ORIGINAL ARTICLE

Involvement of Mediastinal Lymph Nodes Detected by HRCT Chest in Tuberculosis Positive Patients: A Cross-sectional Study at a Tertiary Care Hospital, Sahiwal, Pakistan

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ABSTRACT

Objective: To determine the frequency, distribution, and clinical correlations of mediastinal lymph node involvement in confirmed pulmonary tuberculosis patients using High-Resolution Computed Tomography (HRCT).

Study Design: Cross-sectional study.

Place and Duration of Study: The study was conducted at the Department of Pulmonology, Sahiwal Teaching Hospital, Sahiwal, Pakistan, from January 2024 to June 2025.

Methods: A total of 290 patients aged 18 years and above with sputum smear or GeneXpert-confirmed pulmonary tuberculosis were enrolled using a non-probability convenience sampling technique after obtaining informed consent. Patients with known malignancy, other granulomatous diseases, or those who refused consent were excluded. All participants underwent a detailed clinical evaluation, including assessment of demographic and clinical variables. HRCT of the chest was performed using a standardized imaging protocol for all patients. Mediastinal lymph node involvement was evaluated based on nodal size, anatomical location and radiological characteristics such as necrosis and calcification. Image interpretation was performed independently by two experienced radiologists to ensure accuracy and minimize observer bias.

Results: The most frequently involved groups were subcarinal (62.1%), right paratracheal (53.1%), and hilar (41.0%) nodes; prevascular and para-aortic nodes were involved in 24.1% and 17.6% of patients, respectively. Patients aged ≥50 years had significantly higher rates of lymph node involvement than younger patients (78.0% vs 62.0%, *P* = 0.01); similarly, smokers had higher rates of involvement than non-smokers (68.0% vs 52.0%, *P* = 0.03). Diabetes mellitus and hypertension were associated with greater lymphadenopathy (76.0% vs 61.0%, *P* = 0.02; and 81.0% vs 59.0%, *P* = 0.005, respectively).

Conclusion: Mediastinal lymph node involvement is highly prevalent among tuberculosis-positive patients in Pakistan, with subcarinal and paratracheal groups being the most affected. HRCT provides valuable diagnostic and prognostic information, and recognition of mediastinal lymph node patterns can enhance disease assessment and support clinical decision-making.

Keywords: *Diagnostic Imaging, Lymphadenopathy, Mediastinum, Mycobacterium Tuberculosis.*

How to cite this: *Waseem M, Javed I, Ejaz R, Mir A, Shafiq H, Razzaq M. Involvement of Mediastinal Lymph Nodes Detected by HRCT Chest in Tuberculosis Positive Patients: A Cross-sectional Study at a Tertiary Care Hospital, Sahiwal, Pakistan. Life and Science. 2026; 7(2): 161-167. doi: http://doi.org/10.37185/LnS.1.1.1087*

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Received: Aug 08, 2025; 1st Revision Received: Nov 11, 2025
2nd Revision Received: Feb 05, 2026; Accepted: Feb 11, 2026

Introduction

Over the past decades, despite the advances in diagnostic and therapeutic strategies, Tuberculosis (TB) is still one of the major global public health challenges. It is caused by *Mycobacterium tuberculosis*. The primary affected tissue by TB is the lungs, but it can involve any other organ system.[1]

According to the World Health Organization (WHO) "Global Tuberculosis Report 2024", an estimated 10.8 million people developed TB worldwide in 2023, with a significant proportion residing in low to middle-income countries.[2] Pakistan is ranked among the 5th highest TB burden countries, with a prevalence of 348 per 100,000, an incidence of 276 per 100,000, and an annual mortality rate of 34 per 100,000. These figures are the contributing reason for the urgent need to increase public awareness and education to prevent disease spread and to safe the wider community.[3] This high burden highlights the need for improved diagnostic approaches and better understanding of disease patterns to enhance patient outcomes, specially in developing countries.

The clinical presentation of pulmonary TB varies widely, ranging from asymptomatic infection to severe respiratory symptoms. In the pathophysiology of pulmonary TB, the involvement of the lymphatic system is very important, particularly the mediastinal lymph nodes.[4] Mediastinal lymphadenopathy in TB occurs due to the migration of *M. tuberculosis* via lymphatic channels from the primary site of infection in the lungs.[5] As lymph nodes act as sites for processing of antigens and initiation of cellular immunity, this lymphatic involvement is an essential aspect of the host immune response.[6] Before the extensive pulmonary parenchymal involvement, mediastinal lymph nodes can even enlarge and make it an important and critical parameter in the early detection and assessment of the severity of the disease.[7] Beyond its biological role, mediastinal lymph node involvement may provide important clinical insights into disease extent and activity.

In the past few decades, the assessment of mediastinal lymph nodes was completely reliant on chest radiography, with limited sensitivity and specificity for detecting lymph node enlargement, especially when the nodes are small or invisible due to surrounding structures. The drawback of conventional radiography is that it cannot detect early mediastinal lymphadenopathy, leading to delayed diagnosis and treatment initiation.[8] Computed tomography (CT) scanning, particularly High-Resolution Computed Tomography (HRCT), has revolutionized the imaging techniques of the thorax by providing detailed visualization of the mediastinum, lung parenchyma, and lymph nodes.[9] With the help of HRCT, the precise assessment of size, number, anatomical location, and morphological characteristics of lymph nodes can be done. It helps facilitate early diagnosis, staging, and monitoring of pulmonary TB.[10] This improved visualization makes HRCT a valuable tool not only for detection but also for comprehensive characterization of lymph node involvement.

The involvement of mediastinal lymph nodes in TB has significant clinical implications. First, it may reflect the severity of infection and the host's immune response. Enlarged lymph nodes can compress adjacent structures, such as the airways or blood vessels, resulting in clinical manifestations such as cough, dyspnea, or, in severe cases, superior vena cava syndrome. Second, mediastinal lymphadenopathy may complicate the radiological assessment of pulmonary infiltrates, particularly in patients with coexisting lung pathology. Accurate detection and characterization of lymph nodes by HRCT thus aid clinicians in differentiating TB from other infectious, inflammatory, or neoplastic conditions affecting the mediastinum. Several studies have reported varying occurrences of mediastinal lymph node involvement in pulmonary TB, which is an important prognostic marker. For instance, in pediatric populations the T.B is often presented with lymph node enlargement but in adults both parenchyma and lymph nodal involvement have been seen.[11] Specific lymph node, such as subcarinal, right paratracheal and hilar nodes are more frequently involved due to anatomical patterns of lymphatic drainage.[12] However, most available studies focus on general radiological findings, with limited emphasis on detailed HRCT-based mapping of lymph node distribution and its clinical relevance, particularly in adult populations. The use of HRCT also provides an opportunity to study associations between the involvement of lymph nodes and various clinical and demographic factors, such as age, gender, comorbidities like diabetes mellitus or hypertension, and lifestyle factors such as smoking. Evaluating these associations is critical for understanding disease pathogenesis, identifying high-risk groups, and making patient management strategies. Understanding these associations can help identify

high-risk patients and support more targeted clinical evaluation and management. Despite the recognized presence of mediastinal lymphadenopathy in TB, there is a lack of comprehensive local data in Pakistan regarding its frequency, anatomical distribution, and relationship with clinical risk factors. This gap limits the ability to utilize lymph node involvement as a marker of disease severity in routine clinical practice.Therefore, this study aims to provide a detailed HRCT-based evaluation of mediastinal lymph node involvement in pulmonary TB patients and to explore its association with key clinical variables, thereby contributing to improved disease assessment and management in high-burden settings.

Methods

The cross-sectional study was conducted at the Department of Pulmonology, Sahiwal Teaching Hospital, Sahiwal, Pakistan. The study was carried out over a period of 18 months, from January 2024 to June 2025, after obtaining ethical approval from the Institutional Review Board of the hospital, vide letter no: 95/IRB/SLMC/SWL, dated: 16th November 2023, and Informed consent was obtained from all participants after explaining the purpose and procedure of the study. Inclusion Criteria was patients aged 18 years and above who signed informed consent and patients with confirmed sputum smear or GeneXpert positive for Mycobacterium tuberculosis. Exclusion Criteria was patients who refused to sign the consent, with age less than 18 years, and with known malignancy or other granulomatous diseases. The sample size was calculated using the standard formula for a single population proportion: $N = Z^2 \times p \times (1-p) / d^2$, where Z = 1.96 for a 95% confidence level, P = 0.75 (anticipated prevalence of mediastinal lymphadenopathy based on previous studies), and d = 0.05 (margin of error). The calculated sample size was 288, which was rounded up to 290 patients. A total of 290 patients were selected using a non-probability convenience sampling technique.

All eligible patients underwent a detailed clinical assessment, which included demographic information (age, gender) and medical history (hypertension, diabetes, and smoking). Confirmed tuberculosis-positive patients were referred for High Resolution Computed Tomography (HRCT) of the chest. HRCT scans were performed using a standardized protocol. Radiological evaluation focused on the detection, size, and characteristics of mediastinal lymph nodes. Lymph node involvement was classified based on location (Paratracheal, Subcarinal, Hilar, etc.), size (short-axis diameter >10 mm considered significant), and radiological features (calcification, necrosis, enhancement patterns).[12,13] Radiological interpretation was performed by two experienced radiologists independently to avoid discrepancies. Mediastinal lymph node involvement was recorded and correlated with clinical and laboratory findings.

outcome: the frequency and anatomical distribution of mediastinal lymph node involvement on HRCT in patients with pulmonary tuberculosis. Secondary outcomes included the association of mediastinal lymphadenopathy with demographic and clinical variables such as age, gender, diabetes mellitus, hypertension, and smoking status.

Data was analyzed by using SPSS version 25. Quantitative variables were expressed as mean ± standard deviation (SD). The association between mediastinal lymphadenopathy and categorical clinical variables was evaluated using the Chi-Square test, and a P-value ≤ 0.05 was considered statistically significant.

Results

A total of 290 patients with GeneXpert- or sputum smear-confirmed pulmonary tuberculosis (TB) were included in the study. The mean age of participants was 47.6 ± 15.3 years. Of these, 165 (56.9%) were males and 125 (43.1%) were females. Diabetes mellitus was reported in 102 (35.2%) patients, hypertension in 88 (30.3%), and 112 (38.6%) had a history of smoking. The demographic and clinical characteristics of the study population are summarized in Table 1.

Table 1: Demographic and clinical characteristics of study participants according to mediastinal lymph node involvement (N = 290)

Variable	Category	Lymph Node Involved (N=217)	Not Involved (N=73)
Age (years)	Mean ± SD	49.3 ± 14.8	42.1 ± 15.2
Age Groups	≤50 years	80 (36.9%)	47 (64.4%)
	>50 years	137 (63.1%)	26 (35.6%)
Gender	Male	124 (57.1%)	41 (56.2%)
	Female	93 (42.9%)	32 (43.8%)
Diabetes Mellitus	Present	91 (41.9%)	11 (15.1%)
	Absent	126 (58.1%)	62 (84.9%)
Hypertension	Present	152 (70.0%)	50 (68.5%)
	Absent	65 (30.0%)	23 (31.5%)
Smoking Status	Smoker	96 (44.2%)	16 (21.9%)
	Non-smoker	121 (55.8%)	57 (78.1%)

Table 2. Frequency and distribution of mediastinal lymph node involvement (N = 290)

Lymph Node Group	Frequency (N)	Percentage (%)	χ^2	*P*-value
Subcarinal	180	62.1%	4.25	0.039*
Right Paratracheal	154	53.1%	3.85	0.050
Hilar	119	41.0%	2.10	0.147
Prevascular	70	24.1%	0.21	0.647
Para-aortic	51	17.6%	0.34	0.560

**P-value < 0.05 considered statistically significant*

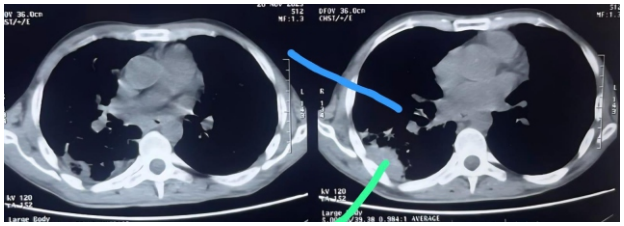

Fig.1: The green arrow shows consolidation with blue arrow showing involved Hilar lymph node

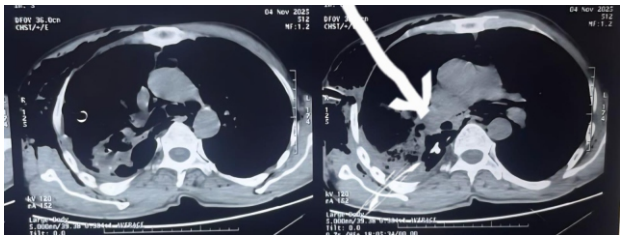

Fig.2: The peripheral area shows consolidation with white arrow showing involved Hilar lymph node

This study evaluated the frequency and distribution of mediastinal lymph node involvement in sputum smear, GeneXpert confirmed pulmonary tuberculosis patients using HRCT chest imaging, and explored its association with key demographic and clinical variables (Table 2). According to the findings, mediastinal lymphadenopathy is highly prevalent among patients of pulmonary TB, with a ratio of 74.8%. The most affected groups were the subcarinal, right paratracheal, and hilar lymph nodes (Figure 1 and Figure 2). Moreover, lymphadenopathy was significantly associated with older age, diabetes mellitus, and smoking status. All these factors show how they reflect the severity of infection and the body's immune response.

Discussion

The high frequency of mediastinal lymphadenopathy observed in this study aligns with previously published evidence, which indicates that lymph node involvement is a common feature of active tuberculosis.[14] In our study, HRCT chest was used with its superior ability to visualize mediastinal structures. In adult TB patients, the rate of involvement of lymph nodes was between 60% and 80%. Subcarinal and right paratracheal lymph nodes were predominantly involved (Figure 1). Both these lymph nodes receive lymph directly from the lower trachea and main bronchi, and these areas can be affected in pulmonary TB frequently.[15]

In our study, the significant association between involvement of lymph nodes and consolidation with age suggests that older individuals may develop more extensive lymphatic disease. Immunosenescence, age-related immune dysfunction, is characterized by declining cell-mediated immunity

that can impair the host response to Mycobacterium tuberculosis, resulting in larger or more numerous lymph nodes.[16,17] This finding is supported by a previous study done by Alsehali A et al., reporting that TB is more severe and common among individuals aged above 50 years with slower treatment response in relevance to immune dysfunction.[18]

The strong association between diabetes mellitus and lymph node involvement reflects the give and take relationship between metabolic disorders and TB. In diabetes, the normal functioning of macrophages is compromised, leading to decreased cytokine production and impaired phagocytosis, collectively weakening immune containment of the bacilli.[19,20] This immunological deficit may contribute to more extensive lymphatic spread of the infection. A study done by Zhan S et al. also described lymphadenopathy among diabetic TB patients.[21] Due to the rising prevalence of diabetes in Pakistan, the coexistence of both conditions (diabetes and TB) warrants clinical attention, early screening, and integrated management approaches. Smoking is also correlated significantly with lymph node involvement in our study. Cigarette smoke is known to impair mucociliary clearance, damage airway epithelium, and suppress both innate and adaptive immunity.[22] Smokers are reported to have higher rates of active TB, more severe parenchymal disease, and delayed sputum conversion.[23]

Our results fall within this range, reinforcing the diagnostic utility of HRCT in TB endemic regions. The role of HRCT in detecting mediastinal lymphadenopathy cannot be ignored. As compared to conventional radiography, HRCT provides high-resolution assessment of lymph node size, morphology, calcification, and necrosis. All these features not only help to diagnose TB on time but also help to differentiate it from malignancies, sarcoidosis, fungal infections, and other granulomatous diseases.[9] In the present study, with the help of HRCT, involvement of multiple groups of lymph nodes was visualized in the majority of patients, revealing patterns that might otherwise be ignored. This highlights the value of HRCTs in guiding clinical decision-making, especially in cases where the diagnosis is uncertain, or sputum studies are inconclusive. The findings of this study give important insights for clinical practice in Pakistan. First, the high prevalence of mediastinal lymphadenopathy suggests that routine HRCT may benefit selected patient groups, especially older individuals, diabetics, and smokers, to better assess disease extent and guide timely treatment. Second, in atypical TB presentation, HRTC can help to identify the most frequently involved lymph node groups. At the end, understanding the associations between lymphadenopathy and risk factors can help clinicians to predict the severity of disease, anticipate complications, and maintain follow-up schedules.

Conclusion

This study demonstrates a high frequency of mediastinal lymph node involvement among pulmonary TB patients, with subcarinal and right paratracheal nodes being most commonly affected. Older age, diabetes mellitus, and smoking were significantly associated with nodal involvement, indicating their potential value as indicators of disease severity. HRCT remains a valuable tool for detailed assessment of mediastinal structures. To improve diagnostic accuracy and early, effective patient management, it should be considered in appropriate clinical contexts.

A key limitation of this cross-sectional study is the lack of correlation between HRCT findings and treatment outcomes, which limits the ability to establish the prognostic significance of mediastinal lymphadenopathy. Without longitudinal follow-up, it remains unclear how lymph node involvement evolves during therapy and whether it can reliably predict treatment response or disease progression. Future studies should incorporate prospective longitudinal designs to evaluate changes in lymph node involvement over time and to assess its relationship with clinical recovery, treatment response, and risk of relapse.

Acknowledgment: None

Conflict of Interest: The authors declare no conflict of interest

Grant Support and Financial Disclosure: None

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Author Contributions

MW: Conception, design of the work, and approval for final submission
IJ: Data acquisition, curation, statistical analysis, and approval for final submission
RE: Writing the original draft, proofreading, and approval for final submission
AM: Manuscript writing for methodology design, investigation, and approval for final submission
HS: Validation of data, interpretation, write-up of results, and approval for final submission
MR: Revising, editing, supervising for intellectual content, and approval for final submission
AM is the nominated guarantor and takes full responsibility for the overall content and integrity of the work