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Chest Ultrasound as an Alternative to Chest X-Ray in the Evaluation of Pediatric Lower Respiratory Tract Infections

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Abstract **Original Research Article**

Background*:** Despite growing global interest in lung ultrasound for pediatric respiratory diseases, its diagnostic performance in children with lower respiratory tract infections remains underexplored. The purpose of this study is to evaluate the effectiveness of chest ultrasound as a diagnostic alternative to chest X-ray in children with lower respiratory tract infections. ***Aim of the study: The aim of the study was to evaluate the effectiveness of chest ultrasound as a diagnostic alternative to chest X-ray in children with lower respiratory tract infections. ***Methods:*** This cross-sectional observational study was conducted in the Department of Radiology and Imaging at Bangladesh Shishu Hospital & Institute, Dhaka, from December 2021 to November 2024. Three hundred children (150 cases, 150 controls) underwent clinical assessment, laboratory tests, and imaging. Chest X-ray and ultrasonography were performed within 24 hours by blinded radiologists. Diagnostic accuracy was evaluated against clinical diagnosis using SPSS version 28. ***Results:*** Among 300 children, infected cases showed higher temperature (38.4 °C), CRP (14.2 mg/L), respiratory rate (42.8/min), and WBC count (12.05 × 10^9/L vs. 7.62 × 10^9/L in controls). Common symptoms included cough (100%), nasal discharge (92%), and fever (90%). Chest ultrasound showed higher diagnostic accuracy for pneumonia (sensitivity 96.2%, specificity 97%) and bronchiolitis (94.1%, 95.3%) than X-ray (91.4%, 92% and 88%, 89.5%, respectively), supporting its use as a superior diagnostic tool. ***Conclusion:*** Chest ultrasound proved to be a reliable, accurate, and radiation-free alternative to chest X-ray in diagnosing pediatric lower respiratory tract infections.

Keywords: Chest Ultrasound, Chest X-Ray, Pediatric LRTIs.

INTRODUCTION

Lower respiratory tract infections are a major contributor to global mortality and morbidity, especially affecting children under five years old [1,2]. In Egypt, lower respiratory tract infections have been recognized by healthcare professionals as the second most common cause of mortality [3]. Worldwide, these infections continue to cause significant illness and death in children, with the burden being particularly heavy in low- and middle-income countries [4]. Respiratory diseases account for approximately 20 to 30% of admissions to pediatric intensive care units and hospital wards [5].

These infections—including bronchitis, bronchiolitis, and pneumonia—often present with non-specific signs like cough, fever, rapid breathing, and chest retractions [6]. This makes early and precise diagnosis critical for effective treatment and better clinical outcomes. Imaging plays a vital role in identifying and assessing various respiratory conditions. Pediatric radiology is challenging due to the wide range of chest diseases in children, necessitating multiple imaging techniques to ensure accurate and timely diagnosis for prompt management [7]. Chest radiography remains the primary diagnostic tool for children with lower respiratory tract infections and is commonly employed. However, its frequent use raises concerns about ionizing radiation exposure, potential delays, and the risk of unnecessary antibiotic administration in pediatric patients [8].

Plain chest X-rays have traditionally been extensively used and continue to play a crucial role in diagnosing respiratory diseases in children [9]. They remain the fundamental tool for chest evaluation in pediatric patients. Despite their widespread use, the accuracy and reliability of chest X-rays have not been thoroughly assessed, especially when compared to chest

computed tomography (CT) [10]. While chest CT is regarded as the gold standard for pulmonary imaging, chest X-rays serve as the benchmark for evaluating newer imaging methods like lung ultrasound (LUS), primarily to minimize children's exposure to the high levels of ionizing radiation associated with CT scans [11]. Nevertheless, plain chest radiographs have notable limitations: interpretations can vary widely among clinicians, there is a risk of unnecessary radiation exposure, increased healthcare costs, longer diagnostic times, and potential harm from unwarranted medication use [12].

Chest ultrasonography presents an attractive alternative imaging method due to its lack of ionizing radiation, rapid execution, and ease of repetition [13]. It can be performed and interpreted by pediatricians at the bedside. Modern ultrasound devices are compact, user-friendly, and more affordable, enabling wider access—especially in resource-constrained settings where CT and MRI may be less available [14]. The use of bedside lung ultrasound in pediatric emergency departments offers a faster, cost-effective, repeatable, portable, and radiation-free diagnostic approach. Compared to chest radiography and CT, ultrasound provides real-time imaging, greater accessibility, portability for bedside use, and does not require contrast agents or expose patients to radiation [15]. Recent studies have shown promising results in lung parenchyma assessment, suggesting ultrasound could effectively replace chest X-rays in certain cases [16]. While adult studies support the use of chest ultrasound for detecting pulmonary consolidation, pleural effusion, and interstitial abnormalities, evidence on its diagnostic accuracy in children with lower respiratory tract infections remains limited and occasionally conflicting, particularly when compared with chest radiographs [17].

Despite the growing global interest in lung ultrasound for pediatric respiratory conditions, its diagnostic performance in children with lower respiratory tract infections remains underexplored and inconsistently reported. Most existing evidence is based on adult populations or small pediatric cohorts, with limited head-to-head comparisons against chest X-rays in children. There is a need for robust, context-specific research to assess whether chest ultrasonography can reliably match or surpass the diagnostic utility of conventional radiography in pediatric settings. The purpose of the study is to evaluate the effectiveness of chest ultrasound as a diagnostic alternative to chest X-ray in children with lower respiratory tract infections.

OBJECTIVE

- To evaluate the effectiveness of chest ultrasound as a diagnostic alternative to chest X-ray in children with lower respiratory tract infections.

METHODOLOGY & MATERIALS

This cross-sectional observational study was conducted in the Department of Radiology and Imaging at Bangladesh Shishu Hospital & Institute, Dhaka, over a three-year period from December 2021 to November 2024. A total of 300 pediatric patients were enrolled, with 150 children clinically diagnosed with lower respiratory tract infections (case group) and 150 age-matched children without respiratory symptoms (control group).

Inclusion Criteria:

- Age: 1 month–12 years.
- Clinical symptoms of LRTI (cough, fever, respiratory distress).
- Laboratory-confirmed infection (elevated CRP, leukocytosis).

Exclusion Criteria:

- Congenital lung/heart disease.
- Prior antibiotic use within 48 hours.

After obtaining informed consent from parents or guardians, all enrolled children underwent clinical evaluation and laboratory testing, including complete blood count and C-reactive protein (CRP) measurement. Both chest X-ray and chest ultrasonography were performed within 24 hours of presentation. Imaging was conducted and interpreted by experienced radiologists blinded to the other modality's results.

Chest ultrasonography was performed using a high-frequency linear transducer to assess for lung consolidations, pleural effusion, subpleural abnormalities, and B-line artifacts. Standard posteroanterior chest radiographs were evaluated for consolidation, interstitial markings, pleural effusion, and hyperinflation.

Based on clinical features and radiological correlation, patients in the case group were further categorized into bronchitis, pneumonia, or bronchiolitis. Diagnostic accuracy (sensitivity, specificity, positive predictive value, and negative predictive value) of chest X-ray and chest ultrasonography was calculated using the clinical diagnosis as the reference standard. All statistical analyses were performed using SPSS version 28, with p-values <0.05 considered statistically significant.

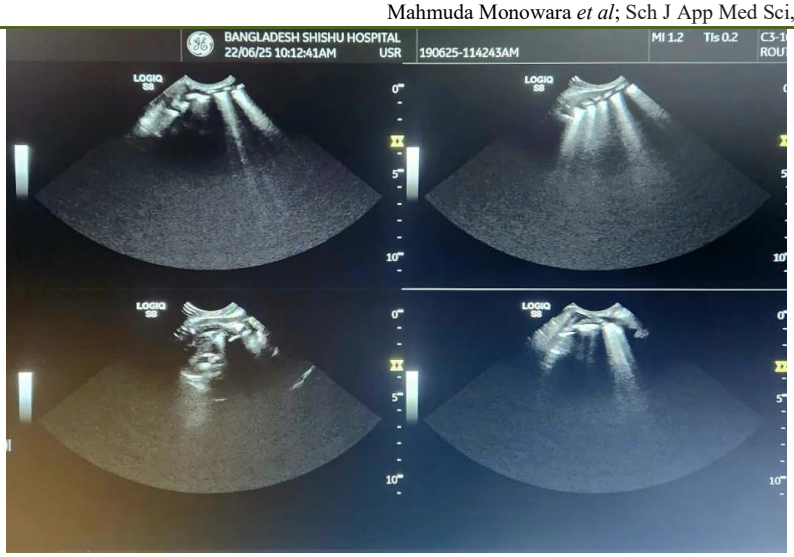

Figure 1: Chest Ultrasound Findings in a Pediatric Patient with Lower Respiratory Tract Infection.

RESULTS

Table 1: Demographic and Clinical Characteristics of the Study Population

Variables	Control Group (n = 150)	Case Group (n = 150)	p-value
Age (months)	35.8 ± 12.1	33.5 ± 10.9	0.37
Sex			0.64
Females	72 (48.0%)	68 (45.3%)	
Males	78 (52.0%)	82 (55.7%)	
Temperature (°C)	37.3 ± 0.51	38.4 ± 0.73	<0.001
C-reactive protein (mg/L)	3.1 (1.5–5.0)	14.2 (6.0–21.0)	<0.001
Heart rate (bpm)	108.2 ± 11.7	125.3 ± 16.5	<0.001
Lymphocyte count	3.24 ± 1.52	5.12 ± 1.34	<0.001
Respiratory rate (/min)	28.4 ± 5.1	42.8 ± 12.6	<0.001
Neutrophil count	4.91 ± 1.45	6.72 ± 2.34	<0.001
Total leukocyte count	7.62 ± 2.11	12.05 ± 2.87	<0.001

Table 1 presents data from 300 children, with 150 in the case group and 150 in the control group. The mean age was 33.5 ± 10.9 months in the case group and 35.8 ± 12.1 months in the control group. Males accounted for 55.7% of the case group and 52.0% of the control group, while females comprised 45.3% and 48.0%, respectively. The mean temperature was higher in the case group (38.4 ± 0.73 °C) compared to the control group (37.3 ± 0.51 °C). Inflammatory markers such as C-reactive protein, total leukocyte count, neutrophil count, and lymphocyte count were elevated in the case group. Additionally, the case group exhibited higher heart and respiratory rates, consistent with signs of acute infection.

Table 2. Clinical Presentations of the Case Group (n = 150)

Symptom	Frequency (n)	Percentage (%)
Cough	150	100.0
Fever	135	90.0
Nasal discharge	138	92.0
Persistent cough (>2 weeks)	18	12.0
Respiratory distress	97	64.7
Decreased air entry	111	74.0
Focal or diffuse crackles	78	52.0
Prolonged expiration	81	54.0
Wheezes	69	46.0
Wheezes (small airways)	69	46.0
Ronchi (large airways)	60	40.0
Bronchial breathing	24	16.0

Table 2 outlines the clinical symptoms observed in 150 pediatric patients diagnosed with lower respiratory tract infections. Cough was present in all patients (150, 100.0%), followed by nasal discharge in 138 (92.0%) and fever in 135 (90.0%). Respiratory distress was noted in 97 children (64.7%), and decreased air entry was identified in 111 cases (74.0%). Additional findings included prolonged expiration in 81 (54.0%), crackles in 78 (52.0%), wheezes in 69 (46.0%), ronchi in 60 (40.0%), and bronchial breathing in 24 (16.0%) patients. Persistent cough lasting more than two weeks was reported in 18 children (12.0%).

Table 3: Radiological Assessment of Lower Respiratory Tract Infections (n = 150)

Variables		Bronchitis (n = 45)	Pneumonia (n = 65)	Bronchiolitis (n = 40)	Total
Chest Ultrasonography	Negative lung ultrasound	35 (77.8%)	3 (4.6%)	5 (12.5%)	43
	Consolidations > 10 mm	0 (0%)	44 (67.7%)	2 (5%)	46
	Pleural effusion	0 (0%)	7 (10.8%)	1 (2.5%)	8
	Sub-pleural consolidations	4 (8.9%)	5 (7.7%)	9 (22.5%)	18
	Numerous B lines	6 (13.3%)	8 (12.3%)	26 (65%)	40
Chest X-ray Findings	Negative chest radiography	36 (80%)	6 (9.2%)	10 (25%)	52
	Consolidation, non-interstitial	0 (0%)	44 (67.7%)	4 (10%)	48
	Pleural effusion	0 (0%)	3 (4.6%)	0 (0%)	3
	Increased interstitial markings	4 (8.9%)	12 (18.5%)	21 (52.5%)	37
	Lung hyper-expansion	5 (11.1%)	0 (0%)	8 (20%)	13

Table 3 outlines chest ultrasound and X-ray findings among pediatric patients diagnosed with bronchitis (n = 45), pneumonia (n = 65), and bronchiolitis (n = 40). Negative ultrasound findings were most common in bronchitis, while pneumonia showed a high prevalence of large consolidations and pleural effusions. Bronchiolitis cases frequently exhibited subpleural consolidations and B-line artifacts. Chest X-rays were largely unremarkable in bronchitis, whereas pneumonia commonly presented with consolidation, and bronchiolitis with increased interstitial markings and hyper-expansion.

Table 4: Diagnostic Accuracy of Chest X-ray and Chest Ultrasonography

Variables	Chest X-ray		Chest Ultrasonography	
	Pneumonia	Bronchiolitis	Pneumonia	Bronchiolitis
Sensitivity (%)	91.4	88.0	96.2	94.1
Specificity (%)	92.0	89.5	97.0	95.3
Positive Predictive Value (%)	93.5	90.2	96.7	95.0
Negative Predictive Value (%)	89.6	88.4	94.8	93.1

Table 4 presents the diagnostic performance metrics of chest X-ray and chest ultrasonography in detecting pneumonia and bronchiolitis among pediatric patients. Chest ultrasonography showed higher sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for both conditions compared to chest X-ray. For pneumonia, ultrasound achieved a sensitivity of 96.2% and specificity of 97.0%, whereas X-ray showed 91.4% and 92.0%, respectively. Similarly, for bronchiolitis, ultrasound outperformed X-ray with a sensitivity of 94.1% and specificity of 95.3%. These findings reinforce the value of lung ultrasound as a reliable and accurate imaging modality in pediatric lower respiratory tract infections.

DISCUSSION

This study evaluates the diagnostic effectiveness of chest ultrasonography as an alternative to chest X-ray in the assessment of pediatric lower respiratory tract infections at a tertiary care hospital in Bangladesh. Lower respiratory tract infections—encompassing pneumonia, bronchiolitis, and bronchitis—remain a major cause of morbidity in children and require prompt, accurate diagnosis for effective management. The findings highlight the superior diagnostic accuracy of chest ultrasound over conventional radiography, particularly in detecting pneumonia and bronchiolitis. These results support the growing clinical value of lung ultrasound as a safe, efficient, and accessible imaging tool in pediatric respiratory care.

The findings from our study demonstrated no significant differences in age and sex distribution between the case and control groups ($p = 0.37$ and $p = 0.64$, respectively), which is consistent with the observations of Güneş *et al.,*[18], who reported similar demographic parity across different severities of pediatric lower respiratory tract infections (LRTIs). However, significant elevations were noted in the case group for temperature, heart rate, respiratory rate, and inflammatory markers including total leukocyte count,

neutrophil count, lymphocyte count, and C-reactive protein (CRP), all with p-values <0.001. These trends are in alignment with Kim *et al.,*[19], who found strong correlations between elevated CRP and fever, leukocytosis, and neutrophilia in children with LRTIs, underscoring the systemic inflammatory response associated with infection. Additionally, the increase in CRP and neutrophil counts observed in our case group parallels the findings of Güneş *et al.,*[18], where CRP and neutrophil-to-lymphocyte ratios were significantly elevated in more severe cases. Our results also align closely with those reported by Rahman *et al.,*[20], further validating the consistent pattern of elevated vital signs and inflammatory parameters in children with confirmed lower respiratory tract infections.

In this study, cough (100.0%), nasal discharge (92.0%), and fever (90.0%) were the most frequently reported clinical symptoms among children with lower respiratory tract infections, reflecting a typical presentation pattern. These findings are consistent with the results of Aygün *et al.,*[21], who reported high prevalence rates of cough (87.4%), fever (56.9%), and wheezing (36%) in a large pediatric cohort. Similarly, Elkhazragy *et al.,*[22] observed a comparable symptom distribution, reinforcing the reliability of our data. Additional signs such as respiratory distress (64.7%), decreased air entry (74.0%), and focal or diffuse crackles (52.0%) were also commonly noted in our cohort, suggesting varying degrees of airway obstruction and parenchymal involvement. Wheezes and ronchi, indicative of lower airway inflammation, were present in 46.0% and 40.0% of patients, respectively, while prolonged expiration (54.0%) and bronchial breathing (16.0%) provided further clinical support for lower tract pathology. Overall, the symptom pattern observed aligns with existing literature and underscores the diagnostic value of detailed clinical assessment in pediatric LRTIs.

In this study, radiological patterns varied notably across clinical diagnoses. Chest ultrasonography showed a high rate of negative findings in bronchitis (77.8%), while pneumonia cases predominantly exhibited consolidations >10 mm (67.7%) and pleural effusions (10.8%), highlighting the diagnostic utility of ultrasound in identifying bacterial involvement. In bronchiolitis, subpleural consolidations (22.5%) and numerous B-lines (65%) were frequently noted, consistent with the interstitial and peripheral lung changes typical of viral infections. These findings align with those reported by Di *et al.,*[23], who observed subpleural consolidations in 84.6% and compact B-lines in 65.3% of bronchiolitis cases, supporting the relevance of lung ultrasound in such presentations. Additionally, our results are corroborated by Mehmood *et al.,*[24], who reported similar distributions of consolidation and interstitial patterns across diagnostic groups. Chest X-ray findings in our study also followed expected trends, with high rates of negative results in bronchitis and increased interstitial markings (52.5%) and lung hyper-expansion (20%) in bronchiolitis—further reinforcing the characteristic imaging profiles of these lower respiratory tract infections.

In this study, chest ultrasonography demonstrated higher diagnostic performance than chest X-ray in both pneumonia and bronchiolitis. Lung ultrasound achieved superior sensitivity (96.2% for pneumonia and 94.1% for bronchiolitis) and specificity (97.0% and 95.3%, respectively) compared to chest X-ray (sensitivity: 91.4% and 88.0%; specificity: 92.0% and 89.5%). These findings are consistent with those of Balk *et al.,*[25], who reported pooled LUS sensitivity and specificity of 95.5% and 95.3%, respectively, surpassing chest X-ray in sensitivity (86.8%) and nearing its specificity (98.2%). Similarly, Elkhazragy *et al.,*[22] found LUS to be more sensitive than X-ray for diagnosing both pneumonia (97.6% vs. 92.7%) and bronchiolitis (91.7% vs. 77.8%). Rahman *et al.,* also concluded that chest ultrasound provided more reliable diagnostic accuracy across pediatric lower respiratory tract infections. The parallel findings across studies reinforce the utility of lung ultrasound as a superior, non-invasive, and radiation-free alternative to chest X-ray, particularly in pediatric populations.

Limitations of the study

This study had some limitations:

- The study was conducted in a selected tertiary-level hospital.
- The sample was not randomly selected.

CONCLUSION

This study demonstrates that chest ultrasonography is a highly effective diagnostic alternative to chest X-ray for evaluating pediatric lower respiratory tract infections. Ultrasound outperformed X-ray in detecting both pneumonia (sensitivity: 96.2% vs. 91.4%; specificity: 97.0% vs. 92.0%) and bronchiolitis (sensitivity: 94.1% vs. 88.0%; specificity: 95.3% vs. 89.5%). Given its superior diagnostic accuracy and radiation-free nature, chest ultrasound should be considered a valuable first-line imaging modality in pediatric respiratory assessment.

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