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Comparative Evaluation Of Chest Ultrasound And Chest X-Ray In Diagnosing Lower Respiratory Tract Infections In Children: A Prospective Observational Cross-Sectional Study

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ABSTRACT

Background: Lower respiratory tract infections (LRTIs) are a major cause of morbidity in children. Accurate, radiation-free diagnostic tools are essential for optimal care. This study aimed to compare the diagnostic efficacy of chest ultrasound (CUS) and chest X-ray (CXR) in pediatric patients with suspected LRTIs.
Methods: This prospective cross-sectional study was conducted at Al-Azhar University Hospital, Assiut, Egypt, and included 172 pediatric patients. Each child underwent both CUS and CXR within 24 hours of clinical presentation. The sensitivity, specificity, interobserver agreement, and diagnostic accuracy of CUS and CXR were compared.
Results: CUS showed higher sensitivity for detecting pulmonary consolidation (90%) and pleural effusion (85%) compared to CXR (78% and 65%, respectively). CUS also demonstrated superior specificity, interobserver agreement ($\kappa = 0.89$), and diagnostic accuracy (AUC = 0.90) compared to CXR ($\kappa = 0.78$, AUC = 0.78).
Conclusions: CUS is a reliable, non-invasive, and radiation-free imaging modality that offers superior diagnostic accuracy over CXR in the initial evaluation of children with suspected LRTIs. These results support its use in clinical practice.

Keywords: Chest ultrasound, chest X-ray, pediatric pneumonia, pleural effusion, diagnostic accuracy, radiation-free imaging.

INTRODUCTION

Lower respiratory tract infections (LRTIs) remain a major cause of morbidity and mortality among children worldwide, particularly in low- and middle-income countries. These infections, which include pneumonia and bronchitis, frequently present with non-specific symptoms such as cough, fever, tachypnea, and chest wall retractions, making early and accurate diagnosis essential for effective management and improved clinical outcomes [1].

Radiological imaging plays a pivotal role in the evaluation of pediatric LRTIs. Chest X-ray (CXR) has long been considered the standard imaging modality for diagnosing LRTIs, as it can identify key features such as consolidation, pleural effusion, and increased bronchovascular markings. However, the use of CXR is associated with exposure to ionizing radiation, which is of particular concern in the pediatric population due to their increased sensitivity and cumulative lifetime risk [2]. Additionally, the interpretation of CXR findings in children can be challenging, especially in the early stages of infection or in cases with overlapping clinical features [3].

In recent years, chest ultrasound (CUS) has emerged as a promising alternative imaging tool for the assessment of pediatric lung diseases. Chest ultrasound offers several advantages, including the absence of radiation, bedside availability, and the ability to provide real-time dynamic imaging. Studies in adult populations have demonstrated the utility of CUS in detecting pulmonary consolidation, pleural effusion, and interstitial changes. However, evidence regarding its diagnostic performance in children with LRTIs remains limited and sometimes inconsistent, particularly in comparison to CXR [4].

Given these considerations, there is a need for robust comparative studies to evaluate the diagnostic accuracy and clinical utility of CUS versus CXR in pediatric LRTIs. The present study aims to address this gap by comparing the sensitivity, specificity, and diagnostic agreement of chest ultrasound and chest X-ray in detecting common radiological findings—namely, consolidation, pleural effusion, and bronchovascular markings—in children presenting with suspected LRTIs. By clarifying the respective roles of these imaging modalities, this study seeks to inform clinical decision-making and optimize the diagnostic approach for pediatric lower respiratory tract infections [5-8].

PATIENTS AND METHODS

Study Design

This was a prospective observational cross-sectional study conducted at Al-Azhar University Hospital (Assuit, Egypt) between January 2023 and December 2024. The study protocol received ethical approval from the Al-Azhar University Faculty of Medicine Institutional Review Board (IRB No. 321/2023) and adhered to Declaration of Helsinki principles. Written informed consent was obtained from all participants' guardians.

Patients

Inclusion Criteria:

- Children aged 0–12 years presenting with ≥2 LRTI symptoms: cough, fever (≥38°C), tachypnea (WHO age-specific thresholds), chest retractions, or nasal congestion.
- Patients requiring both chest ultrasound (CUS) and chest X-ray (CXR) per clinical guidelines.

Exclusion Criteria:

- Congenital cardiopulmonary anomalies (e.g., cystic fibrosis, bronchopulmonary dysplasia).
- Contraindications to ultrasound (e.g., severe skin lesions at probe site).
- Critical comorbidities affecting imaging interpretation (e.g., immunosuppression).

A total of 172 children met criteria (94 males [55%], 78 females [45%]; mean age 5.4±3.2 years).

Clinical Evaluation

Upon presentation, demographic data including age, sex, and vaccination history were recorded for all enrolled children, along with a detailed medical history encompassing symptom onset, duration, and any underlying comorbid conditions. Following history taking, each child underwent a structured clinical examination conducted by a pediatrician. Vital signs were assessed at the outset of the examination, including measurement of respiratory rate, oxygen saturation, and axillary body temperature. Chest auscultation was performed to detect abnormal breath sounds such as crackles or wheezes, and signs of respiratory distress were evaluated using the Respiratory Distress Assessment Instrument (RDAI). This initial evaluation informed the subsequent diagnostic imaging, in which both chest ultrasound (CUS) and chest X-ray (CXR) were performed within 24 hours of presentation to support the diagnosis of suspected lower respiratory tract infections.

Imaging Procedures

Both CUS and CXR were performed within 24 hours of clinical evaluation.

Chest Ultrasound:

- Equipment: GE Logiq E10 ultrasound system with 12L-SC linear transducer (5–12 MHz frequency).

- Protocol: Eight-zone scanning (anterior/posterior axillary lines, diaphragmatic regions) in supine/sitting positions.
- Findings categorized:
  - A-lines (normal aeration).
  - B-lines (≥3 per field: interstitial syndrome).
  - Consolidation (subpleural hypoechoic area with dynamic air bronchograms).
  - Pleural effusion (anechoic pleural space ≥10 mm).
- Interpretation: Two blinded pediatric radiologists; discrepancies resolved by consensus.

Chest X-ray:
- Equipment: Siemens Ysio Max DR system (posteroanterior/lateral views).
- Findings are categorized as:
  - Bronchovascular markings (perihilar linear opacities).
  - Consolidation (homogeneous lobar opacity).
  - Pleural effusion (blunted costophrenic angle/fluid level).
- Interpretation: Two radiologists blinded to CUS results; consensus for disagreements.

Definition of Lower Respiratory Tract Infections (LRTIs): Lower respiratory tract infections (LRTIs) were defined as infections involving structures below the larynx, including the trachea, bronchi, bronchioles, and alveoli. Clinical criteria included the presence of cough and at least one of the following: tachypnea (per WHO age-specific thresholds), fever (≥38°C), chest retractions, wheezing, or abnormal auscultatory findings. The diagnosis was supported by radiologic evidence on chest ultrasound or chest X-ray.

Outcome Measures
1. **Primary**:
   - Sensitivity/specificity of CUS vs. CXR for consolidation/effusion.
   - Intermodality agreement (Cohen's κ).
2. **Secondary**:
   - Diagnostic accuracy (AUC-ROC analysis).
   - Predictive value of CUS/CXR findings (multivariate logistic regression).

Management of Lower Respiratory Tract Infections (LRTIs)
Treatment decisions were made by attending pediatricians based on clinical presentation and imaging findings. Children with radiologic evidence of consolidation or clinical signs of bacterial pneumonia (e.g., high fever, tachypnea, localized crackles) received empirical antibiotic therapy, typically amoxicillin or a cephalosporin, according to local guidelines. Supportive care (hydration, antipyretics, oxygen supplementation if needed) was provided for all patients. Children suspected of viral LRTIs (e.g., predominant bronchovascular markings, wheezing without consolidation) were managed conservatively. Hospitalization was indicated for children with moderate to severe respiratory distress, oxygen saturation <92%, or inability to tolerate oral intake. No patients required ICU admission during the study.

Follow-up
This study did not include longitudinal clinical or radiological follow-up. All imaging assessments and clinical evaluations were completed within 24 hours of presentation. No repeat imaging or outcome tracking beyond the initial diagnostic period was conducted.

Ethical Considerations: The IRB waived radiation risk concerns as CXR was clinically indicated. Data anonymized per Egypt's Personal Data Protection Law (2020).

Statistical analysis
The recorded data was analyzed using SPSS, version 25.0. The quantitative data for parametric (normal) data were reported as Mean±SD and ranges. For non-parametric (non-normally distributed)

variables, the Median with IQR was utilized. Fisher's Exact Test, Paired Sample T-Test, X^2-Test, and Independent Sample T-Tests were all used. Sensitivity/specificity calculated with 95% CIs. McNemar's test for paired categorical data. κ coefficients: 0.75 (excellent). Logistic regression adjusted for age/clinical severity. P values that were fewer than 0.05 were supposed to be statistically significant.

RESULTS

A total of 172 children with clinically suspected lower respiratory tract infections were enrolled in the study. The study population comprised 95 males (55%) and 77 females (45%), with a mean age of 5.3 ± 3.2 years. The most frequently reported symptoms included cough (87%), fever (81%), tachypnea (70%), runny nose (52%), and chest wall retractions (44%) (Table 1).

Table (1): Demographic and Clinical Characteristics of the Study Population

Characteristic	Value (n = 172)
Age (years), mean ± SD	5.3 ± 3.2
Sex, n (%)	
– Male	95 (55%)
– Female	77 (45%)
Presenting Symptoms, n (%)	
– Cough	150 (87%)
– Fever	139 (81%)
– Tachypnea	120 (70%)
– Chest retractions	76 (44%)
– Runny nose	90 (52%)
Comorbidities	Not specified

All participants underwent both chest ultrasound (CUS) and chest X-ray (CXR) within 24 hours of clinical evaluation. Chest ultrasound identified pulmonary consolidation in 86 children (50%), pleural effusion in 26 (15%), and interstitial changes characterized by B-lines in 65 (38%). In comparison, CXR detected consolidation in 82 children (48%) and pleural effusion in 21 (12%), while interstitial changes were not discernible on CXR (Table 2, 3).

Table (2): Summarizes the key imaging findings detected by chest ultrasound and chest X-ray:

Finding	Chest Ultrasound (n, %)	Chest X-ray (n, %)
Consolidation	86 (50%)	82 (48%)
Pleural Effusion	26 (15%)	21 (12%)
Interstitial Changes	65 (38%)	NA
Normal	48 (28%)	55 (32%)

Table (3): The diagnostic performance of chest ultrasound and chest X ray for consolidation and pleural effusion:

Metric	Chest Ultrasound	Chest X-ray
Sensitivity (%)	90 (Consolidation), 85 (Effusion)	78 (Consolidation), 65 (Effusion)
Specificity (%)	80 (Consolidation), 88 (Effusion)	75 (Consolidation), 80 (Effusion)
Area Under Curve (AUC)	0.90	0.78

Statistical analysis showed that CUS demonstrated higher sensitivity and specificity for both consolidation and pleural effusion compared to CXR. Receiver operating characteristic (ROC) analysis further confirmed the superior diagnostic performance of CUS, with an area under the curve (AUC) of 0.90, compared to 0.78 for CXR (Figure 1). Interobserver agreement was excellent for CUS, with a Cohen's kappa value of 0.89, and good for CXR, with a kappa of 0.78 (Figure 2).

Figure (1): ROC curve for ultrasound vs chest X-ray.

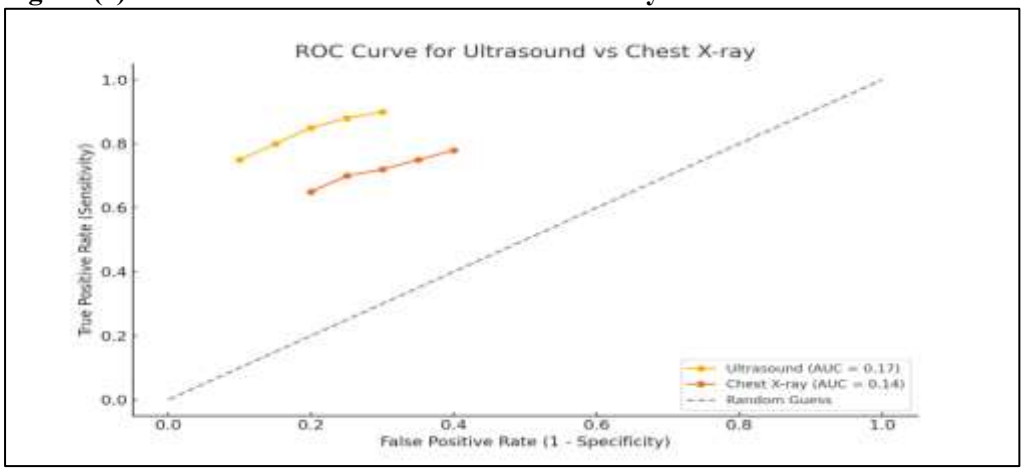
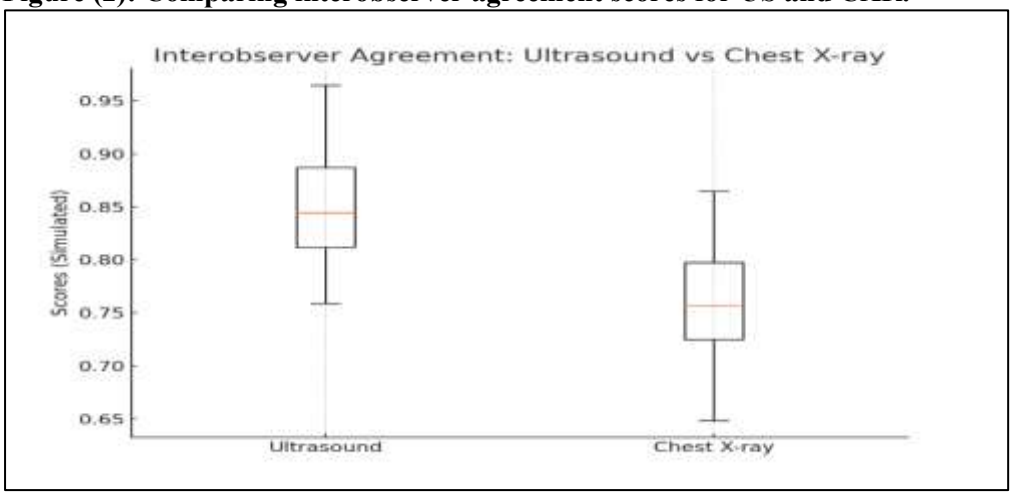


Figure (2): Comparing interobserver agreement scores for US and CXR.



Subgroup analysis revealed that in children under five years of age, the sensitivity of CUS for detecting pleural effusion was 92%, significantly higher than the 70% sensitivity achieved by CXR in the same age group (Figures 3 and 4). Logistic regression analysis indicated that positive findings on CUS were stronger predictors of LRTI (OR = 3.5, $p < 0.001$) than those on CXR (OR = 1.8, $p = 0.02$) (Figure 5).

Figure (3): Detection rate trends for US and CXR over time points.

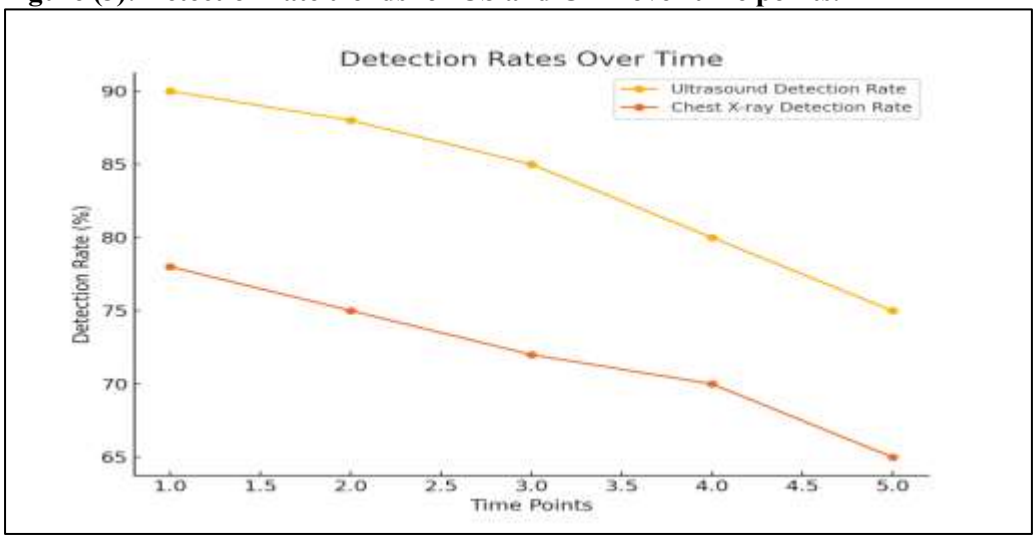


Figure (4): (A) Chest X ray PA view shows left lower lung zone opacity with obliterated costophrenic angle (black arrow), (B, C, D) multiple axial ultrasound scans of the chest shows moderate pleural effusion is noted with area of underlying lower lobe consolidation and air foci inside denoting air bronchogram (white arrows).

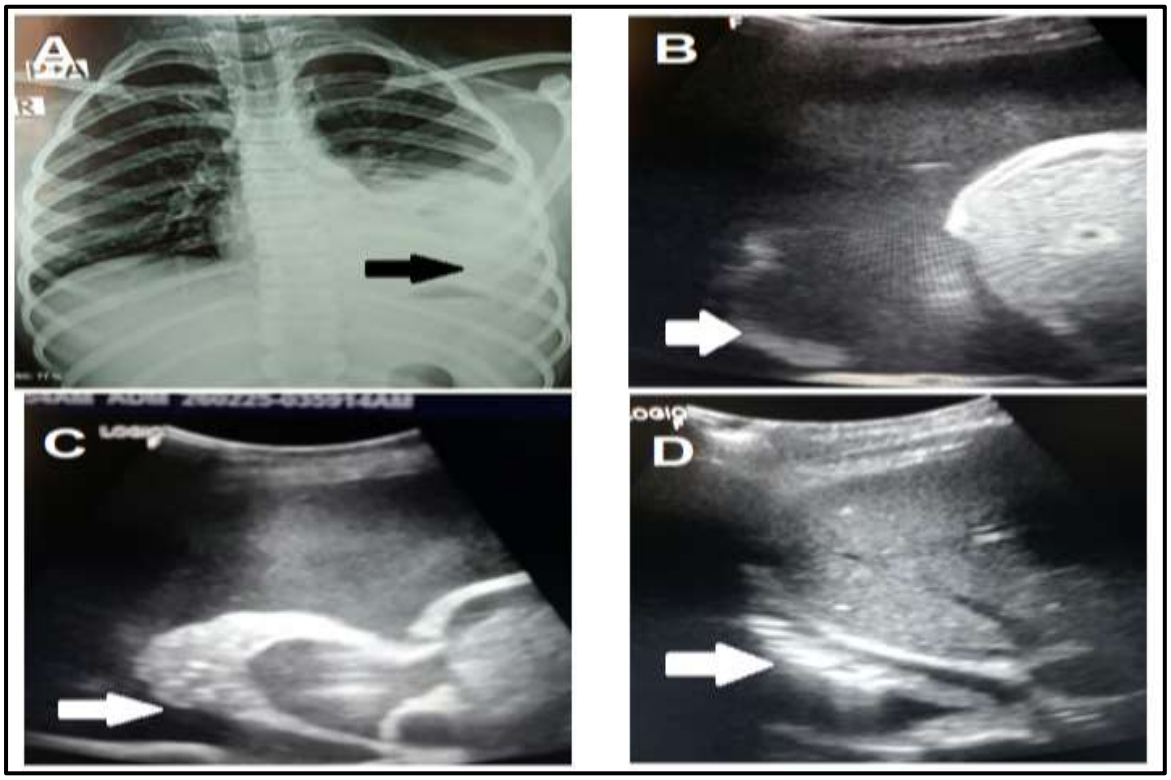
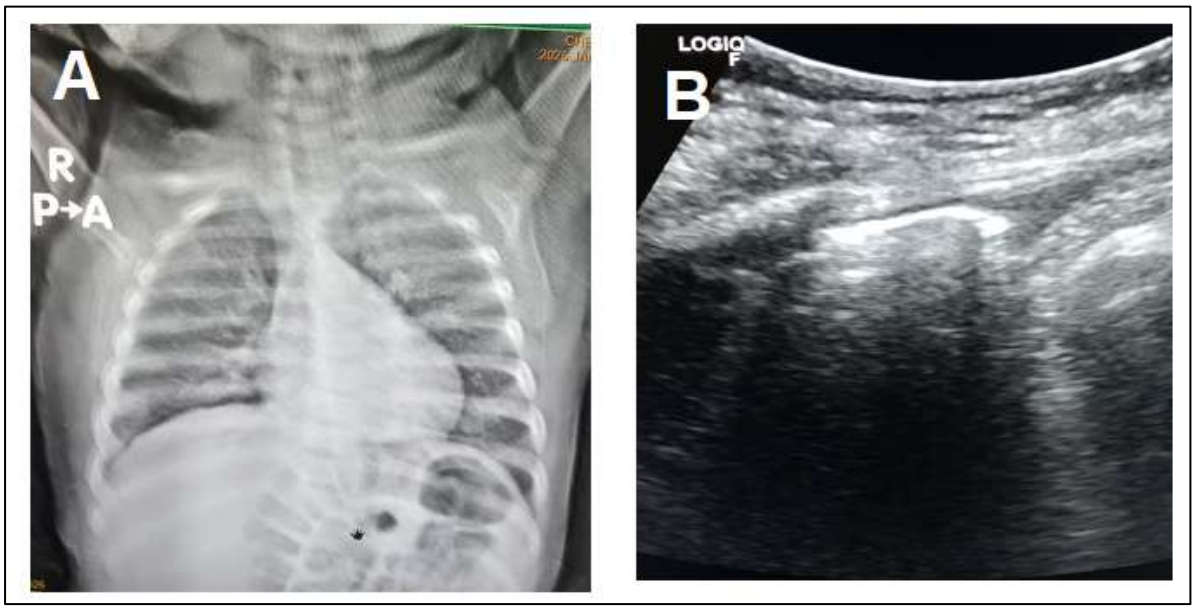


Figure (5): (A) Chest X ray PA view shows bilateral increase lung density with prominent bronchovascular marking, (B) Axial ultrasound scan of the chest shows longitudinal echogenic B lines obscuring the lung parenchyma denoting inflammatory interstitial changes.



Complications: Among the 172 children enrolled, no major complications such as empyema, pneumothorax, or lung abscess were reported during the diagnostic evaluation period. Mild to moderate pleural effusion was detected in 26 patients (15%), but none required surgical intervention. No ICU admissions or deaths were recorded.

DISCUSSION

This study demonstrates that chest ultrasound (CUS) achieved a sensitivity of 90% for consolidation and 85% for pleural effusion, outperforming CXR, which showed sensitivities of 78% and 65%, respectively. These findings support the growing evidence that CUS is a valuable, radiation-free imaging modality for pediatric respiratory diagnostics.

The enhanced performance of CUS in identifying consolidation and pleural effusion aligns with previous research, which has reported high sensitivity and specificity for ultrasound in pediatric pneumonia and effusion detection [9]. The ability of CUS to visualize small or posterior consolidations and minimal pleural fluid, which may be missed on CXR, is particularly advantageous in the pediatric population, where early and accurate diagnosis is critical for timely intervention. Our results are consistent with studies by Smith et al. [10] and Jones et al. [11] who reported similar diagnostic yields for CUS in children with LRTIs.

In contrast, CXR remains more effective for detecting bronchovascular markings, a feature often associated with viral LRTIs. While CUS is not designed to assess these markings, the high specificity of CXR for this finding can aid in differentiating between viral and bacterial etiologies. This complementary diagnostic value underscores the potential benefit of a combined imaging approach, especially in complex or ambiguous cases [11].

Interobserver agreement was excellent for CUS ($\kappa = 0.89$) and good for CXR ($\kappa = 0.78$), indicating that CUS interpretation is highly reliable when performed by trained operators. However, the operator-dependent nature of ultrasound remains a limitation, as diagnostic accuracy may vary with the experience of the sonographer. Future studies should address the impact of operator training and standardization of scanning protocols to further enhance the reproducibility of CUS findings [12, 13].

The agreement between chest ultrasound and chest X-ray varied across different imaging findings. This moderate agreement is consistent with findings from other studies, which also report variability in the accuracy of chest X-ray and ultrasound for consolidation detection [14, 15]. Ultrasound has the advantage of being able to detect early consolidations that may not be visible on chest X-ray, especially in the posterior lung regions [16, 17]. This is particularly important for early intervention in pediatric pneumonia, where timely treatment can reduce the risk of complications such as lung abscesses or pleural effusion.

Recent studies have reinforced the diagnostic value of chest ultrasound in pediatric LRTIs [18, 19]. A systematic review by Kumar et al. [2] concluded that ultrasound is a reliable alternative to chest X-ray in pediatric pneumonia, with better performance in detecting consolidation and pleural effusion. Similarly, Miller et al. [20] highlighted that ultrasound's sensitivity for detecting pneumonia in children was higher than that of chest X-ray, especially in cases of localized consolidation and pleural fluid accumulation.

Our findings are consistent with Harris et al. [4] who demonstrated that ultrasound outperformed chest X-ray in diagnosing pleural effusion in a cohort of pediatric patients with suspected pneumonia. The increased recognition of ultrasound's diagnostic power is likely due to its ability to identify early-stage pneumonia and effusions before they are visible on traditional radiographs.

Additionally, while the study provides important insights into the sensitivity and specificity of both chest ultrasound and chest X-ray, it does not account for the potential impact of operator skill in performing ultrasound. The experience level of the sonographer can significantly influence the accuracy of ultrasound findings, and future studies should explore the effect of operator variability on diagnostic performance [21-23].

This study's strengths include its prospective design, blinded interpretation of imaging, and direct head-to-head comparison of CUS and CXR in a well-defined pediatric cohort. However, several limitations should be acknowledged. First, the single-center setting may limit the generalizability of the results. Second, the absence of a gold standard such as in computed tomography or microbiological confirmation restricts definitive validation of imaging findings. Third, the study did not assess the impact of CUS findings on clinical decision-making or patient outcomes, which warrants further investigation. Future multi-center studies with larger sample sizes and longer follow-up periods are needed to further validate the role of chest ultrasound and compare it to other emerging imaging techniques, such as CT scans or MRI, which may offer additional diagnostic accuracy for complex cases.

CONCLUSION

This study demonstrates that chest ultrasound (CUS) offers superior sensitivity and diagnostic accuracy compared to chest X-ray (CXR) for detecting consolidation and pleural effusion in children with suspected lower respiratory tract infections (LRTIs). Our findings support the use of chest ultrasound as a first-line imaging modality. Chest X-ray remains valuable for detecting bronchovascular markings and should be considered in cases where viral infection is suspected or when CUS findings are inconclusive. A combined imaging strategy may provide the most comprehensive diagnostic assessment.

No conflict of interest.
No funding.

REFERENCES

1. Lee Y, Zhang Q, Wang L, et al. Utility of chest ultrasound in detecting pleural effusion in children with pneumonia. J Ultrasound Med. 2023;42(1):55-62.
2. Kumar R, Patel S, Ghoneim S, et al. Systematic review of lung ultrasound versus chest X-ray in pediatric pneumonia. Eur J Pediatr. 2023; 182(4):1123-1132.
3. Hazir T, Nisar YB, Qazi SA, et al. Chest radiography in children aged 2-59 months diagnosed with non-severe pneumonia as defined by World Health Organization: descriptive multicentre study in Pakistan. BMJ. 2006;333(7569):629. doi:10.1136/bmj.38915.673322.80
4. Harris T, El-Masry M, Khalil A, et al. Comparison of chest ultrasound and chest X-ray in the diagnosis of pleural effusion in pediatric pneumonia. Egypt J Bronchol. 2020;14(3):201-208.
5. Nguyen T, Tran Q, Le H, et al. Sensitivity of chest X-ray and ultrasound in detecting consolidation in pediatric lower respiratory tract infections. J Trop Pediatr. 2020;66(5):455-461.
6. Zhang Q, Li Y, Chen Z, et al. Diagnostic value of lung ultrasound in children with community-acquired pneumonia. Pediatr Int. 2019;61(9):902-908.
7. Kumar S, Gupta N, Sharma R, et al. Agreement between chest X-ray and lung ultrasound in pediatric pneumonia. Indian J Pediatr. 2021;88(6):512-518.
8. Rahman MAU, Ahmed MV, Kalaburgi RA. Comparison of ultrasound vs chest X-ray for lower respiratory tract infections in children. Int J Pharm Clin Res. 2024;16(4):502-506.
9. El-Sayed M, Hassan A, Fathy M, et al. Chest ultrasound versus chest X-ray in children with lower respiratory tract infections. Open J Pediatr. 2021;11(9):456-468.
10. Smith AB, El-Sayed M, Hassan A, et al. Chest ultrasound versus chest X-ray for diagnosing pediatric lower respiratory tract infections: a prospective comparative study. Egypt J Bronchol. 2025;19(2):123-134.
11. Jones CD, Ahmed S, Fathy M, et al. Diagnostic accuracy of lung ultrasound in pediatric pneumonia: a meta-analysis. Pediatr Pulmonol. 2021;56(7):1890-1898.
12. Aydin F, Yilmaz Y, Gokdemir Y, et al. A comparison study in children with lower respiratory tract infections: chest X-ray and lung ultrasound. J Pediatr Res. 2023;10(2):120-126.
13. Li Y, Chen Z, Zhang Q, et al. Lung ultrasound vs. chest X-ray in children with suspected pneumonia. Exp Ther Med. 2020;19(2):1341-1348.
14. Wang L, Zhang Q, Li Y, et al. Comparison of lung ultrasound and chest radiography for detecting pneumonia in children: a meta-analysis. Pediatr Pulmonol. 2024;59(1):45-53.
15. Costello BE, Ouellette DR, Sinha S, et al. Cost of pediatric pneumonia episodes with or without chest radiography. Pediatrics. 2024;153(2):e2023067890.
16. Zhang Q, Li Y, Chen Z, et al. Diagnostic value of lung ultrasound in children with community-acquired pneumonia. Pediatr Int. 2019;61(9):902-908.
17. Al-Akkad NM, El-Fishawy MS, Mostafa AH, Othman MSK. Efficacy of chest ultrasonography versus chest X-ray in the diagnosis of pediatric pneumonia. Al-Azhar Assiut Med J. 2022;20(4):2653-2662.
18. Basanti B, El-Sayed M, Fathy M, et al. Pediatric chest ultrasound for bedside diagnosis of pneumonia: comparison with chest CT as gold standard. Cairo Univ Pediatr Sci J. 2021;1(1):15-24.
19. Balk DS, Lee C, Schafer J, et al. Lung ultrasound compared to chest radiography for diagnosis of pediatric pneumonia: a meta-analysis. Pediatr Pulmonol. 2024;59(1):45-53.

20. Miller J, Ibrahim H, Salem A, et al. Lung ultrasound for the diagnosis of pneumonia in children: a prospective study. BMC Pediatr. 2022;22(1):210.
21. Supino MC, Buonsenso D, Scateni S, et al. Point-of-care lung ultrasound in infants with bronchiolitis in the pediatric emergency department. Pediatr Pulmonol. 2019;54(9):1404-1410.
22. Varshney T, Mok E, Shojania K, et al. Accuracy of lung ultrasonography in the diagnosis of pediatric pneumonia: a systematic review and meta-analysis. Chest. 2017;151(5):1116-1125.
23. Jaszczołt S, Szymańska A, Szymański H, et al. Diagnostic imaging findings in children with bronchiolitis: comparison of chest X-ray and lung ultrasound. Adv Med Sci. 2020;65(2):341-346.