three groups was quite similar, 11(34.38%) patients had parenchymal diseases and 12 (37.5%) has pleural diseases. 9 patients (28.13%) had mixed diseases. Since our study was regarding efficacy of ultrasound in diagnosis of pulmonary diseases, for purpose of analysis findings were classified as pleural andparenchymal. 12 patients of pleural disease and 9 patients with mixed disease had overall 22 pleural findings. One patient had two pleural findings 11 patients of parenchymal disease and 9 patient with mixed disease had overall 28 parenchymal findings, since many patients had more than one parenchymal findings. Thus overall 50 radiological findings were observed in study population.

Table 1: Case distribution according to location of diseases

Location	Frequency	%
Parenchymal	11	34.38
Pleural	12	37.5
Mixed	9	28.13
Total	32	100

Table 2: Distribution of Radiological findings

	Frequency
Pleural findings	22
Parenchymal findings	28
Total findings	50

4. Discussion

Chest X-Ray is the main imaging approach in pulmonary pathologies, however many limitations for its use exist. It is a time consuming procedure, involves exposure to radiation and its interpretation has high inter-observer variability. Chest CT scan, despite its higher diagnostic accuracy than plain Chest X-Ray, has its own limitations ie: exposure to radiation, high cost, availability & need for transportation to CT-scanner.

Table 3: Distribution of pleural findings & parenchymal findings

Pleural findings	**Frequency**	**%**
Pleural effusion	17	77.2
Pneumothorax	1	4.54
Hydropneumothorax	2	9.09
Pleural thickening	2	9.09
Total	22	100
Parenchymal findings		
Consodilation	7	25
Collapse	8	28.57
Atelectasis	4	14.29
Fibrocavitatory lesion with necrosis	3	10.71
Lung absecss	3	10.71
IPF	2	7.14
Bulla/Bleb	1	3.57
Total	28	100

Table 4: Efficacy of thoracic USG in diagnosis of pleural & parenchymal findings

Finding	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**Accuracy**
Pleural effusion	100%	100%	100%	100%	1.00
Pneumothorax	100%	100%	100%	100%	1.00
Hydropneumothorax	100%	100%	100%	100%	1.00
Pleural thickening	100%	100%	100%	100%	1.00
Consodilation	71.43%	97.67%	83.33%	95.45%	0.94%
Collapse	37.50%	97.62%	75%	95.45%	0.94%
Atelectasis	50%	97.83%	66.67%	95.74%	0.94%
Fibrocavitatory lesions with necrosis	33.33%	100%	100%	95.92%	0.96%
Lung abscess	33.33%	100%	100%	95.92%	0.96%
IPF	0%	100%		96%	0.96%

Pleural effusion is one of the commonly reported problems in OPD patients. Diagnosis of pleural effusion is done through correlation between physical examination and chest radiograph. These methods have limited sensitivity and specificity due to positioning limitations. Yousefifard et al.[14] in a systematic review of 12 studies in 2016 found chest radiography had only 51% sensitivity in diagnosis of pleural effusion. In our study USG showed 100% sensitivity, specificity, positive and negative predictive value for diagnosis of pleural effusion and these findings are consistent with those published by Hesham et al.[15] Thoracic US is the "gold standard" method for studying pleural effusions. It is more sensitive than chest radiography or CT in the detection of small amounts of pleural fluid (less than 10 ml). In ultrasound pleural effusion appears as an anechoic space between the parietal & visceral pleural. Four types of effusion may be distinguished on US. 1. Anechoic, 2. Complex nonseptate. 3. Complex septate. 4. Homogeneously hyperechogenic.

The accuracy of ultrasound for pneumothorax diagnosis has been compared to chest radiography in four meta-analysis, which showed that chest radiography had poorer pooled sensitivity of 39-52% compared to 78-90% pooled sensitivity of Ultrasonography. In our study ultrasonography had 100% sensitivity, specificity, negative and positive predictive values.

I.I. Elmahalawy et al.[16]in 2017 also diagnosed pneumothorax with sensitivity of 96%, specificity of 98%, PPV 93% and NPV 99%. Thus, it can be stated that for the diagnosis of pneumothorax USG should always be considered as it has better diagnosing capacity compared to that of chest radiographs.

In our study, USG showed 100% sensitivity, & specificity with an accuracy of 1.00 for pleural thickening. Helala et al,[17] reported sensitivity 92%, specificity 100% and accuracy 98%. The normal pleural thickness is only 0.2 to 0.4mm. Pleural membranes appears as a single echogenic line that moves while breathing (lung sliding). With such high sensitivity and specificity ultrasonography leads the race over traditional radiographs in the diagnosis of pleural thickening. Pleural findings including pleural effusion, pneumothorax, hydropneumothorax, pleural thickening all together on USG had same sensitivity, specificity, positive predictive value of 100%.

Parenchymal disease can also be detected by Ultrasonography as long as there is no air between

the probe & the lesion and beam reaches the pleura. Even thin layer (1-2cm) of air can seriously reduce the visualization of solid lesions, regardless of their size. In certain cases, US imaging can also reveal deeper- seated pulmonary lesions, eg, when surrounding parenchyma is consolidated ie; atelectasis, or when the lesion is surrounded by pleural effusion, which act as an acoustic window.

With respect to consolidation in our study, specificity was observed to be as high as 97.67% whereas sensitivity was 71.43% only with accuracy of 0.94. Lung consolidation on ultrasound appears as an echo-poor or tissue like image. A systematic review by Hew et al[18] in 2015 examined the accuracy of ultrasound for consolidation referenced to CT. The sensitivity of ultrasound was greater than chest radiography (91-100% versus 38-68%). USG had high sensitivity because it focused on the imaging finding of consolidation rather than underlying aetiology. Lung consolidation can result from several different pathologic conditions which include not only pneumonia but also ARDS, lung contusion & atelectasis, pulmonary edema, pulmonary infarction. With the second approach of measuring the accuracy of ultrasound for a specific consolidative aetiology: three reviews,[18–20] suggest ultrasound is sensitive (94-97%) and specific (90-96%) for pneumonia in adults. Meta-analysis of 5 studies by Ye et al[18] 2015 found that ultrasound had greater pooled sensitivity compared with chest radiography (95% versus 77%) for diagnosis of adult CAP. Two meta-analysis conducted by Hu et al[19] and Chavez et al[20] evaluated the diagnostic accuracy of ultrasound for detecting pneumonia with very high sensitivity (97% and 94%) and specificity (94% and 96%). Hu et al.[19] included studies in children which help explain high sensitivity observed by them. Therefore, it is still unclear whether USG is a sensitive tool in detecting consolidation or not, but is definitely a specific tool in the diagnosis of the same.

On considering atelectasis, in our study significant specificity as high as 97.83% was observed but sensitivity of 50% with accuracy of 0.94 and PPV of 66.67% and NPV of 95.74% is suggestive of poorer diagnostic capability of USG. Lung atelectasis and consolidation are different in pathophysiology but similar in image and hence differentiating between pneumonia and atelectasis is probably difficult on the basis of clinical ground, it is easily accomplished with ultrasound. Atelectatic lung segments (clinically the most commonly encountered mimickers) will show the absence of regional blood flow in the affected area of the lung on colour doppler interrogation. Vascular flow in pneumonia is seen as a classic branching pattern in the infected consolidated lung. Dynamic air/ fluid bronchogram have the highest specificity for pneumonia, which is absent in atelectasis. A study by Yang et al,[21] has described the diagnosis of atelectasis/consolidation in multiple trauma patients with mechanical ventilation in 2009, with sensitivity of 81.8%, specificity of 100%, PPV of 100%, NPV of 85.9% and accuracy of 0.914. Further analysis showed that ultrasound was as effective as CT in diagnosing lung atelectasis / consolidation in lower lung, but not in upper lungs.

Collapse had high specificity of 97.62% but had very poor sensitivity of 37.50%. Though USG has very high specificity, with such a poor sensitivity there is no point of subjecting a patient to USG for making a diagnosis in suspicion of lung collapse. Further collapse cannot be diagnosed by USG in upper and middle zones without effusion, however sub segmental collapse can be seen if it is along with effusion.

Lung abscess on statistical analysis had similar results as that of fibrocavitatory lesions with necrosis, i.e, poor sensitivity 33.33% but excellent specificity100.00, thereby questioning the role of USG as a beneficial modality in its diagnosis. Pulmonary abscess appears as circumscribed, collection of corpuscular fluid. Miroabscesses in necrotizing pneumonia are seen within consolidated lung as rounded hypoechoic or anechoic lesions with ill-defined margins. They can be much better appreciated by CT scan in comparison to USG. Pulmonary abscesses cannot be differentiated from tumors undergoing colliquative necrosis based on US findings alone.

Uniformly anechoic pulmonary lesions, usually well circumscribed, may represent cysts (congenital, bronchogenic, parasitic, or pleural) or, pulmonary infarcts. Lipoma, which are benign tumors, appears on US as localized nodules that are hypoechoic or anechoic. Nodular or ovoid solid lesions with blurred margins are suggestive of lung tumors. Centrally located lesions are better seen in CT-scan as compared to USG. In present study no peripheral lung tumor was seen.

Though fibrosis in periphery is better appreciated by USG as compared to CT scan, it would not be wrong to say that USG is not useful in the diagnosis of IPF and bullae or blebs as it was not at all sensitive to these findings and so specificity of 100% has no significance left thereafter.

5. Conclusion

Pleural findings including pleural effusion, pneumothorax, hydropneumothorax and pleural thickening all together on USG had excellent results and that too comparable with that to CT scan. So it won't be wrong to say that be it a single pleural entity or be it all pleural diseases together, diagnostic ability of USG is at par with that of CT scan. As far as parenchymal findings are concerned except for consolidation, despite high specificity, low sensitivity of USG limit it's usefulness in their diagnosis.

6. Source of Funding

None.

7. Conflict of Interest

None.

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