European Journal of Clinical Pharmacy
Print ISSN: 2385-409X **Online ISSN**: Applied
Website: https://farmclin.es/

Article

Role of point-of-care lung ultrasound in early diagnosis of community-acquired pneumonia

Article History:
Received: 05/11/2025
Accepted: 17/12/2025
Published:31/12/2025

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How to cite this article:
Ahmed Jamal Chaudhary MD, Hafsa Zahid, Muhammad Imran Farid, Aamir waheed, Aamir waheed, Anum Mahboob, Faisal Hassan Zahid Chaudery, Imran Tahir, Role of point-of-care lung ultrasound in early diagnosis of community-acquired pneumonia European Journal of Clinical Pharmacy, vol. 7, no. 1, 2025, pp. 5212–5217

Abstract: *Objective: To evaluate the diagnostic utility of point-of-care lung ultrasound (LUS) in the early detection of community-acquired pneumonia (CAP) and to compare its performance with conventional chest radiography.*

Study Design: Cross-sectional analytical study.

Place and Duration of Study: Conducted at Evercare Hospital Lahore from April 2024 to April 2025.

Methodology: A total of 155 patients presenting with clinical suspicion of CAP were enrolled. All patients underwent bedside lung ultrasound and chest X-ray evaluation. Key ultrasound findings, including consolidation, B-lines, air bronchograms, pleural effusion, and pleural irregularity, were recorded. Diagnostic performance of LUS was assessed in terms of sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), and compared with chest radiography.

Results: The mean age of patients was 46.8 ± 15.2 years, with a predominance of males. LUS detected pneumonia in 78.1% of cases compared to 62.6% by chest X-ray. Common ultrasound findings included B-lines (76.8%), consolidation (69.7%), and pleural irregularity (65.8%). LUS demonstrated higher sensitivity (92.1%) than chest X-ray (76.2%), with comparable specificity (85.7% vs. 71.4%). Clinical features such as fever, cough, and dyspnea were observed in most patients. LUS also effectively identified associated pleural effusion in 24.5% of cases.

Conclusion: Point-of-care lung ultrasound is a sensitive, rapid, and non-invasive modality for early diagnosis of CAP, outperforming chest radiography in detection rates

Keywords: Lung ultrasound, community-acquired pneumonia, chest X-ray, diagnostic accuracy, bedside imaging

INTRODUCTION

Community-acquired pneumonia (CAP) has continued to be one of the most significant causes of morbidity and mortality worldwide, especially in children, the elderly and people with underlying comorbid conditions such as chronic obstructive pulmonary disease, diabetes mellitus and cardiovascular disorders [1]. It contributes to a significant healthcare burden, particularly in low- and middle-income nations, where access to state-of-the-art diagnostic facilities may be limited [2]. Early detection is vital because the later the diagnosis and the treatment the higher the risk of complications, length of stay in the hospital, and mortality rates. Traditionally, CAP diagnosis is made through a combination of clinical manifestations, including fever, cough, dyspnea, and auscultation, with laboratory indicators, including an increase in white blood cell count and inflammatory markers [3]. The first-line imaging modality is chest radiography which has several limitations. It is usually less sensitive in the initial phases of pneumonia, in dehydrated patients, and in obese patients or in patients with underlying pulmonary disease [4]. Also, interpretations of chest X-rays can vary among clinicians, increasing the risk of misdiagnosis. Although computed tomography (CT) has a better sensitivity and specificity, its regular application is limited by high costs, exposure to radiation and restricted availability especially during emergencies and resource-depleted cases [5]. Over the past few years, point-of-care lung ultrasound (POCUS) has gained significant popularity as a useful diagnostic tool for lung diseases at the bedside. Lung ultrasound is repeatable, radiology free, portable, and could be conducted in real time and at the bedside of the patient unlike the conventional imaging modalities [6]. It is particularly useful in the case of critically ill patients, for whom transportation to radiology departments can be dangerous or unfeasible. Lung ultrasound is based on the principle of visualizing the artifacts created by the propagation of ultrasound waves in the lungs in contact with air and fluid, which indirectly makes it possible to see lung pathology [7].

Typical ultrasound images of pneumonia are subpleural consolidations, dynamic air bronchograms, abnormal or thickened pleural lines and focal B-lines. These characteristics allow clinicians to distinguish between pneumonia and other respiratory diseases like pulmonary edema or atelectasis [8,9]. Notably, lung ultrasound has been shown to be more sensitive than chest radiography for detecting early, small peripheral lesions that are not readily visible on X-ray [10]. This has been reported in several studies, suggesting that the diagnostic accuracy of lung ultrasound is comparable to that of a CT scan, making it a viable alternative in most clinical settings [11]. The other important benefit of POCUS is in clinical decision-making and monitoring. It enables quick evaluation of the disease course and response to treatment, as well as the identification of complications such as pleural effusion or lung abscess [12]. This dynamic capability improves patient management by enabling timely changes in therapy. In addition, clinical scoring and diagnostic pathways can be incorporated into lung ultrasound, enhancing overall diagnostic efficiency [13].

OBJECTIVE

To evaluate the diagnostic utility of point-of-care lung ultrasound (LUS) in the early detection of community-acquired pneumonia (CAP) and to compare its performance with conventional chest radiography.

METHODOLOGY

This was a cross-sectional analytical study, conducted at Evercare Hospital Lahore from April 2024 to April 2025. A total of 155 patients were enrolled, calculated using the WHO sample size calculator with a confidence level of 95%, margin of error of 8%, and anticipated prevalence based on previous literature. Non-probability consecutive sampling was used to recruit patients presenting with suspected community-acquired pneumonia. Adult patients presenting with clinical features suggestive of community-acquired pneumonia were included. Patients aged ≥18 years of either gender presenting with symptoms suggestive of pneumonia, including fever, cough, dyspnea, and/or pleuritic chest pain, along with clinical suspicion of lower respiratory tract infection. Patients with hospital-acquired pneumonia, known chronic lung diseases (e.g., pulmonary fibrosis, lung malignancy), pulmonary edema due to cardiac causes, immunocompromised states (e.g., HIV/AIDS, chemotherapy), or those unwilling to participate were excluded.

DATA COLLECTION

After approval from the institutional ethical review committee, patients fulfilling the inclusion criteria were enrolled after obtaining informed consent. Baseline demographic and clinical data including age, gender, comorbidities, presenting symptoms, and vital signs were recorded on a structured proforma. All patients underwent point-of-care lung ultrasound (POCUS) performed by trained clinicians using a standardized scanning protocol covering anterior, lateral, and posterior lung zones. Ultrasound findings including presence of B-lines, subpleural consolidation, dynamic air bronchograms, pleural line irregularities, and pleural effusion were documented. All patients also underwent chest radiography as part of routine diagnostic evaluation, and where clinically indicated, computed tomography (CT) of the chest was used as a reference standard. The diagnosis of community-acquired pneumonia was established based on combined clinical, radiological, and laboratory findings. The primary outcome was the diagnostic accuracy of lung ultrasound in detecting community-acquired pneumonia. Secondary outcomes included sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and comparison of ultrasound findings with chest X-ray and CT scan results.

STATISTICAL ANALYSIS

Data were entered and analyzed using SPSS version 25. The Shapiro–Wilk test was applied to assess normality. Quantitative variables such as age and duration of symptoms were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Diagnostic performance parameters including sensitivity, specificity, PPV,

and NPV of lung ultrasound were calculated using CT scan or composite clinical diagnosis as the reference standard. Chi-square test was used for comparison of categorical variables, and a p-value ≤0.05 was considered statistically significant.

RESULTS

The study included 155 patients with a mean age of 46.8 ± 15.2 years, with a male predominance (59.4%) compared to females (40.6%). Comorbid conditions were present in a notable proportion, with hypertension in 31.0% and diabetes mellitus in 26.5% of patients. Clinically, the majority presented with typical symptoms of community-acquired pneumonia, including fever in 82.6%, cough in 78.7%, and dyspnea in 65.8%, indicating a predominantly symptomatic cohort at presentation.

Table 1: Baseline Demographic and Clinical Characteristics (n = 155)

Variable	Category	n (%) / Mean ± SD
Age (years)	—	46.8 ± 15.2
Gender	Male	92 (59.4%)
	Female	63 (40.6%)
Hypertension	Yes	48 (31.0%)
	No	107 (69.0%)
Diabetes Mellitus	Yes	41 (26.5%)
	No	114 (73.5%)
Fever	Present	128 (82.6%)
Cough	Present	122 (78.7%)
Dyspnea	Present	102 (65.8%)

B-lines were the most common finding, present in 76.8% of patients, followed by subpleural consolidation in 69.7% and pleural line irregularity in 65.8%. Dynamic air bronchograms were observed in 61.9% of cases, supporting the diagnosis of alveolar involvement. Pleural effusion was less frequent, detected in 24.5% of patients.

Table 2: Lung Ultrasound Findings (n = 155)

Variable	Category	n (%)
Subpleural Consolidation	Present	108 (69.7%)
	Absent	47 (30.3%)
B-lines	Present	119 (76.8%)
	Absent	36 (23.2%)
Dynamic Air Bronchograms	Present	96 (61.9%)
	Absent	59 (38.1%)
Pleural Effusion	Present	38 (24.5%)
	Absent	117 (75.5%)
Pleural Line Irregularity	Present	102 (65.8%)
	Absent	53 (34.2%)

When comparing diagnostic modalities, lung ultrasound demonstrated a higher detection rate for pneumonia (78.1%) compared to chest X-ray (62.6%), approaching the detection rate of CT scan, which served as the reference standard (81.3%).

Table 3: Comparison of Diagnostic Modalities (n = 155)

Modality	Positive for Pneumonia n (%)
Lung Ultrasound	121 (78.1%)
Chest X-ray	97 (62.6%)
CT Scan (Reference)	126 (81.3%)

Lung ultrasound showed markedly better diagnostic accuracy than chest X-ray across all parameters. It demonstrated higher sensitivity (92.1% vs. 76.2%), specificity (85.7% vs. 71.4%), positive predictive value (95.0% vs. 88.2%), and negative predictive value (78.3% vs. 52.6%), indicating its strong reliability in both confirming and ruling out pneumonia.

Table 4: Diagnostic Accuracy of Lung Ultrasound vs Chest X-ray

Parameter	Lung Ultrasound (%)	Chest X-ray (%)
Sensitivity	92.1	76.2
Specificity	85.7	71.4
Positive Predictive Value (PPV)	95.0	88.2
Negative Predictive Value (NPV)	78.3	52.6

A positive lung ultrasound was strongly associated with adverse outcomes, present in 90.9% of such cases ($p<0.001$). Similarly, the presence of dynamic air bronchograms (87.5%, $p=0.008$) and subpleural consolidation (88.0%, $p=0.012$) were significantly linked with worse outcomes. Additionally, hospitalization was required in 66.5% of patients and showed a significant association ($p=0.02$).

Table 5: Association of Ultrasound Findings with Clinical Outcomes

Variable	Category	Outcome Present n (%)	p-value
Positive Lung Ultrasound	Yes	110 (90.9%)	<0.001
	No	11 (9.1%)	—
Dynamic Air Bronchograms	Present	84 (87.5%)	0.008
	Absent	37 (62.7%)	—
Subpleural Consolidation	Present	95 (88.0%)	0.012
	Absent	26 (55.3%)	—
Hospitalization	Required	103 (66.5%)	0.02

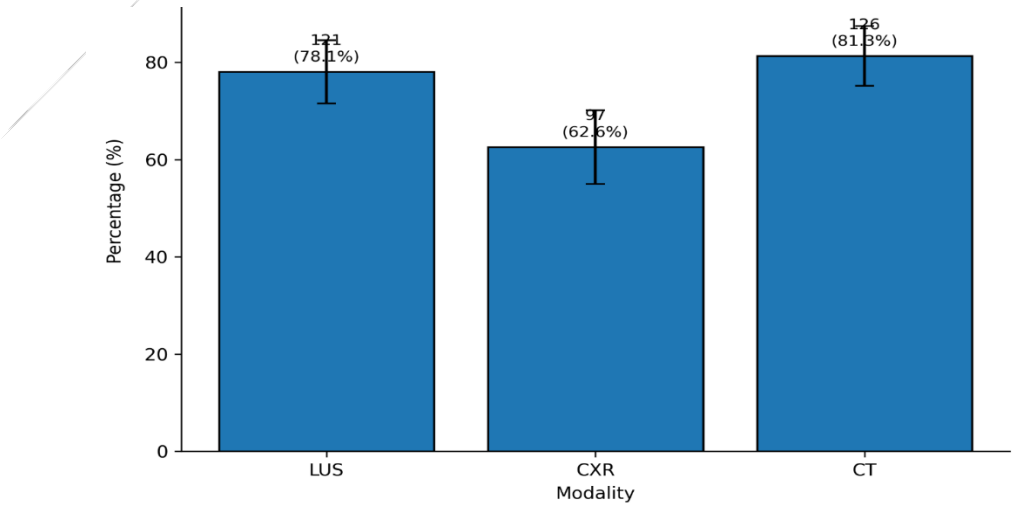

Figure 1: Detection rate of pneumonia by modality

DISCUSSION

This study evaluated the role of point-of-care lung ultrasound (LUS) in the early diagnosis of community-acquired pneumonia (CAP) and demonstrated that LUS has a high diagnostic yield with favorable clinical applicability. The results indicated that LUS detected pneumonia in a significant percentage of patients and had greater sensitivity than chest X-ray (CXR), supporting its importance as a first-line bedside imaging test. This is consistent with the emerging evidence that LUS is able to predictably detect pulmonary pathology based on characteristic appearances, including consolidation, B-lines, and dynamic air bronchograms that were common in the current cohort. The first one is the prevalence of respiratory tract infections and the high rate of ultrasound appearances, including B-lines and subpleural consolidations, which emphasise the usefulness of LUS in detecting earlier inflammatory and interstitial changes. Its diagnostic accuracy in distinguishing between pneumonia and other causes of lung opacity is further supported by the detection of air bronchograms in a large number of cases. These results align with the existing literature, which has shown that LUS is especially sensitive for detecting peripheral lung lesions and is usually better than CXR at early or mild stages of the disease [14].

The other significant finding was that LUS was highly effective in diagnostic performance compared with conventional imaging. The increased sensitivity and similar specificity of LUS indicate that it may be a useful substitute for CXR, particularly in resource-restricted environments or emergency situations where prompt decision-making is essential. Past studies have also indicated that LUS decreases diagnostic delays and enhances timely treatment initiation and, in the process, it may decrease morbidity related to CAP [15]. These findings have also been highlighted in the clinical relevance due to high percentage of patients that present with the common symptoms of fever, cough, and dyspnea, which means that LUS can be easily incorporated into regular clinical examination. The fact that LUS can provide immediate bedside images free of radiation is especially beneficial for the pediatric population and critically ill patients, who may need repeated imaging [16].

Besides, LUS was shown to be a highly applicable tool for detecting complications such as pleural effusion and informing clinical management. The comparatively low rate of effusion detection compared with consolidation reflects the disease spectrum in CAP, in which parenchymal involvement is more prevalent at the earliest stages. The sensitivity of ultrasound, however, in the evaluation of pleural pathology is emphasised by the fact that it is able to detect even small effusions [17]. Although LUS has its merits, there are some constraints of this tool that should not be ignored. It has variable levels of diagnostic accuracy depending on the operator which involves proper training and experience. Also, LUS can have low sensitivity for identifying deep or central lung lesions that do not reach the pleural surface. The limitations, however, are usually outweighed by its advantages, especially when it is employed as a component of a multimodal approach to diagnosis [18-20].

This research has several limitations that should be considered. The cross-sectional study provides only a single evaluation and fails to detect any changes in ultrasound results or their effects on long-term outcomes. Since the study is single-centred, the applicability of the results can be questioned. Lung ultrasound is operator-dependent, and the lack of formal evaluation of interobserver variability can affect reproducibility. Furthermore, insufficient blinding may have led to observer bias. Clinical and conventional imaging, as opposed to a consistent gold standard like CT in all patients, might have led to misclassification, especially at an early or subtle disease. Lung ultrasound can also fail to identify deep or central lesions that do not reach the pleural surface, thereby underestimating the disease burden. The sample size, though sufficient to the primary analysis, may not work well in making in-depth subgroup comparisons. In addition, there is a lack of microbiological confirmation that restricts the association with certain pathogens. Finally, the lack of complete contingency data did not allow for making strong statistical comparisons, such as specific confidence intervals and p-values on certain diagnostic measures.

CONCLUSION

Point-of-care lung ultrasound is a highly effective, rapid, and reliable tool for the early diagnosis of community-acquired pneumonia, demonstrating superior sensitivity and comparable specificity to conventional chest radiography. Its ability to detect key pathological features at the bedside, without radiation exposure, makes it particularly valuable in resource-limited settings and acute care scenarios.

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