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The Relationship between Diabetes Mellitus and Respiratory Function in smoker Patients Eligible for Coronary Artery Bypass Grafting

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Abstract

In diabetics, the respiratory system characterized by a growth of fibroblasts and vascular endothelium, increased density of pulmonary microspheres, and thickening of the walls of pulmonary vesicles caused by increased collagen and elastin. These related types of damage to the alveolar-capillary barrier and reduction in pulmonary capacity and flow result in further adverse effects on the body's functional state. Investigate the potential relationships between diabetes and respiratory parameters in smoker Patients Eligible for Coronary Artery Bypass Grafting. Assess early changes in lung volumes by pulmonary function tests before and following CABG in smoking adults and identify how diabetes might influence these changes by comparing diabetic with non-diabetic. This study was a prospective controlled study performed over 200 consecutive patients undergoing elective coronary artery bypass surgery. Two hundred fifty-six patients were admitted to our research, and 56 of them were excluded (41 did not meet our inclusion criteria, and 15 declined to participate), so we were left with 200 cases included in the study. There was a statistically significant difference between diabetic and non-diabetic patients regarding pulmonary function tests. Patients with diabetes eligible for CABG had lower spirometry parameters compared to patients without diabetes. This indicates that these categories of patients require respiratory tests and treatment aimed at improving respiratory function before and after cardiac surgery.

Keywords: Coronary artery bypass grafting (CABG), Smokers, Diabetics, pulmonary function tests, and respiratory parameters

Full-length article **Corresponding Author*, e-mail: Maqdad@hsc.edu.kw

1. Introduction

Coronary artery bypass grafting (CABG) is a major surgical operation where atheromatous blockages in a patient's coronary arteries bypassed with harvested venous or arterial conduits. The bypass restores blood flow to the ischemic myocardium, which, in turn, restores function viability and relieves anginal symptoms. Almost 400,000 CABG surgeries performed each year; making it the most commonly performed major surgical procedure. However, surgical trends have decreased as alternative options such as medical treatment and percutaneous coronary intervention (PCI) have increased [1-2]. Although most people are aware of the association between smoking and heart disease, cigarette smoking is still the most preventable cause of death [3].

Cigarette smoking is one of the known major risk factors of coronary artery disease, and chronic smoking may cause postoperative alveolar collapse because of damage to the ciliary epithelium; however, the cessation of smoking results in significant improvement in small airway function [4]. Although CABG surgery is an effective coronary revascularization technique, it is often associated with a decrease in pulmonary function. During the first week after CABG surgery, the slow vital capacity decreases by 30-60%; even for one year, it remains reduced by 12%. Pulmonary complications are a leading cause of morbidity and mortality after CABG surgery. A deeper understanding of the mechanisms leading to worse pulmonary function after CABG surgery could lead to optimized postoperative care and, thus, reduced morbidity and mortality [5].

CABG performed by median sternotomy, significantly affecting the mobility of the chest. Before the operation, pulmonary function and capacity can be assessed using spirometry, which measures air volume in the lungs and airflow through the airways during inhalation and exhalation [6]. Spirometry is one of the most readily available and helpful tests for pulmonary function. It measures the volume of air exhaled at specific time points during complete exhalation by force, which preceded by a maximal inhalation. The most critical variables reported include total exhaled volume, known as the forced vital capacity (FVC), the volume exhaled in the first second, and known as the forced expiratory volume in one second (FEV1), and their ratio (FEV1/FVC) [7].

The following pulmonary function tests (PFTs) were measured: vital capacity (VC), forced vital capacity (FVC), vital capacity as a percent of predicted (%VC), forced expiratory volume in the first second (FEV1.0), ratio between FEV1.0 and FVC (FEV1.0%), and percent predicted FEV1.0 (%FEV1.0). Although recent guidelines for the diagnosis of lung disease have utilized PFTs to diagnose and classify the severity of pulmonary function, preoperative spirometry assessments have revealed differential diagnoses [8]. Diabetes is a chronic metabolic disease caused by a disorder of insulin secretion. Diabetes is a multisystemic disease primarily associated with the pancreas but also affects the skeletal muscles, gastrointestinal tract, kidneys, and brain [9-10].

It increasingly observed in people diagnosed with heart disease. In diabetics, the respiratory system characterized by a growth of fibroblasts and vascular endothelium, increased density of pulmonary microspheres, and thickening of the walls of pulmonary vesicles caused by increased collagen and elastin. These related types of damage to the alveolar-capillary barrier and reduction in pulmonary capacity and flow result in further adverse effects on the body's functional state. This may not only contribute to deepening respiratory failure symptoms but also indirectly affect the cardiovascular system [11]. The present study aimed to investigate the potential relationships between the occurrence of diabetes and respiratory parameters in smoker Patients Eligible for Coronary Artery Bypass Grafting. Assess early changes in lung volumes by pulmonary function tests before and following CABG in smoking adults and identify how diabetes might influence these changes by comparing diabetic with non-diabetic.

2. Materials and Methods

Two hundred consecutive patients undergoing elective coronary artery bypass surgery were included in this prospective controlled study. Emergency patients and those who underwent a valve operation in addition to a CABG operation were not included in the study. The first group consisted of 32 patients with diagnosed diabetes (16.0%), while the second group consisted of 168 patients without diabetes (84.0%). Informed written consent obtained from each patient to be included in this study. Patient and procedure information collected prospectively for all patients. Patient data included age, sex, Residence, BMI, and number of patients with Airflow obstruction and diabetes.

DM defined by measurements of fasting plasma glucose ≥126 mg/dL or glycated hemoglobin A1C (HbA1C) ≥6.5percentage in the presence of confirmatory testing. Patients on antidiabetic medications were also included as diabetics in the study. Body mass index (BMI) was calculated using the formula BMI = body weight (kg)/height (m) ^{2}. Average body weight diagnosed for BMI in the range 18.5–24.99 kg/m^2, overweight for 25–29.99 kg/m^2, and obesity for ≥30 kg/m^2. Patients defined as smokers if they had smoked cigarettes within one month of surgery. Patients who not classified as current smokers but had a history confirming any form of tobacco use in the past classified as previous smokers.

2.1. Pulmonary Function Tests

Lung volumes (IVC and FEV_1) were measured by spirometry (Vicatest P2a*). Spirometry standardized according to American Thoracic Society recommendations and performed with the patient in a sitting position [6]. The value recorded was the best (the highest IVC, FEV_1, and forced vital capacity [FVC] measurement) of three consecutive attempts. Predicted values for pulmonary functions calculated from regression equations according to age, BMI, and sex [12].

2.2. Operation technique

All patients operated electively. By performing a median sternotomy, arterial cannulation from the ascending aorta, and venous cannulation from the right atrium with a two-stage venous cannula connected to a cardiopulmonary bypass (CPB) device. Moderate hypothermia (28°C) achieved; cardiac arrest completed with 10 to 15 mL/kg cold blood cardioplegia or 5 mL/kg cold crystalloid cardioplegia (St. Thomas II) after insertion of the aortic cross-clamp. After the surgical procedure, reperfusion achieved with 5 mL/kg warm blood cardioplegia before the cross-clamp removed. A roller head pump and hollow fiber membrane oxygenator used in the CPB device. The left internal mammary artery (LIMA) and saphenous vein used as the graft in all patients. During the operation, systemic antibiotic prophylaxis, decompression of the left ventricle, and loading excessive fluid avoided. The patients were extubated as soon as possible (after achieving predetermined extubation criteria).

Criteria for the extubation were: 1) resolution of the disease state or condition, 2) hemodynamic stability, 3) adequate oxygenation status on a decreased FiO2 and decreased PEEP/CPAP, and 4) adequate ventilatory status and PaCO2. On the 4th postoperative day and four months postoperatively, the patients asked to quantify their sternotomy wound pain at rest, while taking a deep breath, while coughing, and at the performance of the pulmonary function test. A continuous unmarked visual analog scale (VAS) from zero (no pain) to 10 (worst imaginable pain) was used. Patients were also asked to state the level of thorax pain (severe, moderate, minor, or no pain) over the four months after surgery and their subjective experience of breathing (improved, unaltered, impaired) compared to the preoperative status.

The following outcomes analyzed death from any hospital origin and other postoperative complications occurred during the same hospitalization after CABG or within the first 30 days postoperatively. The following postoperative complications analyzed. Stroke (cerebrovascular accident/CVA) characterized as any transient or permanent neurological abnormality proven by CT or MRI of the brain, reoperation for hemostasis review, circulatory shock requiring Intra-aortic balloon pump (IAB). Respiratory complications characterized by the use of mechanical ventilation > 24 h. Alternatively, pulmonary infection requiring postoperative unit stay, acute kidney injury (AKI) requiring dialysis process, mediastinitis, sepsis from any source, atrial fibrillation (AF), and complete atrioventricular block (CAVb) requiring a temporary or permanent pacemaker.

2.3. Statistical Analysis

Statistical analysis will performed using SPSS software. The chi-square test will used for qualitative data. Qualitative variables will expressed as percentages (percentage). Logistic regression models will used to determine odds ratios and confidence intervals. Three individual models for diabetes will used to characterize the relationships between diabetes and the spirometry parameters FVC, FEV1.0, and PEF. Three subsequent models showing the relationship between diabetes and spirometry parameters will adjusted for gender, age, BMI, and cigarette smoking. Discriminant analysis will used. The significance level will be set at $p \leq 0.05$.

Data fed to the computer and analyzed using IBM SPSS software package version 20.0 *(Armonk, NY: IBM Corp)*. Qualitative data described using numbers and percentages. The Kolmogorov-Smirnov test used to verify the normality of the distribution. Quantitative data described using range (minimum and maximum), mean, standard deviation, median, and interquartile range (IQR). The significance of the obtained results judged at the 5% level. The test used was student t-test (t) for normally distributed quantitative variables, to compare between two different groups

3. Results and discussion

3.1. Results

This study was a prospective controlled study that performed over 200 consecutive patients undergoing elective coronary artery bypass surgery. Two hundred fifty-six patients were admitted to our study, and 56 of them were excluded (41 did not meet our inclusion criteria, and 15 declined to participate), so we were left with 200 cases included in the study. The mean age of the studied cases was 57.07 (±7.99 SD) with range (44-70), among the studied cases, there were 42 (21%) females and 158 (79%) males, there were 65 (32.5%) rural residents and 135 (67.5%) urban residents, the mean BMI was 26.82 (±2.78 SD) with range (22.1-31.9). Among the studied cases there were 28 (14%) with airflow obstruction and 32 (16%) with diabetes as shown in Table 1.

3.2. Discussion

Coronary artery bypass grafting (CABG) surgery aimed at reducing the symptoms related to coronary artery disease, preventing possible complications, and improving the quality of life (QoL) of the patients. On the other hand, CABG is a major surgery that might lead to vital complications. Postoperative pulmonary complications (PPCs), a well-reported group of complications following cardiac surgery, are associated with a 4-time increase in mortality, extended intensive care unit and hospital stay, and over $20,000 institutional cost per case [13]. CABG performed by median sternotomy, which significantly affects the mobility of the chest. Prior to the operation, pulmonary function and capacity can assessed with spirometry, which measures air volume in the lungs and airflow through the airways during inhalation and exhalation [6].

Spirometry is one of the most readily available and helpful tests for pulmonary function. It measures the volume of air exhaled at specific time points during complete exhalation by force, which preceded by a maximal inhalation. The most critical variables reported include total exhaled volume, known as the forced vital capacity (FVC), the volume exhaled in the first second, and known as the forced expiratory volume in one second (FEV1), and their ratio (FEV1/FVC). The following pulmonary function tests (PFTs) were measured: vital capacity (VC), forced vital capacity (FVC), vital capacity as a percent of predicted (%VC), forced expiratory volume in the first second (FEV1.0), ratio between FEV1.0 and FVC (FEV1.0%), and percent predicted FEV1.0 (%FEV1.0) [7].

Diabetes is a chronic metabolic disease caused by a disorder of insulin secretion. It is a multi-systemic disease primarily associated with the pancreas but also affects the skeletal muscles, gastrointestinal tract, kidneys, and brain [9-10]. It increasingly observed in people diagnosed with heart disease. In diabetics, the respiratory system characterized by a growth of fibroblasts and vascular endothelium, increased density of pulmonary microspheres, and thickening of the walls of pulmonary vesicles caused by increased collagen and elastin. These related types of damage to the alveolar-capillary barrier and reduction in pulmonary capacity and flow result in further adverse effects on the body's functional state. This may contribute to deepening respiratory failure symptoms and indirectly affect the cardiovascular system [11].

The study aimed to investigate the potential relationships between the occurrence of diabetes and respiratory parameters in smoker Patients Eligible for Coronary Artery Bypass Grafting. Two hundred fifty-six patients were admitted to our study, and 56 of them were excluded (41 did not meet our inclusion criteria, and 15 declined to participate), so we were left with 200 cases included in the study. The mean age of the studied cases was 57.07 (±7.99 SD) with range (44-70), among the studied cases there were 42 (21%) females and 158 (79%) males, there were 65 (32.5%) rural residents and 135 (67.5%) urban residents, the mean BMI was 26.82 (±2.78 SD) with range (22.1-31.9). Among the studied cases there were 28 (14%) with airflow obstruction and 32 (16%) with diabetes.

Another study by Szylińska et al [11] carried out in 2013 and began with a group of 502 patients with coronary artery disease who were eligible for coronary artery bypass grafting at the Department of Cardiothoracic Surgery of the Pomeranian Medical University in Szczecin. Patients who had not had a spirometry test excluded from the study. Also excluded were patients with a recent myocardial infarction, with acute coronary syndrome, or with resting pains, those who could not reliably examined, and those who refused to participate in the study. Further analysis involved 367 patients (287 men and 80 women) aged 68.7 ± 8.4 years. The first group consisted of 138 patients with diagnosed diabetes (37.6%), while the second group consisted of 229 patients without diabetes (62.4%). The current study showed a statistically significant difference between diabetic and non-diabetic patients regarding pulmonary function tests.

For many years, researchers have discussed the effects of diabetes on the respiratory system. In a study by Szylińska et al. [11], patients with diabetes eligible for coronary artery bypass grafting had significantly reduced FVC and FEV1.0 compared to patients without diabetes. This is consistent with the results reported by other authors [14-17]. Our research shows a decrease in spirometric parameters with and without adjustment, which indicates that demographic data did not interfere with decrease in pulmonary function tests in patient’s diabetes. In a long-term follow-up study of patients with diabetes, Kaminsky observed a gradual decline in FVC and FEV1.0 [14]. Similarly, in a seven-year follow-up, Davis et al. demonstrated a decrease in FEV1.0 in patients with diabetes, and, in addition, by analyzing the risk of death, they found that a 10% decrease in FEV1.0 could contribute to increased mortality [15]. In a study conducted by Litonjua et al. on 352 men with diabetes or at risk for diabetes, spirometry parameters, mainly FVC and FEV1.0, lower compared to those of 352 healthy subjects [16].

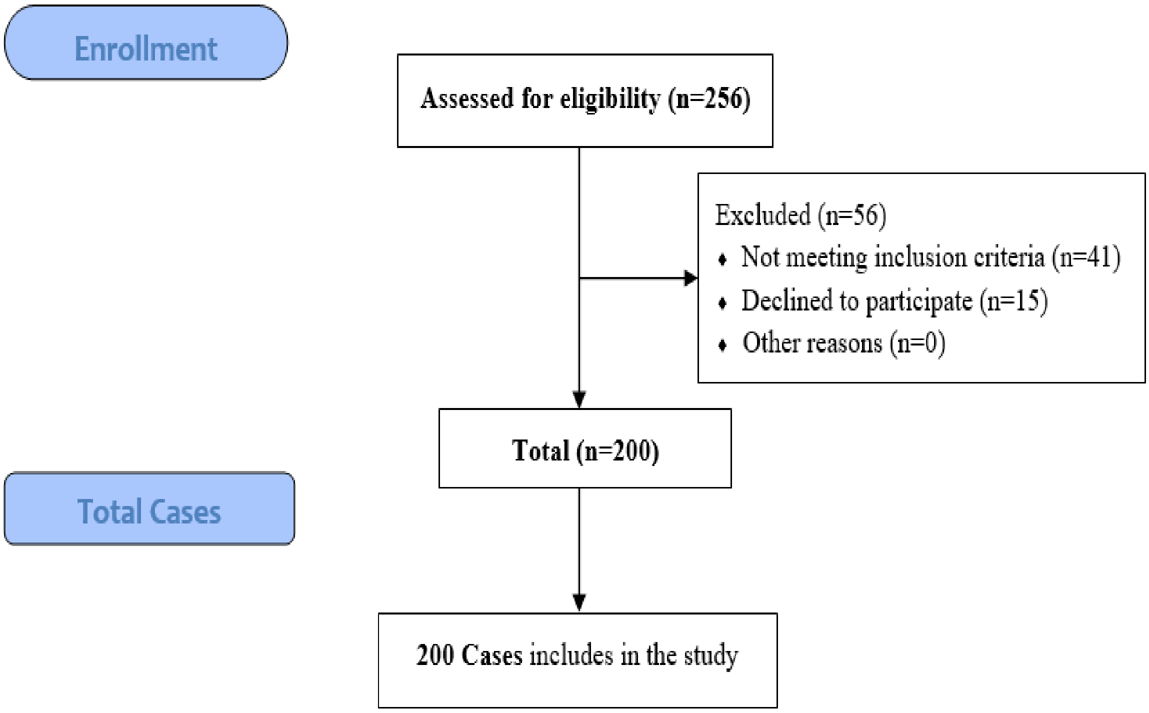

Figure 1. Flowchart of the study

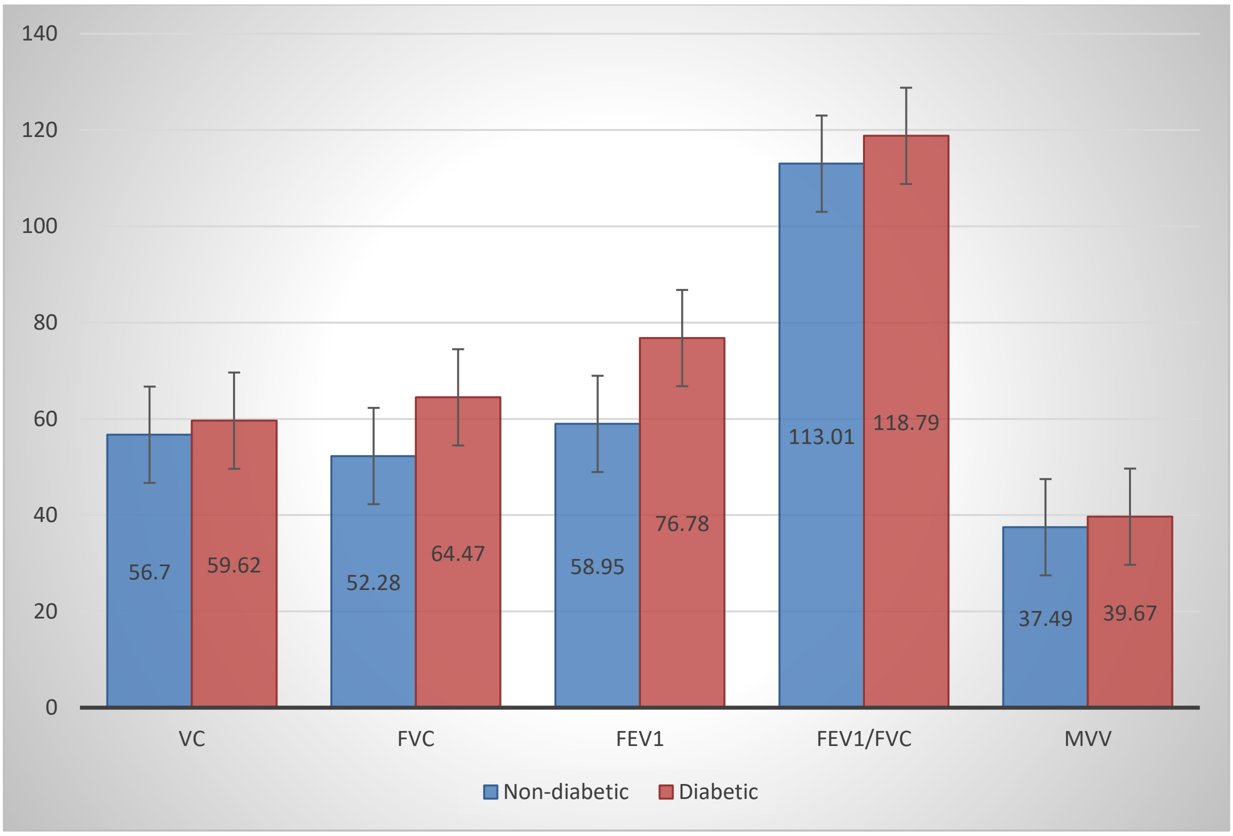

Figure 2. Comparison between Pre and Postoperative pulmonary function tests

Table 1. Distribution of the studied cases according to historical data

	Subjects (n = 200)	
Age		
Range.	44 – 70	
Mean ± SD.	57.07 ± 7.99	
Sex	No.	%
Female	42	21.0
Male	158	79.0
Residence	No.	%
Rural	65	32.5
Urban	135	67.5
BMI		
Range.	22.1 – 31.9	
Mean ± SD.	26.82 ± 2.78	
	No.	%
Airflow obstruction	28	14.0
Diabetes	32	16.0

Data presented as frequency (percentage) unless otherwise mentioned, SD: Standard deviation.

Table 2. Comparison between diabetic and non-diabetic patients according to pulmonary function tests

	Subjects		t	p-value
	Non-diabetic (n = 168)	Diabetic (n = 32)		
VC				
Range.	40.1 – 74.1	40.7 – 72.9	1.495	0.137
Mean ± SD.	56.7 ± 10.12	59.62 ± 10.19		
FVC				
Range.	35.9 – 73.9	41 – 73.9	6.368	<0.001*
Mean ± SD.	52.28 ± 10.36	64.47 ± 7.15		
FEV1				
Range.	37.6 – 92.4	43.9 – 92.1	8.155	<0.001*
Mean ± SD.	58.95 ± 11.94	76.78 ± 10.66		
FEV1/FVC				
Range.	98.2 – 129.5	99 – 128	7.872	0.535
Mean ± SD.	113.01 ± 8.9	118.79 ± 7.73		
MVV				
Range.	17.7 – 58	17.8 – 55.2	3.432	<0.001*
Mean ± SD.	37.49 ± 11.25	39.67 ± 11.77		

Data presented as frequency (percentage) unless otherwise mentioned, SD: Standard deviation.

This table shows a statistically significant difference between diabetic and non-diabetic patients regarding pulmonary function tests, as shown in Table 2.

Table 3. Regression analysis for patients with diabetes

	Exp(B)	95% C.I. for EXP(B)	Significance
VC	1.015	(0.966 – 1.067)	0.549
FVC	0.269	(0.114 – 0.631)	0.003*
FEV1	3.588	(1.666 – 7.726)	0.001*
FEV1/FVC	0.513	(0.325 – 0.810)	0.004*
MVV	1.000	(0.959 – 1.043)	0.998

Data presented as frequency (percentage) unless otherwise mentioned, SD: Standard deviation.

The regression analysis showed that diabetes affected pulmonary function tests, as shown in Table 3.

Similar results obtained in a three-year assessment by Yeh et al. in which 1100 patients with diabetes had lower FVC and FEV 1.0 than those without diabetes. After three years, the results deteriorated further, and the differences were statistically significant [17]. Lawlor et al. also demonstrated a reverse correlation between FVC and FEV1.0 and type 2 diabetes in women [18]. Similar results obtained in our study, as patients with diabetes eligible for CABG had lower pulmonary function tests than those without diabetes. In the current study, the regression analysis showed that diabetes affected pulmonary function tests. While forced vital capacity is a static parameter that is difficult to compare unless adjusted for patient gender, age, and body weight, forced expiratory volume in one second is a functional parameter that reflects the volume and flow of air through the airways, and as such is 24 that are more beneficial.

McAllister et al. described FEV1.0 as a strong predictor of a high postoperative mortality rate and more extended hospital stays in cardiac surgery patients. In addition, McAllister argues that FEV1.0 should be included in the current euroSCORE perioperative assessment [19-20]. It has [21-22] shown that obesity increases the risk of type 2 diabetes. People with a BMI above 35 have a 20 times higher risk of developing diabetes than those with a BMI within the normal range [6]. The concurrence of diabetes and obesity significantly increases the risk of cardiovascular complications and mortality [23-25]. Every patient eligible for cardiac surgery should have a spirometry test before surgery to provide information about his or her respiratory status. It could significantly help in planning anesthesia, surgery, and postoperative care.

4. Conclusion

In this study, patients with diabetes eligible for CABG had lower spirometry parameters than patients without diabetes. This indicates that these categories of patients require respiratory tests and treatment to improve respiratory function before and after cardiac surgery.

Limitations of the study

The limitation of our study consisted of the low number of patients with diabetes with normal BMI. As most patients with diabetes had above-normal BMI, further tests with a more significant number of patients with average body mass would yield results that are more reliable.

Strengthens of the study

The relevance of the study is not limited by the fact that spirometry was measured after surgery, which was not addressed in previous research

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable

Declaration of Generative AI and AI-assisted technologies in the writing process

While preparing this work, the author(s) did not use generative AI and AI-assisted technologies in writing.

Availability of data and materials

All data generated or analyzed during this study are included in this published article. In addition, the materials and any of the plants used in the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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