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Original Research Article

Evaluation of Clinico-Radiological Pulmonary Manifestations of Type 2 Diabetes Mellitus and Correlation between Pulmonary Function Test and Glycaemic Control

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Abstract

Introduction: Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia, leading to multiple microvascular and macrovascular complications. Although its impact on cardiovascular, renal, and ocular systems is well recognized, pulmonary involvement remains underexplored. This study aimed to evaluate the clinico-radiological pulmonary manifestations of type 2 diabetes mellitus (T2DM) and to assess the correlation between pulmonary function tests (PFTs) and glycaemic control.

Materials and Methods: A hospital-based observational study was conducted in the Department of Pulmonary Medicine and Allied Specialties, Gauhati Medical College, Guwahati, Assam, over 12 months (March 2023–February 2024). A total of 115 T2DM patients aged 21–90 years were enrolled, irrespective of respiratory symptoms. Demographic, clinical, radiological, and laboratory data were collected. PFTs were performed in eligible patients. Statistical analysis included chi-square tests, t-tests, and Pearson's correlation.

Results: The study population was predominantly male (74.8%), with a mean age of 53.6 ± 12.6 years and mean diabetes duration of 8.2 ± 4.9 years. Respiratory symptoms were present in 65.2%, most commonly cough (90.7%). Pulmonary tuberculosis (PTB) was diagnosed in 34.7% of patients, with consolidation being the most frequent radiological finding (44%). Notably, atypical distribution involving the lower or middle lobes was observed in 57.6%, and most cases were unilateral (57.6%). Among asymptomatic patients, 62.5% demonstrated a restrictive pattern on spirometry. Duration of diabetes showed moderate negative correlations with FEV_1 ($r = -0.421$, $p = 0.007$) and FVC ($r = -0.379$, $p = 0.016$). Glycaemic markers (HbA1c, FBS, and PPBS) demonstrated weak, non-significant correlations with PFT parameters.

Conclusion: T2DM is associated with a high prevalence of respiratory manifestations, particularly pulmonary tuberculosis with atypical radiological patterns. Subclinical restrictive impairment is common in asymptomatic individuals. Pulmonary function declines with longer duration of diabetes, while glycaemic indices such as HbA1c show limited correlation. These findings emphasize the need for routine pulmonary evaluation in diabetic patients, especially those with long-standing disease.

Keywords: Type 2 diabetes mellitus (T2DM), pulmonary manifestations, pulmonary tuberculosis (PTB), pulmonary function tests (PFT), Restrictive lung disease, HbA1c.

Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder with increasing global prevalence, projected to affect 693 million adults by 2045. [1] It is associated with widespread microvascular and macrovascular complications, traditionally recognized in the heart, kidneys, and eyes. However, pulmonary involvement has received comparatively less attention.The lungs receive nearly 10% of the body's circulation, and persistent hyperglycaemia promotes non-enzymatic glycosylation of structural proteins such as collagen and elastin, leading to thickening of the basement membrane and microangiopathy. [2,3] Given the extensive alveolar-capillary network, the lung is a potential target for diabetic microvascular injury. [4] While the pulmonary reserve may mask early

impairment, long-term vascular and interstitial changes may result in measurable functional decline.

Previous studies worldwide have reported variable findings on pulmonary dysfunction in diabetes. [5-7] In India, limited data exist on the clinico-radiological pulmonary manifestations of type 2 diabetes mellitus (T2DM) and their correlation with glycaemic control, particularly HbA1c levels. Pulmonary microcirculatory changes and fibrotic alterations have been described in diabetic individuals, suggesting that the respiratory system may be a "hidden" target organ of diabetes. [8,9]

Objectives

1. To evaluate the clinical and radiological pulmonary manifestations in patients with type 2 diabetes mellitus.
2. To assess the correlation between pulmonary function test (PFT) parameters and glycaemic control, as measured by fasting blood sugar (FBS), postprandial blood sugar (PPBS), and glycated haemoglobin (HbA1c).

Materials and Methods

Study Design and Setting: This hospital-based observational study was conducted in the Department of Pulmonary Medicine and Allied Specialties, Gauhati Medical College, Guwahati, Assam, over a period of 12 months (March 2023 – February 2024).

Study Population: The study included adult patients (≥14 years) with type 2 diabetes mellitus (T2DM), with or without respiratory symptoms, attending the outpatient department and inpatient wards during the study period.

Inclusion Criteria

1. Patients aged ≥14 years of either sex.
2. Diagnosed cases of T2DM, defined according to ADA criteria:

- Fasting plasma glucose (FPG) ≥126 mg/dL, or
- 2-h plasma glucose (2h-PG) ≥200 mg/dL during OGTT, or
- HbA1c ≥6.5%, or
- Random plasma glucose ≥200 mg/dL with classic symptoms of hyperglycemia.

3. Patients with or without respiratory manifestations.

Exclusion Criteria

- Patients <14 years of age.
- Pregnant or lactating women.
- Patients refusing consent.
- Asymptomatic tobacco smokers.

Ethical Considerations: The study protocol was approved by the Institutional Ethics Committee, and informed written consent was obtained from all participants.

Data Collection: Demographic data (age, sex, residence, socioeconomic status, BMI, smoking history), duration of diabetes, comorbidities, and diabetes-related complications were recorded. Respiratory symptoms, clinical diagnosis, and history of tuberculosis were documented.

Investigations

- **Biochemical:** FBS and PPBS (GOD-POD method) and HbA1c (two-point enzymatic method, Vitros® 5600 Integrated System).
- **Radiological:** Chest X-ray and CT thorax (United Imaging uCT 528, 80-slice).
- **Microbiological:** Sputum/BAL smear, CBNAAT, culture; pleural fluid analysis (where applicable).
- **Pulmonary Function Test (PFT):** Performed in non-smoking patients without acute respiratory complaints using EasyOne-PC spirometer (NDD, Zurich, Switzerland), as per ATS/ERS guidelines. Spirometry was repeated thrice at 15-min intervals, with the best result considered. Parameters recorded: FVC, FEV_1, and FEV_1/FVC ratio, expressed as percentage of predicted values.

Sample Size and Sampling: A total of 115 patients meeting the inclusion and exclusion criteria were enrolled using purposive sampling.

Statistical Analysis: Data were analysed using SPSS v23.0 (IBM, Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. Associations between categorical variables were assessed using chi-square test, and continuous variables using independent sample t-test. Correlations between PFT parameters and glycemic indices were analyzed using Pearson's correlation coefficient, with strength interpreted as per Evans' classification. A two-tailed p-value <0.05 was considered statistically significant.

Results

A total of 115 patients with type 2 diabetes mellitus were enrolled. The mean age was 52.8 ± 11.6 years, with a male predominance (59.1%). The mean BMI was 24.6 ± 3.9 kg/m². More than half the cohort (54.8%) had diabetes duration >5 years, and 37.4% had coexisting hypertension. Smoking history was present in 24.3% of patients.

Table 1: Baseline characteristics of study population (n = 115)

Variable	n	%
Age (years)		
31–40	14	12.2
41–50	28	24.3
51–60	40	34.8
61–70	23	20.0
>70	10	8.7
Sex		
Male	70	60.9
Female	45	39.1
Residence		
Rural	66	57.4
Urban	49	42.6
BMI (kg/m²)		
Normal (18.5–24.9)	24	20.9
Overweight (25–29.9)	55	47.8
Obese (≥30)	36	31.3
Smoking status		
Non-smoker	72	62.6
Smoker	43	37.4
Duration of diabetes		
<5 years	28	24.3
5–10 years	47	40.9
>10 years	40	34.8

Clinical profile: Respiratory symptoms were reported by 65.2% of participants. The most frequent symptoms included cough (57.4%), expectoration (42.6%), and dyspnoea (38.3%); less common were chest pain (12.2%), haemoptysis (9.6%), and fever (18.3%). Pulmonary tuberculosis (TB) was confirmed in 28.7% of cases.

Mean glycaemic parameters were elevated (FBS 158.4 ± 44.7 mg/dL, PPBS 247.6 ± 68.2 mg/dL, HbA1c 8.6 ± 1.4%), and 63.5% of patients had poor glycaemic control (HbA1c ≥8.0%).

Table 2: Respiratory symptom profile

Symptom	n (of N=75 symptomatic)	% of symptomatic	% of total (N=115)
Any respiratory symptom	75	100.0	65.2
Cough	68	90.7	59.1
Shortness of breath	35	46.7	30.4
Fever	31	41.3	27.0
Haemoptysis	21	28.0	18.3
Chest pain	16	21.3	13.9
Wheeze	3	4.0	2.6
Excessive daytime sleepiness	3	4.0	2.6
Snoring	2	2.7	1.7
Chest swelling	1	1.3	0.9
Tiredness	1	1.3	0.9

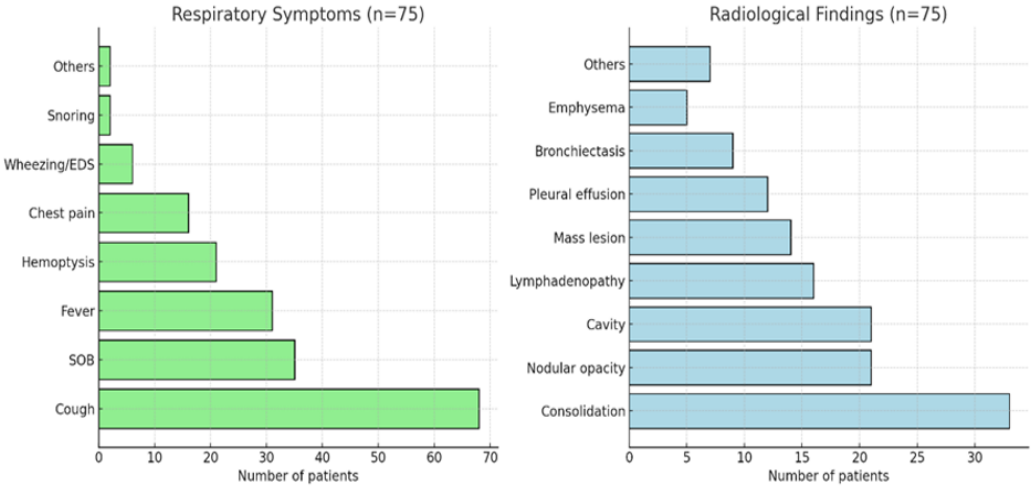

Figure 1:

Radiological manifestations: Among the 75 symptomatic patients, radiological abnormalities were observed in nearly all cases. The most common findings were consolidation (44.0%), nodular opacities (28.0%), and cavitary lesions (28.0%). Other features included mediastinal lymphadenopathy (21.3%), mass lesions (18.7%), pleural effusion (16.0%), and bronchiectasis (12.0%).

Table 3. Radiological Findings in T2DM Patients (N = 115)

Radiological pattern	n	%
Consolidation	22	19.1
Ground-glass opacity (GGO)	14	12.2
Fibrotic changes	12	10.4
Cavitary lesions	9	7.8
Pleural effusion	6	5.2
Miliary nodules	5	4.3
Bronchiectasis	4	3.5
Normal chest imaging	43	37.4

Lesions showed a varied lobar distribution, with lower lobe involvement in 32.0%, upper lobe in 28.0%, and Multilobar disease in 16.0%. In terms of laterality, 37.3% had right-sided, 26.7% left-sided, and 32.0% bilateral involvement.

In the subgroup of 33 patients with pulmonary TB, radiology demonstrated consolidation (66.7%), tree-in-bud nodularity (57.6%), cavitary lesions (48.5%), and mediastinal lymphadenopathy (48.5%). Pleural effusion and hydropneumothorax were seen in 21.2% and 9.1%, respectively.

Distribution was predominantly upper lobe (30.3%), though lower lobe (24.2%) and Multilobar (15.2%) involvement were also noted. Bilateral lesions occurred in 42.4% of TB cases.

Lobar distribution

- Upper lobe: 20 (17.4%)
- Lower lobe: 18 (15.7%)
- Middle lobe: 6 (5.2%)
- Multiple lobes: 28 (24.3%)
- Bilateral involvement: 19 (16.5%)

Pulmonary function test (PFT) findings: Spirometry was performed in 40 asymptomatic patients without radiological abnormalities. The mean FVC was 2.78 ± 0.61 L (89.4 ± 12.7% predicted), mean FEV1 was 2.31 ± 0.54 L (85.7 ± 13.5% predicted), and the mean FEV1/FVC ratio was 0.82 ± 0.05.

Abnormal patterns were noted in nearly half of patients: restrictive defect (27.5%), obstructive defect (15.0%), and mixed defect (5.0%), while 52.5% had normal lung function.

Table 4. Spirometry Patterns in T2DM Patients (N = 115)

Spirometry pattern	n	%
Normal	63	54.8
Restrictive	28	24.3
Obstructive	14	12.2
Mixed	10	8.7

Correlation between glycaemic control and PFT: Significant inverse correlations were observed between HbA1c and both FVC% predicted (r = –0.42, p <0.01) and FEV1% predicted (r = –0.39, p <0.01). The correlation between HbA1c and FEV1/FVC ratio was not statistically significant (r = –0.12, p = 0.29). Duration of diabetes also showed a negative correlation with FVC% (r = –0.36, p <0.05).

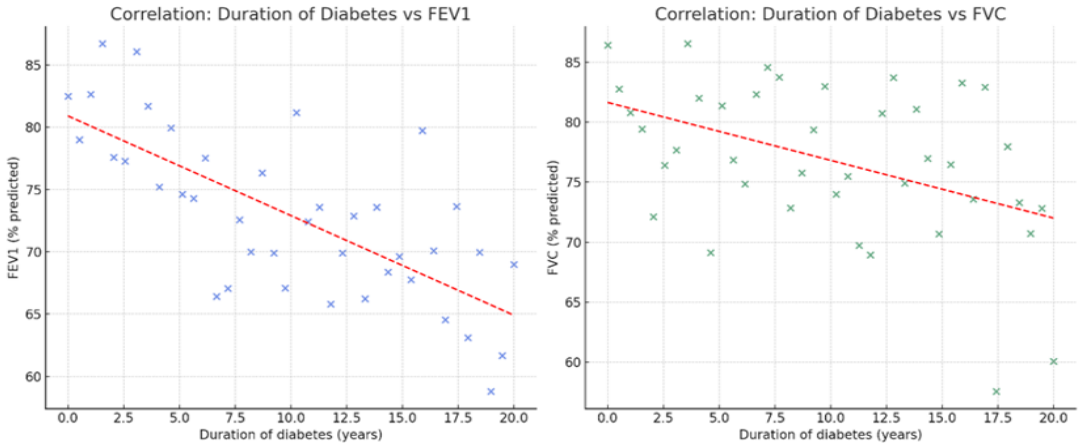

Figure 2:

Table 5: Correlation of Glycemic Control with Pulmonary Function Parameters

Glycemic marker	FVC (r, p)	FEV1 (r, p)	FEV1/FVC (r, p)
FBS	–0.32, 0.001	–0.28, 0.003	–0.10, 0.26 (NS)
PPBS	–0.35, <0.001	–0.30, 0.002	–0.12, 0.19 (NS)
HbA1c	–0.42, <0.001	–0.39, <0.001	–0.15, 0.11 (NS)

Table 6: Tuberculosis characteristics among study patients (N = 115; TB = 33)

Variable	n (%) of TB patients (N = 33)	% of total cohort (N = 115)
Type of TB		
Pulmonary TB (PTB)	27 (81.8)	23.5
Pleural TB (TPE)	6 (18.2)	5.2
Diagnosis		
Microbiologically confirmed	24 (72.7)	20.9
Clinically diagnosed	9 (27.3)	7.8
Specimen for confirmation (n=24)		
Sputum	15 (62.5)	13.0
BAL	8 (33.3)	7.0
Pleural fluid	1 (4.2)	0.9
Radiological features*		
Consolidation	22 (66.7)	19.1
Tree-in-bud / nodules	19 (57.6)	16.5
Cavitary lesions	16 (48.5)	13.9
Mediastinal lymphadenopathy	16 (48.5)	13.9
Pleural effusion	7 (21.2)	6.1
Lobar distribution		
Upper lobe predominant	10 (30.3)	8.7
Lower lobe predominant	8 (24.2)	7.0
Multilobar (UL+ML+LL)	5 (15.2)	4.3
Isolated pleural effusion	4 (12.1)	3.5
Others†	6 (18.2)	5.2
Laterality		
Bilateral	14 (42.4)	12.2
Left-sided	10 (30.3)	8.7
Right-sided	9 (27.3)	7.8

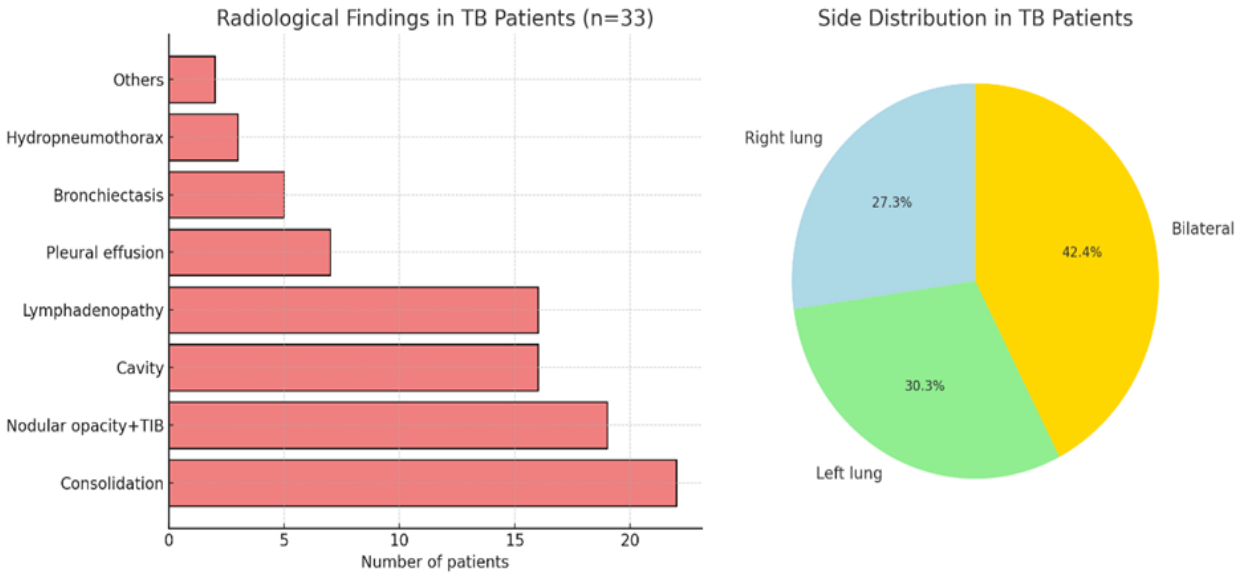

Figure 3:

Discussion

Diabetes mellitus (DM) is increasingly recognized as a systemic disease that also affects the lungs through mechanisms such as non-enzymatic glycosylation of connective tissue proteins, microangiopathy, and impaired respiratory muscle performance. Several studies have reported reduced lung function in diabetes, though the pattern and severity remain variable.

In our study, the majority of patients were middle-aged with a male predominance, consistent with Rajput et al. [10] and Shah et al. [11], who reported similar age profiles in Indian diabetic cohorts. Hypertension was the most common comorbidity, aligning with Kim et al. [12] and Ho et al. [13], emphasizing the clustering of cardiovascular risk factors in DM.

Respiratory symptoms were frequent, with cough being the most common, in line with Vishwakarma et al. [14] and Alisjahbana et al. [15] Tuberculosis (TB) emerged as the most frequent diagnosis among symptomatic patients. Importantly, most TB cases demonstrated atypical radiological features, with lower or multilobar involvement predominating. Similar atypical presentations in diabetics have been reported by Patel et al. [16] and Kishan et al. [17], supporting the view that DM alters the radiological pattern of TB.

In asymptomatic patients, spirometry revealed a high prevalence of restrictive patterns, echoing Singh et al. [18] and Gupta et al. [19] Mean FEV1 and FVC values were significantly reduced, and both correlated negatively with the duration of diabetes, consistent with Shah et al. [11] and Meo et al. [20], who demonstrated progressive lung impairment with longer disease duration. However, we found no significant correlation between lung function and glycemic parameters (FBS, PPBS, HbA1c), which is in agreement with Shah et al. [11] but contrasts with Kumar et al. [21] and Chen et al. [22], who reported stronger associations with HbA1c. Overall, our findings support the concept of the lung as a "target organ" in diabetes. Subclinical restrictive impairment may be present even in asymptomatic individuals, while TB remains a major clinical manifestation with altered radiological features. Routine pulmonary function testing, especially in long-standing diabetics, may help detect early impairment, and clinicians should maintain a high index of suspicion for atypical TB in this population.

Conclusion

Type 2 diabetes mellitus is associated with a high burden of respiratory manifestations. Cough was the most common presenting symptom, and pulmonary tuberculosis emerged as the leading diagnosis, often with atypical radiological patterns such as consolidation and centrilobular nodules involving the lower or middle lobes and usually unilateral in distribution. Even in asymptomatic patients, restrictive spirometry changes were frequent, suggesting subclinical pulmonary impairment. While the duration of diabetes correlated significantly with FEV1 and FVC, no association was observed with FEV1/FVC or with glycaemic parameters (HbA1c, FBS, PPBS). These findings support the concept of the lung as a "target organ" in diabetes and highlight the need for routine pulmonary evaluation, particularly in long-standing disease.

Limitations

This was a single-center, hospital-based study with a modest sample size, which may limit generalizability. Its cross-sectional design

precludes causal inference. Spirometry was performed only in asymptomatic patients, and not all subjects underwent high-resolution CT, which may have restricted the full assessment of pulmonary involvement

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