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Diagnostic Accuracy of Lung Ultrasound in Diagnosis of Pneumonia in Children using Chest X-RAY as Gold Standard

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ABSTRACT

Objective: To determine the diagnostic accuracy of lung ultrasound (LUS) in the diagnosis of *pneumonia* in children using chest x-ray as the gold standard.

Study Design: Comparative cross-sectional study.

***Place and Duration of Study*:** Department of Radiology, Combined Military Hospital, Sialkot Pakistan, from Feb to Aug 2021

Methodology: All patients underwent clinical examination, chest radiograph (anterior-posterior view), lung ultrasound and blood sample analysis in the first 24 hours after admission. A pre-specified hospital radiologist carried out a lung ultrasound. The examination was performed with the patient sitting upright or supine. The presence of pneumonia on x-ray and USG were recorded. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of lung ultrasound in the diagnosis of pneumonia by taking chest x-ray as the gold standard was calculated in all the study participants.

Results: In this study, 262 patients with clinical features of *pneumonia* were enrolled. The mean age of the study participants was 3.27±2.344 years. Sensitivity (Se), specificity (Sp), positive predictive value (PPV), negative predictive value (NPV), accuracy and frequency of lung ultrasonography (US) vs chest radiography (CR) in diagnosing *pneumonia* was 95.28%, 87.5%, 99.59%, 36.84%, 95.04% and 96.95% respectively.

Conclusion: Lung ultrasound emerged as a sensitive diagnostic tool to diagnose pneumonia in children. Sensitivity, specificity, positive predictive value, and negative predictive value all favoured the use of this modality to diagnose *pneumonia* in paediatric patients.

Keywords: Chest radiograph, Paediatric *pneumonia*, Ultrasonography.

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INTRODUCTION

Pneumonia is one of the leading causes of mortality and morbidity in children under five years of age. It is responsible for 150-160 million new cases each year. The majority of these cases occur in developing countries like Pakistan.[1] Developing countries are more at a disadvantage about this illness as it has alarmingly high mortality and morbidity in these patients.[2,3] The situation in Pakistan is equally dismal. Though a common illness, it still sometimes poses a diagnostic challenge for the treating team, and delay in prompt diagnosis may result in poor outcomes.[4,5]

Regarding clinical criteria, WHO guidelines do not recommend a chest x-ray for confirmation in every case.[6] Both clinical features and microbiology involve different issues in diagnosing this disease.4 Chest radiographs are considered as gold standard.[7] Lung ultrasound (LUS) is an innovative investigation especially suitable for resource-limited Countries. Chest radiographs have been used routinely in various centres worldwide to diagnose *pneumonia* and have shown good results.[8,9]

Pakistan is a lower and middle-income country with a huge population of children, mostly under two years of age. Prevention of radiation exposure for diagnosis of common illnesses like *pneumonia* may be a breakthrough in managing this disease. Limited local has been available in the paediatric age group regarding using ultrasound lungs as a diagnostic modality for *pneumonia*. We planned this study to determine the diagnostic accuracy of lung ultrasound in diagnosing *pneumonia* in children using chest X-rays as the gold standard at our tertiary care hospital.

METHODOLOGY

The comparative cross-sectional study was conducted at the Department of Radiology, Combined Military Hospital, Sialkot Pakistan, from February to August 2021 after approval from the Hospital Ethical Committee (ERC/08/2020). The sample size was

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calculated with expected percentage of *pneumonia* as 18%, Sensitivity as 86% and specificity as 89%.[8]

Inclusion Criteria: All admitted children of either gender aged 6 months to 12 years presenting with clinical features of *pneumonia* assessed by consultant paediatrician, were included.

Exclusion Criteria: Children with known lung pathologies other than *pneumonia* or those with congenital abnormalities were excluded. Those under treatment for any solid or hematopoietic malignant conditions were also excluded. The analysis did not include those with severe chest tenderness or reported allergies to ultrasound gel.

A non-probability consecutive sampling technique was used to gather the sample. Two hundred and sixty-two patients fulfilling the criteria laid down for the study were recruited. Children underwent clinical assessment at the time of presentation. A consultant paediatrician assessed them, took detailed clinical history, and performed relevant local and systemic evaluation. Baseline laboratory investigations (Complete blood picture, urine R/E, liver function test, renal function tests, and C-reactive protein) were sent to the laboratory soon after the clinical impression. Chest X-rays were also performed in all these children per standard protocol and interpreted by a consultant radiologist blinded by ultrasound findings. One consultant radiologist was deputed to perform all ultrasound lungs of patients for this study and was blinded to chest x-ray findings. The same radiologist interpreted the ultrasound lung as per the set protocols.[9] The presence of *pneumonia* on x-ray,[10] and USG were recorded. All the data were collected on a pre-designed proforma.

Results were analysed using the Statistical Package for Social Sciences (SPSS) v25.0. Quantitative variables were presented as mean and standard deviations. Qualitative variables were presented as frequency and percentages. A 2x2 contingency table was generated to calculate the sensitivity, specificity, PPV, NPV and accuracy of lung ultrasound in diagnosing *pneumonia* by taking chest X-ray as the gold standard.

RESULTS

In this study, 262 patients with clinical features of *pneumonia* were enrolled. Among these patients, 164(62.6%) were males, while 98(37.4%) were females. The mean age of the study participants was 3.27±2.344 years. The majority of the patients (100,38.2%), had a duration of illness of 3-6 days, while 82(31.3%) and 80(30.5%) patients had a duration of illness of 7-10 days and > ten days, respectively. Table-I summarises the frequency distribution of *pneumonia* on ultrasound and chest X-ray while Table-II compares the findings on both the modalities used in the study. Among patients, 254(96.9%) were diagnosed on chest x-ray and 243(92.7%) on lung ultrasound. Table-III shows the different ratios studied regarding diagnostic modalities included in the study. It was revealed that Sensitivity (Se), specificity (Sp), positive predictive value (PPV), negative predictive value (NPV), accuracy and frequency of lung ultrasonography (US) vs chest radiography (CR) in diagnosing *pneumonia* was 95.28%, 87.5%, 99.59%, 36.84%, 95.04% and 96.95% respectively.

Table-I: Frequency Distribution of Pneumonia on Ultrasound and Chest X-ray (n=262)

Pneumonia on Lung Ultrasound	n (%)
Yes	243(92.7%)
No	19(7.3%)
Pneumonia on chest X-ray	
Yes	254(96.9%)
No	8(3.1%)

Table-II: Findings of Ultrasound and Chest X-ray (n=262)

Pneumonia on Lung Ultrasound	Pneumonia on Chest X-ray	
	Yes	No
Yes	242(92.3%)	1(0.3%)
No	12(4.5%)	7(2.7%)

Table-III: Diagnostic Parameters Lung Ultrasound in Diagnosis of Pneumonia (n=262)

Sensitivity	95.28%
Specificity	87.5%
Negative Predictive Value	36.84%
Positive Predictive Value	99.59%
Diagnostic Accuracy	95.04%

DISCUSSION

Our study demonstrated a good sensitivity and specificity of ultrasound lungs in diagnosing *pneumonia* in children. Previously, clinical examination was the mainstay of diagnosing this common but potentially lethal condition in children. Recent advances in imaging have revolutionised the diagnosis in each field, and clinicians now rely more on imaging techniques. Clinicians commonly use chest X-rays to support their clinical findings in patients diagnosed with *pneumonia*, but it has limitations like radiological expertise and radiation exposure.10-12 Usually, lung ultrasound is not a modality of choice for various

pathologies, but recent studies have demonstrated its role in diagnosing pathologies related to consolidation.[13]

Recent studies have supported using ultrasound lungs in diagnosis and serial assessments of patients suffering from community-acquired pneumonia.14-16 Results generated by Reissig et al. in their study were promising and clearly showed high sensitivity and specificity of ultrasound lung in cases of *pneumonia*.[14] Urbanowska *et al*.[17] performed a study on one hundred and six paediatric patients regarding the role of ultrasonography of lungs in diagnosing *pneumonia*. Their results favoured the use of USG lungs for this purpose as this diagnostic modality had high sensitivity & specificity to pick up patches of consolidation.

An interesting meta-analysis having more than 700 children and neonates data showed that the overall sensitivity of USG lung in diagnosing *pneumonia* is around 95%, making it a very effective and safe tool in children and may save them from unnecessary exposure to x-rays at this tender age.[18] Esposito *et al*. in Milan, Italy, in a cohort of 103 patients, showed sensitivity and specificity of 97.9% (48/49) and 94.5% (55/58) for LUS compared with 92.1% (47/52) and 94.5% (52/55) for chest radiograph respectively, CXR was the gold standard in this study.[6] A Taiwanese study published by Ho *et al*. published similar findings and emphasised the accuracy of USG lungs in picking up a lesion of consolidation. They also highlighted that this modality could prevent radiation exposure compared to an X-ray chest.[7]

Despite ample literature available on this subject worldwide, local data is limited in this regard. Still, a chest X-ray is considered only radiological in the investigation, which could help or support the clinical diagnosis of pneumonia in children. In a study by Shah *et al*. the sensitivity and specificity of the USG lung to diagnose pneumonia was comparable with that of a chest X-ray.[8] This modality can also be employed in the follow-up of patients with pneumonia, and the whole pathway to recovery can be monitored effectively.[14-16] True *pneumonia* size estimation is still an issue with ultrasound lungs, but clinicians and researchers have been working on this limitation. Decreased air bronchogram and the volume of pleural effusion can also be estimated with the help of USG lung. They can be compared with the baseline to determine treatment's impact on patients managed for *pneumonia*.[15] Our findings support the findings generated by studies done in other parts of the world, and we recommend using USG lung for routine diagnosis and monitoring of *pneumonia* in children.

LIMITATIONS OF STUDY

Ultrasonography is an operator-dependent technique; therefore, results may vary according to the expertise of the operator operating the machine.

CONCLUSION

Lung ultrasound emerged as a sensitive diagnostic tool to diagnose pneumonia in children. Sensitivity (Se), specificity (Sp), positive predictive value (PPV), and negative predictive value (NPV) all favoured the use of this modality to diagnose pneumonia in paediatric patients.

Conflict of Interest: None.

Authors Contribution:

Following authors have made substantial contributions to the manuscript as under:

NS & AI: Study design, drafting the manuscript, approval of the final version to be published.

MT & RM: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

AAA & MU: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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