

SPECTRUM OF CT CHEST FINDINGS IN DIABETIC PATIENTS WITH PULMONARY TUBERCULOSIS AND THE INFLUENCE OF GLYCAEMIC CONTROL

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Received : 28/02/2025
Received in revised form : 20/04/2025
Accepted : 08/05/2025

Keywords:

Pulmonary Tuberculosis, Diabetes Mellitus, CT Chest, Glycemic Control, India, Radiological Manifestations.

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DOI: 10.47009/jamp.2025.7.3.125

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (3); 647-651



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ABSTRACT

Background: The co-occurrence of Tuberculosis (TB) and Diabetes Mellitus (DM) is a significant public health concern, particularly in high-burden countries like India¹. DM is known to increase the risk and severity of TB, but its influence on radiological manifestations, especially in relation to glycaemic control, remains understudied². This study aimed to comprehensively evaluate and compare CT chest findings in pulmonary TB (PTB) patients with controlled and uncontrolled DM in India and to assess the impact of glycaemic control on these findings. **Materials and Methods:** This cross-sectional study included 42 adult patients with a clinical diagnosis of PTB and DM who underwent contrast-enhanced CT chest. Demographic and clinical details, including HbA1c levels for diabetic patients, were recorded. CT chest scans were evaluated for parenchymal findings (nodular opacities, consolidation, cavitation, etc.), bronchial abnormalities, lymphadenopathy, and pleural involvement. Statistical analysis was performed to compare findings between groups and to assess the association with glycaemic control (HbA1c $\leq 7\%$ vs $> 7\%$). **Result:** While overall CT findings such as nodular opacities, consolidation, and cavitation were prevalent in both groups, the distribution of lesions differed. When assessing the impact of glycaemic control, consolidation was more frequently distributed in superior segments (26% vs 14%, $p=0.517$), lingular segments (17% vs 0%, $p=0.237$), and the right middle lobe (23% vs 0%, $p=0.160$) in patients with uncontrolled DM (HbA1c $> 7\%$) compared to those with controlled DM (HbA1c $\leq 7\%$), although these differences were not statistically significant. **Conclusion:** Our study suggests that diabetic patients with pulmonary tuberculosis exhibit a distinct pattern of CT chest findings, particularly in the distribution of centrilobular nodules and cavitation. Although the influence of glycaemic control on specific CT findings did not reach statistical significance in our sample, likely due to the smaller number of patients with controlled DM, there was a trend towards more extensive consolidation in atypical locations in patients with poorer glycaemic control. Further studies with larger cohorts are warranted to definitively elucidate the role of glycaemic control in shaping the radiological presentation of PTB in diabetic individuals.

INTRODUCTION

Tuberculosis (TB) and Diabetes mellitus (DM) represent major global health challenges, with a particularly significant intersection in countries like India, which bears a substantial burden of both diseases. Approximately one-third of the world's

population is infected with Mycobacterium tuberculosis, making it a leading cause of death from a single infectious agent worldwide. Concurrently, the global prevalence of DM has nearly doubled since 1980, reaching 8.5% in the adult population. This increase has been notably rapid in low-income countries like India, which is also considered a TB-

endemic region, accounting for one-fourth of the global TB burden. The convergence of these two epidemics is evident in the estimated one million individuals globally who suffer from both active TB and DM. The coexistence of these conditions can lead to complex interactions, influencing both the clinical and radiological presentation of TB.^[1,2]

Numerous studies conducted over the past few decades have established that individuals with DM face an approximately threefold increased risk of developing active TB. Furthermore, DM has been associated with increased TB disease severity and potentially altered treatment outcomes. However, there is a relative paucity of research specifically investigating whether and how DM affects the diagnostic radiological findings of pulmonary TB.^[3,4] Understanding these alterations is crucial for timely and accurate diagnosis, especially in settings where both conditions are highly prevalent.

Multi-detector Computed Tomography (MDCT) has emerged as an invaluable tool for the assessment of pulmonary tuberculosis. Its ability to acquire high-resolution and isotropic volume data allows for detailed evaluation of pulmonary manifestations, often revealing findings that may be missed on plain radiographs. The application of various 3D image post-processing techniques further enhances the interpretation of MDCT data, making it ideal for a comprehensive assessment of PTB.^[5]

Given the high prevalence of both TB and DM in India, this study was designed with the primary purpose of comprehensively evaluating and comparing MDCT chest findings in pulmonary TB patients with and without DM within this specific endemic context. A secondary, and equally important, objective was to investigate the potential influence of glycaemic control, as assessed by glycosylated hemoglobin (HbA1c) levels, on the CT chest findings observed in diabetic patients with pulmonary tuberculosis. By elucidating these radiological characteristics, particularly in relation to glycaemic status, we aim to contribute to a more nuanced understanding of TB-DM co-morbidity and potentially improve diagnostic accuracy and clinical management strategies.

MATERIALS AND METHODS

Study Design and Setting: This study employed a cross-sectional design and was conducted in the Department of Radiodiagnosis, Maulana Azad Medical College and associated Lok Nayak Hospital, New Delhi.

Study Period and Population: The study was conducted over a period of one year. The study population comprised adult patients of either sex with a clinical diagnosis of pulmonary tuberculosis and diabetes mellitus who were referred to the Department of Radiodiagnosis, Lok Nayak Hospital for chest CT examination.

Sample Size: The study included 42 adult patients of pulmonary tuberculosis (PTB) with Diabetes mellitus

Inclusion Criteria

- Adult patients with a clinical diagnosis of pulmonary tuberculosis referred for CT chest who are known diabetics

Exclusion Criteria

- Patients coinfectd with HIV/AIDS or other underlying diseases or treatment causing immunosuppression (excluding DM).
- Patients with a significant allergic history and previous history of contrast allergy.
- Pregnant patients.
- Patients with markedly deranged Renal Function Tests (RFT)

Ethical Considerations and Consent: The study was conducted after obtaining approval from the Institutional Ethics Committee. The procedure was explained to each patient in their vernacular language, and written informed consent was obtained in every case prior to their participation. Confidentiality and privacy were ensured at all stages of the study.

Data Collection and Methodology: Relevant demographic and clinical details, including presenting symptoms (cough, sputum production, fever, weight loss, night sweats, loss of appetite, haemoptysis), were recorded for all patients using a structured proforma. For all diabetic patients, the glycaemic index, as reflected by the most recent HbA1c value, was noted.

Computed Tomography: Patients were examined after an overnight fast using a 128-slice multi-detector CT scanner. Intravenous administration of non-ionic iodinated contrast (1ml/kg) was performed. Images were acquired with the patient in a supine position during a single breath-hold. All images were displayed in mediastinal and lung window settings. High-resolution CT (HRCT) sections were also obtained by reconstruction with 1-mm slice thickness in the axial plane using a high spatial frequency bone algorithm. Sagittal and coronal reconstructions were also generated.

CT findings were systematically noted in all cases, encompassing:

- **Pulmonary findings**
 - Nodular opacities (Miliary nodules, Centrilobular nodules, Larger nodules, Calcified nodules)
 - Consolidation (Lobular/subsegmental or Segmental/lobar)
 - Cavitation (Single or Multiple in a single lesion)
 - Fibrotic opacities
 - Ground glass opacities
 - Emphysema
 - Bronchial abnormalities (Bronchiectasis and Bronchial wall thickening)
 - Other findings (e.g., Air-fluid level in cavity, Aspergilloma)

- **Extra-pulmonary findings**

- Mediastinal/hilar lymphadenopathy (Presence, Location, Pattern: homogenous/heterogeneous/rim enhancement, and Calcification)
- Pleural effusion
- Empyema
- Pleural thickening
- Pericardial effusion
- Other findings (e.g., Pott's spine)

The CT chest findings were associated with HbA1c levels, categorized into $\leq 7\%$ (controlled DM) and $>7\%$ (uncontrolled DM) based on the target for clinical control of diabetes mellitus.

The diagnosis of pulmonary tuberculosis was established based on one or more of the following criteria

1. Positive Sputum Acid-Fast Bacilli (AFB) smear.
2. Positive Sputum Cartridge Based Nucleic Acid Amplification Test (CB-NAAT).
3. Positive culture for Mycobacterium tuberculosis.
4. Fine Needle Aspiration Cytology (FNAC) or Histopathological Examination (HPE) findings consistent with TB.
5. Elevated Pleural Fluid Adenosine Deaminase (ADA) levels.
6. Clinical and radiological response to anti-tubercular treatment

Statistical Analysis: The collected data were entered into MS Excel and analyzed using SPSS 25 version. Qualitative variables were expressed as percentages and frequencies. The association between categorical variables was analysed using the Chi-square test or Fisher's exact test, with a p-value of ≤ 0.05 considered statistically significant and a 95% Confidence Interval (CI).

RESULTS

The study included a total of 42 adult patients with pulmonary tuberculosis (PTB) who had diabetes mellitus (DM). The diagnosis was confirmed through various microbiological, pathological, and clinical response criteria.

Demographics and Clinical Presentation: The age range of patients was 18 to 85 years, with a mean age of 54.8 years. This group included 24 males (57%) and 18 females (43%), giving a male-to-female ratio of approximately 4:3. The maximum number of patients in this group were in the 60-79 years' age range.

HbA1c values for the 42 diabetic PTB patients showed that 7 (17%) had levels $\leq 7\%$, 17 (40%) had levels between 7.1% and 8%, and 18 (43%) had levels between 8.1% and 9%. None had HbA1c $>9\%$. All patients, presented with cough. Sputum production was observed in 98% of patients. Fever was reported in 57% of patients. Loss of appetite was seen in 17% patients.

Sputum AFB was positive in 69% of patients. Sputum CB-NAAT positivity was 33%. Rest of the patients had positive results from culture, FNAC/HPE, or pleural fluid ADA levels or post-treatment clinical improvement.

Chest X-Ray Findings: A normal chest X-ray was observed in 15% of patients. The most common chest radiograph finding in was nodular opacities (43%), followed by consolidation (38%). Cavitation was seen in 14% of patients. Miliary nodules were not observed. Fibrotic opacities were seen in 17% of patients. Mediastinal widening and hilar prominence were sparingly seen. Pleural effusion was seen in 21 % of patients.

CT Chest Findings

All patients in exhibited some form of lung parenchymal abnormality on CT chest.

Overall Parenchymal Findings

Nodular opacities were seen in 93% of patients. Consolidation was present in 64% of patients. Cavitation was observed in 38% patients. Fibrotic opacities were seen in 16% patients. Ground glass opacities and emphysematous changes were infrequent (7% and 5% respectively).

Patterns of Nodular Opacities

Miliary nodules were less frequent (3%). The tree-in-bud pattern of centrilobular nodules was seen in 28% patients. Cavitary nodules and larger nodules ($>10\text{mm}$) were observed in around 13% and 10 % respectively. Calcific nodules were not observed.

Pattern of Consolidation and Cavitation

Lobular/subsegmental consolidation was noted in 55% patients. Segmental/lobar consolidation was seen in 24% patients. Cavitations were seen in 38% patients. Multiple cavities within a single lesion were seen in 21 % patients.

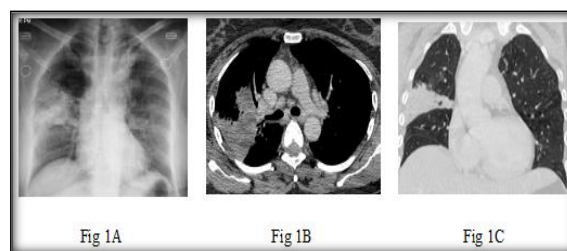


Figure 1: Chest X-ray shows near homogenous opacity in right mid zone (1A) and Contrast enhanced CT chest images: mediastinal (1B), and coronal MPR in window (1C) reveal, homogeneously enhancing enlarged subcarinal lymph nodes (1B), segmental consolidation of posterior segment of right upper lobe (all images).

Bronchial Abnormalities

Bronchiectasis was observed in 22% patients. Bronchial wall thickening was present in 24% of patients.

Lymphadenopathy

Mediastinal or hilar lymphadenopathy was noted in 71% patients. The most common location was subcarinal (87%), followed by right paratracheal (83%). Aorto-pulmonary window lymph node

involvement was there in 63% patients. The most common lymph nodal enhancement pattern was homogenous (77%). Calcified lymph nodes were uncommon (10%). Conglomeration of lymph nodes were seen in 27%.

Pleural Involvement

Pleural effusion was seen in 21% patients. Empyema was less frequent (7%). Pleural thickening was also less common (2%).

Distribution of Parenchymal Findings

Centrilobular nodules were seen in the right middle lobe (77%), basal segments of lower lobes (69%) and lingular segments (54%). Upper lobe involvement with centrilobular nodules was also observed in 92% patients.

Upper lobe consolidation was common (74%). Basal segment consolidation was seen in 41% patients.

Cavitation was seen in the upper lobes of 88% patients. Lingular distribution of cavities were noted in 31% patients.

CT Chest Findings with Respect to Glycaemic Index

Among the patients studied, centrilobular nodules were slightly more common in those with HbA1c $\leq 7\%$ (71%) compared to those with HbA1c $> 7\%$ (60%) ($p=0.511$). Conversely, consolidations were more frequent in patients with HbA1c $> 7\%$ (69%) than in those with HbA1c $\leq 7\%$ (43%) ($p=0.127$). Cavitations were more common in patients with HbA1c $\leq 7\%$ (57%) than those with HbA1c $> 7\%$ (34%) ($p=0.326$).

When analyzing the distribution of parenchymal findings in relation to glycaemic index in diabetic TB patients, centrilobular nodules were similarly distributed across lung lobes and segments in both HbA1c groups. However, consolidation was more frequently seen distributed in superior segments (26% vs 14%, $p=0.517$), lingular segments (17% vs 0%, $p=0.237$), and the right middle lobe (23% vs 0%, $p=0.160$) in patients with uncontrolled diabetes (HbA1c $> 7\%$) compared to those with controlled diabetes (HbA1c $\leq 7\%$), although these differences did not reach statistical significance.

Table 1: CT chest findings with respect to glycaemic index (HbA1c)

Findings	HbA1c $\leq 7\%$ (n=7)	HbA1c $> 7\%$ (n=35)	p-value
Centrilobular nodules	5(71%)	21(60%)	0.511
Consolidations	3(43%)	24(69%)	0.127
Cavitations	4(57%)	12(34%)	0.326
Total	12	57	

($p \leq 0.05$ – Significant, CI = 95 %)

Table 2: Distribution of parenchymal findings in relation with glycaemic index in Diabetic TB patients.

Findings		Glycaemic	Index	p-value
		≤ 7 (n=7)	> 7 (n=35)	
Centrilobular nodules	Upper lobes (excluding lingula)	4(57%)	20(57%)	1.000
	Superior segments	3(43%)	17(49%)	0.782
	Lingular segments	3(43%)	13(37%)	0.776
	Right middle lobe	3(43%)	15(43%)	1.000
	Basal segments	3(43%)	14(40%)	0.888
Consolidation	Upper lobes (excluding lingula)	3(43%)	16(47%)	0.890
	Superior segments	1(14%)	9(26%)	0.517
	Lingular segments	0	6(17%)	0.237
	Right middle lobe	0	8(23%)	0.160
	Basal segments	2(29%)	9(26%)	0.875

($p \leq 0.05$ – Significant, CI = 95 %).

DISCUSSION

The interplay between diabetes mellitus and tuberculosis has been recognized for a long time, and the increasing global prevalence of DM, particularly in TB-endemic regions like India, has heightened concerns about its impact on TB epidemiology, clinical presentation, and radiological manifestations.^[1,2] Our study aimed to described CT chest findings in PTB patients with DM in an Indian setting and to explore the influence of glycaemic control on these findings.

The clinical presentation, with cough being universal, is consistent with typical PTB.^[6] The higher prevalence of loss of appetite in diabetic patients could be attributed to the systemic effects of DM or altered inflammatory responses.^[7]

There was high frequency of fibrotic opacities in our patients on chest X-ray which might suggest a

potential for more chronic or altered disease progression in this group. The observation of normal chest X-rays in a notable proportion of patients underscores the importance of CT for a more sensitive evaluation, as these patients demonstrated CT abnormalities like centrilobular nodules and lymphadenopathy.

Our CT chest findings revealed that nodular opacities and consolidation were the most common parenchymal abnormalities, consistent with the literature⁸. There was predominant distribution of centrilobular nodules in the lingula, right middle lobe, and basal segments of lower lobes which suggests a tendency for more widespread and potentially atypical involvement in diabetic patients⁸. There was also higher frequency of cavitation in the upper lobes which could indicate a more aggressive or altered cavitary process. These findings corroborate observations from studies like Ikezoe et

al. (1992),^[9] and Wu et al. (2016),^[8] which reported a higher prevalence of non-segmental distribution and lower lobe involvement in diabetic TB patients. Intrathoracic lymphadenopathy was common, with the right paratracheal and subcarinal regions being the most frequently involved, which aligns with established patterns of tuberculous lymphadenitis.^[10] The homogenous enhancement pattern being more commonly observed in our study was in contrast with previous literature.^[11,12] The lower frequency of calcified lymph nodes in our patients could suggest a less contained or chronic form of lymph node disease. When examining the influence of glycaemic control, our study showed a trend towards a higher frequency of consolidation in superior segments, lingular segments, and the right middle lobe in patients with uncontrolled DM (HbA1c >7%) compared to those with controlled DM (HbA1c ≤7%), although these differences did not reach statistical significance. This observation aligns with the hypothesis that poorer glycaemic control might be associated with a more disseminated or atypical pattern of lung involvement.^[13] The lack of statistical significance could be attributed to the relatively small number of patients in the controlled DM group (n=7), limiting the power to detect subtle differences. Huang et al. (2017),^[14] also reported a higher likelihood of unusual findings and all-lobe involvement on CT scans in diabetic patients with HbA1c > 8%.

Limitations

Our study has certain limitations. The cross-sectional design limits the ability to establish temporal relationships. The sample size was relatively small, which might have affected the statistical power to detect significant associations, especially regarding the influence of glycaemic control. Furthermore, the study was conducted in a single tertiary care center, which might limit the generalizability of the findings.

CONCLUSION

This study provides a comprehensive description of CT chest findings in pulmonary tuberculosis patients with diabetes mellitus in India and explores the potential influence of glycaemic control in diabetic patients. Our findings suggest that diabetic patients with PTB exhibit a distinct pattern of CT chest involvement, characterized by a higher frequency of centrilobular nodules in the lingula, right middle lobe, and basal segments of the lower lobes. While the impact of glycaemic control on specific CT features did not reach statistical significance in our cohort, there was a notable trend towards more extensive consolidation in atypical locations in diabetic patients with poorer glycaemic control. This highlights the possibility that suboptimal glycaemic

management may contribute to a more disseminated and potentially challenging radiological presentation of PTB in diabetic individuals.

Further research with larger, multi-centric studies, including longitudinal follow-up and a greater representation of patients across the spectrum of glycaemic control, is warranted to definitively elucidate the intricate relationship between glycaemic status and the radiological manifestations of pulmonary tuberculosis in diabetic patients. A better understanding of these patterns can contribute to improved diagnostic accuracy, tailored management strategies, and ultimately better outcomes for individuals suffering from this dual burden of disease.

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