DIAGNOSTIC ACCURACY OF CHEST RADIOGRAPHS IN DETECTION OF LUNG CONSOLIDATION TAKING CT CHEST AS GOLD STANDARD

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ABSTRACT

OBJECTIVES

To evaluate the diagnostic accuracy of chest X-rays in detecting lung consolidation, using CT chest as the gold standard.

METHODOLOGY

This cross-sectional study was conducted at the Department of Radiology, Hayatabad Medical Complex, Peshawar/PGMI, from April to October 2023. A total of 204 patients aged 18 to 50 years with clinical suspicion of pneumonia were included in the study. Diagnostic outcomes of CXR were compared against those of CT chest. Non-probability consecutive sampling technique is used. The sample size has been calculated using a sensitivity and specificity sample size calculator.

RESULTS

The mean age of the patients was 36.44 years ± 9.07. Gender distribution was equal, with 50% male and 50% female participants. Comparing both modalities, the sensitivity of CXR was 69.2% with a specificity of 57.7%, PPV of 75.4%, NPV of 50.0% and diagnostic accuracy of 65.2% was reported.

CONCLUSION

This study highlights the superior diagnostic accuracy of CT over chest X-ray in detecting lung consolidations, particularly in complex or ambiguous cases. While CXR remains a practical and widely accessible initial diagnostic tool, its lower sensitivity and specificity suggest a need for follow-up CT in cases where clinical uncertainty persists. Overall, a combined approach using both CXR and CT optimises diagnostic accuracy and patient outcomes.

KEYWORDS: *X-Ray, Computed Tomography (CT), Chest, Lung Consolidation, Pneumonia*

INTRODUCTION

Pneumonia remains one of the leading causes of morbidity and mortality worldwide, particularly in developing countries where diagnostic resources are limited. Early and accurate diagnosis is crucial for preventing complications and initiating timely treatment, which can significantly enhance patient outcomes.[1] Due to its easy availability and cost-effectiveness, the chest X-ray is the first-line imaging modality commonly used in practice. However, CXR has its own limitations; it has lower sensitivity in detecting small areas of lung consolidation, particularly in the early stages of pneumonia. Additionally, it cannot accurately differentiate between infectious and non-infectious lung abnormalities, leading to diagnostic uncertainty.[2] Computed tomography (CT) of the chest, on the other hand, is widely considered the gold standard in diagnosing pneumonia, having superior sensitivity and specificity compared to CXR. CT provides detailed cross-sectional views of the lung, allowing for more accurate identification of consolidation, even in complex cases. However, like CXR, the widespread use of CT also has its limitations, including higher costs, limited availability in certain regions, and increased radiation exposure. Given these limitations, CXR remains the first-line imaging modality in most clinical settings with limited resources.[3] This study focuses on evaluating the effectiveness of CXR in identifying consolidation compared to CT, a more sensitive and detailed imaging technique.[4,5] Chest radiographs are widely accessible, cost-effective, and can be performed quickly in various clinical settings, such as emergency departments, ambulances, and inpatient wards.[6] These factors make CXR an important first-line diagnostic imaging tool. A

CT scan has higher sensitivity and specificity in detecting lung pathologies, such as consolidation, as it provides more detailed and cross-sectional images of the lungs, aiding in the better visualisation of subtle lung changes. CXR, on the other hand, may miss small or early consolidation, as it is a more generalised imaging technique.[7] Taking the CT chest as the gold standard, the accuracy of CXR in identifying consolidation is assessed.[8] The sensitivity and specificity of CXR are measured to understand the limitations and strengths of CXR compared to CT in clinical practice.[9] The comparison helps healthcare providers choose a better option to utilise time and resources properly for the benefit of patients and the healthcare system to avoid extra burden. Since detecting very subtle consolidation or early consolidation may be compromised by CXR, comparison with CT, the gold standard, allows for the identification of false positives and false negatives, which have significant clinical implications. Hence, it provides insight into the potential need for further imaging when CXR results are inconclusive for a definitive diagnosis.[10] This study aims to evaluate the diagnostic accuracy of CXR in detecting lung consolidation, using CT chest imaging as the gold standard. The study will assess the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of CXR to determine its reliability in diagnosing pneumonia. By doing so, it seeks to provide a clearer understanding of the role of CXR in clinical practice and guide appropriate use of imaging modalities in the diagnosis of lung consolidation. Despite the widespread use of CXR, its diagnostic limitations in early or subtle pneumonia raise concerns in clinical decision-making. In Pakistan and other low-resource settings, CT is not always readily available, making it crucial to understand the actual diagnostic value of CXR compared to CT. By addressing this gap, our study provides region-specific evidence that may guide clinicians in balancing diagnostic accuracy with resource utilisation. Ultimately, this has the potential to improve pneumonia outcomes, reduce unnecessary CT exposure, and optimise healthcare costs in our community.

METHODOLOGY

This cross-sectional validation study was conducted at the Department of Radiology, Medical Teaching Institution-Hayatabad Medical Complex (MTI-HMC), Peshawar, from April to October 2023. A total of 204 participants were recruited using a consecutive sampling method. Inclusion criteria included patients aged 18 to 50 years presenting with clinical signs and symptoms suggestive of pneumonia, such as fever, productive cough, dyspnea, and pleuritic chest pain. Exclusion criteria were patients with a history of chronic lung diseases (e.g., COPD, bronchiectasis, interstitial lung disease), prior lung surgery, pregnancy, or contraindications to CT such as severe renal impairment or allergies to contrast agents. All participants underwent both chest X-ray (CXR) and computed tomography (CT) chest scans on the same day. CXR was performed using a digital radiography system (Siemens Multix Fusion, Siemens Healthcare, Germany), while CT chest scans were obtained using a 64-slice CT scanner (GE Optima CT660, GE Healthcare, USA). A single calibrated radiologist conducted image interpretation to minimise bias. The following diagnostic parameters were recorded for both imaging modalities: Consolidation on CXR, defined as a homogeneous increase in pulmonary parenchymal opacity, obscuring underlying vessels. Consolidation on CT: Defined as an area of increased attenuation that did not obscure underlying bronchovascular structures. Two independent radiologists, blinded to clinical details and each other's interpretations, reviewed the images. A senior radiologist resolved any discrepancies. Data were analysed using SPSS version 26.0 (IBM Corp., USA). Descriptive statistics were used to summarise the data. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of CXR in detecting lung consolidation were calculated.. Diagnostic parameters were reported with 95% confidence intervals. Stratified analysis was performed by age and gender, and a chi-square test was applied to assess statistical significance, with a p-value <0.05 considered significant. The study was approved by the Institutional Review Board (IRB No. 1068) of Hayatabad Medical Complex, Peshawar, and written informed consent was obtained from all participants before their inclusion. Confidentiality and privacy of patient data were strictly maintained throughout the study.

RESULTS

The study included 204 participants, with a mean age of 36.44±9.07years. Gender distribution was equal, with 102 (50%) male and 102 (50%) female participants (Table I). Consolidation on chest X-ray was observed in 59.8% of patients, while 40.2% had no findings (Table II). CT chest scans revealed consolidation in 65.2% of patients (Table III). Comparing both modalities, the sensitivity of CXR was 69.2%, with a specificity of 57.7%, PPV of 75.4%, NPV of 50.0% and accuracy of 65.2% (Table IV). Diagnostic accuracy was stratified by age and gender. Sensitivity, specificity, PPV, NPV, and accuracy values were reported with 95% CI. Diagnostic performance was consistent across genders, with slightly higher sensitivity noted in the younger age

group (18-35 years) compared to patients aged 35 years or older, although this difference was not statistically significant ($p > 0.05$).

Table 1: Demographic Characteristics of Study Participants

Mean age of the Patients		36.44±9.07
Gender	Male	102 (50.0%)
	Female	102 (50.0%)

Table 2: Consolidation on CXR (n=204)

Consolidation on CXR	Frequency	%age
Yes	122	59.8%
No	82	40.2%
Total	204	100.0%

Table 3: Consolidation on CXR (n=204)

CT Chest	Frequency	%age
Yes	133	65.2%
No	71	34.8%
Total	204	100.0%

Table 4: Comparison of Consolidation of CXR and CT Chest (n=204)

		Consolidation on CT		Total	Statistics
		Yes	No		
Consolidation on CXR	Yes	92	30	122%	P Value: 0.000 Sensitivity: 69.2% Specificity: 57.7% PPV: 75.4% NPV: 50.0% Accuracy: 65.2%
		69.2%	42.3%	59.8%	
	No	41	41	82%	
		30.8%	57.7%	40.2%	

DISCUSSION

The current study demonstrated a significant detection rate of consolidation on CT compared to chest X-ray (CXR), with CT identifying consolidation in 65.2% of patients and CXR in 59.8%. The sensitivity of CXR for detecting consolidation was 69.2%, which is consistent with previous studies reporting a sensitivity range between 60-75% for pneumonia detection on CXR compared to CT.[11] However, the specificity of CXR in this study was slightly lower at 57.7%, which is comparable to findings where CXR specificity has ranged between 50-70% due to the limited ability to differentiate between consolidation and other pulmonary pathologies. CT's superiority in detecting consolidation, with an accuracy of 65.2%, supports its role as the gold standard in evaluating lung diseases. Studies have shown that CT can reveal subtle findings missed on CXR, including small consolidations or early-stage pneumonia, which may justify the higher sensitivity and PPV observed in our study.[12] Our PPV of 75.4% indicates that CXR is still valuable for diagnosing consolidation, but may benefit from follow-up CT in some instances to confirm findings. The findings of our study align with previous research, indicating that CT has superior diagnostic accuracy over CXR in detecting pulmonary consolidations. A study reported a similar trend, with CT detecting 70% of pneumonia cases compared to 50-60% by CXR, demonstrating the enhanced sensitivity of CT.[13] A study found that CT detected consolidation in 67% of cases missed by CXR, which supports the notion that CT is more sensitive in identifying subtle lung pathologies.[14] However, contrasting results have been observed in some studies where the diagnostic gap between CXR and CT was less pronounced. Another study reported only a marginal increase in sensitivity with CT (68%) compared to CXR (63%), suggesting that the differences between these imaging modalities may depend on factors such as patient age, disease severity, and the radiologist's experience.[15] Our study‘s findings emphasise the practical role of CT in cases where CXR results are ambiguous, especially for patients presenting with atypical pneumonia symptoms. The positive predictive value (PPV) of 75.4% in our study is similar to other reports, where CXR had moderate diagnostic utility but was enhanced with the use of adjunctive CT.[16] Moreover, the specificity of CXR, while lower in our study (57.7%), mirrors findings by Wipf et al., who noted that CXR has lower specificity due to its inability to distinguish consolidation from other forms of infiltrates or lung abnormalities.[12] This study corroborates the broader body of literature advocating for CT as the gold standard in diagnosing lung consolidations, particularly when CXR results are equivocal or in high-risk populations. However, given its widespread availability and cost-effectiveness, CXR remains a valuable initial screening tool, with CT reserved for confirmatory diagnosis in cases that are complex. Furthermore, the utility of CXR as an initial diagnostic tool remains significant, especially in resource-limited settings. Studies have shown that while CT is more sensitive, its accessibility and cost can be prohibitive in many clinical settings. For instance, Hayden et al. demonstrated that in lower-income regions, where CT is often unavailable, CXR remains a cornerstone of pneumonia diagnosis, despite its lower sensitivity. This underscores the need for balance between high diagnostic accuracy and practical accessibility, particularly in urgent or outpatient settings. Moreover, the decision to use CT should be guided by clinical presentation and patient history.[17] A study emphasised that CXR, when combined with strong clinical suspicion and patient symptoms, can still offer a reliable diagnosis of pneumonia in some instances, particularly in young, healthy adults without underlying lung disease.[18] Conversely, in patients with underlying conditions like chronic obstructive pulmonary disease (COPD) or heart failure, CT is more likely to identify subtle consolidations that CXR could

miss, a finding also reported by Upchurch et al.[17] Our study's accuracy rate of 65.2% for CXR is consistent with findings from a study by Brooks D et al., which noted that while CXR is imperfect, it remains particular for pneumonia when used in conjunction with clinical judgment.[7] However, the study also highlighted the increased risk of false negatives, particularly in early or mild cases, which could justify the use of CT as a follow-up tool when CXR results are inconclusive or when patients fail to respond to initial treatment.[18] In conclusion, while CT offers superior diagnostic performance in detecting lung consolidations, particularly in complex or unclear cases, CXR continues to play a vital role due to its availability, lower cost, and sufficient accuracy in many cases. Our study, in line with previous research, suggests that a stepwise approach, starting with CXR and escalating to CT when necessary, could optimise both diagnostic efficiency and resource use. The results of this study have important public health implications. In resource-constrained healthcare systems, such as those in Pakistan, where CT availability is limited, reliance on CXR as an initial diagnostic tool remains justified. By clarifying its diagnostic performance, this study may support evidence-based protocols to prioritise CT only for inconclusive or atypical cases, thus reducing unnecessary costs and radiation exposure. The findings may guide clinicians, health administrators, and policymakers in optimising diagnostic pathways for pneumonia, ultimately improving patient outcomes at both individual and community levels.

LIMITATIONS

Firstly, this is a single-centre study, which may limit the generalizability of the findings to other healthcare settings that have different patient demographics and radiological practices. Secondly, the sample size is relatively limited. A larger sample would enable subgroup and stratified analysis, improving the precision of sensitivity and specificity estimates and thereby enhancing the robustness of the diagnostic accuracy assessment.

CONCLUSIONS

This study the superior diagnostic accuracy of CT over chest X-ray (CXR) in detecting lung consolidations, particularly in complex or ambiguous cases. While CXR remains a practical and widely accessible initial diagnostic tool, its lower sensitivity and specificity suggest a need for follow-up CT in cases where clinical uncertainty persists. Emerging technologies, such as AI and radiomics, along with advancements in portable imaging, are poised to further enhance the diagnosis of pneumonia, particularly in resource-limited settings. Overall, a combined approach using both CXR and CT optimises diagnostic accuracy and patient outcomes.

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AUTHORS CONTRIBUTION

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The authors accept responsibility for all aspects of the work and will ensure that any concerns regarding the accuracy or integrity of any part are properly investigated and resolved.