Journal of Population Therapeutics & Clinical Pharmacology

Pulmonary function test prior and post CABG in smoking adults

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Received: 22-9-2023 **Accepted: 2-12-2023** **Published: 1-2024**

ABSTRACT

Background: Coronary artery bypass grafting (CABG) is a relatively safe and commonly performed cardiac operation with most recent studies quoting a mortality of 0.6–3.0%.
Aim: To assess early changes in lung volumes by pulmonary function tests before and following CABG in smoking adults and to identify: how sex, age and diabetes might influence these changes.
Patients and methods: This prospective controlled study was conducted on 200 consecutive patients undergoing elective coronary artery bypass surgery. Emergency patients and those who underwent a valve operation in addition to a CABG operation were not included in the study.
Results: According to operation data, the cardiopulmonary bypass time was 98.89 (±25.14 SD) with a range (of 59-141) minutes, the mean cardiac ischemic time was 67.8 (±26.6 SD) with range (25-127) minutes, the meantime in the ICU time was 53.54 (±27.98 SD) with range (4-102) hours, according to cardioplegia there were 13 (6.5%) cold and the rest were warm and according to topical cooling there were 13 (6.5%) with ice slush. There was a high statistically significant difference between Pre- and Post-operative pulmonary function tests.
Conclusion: Cigarette smoking negatively impacts pulmonary functions, leading to obstructive and restrictive respiratory issues postoperatively. Preoperative evaluation of the pulmonary status of patients with a history of smoking who are scheduled for elective revascularization surgery is important, and smoking cessation should be strongly encouraged performed preoperatively as early as possible to minimize postoperative respiratory complications.
Keywords: CABG, pulmonary function, respiratory complications, Cigarette smoking

INTRODUCTION

Coronary artery bypass grafting (CABG) is a relatively safe and commonly performed cardiac operation with most recent studies quoting a mortality of 0.6–3.0% **(1).**
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 **(2).**
Patients undergoing CABG often develop atelectasis and severe reductions in lung volumes and oxygenation in the early postoperative period. The reason for the pulmonary impairment is

multifactorial and maybe because of anaesthesia, intra-operative events, mechanical alterations, diaphragmatic dysfunction, medication and the patient's postoperative hemodynamic status **(3).**

Postoperative pain contributes to pulmonary dysfunction. The sternotomy causes considerable pain and may persist for years after surgery. The subclavian veins should only be considered when other options are not available. Furthermore, tunnelled cuffed catheters should not be placed on the same side as a maturing arteriovenous fistula **(4).**

In the past, the female gender was reported to be an independent predictor for early and late mortality after coronary artery bypass graft surgery (CABG). In-hospital mortality after CABG was up to twice as high in women compared to men **(5).**

However, there are inconsistent reports in the current literature. In very high-risk patients, female and male mortality rates after CABG were found to be similar, whereas female gender was otherwise an independent predictor of higher operative CABG mortality. In other studies, no gender-specific differences in perioperative mortality and long-term survival after CABG were observed **(6).**

Patients with diabetes constitute a high-risk group for early cardiovascular surgical morbidity and mortality. They also account for up to 38% of patients undergoing cardiac procedures, especially coronary revascularization. There is considerable information on perioperative morbidity and mortality in patients with diabetes after CABG in which poor early outcomes and higher in-hospital morbidity and mortality have been demonstrated compared with nondiabetic patients **(7).**

The present study aimed to assess early changes in lung volumes by pulmonary function tests before and following CABG in smoking adults and to identify: how sex might influence these changes by comparing males with females, how age might influence these changes by comparing above 60 with those below 60 years and how diabetes might influence these changes by comparing diabetic with non-Diabetic.

PATIENTS AND METHODS

This prospective controlled study was conducted on 200 consecutive patients undergoing elective coronary artery bypass surgery. 256 patients were admitted in our study, and 56 of them were excluded (41 didn't meet our inclusion criteria and 15 declined to participate), so we were left with 200 cases included in the study.

Exclusion criteria: Emergency patients and those who underwent a valve operation in addition to a CABG operation were not included in the study.

Informed written consent was obtained from each patient to be included in this study.

Methods

Patient and procedure information was collected prospectively for all patients. Patient data included age, sex, comorbid conditions (diabetes, hypertension, preoperative dialysis-dependent RF, chronic obstructive pulmonary disease [COPD], congestive heart failure, cancers, and liver disease), current cardiac condition (recent [<7 days] myocardial infarction, current congestive heart failure), and previous cardiac surgery.

HTN was defined by at least two of blood pressure (BP) measurements exceeding 140 over 90 mmHg. Blood pressure was measured using a manual mercury sphygmomanometer in all cases. Trained nurses measured blood pressure in both hands in a sitting position after resting for 5 min. The higher BP was registered in a pre-specified datasheet. This protocol was repeated after 3 min. In case of difference (more than 10 mmHg in systolic blood pressure of 5 mmHg in diastolic blood pressure), the measurement was repeated for the third time and the two measurements closer together were used. The mean systolic and diastolic blood pressure of the two measurements was

calculated. Participants with high blood pressure were defined as follows: mean systolic blood pressure ≥140 mmHg or mean diastolic blood pressure of ≥90 mmHg or who were taking blood pressure medications. DM was defined by measurements of fasting plasma glucose ≥126 mg/dL or glycated haemoglobin A1C (HbA1C) ≥6.5% in the presence of confirmatory testing. Patients on antidiabetic medications were also included as diabetics in the study.
Patients were defined as smokers if they had smoked cigarettes within one month of surgery. Patients who were not classified as current smokers but had a history confirming any form of tobacco use in the past were classified as previous smokers.

Pulmonary Function Tests

Lung volumes (IVC and FEV_1) were measured by spirometry (Vicatest P2a*). Spirometry was standardized according to American Thoracic Society recommendations and was performed with the patient in a sitting position. (14) The value recorded was the best (the highest IVC, FEV_1, and forced vital capacity [FVC] measurement) of 3 consecutive attempts. Predicted values for pulmonary functions were calculated from regression equations according to age, height, and sex **(8).**

Operation technique:

All patients were 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 was connected to a cardiopulmonary bypass (CPB) device. Moderate hypothermia (28°C) was achieved, and cardiac arrest was achieved 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 was achieved with 5 mL/kg warm blood cardioplegia before the cross-clamp was removed. A roller head pump and hollow fibre membrane oxygenator were used in the CPB device. The left internal mammary artery (LIMA) and saphenous vein were used as the graft in all patients. During the operation, systemic antibiotic prophylaxis, decompression of the left ventricle, and loading excessive fluid were avoided. The patients were extubated as soon as possible (after achieving predetermined extubation criteria).

Criteria for the extubation were: resolution of the disease state or condition, hemodynamic stability, adequate oxygenation status on a decreased FiO2 and decreased PEEP/CPAP; and adequate ventilatory status and PaCO2. On the 4th postoperative day and 4 months postoperatively, the patients were 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 analogue scale (VAS) from 0 (no pain) to 10 (worst imaginable pain) was used. Patients were also asked to state the level of thorax pain (severe, moderate, little or no pain) over the 4 months after surgery and their subjective experience of breathing (improved, unaltered, impaired) compared to the preoperative status.

The following outcomes were 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 were 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, or 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 temporary or permanent pacemaker.

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

RESULTS

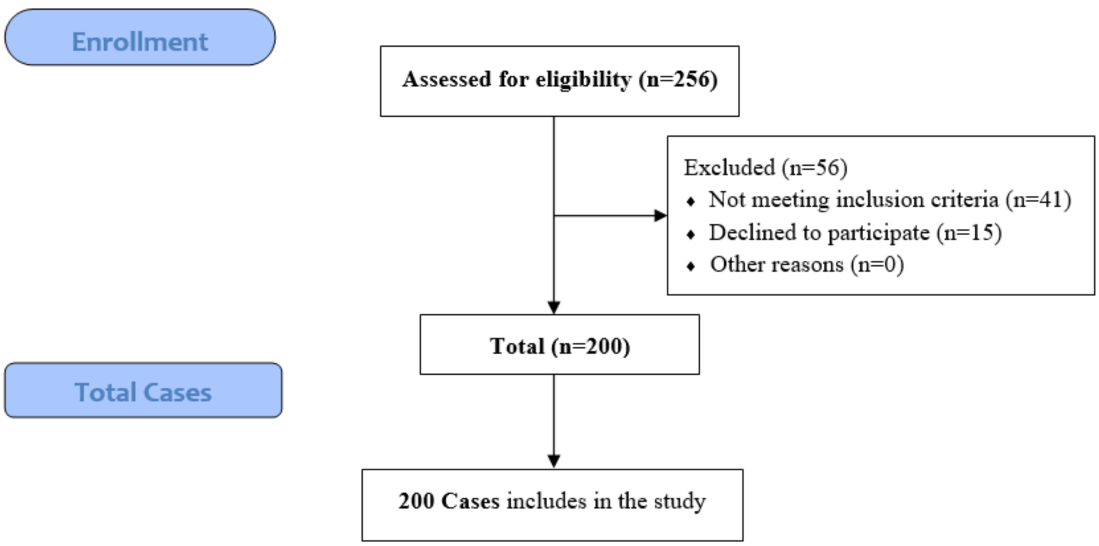

Figure 1: flowchart of the study

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 **Error! Not a valid bookmark self-reference.**.

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 are presented as frequency (%) unless otherwise mentioned, SD: **Standard deviation**

According to operation data, the cardiopulmonary bypass time was 98.89 (±25.14 SD) with range (59-141) minutes, the mean cardiac ischemic time was 67.8 (±26.6 SD) with range (25-127) minutes, the meantime in ICU time was 53.54 (±27.98 SD) with range (4-102) hours, according to cardioplegia there were 13 (6.5%) cold and the rest were warm and according to topical cooling there were 13 (6.5%) with ice slush as shown in **Table 2**.

Table 2: Distribution of the studied cases according to operation data

	Subjects (n = 200)	
Cardiopulmonary bypass time (min)		
Range.	59 – 141	
Mean ± SD.	98.89 ± 25.14	
Cardiac ischemic time (min)		
Range.	25 – 127	
Mean ± SD.	67.8 ± 26.6	
Time in the ICU (hrs.)		
Range.	4 – 102	
Mean ± SD.	53.54 ± 27.98	
Cardioplegia	No.	%
Cold	13	6.5
Warm	187	93.5
Topical cooling	No.	%
Ice slush	13	6.5
Non	187	93.5

Data are presented as frequency (%) unless otherwise mentioned, SD: **Standard deviation**

Table 3 shows that there was a high statistically significant difference between Pre and Post-operative pulmonary function tests.

Table 3: Comparison between Pre and Post-operative pulmonary function tests

	Subjects (n = 200)		t	p-value
	Preoperative	**Post-operative**		
VC				
Range.	40.1 – 74.1	19 – 60.5	38.266	<0.001*
Mean ± SD.	57.17 ± 10.16	34.45 ± 11.46		
FVC				
Range.	35.9 – 73.9	19.2 – 63.3	38.070	<0.001*
Mean ± SD.	54.23 ± 10.86	32.75 ± 10.87		
FEV1				
Range.	37.6 – 92.4	18 – 76.1	43.592	<0.001*
Mean ± SD.	61.81 ± 13.42	35.81 ± 14.75		
FEV1/FVC				
Range.	98.2 – 129.5	48.3 – 247.3	0.621	0.535
Mean ± SD.	113.94 ± 8.96	112.33 ± 38.51		
MVV				
Range.	17.7 – 58	11.2 – 51.1	42.082	<0.001*
Mean ± SD.	37.84 ± 11.33	29.27 ± 11.55		

Data are presented as frequency (%) unless otherwise mentioned, SD: **Standard deviation**

DISCUSSION

Coronary artery bypass grafting surgery (CABG) is considered an important approach for treating coronary heart disease. After open heart surgery, patients are at risk of postoperative complications, such as death and wound complications. For the past decade, the focus on preventing these complications by improving surgical techniques has remarkably decreased mortality rates, although they remain elevated compared to other types of surgery **(9).**

Tobacco smoking is considered one of the leading global causes of preventable mortality and morbidity. It is a pre-exposing factor that increases the risk of peripheral vascular disease, CAD, and chronic obstructive pulmonary disease (COPD) **(10).**

The effect of smoking on postoperative pulmonary complications (PPCs) has been addressed in a few articles. One serious set of complications patients face is pulmonary complications resulting from the disruption of normal ventilation. Pulmonary complications vary and may include pneumonia or atelectasis. The effects and outcomes of PPCs also differ, from increased financial costs and prolonged stay in hospital to increased major morbidity and mortality **(11).**

In this study, we found that there was a high statistically significant difference between Pre and Post-operative pulmonary function

Arabaci et al. found that postoperative deterioration in the smoking group was significantly greater than in the nonsmoking group. patients in both groups developed a severe restrictive ventilatory defect after CABG surgery. (P<0.0001 for both), and this restriction was significantly greater in the smoking group compared to the nonsmokers (P<0.0001). These results suggest that the changes are related primarily to the altered mechanics of the chest wall induced by the surgery and anaesthesia. In addition, this restrictive respiratory impairment was accompanied by a significant decrease in PaO_2 and an increase in $PaCO_2$ **(12)**.

Howatt and co-workers found a severe drop in VC on the first postoperative day, with a return to normal by three to eight months **(13)**.

Braun et al. revealed that all static lung volumes decreased significantly in the postoperative period **(14).**

Dull and Dull, observed decreases of up to 50% in PFTs in some of their 49 patients 24 and 48 hours following CABG. It was concluded that after CABG, there was a significant worsening of pulmonary function **(15)**.

Warner et al found that postoperative pulmonary complications occurred in a third of their current smokers and patients who had stopped smoking for 2 months or less had a pulmonary complication rate almost 4 times that of patients who had stopped for more than 2 months. Patients who had stopped smoking for more than 6 months had rates similar to those who had never smoked (11.1% and 11.9%, respectively) **(16)**.

In another study **by Kaul et al.,** postoperative pulmonary complications which developed in 7.7 per cent of the patients were more frequent in smokers and those with preoperative pulmonary dysfunction ($P<0.001$); pneumonia and atelectasis were the most common postoperative pulmonary complications and the recovery of pulmonary functions was delayed in such patients. Pulmonary complications are two to six-fold more prevalent in smokers than nonsmokers **(17)**.

Johnson et al. found that smokers with chronic heart failure had reduced expiratory flows compared to nonsmokers ($p < 0.05$), indicating an additive effect of smoking. Diffusion capacity of the lung for carbon monoxide (DLCO) was reduced in smokers and in subjects who underwent CABG **(18)**

Although all data were prospectively collected, there are a few limitations in our work. Firstly, the smoking status was determined based on self-report with no biochemical proof of the patient's smoking habits. However, self-reported smoking habits are accurate in studies of different populations. Secondly, we did not record the number of cigarettes smoked per day or the number of pack-years smoked. Thirdly, our electronic database did not record the preoperative laboratory data for all CABG patients. However, within these acceptable limitations, we believe our work will shed more light on the subject.

CONCLUSION

The results of this study show that cigarette smoking affects pulmonary functions by causing obstructive-type respiratory problems and a worsening of existing restrictive-type respiratory problems postoperatively. These results concluded that preoperative evaluation of the pulmonary status of patients with a history of smoking who are scheduled for elective revascularization surgery is important and that smoking cessation should be strongly encouraged and performed preoperatively as early as possible to minimize postoperative respiratory complications.

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