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Original Research Article

Impact of Left Ventricular Ejection Fraction on Pulmonary Function Test Values after Phase I Cardiac Rehabilitation in Patients with Coronary Artery Bypass Graft

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ABSTRACT

Background and purpose: Coronary artery Bypass Graft (CABG) is the commonly performed revascularization procedure after a major vessel block. Studies indicated that pulmonary functions reduced with left ventricular dysfunction after CABG. The aim of our study was to compare the pulmonary functions of patients with reduced left ventricular ejection fraction to normal or high left ventricular ejection fraction after Phase I cardiac rehabilitation in CABG patients.
Materials and Methods: we included 50 subjects posted for CABG and divided into two groups based on the left ventricular ejection fraction, group 1(LVEF<50%) and group 2
(LVEF≥50%), PFT was done pre operatively as well as post operatively after phase I cardiac rehabilitation.
Results: 50 subjects completed the study with the mean age 53.08 in group 1 and 53.20 in group 2, there was a marked reduction in postoperative pulmonary function values such as FVC,FEV1,VC and FEV1/FVC ratio than pre operatively, mean difference of all the pulmonary function test values were significant($p < 0.05$) in both the groups except FEV1/FVC($p = 0.177$) which was not significant in group 2,In between group comparison, there was a reduction of FVC($p=0.26$) and FEV1/FVC($p=0.000$) ratio but there was no significant difference in FEV1($p=0.185$) and VC($p=0.937$) between both the groups.
Conclusion: Pulmonary function test values were reduced postoperatively in both the groups. Postoperatively Pulmonary function tests values reduced more in groups with low left ventricular ejection fraction than normal or higher left ventricular ejection fraction mainly FVC and FEV1/FVC.

Key words: left ventricular ejection fraction, pulmonary function tests, coronary artery bypass grafting and Phase I cardiac rehabilitation.

INTRODUCTION

Lifestyles of populations across the world have changed dramatically in the 20th century. Cardiovascular disease (CVD) has emerged as the leading cause of death all over India, with coronary heart disease (CHD) affecting Indians at least 5-6 years earlier than their western counterparts. [1] According to WHO, in 2001, 17 million people died of CVD .Of these, 78% were in the low and middle income countries. [2]

Unhealthy dietary habits, sedentary lifestyle, an atherogenic dyslipidaemia and high incidence of smoking and diabetes have been largely contributory. At the

same time, however, better medical facilities have come up and coronary interventions and cardiac surgeries are being performed in nearly all major Indian cities, especially the metros. In India around 60,000 CABGs were performed in the year 2010; in 2013 it crossed more than 1 lakh according to industry sources. [3]

Coronary artery bypass surgery remains an established form of treatment for coronary artery disease and the majority of coronary surgical procedures are performed for multiple vessel disease. Overall, the mortality rate of coronary artery surgery is low, at around 2% –3 %. [4]

The coronary artery bypass graft operation consists of the construction of new pathways (conduits) between the aorta (or other major arteries) and segments of the coronary arteries beyond stenosing or obstructing lesions for the purpose of bringing blood to myocardium made ischemic by these lesions. [5]

There are 2 different methods of doing CABG: the traditional way, which is called the on-pump CABG, and the newer way, which is called the off-pump CABG (OPCAB).

The use of CABG is reasonable as a revascularization strategy in patients with multi vessel CAD with recurrent angina or myocardial infarction within the first 48 hours of ST segment elevation myocardial infarction presentation as an alternative to a more delayed strategy. It has been shown to be highly effective for the relief of severe angina, and to have prolonged life in subsets of patients. [6]

Seven core variables (priority of operation, age, prior heart surgery, sex, left ventricular ejection fraction [LVEF], percent stenosis of the left main coronary artery and a number of major coronary arteries with significant stenosis) are the most consistent predictors of mortality after coronary artery surgery. [7]

Postoperative pulmonary complications (PPCs) are the most common complications observed and managed after abdominal or cardiothoracic surgery. Despite numerous advances in preoperative, intraoperative, and postoperative care, PPCs continues to contribute to patient morbidity and mortality, length of stay, and overall use of resources. [8] Its pathophysiology is complex and reflects the combined effects of general anesthesia, surgical injury, median sternotomy and cardiopulmonary bypass (CPB) to produce hypoxia, atelectasis, pleural effusion and dysfunction of the diaphragm. [9] Postoperative pulmonary dysfunction results in increased work of breathing, shallow respirations, ineffective cough, and hypoxemia. [10]

Ejection fraction refers to the amount of blood ejected from the left ventricle as a percentage of the total volume in the left ventricle prior to the contraction (i.e., the end-diastolic volume). [11] Normal LVEF ranges from 50-70%, ejection fraction is one of the most important predictors of prognosis. Those with significantly reduced ejection fraction typically have poor prognosis. The severity of left ventricular dysfunction was associated with poor survival. Coronary bypass patients had a worse outcome only if their preoperative ejection fraction <50%. [12]

The World Health Organization (WHO) has defined Cardiac rehabilitation as the ‘sum of activity and interventions required to ensure the best possible physical, mental, and social conditions so that patients with chronic or post-acute cardiovascular disease may, by their own efforts, preserve or resume their proper place in society and lead an active life.

According to American college of sports medicine (ACSM), cardiac rehabilitation can be divided into 4 phases. Phase I, known as the hospital phase, aims to minimize the effects of restriction to bed

and ends with hospital discharge. Phase II (up to 12 week) starts immediately after discharge and is known as the early out-patient phase. The aim is to develop activities that simulate the metabolic expense of everyday activities. Phase III known as the late out-patient phase (variable duration) aims to develop exercises with more intensity. The fourth and final phase is known as the preventive phase and should have a starting date but not a finishing one, where the patient will choose a cyclical activity of greater affinity, carrying out the program at least 3 times a week throughout one's lifetime. [13]

Phase I of cardiac rehabilitation is an inpatient program that is designed primarily for those recovering from myocardial infarction or coronary artery bypass graft. The program combines low-level exercise and patient education, generally lasting from 3 to 7days.

Inpatient exercise starts with a physician's order. Low-level exercise during the hospital stay has been shown to be safe, feasible and beneficial. Typically, patients are progressed one or two steps each day. The activities of the phase I should not exceed 3-5 METs. The duration of exercise initially is 5 to 10 minutes per session and is gradually increased to 20 or even 30 minutes per session.

Pulmonary function tests (PFTs) help in the evaluation of the mechanical function of the lungs. Spirometry is a physiological test that measures how an individual inhales or exhales volumes of air as a function of time. The primary signal measured in spirometry may be volume or flow. PFT including Vital Capacity (VC), Forced Vital capacity (FVC) and Forced FEV1 were an important predictor of lung function before and after CABG.

The most basic test of pulmonary function is the measurement of vital capacity (VC).This test simply measures the largest volume of air that can be moved into or out of the lungs. Forced vital capacity (FVC) is the maximum volume of gas the patient can exhale as forcefully and as quickly as possible. The FEV_1 is a measurement of the volume exhaled in the first second of the FVC and reflects the airflow in the large airways. The FEV_1/FVC ratio also called the forced expiratory volume in 1 second -to-vital capacity ratio.

The test is having high level of validity and reliability to find out pulmonary functions after any major surgery. To ensure validity each patient must perform a minimum of three acceptable pulmonary function maneuvers. To ensure the reliability, the largest value and second largest value from the acceptable trials should not vary by more than 0.150 litre.

LVEF is a major predictor of prognosis after CABG. Studies showed that patients with LVEF <50% showed pulmonary complication and poor prognosis after CABG. PFT is the objective evaluation of the function of respiratory system, but the exact relationship between LVEF and pulmonary function test values are unexplained, so the need for this study to evaluate the impact of LVEF on PFT values after phase I cardiac rehabilitation in patients with CABG.

The objective of the study was to find out the PFT values of patients with low and normal LVEF after Phase I cardiac rehabilitation and to compare the PFT values in patients with low and normal LVEF after Phase I cardiac rehabilitation.

MATERIALS AND METHODS

We recruited 50 subjects who had undergone isolated CABG, which included male and female subjects; subjects were selected from the population group satisfying the inclusion criteria from the patients of the department of cardiothoracic surgery in a teaching hospital, by using purposive sampling. The

study was approved by the University ethics committee and informed consent was obtained from all the subjects before recruitment into the study. We included subjects whose age was between 40-65 years and patients with isolated CABG. We excluded the patients above 65 years, patients with chronic obstructive pulmonary disease (COPD), recent myocardial infarction, renal failure, other than isolated CABG and non cooperative patients.

These patients were divided into 2 groups, according to left ventricular ejection fraction, group 1 was patients with LVEF <50% and group 2 was patients with LVEF ≥50%, with 25 subjects in each group.

The nature, need and duration of the treatment were explained to the subjects preoperatively as well as any particular co- operation required was indicated. All subjects underwent pre-operative chest physiotherapy to clear the secretion and to improve the lung function. It was started once the patient is admitted the hospital for CABG. All the patients receive general information about postoperative routines by physical therapist.

Postoperatively subjects had undergone phase I cardiac rehabilitation. The phase I cardiac rehabilitation included physiotherapy techniques like incentive spirometry, coughing, huffing, chest manipulation, segmental expansion and mobilization.

Post operatively the exercises were started approximately 1 hour after extubation and the patients were encouraged to perform exercises. All patients receive chest physical therapy twice daily till the 7th post-operative day.

PFT was performed preoperatively and post operatively after phase 1 cardiac rehabilitation. The evaluation of pulmonary function was performed by using True flow by and ndd (CE0120) Switzerland. The PFT was performed in the morning time one hour after chest physical therapy. Calibration of the equipment was done every day before the measurement was taken. The patient sat on a chair with the nose clipped and the procedure was done according to the method recommended by the European Respiratory Society. The best of three readings which were taken according to the correct technique was taken as the final reading. PFT including Vital Capacity (VC), Forced Vital capacity (FVC) and Forced FEV1 were performed; FEV1/FVC ratio is also calculated. [14]

Recording FVC:

The patient was in comfortable sitting position on the chair, Breathing manoeuvres were taught. And then the patient was instructed to keep the disposable mouth piece attached to the transducer halfway in mouth above tongue. The nose clip was applied and patient was asked to inspire maximally. (There should be a minimal pause at maximal inspiration; a prolonged pause may decrease flow during subsequent expiration).Then the patient was asked to expire as forcefully and rapidly as possible into the transducer up to 6 seconds followed by a deep inspiration. With this maneuvers Easy on PC sensor measured automatically FEV1 and FEV1/FVC ratio.

Patient perform the same manoevures 3 times and asked to take rest in between and also asked to put a pillow or rolled-up blanket against the chest to support the incision during performing forceful breathing manoeuvers. The highest value of three technically satisfactory manoeuvres is retained. [15, 16]

Recording SVC:

The patients were in a sitting position on the chair and a nose clip was used. The subject with his nose clip was asked to do tidal breathing for certain period of time, after a minimum of quite breathe he was asked to take a deep

inspiration followed by deep expiration and then breathe normally. [16]

Therapist asked the Patient to perform the same manoeuvres 3 times and asked to take rest in between and also asked to put a pillow or rolled-up blanket against the chest to support the incision during performing forceful breathing manoeuvres. The highest value of three technically satisfactory manoeuvres is retained.

After collecting the data from all the patients in the two groups, the values will be analyzed, and compared between two groups.

Statistical analysis:

Statistical analysis was performed with the SPSS Version 16.0.Inter group comparisons of pulmonary function test like FVC, FEV1, VC and FEV1/FVC ratio between group 1(LVEF<50%) and group 2(LVEF≥50%) were performed by using Independent sample test and Intra group comparisons of pre and post values of pulmonary function test FVC, FEV1, VC and FEV1/FVC ratio were performed in group 1 and group 2 by using paired t test. Data are presented as mean ± standard deviation. .05% of probability was adopted as the level for the statistical significance.

RESULTS

In this study base line assessment was done 56 subjects, after drop out in each group final outcome was measured from 50 subjects. The demographic data is illustrated in Table 1.

Table 1: Demographic distribution of subjects.

Characteristics	Group 1 (N= 25) LVEF < 50% No:25	Group 2 LVEF ≥ 50% No:25	P value (< 0.05)
Gender M:F %	80:20	88:12	
Age Mean ± SD	53.08 ± 7.81	53.20 ± 6.38	0.953
BMI Mean ± SD	20.48 ± 1.76	21.29 ± 1.96	0.128
LVEF Mean ± SD	40.36 ± 5.61	56.76±3.76	0.001

S D = standard deviation, BMI = Body mass index, LVEF = left ventricular ejection fraction

In group 1, mean age of the patients being 53.08 with standard deviation of 7.81.In group 2, mean age of the patients being 53.20 with standard deviation of 6.38.With test of homogeneity of variances, p value obtained was 0.953 which is not significant. This implies that both groups are equally distributed. In group 1, mean BMI of the patients being 20.4 with standard deviation of 1.76. In group 2, mean BMI of the patients being 21.29 with standard deviation of 1.96.With test of homogeneity of variances, p value obtained was 0.128 which is not significant. In group 1, mean LVEF of the patients being 40.36 with standard deviation of 5.61. In group 2, mean LVEF of the patients being 56.76 with standard deviation of 3.76.With test of homogeneity of variances, p value obtained was 0.001 which is significant. This implies that both groups have not equal LVEF.

In the paired t test for the pre operative to postoperative comparison, there was reduction in mean values of FVC, FEV1, VC and FEV1/FVC. (Table 2)

Table 2: Intra group comparison of pre and post pulmonary function test in each group

PFT outcome	Group I		Group 2	
	Pre (mean ± SD)	Post (mean ± SD)	Pre (mean ± SD)	Post (mean ± SD)
FVC (L)	3.33 ± 0.68	1.54 ± 0.88	3.85 ± 0.51	2.51 ± 0.34
FEV1 (L)	2.60 ± 0.62	1.37 ± 0.36	3.14 ± 0.51	2.16 ± 0.28
VC (L)	3.38 ± 0.64	2.02 ± 0.41	4.02 ± 0.44	2.67 ± 0.27
FEV1/FVC (%)	82.88 ± 9.8	77.32 ± 6.1	97.4 ± 11.38	88.64 ± 9.46

S.D-Standard Deviation, FVC-Forced Vital Capacity, FEV1-Forced Expiratory Volume in 1 second, VC-Vital Capacity.

The result proves that there is a significant reduction from the pre FVC to the post FVC value of pulmonary function test.

FEV1 for group 1, the mean pre FEV1 values was 2.60 and mean post FEV1 values was 1.37 which shows a mean difference of 1.22 and t value is 9.6 and P 0.000 ($p<0.05$).

Table 3: Intra group comparison of paired difference of pre and post

	Group 1 paired difference (Mean ± SD	t	P value	Group 2 paired difference (Mean ± SD	t	P value
FVC pre-post (L)	1.78 ± 0.80	11.03	0.000	1.33 ± 0.54	12.1	0.000
FEV1 pre-post (L)	1.22 ± 0.63	9.6	0.000	0.99 ± 0.55	8.9	0.000
VC pre-post (L)	1.35 ± 0.68	9.8	0.000	1.34 ± 0.51	13.0	0.000
FEV1/FVC Pre-post (٪)	-33.84 ± 14.9	11.33	0.000	-3.56 ± 12.7	-1.39	0.177

S.D-Standard Deviation, FVC-Forced Vital Capacity, FEV1-Forced Expiratory Volume in 1 second, VC-Vital Capacity.

The result proves that there is a significant reduction of PFT values post operatively.

When the inter group comparison of group 1 and group 2 were performed there were significant difference in FVC and FEV1/FVC ratio (Table 4).

Table 4: Inter group comparisons of group 1 and group 2 were performed by using Independent sample test.

	EF<50% Mean±SD	Ef ≥50% Mean±SD	t value	P value
FVC (L)	1.78±0.80	1.33±0.54	2.031	0.26*
FEV1 (L)	1.27±0.63	0.97±0.55	0.344	0.185
VC (L)	1.35±0.68	1.34±0.51	0.79	0.937
FEV1/FVC (%)	-33.8±14.93	-3.5±12.7	-7.702	0.000*

S.D-Standard Deviation, FVC-Forced Vital Capacity, FEV1-Forced Expiratory Volume in 1 second, VC-Vital Capacity.

DISCUSSION

The purpose of the study was to find out the effect of LVEF on pulmonary function values in CABG patients after Phase I cardiac rehabilitation.

In this study, Subjects were divided into two groups according to left ventricular ejection fraction, group 1 was patients with LVEF <50 %(22 men, 3 female) and group 2 was patients with LVEF ≥50 %(20 men, 5 female), 25 subjects in each group. Mean age of group1 was 53.08±7.08 and mean age of group 2 was 53.20±6.38 .Mean BMI was in group 1 was 20.47±1.76 and in group 2 was 21.29±1.96.Mean EF in group 1 was 40.36±5.61 and in group 2 was 56.76±3.76.

All patients received a cardiac rehabilitation before and after CABG operation. All patients receive chest physical therapy twice daily till the 7th post-operative day. The preoperative values and post operative values of pulmonary function like FVC, FEV1, VC, and FEV1/FVC ratio were obtained by pulmonary function test.PFT values of about 50 patients were taken, among which few patients were not able to perform 3 trials at a time though rest period was given in between because of chest pain, breathlessness and productive sputum, so the highest value of technically satisfactory manoeuvres is retained.

The results shows that in both the group 1(LVEF<50%) and group 2(LVEF>50%) there was a decrease in mean post values of FVC,FEV1, VC and FEV1/FVC ratio than mean pre value of FVC,FEV1, VC and FEV1/FVC.

The reductions in lung volumes and oxygenation are common during the initial period which may be due to lung collapse after heart surgery. The effects of the median sternotomy, post operative pain, neurological impairment due to phrenic nerve affection, pleural effusion and muscular impairment as a result of decreased intercostal blood flow secondary to internal mammary artery harvesting, use of anaesthesia that leads to relaxation changes in thorax mechanics, pain and the use of cardiopulmonary bypass negatively influence lung function.

Westerdahl et al found that pulmonary function reduced on the fourth post-operative day of CABG with 60- 75% of the pre-operative values. [17] In a recent systematic review, Pasquina et al reported that VC was 37-72% of pre-operative values in 11 trials and FEV1 were 34-72%

in eight trials of preoperative values for cardiac surgery. [18]

In the postoperative period there was a generalized decrease in PFT variable after CABG in both the group. Mean difference of all the values were significant in both the group except FEV1/FVC ratio. 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, rib fracture, retraction trauma to costochondral cartilage, undiagnosed atelectasis, sternal instability, impairment of blood supply to intercostals muscles.

Goyal et al reported a marked decrease in pulmonary function in the post operative period (12th to15th) day by 30-40% in all the variables of pulmonary functions except FEV1/FVC which showed a marginal rise in the postoperative period indicative of a restrictive pathology. [19]

Shenkman et al 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. [20]

The results of intergroup comparison of group 1and group 2 shows significant difference in FVC and FEV1/FVC ratio, which prove that there was a significant decrease in FVC and FEV1/FVC ratio in group 1 than in group 2 which was having LVEF values <50% which shows that patients with poor LVEF has more restrictive pulmonary function than normal LVEF.

Patients with reduced left ventricular ejection fraction, there was a decrease in PFT values which shows there was an increase in extra vascular fluid in the lungs which reduce or altered the lung compliance and increased pulmonary resistance, may result in increased respiratory work and oxygen consumption which reduce FVC and FEV1/FVC ratio.

In this study, the alterations in pulmonary function in subjects after undergoing CABG demonstrate the need for early intervention in the preoperative period with the goal of optimizing pulmonary function. Physiotherapy, including incentive spirometer and breathing exercises should be continued in the postoperative period. Pre and post operative evaluation of pulmonary function should be done as a routine in patients undergoing CABG surgery even if the patient is asymptomatic. CABG produces long term changes in pulmonary functions so chest physical therapy mainly breathing exercise, incentive spirometer should be continued for a long period. Postoperative pain was related to a larger decrease in postoperative lung volumes. Therefore, it is important to determine optimal pain relief for the patient.

The frequency and duration of chest physical therapy can be increased in patient with low left ventricular ejection fraction groups to reduce the hospital stay and to reduce the economical burden of the patient.

The limitations of our study was post operative pain and breathlessness interfered with the patients performance and cooperation and less sample size can lead to less statistical weightage. Future prospective studies can be done with gender wise different graft wise comparison.

CONCLUSION

Study concluded that the pulmonary function test values reduce postoperatively in both the groups. Comparison between the groups showed there was a significant difference mainly FVC and FEV1/FVC ratio in patient with low left ventricular ejection fraction than normal or high left ventricular ejection fraction patients and it shows comparatively restrictive pattern of disease

was more with low left ventricular ejection fraction than normal or high left ventricular ejection fraction patients after CABG.

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