



Original Article

Correlation Between HbA1c Levels and Pulmonary Function Tests in Patients with Type 2 Diabetes Mellitus

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder associated with various microvascular and macrovascular complications. Emerging evidence suggests that the lungs may also be affected in diabetes due to chronic hyperglycemia and connective tissue alterations.

Objectives: To evaluate pulmonary function parameters in patients with Type 2 Diabetes Mellitus and assess their association with HbA1c levels.

Materials and Methods: A hospital-based cross-sectional observational study was conducted among 120 patients with Type 2 Diabetes Mellitus attending a tertiary care teaching hospital. HbA1c estimation was performed using standardized laboratory methods. Pulmonary function tests were assessed using computerized spirometry. Parameters including Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), FEV1/FVC ratio, Peak Expiratory Flow Rate (PEFR), and Forced Expiratory Flow 25–75% (FEF25–75%) were recorded. Statistical analysis was performed using ANOVA and Pearson's correlation test.

Results: The mean age of the study participants was 54.3 ± 8.7 years and the mean HbA1c level was $8.4 \pm 1.6\%$. Pulmonary function parameters including FVC, FEV1, PEFR, and FEF25–75% showed significant reduction in patients with higher HbA1c levels ($p < 0.05$). The mean FVC and FEV1 values were 76.5 ± 11.8 and 73.4 ± 12.2 respectively. FEV1/FVC ratio remained relatively preserved and did not show statistically significant variation, suggesting predominantly restrictive pulmonary involvement in diabetic patients.

Conclusion: Poor glycemic control was associated with reduced pulmonary function in patients with Type 2 Diabetes Mellitus. Periodic pulmonary function assessment along with regular HbA1c monitoring may help in early detection of subclinical pulmonary involvement in diabetic patients.

Keywords: Type 2 Diabetes Mellitus, HbA1c, Pulmonary Function Test, Spirometry, FVC, FEV1, PEFR, Diabetes Mellitus.

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from insulin resistance and impaired insulin secretion. The prevalence of diabetes has increased rapidly worldwide, especially in developing countries such as India, making it a major public health concern. Chronic hyperglycemia leads to microvascular and macrovascular complications affecting multiple organs including the kidneys, retina, nerves, cardiovascular system, and lungs.[1,2]

The lungs are increasingly recognized as a potential target organ in diabetes because of their extensive microvascular network and abundant connective tissue. Persistent hyperglycemia causes non-enzymatic glycosylation of collagen and elastin within the pulmonary interstitium, leading to reduced lung elasticity and pulmonary compliance. Diabetic microangiopathy, oxidative stress, and chronic low-grade inflammation may further contribute to structural and functional alterations in the respiratory system.[3,4]

Pulmonary function tests (PFTs) are simple, non-invasive methods used to assess respiratory function. Spirometric parameters such as Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), FEV1/FVC ratio, and Peak Expiratory Flow Rate (PEFR) are commonly used to evaluate pulmonary involvement. Several studies have reported reduced FVC and FEV1 values in diabetic patients, suggesting predominantly restrictive pulmonary impairment.[5,6]

The reduction in pulmonary function among diabetic patients may be attributed to thickening of the alveolar epithelial basal lamina, reduced pulmonary capillary blood volume, autonomic neuropathy affecting respiratory muscles, and impaired elastic recoil of lung tissue. These structural and physiological changes may remain asymptomatic during the early stages and become clinically evident only after significant pulmonary involvement.

Glycated hemoglobin (HbA1c) reflects average blood glucose levels over the preceding two to three months and is considered a reliable indicator of long-term glycemic control. Elevated HbA1c levels may be associated with worsening pulmonary function because of chronic metabolic and inflammatory damage.[7,8]

Previous studies have demonstrated an association between poor glycemic control and reduced lung function. Davis et al. reported that increased glycemic exposure was associated with decreased pulmonary function in patients with T2DM.[4] Similarly, Klein et al. observed a significant reduction in spirometric parameters among diabetic individuals.[6] Meo et al. also demonstrated reduced ventilatory function among patients with poorly controlled diabetes.[7]

Despite growing evidence, pulmonary complications in diabetes remain under-recognized in routine clinical practice. Early identification of pulmonary dysfunction may help in preventing progression and improving quality of life in diabetic patients. Assessment of pulmonary function may therefore serve as an additional tool in the routine evaluation of diabetic patients.

The present study was undertaken to evaluate the correlation between HbA1c levels and pulmonary function test parameters in patients with Type 2 Diabetes Mellitus.

MATERIALS AND METHODS:

Study Design

The present study was designed as a hospital-based cross-sectional observational study.

Study Setting

The study was conducted in the Department of Physiology in collaboration with the Department of Biochemistry and the Department of General Medicine at a tertiary care teaching hospital after receiving approval from the institutional ethics committee

Study Duration

The study was conducted over a period of six months after obtaining approval from the Institutional Ethics Committee.

Study Population

The study population consisted of patients diagnosed with Type 2 Diabetes Mellitus attending the outpatient department of General Medicine.

Sample Size

A total of 120 patients with Type 2 Diabetes Mellitus were included in the study.

Sampling Technique

Participants fulfilling the inclusion criteria were recruited by convenience sampling method. Written informed consent was obtained from all participants after explaining the purpose and procedure of the study in their local language

Inclusion Criteria

1. Patients diagnosed with Type 2 Diabetes Mellitus.
2. Age between 35 and 65 years.
3. Patients of either sex.
4. Patients willing to provide written informed consent.

Exclusion Criteria

1. Smokers and chronic alcoholics.
2. Patients with chronic respiratory diseases such as bronchial asthma and chronic obstructive pulmonary disease.
3. Patients with pulmonary tuberculosis.
4. Patients with acute respiratory tract infections.
5. Patients with cardiovascular diseases including ischemic heart disease and heart failure.

6. Pregnant women.
7. Patients with chest wall deformities or neuromuscular disorders.
8. Patients unable to perform spirometry adequately.

Data Collection Procedure

Patients fulfilling the inclusion criteria were enrolled after obtaining informed consent. A detailed clinical history was obtained including duration of diabetes, treatment history, history of hypertension, respiratory symptoms, smoking status, and associated comorbidities.

General physical examination was carried out in all participants. Anthropometric measurements including height and weight were recorded using standardized instruments. Body Mass Index (BMI) was calculated using the formula:

$$\text{BMI} = \text{Weight (kg)} / \text{Height (m}^2\text{)}$$

Blood pressure was measured using a standard sphygmomanometer after adequate rest.

Biochemical Analysis

Sample Collection

Approximately 2 mL of venous blood was collected under aseptic precautions from each participant.

Estimation of HbA1c

HbA1c estimation was performed using standardized laboratory methods such as High-Performance Liquid Chromatography (HPLC) or immunoturbidimetric assay depending on the availability of institutional laboratory facilities. Approximately 2 mL of venous blood was collected in EDTA vacutainer tubes under aseptic precautions and transported immediately to the central biochemistry laboratory for analysis.

PULMONARY FUNCTION PARAMETERS:

Pulmonary function parameters were assessed using computerized spirometry with a **digital spirometer (RMS Helios 401)** according to the guidelines of the American Thoracic Society (ATS).

Participants were instructed to sit comfortably in an upright position and wear a nose clip to prevent air leakage. After taking maximal inspiration, the participant was instructed to expire forcefully and rapidly into the mouthpiece connected to the spirometer. A minimum of three acceptable maneuvers were recorded and the best reading was selected for analysis. The following pulmonary function parameters were recorded:

1. **Forced Vital Capacity (FVC)**
 - Recorded as the maximum volume of air exhaled forcefully after maximal inspiration.
2. **Forced Expiratory Volume in One Second (FEV1)**
 - Recorded as the volume of air exhaled during the first second of forced expiration.
3. **FEV1/FVC Ratio**
 - Calculated automatically by the spirometer as the percentage of FVC exhaled during the first second.
4. **Peak Expiratory Flow Rate (PEFR)**
 - Recorded as the maximum expiratory flow achieved during forced expiration.
5. **Forced Expiratory Flow 25–75% (FEF25–75%) (wherever applicable)**
 - Recorded as the average expiratory flow during the middle half of forced expiration and used as an indicator of small airway function.

All values were expressed as percentage of predicted values adjusted for age, sex, height, and body surface area.

STATISTICAL ANALYSIS:

Data obtained from the study were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software version 22.0. Continuous variables were expressed as mean \pm standard deviation (Mean \pm SD). Categorical variables were expressed as frequencies and percentages. Comparison of pulmonary function parameters among different HbA1c categories was performed using one-way Analysis of Variance (ANOVA) test. A p-value of less than 0.05 was considered statistically significant.

RESULTS:

A total of 120 patients with Type 2 Diabetes Mellitus were included in the study. Among them, 68 (56.7%) were males and 52 (43.3%) were females. The mean age of the participants was 54.3 ± 8.7 years. The mean duration of diabetes was 8.2 ± 4.5 years. The average BMI was 27.1 ± 3.4 kg/m² and the mean HbA1c level was $8.4 \pm 1.6\%$, indicating poor glycemic control among the study participants. (Table 1)

Table 1: Demographic and Clinical Profile of Study Participants

Variable	n (%) / Mean \pm SD
Total study participants	120
Gender	
Male	68 (56.7%)

Female	52 (43.3%)
Age (years)	54.3 ± 8.7
Duration of diabetes (years)	8.2 ± 4.5
Body Mass Index (kg/m ²)	27.1 ± 3.4
HbA1c (%)	8.4 ± 1.6

Pulmonary function parameters such as FVC, FEV1, PEFR, and FEF25–75% showed reduced mean values among patients with Type 2 Diabetes Mellitus. However, the FEV1/FVC ratio remained relatively preserved, suggesting predominantly restrictive pulmonary involvement. (Table 2)

Table 2: Pulmonary Function Parameters of Study Participants

Parameter	Mean ± SD
FVC	76.5 ± 11.8
FEV1	73.4 ± 12.2
FEV1/FVC Ratio	82.1 ± 6.5
PEFR	71.8 ± 10.9
FEF25–75%	69.6 ± 11.4

Pulmonary function parameters including FVC, FEV1, PEFR, and FEF25–75% showed significant reduction with increasing HbA1c levels. However, FEV1/FVC ratio did not show statistically significant variation among different HbA1c categories. (Table 3)

Table 3: Comparison of Pulmonary Function Parameters According to HbA1c Levels

Parameter	<7% HbA1c (Good Control) Mean ± SD	7–8% HbA1c (Moderate Control) Mean ± SD	>8% HbA1c (Poor Control) Mean ± SD	p-value
FVC (% predicted)	84.2 ± 8.6	77.3 ± 10.1	70.6 ± 11.5	<0.001*
FEV1 (% predicted)	81.5 ± 9.2	74.2 ± 10.8	67.1 ± 12.3	<0.001*
FEV1/FVC Ratio	83.4 ± 5.1	82.6 ± 5.8	81.8 ± 6.4	0.28
PEFR (% predicted)	79.8 ± 8.4	72.4 ± 9.6	65.2 ± 10.7	0.003*
FEF25–75% (% predicted)	76.2 ± 9.1	69.8 ± 10.4	62.5 ± 11.2	0.005*

*Statistically significant (p <0.05)

DISCUSSION:

The present study was undertaken to evaluate the correlation between HbA1c levels and pulmonary function parameters in patients with Type 2 Diabetes Mellitus. The findings of the present study demonstrated a significant reduction in pulmonary function parameters among diabetic patients with poor glycemic control. A statistically significant negative correlation was observed between HbA1c levels and pulmonary function parameters including FVC, FEV1, PEFR, and FEF25–75%, suggesting that worsening glycemic control is associated with progressive pulmonary impairment.

In the present study, the mean HbA1c level among study participants was 8.4 ± 1.6%, indicating poor glycemic control in the majority of patients. Chronic hyperglycemia is known to produce structural and functional alterations in various organs through non-enzymatic glycosylation, oxidative stress, and chronic inflammation.[11,12]

The lungs are increasingly considered as a target organ in diabetes mellitus because of their extensive microvascular network and connective tissue content. Persistent hyperglycemia may result in glycosylation of collagen and elastin fibers within the pulmonary interstitium, leading to reduced lung elasticity and impaired pulmonary compliance.[13] Diabetic microangiopathy affecting alveolar capillaries may also contribute to pulmonary dysfunction by impairing gas exchange and pulmonary blood flow.[14]

In the present study, mean FVC and FEV1 values were reduced among diabetic patients. The reduction in these spirometric parameters suggests predominantly restrictive pulmonary impairment. Similar findings were reported by Davis et al., who demonstrated decreased pulmonary function in patients with increased glycemic exposure.[14] Klein et al., in a systematic review, also concluded that diabetes mellitus is associated with modest but significant reduction in lung function parameters.[15]

The reduction in pulmonary function may be attributed to thickening of alveolar epithelial basal lamina, reduced elastic recoil of lung tissue, autonomic neuropathy affecting respiratory muscles, and chronic systemic inflammation.[16]

Oxidative stress associated with diabetes may further contribute to pulmonary tissue damage and progressive decline in respiratory function.[17]

The present study also demonstrated a significant reduction in PEFr and FEF_{25-75%} values with increasing HbA_{1c} levels. PEFr reflects expiratory muscle effort and large airway flow, whereas FEF_{25-75%} is considered an indicator of small airway function. Reduced values may indicate early airway involvement and decreased respiratory muscle performance in diabetic patients.[18]

In contrast, FEV₁/FVC ratio did not show statistically significant correlation with HbA_{1c} levels in the present study. This finding supports the predominantly restrictive pattern of pulmonary involvement observed in diabetes mellitus, where both FEV₁ and FVC decrease proportionately, resulting in relatively preserved FEV₁/FVC ratio.[19]

The findings of the present study are consistent with those reported by Meo et al., who observed significantly lower spirometric parameters among patients with poorly controlled diabetes.[20] Similarly, Walter et al. demonstrated an association between elevated blood glucose levels and decline in pulmonary function in the Framingham Heart Study.[21] Early pulmonary involvement in diabetes often remains asymptomatic and may go unnoticed during routine clinical evaluation. Therefore, pulmonary function testing may serve as a useful non-invasive tool for early identification of subclinical pulmonary impairment in diabetic patients.[22]

CONCLUSION:

The present study demonstrated that poor glycemic control was associated with reduced pulmonary function in patients with Type 2 Diabetes Mellitus. Pulmonary function parameters such as FVC, FEV₁, PEFr, and FEF_{25-75%} showed significant reduction with increasing HbA_{1c} levels, suggesting predominantly restrictive pulmonary involvement.

Periodic pulmonary function assessment along with regular HbA_{1c} monitoring may help in early detection of subclinical pulmonary involvement in diabetic patients.

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