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Original Article

Study of pre & postoperative pulmonary functions in coronary artery bypass graft surgery patients

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Abstract:

Impaired pulmonary functions are common in coronary artery disease (CAD) patients undergoing coronary artery bypass graft (CABG) surgery. The objective of this study was to study sequential changes in pulmonary functions tests up to a period of 4 months after surgery. 50 patients undergoing CABG surgery were included in the study & their pulmonary functions were tested prior to surgery and repeated 7 days, 1 month and 4 months after surgery.It has been found that forced vital capacity (FVC) dropped from 85% of predicted preoperative value to 56% (P = 0.0000) on 7th postoperative day, recovered to 71.6% (P = 0.0000) 1 months after and to 84.2% (P = 0.4008) 4 months after the surgery. Forced expiratory volume in 1st second (FEV1) decreased from 88.38% to 59.06% (P = 0.0000) on the 7th postoperative day and recovered to 75.42% (P = 0.000) 1 month after the surgery and to 85.78% (P = 0.0308) 4 months after the surgery. Ratio of FEV1/FVC improved marginally from 79% preoperative value to 81% on 7th postoperative day and 1 month after and again reached to 78%, 4 months after the surgery suggestive of a restrictive ventilatory defect. Peak expiratory flow rate (PEFR) declined from 81.9% to 50.56% (P = 0.0000) recovered to 72.58% (P = 0.0000) and 83.92% (P = 0.0843) on the 7th postoperative day, 1 month and 4 months after surgery respectively. Maximal mid expiratory flow Rate (MMEFR) declined from 83.48% to 57.72% (P = 0.0000) then to 72.74% (P = 0.0000) and 82.02% (P = 0.4183) on 7th postoperative day, 1 month and 4 months after surgery respectively.We conclude that CABG produces long term changes in pulmonary functions hence pre and postoperative evaluation of pulmonary function should be done as a routine even if the patient is asymptomatic.

Keywords: Coronary artery bypass graft surgery (CABG),Coronary artery disease (CAD), Pulmonary function tests (PFT)

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Introduction:

Pulmonary complications are one of the most common causes of postoperative morbidity and mortality after coronary artery bypass graft (CABG) surgery. Patients undergoing coronary artery bypass graft surgery often develop atelectasis and severe reduction in lung volumes and oxygenations (1, 2) in the early postoperative period. Number of reasons has been attributed to this reduced lung functions like effects of anesthesia, intraoperative events, mechanical alteration, diaphragmatic dysfunction, medication etc. (3-5). Postoperative pain is another important cause of respiratory dysfunction. The sternotomy causes considerable pain and may persist for years after surgery (6). In addition to all these causes now-a-days there is increased use of internal mammary artery (IMA) in coronary artery bypass graft (CABG) surgery due to its long term potency rate (7, 8). This increases the incidence of pleurotomy and decrease in intercostal muscle blood supply which adversely affects postoperative pulmonary mechanics (9).

Due to the combined effects of all above mentioned factors, reduction in pulmonary functions in early postoperative period is common and well described. This study was undertaken to know sequential changes in pulmonary functions up to a period of 4 months after coronary artery bypass graft surgery.

Aim:

To study long-term changes in pulmonary functions after CABG surgery.

Material and Methods:

This was a case control study. A total of 100 subjects were enrolled for the study after obtaining Institutional Ethical Committee approval. All these subjects were in the age group of 40-70 years, 50 of them were healthy adults who did not have CAD (control group) and 50 were cases of CAD who underwent CABG surgery.

Inclusion Criteria:

1. Age: 40 - 70 years
2. Sex: Male
3. History of CAD and undergoing CABG surgery.

Exclusion Criteria:

1. Previous cardiac surgery
2. Unstable angina
3. Age more than 70 years
4. Renal dysfunction

A detailed assessment of cardiac and respiratory status was done. Pulmonary function tests (PFTs) were performed a day prior to surgery and these readings were compared with the control group. Out of 50 patients in 27 patients internal mammary artery graft was used and in 23 patients internal mammary plus reverse saphenous vein graft was used. The pulmonary function tests were repeated on 7th postoperative day and then 1 month and 4 months after CABG surgery. The patients were trained for the breathing

exercises by the anesthetists under supervision for 7 days after the surgery and were advised to continue the same at home.

Pulmonary function tests were performed by using computerized medspirror. The following variables werestudied viz .

- Forced vital capacity (FVC)
- Forced expiratory volume at the end of 1 second (FEV1)
- Ratio of FEV1/FVC
- Peak Expiratory Flow Rate (PEFR)
- Maximal Mid Expiratory Flow Rate Between 25 - 75% (MMEFR)

These entire variables were compared with the predicted values of age, sex, height, and weight and expressed as a percentage of normal value in all the patients, every time the test was repeated thrice and the best response was selected.

Statistical Analysis:

Continuous variable was presented as mean ± SD. Preoperative and postoperative changes were compared by paired t-test and mean changes in pulmonary function test at different time interval in cases were compared by unpaired t-test. Categorical variables were presented in percentages.

Results:

Table I shows demographic data of cases.Table II shows comparison of PFT variables in preoperative readings of cases with the control group.It was observed that preoperative values of FVC, FEV1, FEV1/FVC, and PEFR were slightly less than the control group but it was not statistically significant except MMEFR which was highly significant. MMEFR is a parameter which indicates small airway obstruction which can be attributed to the history of smoking in 27 patients.

Table I: Demographic data of cases

Variables	Mean ± SD
Age (years)	57.14 ± 6.38
Height (cm)	165.88 ± 5.69
Weight (Kg)	62.56 ± 9.86
BMI (Kg/m^2)	22.75 ± 3.12
Smokers (n)	27
Diabetes mellitus (n)	29
Hypertension (n)	36
Dyslipidemia (n)	36

BMI: Body Mass Index = Weight (Kg)/Height (m2). n = no. of patients

Table II: Study of preoperative pulmonary functions in cases & control

Variable	Cases (Preoperative)	Control	P - value
FVC (L/S)	2.54 ± 0.42	2.65 ± 0.47	0.2530 NS
FEV1 (L/S)	2.02 ± 0.32	2.16 ± 0.42	0.0644 NS
FEV1/FVC (%)	79 ± 0.07	82 ± 0.08	0.1961 NS
PEFR (L/S)	6.43 ± 0.91	6.69 ± 1.38	0.2661 NS
MMEFR (L/S)	2.47 ± 0.06	2.82 ± 0.67	0.0038 HS

Values are presented as mean ± SD, FVC-Forced vital Capacity, FEV1-Forced Expiratory Volume in 1st second of forced expiration, PEFR-Peak Expiratory flow Rate, MMEFR-Maximal Mid Expiratory Flow Rate (FEF 25 - 75%)

Table III shows sequential changes in different variables of PFT before (Preoperative) and after (Postoperative) CABG with their statistical significance. Forced vital capacity dropped from 85% of predicted preoperative value to 56% (P = 0.0000) on the 7thpostoperative day and then recovered to 71.6% (P = 0.0000) 1 month after and to 82.2% (P = 0.4008) 4 months after the surgery.

Forced expiratory volume in 1st second of expiration (FEV1) decreased from 88.38% to 59.06% (P = 0.0000) on the 7th postoperative day and recovered to 75.42% (P = 0.0000) 1 month after surgery and to 85.78% (P = 0.305) 4 months after surgery.Ratio of FEV1/FVC improved marginally from 79% preoperative value to 81% on 7th postoperative day and 1 month after surgery and again reached a value of 78% 4 months after surgery suggestive of a restrictive ventilatory defect. Peak expiratory flow rate (PEFR) declined from 81.9% to 50.56% (P = 0.0000) on the 7thpostoperative day, recovered to 72.58% (P = 0.000) 1 month after and to 83.92 (P = 0.0843) 4 months after surgery.

Maximal mid expiratory flow rate (MMEFR) declined from 83.48% to 57.72% (P = 0.0000) on the 7thpostoperative day and then returned to 72.74% (P = 0.0000) 1 month after and to 82.02% (P = 0.4183) 4 months after surgery.

Discussion:

In the current study we evaluated the pulmonary functions of CABG patients before and after surgery. This study is unique because PFTS were estimated preoperatively and early and late postoperative period after surgery. Previous studies reported only some preoperative PFTs or

Table III: Preoperative and postoperative pulmonary function tests

Variable	Preop I (% Predicted)	7th Postop day II (% Predicted)	1 month Postop III (% Predicted)`	4 month Postop IV (% Predicted)
F_1VC in L	2.55 ± 0.42 SD	1.68 ± 0.39	2.16 ± 0.39	2.52 ± 0.31
	(80.02 ± 12.42)	56.22 ± 13.66)	71.6 ± 9.36)	(84.2 ± 8.72)
FEV_1(L)	2.02 ± 0.32	1.35 ± 0.31	1.74 ± 0.25	1.97 ± 0.27
	(88.38 ± 13.39)	59.06 ± 15.47)	(75.42 ± 10.16)	85.78 ± 9.88)
FEV_1/FVC (%)	79 ± 0.07	81 ± 0.08	81 ± 0.06	78 ± 0.05
PEFR (L/S)	6.43 ±0.91	3.97 ± 1.03	5.73 ± 1.00	6.59 ± 0.75
	(81.9 ±11.58)	(50.56 ± 13.75)	(72.58 ± 11.89)	(83.92 ± 8.55)
MMEFR (L/S)	2.47 ± 0.48	1.72 ± 0.45	2.17 ± 0.37	2.45 ± 0.3
	(83.48 ± 14.73½)	(57.72 ± 13.72)	(72.74 ± 9.83)	(82.02 ± 8.22)

Values (absolute and percent of predicted) are presented as mean ± SD, FVC-Forced vital Capacity, FEV1-Forced Expiratory Volume in 1st second of forced expiration, PEFR-Peak Expiratory flow Rate, MMEFR-Maximal Mid Expiratory Flow Rate (FEF 25 - 75%).

were performed at a single point after surgery.

Coronary artery bypass graft (CABG) surgery is being increasingly performed using internal mammary artery (IMA) in addition to radial artery and saphenous venous graft. A decrease in lung functions postoperatively has been reported earlier also (9,10). Many factors have an influence on this impairment. Altered mechanics after opening the thoraxand reduced rib cage expansion may possibly persist for many months. Other possible reasons are effects of sternotomy, neurological impairment due to phrenic nerve injury, pleural effusion and muscular impairment as a result of decreased intercostal blood flow secondary to IMA harvesting.

From the preoperative assessment, it was obvious that our patients did not have any parenchyma restrictive lung disease. In the postoperative period, there was a generalized decrease in PFT variable up to a period of one month after CABG. All the values showed a decrease except FEV1/FVC. This is indicative of a restrictive pattern or respiratory ventilatory defect. Restrictive pattern could be because of alteration in chest wall mechanics i.e. secondary to changes in chest wall affecting its performance as bellow. Number of factors affects integrity of the chest wall such as injury to the chest wall due to sternotomy, diaphragmatic paresis due to cooling of pericardium (11). Rib fracture, retraction trauma to costochondral cartilage, undiagnosed atelectasis, sternal instability(8),and impairment of blood supply to intercostal muscles, violation of the pleural space affect the integrity of the chest wall.

When the PFTs were repeated 4 months after CABG all the variables returned to almost preoperative values with a marginal difference of 2-3% peak expiratory flow rate rather showed a rise of 2-3%.

Goyal V et al(12) reported a marked decrease in pulmonary function in the postoperative period (12^{th}-15^{th} day) by 30-40% ($P < 0.001$) in all the variables of pulmonary functions except FEV1/FVC which showed a marginal rise in the postoperative period indicative of a restrictive pathology. Braun SR et al(10) reported significant reduction in lung volumes, diffusion and PaO_2, two weeks after CABG surgery. They repeated all these tests on an average 116 days after cardiac revascularization and found that all these parameters showed improvement; however VC, TLC, IC & FRC remained significantly reduced relative to their preoperative values. VC was 17% less than the preoperative levels.

Westerdahl E et al (13) studied pulmonary functions 4 days and 4 months after CABG surgery and documented that a severe reduction in pulmonary functions was present after the surgery. 4 months postoperatively the patients still showed a significant decrease (6-13%) of preoperative values in vital capacity ($P < 0.001$). Inspiratory capacity ($P < 0.001$), forced expiratory volume in 1 second ($P < 0.001$), peak expiratory flow rate ($P < 0.001$), functional residual capacity ($P = 0.05$), total lung capacity ($P < 0.001$) and single breath carbon monoxide diffusion capacity ($P < 0.01$).

Shenkman Z et al (14) studied pulmonary functions preoperative, 3 weeks & 3.5 months postoperative and documented a significant reduction in pulmonary functions in FVC, FEV1, FEF50, FEF75, PEFR and MVV but not in FEV1/FVC in both postoperative examinations. Of these FVC, FEV1` and PEFR significantly recovered late after surgery.

Summary:

A significant restrictive decrease in pulmonary function upto approximately 30% is observed in the early postoperative period.1 month after CABG all the variables of PFT showed a restrictive decrease by 10-15% of the preoperative values, 4 months after CABG, FVC, FEV, MMEFR 25% - 75% returned topreoperative values with a marginal difference of 2-3% which was no significant statistically, PEFR on the contrary has increased by 2%.
Conclusion:

We conclude that pre and postoperative evaluation of pulmonary function should be done as a routine in patients undergoing CABG surgery even if the patients are asymptomatic.CABG produces long term changes for a period of 4 months postoperatively in pulmonary functions, so breathing exercise should be continued for a long period i.e. for a period of at least 4 months.

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