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Research Article

The Effect of Open Heart Surgery on FVC, FEV1 and FVC/FEV1 of Patients

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Abstract

Background: In Iran, 25 000 open heart surgeries are performed annually, which are mainly dedicated to coronary artery bypass surgery. Pulmonary complications after open heart surgery impose a high socio-economic burden on the society because of the length of hospital stay and the use of mechanical means. In this study, we aimed to investigate the possibility of impaired forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and FVC/FEV1 indices before and after open heart surgery, which has been directly addressed in fewer studies.

Methods: In this cross-sectional study, all 125 candidates for open heart surgery who referred to Shahid Mohammadi Hospital of Bandar Abbas University of Medical Sciences during 2107-2018 were included. The patients were evaluated by spirometry three times. Before the operation, FEV1, FVC, FEV1/FVC were measured 3-10 days and 3-6 months after surgery. Then, the changes obtained from the evaluation were extracted three times before surgery, and 3-10 days and 3-6 months after surgery, using IBM SPSS, version 17, descriptive statistics (mean, standard deviation, percentage, etc.), and one-way and repeated measures analysis of variance.

Results: FVC decreased by 0.6 in both patients with asthma and healthy ones. The mean FVC was also 0.4 in the diabetic group and 0.7 in the non-diabetic group. Mean FEV1 before surgery A, one week after surgery B and three to six months after surgery C in the two asthma and healthy groups showed a decrease of 1.2 and 1.3, respectively. Mean FEV1 before surgery A, one week after surgery B and three to six months after surgery C in smokers and non-smokers decreased by 0.9 and 1, respectively.

Conclusion: Based on the results of our study, there is no doubt about the development of pulmonary dysfunction after heart surgery. This disorder occurred in the present study independent from asthma, diabetes, and smoking.

Keywords: Heart failure, Carotid arteries, Coronary artery Bypass, Mortality

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Background

According to the Iranian Ministry of Health and Medical Education reports, cardiovascular diseases are the most important cause of death with a prevalence of more than 35% higher than accidents and cancers (1). Coronary artery bypass graft surgery is a common treatment for patients with coronary heart disease and is one of the most common surgical interventions performed in the world (2). In Iran, 25 000 open heart surgeries are performed annually, mainly by coronary artery bypass grafting (CABG) (3).

In this technique, heart pumping as well as lung gas exchange are temporarily replaced by a special mechanical device called an oxygenator pump that is connected to the vascular system (4).

Therefore, impaired gas exchange because of acute lung tissue damage is a common and well-known complication of CABG. Therefore, all postoperative patients are placed in the intensive care unit and closely monitored for pulmonary function, which of course does not completely prevent the occurrence of gas exchange disorders between tissues and pulmonary function (5-7). Pulmonary complications after open heart surgery impose a high socio-economic burden on the society because of the length of hospital stay and the use of mechanical propellers. Pulmonary dysfunction is monitored using indicators, some of the most important of which are the forced vital capacity (FVC) size (measuring unit: liter), the volume of forced expiratory volume in one second (FEV 1) size (measuring unit: liter), and the FEV1/FVC ratio.

Some studies have shown that lung function is impaired in patients undergoing open-heart surgery. A study on 41 patients examining the index of changes in residual lung volume after heart surgery showed a reduction in lung volume of about 50% after surgery. The practice was 12%-20% (8,9). In another study using CT scans as a postoperative attraction reference, 26 patients were examined and the researchers found that about 16%-20% of lungs underwent atelectasis after surgery (10).

On the other hand, a study on children aged 2-12 years with congenital heart disease showed that fluid around the arteries caused respiratory problems in the first 24 hours after surgery. Moreover, it seems that if the patient has problems with these indicators before entering the surgical process, it is less likely that the indicators will return to normal or will occur in a longer period of time (11).

We aimed to investigate the possibility of disruption in the indicators of FVC, FEV1 and FVC/FEV1 before and after open heart surgery, which has been directly studied less, considering the effect of some enabling factors. If this possibility is proven, in addition to identifying high-risk groups with preoperative lung dysfunction, it will be necessary to consider measures to provide more accurate postoperative care, especially in high-risk groups.

Patients and Methods

In this cross-sectional study, all 125 patients undergoing open heart surgery who had referred to Shahid Mohammadi Hospital of Bandar Abbas University of Medical Sciences were enrolled during 2017-2018. The exclusion criteria were recent eye surgery, recent surgery on the chest and abdomen, abdominal and cerebral aneurysms, unstable cardiac conditions, hemoptysis, pneumothorax, chest and abdominal pain, nausea, and diarrhea. Thus, eventually 125 available surgical candidates entered the study according to inclusion criteria.

These patients were evaluated three times with spirometry. Before surgery, 3-10 days after surgery, and 3-6 months after surgery. FEV1, FVC, FEV1/FVC were evaluated each time as indicators to track the changes. In this study, SPIROLAB 3 device (MIR Company, Italy, 2018) was used and following the standard operation protocol (12). All tests were performed by a qualified physician and uncertain results were excluded from the study. Then, the changes obtained from the evaluation were extracted three times at baseline, and 3-10 days and 3-6 months after surgery, using IBM SPSS software, version 17, descriptive statistics (mean, standard deviation, percentage, etc), and one-way and repeated measures analysis of variance. Patients who were admitted to the intensive care unit because of the effects of prolonged intubation or repetition were excluded from the study. Furthermore, the effect of variables such as diabetes, asthma, and smoking were also considered as possible intervening factors on changes of lung function in the patients.

Results

Ventilation data of all 125 patients undergoing open heart surgery who had referred to Shahid Mohammadi hospital of Bandar Abbas University of Medical Sciences were measured and compared in three phases of their hospitalization and follow-up, using repeated measurement test.

The results showed that the mean FVC, FEV1 and FEV1/FVC index generally decrease immediately after surgery and, then increase during 3-6 months after surgery, but did not reach its baseline amounts ($P=0.01$, Table 1).

Further analysis to detect the probability of the meaningful relationships between asthma, Diabetes and smoking habit with FVC, FEV1 and FEV1/FVC changes after open heart surgery was also done. The results are shown in 3 categories (A, B and C) as follows:

FVC Changes

The Effect of Asthma on FVC

To compare the amount of FVC in the three times, asthma was considered as covariate agent. The results showed that FVC changes before surgery, 1 week after surgery and 3 to 6 months after surgery significantly reduced in both the asthma group and in the non-asthma group to 0.6. In other words, not getting asthma does not protect a person from meaningful change (Table 2).

Table 1. The mean (SD) FVC , FEV1 and FEV1/FVC Index Before, 1 Week After

Ventilation Index	FVC Before Surgery	FVC 1 Week After Surgery	3-6 Months After Surgery	*P* Value
FVC, L	2.3 (0.1)	1.3 (0.17)	1.8 (0.8)	0.01
FEV1, L	2.3 (0.19)	1.4 (0.27)	1.8 (0.16)	0.01
FEV1/FVC	71.6 (10)	71 (13)	69 (10.7)	0.01

Table 2. Comparison of mean (SD) in liter OF FVC Before Surgery A, 1 Week After Surgery B and 3 to 6 Months After Surgery C According to Asthma, Diabetes, and Smoking Using Repeated Measures Test

Probable Enabling Factors	Condition	FVC Before Surgery	FVC1 Week After Surgery	FVC 3-6 Months After Surgery	*P* Value
Asthma	Yes	2.3 (0.9)	1.3 (0.7)	1.7 (0.7)	0.01
	No	2.3 (0.1)	1.2 (0.7)	1.7 (0.8)	0.01
Diabetes	Yes	2.2 (0.9)	1.4 (0.7)	1.8 (0.6)	0.01
	No	2.4 (0.1)	1.3 (0.7)	1.7 (0.8)	0.01
Smoking	Yes	2.3 (0.9)	1.3 (0.7)	1.8 (0.4)	0.01
	No	2.5 (0.1)	1.3 (0.7)	1.6 (0.6)	0.01

The Effect of Diabetes on FVC

To compare the amount of FVC in the three times, diabetes was considered as covariate agent. The results showed that FVC changes before surgery, 1 week after surgery, and 3 to 6 months after surgery significantly reduced in both the diabetic group and the non-diabetic group to 0.4 and 0.7, separately. In other words, not getting diabetes does not protect a person from meaningful change (Table 2).

The Effect of Smoking on FVC

To compare the amount of FVC in the three times, smoking was considered as covariate agent. The results showed that FVC changes before surgery, 1 week after surgery, and 3 to 6 months after surgery significantly reduced in both the smoking group and in the non-smoking group to 0.5 and 0.9, respectively. In other words, not smoking does not protect a person from meaningful change (Table 2).

FEV1 Changes

The Effect of Asthma on FEV1

To compare the amount of FEV1in the three times, asthma was considered as covariate agent. The results showed that FEV1changes before surgery, 1 week after surgery, and 3 to 6 months after surgery significantly reduced in both the smoking group and in the group without asthma to 1.2 and 1.3, respectively. In other words, not getting asthma does not protect a person from meaningful change (Table 3).

The Effect of Diabetes on FEV1

To compare the amount of FEV1in the three times, diabetes was considered as covariate agent. The results showed that FEV1changes before surgery, 1 week after surgery, and 3 to 6 months after surgery significantly reduced in both the diabetes group and the non-diabetes group to 0.8 and 0.6, respectively. In other words, not getting diabetes does not protect a person from meaningful change (Table 3).

The Effect of Smoking on FEV1

To compare the amount of FEV1in the three times, smoking was considered as covariate agent. The results showed that FEV1changes before surgery, 1 week after surgery, and 3 to 6 months after surgery significantly reduced in both the smoking group and in the non-smoking group to 0.9 and 1, respectively. In other words, not smoking does not protect a person from meaningful change (Table 3).

FEV1 / FVC Changes

The Effect of Asthma on FEV1/FVC

To compare the amount of FEV1/FVC in the three times, asthma was considered as covariate agent. The results showed that FEV1/FVC changes before surgery, 1 week after surgery and 3 to 6 months after surgery h significantly reduced in both the asthma group and in the non- asthma group to 0.6 and 0.3, respectively. In other words, not getting asthma does not protect a person from meaningful change (Table 4).

The Effect of Diabetes on FEV1/FVC

To compare the amount of FEV1/FVC in the three times, diabetes was considered as covariate agent. The results showed that FEV1/FVC changes before surgery, 1 week after surgery, and 3 to 6 months after surgery significantly reduced in both the diabetes group and in the group without diabetes to 0.8 and 0.6, respectively. In other words, not getting diabetes does not protect a person

Table 3. Comparison of FEV1 mean (SD) in liter Before Surgery A, 1 Week After Surgery B, and 3 to 6 Months After Surgery C According to Asthma, Diabetes, and Smoking Using Repeated Measures Test

Probable Enabling Factors	Condition	FEV1 Before Surgery	FEV1 1 Week After Surgery	FEV1 3 to 6 Months After Surgery	*P* Value
Asthma	Yes	2.5 (7.1)	1.8 (6)	1.3 (0.5)	0.001
	No	2.7 (6)	1.7 (6)	1.4 (0.4)	0.001
Diabetes	Yes	2.3 (7.1)	1.8 (6)	1.5 (0.5)	0.001
	No	2.1 (7)	1.7 (6)	1.5 (0.4)	0.001
Smoking	Yes	2.4 (7.1)	1.6 (6)	1.5 (0.3)	0.001
	No	2.4 (6)	1.7 (3)	1.4 (0.5)	0.001

Table 4. Comparison of FEV1/FVC (%) Before Surgery, 1 Week After Surgery, and 3 to 6 Months After Surgery According to Asthma, Diabetes and Smoking Using Repeated Measures Test

Probable Enabling Factors	Condition	FEV1/FVC Before Surgery	FEV1/FVC 1 Week After Surgery	FEV1/FVC 3-6 Months After Surgery	*P* Value
Asthma	Yes	70.6 (10.6)	72 (12.3)	70 (12.7)	0.001
	No	70.3 (10)	72 (12.1)	70 (12.3)	0.001
Diabetes	Yes	70.6 (10.1)	72 (11.3)	70 (11.7)	0.001
	No	70 (10)	72 (12.3)	70 (13)	0.001
Smoking	Yes	70.6 (10.8)	71 (12.3)	69 (12.7)	0.001
	No	71 (12)	73 (11.3)	70 (11)	0.001

from meaningful change (Table 4).

The Effect of Smoking on FEV1/FVC

To compare the amount of FEV1/FVC in the three times, smoking was considered as covariate agent. The results showed that FEV1/FVC changes before surgery, 1 week after surgery, and 3 to 6 months after surgery significantly reduced in both the smoking group and in the non-smoking group to 1.6 and 1, respectively. In other words, not smoking does not protect a person from meaningful change (Table 4).

Discussion

This study had one main result and three minor results as follows:

- In general, lung function indicators decrease after open heart surgery over a 6-month period. Having or not having diabetes and asthma, and smoking do not affect the rate at which FVC decreases at different times after surgery.
- Having or not having diabetes, asthma, and smoking have no effect on reducing FEV1 at different times after surgery.
- Having or not having diabetes, asthma and smoking have no effect on reducing FEV1/FVC at different times after surgery.

Decreased lung volume and atelectasis are common after open heart surgery. A study aimed at examining the factors affecting lung volume was performed on the second day after surgery. Surgery patients examined the factors affecting lung volume after surgery and reduction of lung volume with single-variable and multivariate methods. The relationship between pain (measured on a numerical scale) and postoperative lung volume reduction was calculated by Spearman correlation test. Lung volume decreased by 50%. The study also found that people with a BMI of more than 25 had a significant reduction in their lung volume compared with normal individuals (13).

Decreased lung volume and oxygen delivery are common consequences of open heart surgery. (14-17). A study showed that the mean FVC and FEV 1 decreased by 50-50% during the three days after surgery compared to preoperative values (18).

Some other studies found a 63% reduction in VC on the second day of surgery compared to the day before surgery. Atelectasis because of reduced oxygenation has also been reported as a postoperative complication (6-9). On the second day after surgery, an average reduction of 63% in vital capacity was reported compared to preoperative values. Chronic obstructive pulmonary disease is a general health condition, a history of smoking, and age-related risk factors for lung volume disorder after surgery (19, 20).

In one study, on the second day after open heart surgery, lung function decreased by about 50% and lung volume after surgery decreased by less than 40% of the predicted values of the second day. This reduction was more common in young, obese, and men (5). These results have been repeated in other studies (8, 21-25). In these studies, the reason for the decrease in lung function in young people has been linked to their greater ability to feel pain than older people.

Postoperative pain may be accompanied by changes in the thoracic mechanics of the accompanying surgery, which in turn can affect the function of deep breathing and effective coughing (26). Patients with more pain have the greatest reduction in lung volume (27). Therefore, it is important to determine the desired pain relief for the patient.

Clinical results in 2241 consecutive patients undergoing coronary artery bypass graft and/or valves from 2001 to 2007 at a regional heart center showed that a decrease in FEV1 was strongly associated with an increased risk of length of stay and mortality in the hospital. In the mentioned study, the variables of age, sex, height, body mass index, socioeconomic status, smoking, cardiovascular risk factors and long-term use of B steroids for lung diseases were controlled (28).

In the 1980s, review articles showed that performing lung tests before heart or lung surgery had little effect on predicting a patient's lung function after surgery. These findings were related to the use of articles that did not have a proper design, but unfortunately coerced the American College of Physicians to consider the accuracy of preoperative pulmonary tests to be ambiguous in their guidelines (29). At the same time, another group of studies showed that a strong link between the results of preoperative and postoperative pulmonary function tests should not affect the importance of the results of the patient's medical history and health conditions, as these factors also affect the outcome of the patient's pulmonary function after surgery (30, 31).

In one study, 50 consecutive patients with severe mitral stenosis undergoing mitral valve replacement surgery were followed up using a prospective approach. Lung function calculation tests such as FVC, FEV1, FEV1/FVC ratio, compulsory cardiopulmonary resuscitation 25-75%, maximum flow rate, and maximum ventilation voluntary (MVV) were performed in each patient one day before and six months after surgery. The results of the study showed that all indicators improved significantly (32).

In this prospective study, lung function and health-related quality of life were examined one year after heart surgery. One year after surgery, FVC and FEV1 decreased significantly in 1 second (4%-5%) compared to preoperative values. Oxygen saturation was unchanged. One year later, static and dynamic measurements in lung function decreased slightly, while health-related quality of life improved compared to preoperative values. The measurement of low pain and environmental oxygen saturation was the same as before surgery (33).

Subsequent studies suggest that chronic obstructive pulmonary disease may be considered as an effective and independent variable on patient lung function after open heart surgery. Because some studies have shown that having this disorder independent of disorders such as hypertension, ischemic heart disease and diabetes, affects the reduction of postoperative pulmonary function and can greatly prolong need of oxygen therapy (POT) by 100% and duration of staying in hospital by 60 % (34,35).

Moreover, since many of our patients were old and could not perform spirometry properly despite receiving enough instruction, we should look for a modality that does need patient cooperation such as artery blood gas (ABG) or imaging to replace demanding tests such as spirometry, to monitor patients before and after surgery.

Another pitfall of this study is that many patients are not at their best after surgery because of pain and postsurgical convalescence period. Therefore, it is difficult to differentiate between the causes of deteriorations in the lung capacity. Additionally, it is obvious that diffusing capacity for carbon monoxide (DLCO) is main part of lung function test but unfortunately, we could not to perform a DLCO because of lack of resource at that time and subsequently missed some valuable information about the patients' lung function quality.

Conclusion

According to our study, there is no doubt about the development of pulmonary dysfunction after heart surgery. The disorder occurred in the present study, independent of asthma, diabetes and smoking. However, it is important to note exactly which tests can predict the extent of the disorder. Further prospective studies are needed to confirm the importance of using tools to predict postoperative lung function, including spirometry. For example, the use of spirometry may not be appropriate in patients with abdominal problems who have undergone abdominal surgery and whose data may not be considered reliable because of the patient's inability to participate properly.

Conflict of Interests

None to be declared.

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