The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 5, 2025

ACCURACY OF DIGITAL XRAY TO DIAGNOSE PULMONARY TB IN POPULATION OF TOBA TEK SINGH

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DOI: https://doi.org/10.5281/zenodo.15526013

Keywords
Pulmonary tuberculosis (TB), high-resolution computed tomography (HRCT)

Article History
Received on 20 April 2025
Accepted on 20 May 2025
Published on 27 May 2025

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Abstract

Background: *Pulmonary tuberculosis (TB) remains a major health concern globally, with early and accurate diagnosis being crucial for effective treatment and prevention. X-rays are commonly used for TB screening, but their diagnostic accuracy may vary, especially when compared to the gold standard of high-resolution computed tomography (HRCT). In the population of Toba Tek Singh, evaluating the diagnostic performance of X-rays in detecting pulmonary TB in comparison to HRCT can provide insights into their reliability and potential limitations in this specific region.* ***Objective:*** *To diagnostic accuracy of x-rays in diagnosing pulmonary tuberculosis while keeping high resolution computed tomography as a gold standard in population of Toba Tek Singh.* ***Methodology:*** *The research was conducted at DHQ Hospital Toba Tek Singh in Radiology department, involving patients with pulmonary tuberculosis referred for Computed Tomography in the radiology department. Data collection from CT imaging was conducted after obtaining informed consent.* ***Results:*** *The study included 84 participants which had a mean age of 47 years, with a nearly equal gender distribution. X-ray results showed most cases without cavitation (70.2%), fibrosis (86.9%), and consolidation (59.5%). HRCT revealed tree-in-bud and centrilobular nodules in 31% and 44% of cases, respectively. Statistical tests showed no significant associations between cavitation, nodules, pleural effusion, consolidation, lymphadenopathy, or infiltrates on X-ray and the final diagnosis on HRCT. However, fibrosis on X-ray had a significant association with the final diagnosis, indicating its potential diagnostic value.* ***Conclusion:*** *The study indicates that certain radiological findings on X-ray and HRCT, such as fibrosis, may be significant for diagnosing diseases in the sample population. However, no statistically significant associations were found between other features like cavitation, nodules, pleural effusion, and consolidation on X-ray with the final diagnosis. These findings suggest that while certain imaging features may help inform clinical decisions, further investigation is needed to explore the diagnostic utility of these radiological markers.*

INTRODUCTION

Tuberculosis (TB) is still a major issue in developing and industrialized nations. Control depends on early detection and treatment of active cases, particularly those with positive sputum smears for acid-fast bacilli (AFB). However, active TB individuals with negative sputum smears may still be a source of disease transmission.[1] Gram-positive, acid-fast bacilli belonging to the genus Mycobacterium are the cause of tuberculosis (TB), a chronic granulomatous infectious disease. The most common cause of tuberculosis in humans is Mycobacterium tuberculosis, which primarily affects the lungs and leads to pulmonary tuberculosis. Additionally, it can cause extra-pulmonary tuberculosis by affecting the skin, lymph nodes, bones, joints, intestine, meninges, and other body tissues.[2]

The World Health Organization (WHO) reports that TB caused 1.4 million deaths and 10.1 million new cases in 2016. Most notably, a third of people worldwide are infected with latent tuberculosis. Mycobacterium tuberculosis (MBT), the causative agent of tuberculosis (TB), becomes virulent in 10% of cases among this infected group and primarily affects the lungs due to its respiratory mode of transmission.[3]

Pulmonary tubercul0sis (TB) is a global infection and a leading cause of morbidity and mortality worldwide, particularly in developing nations. The World Health 0rganization's Global Tuberculosis Report estimated that there were 8.7 million new cases of TB in the world in 2011, equating to 125 cases per 100k population, and that 59% of the cases were from Asia.10 Pulmonary tuberculosis (PTB) is the major source of most TB disease in children and adults worldwide. It is from this type of TB that infection is transmitted to other individuals through droplet nuclei dissemination due to sneezing, coughing, and speaking.[4]

TB disease and infection are more likely to occur in close contacts of patients with sputum acid-fast bacilli (AFB) smear+ tuberculosis (TB). 50% of TB patients' household contacts contract Mycobacterium tuberculosis in H.incidence settings, and 4% go on to develop active TB disease within a year.[5]

There are two types of tuberculosis (TB): latent and active. Primary TB, which appears shortly after infection, and post-primary (reactivation) TB, which follows a protracted latent phase, are both considered forms of active TB. Children and people with weakened immune systems are more likely to have primary TB, which frequently manifests as lymphadenopathy, pulmonary consolidation, and pleural effusion. Centrilobular nodules, consolidations, and cavities are common after primary TB. Chest radiography aids in risk assessment and the identification of active TB that is asymptomatic. Fibronodular opacities in the apical and upper lung zones are indicative of inactive tuberculosis. To differentiate it from active disease, radiographic finding is deemed inactive if it stays stable for six months.[6]

CT scans show different patterns of tuberculosis (TB) spread, with primary TB typically presenting as lymphohematogenous spread and postprimary (reactivation) TB as bronchogenic spread. High-resolution CT (HRCT) is useful in assessing disease progression, spread patterns, and response to therapy. Early bronchogenic spread is often seen with centrilobular nodules (2–4 mm) or cavitating linear lesions due to caseation necrosis that can become large nodules or lobular consolidation.[7]

Cavitation usually starts around the bronchioles, and the treatment produces fibrosis, distortion of broncho-vascular markings, emphysema, and bronchiectasis. Para-cicatricial and lobular emphysema are detected by HRCT, while early miliary spread of tubercle bacilli is seen as ground-glass opacities with poorly defined nodules that later become discrete. CT is also crucial in evaluating chronic destructive pulmonary lesions and tracheobronchial TB.[8]

This study aims to evaluate the diagnostic accuracy of chest X-rays compared to HRCT in diagnosing Pulmonary TB in the local population. Establishing the reliability of X-rays as a diagnostic tool relative to HRCT can help optimize resource all0cation, improve diagnostic efficiency, and enhance TB management strategies in underprivileged areas like Toba Tek Singh. This research can also guide public health policies and clinical practices to balance cost, accessibility, and diagnostic accuracy in TB-endemic regions. Materials and Methods: It was a cross-sectional analytical study conducted in 3 month as BS research from 16th Jan 2025 to 16th Mar 2025 at DHQ

Hospital Toba Tek Singh, Pakistan. A total of 84 females and males were included which had pulmonary TB. The study aimed to evaluate the diagnostic accuracy of x-rays in diagnosing pulmonary tuberculosis while keeping high resolution computed tomography as gold standard in population of Toba Tek Singh. Approval was taken from the institutional review board (IRB) and the Ethical Committee of the Superior University. An X-ray Machine GE 500 MA and CT-Scan Hitachi 16 Slice Machine were used for this study. Patients have been explained the procedure and also aim of the research therefore a written informed consent was signed. ACR guidelines for Xray and CT scan imaging were followed in the study. The privacy of the patient was given priority while scanning the patient and publication. The complete CT scan was performed with HR CT by accredited Radiographer. Statistical Package for the Social Sciences (SPSS) version 25 (SPSS 24, IBM, Armonk, NY, United States of America) software was used for the evaluation of data(Zaman et al., 2019). The results were summarized in the form of Bar charts and tables. Correlation was evaluated while using Pearson correlation and Paired Sample T-Test was applied to check relation between both modalities, all variables were tabulated with their frequencies. Bar charts were drawn against their percentages.

Results

The results from this study indicated several key findings related to the imaging characteristics observed in the sample population. The mean age of the participants was 47 years, with a gender distribution of 47.6% females and 52.4% males. On X-ray, the most common findings were the absence of cavitation (70.2%), fibrosis (86.9%), and consolidation (59.5%). Lymphadenopathy was extremely rare, observed in only 1.2% of cases. On HRCT, tree-in-bud and centrilobular nodules were present in 31% and 44% of the cases, respectively, while cavitary lesions, bronchiectasis, and pleural thickening were also noted in significant proportions. Statistical analyses, such as the Chi-square tests, were performed to assess the association between these imaging features and the final diagnosis on HRCT. The results showed no significant association between cavitation, nodules, pleural effusion, consolidation, lymphadenopathy, or infiltrates on X-ray and the final diagnosis. However, the presence of fibrosis on X-ray was found to have a statistically significant association with the final diagnosis, suggesting its potential role as a reliable diagnostic indicator. These findings highlight the importance of combining various imaging modalities in diagnosing pulmonary conditions, though certain features like fibrosis may be more predictive than others. A Chi-square test was conducted to determine whether there is a statistically significant association between pleural effusion observed on X-ray and the final diagnosis on HRCT. The Pearson Chi-square value is 0.114 with 1 degree of freedom and a p-value of 0.735, which is well above the standard significance level of 0.05. This indicates that the relationship between pleural effusion on X-ray and the final diagnosis on HRCT is not statistically significant. The Continuity Correction yielded a Chi-square value of 0.000 with a p-value of 1.000, further confirming the lack of association. Similarly, the Likelihood Ratio ($\chi^2 = 0.112$, $p = 0.738$) and Fisher's Exact Test ($p = 0.742$, two-sided) also suggest no significant association. Based on these results from a sample of 84 cases, it can be concluded that there is no statistically significant relationship between the presence of pleural effusion on X-ray and the final diagnosis shown in table below.

Discussions:

The study included 84 participants with an age range of 16 to 80 years (mean: 47 ± 17.5 years) and a nearly even gender distribution (52.4% males, 47.6% females). To check the diagnostic accuracy of x-rays in diagnosing pulmonary tuberculosis while keeping high resolution computed tomography as gold standard in population of Toba Tek Singh, a small town of Pakistan. The primary focus was to investigate whether various radiological features of tuberculosis observed on chest X-ray are significantly associated with the final diagnosis as determined by HRCT which serves as a more advanced and definitive imaging modality. A comparative analysis of imaging modalities demonstrated that findings, including cavitation, nodules, consolidation, pleural effusion, infiltrates, and lymphadenopathy, did not show statistically significant associations with HRCT-confirmed outcomes. Fibrosis was identified in 13.1% of cases on chest X-ray and showed a significant correlation with disease presence on HRCT. This

finding is consistent with prior literature which highlights that interstitial fibrotic changes particularly reticular opacities and honeycombing are among the more reliably visualized abnormalities on CXR when disease is at an advanced stage. Hansell et al. emphasized that although CXR may miss early interstitial changes, it can demonstrate advanced fibrotic patterns, particularly in the lower lung zones, which often correspond with HRCT findings. Similarly, Copley et al. found that radiographic evidence of fibrosis correlated well with HRCT in patients with known interstitial lung disease, though CT remained more sensitive. [9-11]

Conversely, cavitation, observed in 29.8% of cases, did not show a statistically significant association with HRCT findings ($p = 0.215$). This contrasts with the work of Imali et al., who reported that cavitary lesions on CXR can often indicate necrotizing infections or tuberculosis and generally align with CT findings in high-prevalence settings. However, our findings may be influenced by the diversity of etiologies for cavitation and the possibility of early-stage or atypical lesions being missed on CXR. [40] Consolidation, present in 40.5% of cases on CXR, also lacked significant correlation with final diagnosis ($p = 0.199$). Although radiographically visible, consolidation is a nonspecific finding and can result from infections, malignancy, or inflammatory conditions. Boiselle et al. noted that consolidation seen on X-ray does not reliably differentiate among these causes without adjunctive imaging. The non-significant findings in our study support this view, suggesting that consolidation alone on CXR is insufficient for diagnostic certainty without further imaging, such as HRCT. [12]

Nodules were observed in 46.4% of cases but did not correlate with final diagnosis ($p = 0.705$). This outcome aligns with findings by Erasmus et al., who documented the limited sensitivity of chest radiography in detecting pulmonary nodules, particularly those <6 mm in diameter, which are far more reliably identified and characterized on HRCT. This reinforces the utility of HRCT in evaluating patients with suspected nodular lung disease. [13] Pleural effusion was present in 16.7% of our cases, yet no statistically significant relationship with HRCT diagnosis was found ($p = 0.735$). Previous studies, including those by Porcel et al., have noted that small effusions may be overlooked or misinterpreted on frontal chest radiographs due to patient positioning and technical factors. HRCT remains superior for detecting subtle effusions and evaluating their composition and adjacent parenchymal involvement. [14] Lymphadenopathy was identified in only one case (1.2%), severely limiting the statistical power for analysis. Nonetheless, the lack of significant association is not surprising, as several studies have shown that CXR performs poorly in detecting mediastinal and hilar lymphadenopathy due to overlapping anatomical structures. Webb et al. emphasized the superiority of CT in evaluating mediastinal nodes, especially in diseases like lymphoma or sarcoidosis.[44] Lastly, infiltrates, observed in 7.1% of cases, did not significantly predict HRCT-diagnosed disease ($p = 0.199$). Infiltrates are nonspecific radiologic findings and can represent a wide range of pathology, from infections to inflammatory or neoplastic processes. The low prevalence in our cohort and the nonspecific nature of this finding likely contributed to the lack of statistical significance. This is consistent with prior studies which caution against relying solely on CXR for infiltrate evaluation.[15-17]

Overall, these results reinforce existing literature highlighting the limitations of chest radiography in accurately diagnosing pulmonary pathology, especially when findings are equivocal. Only fibrosis on CXR showed a significant relationship with HRCT-confirmed diagnosis, underscoring its potential diagnostic utility in advanced interstitial lung disease. However, the study supports the use of HRCT as a critical adjunct to CXR, especially when radiographic findings are inconclusive or when precise anatomical and pathological detail is required.[18]

Conflict of Interest

We believe that this manuscript is appropriate for publication by this journal. We have no conflicts of interest to disclose.

Ethical Statement

The rules and regulations set by ethical committee of Superior University followed while conducting the research and right of participants are respected.

Impact Statement

We already know the increasing morbidity and mortality due to pulmonary TB. That's why it was important to evaluate the diagnostic accuracy of chest X-rays compared to HRCT in diagnosing Pulmonary TB in the local and the poor people of backward areas Establishing the reliability of X-rays as a diagnostic tool relative to HRCT can help optimize resource all0cation, improve diagnostic efficiency, and enhance TB management strategies in underprivileged areas like Toba Tek Singh. This research can also guide public health policies and clinical practices t0 balance cost, accessibility, and diagnostic accuracy in TB-endemic regions

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Table 1

X-ray Finding	Chi-square (χ^2)	df	p-value	Fisher's Exact (2-sided)
Cavitation	1.538	1	0.215	0.277
Nodules	0.144	1	0.705	0.803
Pleural Effusion	0.114	1	0.735	0.742
Fibrosis	5.893	1	**0.015**	**0.025**
Consolidation	1.647	1	0.199	0.305
Lymphadenopathy	0.337	1	0.561	1.000
Infiltrates	3.227	2	0.199	0.2999