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Diagnostic Accuracy of Chest Ultrasonography versus Chest X-ray in Detecting Community-Acquired Pneumonia in Children: A Prospective Observational Study.

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Abstract

Background:
Pneumonia remains a leading cause of childhood morbidity and mortality worldwide. Chest X-ray (CXR) is a conventional imaging modality for diagnosis, but it has limitations, including radiation exposure and variable interpretation. Lung ultrasonography (LUS) has emerged as a radiation-free, point-of-care diagnostic alternative. This study evaluated the diagnostic performance of LUS in detecting community-acquired pneumonia (CAP) in children and compared it with CXR.

Objectives:
To assess the role of chest ultrasonography in diagnosing community-acquired pneumonia in children and to compare its diagnostic yield with that of chest X-ray.

Methods:
A hospital-based prospective observational study was conducted from January to December 2019 at a tertiary pediatric center. Children aged 2 months to 5 years with clinical features of CAP were included in the study. Each child underwent CXR and LUS. Findings from both modalities were compared to assess their diagnostic accuracy.

Results:
A total of 159 children were included, with a mean age of 16.9 ± 16.58 months. Chest ultrasound detected pneumonia in 134 (84.3%) cases, whereas CXR detected it in 113 (71%) cases ($p < 0.0001$). Subpleural consolidation (38.4%) and B-line with pleural line abnormalities (27%) were common LUS findings. CXR showed consolidation in 34.6% and perihilar infiltrates in 27.7% of cases. LUS detected pneumonia in 26 cases missed by CXR, while CXR detected pneumonia in 5 cases missed by LUS.

Conclusion:
Lung ultrasonography is a simple, radiation-free, and reliable imaging modality with higher detection rates than chest X-ray in pediatric pneumonia. It can be used effectively for both diagnosis and follow-up, especially in resource-limited settings.

Recommendations:
Lung ultrasound should be integrated into pediatric emergency protocols as a first-line imaging tool for suspected pneumonia in children.

Keywords: *Community-acquired pneumonia, chest ultrasonography, lung ultrasound, chest X-ray, children, diagnosis, radiation-free imaging.*
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Introduction

Pneumonia is a significant contributor to morbidity and mortality among children under five years of age worldwide. According to the World Health Organization, it accounts for nearly 15% of all deaths in this age group, with approximately 150 million new cases reported annually. The burden is especially severe in low- and middle-income countries such as India, which has one of the highest pediatric pneumonia-related mortality rates globally [1].

Community-acquired pneumonia (CAP), defined as pneumonia acquired outside a hospital or healthcare setting, remains a leading cause of pediatric hospital admissions. Prompt and accurate diagnosis is essential to initiate appropriate therapy, prevent complications, and improve patient outcomes.

Chest radiography (CXR) has traditionally been considered the gold standard for diagnosing pneumonia in children. However, it is associated with several limitations, including exposure to ionizing radiation, reduced diagnostic accuracy in younger children due to poor cooperation, variable interpretation among clinicians, and logistical delays in obtaining imaging, especially in resource-constrained settings [2,3]. Furthermore, CXR has limited sensitivity for detecting small or early-stage lesions and posterior consolidations [4].

In recent years, lung ultrasonography (LUS) has emerged as a valuable alternative diagnostic tool for pediatric pneumonia. It is a non-invasive, radiation-free, bedside imaging modality that allows for rapid evaluation and is well tolerated by children. Multiple meta-analyses and prospective studies have demonstrated that LUS has comparable or superior sensitivity and specificity compared to CXR in diagnosing pneumonia, particularly for identifying subpleural consolidations and pleural abnormalities [1–3,5,6]. Additionally, LUS can be performed repeatedly without risk, making it particularly useful for both initial diagnosis and follow-up evaluation.

Given its diagnostic advantages and safety profile, this study aims to assess the diagnostic accuracy of LUS in children with clinically suspected community-acquired pneumonia and compare its effectiveness with chest radiography.

Methodology

Study Design and Setting:

This was a hospital-based prospective cross-sectional study conducted at the Indira Gandhi Institute of Child Health, a tertiary care pediatric hospital in Bengaluru, Karnataka, India. The study was carried out over one year, from January 2019 to December 2019.

Study Population:

Children aged 2 months to 5 years admitted with clinical features suggestive of community-acquired pneumonia (CAP) were eligible for inclusion. CAP was defined based on WHO and IMNCI criteria, which included symptoms such as cough, fever, fast breathing, chest indrawing, and auscultatory findings.

Inclusion Criteria:

Children aged 2 months to 5 years
Clinical diagnosis of CAP at admission

Exclusion Criteria:

Children with congenital heart disease
Children with congenital lung malformations

Sample Size Determination:

Using a sensitivity estimate of 90% for both chest X-ray and ultrasonography, and the incidence of pneumonia in Karnataka as 15.5 per 1000 children, with 5% precision and 95% confidence interval, the calculated minimum sample size was 158. A total of 159 children were enrolled.

Data Collection Procedures:

After obtaining ethical clearance and informed parental consent, children meeting the inclusion criteria were consecutively recruited. Each participant underwent:

Clinical evaluation by a paediatrician.

Chest X-ray, interpreted by an independent radiologist blinded to ultrasonography findings.

Lung ultrasonography (LUS) is performed by a radiologist using a high-frequency linear probe (7–12 MHz). The lung fields were divided into 12 anatomical regions for systematic scanning.

Variables Assessed:

Clinical variables included age, sex, immunization status, presenting symptoms, and respiratory signs. Imaging findings from both CXR and LUS, such as consolidation, pleural effusion, B-lines, and pleural abnormalities, were documented and compared.

Data Analysis:

Data were entered in Microsoft Excel and analyzed using SPSS version 20. Descriptive statistics were used to

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summarize demographic and clinical characteristics. Diagnostic yield was compared using the chi-square test. A p-value of <0.05 was considered statistically significant.

Ethical Considerations:

The study received approval from the Institutional Ethics Committee of the Indira Gandhi Institute of Child Health. Written informed consent was obtained from the parents or legal guardians of all participants.

Results

Participant Flow

During the study period (January 2019 – December 2019), a total of 178 children aged between 2 months and 5 years presented with clinical features suggestive of community-acquired pneumonia and were screened for eligibility. Among them, 11 children were excluded due to the presence of congenital heart disease (n = 7) or congenital lung malformations (n = 4).

Thus, 167 children were eligible, of whom 8 did not complete the full diagnostic protocol (either chest X-ray or ultrasonography was not performed due to early discharge or parental refusal). Finally, 159 children were enrolled and included in the analysis.

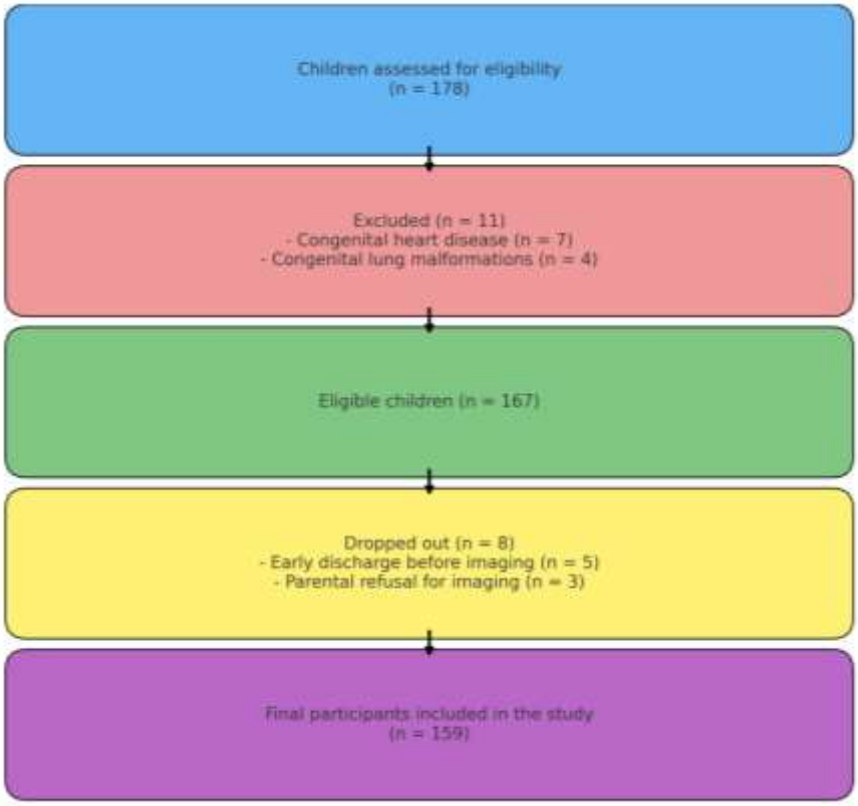

Figure 1. Participant Flow Diagram

A total of 159 children aged between 2 months and 5 years, clinically diagnosed with community-acquired pneumonia, were enrolled in the study. The mean age of the participants was 16.9 ± 16.58 months with a median of 10 months. Males constituted 59.74% of the study population. The mean weight was 8.2 ± 3.6 kg. Regarding immunization status, 77.3% were fully immunized, 19% were partially immunized, and 3.7% were unimmunized (Table 1).

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Table 1: Baseline Characteristics of the Study Group (N = 159)

Variable	Value
Total Patients	159
Age (Mean ± SD)	16.9 ± 16.58 months
Age (Median)	10 months
Male (%)	95 (59.74%)
Female (%)	64 (40.25%)
Weight (Mean ± SD)	8.2 ± 3.6 kg
Weight (Median)	7.8 kg
Fully Immunized (%)	123 (77.3%)
Partially Immunized (%)	30 (19%)
Unimmunized (%)	6 (3.7%)

The most common presenting complaint was hurried breathing, reported in 81.1% of cases, followed by cough (56%) and fever (44%). Chest indrawing was observed in 30.1% of children, while general danger signs were present in 20.7% of cases. Less frequently reported symptoms included stridor and cyanosis (Table 2).

Table 2: Presenting Complaints in the Study Group

Presenting Feature	Frequency (%)
Hurried Breathing	81.1%
Cough	56%
Fever	44%
Chest Indrawing	30.1%
General Danger Signs	20.7%
Stridor	4.4%
Cyanosis	3.77%

Clinical signs such as tachypnea were present in all subjects (100%). Subcostal retraction was noted in 58.5%, nasal flaring in 49%, and oxygen saturation below 90% in 39%. On auscultation, crepitations were found in 80.5% of cases, with wheeze alone in 37.1% and both crepitations and wheeze in 30.8% (Table 3).

Table 3: Clinical and Auscultatory Findings

Clinical/Auscultatory Finding	Frequency (%)
Tachypnea	100%
Subcostal Retraction	58.5%
Nasal Flaring	49%
SpO_2 <90%	39%
Crepitations	80.5%
Wheeze	37.1%
Crepitations + Wheeze	30.8%
Air Entry Difference	23.89%
Crepitations + Reduced Air Entry	23.27%

Chest X-ray revealed consolidation in 34.6% of cases, perihilar interstitial infiltrates in 27.7%, and was normal in 29%. In comparison, chest ultrasound identified subpleural consolidation in 38.4%, pleural line abnormalities with B-lines in 27%, and was normal in 15.7%. Combined findings such as consolidation with effusion were observed in 10.7% of ultrasound evaluations (Table 4).

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Table 4: Radiological Findings on Chest X-ray and Chest Ultrasonography

Modality	Finding	Frequency (%)
Chest X-ray	Consolidation	34.6%
Chest X-ray	Perihilar Interstitial Infiltration	27.7%
Chest X-ray	Normal	29%
Chest USG	Subpleural Consolidation	38.4%
Chest USG	B-line + Pleural Line Abnormalities	27%
Chest USG	Consolidation + Effusion	10.7%
Chest USG	Normal	15.7%

Chest ultrasound detected pneumonia in 84.3% of cases, significantly higher than the 71% detection rate by chest X-ray. This difference was found to be statistically significant ($p < 0.0001$) (Table 5).

Figure 1 depicts a chest X-ray demonstrating pleural effusion. A homogenous opacity with blunting of the costophrenic angle is visible, consistent with fluid accumulation in the pleural cavity, a common complication of pneumonia.

Figure 1. Chest X-ray showing pleural effusion in a pediatric patient with community-acquired pneumonia.

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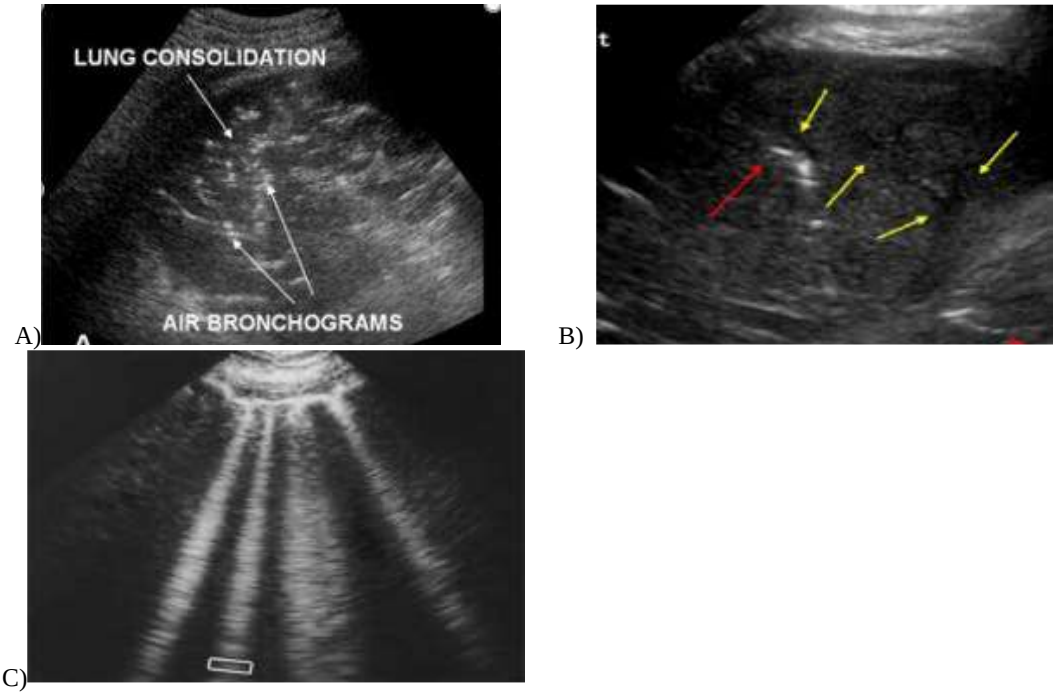

Figure 2. Chest sonograms showing abnormal lung parenchymal findings
a) air bronchograms, b) Fluid bronchograms, c) B-lines.

(A) Air bronchograms within a subpleural consolidation,
(B) Fluid bronchograms indicating fluid-filled bronchi, and
(C) Multiple confluent B-lines, indicating interstitial involvement.

Table 5: Comparative Diagnostic Yield of Chest Ultrasound and Chest X-ray

Test	Suggestive of Pneumonia (%)
Chest Ultrasound	134/159 (84.3%)
Chest X-ray	113/159 (71.0%)

Discussion:

Pneumonia remains a leading cause of morbidity and mortality among children under five years, particularly in low- and middle-income countries. Timely and accurate diagnosis is essential to initiate appropriate management and reduce complications. In this study, lung ultrasonography (LUS) demonstrated a higher diagnostic yield than chest X-ray (CXR) in detecting community-acquired pneumonia (CAP), supporting its utility as a valuable diagnostic modality in pediatric respiratory illness.

Among 159 children studied, LUS detected pneumonia in 134 cases (84.3%), compared to 113 cases (71%) detected by CXR ($p < 0.0001$). This statistically significant difference affirms the superior sensitivity of LUS, especially in detecting small subpleural consolidations and pleural abnormalities, which are often missed by standard radiographs. These findings align with previous studies reporting high diagnostic accuracy for LUS, with sensitivities and specificities ranging between 90–95% and 93–98%, respectively [7–9].

In this study, subpleural consolidation (38.4%) and B-lines with pleural line abnormalities (27%) were the most common ultrasound findings. By comparison, CXR most frequently showed consolidation (34.6%) and perihilar infiltrates (27.7%). Similar ultrasound features have been observed in other pediatric studies [8,10], reinforcing the reproducibility and diagnostic value of LUS.

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Interestingly, 26 children had positive LUS findings despite normal CXR results, likely due to LUS's higher resolution in detecting posterior or basal peripheral lesions. Conversely, 5 cases showed CXR findings but were negative on LUS—likely reflecting central or retrocardiac consolidations not extending to the pleura, which are less accessible via ultrasound [11,12].

Auscultatory findings such as crepitations and wheeze were commonly associated with positive LUS results, highlighting the importance of integrating clinical examination with bedside imaging. LUS offers additional benefits: it is non-invasive, radiation-free, repeatable, and suitable for bedside use, making it ideal for emergency and resource-limited settings [7,9].

However, limitations exist. LUS may miss consolidations obscured by bony structures or not in contact with the pleural surface. Furthermore, computed tomography (CT)-the diagnostic gold standard was not used due to financial constraints, limiting the ability to determine true sensitivity and specificity [10,12].

Despite these limitations, the study reinforces the growing body of evidence supporting LUS as a complementary or alternative imaging tool to CXR in diagnosing pediatric pneumonia [7–12].

Conclusion:

Lung ultrasonography (LUS) is an effective, safe, and radiation-free imaging modality that demonstrated superior diagnostic yield compared to chest X-ray in detecting community-acquired pneumonia in children. It identified pneumonic features in a greater number of cases, particularly subpleural consolidations and pleural abnormalities, which were frequently missed on X-ray. Given its bedside applicability, non-invasiveness, and reproducibility, LUS can serve as a valuable diagnostic tool, especially in emergency settings and in resource-limited environments. Although limitations exist in visualizing deep or central lesions, LUS can significantly reduce reliance on radiographic imaging. Incorporating LUS in pediatric pneumonia protocols may improve early diagnosis, reduce radiation exposure, and optimize patient care outcomes.

Limitations:

This study has a few limitations. Lung ultrasonography may miss deeply seated or centrally located consolidations that do not extend to the pleural surface, especially in regions obscured by bone such as the scapula. Additionally, the study did not utilize chest CT, the gold standard for confirmatory diagnosis, due to financial and logistical constraints. As a result, the sensitivity and specificity of ultrasound could not be accurately determined, and findings were based solely on clinical correlation and imaging comparison with chest X-ray.

Recommendations:

Lung ultrasonography (LUS) should be incorporated into routine clinical protocols for the diagnosis of community-acquired pneumonia in children, especially in emergency and resource-limited settings. It offers a radiation-free, bedside, and repeatable imaging option with a higher diagnostic yield than a chest X-ray. Training pediatricians and emergency physicians in basic lung ultrasound techniques can enhance early detection and reduce reliance on radiographic imaging. National pediatric guidelines should consider including LUS as a first-line or adjunct diagnostic tool. Further multicenter studies using CT as the reference standard are recommended to validate LUS accuracy and establish standardized diagnostic criteria.

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List of abbreviations:

CAP – Community-Acquired Pneumonia
CXR – Chest X-ray
LUS – Lung Ultrasonography
CT – Computed Tomography
WHO – World Health Organization
SPSS – Statistical Package for the Social Sciences

Source of funding:

The study had no funding.

Conflict of interest:

The authors declare no conflict of interest.

Author contributions:

NKU-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript. MSH-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript, revision of the manuscript. NB: Review of literature and preparing the first draft of the manuscript. Statistical analysis and interpretation. RD-Concept and design of the study, results interpretation,

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review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript.RMGR-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript.

Data availability:

Data is Available

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