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Original Research Article

A Hospital Based Observational Study Assessing the Role of Lung Ultrasound: A Complementary Imaging Tool for Chest X-Ray in the Evaluation of Dyspnea

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Abstract

Aim: The aim of the present study was to assess the role of lung ultrasound: a complementary imaging tool for chest x-ray in the evaluation of dyspnea.

Material & Methods: A cross-sectional study, conducted over a duration of 1 year in the Department of Radiodiagnosis. The study population comprised 50 patients of either sex, presenting with a complaint of dyspnea. All patients with a clinical history suggestive of acute coronary syndrome as a cause of dyspnea, patients on invasive ventilatory support, or with suspected/known metabolic causes of dyspnea were excluded from the study.

Results: The most common non-translobar consolidation was seen in 83.33% of cases identified by "Fractal sign/shred sign." Translobar consolidation was identified by the "Lung sign." Six patients with "Unilateral lung rockets" were also diagnosed with pneumonia. Out of 50 cases included in our study, 45 cases showed concordant diagnosis on ultrasound and chest X-ray (90%). Chest X-ray was found to have a sensitivity, specificity, positive predictive value, and negative predictive value of 100%.

Conclusion: A high concordance was noted between ultrasound and chest X-ray for diagnosis of all pathologies studied ($p < 0.01$), the highest noted in pneumonia/pleural effusion and diffuse interstitial syndrome (κ ¼ 0.9). Hence, ultrasound may be considered a complimentary imaging modality for Chest-X-ray in the evaluation of dyspnoea.

Keywords: A-Lines, B-Lines, Dyspnoea, Lung Ultrasound, Pneumonia, Emergency.

Introduction

Dyspnea is one of the most common presenting symptoms encountered in hospital admissions, with chest X-ray being the first-line radiological investigation ordered for its assessment. Infective lung disease is a spectrum of pulmonary disorders with high prevalence in clinical practice and a very common cause of hospital admission for dyspnea. The most recent evidence, reported in the pre-COVID 19 era, showed an annual hospitalization rate for community-acquired pneumonia (CAP) among US adults ≥65 years ranging from 847 to 3500 per 100,000 persons. [1] Among imaging technologies, chest radiography (X-ray), lung ultrasound (LUS), and chest high-resolution computed tomography (HRCT) are routinely employed in clinical practice. [2] Although CT scan is the gold standard and offers the definitive diagnosis in cases of clinical dilemma, high cost and unavailability in resource poor settings apart from exposure to ionizing radiation hinder its feasibility in all cases.

Traditionally, the role of chest ultrasound was limited to the diagnosis of pleural effusion and guiding interventions such as thoracocentesis. Its major drawback was poor penetration of the ultrasound beam due to the overlying thoracic cage and air content within the lung which led to artifacts. [3] Lung ultrasound demonstrated in the last decade to be of significant value in the clinical assessment of different pleuro-pulmonary disorders. [2,4] It is a complementary diagnostic tool, and a valuable guide for both diagnostic and therapeutic interventional procedures demonstrated to have a valuable accuracy, in combination with

clinical findings, in the diagnosis of pneumonia. [5-8] One of the most important and recognized application of LUS in clinical practice is for the detection and characterization of pleural effusions and as a guide for thoracentesis. [9] The routine use of LUS in the assessment of pleural effusion before and during the execution of the thoracentesis demonstrated to significantly reduce the rate of thoracentesiss related complications [9,10] Finally, LUS is a valuable technique as guidance of percutaneous transthoracic needle biopsy, with a rate of complications <0.5% in the case series. [6,11]

In recent years, lung ultrasound has gained popularity, particularly in the emergency and critical care units where it is used as point-of-care-ultrasound and has become an indispensable tool to the intensivist. Hence the aim of the study was to assess the role of lung ultrasound: a complementary imaging tool for chest x-ray in the evaluation of dyspnea.

Material & Methods

A cross-sectional study, conducted over the duration of 1 year in the Department of Radiodiagnosis, Katihar Medical College and Hospital, Katihar, Bihar, India and Arc Hospital, Bhagalpur, Bihar. The study population comprised 50 patients of either sex, presenting with a complaint of dyspnea. All patients with a clinical history suggestive of acute coronary syndrome as a cause of dyspnea, patients on invasive ventilatory support, or with suspected/known metabolic causes of dyspnea were excluded from the study. Ethical clearance was obtained from the Institutional Ethics Committee. Written informed consent/assent was documented from each patient.

Methodology

Relevant history, clinical examination, and laboratory findings were recorded. All patients underwent chest-X-ray and chest ultrasound. Each modality was interpretated by two different investigators, blinded to each other. The ultrasound examinations were performed and interpreted by the first author, who had been trained by a senior resident with nearly 6 years of experience in ultrasound. The images were reviewed by a consultant with more than 15 years of experience in ultrasound.

Longitudinal scans of the anterior and lateral chest wall were performed with the patient in the supine or semi-recumbent position. This was followed by an examination of the posterior chest wall with patient in the sitting position, depending on the clinical status of the patient. The lung chest wall interface showing the pleural line and various artifacts were imaged in all cases on gray scale ultrasound and the findings were analyzed for the following features.

• Rib shadows and underlying pleural line for the "Batwing" appearance, and A-lines.

• Lung sliding on B and M modes.

• B-Lines: location, laterality, pattern based on number of B-lines.

• Collections: lung line, quad sign, septations, internal echoes, shred sign, sub-B-lines.

• Consolidation: fractal sign, C-line, lung sign, sonographic air–bronchograms.

A diagnosis was made based on the ultrasound findings for the cause of dyspnea, and appropriate lung profile as devised by the BLUE Protocol was assigned. Chest ultrasound findings were correlated with chest X-ray findings, and concordance was checked. Due to ethical considerations, CT scans could not be used as a reference standard. Final diagnosis at the time of discharge was considered the gold standard for patients with no previous CT scans. However, in patients who had undergone a CT scan, findings were recorded in cases of discordance.

Statistical Analysis

The obtained data were entered in the MS-Excel and analyzed using the SPSS version 25.0. Qualitative data were expressed in percentage and statistical difference between the proportions were tested by chi-square test or Fischer's exact test. Sensitivity, specificity, positive predictive value, and negative predictive value of chest X-ray and chest ultrasound were calculated for different pathologies. The concordance between chest ultrasound and chest X-ray findings was analyzed using Cohen's kappa value with 'p' value less than 0.05 considered statistically significant.

Results

Table 1: Chest ultrasound features in patients with consolidation (n=24)

Imaging findings	Diagnostic categories showing consolidation			
	Consolidation with pleural effusion (n=15)	Consolidation only (n=8)	Hydropneumothorax/ Pneumothorax (n=2)	Total
'Fractal sign'	12	6	2	20
'Lung sign'	3	1	1	5
C-line	1	3	0	4
Air bronchogram	15	5	2	22

Effusion	15	0	2	17
Unilateral lung rocket	4	2	0	6
Irregular/thickened pleural line	2	5	1	8

The most common non-translobar consolidation was seen in 83.33% of cases identified by "Fractal sign/shred sign." Translobar consolidation was identified by the "Lung sign." Six patients with "Unilateral lung rockets" were also diagnosed with pneumonia.

Table 2: Chest ultrasound features in patients with Pleural effusion (n=25)

Imaging finding	Diagnostic categories showing pleural effusion				
	Pleural effusion only (n =4)	Consolidation with associated pleural effusion (n=15)	Pulmonary edema (n=4)	Hydro-pneumothorax (n=2)	Total
Lung line	4	15	4	2	25
Sinusoidal sign	3	14	3	2	22
Quad sign	4	12	2	2	20
Septations	2	4	0	0	6
Internal echoes	2	8	0	0	10
Shred/Fractal sign	0	14	0	3	17
Sub B-Lines	4	10	1	0	16

Pleural effusion was found in patients with pneumonia, pulmonary edema and hydropneumothorax in the study. Visualization of the "Lung line" identified was seen as the presence of pleural effusion. Internal septations and internal echoes were used to help characterize the collection as an empyema.

Table 3: Concordance of USG pathology with chest X-ray findings and Concordance of individual diagnoses on USG with chest X-ray findings

	No.	%
Concordance present	45	90
Concordance absent	5	10
Pathology	Concordance	Discordance
Pneumonia/pleural effusion	26	2
Pneumothorax/ hydropneumothorax	6	1
Interstitial lung disease (ILD)	4	0
Pulmonary edema	3	1
Acute exacerbation of COPD/asthma	6	0
Pulmonary infarct	0	1

Out of 50 cases included in our study, 45 cases showed concordant diagnosis on ultrasound and chest X-ray (90%).

Table 4: Comparison of Ultrasound and Chest-X Ray in ability to correctly diagnose the studied pathology

Pathology	Correctly diagnosed on USG	Correctly diagnosed on CXR	p-Value
Pneumothorax	7	6	0.92
Pulmonary edema	6	5	0.90
Pleural effusion/pneumonia	25	25	—
ILD	3	4	—
Acute exacerbation of COPD/asthma	6	6	0.40
Pulmonary infarct	1	0	—
Old Koch's with URTI	0	1	—

Chest X-ray was found to have a sensitivity, specificity, positive predictive value, and negative predictive value of 100%.

Discussion

For many years ultrasound has not been employed for the evaluation of the lung. [12] All diagnostic ultrasound methods are based on the principle that ultrasound is reflected by an interface between media with different acoustic impedance. In normal conditions, with aerated lungs, the ultrasound beam finds the lung air and no image is visible, because no acoustic mismatch may reflect the beam, which is rapidly dissipated by air. [13] Dyspnea is one of the most common presenting symptoms encountered in hospital admissions, with chest X-ray being the first-line radiological investigation ordered for its assessment. However, this modality has its limitations in the form of exposure to ionizing radiation and decreased sensitivity for certain findings in supine position. Although CT scan is the gold standard and offers the definitive

diagnosis in cases of clinical dilemma, high cost and unavailability in resource poor settings apart from exposure to ionizing radiation hinder its feasibility in all cases.

The most common non-translobar consolidation was seen in 83.33% of cases identified by "Fractal sign/shred sign." Translobar consolidation was identified by the "Lung sign." Six patients with "Unilateral lung rockets" were also diagnosed with pneumonia. Out of 50 cases included in our study, 45 cases showed concordant diagnosis on ultrasound and chest X-ray (90%). Consolidations due to infective lung disease are mostly visualized as mixed, hypo- and hyperechoic, or hypoechoic, images by LUS, with regular margins, and associated with pleural effusion in about half of the cases. Hyperechoic spots, defined by some authors as "air bronchogram," may be detected within lung consolidation by LUS in a significant percentage of cases, as well. [14] In this context, it is important to underline that this hyperechoic images does not match to the chest HRCT finding of the air bronchogram, as properly defined. Hence, operators should not be misled by the visualization of these hyperechoic spots within the lesions by LUS, as their clinical significance is not comparable to what observed by chest HRCT. This misleading may indeed lead to errors and confusion in the differential diagnosis. [15] Our findings were consistent with Mathis et al [16] with the infarcted region appearing as a subpleural, hypoechoic wedge-shaped area with no doppler signal. Previously performed upper limb venous doppler had also revealed thrombus in right brachial and axillary vein. Chest X-ray was found to have a sensitivity, specificity, positive predictive value, and negative predictive value of 100%. The difference could be attributed to the small sample size and the fact that dyspnea was considered as the mandatory inclusion criteria for patient selection in our study and febrile patients with no respiratory distress were excluded. Hence, there were no radiographically occult cases. Diffuse interstitial syndrome [17,18] is diagnosed on ultrasound by demonstrating multiple (three or more) B-lines [19] in more than one scanning zone on the anterolateral chest, bilaterally. Diffuse interstitial syndrome is seen in pulmonary edema and interstitial lung disease. [20,21]

Conclusion

Ultrasound is a useful imaging modality in the evaluation of dyspnea. With its noninvasive nature, easy availability, and lack of ionizing radiation, ultrasound is capable of diagnosing common respiratory pathologies causing dyspnea including pneumonia, pneumothorax, pulmonary edema and acute exacerbation of COPD/severe asthma, apart from its traditional use in detecting pleural effusion. It also shows a high concordance with Chest X-ray, the current first-line imaging investigation for evaluation of dyspnea in diagnosis of these pathologies and can hence be considered a complimentary imaging modality for the same.

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