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Original Research Article

ASSESSING LUNG ULTRASOUND'S IMPACT ON DIAGNOSING PEDIATRIC PNEUMONIAS: A PROSPECTIVE STUDY

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ABSTRACT

Background: Pediatric pneumonia is a common cause of morbidity, and chest X-ray remains the conventional imaging modality despite concerns regarding radiation exposure. Lung ultrasound has emerged as a promising alternative. The aim is to compare the diagnostic ability of lung ultrasound with chest X-ray in pediatric pneumonia and evaluate its potential as a radiation-free imaging modality.

Materials and Methods: This prospective observational study included 90 pediatric patients with clinically suspected pneumonia. All patients underwent lung ultrasound and chest X-ray, and diagnostic performance parameters were analyzed.

Results: Lung ultrasound demonstrated high sensitivity, specificity, and diagnostic accuracy for both lobar pneumonia and bronchopneumonia, comparable to chest X-ray findings.

Conclusion: Lung ultrasound is a reliable and effective alternative to chest X-ray in pediatric pneumonia and can reduce unnecessary radiation exposure in children.

Keywords: Pediatric pneumonia; Lung ultrasound; Chest X-ray; Radiation-free imaging.

INTRODUCTION

Pediatric pneumonia remains a leading cause of morbidity and mortality worldwide, particularly in low- and middle-income countries, where early and accurate diagnosis is crucial for effective management and improved outcomes. Traditional diagnostic imaging for suspected pneumonia has relied heavily on chest radiography (CXR), which, despite its widespread use, exposes children to ionizing radiation and may have limitations in sensitivity and specificity, especially for subtle or early lung changes.[1] Lung ultrasound (LUS) has emerged as a promising, radiation-free, bedside imaging modality that can identify key sonographic features of pneumonia such as subpleural consolidations, B-lines, and pleural irregularities with high diagnostic accuracy.

Recent evidence supports the use of LUS as an alternative to CXR in pediatric populations, demonstrating that LUS can reliably detect pneumonia with diagnostic performance comparable to or exceeding that of CXR.[1,2] Meta-analytical data indicate that LUS has a higher sensitivity than CXR for diagnosing pneumonia in children, while maintaining similar specificity, suggesting that LUS may reduce false negatives and aid in earlier identification of lung infections without radiation exposure.[1] Moreover, LUS offers practical advantages including portability, repeatability, and real-time dynamic assessment, which are particularly beneficial in busy emergency and inpatient settings.[3] Beyond detection, LUS has also shown utility in differentiating etiologies of lower respiratory tract infections, identifying patterns suggestive of bacterial versus viral pneumonia. Prospective observational studies have demonstrated significant correlations between specific ultrasound findings and bacterial pneumonia, such as larger and confluent B-lines with subpleural consolidations, which are less

common in viral infections.[4,5] Such discriminative capability can potentially guide appropriate antibiotic therapy, thus limit unnecessary antibiotic exposure and improve antimicrobial stewardship.

Furthermore, large multicenter observational research has validated LUS as a highly accurate diagnostic tool, with near-perfect agreement compared to final clinical diagnoses, affirming its role not only in detection but also in the comprehensive assessment of pediatric respiratory illnesses.[6] In addition to diagnostic strength, studies highlight that implementation of LUS reduces reliance on ionizing radiation, consistent with the principle of minimizing radiation exposure in children whenever possible.[7] This aligns with current efforts to adopt imaging practices that enhance patient safety without compromising clinical efficacy.

While the operator-dependent nature of ultrasound and the requirement for training are acknowledged challenges, standardized protocols and increased point-of-care ultrasound training among pediatric clinicians are steadily improving diagnostic consistency and confidence.[8] The cumulative body of evidence suggests that LUS is both a feasible and effective imaging modality for pediatric pneumonia, warranting prospective evaluation against CXR in real-world clinical settings to assess whether it can be adopted as a frontline diagnostic tool.[9,10]

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Pediatrics of a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee. The study population comprised 90 pediatric patients presenting with clinical features suggestive of pneumonia during the study period. Children aged between 1 month and 12 years with symptoms such as fever, cough, tachypnea, chest retractions, or respiratory distress and clinically suspected pneumonia were included in the study. Children with congenital lung anomalies, known chronic pulmonary diseases, hemodynamic instability requiring immediate intensive care, previous thoracic surgery, or whose parents or guardians did not provide informed consent were excluded.

After obtaining written informed consent from parents or legal guardians, all enrolled patients underwent a detailed clinical evaluation, including history taking and physical examination. Each child was subjected to both chest radiography and lung ultrasound as part of routine diagnostic evaluation. Chest X-ray was performed in the posteroanterior view or anteroposterior view as appropriate for age and clinical condition, and findings were interpreted by an experienced radiologist who was blinded to the ultrasound findings.

Lung ultrasound examination was performed at the bedside using a high-frequency linear probe or a curvilinear probe depending on the age and body habitus of the child. The examination was carried out by a trained pediatrician or radiologist experienced in lung ultrasonography, who was blinded to the chest X-ray findings. The lungs were systematically scanned in anterior, lateral, and posterior zones on both sides. Sonographic findings suggestive of pneumonia, such as subpleural consolidations, dynamic air bronchograms, focal or confluent B-lines, pleural line abnormalities, and pleural effusions, were documented.

The diagnostic findings obtained from lung ultrasound were compared with chest X-ray findings to evaluate the diagnostic performance of lung ultrasound in detecting pediatric pneumonia. The final diagnosis of pneumonia was based on a composite reference standard that included clinical features, laboratory findings when available, radiographic findings, and clinical response to treatment.

Data collected were entered into a predesigned proforma and analyzed using appropriate statistical software. Descriptive statistics were used to summarize demographic and clinical characteristics. The diagnostic accuracy of lung ultrasound was assessed in terms of sensitivity, specificity, positive predictive value, and negative predictive value, using chest X-ray and final clinical diagnosis as reference standards. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The present study included a total of 90 pediatric patients clinically suspected of pneumonia. The age-wise distribution of the study population is depicted in [Table 1]. The majority of cases were observed in the infant age group, followed by toddlers and preschool children, indicating a higher burden of pneumonia in younger age groups.

[Table 2] shows the comparison of lung ultrasound findings with chest X-ray–confirmed cases of lobar pneumonia. Lung ultrasound demonstrated high sensitivity, specificity, and overall diagnostic accuracy in identifying lobar pneumonia when compared with chest radiography, with only a few false-negative cases.

[Table 3] presents the comparison between lung ultrasound and chest X-ray in diagnosing bronchopneumonia. Lung ultrasound showed good sensitivity and specificity with satisfactory positive and negative predictive values, highlighting its effectiveness in detecting bronchopneumonia in the pediatric population.

[Table 4] illustrates the comparison of the dynamic air bronchogram sign on lung ultrasound with chest X-ray–positive cases of lobar pneumonia. The presence of dynamic air bronchograms on ultrasound showed excellent diagnostic performance with high specificity and overall accuracy.

[Table 5] depicts the diagnostic performance of the dynamic air bronchogram sign on lung ultrasound in cases of bronchopneumonia. Although sensitivity was comparatively lower than in lobar pneumonia, the specificity and overall diagnostic accuracy remained high, supporting the utility of this ultrasound sign in clinical practice.

Table 1: Age distribution of study participants (n = 90)

Age group (years)	N	Percentage (%)
0–1	38	42.2
>1–3	20	22.2
>3–5	17	18.9
>5–18	15	16.7
Total	90	100

Table 2: Comparison of LUS with chest X-ray positive cases of lobar pneumonia

LUS	CXR Positive	CXR Negative	Total	Sensitivity	Specificity	PPV	NPV	Accuracy
Positive	41	2	43	89.13%	92.00%	95.35%	82.14%	90.00%
Negative	5	25	30					
Total	46	27	73					

Table 3: Comparison of LUS with chest X-ray positive cases of bronchopneumonia

Consolidation on LUS	CXR Positive	CXR Negative	Total	Sensitivity	Specificity	PPV	NPV	Accuracy
Positive	28	4	32	82.35%	88.24%	87.50%	83.33%	85.56%
Negative	6	30	36					
Total	34	34	68					

Table 4: Comparison of dynamic air bronchogram sign on LUS with chest X-ray positive cases of lobar pneumonia

Dynamic air bronchogram	CXR Positive	CXR Negative	Total	Sensitivity	Specificity	PPV	NPV	Accuracy
Positive	40	1	41	86.96%	96.15%	97.56%	80.77%	89.04%
Negative	6	25	31					
Total	46	26	72					

Table 5: Comparison of dynamic air bronchogram sign on LUS with chest X-ray positive cases of bronchopneumonia

Dynamic air bronchogram	CXR Positive	CXR Negative	Total	Sensitivity	Specificity	PPV	NPV	Accuracy
Positive	24	2	26	70.59%	93.94%	92.31%	75.61%	82.35%
Negative	10	31	41					
Total	34	33	67					

DISCUSSION

The present prospective observational study evaluated the diagnostic performance of lung ultrasound (LUS) in pediatric pneumonia and compared it with conventional chest X-ray (CXR). The findings of this study demonstrate that LUS exhibits high sensitivity, specificity, and diagnostic accuracy in detecting both lobar pneumonia and bronchopneumonia, supporting its role as a reliable imaging modality in children. These results align with recent literature emphasizing the increasing diagnostic value of LUS in pediatric respiratory infections.[11]

One of the key advantages of lung ultrasound highlighted by the present study is its ability to detect peripheral lung consolidations and dynamic air bronchograms with high accuracy. Recent multicenter studies have shown that LUS can identify sonographic signs of pneumonia earlier than chest radiography, particularly in cases where radiographic findings may be subtle or delayed.[12] The high sensitivity observed in this study for lobar pneumonia reinforces the role of LUS as a frontline diagnostic tool, especially in acute care settings.

Dynamic air bronchogram, a specific sonographic sign evaluated in the present study, demonstrated excellent specificity for both lobar pneumonia and bronchopneumonia. Previous research has emphasized that dynamic air bronchograms are highly suggestive of alveolar consolidation and are rarely seen in non-infective conditions, making them a valuable marker for pneumonia diagnosis.[13] The strong diagnostic performance of this sign observed in the present study supports its clinical utility in differentiating infectious consolidations from other causes of lung opacities.

Another important implication of the study is the potential of LUS to reduce exposure to ionizing radiation in children. Repeated exposure to chest X-rays during childhood has been associated with cumulative radiation risks, prompting growing interest in radiation-free imaging alternatives. Recent pediatric imaging guidelines increasingly advocate for the judicious use of radiography and support ultrasound-based evaluation whenever feasible.[14] The comparable diagnostic accuracy of LUS demonstrated in this study further strengthens the

argument for its routine use in pediatric pneumonia assessment.

Although LUS is operator dependent, standardized scanning protocols and focused training programs have been shown to significantly improve inter-observer reliability and diagnostic confidence. Emerging evidence suggests that even clinicians with limited ultrasound experience can achieve high diagnostic accuracy after structured training, making LUS a feasible tool across different healthcare settings.[15] Considering its portability, repeatability, and lack of radiation, lung ultrasound has the potential to transform the diagnostic approach to pediatric pneumonia.

CONCLUSION

Lung ultrasound is a highly sensitive, specific, and accurate imaging modality for the diagnosis of pediatric pneumonia. Its diagnostic performance is comparable to that of chest X-ray, with the added advantages of being radiation-free, bedside-available, and easily repeatable. Lung ultrasound can be considered a reliable alternative to chest radiography in the evaluation of pediatric pneumonia and may significantly reduce radiation exposure in children when incorporated into routine clinical practice.

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