Original Article

Role of Lung Ultrasound as a Diagnostic Tool in Patients with Undifferentiated Dyspnea Presenting to the Emergency Department at a Tertiary Care Centre: A Prospective Study

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Abstract

Background: In the emergency department (ED), lung ultrasonography is becoming a common adjunct in the assessment of patients who are having trouble breathing. In this study, the percentage of different lung ultrasonography results in patients with acute dyspnea was determined. **Material and Methods:** This was a hospital-based prospective study including adult patients (aged >18 years) who presented with acute onset dyspnea within the preceding 24 hours at the emergency department in National Capital Region Institute of Medical Sciences, Meerut, U.P., India during a one-year period. We examined 150 individuals who had dyspnea when they arrived at our clinic. All patients had their inferior vena cava (IVC), heart, and lung sonographic evaluations done by a researcher who was blind to the imaging and lab data. Utilizing a high-frequency linear probe (5–12 MHz), lung artifacts and abnormalities were assessed, including A-lines, B-lines, lung sliding, subpleural consolidations, pleural abnormalities, pleural effusion, and signs of pneumothorax. The data was imported into Microsoft Excel and then evaluated using SPSS software. **Results:** The majority (60%) were male, and their mean age was 53.5 years (SD 10.7 years), according to our study. The majority of patients (74.66%; 112/150) had a substantial medical history of respiratory disorders. The attending physicians concluded that 62 patients had acute heart failure, 54 had pneumonia, 16 had asthma/COPD, 6 had pulmonary thromboembolism, 4 had pneumothorax, 4 had acute pulmonary hypertensive crisis, 2 had malignancy, and 2 had acute respiratory distress syndrome (ARDS) after evaluating the causes of dyspnea. On the other hand, 60 patients had acute heart failure, 61 had pneumonia, 20 had asthma/COPD, 5 had pulmonary thromboembolism, 4 had pneumothorax, and 2 had ARDS, according to the investigator's ultrasonography diagnosis. **Conclusion:** While the addition of cardiac measurement of contractility alone was unable to differentiate between the causes of pulmonary edema, lung ultrasonography offered a modest level of diagnostic accuracy. However, this enables earlier therapy and more precise patient disposition when combined with other investigative technologies.

Keywords: Acute Dyspnea, Emergency Department, Heart Failure, Asthma, ARDS, Ultrasonography.

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Introduction

Elderly people frequently have acute dyspnea, an urgent condition that needs to be evaluated and treated right once. One can categorize the underlying causes of acute dyspnea into three broad groups: obstructive, parenchymal, and cardiac disorders.[2]

The first stage in creating a treatment strategy is identifying the etiology of dyspnea, which includes a wide range of illnesses. At this stage, physicians use imaging techniques and laboratory testing to both confirm the diagnosis and track the effectiveness of treatment.[3] However, conventional imaging and laboratory techniques have drawbacks, such as limited availability, and can cause unnecessary delays. There are limitations with commonly utilized imaging modalities like magnetic resonance imaging (MRI), computed tomography (CT), and chest radiography (CXR).[4] These include the demand for pregnant patients to give their informed consent, the need to transport unstable patients, the cumulative radiation risk, the absence of precise findings, and rising healthcare expenses.[5]

The physician or other care provider must often make treatment decisions based on limited information, without the time or resources to obtain diagnostic test results to help focus treatment. Lung ultrasonography is becoming more popular and is supported by more evidence as a helpful tool to identify whether someone has acute congestive heart failure, chronic obstructive pulmonary disease, asthma, or other reasons for shortness of breath.[6,7] The lung ultrasonography (LUS) utilized for this

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reason provides information on the lung parenchyma by assessing artifacts. When compared to other imaging techniques, echocardiogram (ECHO) simultaneously provides unique information regarding heart functioning. Furthermore, the assessment of the inferior vena cava (IVC) facilitates fluid management by offering useful information on the patient's volume status.[8,9] Clinicians can adjust treatment plans as necessary because to its real-time imaging capacity, which enables dynamic assessment and continuous monitoring. In this study, the percentage of different lung ultrasonography results in patients with acute dyspnea was determined.

Materials and Methods

The National Capital Region Institute of Medical Sciences' emergency room in Meerut, Uttar Pradesh, India, saw adult patients (over the age of 18) who had acute onset dyspnea within the previous 24 hours during the course of a year.

Inclusion Criteria

1. Dyspnea is the main complaint.
2. Patients who are adults (above the age of 18)

Exclusion Criteria

1. Individuals who have dyspnea after trauma
2. Patients who are expecting
3. History of interstitial lung disease or pneumonectomy
4. Patients with severe obesity or other physical limitations that make it impossible to obtain data with ultrasonography.

Intervention: A POCUS was conducted on each eligible patient by an emergency physician who was blind to their clinical presentations. The doctor had finished a rigorous one-month lung ultrasonography training course that comprised both didactic lectures and practical, supervised practice. At the same time, the on-call emergency physician stabilized the patient while remaining blind to the ultrasound results. Lung sliding, pleural abnormalities, pleural effusion, subpleural consolidations, A-lines, B-lines, and indications of pneumothorax were among the lung artifacts and abnormalities that were evaluated using a high-frequency linear probe (7–12 MHz).

Statistical Analysis: SPSS software version 21.0v was used to evaluate the data after it was entered into Microsoft Excel. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each diagnostic category. To measure agreement between the rapid initial diagnosis and the hospital admission diagnosis we used The Cohen's Kappa for 2 Raters (κ). The level of agreement was statistically significant (κ=0.805, p<0.001). Statistical significance was assessed using p-values calculated for each κ statistic. A p-value of < 0.05 was considered statistically significant.

Results

With a mean age of 53.5 years (SD 10.7 years), our study revealed that 60% of the participants were male. Significant prior medical histories of respiratory problems were present in 74.66% (112/150) of the patients [Table 1]. Orthopnea, paroxysmal nocturnal dyspnea, fever, cough, chest discomfort, and hemoptysis were among the other accompanying symptoms. [Table 2] provides a summary of the collected ultrasonographic results. The attending physicians concluded that 62 patients had acute heart failure, 54 had pneumonia, 16 had asthma/COPD, 6 had pulmonary thromboembolism, 4 had pneumothorax, 4 had acute pulmonary hypertensive crisis, 2 had malignancy, and 2 had acute respiratory distress syndrome (ARDS) after evaluating the causes of dyspnea.

On the other hand, 60 patients had acute heart failure, 61 had pneumonia, 20 had asthma/COPD, 5 had pulmonary thromboembolism, 4 had pneumothorax, and 2 had ARDS, according to the investigator's ultrasonography diagnosis [Table 3].

According to our research, lung ultrasonography performed consistently well as a diagnostic tool for a variety of illnesses in individuals experiencing acute dyspnea. A κ-value of 1.0 supported the 100% sensitivity, specificity, and accuracy of the ultrasound and clinical diagnosis in the instance of pneumothorax (table 4).

Significant inter-observer agreement (κ = 0.832) and high diagnostic reliability were also demonstrated by pleural effusion, with sensitivity and specificity both over 90% [Table 4].

In addition to having excellent agreement (κ = 0.903) and extremely high sensitivity and specificity (>95%), pulmonary edema supported the use of ultrasonography in quickly detecting this disease [Table 4].

With a κ-value of 0.826, pneumonia demonstrated good sensitivity (90.6%) and specificity (92.6%), demonstrating significant agreement and supporting the diagnostic relevance of ultrasound for alveolar consolidations [Table 4].

Table 1: Baseline characteristics

Variables		No. of cases (N=150)	Percentage
Age (yrs) (Mean±SD)		53.5±10.7	
Gender (Male/female)		90 /60	60%/40%
Associated symptoms	Cough	100	66.66%
	Orthopnea	40	26.66%
	Fever	41	27.33%
	Chest pain	30	20.00%
	Hemoptysis	3	2.00%
	None	20	13.33%
Past Medical History	Respiratory	112	74.66%
	Cardiac	30	20.00%
	Others	18	12.00%
	None	40	26.66%

Table 2: Ultrasound findings

Cardiac evaluation variables	Number (%)
Decreased ejection fraction	62 (41.33%)
Right ventricular dilation	18 (12.00%)
Left ventricular dilation	26 (17.33%)
Pericardial effusion	10 (6.66%)
IVC* evaluation variables	
IVC* diameter >2.1 cm on expiration	53 (35.33%)
IVC* collapsibility index <50%	111 (74.00%)
Lung evaluation variables	
Lung sliding	132 (88.00%)
Pleural irregularity	19 (12.66%)
B-lines	109 (72.66%)
Lung point	4 (2.66%)
Consolidation	16 (10.66%)
Pleural effusion	39 (26.00%)
Plankton sign	6 (4.00%)
Jellyfish sign	8 (5.33%)
Thrombosed vein	6 (4.00%)

Table 3: Diagnoses made by the attending physician (Gold standard) versus those made under ultrasound guidance

Diagnosis	Attending physician's diagnosis	Ultrasound-based diagnosis
Acute heart failure	62	60
Pneumonia	54	61
Asthma/ Chronic Obstructive Pulmonary Disease	16	20
Pulmonary Thromboembolism	6	5
Pneumothorax	4	4
Malignancy	2	0
Pulmonary hypertension	4	0
Acute Respiratory Distress Syndrome	2	2

Table 4: Comparison of diagnostic performance for various conditions (sensitivity, specificity, and accuracy)

Diagnosis	κ-value	p-value	Sensitivity	Specificity	Accuracy
Pneumothorax	1.00	< 0.001	100	100	100
Pleural effusion	0.832	< 0.001	92.8	94.6	94.4
Pulmonary edema	0.903	< 0.001	95.3	95.4	95.7
Pneumonia	0.826	< 0.001	90.6	92.6	92.3
ARDS	1.00	< 0.001	100	100	100

Discussion

Ultrasonography (US) has been used as an imaging technique for more than 50 years. Until recently, it was believed that the solid structures of the thoracic cage and the presence of air in the respiratory tract limited the use of ultrasound in the diagnosis and treatment of respiratory disorders by creating artifacts and obstructing the passage of US waves. Clinicians are starting to recognize, though, that these artifacts can be used to diagnose and describe a range of lung diseases.[10]

Our study used linear probes for lung sonography for their high frequency (typically 7–12 MHz) and high-resolution imaging, which is superior for evaluating superficial structures like the pleural line, lung sliding, and diagnosing pneumothorax. They provide excellent, detailed images of the lung surface, whereas curvilinear and phased array probes are better for deep lung structures.

The study group's average age was found to be 53.7 years, and 40% of the participants were female. This is explained by the fact that prevalent causes of dyspnea are linked to a rise in comorbidities with aging. Although studies in the literature with similar age groups often identify pneumonia as a common diagnosis, in our research, acute heart failure was the most common final diagnosis.[11] Our hospital's status as the sole public angiography center in the region may help to explain this outcome, which increases the number of patients who come to us for cardiac follow-up.

Lung ultrasonography depends on the visualization of artifacts, in contrast to other types of ultrasonography. A-lines and B-lines are two essential artifacts in lung ultrasonography. Bright horizontal hyperechoic lines that appear at regular intervals and extend deep to the pleural line are known as A-lines. These lines are a reverberation artifact that appear when the lung is well-aerated. From the pleural line to the bottom of the ultrasound screen, B-lines are visible as vertical lines that continue downward. When edema thickens the interstitium, sound waves can now be reflected and refracted (rather than scattered) before returning to the probe, resulting in the appearance of B-lines.

Our results showed a 95.3% sensitivity and 95.4% specificity, which is in good agreement with those of Patel et al., who found that they could diagnose acute pulmonary edema with 92.3% sensitivity and 100% specificity.[12] Additionally, Lichtenstein reported 97% sensitivity and 95% specificity for pulmonary edema using lung sliding with B-lines.[13] Wang et al. further supported the diagnostic use of LUS for pulmonary edema by reporting sensitivity and specificity of 97% and 98%, respectively.[14] Ghauri et al. found that LUS had much higher sensitivity (91.05%) and specificity (91.18%) than chest X-rays (60.16%–66.67%).[15] Additionally, Pivetta et al. demonstrated a

high diagnostic accuracy for acute decompensated heart failure (ADHF) with LUS, with 97.4% specificity and 97% sensitivity.[16]

In terms of diagnosing pneumonia, our study showed 92.3% accuracy, 90.6% sensitivity, and 92.6% specificity. According to Patel et al., the sensitivity and specificity of LUS for diagnosing pneumonia were 94.11% and 93.93%, respectively, although Dexheimer Neto et al. found 88% and 90%. In a similar vein, Lichtenstein et al. discovered that ultrasound had an 89% sensitivity and a 94% specificity for diagnosing pneumonia.[13]

According to our research, LUS has 100% sensitivity and specificity for diagnosing pneumothorax. These findings concur with those of a study by Bekgoz et al,[18] which also demonstrated 100% sensitivity and specificity for the detection of pneumothoraxes using ultrasonography. According to Lichtenstein, the specificity was 100%, while the sensitivity was slightly lower at 81%.[13]

Our main goal was to compare the ultrasonography diagnosis with the attending physician's gold standard diagnosis. There was excellent agreement for pneumonia (κ=0.826) and acute heart failure (κ=0.952). In a related study with a bigger patient population, Zanobetti et al. found that the Kappa values for pneumonia and acute heart failure diagnosis were 0.788 and 0.810, respectively. Our findings are in line with those of this study with a bigger sample size.[19]

According to Dexheimer et al., 84% of final diagnoses showed good agreement with the results of LUS.[17] Karim and Arora highlighted the general usefulness of LUS as a quick, inexpensive, and efficient bedside diagnostic and monitoring tool for respiratory conditions in critical care.[20]

Even with proper ultrasound training, this discrepancy may be explained by the operator-dependent nature of ultrasonography. Suboptimal ultrasonographic pictures can also be caused by patient characteristics such body habitus and an inability to comply with examination. Furthermore, compared to the majority of ICU patients, the ED patient population is typically more diverse, presenting with a wide range of illnesses. A diagnostic test with a better specificity would have more clinical significance in the emergency department (ED) setting since prompt and appropriate treatment can be facilitated by an accurate diagnosis.

Limitations

There are various restrictions on this study. Generalizability was limited because it was only carried out at one tertiary care facility. Ultrasound interpretation may have been impacted by inter-observer variability, even though the procedures were carried out by qualified medical professionals.

Conclusion

POCUS demonstrated high diagnostic concordance and can serve as a reliable bedside adjunct in the evaluation of undifferentiated dyspnea in the emergency department. While cardiac examination of contractility by itself was insufficient to differentiate between the causes of pulmonary edema, lung ultrasonography offered a modest level of diagnostic accuracy. Nevertheless, this enables earlier therapy and more precise patient disposition when combined with other investigative tools.

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Conflicts of interest

There are no conflicts of interest.

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