Research Article

A Prospective Observational Study Comparing the Diagnostic Use of Point-of-Care Lung Ultrasound with Chest X-Ray in Acute Dyspnoea in the Emergency Department

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Introduction: Acute dyspnea is a common and critical presentation in the Emergency Department (ED), requiring rapid and accurate diagnosis for effective management. While chest X-ray (CXR) has traditionally been used as the first-line imaging modality, point-of-care ultrasound (POCUS) has emerged as a promising bedside diagnostic tool. This study aimed to compare the diagnostic accuracy and efficiency of POCUS with CXR in evaluating patients presenting with acute dyspnea in the ED.

Methods: A prospective observational study was conducted in the Department of Emergency Medicine, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai. A total of 122 patients fulfilling the inclusion and exclusion criteria were enrolled in the study. All patients underwent point-of-care ultrasound (POCUS) and chest X-ray (CXR), and CT chest was taken as the gold standard for the final diagnosis. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated for both modalities.

Results: Point-of-care ultrasound (POCUS) showed a high sensitivity of 92.31%, specificity of 90.91%, positive predictive value (PPV) of 94.74%, negative predictive value (NPV) of 86.96%, and an overall diagnostic accuracy of 91.8%. In contrast, CXR showed a sensitivity of 74.36%, specificity of 81.82%, p PPV of 87.88%, NPV of 64.29%, and diagnostic accuracy of 77.05%. POCUS significantly reduced the time to diagnosis, especially in patients with Grade III dyspnea, where the average time taken was 3 ± 1.5 minutes. The findings of the study reveal that POCUS is a rapid, reliable, and useful bedside diagnostic tool in the assessment and management of acute dyspnea when compared to conventional chest X-ray, although it was found to be less effective in detecting pulmonary tuberculosis.

Conclusion: POCUS outperformed CXR in terms of diagnostic accuracy, speed, and clinical utility in patients with acute dyspnea. Its bedside applicability, real-time interpretation, and avoidance of patient transport make it an essential tool in the emergency department, particularly for critically ill or hemodynamically unstable patients. Integration of POCUS into routine emergency care workflows can enhance early diagnosis, expedite clinical decision-making, and ultimately improve patient outcomes in acute respiratory emergencies.

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Introduction

Patients with dyspnea constitute a significant proportion of emergency department presentations, ward admissions, and intensive care unit admissions.[1] Dyspnea, whether acute or chronic, is a symptom of an underlying condition rather than a distinct disease. The causes may be broadly classified into respiratory, cardiac, neuromuscular, psychogenic, systemic, or multifactorial causes. Pulmonary or cardiovascular conditions most commonly cause acute dyspnea. Respiratory causes may further involve the upper airway, chest wall, diaphragm, or lung parenchyma.[2] The many causes of dyspnea make it a diagnostic challenge. Its rapid evaluation and diagnosis are crucial for reducing mortality and the burden of disease.[3]

Patient history, physical examination, complete blood count, biomarkers, and chest X-rays can help determine the underlying disease. If the examination results

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are not supportive, computed tomography scan, lung ultrasonography, and echocardiography can help to make the diagnosis. Not all hospital emergency departments have specialists who can immediately carry out these examinations, so understanding and making the right decision by the attending physician is needed to provide the best for the patient.[4]

Point-of-care ultrasonography (POCUS) is advanced diagnostic ultrasonography that is performed and interpreted by the attending physician as a bedside test.[5] POCUS has been widely used in many disciplines as a rapid diagnostic tool, especially in emergency medicine. POCUS has been used to aid the diagnosis of multiple medical conditions, ranging from acute appendicitis, airway compromise, abdominal aortic aneurysm, and traumatic injury assessment. The relatively fast use has made it a potential option in situations where a formal radiological investigation may delay the diagnosis. Additionally, the ever-increasing demands of other diagnostic imaging and interventional radiological procedures have underscored the importance of non-radiologists physician's contribution to radiological diagnosis through POCUS.[6]

Chest X-rays (CXRs) are important first-line investigations for acute and chronic dyspnea, but they have significant diagnostic limitations. The sensitivity of CXR is low in the diagnosis of pneumothorax, pleural effusion, and pulmonary edema, particularly in bedside-acquired images.[7] Chest computed tomography (CT) is considered the gold standard for diagnosing several causes of dyspnea, particularly interstitial lung disease (ILD), pulmonary embolism (PE), and malignancy. While chest radiography is typically the first-line, CT offers superior sensitivity for identifying parenchymal lung disease, emphysema, and acute thoracic abnormalities.[8] But, CT may not always be feasible in emergency settings due to radiation exposure, cost, limited availability, and the need for patient transport.[14] In contrast, POCUS provides a rapid bedside alternative that can aid early clinical decision-making.

However, there are limited studies from the Indian emergency department setting comparing POCUS with chest X-ray using CT chest as the reference standard. Early and accurate diagnosis is essential in emergency care to reduce delays in treatment and improve patient outcomes. Hence, this observational study was conducted to compare the diagnostic use of point-of-care lung ultrasound with chest X-ray in patients presenting with acute dyspnea in the emergency department.

Materials And Methods

Study Design and Setting

This was a prospective observational study conducted in the Department of Emergency Medicine, Madras Medical College and Rajiv Gandhi Government General Hospital (RGGGH), Chennai. The study was carried out over a period of 12 months. Patients presenting to the emergency department with acute-onset dyspnoea were included in the study. The objective was to evaluate and compare the diagnostic utility of POCUS with chest X-ray in patients with acute dyspnoea in the emergency department.

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Human Ethics Committee before commencement of the research (IEC Approval Number: 72112023). Written informed consent was obtained from all participants before enrolment. Confidentiality of patient information was maintained throughout the study. All patients received standard emergency care as per institutional protocol.

Study Population and Sample Size

The study population consisted of patients presenting to the emergency department with a complaint of acute-onset dyspnoea. Based on the inclusion and exclusion criteria, the final sample size was 122.

Inclusion and Exclusion Criteria

Patients aged more than 18 years were included in the study. Patients presenting with acute onset dyspnoea of Grade I, Grade II, or Grade III were included. Patients aged less than 18 years, patients with Grade IV dyspnoea, pregnant women with dyspnoea, and patients with a history of severe chest trauma that could obscure imaging findings were excluded. Grade IV dyspnoea patients were excluded because their critical clinical condition often required immediate life-saving interventions, which could delay standardized POCUS assessment and affect adherence to the study protocol.

Study Procedure

Eligible patients presenting to the emergency department with acute dyspnoea were screened by the treating emergency physician based on the inclusion and exclusion criteria. After initial stabilization and routine emergency management, the details of the study were explained to the patients and their attenders. Doubts and queries regarding the study were clarified, following which written informed consent was obtained from all participants. Patients were then enrolled into the study,

and detailed clinical assessment, POCUS examination, chest X-ray, and further investigations were carried out as per the study protocol. The study was conducted over a period of 12 months. To minimize interpretation bias, POCUS was performed and documented before review of chest X-ray and CT chest findings.

Data Collection

Data were collected prospectively using a pre-evaluated semi-structured proforma. Clinical details including demographic data, presenting complaints, duration of dyspnoea, sensorium, vital parameters, relevant medical history, and initial clinical impression were recorded. General physical examination was performed for all patients along with cardiovascular and respiratory system examination. Central nervous system and abdominal examinations were also carried out. Baseline laboratory investigations including complete blood count, coagulation profile, hematocrit, blood grouping, and random blood sugar were performed for all study participants.

Ultrasound Examination

POCUS examination was performed for all study participants by trained emergency physicians. Emergency physicians performed the ultrasound examination without prior knowledge of chest X-ray and CT findings. Complete blinding to clinical information was not feasible in the emergency department setting. The physicians had access to the patient's presenting symptoms, clinical history, physical examination findings, vital parameters, and baseline laboratory investigations as part of routine emergency care. However, POCUS findings were recorded before the availability of chest X-ray and CT chest reports. Lung ultrasound was performed using a 6 to 13 MHz linear probe on a MINDRAY M7 ultrasound machine. The lungs were examined using longitudinal scans over the midclavicular line, anterolateral thoracic region, and posterior thoracic region between the posterior axillary line and spine in supine and lateral decubitus positions according to the BLUE protocol. Findings including lung sliding, A-lines, B-lines, pleural effusion, consolidation, pneumonia, pneumothorax, and lung point were documented.

Chest X-ray Examination

Chest X-ray was performed using standard digital radiography equipment as antero-posterior, posteroanterior, and lateral views, depending on the clinical condition of the patient. The chest X-rays were interpreted by two experienced radiologists independently. The radiologists reviewed the images without knowing the POCUS and CT chest findings. In cases where there was a difference in interpretation, the final report was made after discussion and consensus with a third reviewer. Findings including cardiomegaly, pulmonary vascular congestion, alveolar or interstitial infiltrates, consolidation, pleural effusion, pneumothorax, atelectasis, and masses were documented.

Computed Tomography Chest Examination

CT chest was performed using a standard multi-detector CT scanner. Non-contrast CT was performed routinely, while the decision to administer contrast was made by the treating physician based on clinical suspicion and was not influenced by study participation. The CT chest scans were interpreted by two experienced radiologists independently. The radiologists reviewed the images without knowing the POCUS and chest X-ray findings. In cases where there was a difference in interpretation, the final report was made after discussion and consensus with a third reviewer. CT chest findings were considered the definitive diagnostic reference and were used to categorize the etiology of acute dyspnoea, including acute pulmonary edema, pneumonia, COPD exacerbation, pneumothorax, and pleural effusion.

Statistical Analysis

The collected data were systematically organized and analyzed using appropriate statistical methods. Data were entered in Microsoft Excel 2019 (Microsoft Corporation, Redmond, Washington, USA) and analyzed using Statistical Package for the Social Sciences (SPSS) software version 23.0 (IBM Corp., Armonk, New York, USA). Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as numbers and percentages. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated for point-of-care ultrasound (POCUS) and chest X-ray (CXR) using CT chest diagnosis as the reference standard.

Outcome Measures

Sensitivity was calculated as the ability of the test to correctly identify patients who have the disease. Specificity was calculated as the ability of the test to correctly identify patients who do not have the disease. Positive predictive value (PPV) represents the probability that patients with a positive test result truly have the

disease. Negative predictive value (NPV) represents the probability that patients with a negative test result truly do not have the disease. Diagnostic accuracy was calculated as the overall ability of the test to correctly identify both diseased and non-diseased patients.

Risk and Benefit Assessment

This study did not impose any additional risk on participants. All patients received standard emergency care as per institutional protocol. The study involved only a diagnostic comparison between POCUS and chest X-ray, with CT chest used for definitive diagnosis when indicated. Participants were informed that they were free to withdraw from the study at any stage without affecting their medical care.

Results

A total of 122 patients diagnosed with dyspnea were included in the study. The most common age group was above 50 years, with 104 patients (85.2%). The 41 to 50 years age group had 13 patients (10.6%), and 5 patients (4.09%) were 40 years or below. The mean age was 61.8 years with a standard deviation of 12.14 years. The minimum age was 24 years and the maximum age was 72 years. Male patients were 76 (62.5%) and female patients were 46 (37.5%). History of chronic obstructive pulmonary disease (COPD) was present in 29 patients (24%), and history of tuberculosis was present in 5 patients (4%). Computed tomography (CT) chest revealed clinically significant findings in 78 patients (64%), whereas 44 patients (36%) had no significant findings. POCUS detected abnormalities in 74 patients (61%), while chest X-ray detected abnormalities in 66 patients (54%). No abnormalities were identified in 48 patients (39%) by POCUS and in 56 patients (46%) by chest X-ray (Table 1).

The most common diagnosis was acute pulmonary edema. Acute pulmonary edema was identified in 30 patients on CT chest, 28 patients on POCUS, and 22 patients on chest X-ray. Pleural effusion was identified in 15 patients on CT chest, 14 patients on POCUS, and 14 patients on chest X-ray. Acute exacerbation of COPD was identified in 12 patients on CT chest, 10 patients on POCUS, and 9 patients on chest X-ray. Pneumothorax was identified in 8 patients on both CT chest and POCUS, while chest X-ray identified 5 patients. Pneumonia was identified in 7 patients on CT chest and 6 patients each on POCUS and chest X-ray. Pulmonary tuberculosis was identified in 6 patients on CT chest, 2 patients on POCUS, and 5 patients on chest X-ray (Table 2).

POCUS showed diagnostic performance comparable to CT, which was considered the gold standard, in several key conditions, particularly acute pulmonary edema,

Table 1: Demographic profile, clinical history, and comparison of CT chest, POCUS, and chest X-ray findings in acute dyspnea

Variable/Investigation	*Category/Findings*	*Number of patients (N)*	*Percentage (%)*
Age group (years)	≤40	5	4.09
	41–50	13	10.6
	>50	104	85.2
Gender	Male	76	62.5
	Female	46	37.5
History of COPD	Present	29	24
	Absent	93	76
History of tuberculosis	Present	5	4
	Absent	117	96
Computed tomography (CT) chest	Findings present	78	64
	Findings absent	44	36
Point-of-care ultrasound (POCUS)	Findings present	74	61
	Findings absent	48	39
Chest X-ray	Findings present	66	54
	Findings absent	56	46

Table 2: Comparison of diagnoses in CT chest, POCUS and chest X-ray

Diagnosis	*CT chest*	*POCUS*	*Chest X-ray*
Acute pulmonary edema	30	28	22
Pleural effusion	15	14	14
Acute exacerbation of COPD	12	10	9
Pneumothorax	8	8	5
Pneumonia	7	6	6
Pulmonary tuberculosis	6	2	5

pleural effusion, and pneumothorax. This highlights its usefulness as a rapid bedside diagnostic tool. In contrast, chest X-ray identified fewer cases of conditions such as pulmonary edema and pneumothorax, suggesting lower sensitivity in acute settings. However, POCUS was less effective in detecting pulmonary tuberculosis, likely because ultrasound cannot adequately visualize deeper lung parenchymal lesions, making CT chest and chest X-ray more reliable for such conditions.

Dyspnea due to non-respiratory causes was seen in 44 patients (Table 3). Angioedema was identified in 10 patients (23%), stroke in 7 patients (16%), poisoning in 6 patients (14%), metabolic acidosis in 5 patients (11%), cardiac causes in 5 patients (11%), sepsis in 4 patients (9%), anaemia in 4 patients (9%), and anxiety disorder in 3 patients (7%).

In the comparison of POCUS with CT chest, there were 70 true positive cases, 40 true negative cases, 4 false positive cases, and 8 false negative cases. The false positive cases may be attributed to ultrasound artifacts and overinterpretation of findings, particularly in emergency settings. The false negative cases occurred because POCUS failed to detect certain pathologies that were deep-seated, small in size, or not adjacent to the pleural surface. These findings highlight the limitations of ultrasound and emphasize the role of CT chest as the gold standard in complex cases.

In the comparison of chest X-ray with CT chest, there were 20 false negative cases and 8 false positive cases. The false negative cases occurred because chest X-ray failed to identify actual disease, likely due to low sensitivity or subtle radiological findings. The false positive cases occurred because chest X-ray incorrectly suggested disease, possibly due to artifacts or overinterpretation of non-specific findings such as old scarring or atelectasis (Table 4).

In comparison with CT chest, POCUS showed a sensitivity of 92.31%, specificity of 90.91%, positive predictive value (PPV) of 94.74%, negative predictive

Table 3: Distribution of patients with non-respiratory causes of dyspnea

Diagnosis	*Number of patients (N)*	*Percentage (%)*
Angioedema	10	23
Stroke	7	16
Poisoning	6	14
Metabolic acidosis	5	11
Cardiac causes	5	11
Sepsis	4	9
Anaemia	4	9
Anxiety disorder	3	7

Table 4: Comparison of POCUS and chest X-ray findings with CT chest (POCUS: Point-of-Care Ultrasound; CXR: Chest X-ray)

Comparison of POCUS with CT chest			
POCUS findings	*CT chest positive*	*CT chest negative*	*Total*
POCUS positive	70	4	74
POCUS negative	8	40	48
Total	78	44	122
False positive findings = 4; False negative findings = 8			
Comparison of chest X-ray with CT chest			
Chest X-ray findings	*CT chest positive*	*CT chest negative*	*Total*
CXR positive	58	8	66
CXR negative	20	36	56
Total	78	44	122
False positive findings = 8; False negative findings = 20			

Table 5: Comparison of diagnostic parameters between POCUS and Chest X-ray

Parameter	*POCUS (%)*	*Chest X-ray (%)*
Sensitivity	92.31	74.36
Specificity	90.91	81.82
Positive predictive value (PPV)	94.74	87.88
Negative predictive value (NPV)	86.96	64.29
Diagnostic accuracy	91.8	77.05

Table 6: Distribution of patients by NYHA dyspnea grade and mean time taken for POCUS diagnosis

Dyspnea grading (NYHA)	*Number of patients (N)*	*Percentage of total study population (%)*	*Mean time taken for POCUS diagnosis (minutes)*
Grade I	2	2	9.1 ± 0.2
Grade II	18	14	7.2 ± 1.7
Grade III	102	84	3 ± 1.5

value (NPV) of 86.96%, and diagnostic accuracy of 91.8%. Chest X-ray showed a sensitivity of 74.36%, specificity of 81.82%, PPV of 87.88%, NPV of 64.29%, and diagnostic accuracy of 77.05%. The lower NPV and diagnostic accuracy of chest X-ray indicate limited reliability in ruling out disease, especially in critical diagnostic situations. Overall, POCUS demonstrated higher sensitivity, specificity, PPV, NPV, and diagnostic accuracy compared to chest X-ray (Table 5), supporting its role as a dependable bedside diagnostic tool.

Based on New York Heart Association (NYHA) grading, 2 patients (2%) had Grade I dyspnea, 18 patients (14%) had Grade II dyspnea, and 102 patients (84%) had Grade III dyspnea. The number of patients increased with increasing severity of dyspnea. The time taken by bedside POCUS to arrive at a diagnosis was 9.1 ± 0.2 minutes in Grade I dyspnea, 7.2 ± 1.7 minutes in Grade II dyspnea, and 3 ± 1.5 minutes in Grade III dyspnea (Table 6). The mean time taken for diagnosis decreased with increasing severity of dyspnea .

Overall, the study demonstrated that point-of-care ultrasound (POCUS) had higher sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy compared to chest X-ray in the evaluation of patients presenting with acute dyspnea in the emergency department. POCUS showed better agreement with the final diagnosis and was more effective in the early identification of the causes of dyspnea. The findings of the study reveal that POCUS is a rapid, reliable, and useful bedside diagnostic tool in the assessment and management of acute dyspnea when compared to conventional chest X-ray, although it was found to be less effective in detecting pulmonary tuberculosis.

Discussion

Patients with dyspnea form a significant proportion of emergency and intensive care admissions.[1,2] Dyspnea is a symptom caused by multiple respiratory and cardiovascular conditions, making rapid diagnosis essential for appropriate management and reduction of morbidity and mortality.[2,3] Clinical examination, laboratory investigations, chest X-ray, CT chest, echocardiography, and lung ultrasonography are commonly used in evaluation, though the availability of advanced imaging may be limited in emergency settings.[4]

Point-of-care ultrasonography (POCUS) is a rapid bedside imaging modality widely used in emergency medicine for early diagnosis and clinical decision-making.[5,6] Although chest X-ray remains a routine first-line investigation, it has low sensitivity for detecting pneumothorax, pleural effusion, and pulmonary edema, especially in bedside-acquired images.[7] CT chest is considered the gold standard for diagnosing several causes of dyspnea because of its superior sensitivity in detecting thoracic abnormalities.[7,8]

Previous studies have reported that point-of-care lung ultrasonography (POCUS) has high diagnostic performance in patients presenting with dyspnea in the emergency department. Excellent agreement was observed between emergency physician and attending physician diagnoses for conditions such as pleural effusion, pneumonia, bronchopneumonia, acute pulmonary edema, chronic obstructive pulmonary disease exacerbation, pleuropulmonary tumors, and acute respiratory distress syndrome. The study also showed that POCLUS significantly reduced the time required for diagnosis compared to conventional evaluation methods. The authors concluded that POCUS is a rapid, reliable, and useful bedside tool in the assessment of dyspnea.[9,10] Similar findings were observed in the present study, where POCUS demonstrated a sensitivity of 92.31%, specificity of 90.91%, positive predictive value of 94.74%, negative predictive value of 86.96%, and overall diagnostic accuracy of 91.8%. In comparison, chest X-ray showed a sensitivity of 74.36%, specificity of 81.82%, positive predictive value of 87.88%, negative predictive value of 64.29%, and diagnostic accuracy of 77.05% in the evaluation of patients presenting with dyspnea. Another similar study reported that lung ultrasound detected significantly more abnormalities and showed better reliability with the final clinical diagnosis than chest X-ray.[11]

Point-of-care ultrasound (POCUS) is considered superior to X-ray in many acute clinical scenarios due to its real-time, radiation-free, and portable nature. It offers faster diagnosis, high sensitivity for soft tissue and specific fractures, and immediate bedside availability, reducing the need for patient transport and decreasing diagnostic delays, particularly in emergencies.[12] X-ray limitations in the emergency department (ED) include poor visualization of soft tissues (muscles, ligaments), failure to detect subtle or non-displaced fractures, and reliance on 2D imaging, which can obscure complex injuries. Furthermore, it exposes patients to ionising radiation and may result in false positives that trigger unnecessary, costly, and time-consuming diagnostic cascades.[13]

CT chest was considered the reference standard in the present study because of its high diagnostic accuracy. However, despite its superior imaging capability, CT may not always be feasible in emergency settings due to radiation exposure, cost, limited availability, and the need for patient transport.[14] In contrast, POCUS provides a rapid bedside alternative that can aid early clinical decision-making.

The findings of the present study support the integration of POCUS into routine emergency evaluation of patients presenting with dyspnea. Early bedside diagnosis using ultrasound may facilitate prompt treatment decisions, reduce diagnostic delays, and improve patient management, particularly in critically ill or unstable patients.

Future advances in POCUS may further improve its role in the evaluation of dyspnea in emergency settings. Developments in portable ultrasound technology and artificial intelligence-assisted image interpretation may enhance the speed, accessibility, and diagnostic precision of bedside ultrasound. In addition, combining lung ultrasound with focused cardiac ultrasound may provide a more comprehensive assessment of both respiratory and cardiovascular causes of dyspnea, thereby improving overall clinical evaluation and patient management.

The present study was limited by its single-center design. In addition, POCUS is inherently operator-dependent, and its diagnostic performance may vary according to the experience and training of the examiner. Although standardized scanning protocols were followed, inter-operator variability remains a potential limitation. Further large-scale multicentric studies may help to strengthen and validate the findings of the present study.

Conclusion

This study highlights the important role of POCUS in the timely evaluation and management of patients presenting with dyspnea in the Department of Emergency Medicine. In the present study, POCUS showed higher sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy compared to chest X-ray in identifying the causes of dyspnea. The findings showed that POCUS was more reliable in detecting underlying thoracic pathologies at an early stage. In Grade I dyspnea cases, the average time taken for POCUS diagnosis was longer compared to Grade II and Grade III cases. In Grade III dyspnea cases, POCUS enabled rapid diagnosis within a shorter duration. The time taken for diagnosis decreased with increasing severity of dyspnea. This rapid diagnostic capability allows immediate clinical decision-making and early initiation of targeted treatment. In hemodynamically unstable patients, POCUS offers an additional advantage as it avoids the need for patient transport, which may be risky in critically ill patients.

The bedside availability, ease of use, and real-time interpretation make POCUS a highly practical tool for emergency physicians. Its integration into routine emergency department workflows not only enhances diagnostic efficiency but also contributes to faster, more effective patient care. By enabling early, accurate interventions with minimal delay, POCUS improves outcomes in acute respiratory emergencies.

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