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Comparison of clinico-radiological profile of pulmonary tuberculosis in diabetic and non-diabetic patients in a tertiary care hospital – An observational analytical study

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ABSTRACT

Background: Diabetes mellitus (DM) is becoming more widely acknowledged as a significant comorbidity that negatively affects outcomes of pulmonary tuberculosis (PTB), which remains a significant worldwide health burden. The interplay between TB and DM modifies clinical, microbiological, and radiological characteristics, necessitating detailed evaluation. **Aims and Objectives:** The study aims to evaluate the impact of glycemic management on disease presentation and compare the clinico-radiological and microbiological profiles of PTB patients with and without DM. **Materials and Methods:** This observational, hospital-based study included adult patients newly diagnosed with PTB. Patients were stratified into diabetics and non-diabetics based on history and glycosylated hemoglobin levels. Data on clinical symptoms, sputum smear positivity, and chest radiographic findings were recorded. Diabetics were further categorized based on glycemic control. Statistical analyses were performed to identify differences between groups. **Results:** Diabetic patients had a higher prevalence of cough (98.1%), fever (87.0%), hemoptysis (35.2%), and weight loss (90.7%) compared to non-diabetics ($P<0.05$). Sputum positivity was significantly higher in diabetics (90%) than in non-diabetics (75%) ($P<0.001$). A higher bacillary load (3+smear grade) was observed in 50% of poorly controlled diabetics, compared to 30% of well-controlled diabetics and 20% of non-diabetics ($P<0.001$). Radiologically, diabetics showed more lower lung field involvement (31.5% vs. 10.2%) and multilobar disease (68.5% vs. 45.3%) compared to non-diabetics ($P<0.05$). **Conclusion:** More severe symptoms, larger bacillary loads, and extensive, unusual radiological presentations are linked to DM, especially when it is poorly controlled, in PTB. Hence, for the best care, early identification and stringent glycemic control are essential.

Key words: Pulmonary tuberculosis; Diabetes mellitus; Glycemic control; Bacillary load; Radiographic features

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INTRODUCTION

Despite being a preventable and curable illness, tuberculosis (TB) continues to pose a significant public health concern in India. With over 10 million new cases each year, TB is the world's top infectious agent-related cause of mortality.[1] A substantial risk factor for TB, diabetes mellitus (DM) doubles or triples the chance of getting active illness and raises the possibility of negative consequences such as delayed sputum conversion, treatment failure, relapse, and death.[2] Diabetes is listed as a priority condition for care and prevention initiatives in the global end TB

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Strategy.[3] Recognizing the biological plausibility of this association, the World Health Organization (WHO) and the International Union against TB and Lung Disease proposed a collaborative framework for TB and diabetes management,[4] and India's National Strategic Plan for TB Elimination also designates individuals with DM as a key affected group.[5] Despite the dual burden of TB and DM in India, clinical and radiological comparisons between diabetic and non-diabetic TB patients remain limited.

Aims and objectives

This study aims to estimate the proportion of diabetes among pulmonary TB patients at a tertiary care hospital in Kolkata and to compare the clinical presentation and radiological findings of pulmonary TB between diabetic and non-diabetic patients.

MATERIALS AND METHODS

This hospital-based observational analytical study with a cross-sectional design was conducted in the Department of Respiratory Medicine at a tertiary care hospital in Kolkata, West Bengal. The study spanned 18 months, comprising 1 month of preparation, 12 months of data collection, 3 months of data analysis, and 2 months of report writing.

Study population and sampling technique

Adult patients (aged >18 years) of all genders with microbiologically confirmed pulmonary TB (PTB) who attended the indoor or outdoor departments during the study period were included after providing informed consent. Data were collected on randomly selected 3 days/week, and all consecutive eligible patients on these days were enrolled. Based on patient records from January to March 2023, the estimated sample size for the study was 135.

Inclusion and exclusion criteria

Patients were included if they had microbiologically confirmed PTB diagnosed by smear microscopy, culture, or WHO-endorsed rapid molecular tests (such as Xpert *Mycobacterium tuberculosis*/rifampin or Truenat) and were aged over 18 years. Patients were excluded if they had extra-PTB, severe comorbidities (chronic renal failure, chronic heart disease, chronic liver disease, or cerebrovascular accident), or declined consent.

Definitions

DM was diagnosed based on WHO criteria: Fasting blood sugar (FBS) ≥126 mg/dL, 2-h plasma glucose ≥200 mg/dL during an oral glucose tolerance test, glycosylated hemoglobin (HbA1c) ≥6.5%, or random plasma glucose ≥200 mg/dL with symptoms of hyperglycemia.

Study tools

Data collection was done using a pre-structured case report form, which captured demographic information, clinical history, and examination findings. Radiological investigations included Chest X-ray (postero-anterior view) for all patients and high-resolution computed tomography (HRCT) of the Thorax (GE Healthcare Optima) when clinically indicated. Microbiological investigations involved sputum examination for acid-fast bacillus (AFB) (fluorescent microscopy) and cartridge-based nucleic acid amplification test (CBNAAT) testing (Cepheid India). Blood investigations included FBS, post-prandial blood sugar, HbA1c, and human immunodeficiency virus (HIV) testing (ICTC report).

Methodology

After obtaining approval from the Institutional Ethics Committee and informed consent from participants, data were collected systematically. Patients with clinical suspicion of PTB underwent sputum AFB and CBNAAT testing, and radiological imaging. Bronchoscopy was performed under local anesthesia in selected cases, with bronchial washings sent for microbiological testing. HbA1c levels and blood sugar readings were used to determine the presence of diabetes. PTB with and without DM were the two groups into which the patients were classified.

Outcome assessment

Age, gender, body mass index (BMI) (as defined by the Asia-Pacific categorization), place of residence, educational attainment, and occupation were among the demographic factors that were documented. According to the recommendations of the Indian Council of Medical Research (ICMR) India Diabetes Study, diabetes patients' glycemic control was categorized as good (HbA1c <7.0%), adequate (HbA1c 7.0–8.9%), or bad (HbA1c ≥9%). A symptom score (0–8) was calculated based on the presence of cough, hemoptysis, fever, night sweats, dyspnea, chest pain, anorexia, and weight loss, with scores ≥6 indicating highly symptomatic disease.

Radiological assessment

Chest X-rays were analyzed for lesion location (unilateral or bilateral), involved zones (upper, middle, or lower based on rib landmarks), extent of involvement (single zone, multi-zone, or extensive), and specific lesion types. HRCT Thorax was performed when necessary, including cases with normal chest X-ray but high clinical suspicion, hemoptysis, non-resolving lesions, or to differentiate from other lung diseases.

Ethics

The study protocol was reviewed and approved by the Institutional Ethics Committee of the institute

(IEC Approval no. CMSDH/IEC/55/05-2023). All procedures involving human participants were conducted in accordance with the ethical standards of the institutional ethics committee and with the Helsinki Declaration of 1975, as revised in 2013. Written informed consent was obtained from all participants before their inclusion in the study. No patient names, initials, or hospital numbers were used in any part of the data presentation or illustrative material to maintain confidentiality.

Statistical analysis

Collected data were entered into Microsoft Excel and summarized using tables, charts, and diagrams. Categorical variables were expressed as percentages/proportions, and continuous variables were presented as mean±standard deviation or median±interquartile range as appropriate. Statistical analysis was performed in SPSS statistical software (Version 26.0, IBM Corp., Armonk, NY, USA) using the Chi-square test or Fisher's exact test for categorical variables and independent t-test for continuous variables. A $P<0.05$ was considered statistically significant.

RESULTS

A total of 143 participants were included in the study. Eligibility was determined according to predefined inclusion and exclusion criteria. No participants were lost to follow-up, and complete datasets were available for analysis. Randomization and blinding procedures were not applicable given the observational nature of the study. The patient recruitment flow diagram, as per STROBE, is given in Figure 1.

Demographics

Of the 143 patients, 51 (35.7%) were diagnosed with DM, and 92 (64.3%) were non-diabetic. The mean age of the study population was 45.75±15.6 years. Patients with DM were significantly older (51.67±11.2 years) compared to those without DM (42.47±16.8 years, $P<0.001$). Only 3.9% of PTB with DM patients belonged to the 18–30 years age group compared to 31.5% of PTB without DM ($P=0.0013$), whereas 45.1% of PTB with DM patients were aged 41–50 years versus 23.9% in the non-DM group ($P=0.0100$). No significant age distribution differences were observed in other groups.

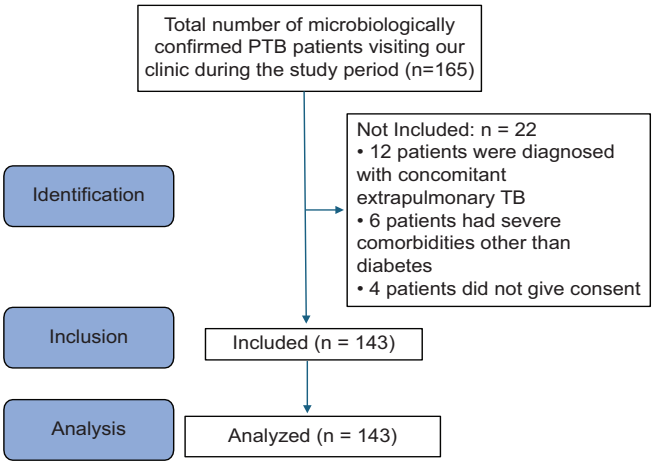

Figure 1: STROBE flow chart: Strengthening the reporting of observational studies in epidemiology. PTB: Pulmonary tuberculosis

Males constituted the majority of the study population (72.7%). Among PTB with DM patients, 70.6% were male and 29.4% were female, compared to 73.9% of males in PTB without DM ($P=0.832$). The mean age among males and females across DM and non-DM groups was comparable.

Regarding BMI, 53.1% of patients were underweight and 34.3% had a normal BMI. Overweight and obesity were more common in the DM group (19.6% overweight, 3.9% obese) compared to the non-DM group (6.5% overweight, no obesity), though the difference was not statistically significant ($P=0.3634$).

Rural residence was observed in 53.1% of patients, with no significant difference based on DM status. Educational status revealed that 51.7% had no formal schooling. Occupationally, 58.7% were manual laborers, 25.9% unemployed, and 15.4% salaried workers.

Baseline history

Addiction history showed 53.1% had a smoking history and 50.3% had alcohol use. Among PTB with DM patients, 56.9% were smokers and 54.9% consumed alcohol, compared to 51.1% and 47.8%, respectively, in the non-DM group ($P>0.05$ for both).

A past history of PTB was found in 27.3% of the study population, with no significant difference between DM and non-DM groups. Similarly, the history of contact with TB patients was comparable (15.7% in PTB with DM vs. 18.5% in PTB without DM).

HIV positivity was reported in 3.5% of patients. Although HIV positivity was higher among PTB with DM patients (7.8%) compared to non-DM (1.1%), the difference was not statistically significant ($P=0.0546$).

Among comorbidities, hypertension was significantly more common in PTB with DM patients (31.4%) than in those without DM (9.8%) ($P=0.0019$). Other comorbidities (chronic renal disease, ischemic heart disease, hypothyroidism, anemia, obesity, and dyslipidemia) were similarly distributed across groups.

A detailed comparison of the rest of the parameters between diabetic and non-diabetic PTB patients is outlined in Table 1 below.

Among PTB with DM patients, glycemic control based on HbA1c revealed that 58.8% had poor control, 25.5% had satisfactory control, and 15.7% had good control.

Presenting symptoms

Cough was nearly universal across all glycemic groups (P=0.737). Hemoptysis and dyspnea were significantly more frequent in the poor glycemic control group (70% and 76.7%, respectively; P=0.008 and P=0.038). Other symptoms (fever, night sweats, anorexia, and weight loss) did not show significant differences.

Radiological profiles

Bilateral lung lesions were most common among patients with poor glycemic control (73.3%), but the difference was not statistically significant (P=0.072). Single zone involvement was highest in good glycemic control patients (75%), whereas extensive lesions were more frequent in the poor control group (43.4%).

Chest X-ray analysis showed that lower zone involvement was significantly higher in the poor control group (83.3%) compared to satisfactory (76.9%) and good control (50%) (P=0.042). Upper and middle zone involvement did not differ significantly.

Radiological appearances such as consolidation, nodules, non-homogeneous infiltrates, and fibrosis were similarly distributed. However, cavity formation was significantly more common in the poor glycemic control group (66.7%) compared to the good control group (25%) (P=0.022).

Sputum AFB grading

Pre-treatment bacillary load varied significantly with glycemic control. Poor glycemic control patients showed the highest bacillary load (96.7% with 3+AFB, P<0.0001). In contrast, 25% of good glycemic control patients had negative sputum AFB (P=0.0268).

A detailed comparison of various features with a degree of glycemic control is given below in Table 2.

Chest X-ray zones and AFB grading

Negative sputum AFB cases predominantly had upper and middle zone involvement. 3+sputum positivity was associated with widespread involvement across upper (65.9%), middle (74.1%), and lower (77.6%) zones, though the difference was not statistically significant (Figure 2).

Extent of radiological involvement and AFB grading

Higher sputum grades were strongly associated with greater radiological severity. Patients with 3+sputum AFB had the highest rates of multi-zone (87.5%) and extensive lesions (93.5%) (P<0.0001). Negative sputum AFB cases were confined mainly to single-zone lesions (Figure 3).

DISCUSSION

In this study, a total of 143 subjects were included, and after conducting proper diabetic screening, it was found that 35.7% of the patients were diagnosed with DM. This suggests that diabetes impacted about one-third of the

Table 1: Distribution of baseline parameters between diabetic and non-diabetic pulmonary tuberculosis patients (n=143)

Parameter	DM (n=51) (%)	Non-DM (n=92) (%)	P-value
Presenting symptoms			
Cough	48 (94.1)	89 (96.7)	0.467
Hemoptysis	26 (51)	34 (37)	0.097
Fever	48 (94.1)	89 (96.7)	0.467
Night sweats	30 (58.8)	53 (57.6)	0.889
Dyspnea	33 (64.7)	38 (41.3)	0.007*
Chest pain	18 (35.3)	36 (39.1)	0.640
Anorexia	35 (68.6)	55 (59.8)	0.307
Weight loss	34 (66.7)	55 (59.8)	0.446
Radiological profile			
Bilateral lesions	32 (62.7)	37 (40.2)	0.011*
Lower zone involvement	39 (76.5)	46 (50)	0.002*
Cavity formation	26 (51)	34 (37)	0.097
Pre-treatment bacillary load (sputum AFB grading)			
Negative	5 (9.8)	9 (9.8)	1.000
Scanty	0 (0)	6 (6.5)	0.092
1+	2 (3.9)	7 (7.6)	0.352
2+	7 (13.7)	17 (18.5)	0.460
3+	37 (72.5)	53 (57.6)	0.001*

*–P<0.05, DM: Diabetes mellitus, AFB: Acid fast bacillus

Table 2: Distribution of symptoms and radiological profile of diabetic TB patients based on glycemic control (n=51)

Parameter	Good control (n=8) (%)	Satisfactory control (n=13) (%)	Poor control (n=30) (%)	P-value
Presenting symptoms				
Cough	8 (100)	12 (92.3)	28 (93.3)	0.737
Hemoptysis	2 (25)	3 (23.1)	21 (70)	0.008*
Fever	7 (87.5)	12 (92.3)	29 (96.7)	0.588
Night sweats	4 (50)	7 (53.8)	19 (63.3)	0.532
Dyspnea	4 (50)	6 (46)	23 (76.7)	0.038*
Chest pain	4 (50)	3 (23.1)	11 (36.7)	0.442
Anorexia	7 (87.5)	9 (69.2)	19 (63.3)	0.238
Weight loss	7 (87.5)	7 (53.8)	20 (66.7)	0.283
Radiological profile				
Bilateral lesions	4 (50)	6 (46.2)	22 (73.3)	0.072
Lower zone involvement	4 (50)	10 (76.9)	25 (83.3)	0.042*
Cavity formation	2 (25)	4 (30.8)	20 (66.7)	0.022*
Pre-treatment bacillary load (sputum AFB grading)				
2+	4 (50)	2 (15.4)	1 (3.3)	0.0029*
3+	1 (12.5)	10 (76.9)	29 (96.7)	<0.0001*

*P<0.05, AFB: Acid fast bacillus

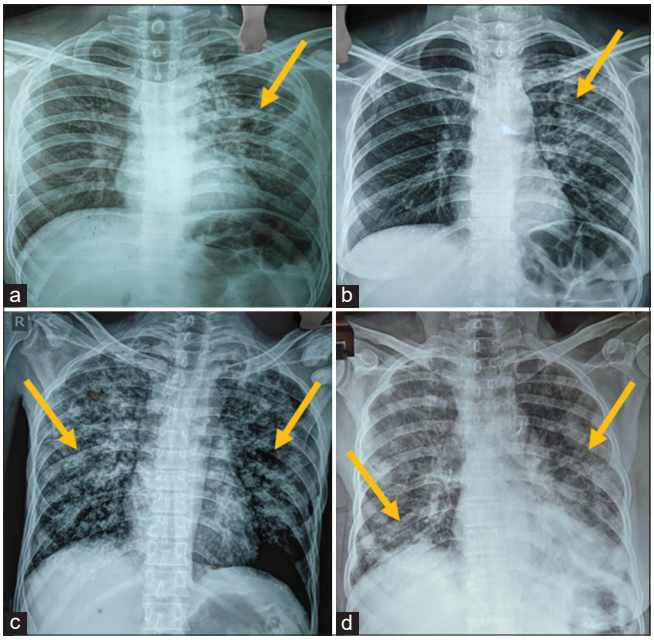

Figure 2: Chest X-ray postero-anterior view of four patients with pulmonary tuberculosis (lesions shown by yellow arrows). (a) and (b) are radiographs of patients who had negative sputum acid-fast bacillus showing predominantly upper and mid-zone unilateral infiltrates on the left lung. (c) and (d) radiographs show extensive bilateral infiltrates of patients who had 3+sputum acid-fast bacillus positivity

individuals in this study. On the other hand, 64.3% of the patients were non-diabetic, meaning that the majority (just over two-thirds) of the patients did not have diabetes.

The observed 35.7% prevalence of diabetes in this study is notably higher than the estimated 11.4% diabetes prevalence in the general population of India, as reported by the ICMR.[6] In a similar vein, diabetes prevalence ranged from 10% to 20% among TB patients in an Indian research.[7] Nearly half (44%) of TB patients had a diabetes diagnosis, according to a Kerala study.[8] Globally, the prevalence of diabetes among TB patients was around 15% in 2019.[9] This demonstrates a global trend of increased diabetes prevalence in TB patients, which has important implications for health-care management.

Furthermore, 58.8% of the diabetes patients in this study had increased blood glucose levels, indicating a considerable proportion of them had poor glycemic control. This finding is comparable to other studies reporting poor glycemic control among TB-diabetes comorbid patients.[10] In the younger age group (18–30 years), individuals with both PTB and DM accounted for only 3.9%, significantly lower compared to those without DM (P=0.0013). Conversely, in the 41–50 years age group, the prevalence of both PTB and DM was 45.1% (P=0.0100), highlighting that middle-aged individuals are more susceptible to both diseases.[11] The mean age of diabetics was higher than that of non-diabetics, consistent with several previous studies.[12]

In the present study, 72.7% of TB cases occurred in males, with a higher prevalence of diabetes among male TB patients (70.6%). Similar male predominance has been documented in other studies.[13]

53.1% of the study participants resided in rural areas; however, no significant difference was found in TB occurrence between diabetic and non-diabetic groups based on rural–urban residence.[14] Notable occupational and socioeconomic factors included the prevalence of manual labor and unemployment. PTB patients also had a high prevalence of low BMI (underweight); irrespective of whether they had diabetes.[15] Most patients were experiencing their first episode of TB. Although diabetic

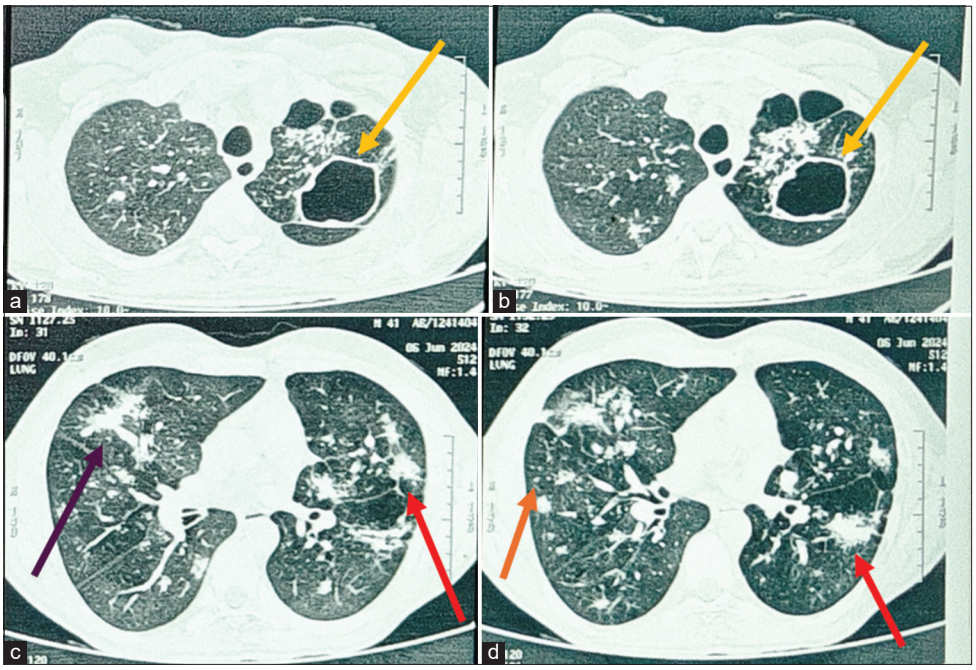

Figure 3: Computed tomography scan thorax sections of a 41-year-old poorly controlled diabetic male with 3+ sputum acid-fast bacillus positivity. Sections (a) and (b) show the left upper lobe large empty cavities with satellite lesions characteristic of tuberculosis (yellow arrows). Section (c) and (d) shows dense tree-in-bud opacities (plum arrow) and consolidation (red arrows) and numerous randomly distributed nodules (orange arrow)

patients are biologically at a higher risk of TB reactivation, this study did not find a significant difference in prior TB history between diabetic and non-diabetic patients.[16] Alcohol consumption and smoking were prevalent in the study sample, especially among male diabetic PTB patients, which may make TB outcomes even more difficult.

Cough (94.1% vs. 95.7%) and fever (94.1% vs. 92.4%) were the most prevalent symptoms among PTB patients with and without DM, without significant differences (P=0.683 and P=0.698). This is consistent with Nielsen et al.,[17] and Mohapatra et al.,[18] who noted similar symptom profiles. Anorexia was also frequent (68.6% vs. 72.8%), aligning with findings from Raza et al.[19] Night sweats appeared less common in diabetics (58.8% vs. 72.8%, P=0.085), potentially reflecting immune dysfunction. Weight loss and dyspnea were comparable between groups, corroborating Rajaa et al.[20] A significant observation was the higher hemoptysis rate among diabetics (50.1% vs. 26.1%, P=0.002), similar to findings by Siddiqui et al.[21] Poor glycemic control further intensified symptoms such as hemoptysis and dyspnea, consistent with the reports of Park et al.[22] However, total symptom scores remained comparable.

In line with the findings of Vulli et al.,[23] and Nair et al.,[24] diabetic patients had a greater bacillary burden, with 78.4% exhibiting 3+sputum AFB values compared to 50% of non-diabetics. Hyperglycemia is known to impair innate and adaptive immunity, enhancing bacillary proliferation.

Consistent with the findings of Saxena et al.,[25] diabetic patients had a higher incidence of lower lobe lung involvement (76.5% (DM) vs 50.0% (non-DM)) and bilateral disease (62.7% (DM) vs 40.2% (non-DM), P<0.05) in chest X-ray and CT scans in our study. In addition, diabetics exhibited features such as consolidation and cavitation, multiple-zone involvement, and more widespread illness. More extensive radiological findings were associated with poorer glycemic control. Thus, diabetes, particularly with poor glycemic control, significantly impacts the clinical, microbiological, and radiological profiles of PTB.

Strengths

The present study has several notable strengths. It comprehensively compares the clinical, microbiological, and radiological profiles of PTB patients with and without DM, highlighting the significant impact of DM, particularly poor glycemic control, on disease severity. The inclusion of symptomatology, bacillary load, and radiographic findings provides a multidimensional assessment rarely captured together in a single study. The study also benefits from a robust sample size and the use of standardized diagnostic criteria for both PTB and DM, ensuring the reliability and reproducibility of findings. Furthermore, by analyzing the effect of glycemic control within the diabetic cohort, the study offers valuable insights into the spectrum of TB manifestations influenced by varying metabolic states.

Limitations of the study

However, some limitations must be acknowledged. As a hospital-based, observational study, it is susceptible to selection bias, and the findings may not be entirely generalizable to community settings. Glycemic control was assessed at a single time point, which may not fully capture fluctuations in glucose levels that could influence disease presentation. The study also did not account for potential confounders such as the duration of diabetes, the presence of diabetic complications, nutritional status, or use of immunosuppressive medications, all of which might independently modify the course of TB. In addition, longitudinal follow-up to assess treatment outcomes, relapse rates, or mortality differences between diabetics and non-diabetics was not conducted, which would have further strengthened the clinical relevance of the findings. Microbiological assessments were limited to smear microscopy, without incorporating more sensitive tools such as culture or molecular diagnostics, which could have provided additional depth to bacillary load estimation.

CONCLUSION

The study underscores the substantial influence of DM on the clinical course of PTB. Diabetics, especially those with poor glycemic control, tend to exhibit more severe symptoms, higher bacillary loads, and extensive, atypical radiographic patterns compared to non-diabetics. These findings highlight the need for heightened clinical vigilance, early diagnosis, and integrated management of TB-DM comorbidity. Routine screening for diabetes in TB patients and vice versa may facilitate earlier interventions and better outcomes. Future multicenter, prospective studies incorporating detailed glycemic profiles, long-term follow-up, and advanced microbiological techniques are warranted to validate and extend these findings. Overall, the study adds valuable evidence to the growing body of literature on the intersection between TB and diabetes and emphasizes the importance of comprehensive, patient-centered approaches in managing this dual burden.

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AIB- Definition of intellectual content, literature survey, prepared first draft of manuscript, implementation of study protocol, data collection, and data analysis; **AR-** Definition of intellectual content, concept, design of study, statistical analysis, and interpretation; **AP-** Concept, design of study, clinical protocol, manuscript preparation, editing, and manuscript revision; **SB-** Statistical analysis and interpretation, manuscript preparation, review of manuscript, and submission of article; **AKD-** Definition of intellectual content, concept, design, clinical protocol, and review manuscript.

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