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Comparative Diagnostic Accuracy of Lung Ultrasound and Chest X-Ray for Early Detection of Pneumonia in Emergency Settings

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ABSTRACT

Background: Pneumonia is a major cause of morbidity and mortality worldwide, requiring prompt and accurate diagnosis, especially in emergency settings. Chest X-ray (CXR) is traditionally used for diagnosis; however, it has limitations in early detection. Lung ultrasound (LUS) has emerged as a rapid, bedside imaging modality with promising diagnostic accuracy.

Objective: To compare the diagnostic accuracy of lung ultrasound and chest X-ray in the early detection of pneumonia in patients presenting to the emergency department.

Methodology: A total of 180 adult patients with clinical suspicion of pneumonia were enrolled. All patients underwent both LUS and CXR within 6 hours of presentation. The final diagnosis was done using a composite clinical reference standard including clinical, laboratory, microbiological findings, and response to treatment. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated for both modalities.

Results: Lung ultrasound showed sensitivity of 95.2%, specificity of 80.0%, PPV of 90.8%, NPV of 88.9%, and overall accuracy of 92.2%. Chest X-ray demonstrated sensitivity of 79.0%, specificity of 75.9%, PPV of 87.5%, NPV of 62.0%, and accuracy of 78.9%. The difference in sensitivity between the two modalities was statistically significant ($p \leq 0.001$). Receiver operating characteristic analysis showed superior performance of LUS (AUC 0.91) compared to CXR (AUC 0.77).

Conclusion: Lung ultrasound is a highly sensitive and accurate modality for early detection of pneumonia and outperforms chest X-ray in emergency settings. It can be used as a reliable first-line or complementary diagnostic tool, particularly in resource-limited environments.

Keywords: Lung Ultrasound; Chest X-Ray; Pneumonia; Diagnostic Accuracy

Introduction

Pneumonia has remained one of the most significant causes of morbidity and mortality in the world with low- and middle-income countries experiencing a delay in the diagnosis and treatment of pneumonia due to limited resources and overcrowded emergency departments. It is an acute pulmonary parenchyma infection that needs early diagnosis and treatment to avoid complications and decrease mortality. Proper and timely diagnosis in emergencies is thus very crucial since delays in initiating the right therapy have been linked to poor clinical outcomes. [1,2] Chest radiography (CXR) has traditionally been the primary imaging modality of the suspected pneumonia due to its wide availability and capability to provide an overall view of thoracic structures.[3] CXR, however, has a number of limitations, one of them being lower sensitivity in the initial stage of the disease, failure to detect small consolidations, and exposure to ionizing rays.[4]

Lung ultrasound (LUS) is a relatively new diagnostic modality that has gained popularity in the past few years as a diagnostic tool to assess pulmonary conditions at the bedside. Some of the benefits of LUS are portability, no radiation, fast and can be repeated many times with no harm.[5,6] Research has established that LUS is more sensitive and specific in the diagnosis of pneumonia and can identify such characteristics as subpleural consolidations, dynamic air bronchograms and pleural effusions more efficiently than conventional radiography.[7] Recent meta-analyses and systematic reviews have revealed that LUS frequently performs better than CXR in the detection of pneumonia, especially in critically ill and emergency department patients.[8,9] In addition, LUS has been reported to identify cases of pneumonia missed on CXR, which would suggest its possible superiority in disease at an early stage.[10]

Although the benefits of LUS in emergency scenarios are pronounced, its widespread use across emergency departments has yet to be fully consistent. Issues like dependency on operators, the absence of standardized protocols and inconsistencies in clinical expertise can affect diagnostic accuracy.[11] In addition, the majority of studies that have been carried out so far have been done under controlled conditions, typically, either in intensive care unit or in pediatric populations, which restricts the generalization of the results to real life emergency departments, especially in resource constrained settings.[12]

Despite increasing evidence that lung ultrasound can be of greater diagnostic value than the chest X-ray, there is still no well-designed and context-specific studies to prove its efficiency in early detection of pneumonia in particular setting of emergency department, especially in developing countries. Also, there is lack of information comparing the two modalities on standardized protocols and uniform reference standards in acute care settings. Addressing this gap is essential to determine whether LUS can reliably replace or complement CXR as a first-line diagnostic tool in emergency practice.

Objective

To compare the diagnostic accuracy of lung ultrasound and chest X-ray in the early detection of pneumonia in patients presenting to the emergency department.

Methodology

This prospective cross-sectional diagnostic accuracy study was carried out in Liaquat University of Medical & Health Sciences (LUMHS), Jamshoro, during a period of 12 months. A total sample size of 180 patients was calculated using the expected sensitivity of lung ultrasound LUS (90%), CXR (75%), confidence level of 95% and a margin of error of 5%.

The study included all consecutive adult patients aged 18 years and above who were clinically suspected to have pneumonia (presence of fever, cough, dyspnea, pleuritic chest pain, and/or abnormal auscultatory findings). Patients who had a known chronic lung disease such as interstitial lung disease, pulmonary malignancy, a known chronic lung disease under treatment, hemodynamic instability necessitating urgent intervention or those who were not willing to give consent were excluded. All subjects gave written informed consent before enrollment.

All patients had lung ultrasound and chest X-ray within 6 hours of presentation. The bedside lung ultrasound examinations were carried out by trained pulmonologists on a portable ultrasound machine with a curvilinear probe (3.5-5 MHz). A standardized scanning protocol, including anterior, lateral, and posterior lung zones, on both sides, was observed. The presence of subpleural consolidation, dynamic air bronchograms, focal B-lines, and the presence of abnormalities in the pleural line were all diagnostic criteria of pneumonia on LUS. Chest radiographs were taken in the posteroanterior view where possible or in the anteroposterior view in bedridden patients and interpreted by a consultant radiologist blinded to the results of LUS. Radiographic signs of pneumonia were the presence of new infiltrates, consolidation or interstitial patterns that are suggestive of infection.

For the purpose of reference standard, final diagnosis of pneumonia was established using a composite clinical diagnosis based on clinical presentation, laboratory parameters including leukocyte count and inflammatory markers, microbiological findings where available, and response to treatment assessed within 48–72 hours of admission. LUS and CXR results were both compared to this reference standard.

The data were collected on a structured proforma and analyzed using SPSS version 26. The quantitative variables (age) were given in the form of mean standard deviation, whereas the qualitative variables (gender and diagnostic results) were in the form of frequencies and percentages. The sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy were measured between LUS and CXR. The chi-square test was used to compare proportions, and a p-value of ≤0.05 was considered statistically significant. To compare diagnostic performance of both modalities, receiver operating characteristic (ROC) curves were plotted. Ethical approval (LUMHS/REC/23) for the study was obtained from the institutional review board prior to commencement.

Results

The mean age of the study cases was 49.6 ± 16.2 years (range: 18–82 years). The most common presenting symptoms were cough found in 162 (90%), fever in 148 (82.2%), and dyspnea in 136 (75.6%) patients. Pneumonia was confirmed in 124 (68.9%) patients, while 56 (31.1%) were classified as non-pneumonia cases (Table 1).

When compared with the reference standard, lung ultrasound correctly identified 118 (95.2%) true positive cases and 48 (85.7%) true negative cases, with 12 (21.4%) false positives and 6 (4.8%) false negatives. In contrast, chest X-ray identified 98 (79.0%) true positives and 44 (78.6%) true negatives, with 14 (25.0%) false positives and 26 (21.0%) false negatives (Table 2).

Lung ultrasound demonstrated a sensitivity of 95.2%, specificity of 80.0%, positive predictive value (PPV) of 90.8%, negative predictive value (NPV) of 88.9%, and overall diagnostic accuracy of 92.2%. Chest X-ray showed a sensitivity of 79.0%, specificity of 75.9%, PPV of 87.5%, NPV of 62.0%, and overall accuracy of 78.9%. The difference in sensitivity between LUS and CXR was statistically significant ($p \leq 0.001$) (Table 3).

ROC analysis showed that lung ultrasound had excellent diagnostic accuracy, with an AUC of 0.91 (95% CI: 0.86–0.96). In comparison, chest X-ray demonstrated moderate diagnostic accuracy, with an AUC of 0.77 (95% CI: 0.69–0.85) (Table 4).

Discussion

The present study demonstrates that lung ultrasound (LUS) has superior sensitivity, negative predictive value, and overall diagnostic accuracy compared to chest X-ray (CXR) for early detection of pneumonia in emergency settings. These observations support the emerging role of LUS as an effective bedside imaging modality, especially in the context of the need to make clinical decisions promptly.

Our findings are in line with the findings of Becerra et al[13], who reported high sensitivity (94.1%) and diagnostic accuracy (95.0%) of LUS, which significantly outperforms

Table 1. Baseline characteristics of study population

Variable		Mean ± SD / n (%)
Age (years)		49.6 ± 16.2
Gender	Male	102 (56.7%)
Gender	Female	78 (43.3%)
Symptoms Found		
Cough		162 (90.0%)
Fever		148 (82.2%)
Dyspnea		136 (75.6%)
Diagnosis of Pneumonia		
Confirmed Pneumonia		124 (68.9%)
Non-Pneumonia		56 (31.1%)

Table 2. Cross-tabulation of LUS and CXR findings against reference standard (n = 180)

Diagnostic Technique		Pneumonia Present (n = 124)	Pneumonia Absent (n = 56)	Total
LUS	Positive	118 (95.2%)	12 (21.4%)	130
	Negative	6 (4.8%)	44 (78.6%)	50
CXR	Positive	98 (79.0%)	14 (25.0%)	112
	Negative	26 (21.0%)	42 (75.0%)	68

CXR. The high similarity in sensitivity confirms the strength of LUS in various clinical settings. However, their greater specificity than our results could be attributed to the fact that they used CT as the reference standard, whereas we used a composite clinical diagnosis, which is more prone to misclassification because of overlap with non-infective pulmonary conditions.

On the same note, Musolino et al[14] have shown that the detection rate of pneumonia using LUS is markedly higher compared to the detection rate of pneumonia using CXR (77.6% vs. 45.6%), which underscores the shortcomings of radiography in detecting early or peripheral lesions. This is especially applicable in the emergency departments where early-staged disease might not have been accompanied by gross radiographic abnormalities. The superior sensitivity of LUS can be attributed to the fact that this method is more sensitive to detect subpleural consolidations and interstitial abnormalities.

Even the high diagnostic performance of LUS is further confirmed by the findings of Elabbas et al,[15] who reported the pooled sensitivity and specificity of 92% and 94% with an AUC of 0.97. In comparison, the slightly less specificity we had noted in our study was perhaps due to real life factors including operator dependence, heterogeneous patient population as well as lack of CT confirmation in all cases. These considerations support the need to adopt standardized protocols and training to maximize LUS performance.

Similar superiority of LUS over CXR in the detection of COVID-19 pneumonia etiology were reported by Sansone et al,[16] supporting the broader applicability of ultrasound in the detection of COVID-19 pneumonia etiology. The lower false-negative rate with LUS in our study is clinically significant, with false-negative rates at early stage potentially leading to delay in treatment. Bocattonda et al[17] also described good diagnostic accuracy of LUS especially in the detection of consolidation and interstitial patterns, but their pediatric population might not be directly comparable. Caroosseli et al,[18] on the other hand, found that LUS was less accurate in diagnosing adult pneumonia. The difference in the two studies can be explained by varying methodologies such as sampling plan, knowledge of the operators, and the use of clinical diagnosis other than imaging-based reference standards. These differences illustrate that LUS performance is very much reliant on operator expertise, and compliance with standardized scanning protocols.

The negative predictive value of LUS in our study is very high with significant clinical implications. A negative LUS is highly reliable in ruling out pneumonia, and may help to reduce unnecessary use of antibiotics and minimise radiation exposure.[19] However, LUS is limited by nature and especially when it comes to identifying central lesions that do not reach the pleural surface.[20] Thus, although LUS is a very effective first-line intervention, it must be combined with clinical evaluation, and in some cases, be

Table 3. Diagnostic performance of LUS and CXR

Parameter	Lung Ultrasound	Chest X-ray	p-value
Sensitivity	95.2%	79.0%	0.001
Specificity	80.0%	75.9%	0.611
Positive Predictive Value	90.8%	87.5%	0.392
Negative Predictive Value	88.9%	62.0%	<0.001
Diagnostic Accuracy	92.2%	78.9%	<0.001

Table 4. ROC analysis of lung ultrasound and chest X-ray

Diagnostic modality	AUC	95% CI	Diagnostic interpretation
Lung ultrasound	0.91	0.86–0.96	Excellent
Chest X-ray	0.77	0.69–0.85	Moderate

corroborated with CXR or CT images.

There are certain limitations which needs to be addressed. This study was carried out in a single center, which can influence generalizability. A composite clinical reference standard was used instead of CT in all patients, potentially introducing verification bias. Operator dependency of LUS and lack of interobserver variability assessment are additional limitations. Moreover, the exclusion of critically ill patients and absence of follow-up imaging can be a limitation in application to some clinical situations.

Conclusion

The sensitivity, negative predictive value, and overall diagnostic accuracy of lung ultrasound were found to be higher than those of a chest X-ray in the early diagnosis of pneumonia in the emergency department. It is a useful diagnostic aid in acute care due to its availability at the bedside, lack of radiation exposure, fast performance, and ability to detect early peripheral lung changes. Despite the fact that chest X-ray is still a useful and widely available diagnostic test; it may not detect early or subtle changes of pneumonia. Thus, lung ultrasound may be regarded as a valid first-line or adjunctive imaging modality in suspected pneumonia in emergency departments, especially in resource-limited settings. Nonetheless, it is suggested that sufficient operator training, standardized scanning protocols, and additional multicenter studies should be undertaken before it is actually adopted in clinical practice to replace chest X-ray.

References

1. National Institute for Health and Care Excellence (NICE). Evidence review for diagnostic accuracy of lung ultrasound compared to chest X-ray for diagnosing pneumonia. In: Pneumonia: diagnosis and management. NICE Guideline No. 250. Evidence Review A. London: National Institute for Health and Care Excellence; 2025.
2. Yang Y, Wu Y, Zhao W. Comparison of lung ultrasound and chest radiography for detecting pneumonia in children: a systematic review and meta-analysis. Ital J Pediatr. 2024;50:12. DOI:10.1186/s13052-024-01583-3.
3. Shi C, Xu X, Xu Y. Systematic review and meta-analysis of the accuracy of lung ultrasound and chest radiography in diagnosing community-acquired pneumonia in children. Pediatr Pulmonol. 2024;59 (12):3130–3147. DOI:10.1002/ppul.27221.
4. Guitart C, Bobillo-Perez S, Rodríguez-Fanjul J, Carrasco JL, Brotons P, López-Ramos MG, et al. Lung ultrasound and procalcitonin, improving antibiotic management and avoiding radiation exposure in pediatric critical patients with bacterial pneumonia: a randomized clinical trial. Eur J Med Res. 2024;29:222. DOI:10.1186/s40001-024-01712-y.
5. Lu X, Jin Y, Li Y, Weng L, Li H. Diagnostic accuracy of lung ultrasonography in childhood pneumonia: a meta-analysis. Eur J Emerg Med. 2022;29(2): 105–117. DOI:10.1097/MEJ.0000000000000883.
6. Kazi S, Hernstadt H, Abo YN, Graham H, Palmer M, Graham SM; ARI Review Group. The utility of chest X-ray and lung ultrasound in the management of infants and children presenting with severe pneumonia in low- and middle-income countries: a pragmatic scoping review. J Glob Health. 2022;12:10013. DOI:10.7189/jogh.12.10013.
7. Sankar K, Rakholia R, Maroof M, Chamoli P, Raipa T. Diagnostic accuracy of bedside lung ultrasound versus chest X-ray for pediatric pneumonia in children under five: a comparative study. Cureus. 2025;17(9):e91509. DOI:10.7759/cureus.91509.
8. Hughes-Davies H, Ukwatte U, Fanshawe TR, Roberts N, Turner PJ, Hayward GN, et al. Diagnostic accuracy of point-of-care lung ultrasound for community-acquired pneumonia in children in ambulatory settings: a systematic review and meta-analysis. Ultrasound. 2025;33(3):197–205. DOI:10.1177/1742271X241289726.
9. Guitart C, Becerra J, Bobillo-Perez S, Carrasco JL, Peon G, Balaguer M, et al. Diagnostic accuracy of lung ultrasound for pneumonia in acutely and critically ill neonates, children, and young adults: a systematic review and meta-analysis. Diagnostics (Basel). 2025;15(24):3122. DOI:10.3390/diagnostics15243122.

10. Sadiq N, Iftikhar A, Tahir M, Mahmood R, Awan AA, Uzair M. Diagnostic accuracy of lung ultrasound in diagnosis of pneumonia in children using chest X-ray as gold standard. Pak Armed Forces Med J. 2023; 73(6):1761–1764. DOI:10.51253/pafmj.v73i6.8785.
11. Mushtaq S, Noreen A, Rasool MR, Nasreen M, Amin M. Diagnostic accuracy of lung ultrasound for detecting pneumonia in children: a comparative study with chest radiography. Pak J Chest Med. 2023;29(4):519–525.
12. Abid I, Qureshi N, Lategan N, Williams S, Shahid S. Point-of-care lung ultrasound in detecting pneumonia: a systematic review. Can J Respir Ther. 2024;60:37–48. DOI:10.29390/001c.92182.
13. Becerra-Hervás J, Guitart C, Covas A, Bobillo-Pérez S, Rodríguez-Fanjul J, Carrasco-Jordan JL, et al. The Clinical Pulmonary Infection Score combined with procalcitonin and lung ultrasound (CPIS-PLUS), a good tool for ventilator-associated pneumonia early diagnosis in pediatrics. Children (Basel). 2024;11(5): 592. DOI:10.3390/children11050592.
14. Musolino AM, Tomà P, De Rose C, Pitaro E, Boccuzzi E, De Santis R, et al. Ten years of pediatric lung ultrasound: a narrative review. Front Physiol. 2022;12:721951. DOI:10.3389/fphys.2021.721951.
15. Elabbas A, Choudhary R, Gullapalli D, Mistry S, Farzana MH, Mallick AH, et al. Lung ultrasonography beyond the diagnosis of pediatrics pneumonia. Cureus. 2022;14(2):e22460. DOI:10.7759/cureus. 22460.
16. Sansone F, Attanasi M, Di Filippo P, Sferrazza Papa GF, Di Pillo S, Chiarelli F. Usefulness of lung ultrasound in paediatric respiratory diseases. Diagnostics (Basel). 2021;11(10):1783. DOI:10.3390/ diagnostics11101783.
17. Boccatonda A, Cocco G, D'Ardes D, Delli Pizzi A, Vidili G, De Molo C, et al. Infectious pneumonia and lung ultrasound: a review. J Clin Med. 2023;12(4): 1402. DOI:10.3390/jcm12041402.
18. Caroselli C. Could lung ultrasound be a valid alternative to ionizing radiation or a complementary diagnostic choice in pediatric respiratory diseases? Transl Pediatr. 2024;13(7):1273–1278. DOI:10. 21037/tp-24-36.
19. Desai D, Shah AB, Dela JRC, Mugibel TA, Sumaily KM, Sabi EM, et al. Lung ultrasonography accuracy for diagnosis of adult pneumonia: systematic review and meta-analysis. Adv Respir Med. 2024;92(3): 241–253. DOI:10.3390/arm92030024.
20. Kozyak BW, Yuerek M, Conlon TW. Contemporary use of ultrasonography in acute care pediatrics. Indian J Pediatr. 2023;90(5):459–469. DOI:10.1007/ s12098-023-04475-2.