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Spirometric Abnormalities AmongPatients with Diabetes Mellitus Type 2/ Erbil City

Ali Adel Mohammed [1]; Omar Qader MoahmmedAmin [2]

[1]M.B.Ch.B
[2]M.B.Ch.B / F.I.C.M.S / I.M.

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ABSTRACT

Background: Chronic diabetic hyperglycemia is linked to persistent damage, dysfunction, and failure of multiple organs, particularly the eyes, kidneys, nerves, heart, lungs, and blood vessels. Pulmonary problems in diabetes result from the thickening of alveolar walls, alveolar capillaries, and pulmonary arterioles, leading to pulmonary dysfunction. This study aimed to determine the prevalence of spirometric abnormalities among patient with type 2 DM and also to determine the correlation of HbA1c with spirometry results in type 2 DM patients.

Methods: The current study included 100 type 2 diabetic patients. Full personal history recording and data related to diabetic status were recorded. Full general and systemic examination followed by pulmonary function tests were performed.

Results: In the included diabetic patients, mean FVC was decreased in 59% of patients, mean FEV1 was decreased in 53% of patients, mean FEV1/FVC ratio was decreased in 28% of patients. In addition, mean PEFR was decreased in 66% of patients and mean partial oxygen saturation percentage was 96.32 ± 1.8 %, 19% of patients had decreased SpO2.

Conclusion: This study reflected the significant negative effect of hyperglycemia upon pulmonary functions. Diabetic hyperglycemia contributes to a restrictive pattern of lung dysfunction that could be mediated by vascular, inflammatory, and metabolic pathways

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia due to defects in insulin secretion, insulin action, or both. Prolonged hyperglycemia is associated with progressive damage and dysfunction of multiple organ systems, including the eyes, kidneys, nerves, cardiovascular system, and lungs.[1] Globally, the prevalence of diabetes has risen dramatically, from 7% of adults in 1990 to an estimated 11.1% by 2025, with type 2 diabetes mellitus (T2DM) constituting over 90% of cases.[1] Projections suggest that by 2050, approximately 853 million individuals will be affected, representing a 46% increase from current figures.[1] In Iraq, diabetes represents a rapidly escalating public health problem, with around two million adults aged 20–79 years living with the disease and a prevalence rate of 9.4%.[2]

Diabetes is classified into four main categories: type 1 diabetes mellitus (T1DM), type 2 diabetes mellitus (T2DM), gestational diabetes mellitus (GDM), and other specific types such as latent autoimmune diabetes in adults (LADA) and maturity-onset diabetes of the young (MODY).[3] T2DM, the predominant form, is characterized by insulin resistance in peripheral tissues combined with β-cell dysfunction, resulting in inadequate insulin secretion to maintain normoglycemia.[4] The condition has a strong association with obesity, sedentary lifestyle, and genetic predisposition, making it a major global health burden.[4]

The diagnosis of diabetes is established through clinical features and laboratory investigations. According to the American Diabetes Association (ADA) guidelines, diagnostic criteria include fasting plasma glucose ≥126 mg/dL, 2-hour plasma glucose ≥200 mg/dL after an oral glucose tolerance test, random plasma glucose ≥200 mg/dL with symptoms, or HbA1c ≥6.5%.[5] In addition, biomarkers such as C-peptide levels and diabetes-related autoantibodies may help distinguish between different types of diabetes.[6,7]

Uncontrolled diabetes is associated with acute metabolic complications such as hypoglycemia, diabetic ketoacidosis, and hyperosmolar hyperglycemic states, as well as long-term microvascular and macrovascular complications, including nephropathy, neuropathy, retinopathy, cardiovascular disease, and cerebrovascular events.[8] Beyond these well-recognized sequelae, growing evidence suggests that the respiratory system is also affected by diabetes. Diabetic patients are at increased risk of respiratory infections, including pneumonia, tuberculosis, and severe influenza outcomes.[9-11] Moreover, diabetes has been linked with chronic obstructive pulmonary disease (COPD), obstructive sleep apnea, and progressive pulmonary function decline.[12-14] Proposed mechanisms include non-enzymatic glycosylation of lung proteins, chronic low-grade inflammation, impaired immune defense, and oxidative stress.[15.16]

Pulmonary function testing, particularly spirometry, provides valuable insights into the functional status of the lungs. Spirometry measures parameters such as forced vital capacity (FVC) and forced expiratory volume in one second (FEV1), which are used to assess obstructive, restrictive, or mixed ventilatory patterns.[17] Abnormalities in spirometry among patients with T2DM may reflect the cumulative effects of chronic

hyperglycemia, microangiopathy, and systemic inflammation on lung tissue.[14,18] These impairments can negatively influence quality of life, disease prognosis, and overall morbidity in diabetic populations.

Given the rising burden of T2DM in Iraq and its potential impact on pulmonary function, studying spirometric abnormalities among diabetic patients in Erbil city is both timely and necessary. Identifying early respiratory changes in this high-risk group may support preventive strategies, improve disease management, and contribute to reducing long-term complications.

Aim of the study:

This study aimed to determine the prevalence of spirometric abnormalities among patient with type 2 DM and also to determine the correlation of HbA1c with spirometry results in type 2 DM patients.

PATIENTS AND METHODS

Study setting

The current cross-sectional study included 100 type 2 diabetic patients. Patients were recruited from respiratory department at Rizgary Teaching Hospitalin collaboration with Department of Medicine/college of medicine Hawler medical university. Patients were in the duration between September 2024 to March 2025.

After recruitment of patients, verbal consent was acquired from patients and the study was approved from hospital director and Erbil health directory.

Inclusion criteria

- Type 2 DM patients from both genders.
- Patients aged 30years or older were included.

Exclusion criteria

- History of drug intake as amiodarone or methotrexate, nitrofurantoin, sulfonamides, or chemotherapeutics.
- Respiratory complications of COVID-19
- Acute or chronic lung infections
- Systemic disease that has effects on lung function like SLE and rheumatoid arthritis, systemic sclerosis, polymyositis/ dermatomyositis and other connective tissue diseases. Also, patients with amyloidosis, sarcoidosis and vasculitides were excluded.
- Smoking history
- Severe disease status as liver cell failure and renal failure and malignancies.
- Occupational lung diseases as Silicosis, Coal Workers' Pneumoconiosis, Asbestosis and Berylliosis.

Study procedure:

Patients were subjected to the following:

- Full personal history recording including: patients' age, gender, body mass index (BMI), residence, marital status, educational level, socioeconomic status and occupation.
- Data related to diabetic status including: DM duration, family history of DM, type of diabetic medications or other medications, corticosteroid use and associated diseases. In addition, serum HbA1c levels were measured and recorded.

- ❖ Full general and systemic examination
- ❖ Pulmonary function tests were done by spirometry recording Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV1),FEV1/FVC ratio and Peak Expiratory Flow Rate (PEFR) in addition to respiratory rate (RR) and Oxygen Saturation (SpO2).

Pulmonary function tests (Ranu et al., 2011)

Pulmonary function tests were done using Spirometer, Piston Medical,Hungary (Figure 1).

FVC: The total volume of air that can be forcibly exhaled after taking a deep breath.

FEV1: The amount of air expelled in the first second of a forced exhalation.

PEFR: The maximum speed of expiration, often used to assess airway obstruction.

RR: The number of breaths taken per minute, an important indicator of respiratory function.

SpO2: The percentage of hemoglobin saturated with oxygen in the blood, typically measured via pulse oximetry.

Statistical analysis

Data was presented as frequencies and proportions. Analysis was completed using SPSS version 25. Pearson Correlation analysis was performedto assess the strength of association between two quantitative variables. The correlation coefficient defines the strength and direction of the linear relationship between two variables.

RESULTS

The current study included 100 type 2 diabetic patients. Demographic data of included patients is illustrated in table 1. The majority of patients aged 40-59 years. more than half (56%) were overweight while 41% were obese. About two-thirds (61%) were males, 72% were living inside the city and 72% were married. More than half (52%) were employed and 43% were of moderate socioeconomic status.

Mean duration of DM was 8.2 ± 6.1 years while mean HbA1c was 8.25 ± 1.2 gm%. Family history of DM was present in 64% of patients, 37% of patients had DM for 5-9 years, 31% for < 5 years, 17% for 15 years or more and 15% for 10-14 years. most of patients (63%) were ondual therapy (one tablet + insulin) while 34% were on triple therapy (two tablet + insulin) and 43% were on other medications. Corticosteroid used was reported in only 17% of patients. Most common associated diseases were dyslipidemia (36%) and hypertension (31%) (Table 2)

Mean Forced Vital Capacity (FVC) was 78 ± 10.9 liters, mean Forced Expiratory Volume in 1 Second (FEV1) was 74.9 ± 12.3 liters. Mean FEV1/FVC ratio was 75.74 ± 10.6, mean Peak Expiratory Flow Rate (PEFR) was 70.48 ± 15.9liters per minute, mean respiratory rate (RR) was 17.55 ± 2.1 per minute and mean partial oxygen saturation percentage was 96.32 ± 1.8 % (Table 3).

Of the included patients, 59% had low FVC, 53% had low FEV1, 28% had low FEV1/FVC ratio, 66% had low PEFR, 6% had increased RR and 19% had decreased SpO2 (Table 4). There was statistically significant negative correlation between HbA1c levels and either of FVC, FEV1, PEFR and SpO2 (Table 5, Figures 1-4).

DISCUSSION

This study aimed to determine the prevalence of spirometric abnormalities among patient with type 2 DM and also to determine the correlation of HbA1c with spirometry results in type 2 DM patients.

The current study included 100 type 2 diabetic patients. The majority of patients aged 40-59 years. This was similar to what previously mentioned by Rani et al., as mean age of type 2 diabetic patients was 50.5±8.25 years.[19] However, older patients were observed in study of Adeoti et al., as mean age of type 2 diabetic patients was69.9±.8 years.[20]

About two-thirds (61%) were males. Similarly, Klein et al., reported that diabetic patients were more commonly males (56%).[21] Also, Kumari et al., reported that diabetic patients were more commonly males (64.4%).[22] Contradicting results were reported by Adeyeye et al., as male diabetic patients represent only 33.5% of diabetic patients.[23]

In this study, more than half (56%) were overweight while 41% were obese. Adeoti et al., reported different findings as 35.6% of patients were overweight and 31.5% were obese.[20] This could be due to inclusion of older patients as muscle mass decreases with advancing age thus lowering body mass index.

Mean duration of DM was 8.2 ± 6.1 years while mean HbA1c was 8.25 ± 1.2 gm%. Similar findings were reported by Adeyeye et al., as means duration of DM was 9.00 ± 8.29 and 7.11 ± 6.47 years in male and female patients respectively.[23] Mean HbA1c was nearly similar in both genders (nearly 8 gm%).

Family history of DM was present in 64% of patients. Type 2 DM exhibits strong familial pattern, Abbas et al., found that individuals with a family history of type 2 diabetes had nearly 5 times higher odds of developing the disease.[24]

Most common associated diseases were dyslipidemia (36%) and hypertension (31%). It was reported previously by Jelinek et al., that hypertension, dyslipidemia, and obesity are the most prevalent comorbidities, often coexisting in over 80% of patients with T2DM.[25]

As regards pulmonary functions in the included diabetic patients, mean Forced Vital Capacity (FVC) was decreased in 59% of patients. Similar findings were reported in previous studies. Rani et al., reported that there was a decrease in FVC in 27.3% of patients.[19] Adeyeye et al., reported that there was a decrease in FVC compared to predicted values.[23] Adeoti et al.,[20] Klein et al.,[21], Kumari et al.,[22] and Jeraud,[26] reported significant decrease in FVC in diabetic patients compared to healthy control subjects.

In addition, mean Forced Expiratory Volume in 1 Second (FEV1) was decreased in 53% of patients. Rani et al., reported that there was a decrease inFEV1 in 21.5% of patients.[19] Adeyeye et al., reported that there was a decrease in FEV1 compared to predicted values.[23] Adeoti et al.,[20] Klein et al.,[21] Kumari et al.,[22] and Jeraud,[26], reported significant decrease in FEV1 in diabetic patients compared to healthy control subjects.

Recently, Mehrabi et al., confirmed these findings, showing that both diabetic and prediabetic individuals had significantly lower FVC and FEV_1 compared to non-diabetics.[27] The authors attributed this to microangiopathy, non-enzymatic glycation

of lung proteins, and oxidative stress, which impair alveolar structure and reduce lung compliance.

In the present study, mean FEV1/FVC ratio was decreased in 28% of patients. In the same context, Kumari et al., reported significant decrease in FEV1/FVC ratio in diabetic patients compared to controls.[22] Surprisingly, Rani et al.,[19] reported that mean FEV1/FVC ratio was increased in 10.3% of diabetic patients which was similar to Adeoti et al.,[20] who reported significant increase in FEV1/FVC ratio in diabetic patients compared to controls. An explanation to these contradicting results could be that FEV_1 and FVC are both typically reduced in T2DM patients, reflecting a restrictive ventilatory pattern. However, the FEV_1/FVC ratio may remain normal or even slightly increased, because both values decline proportionally.[14]

Mean Peak Expiratory Flow Rate (PEFR) was decreased in 66% of patients. Rani et al., reported decrease in PEFR in 20.8% of patients.[19] Adeyeye et al., and Jeraud,[26] reported that there was a significant decrease in PEFR compared to predicted values and compared to healthy control subjects.

Mean partial oxygen saturation percentage was 96.32 ± 1.8 %, 19% had decreased SpO2. This could be attributed to non-enzymatic glycation of hemoglobin, which alters its oxygen-binding affinity and shifts the oxygen dissociation curve to the left, impairing oxygen delivery to tissues.[28] Laursen et al., reported that individuals with screen-detected or known diabetes had a mean SpO_2 of 96.3%, significantly lower than 97.3% in non-diabetic controls.[29]

In the present study, there was statistically significant negative correlation between HbA1c levels and either of FVC, FEV1, PEFR and SpO2. A 2023 cross-sectional study from India compared 100 T2DM patients with healthy controls and found significantly lower predicted values for FVC, FEV_1 and PEFR in diabetics. The decline was more pronounced with higher HbA1c levels and longer disease duration, suggesting a link between poor glycemic control and restrictive lung changes.[30]

Chronic hyperglycemia in diabetes mellitus exerts a multifaceted impact on pulmonary function, positioning the lungs as a target organ of diabetic complications. Structural and biochemical alterations induced by sustained high glucose levels lead to measurable declines in respiratory performance. Notably, diabetic individuals often exhibit reduced FVC and FEV_1, with a preserved FEV_1/FVC ratio—suggestive of a restrictive ventilatory defect.[27]

The underlying mechanisms are complex and include nonenzymatic glycation of collagen and elastin within the alveolar-capillary membrane, resulting in thickening and reduced elasticity. This microangiopathic process impairs gas exchange and contributes to diminished lung compliance. Additionally, hyperglycemia promotes oxidative stress and chronic low-grade inflammation, further compromising alveolar integrity and surfactant production. Insulin resistance and elevated levels of inflammatory markers such as C-reactive protein (CRP) have been associated with poorer spirometry outcomes. Interestingly, studies reveal a non-linear relationship between glycemic control and pulmonary function: individuals with well-controlled diabetes.[31]

Overall, diabetic hyperglycemia contributes to a restrictive pattern of lung

dysfunction, mediated by vascular, inflammatory, and metabolic pathways.

CONCLUSION

Diabetic patients in this study exhibited reduced pulmonary function, reflected by decreased FVC, FEV1, FEV1/FVC ratio, PEFR, and oxygen saturation. A statistically significant negative correlation was observed between HbA1c levels and FVC, FEV1, PEFR, and SpO2, emphasizing the adverse impact of hyperglycemia on lung function. These findings highlight the need for larger-scale studies to further explore the effect of chronic hyperglycemia on pulmonary function and support the inclusion of routine pulmonary function assessment in diabetic patients, particularly those with elevated HbA1c levels.

RECOMMENDATION

Based on the current study results we recommend:

- Further studies on larger scale to assess the effect of diabetic hyperglycemia on pulmonary functions.
- Inclusion of routine pulmonary function assessment in diabetic patients especially those with high levels of HbA1c.

Conflict of interest: None

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TABLES

Table (1): Demographic data of included patients

Variable		No	%
Age (years)	20-39 years	12	12
	40-59 years	70	70
	60 or more years	18	18
BMI	Normal weight	3	3
	Overweight	56	56
	Obese	41	41
Gender	Male	61	61
	Female	39	39

Residence	Inside city	72	72
	Outside city	28	28
Marital status	Married	72	72
	Non-married	28	28
Educational level	Primary	16	16
	Intermediate	22	22
	Secondary	23	23
	College	22	22
	Postgraduate	17	17
Socioeconomic status	Low	36	36
	Moderate	43	43
	High	21	21
Occupation	Un-employed	48	48
	Employed	52	52

Table (2): Data related to diabetic status in included patients

Patients diabetic status	data		
DM duration (years)	Mean ± SD	8.2 ± 6.1	
	Range	1 - 30	
HbA1c	Mean ± SD	8.25 ± 1.2	
	Range	6.5 - 11	
		No	%
Family history of DM	Yes	64	64
	No	36	36
Diabetic duration	< 5 years	31	31
	5-9 years	37	37
	10-14 years	15	15
	15 or more	17	17
Type of diabetic medications	Single therapy (one tablet)	1	1
	Dual therapy (two tablet)	2	2
	Dual therapy (one tablet + insulin)	63	63
	Triple therapy (two tablet + insulin)	34	34
Other medications used	Yes	43	43
	No	57	57
Corticosteroid used	Yes	17	17
	No	83	83
Associated diseases	No	31	31
	Hypertension	31	31
	Ischemic heart disease	2	2
	Dyslipidemia	36	36
	Thyroid disorders	11	11

Table (3): Spirometry data analysis

Spirometry parameters	data	
FVC (liters)	Mean ± SD	78 ± 10.9
	Range	62 – 100
FEV1 (liters)	Mean ± SD	74.9 ± 12.3
	Range	45 – 95
FEV1/FVC ratio	Mean ± SD	75.74 ± 10.6
	Range	55 – 100
PEFR (liters per minute)	Mean ± SD	70.48 ± 15.9
	Range	39 – 100
RR	Mean ± SD	17.55 ± 2.1
	Range	13 – 22
SpO2	Mean ± SD	96.32 ± 1.8
	Range	92 - 99

Table (4): Prevalence of abnormal Spirometry data

		No	%
FVC (liters)	Normal (≥80%)	41	41
	Below normal	59	59
FEV1 (liters)	Normal (≥80%)	47	47
	Below normal	53	53
FEV1/FVC ratio	Normal (≥70%)	72	72
	Below normal	28	28
PEFR (liters per minute)	Normal (≥80%)	34	34
	Below normal	66	66
RR	Normal (12-20)	94	94
	Above normal	6	6
SpO2	Normal (≥95%)	81	81
	Below normal	19	19

Table (5): Correlation between HbA1c and Spirometry data

		HbA1c
FVC (liters)	r value	-0.378
	P value	**0.001**
FEV1 (liters)	r value	-0.371
	P value	**0.001**
FEV1/FVC ratio	r value	-0.160
	P value	0.112
PEFR (liters per minute)	r value	-0.384
	P value	**0.001**
RR	r value	0.065
	P value	0.519
SpO2	r value	-0.327
	P value	**0.001**

FIGURES

Figure (1): Spirometer, Piston Medical, Hungary

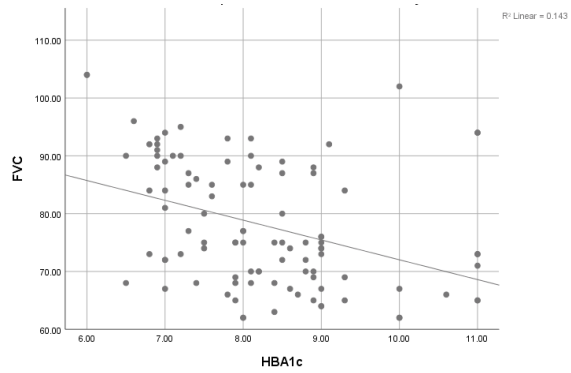

Figure (1): Correlation between HbA1c and FVC

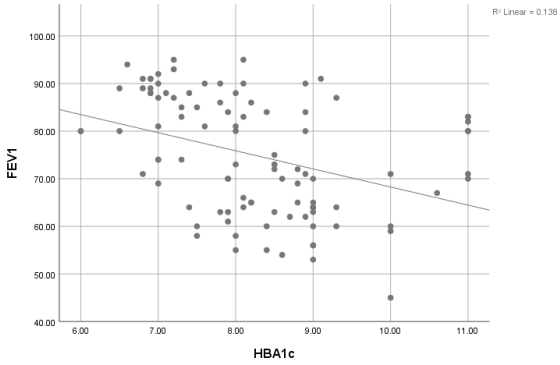

Figure (2): Correlation between HbA1c and FEV1

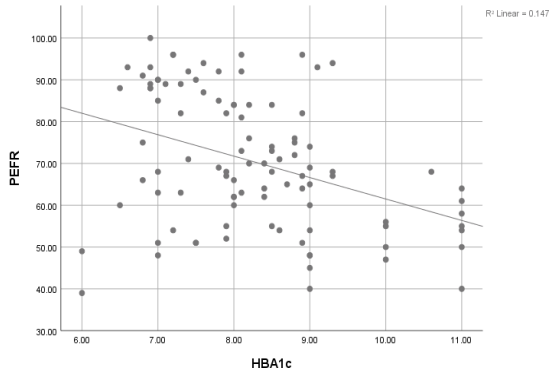

Figure (3): Correlation between HbA1c and PEFR

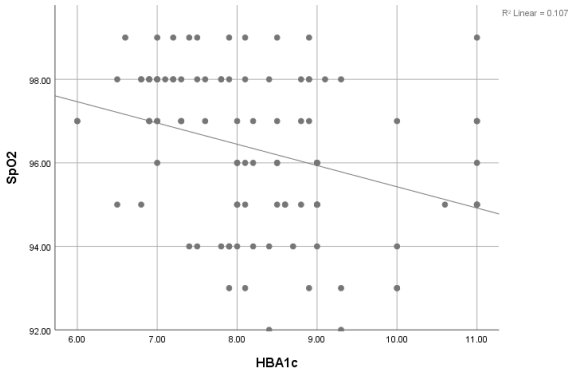

Figure (4): Correlation between HbA1c and SpO2