Research Article

The functional capacity of the patients after open heart surgery following physiotherapy utilizing inspiratory muscle training

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ABSTRACT

Background: Post-operative pulmonary dysfunction is common after open heart surgery. This causes impairment in the routine activities of an individual. Exercise rehabilitation may benefit in open heart surgery patients, improving their exercise capacity. **Objective:** The objective of the study was to assess and compare functional capacity in open heart surgery patients following conventional physiotherapy (CP), and CP plus inspiratory muscle training (IMT). **Materials and Methods:** In this prospective randomized control study, participants were taken from cardiac hospital using balance block computer generated randomization method. There were 102 participants, 52 in Group-A and 50 in Group-B. Group-A has been given CP and the Group-B has been given conventional plus IMT exercise by Pressure Threshold IMT instrument. For the functional capacity measurement, 6 minute walk test (MWT) and incentive spirometry (IS) was used at pre-operative, "at discharge" and at "1st follow-up" of patients. **Results:** Addition of IMT exercises to the conventional physiotherapy did not show statistically significant difference in functional capacity after open heart surgery. Though the component of functional capacity- 6MWT showed an incremental change which was statistically significant within the groups *(P* < 0.05). **Conclusion:** No any significant difference was found in functional capacity in CP and conventional plus inspiratory muscle trainer group in "pre-operative," "at discharge" and "1st follow-up," in open heart surgery patient.

KEY WORDS: Open Heart Surgery; Functional Capacity; 6-Minute Walk Test; Incentive Spirometer; Physiotherapy; Maximum Inspiratory Pressure; Inspiratory Muscle Training

INTRODUCTION

The procedure executed in patients with disease of heart is heart surgery. This surgery is remains the therapeutic option available for better survival of the individuals with coronary artery disease (CAD), and in patients with diseases of the heart valves.[1] For CAD important treatment is bypass graft of coronary artery (known as coronary artery bypass grafting [CABG]). Modern progression in the technology for cardiovascular diagnosis and management had enhanced the valvular heart disease by valve repair or replacement.[2] Patients undergoing heart surgery requires effective cardiac rehabilitation and improved health-care delivery.[3]

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A reduction in lung function is known fact after heart surgery. Radiological signs of lung collapse are commonly seen, in addition to that several studies have been mentioned the diminished lung capacity and oxygenation after operation in the hospital. Chest physiotherapy is regularly practiced to avoid or decrease respiratory complications following cardiac operations.[4-7] Pre-operative as well as post-operative, physiotherapy including of breathing movements stressing inspiration, incentive spirometry (IS), techniques for bronchial hygiene, and early mobilization is specified with the purpose of improving ventilation of lung,

functional capacity (endurance), stopping chest infections, as well as decreasing the hospital stay.[4,5,8-10] The operating procedure for heart leads to diminish in the strength of respiratory muscle. To re-establish this muscle strength, various strategies have been used. The training of respiratory muscle, intentions to increase functional capacity, breathing muscle strength, and decrease risks of operation in patients with heart surgery is one such effective strategy.[1] After surgery, the close influence of anesthesia to abnormalities in air exchange is well acknowledged.[11] Inspiratory muscle training (IMT) will be an essential strategy to lessen post-operative complications, also length of stay after major operative procedure, especially those involving muscles of respiration and impairment to thoracic cage. The 6 minute walk test (MWT) has been a beneficial tool for assessment of functional status, aimed at individuals with moderate impairment. It has been commonly used for assessing the reply to therapeutic procedure or skills after cardiothoracic problems or disease.[12,13] Lung functions can be effectively assessed and considered for treatment by IS to observe the respiratory recovery postoperatively. Chest expansion might be effectively improve after cardiac surgery with IS as evidences mentioned in literature.[14]

Exercise rehabilitation could be helpful in patients undergoing cardiac surgery and improving capacity of body for exercises. But because of dearth of evidence, further randomized clinical studies are required to evaluate the effect of exercise-centered therapy on patient-related outcomes, containing status of functional activities. Therefore, there was a need for assessing and documenting the functional status of patients undergoing open heart surgery at our institute for their optimum care was felt. Therefore, we conducted this study with the objective to assess the functional status (6 MWT, and IS) in patients undergoing open heart surgery following conventional physiotherapy (CP) and CP plus IMT.

MATERIALS AND METHODS

Type of Study

This was a prospective randomized control study.

Inclusion Criteria

Patients posted for elective open heart surgery (Bypass graft and/or Valve replacement), who were hemodynamically stable with age between 18 and 70 years, of both gender and referred for physiotherapy were included in the study.

Exclusion Criteria

Patients who had unstable angina, history of stroke, recently diagnosed severe endocarditis, any severe musculoskeletal condition (affecting walking specially knee joint pain, and any psychiatric problems), pre-existing chronic respiratory diseases, involvement of left main coronary artery, and ejection fraction <30% were excluded from the study.

Methodology

Ethical clearance from the Institutional Ethics Research Board was taken before recruiting the patients in the study. (IEC/HMPCMCE/82/Faculty/1/194/17) All the patients who were posted for elective open heart surgery and referred for physiotherapy, satisfying the inclusion and exclusion criteria were recruited from the B and M Patel Cardiac Centre, Karamsad. Out of 112 patients, ten were excluded from the study as they had either refused, or had major postoperative complications or were lost to follow-up. Written and informed consent form of all the patients was obtained after explaining the purpose of the study.

All medical records were reviewed and basic investigations were recorded. Patients have been distributed into two groups using Balance block – computer generated randomization method – Groups A and B. Control, that is, Group A (control group) was given CP (Education, Breathing exercises, IS, forced expiratory techniques, and ambulation), while Group B (experimental group) was given IMT using inspiratory threshold loading device (Threshold® IMT, Respironics, USA) in addition to CP until they were discharged. These patients were started on breathing exercises at 15% of their maximum inspiratory effort for muscle of inspiration to strengthen. The patients had to do three sets of ten repetitions with 1 min rest, in between each set of exercises. The resistance of IMT was raised gradually from 15% to 45% based on the patient's acceptance with regard to stability of vital signs and pain threshold in the following days [Figure 1].[7,15]

Physiotherapy sessions were delivered to the patients twice a day by the physiotherapist a day before surgery. Subsequently, postoperatively after extubation 6 hourly/day in Intensive care unit (ICU), and thereafter 8 hourly/day in step down ward until they were discharged from the hospital. The functional status (6 MWT, IS), was assessed preoperatively, and baseline parameters were noted. Again the same parameters were measured on the day of discharge as well as on the first follow-up of patients for both the groups. Drug therapy, nebulization, and nursing care were continued and firmly implemented to all the patients as recommended by concerned doctor during the patients hospital stay. After discharge, patients of both the groups were given home exercises.

Measurements

6 MWT

In this test, straight 30 m flat corridor of hospital where patients have been instructed to walk as far as possible with their comfortable speed for 6 min. The patients had instructed when

Figure 1: Instruments used for study

they feel symptoms of chest pain, breathlessness or dizziness than stop walking and resume when possible, as it is symptom-limited test. The total distance in 6 min was documented as covered by patients. Before the test, the patient's resting pulse rate, respiratory rate, blood pressure, and oxygen saturation were monitored in a sitting. After completion of the 6 MWT, a therapist measured immediate post-exercise test data, including vitals, rating of perceived exertion, distance covered, and time required for recovery of the vital to the baseline.[12,13]

IS

In the present study, IS used was Respirometer Respiratory Exerciser of Romsons Medicons (SH-6082). The device was placed at mouth level, patient asked to exhale normally before inhaling, then inhale thoroughly to lift the ball and hold inspiration as long as possible. The procedure was repeated and measurements were noted down in ml (red- 600 ml, yellow-900 ml, and blue-1200 ml) and analyzed.[9,16]

Statistical Analysis

It was done using the STATA 14 with descriptive statistics of data, paired sample-*t*-test, Chi-square test, and independent sample test used for comparing the mean values of variables within and between the both groups as per need. The statistical significance level for each comparison was considered at 5% Level ($P < 0.05$).

RESULTS

In this study, a total of 282 patients were screened for open heart surgery for CABG and valve replacement or both in B and M Patel Cardiac Centre, Karamsad from May 2017 to March 2020, and out of that 112 patients were included as per inclusion and exclusion criteria. However, while conducting the study total 102 patients continued as a part of the study while 10 left as either they had major postoperative complications, or were not cooperative, or lost to follow-up. Therefore, we were left with a total of 102 patients, Group-A had 52 CP as well as Group-B had 50 patients (CP + IMT) [Figure 2].

Table 1 shows the basic demographic details of both groups representing homogenous distribution for age, body mass index (BMI), gender, smoking history, ICU stay, and hospital stay. Furthermore, it shows the surgical characteristics of participants in both the groups.

Table 2 showed that the comparison of mean difference of 6 MWT in which both groups had comparable difference between the "preoperative" to "at discharge" values. Groups A and B showed statistical significance within groups-between "at discharge" to "at follow-up" in 6 MWT.

Table 3 shows that there is no statistical significance between both Groups A and B with respect to 6 MWT. The vital

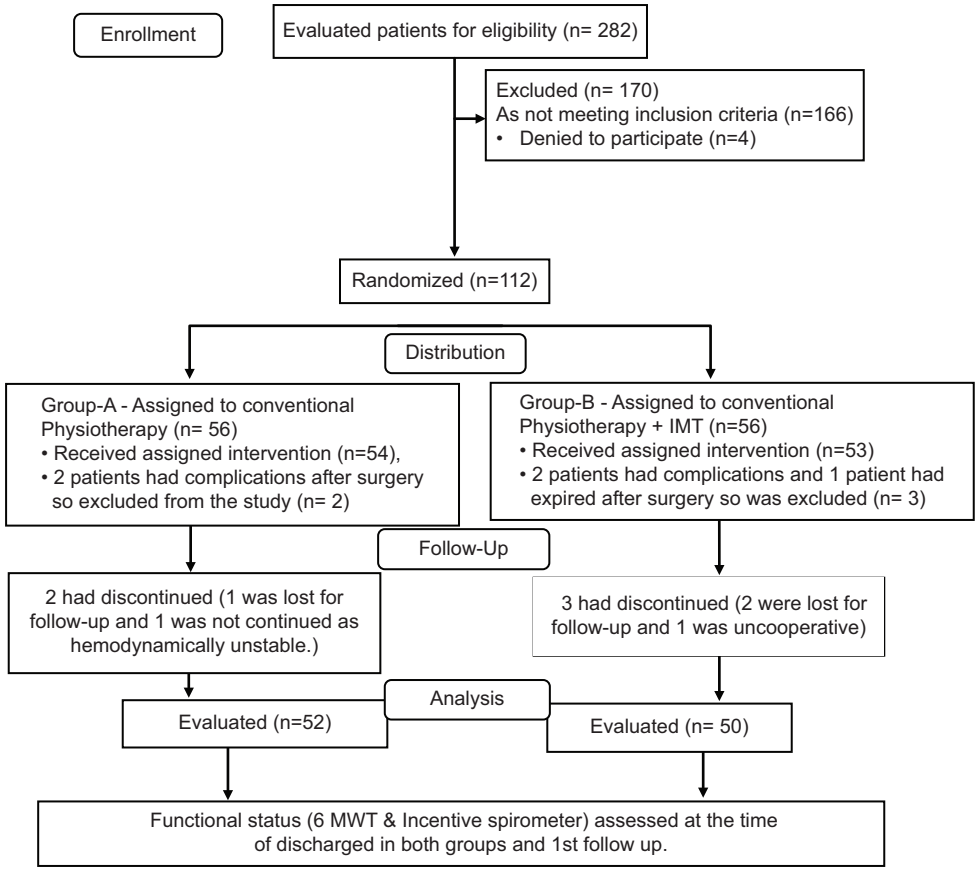

Figure 2: CONSORT flow diagram

Table 1: Basic demographic and surgical characteristics of participants in both groups

Variables	Group – A (%)	Group – B (%)
Total *n* = 102	***n*=52**	***n*=50**
Age (years)	54.04±12.14	53.92±15.35
BMI (kg/m^2)	23.58±4.43	24.30±5.11
Gender		
Male	29 (55.8)	34 (68)
Female	23 (44.2)	16 (32)
Smoking		
No	31 (59.6)	28 (56)
Yes	21 (40.4)	22 (44)
Days for hospital stay	8.38±1.40	9.02±2.11
Days in ICU stay	2.12±0.79	2.48±0.84
Surgery Norms		
CABG	35 (67.3)	28 (56)
Valve replacement	14 (26.9)	16 (32)
CABG+valve replacement	2 (3.8)	5 (10)
ASD closure	1 (1.9)	1 (2)

BMI: Body mass index, CABG: Coronary artery bypass Graft, ASD: Arterial septal defect, CABG: Coronary artery bypass grafting

parameters in both groups showed an increase at the end of the 6 MWT which was not more than 20% of its baseline value and returned back to the baseline after the 4 m of rest at "preoperative," "at discharge," and "at follow-up."

Table 2: Difference of 6 MWT in Pre-operative, discharged, and follow-up within the group comparison

Group	6 MWT distance difference	Mean±SD	Sig. (two tailed)
A	Pre-operative and discharge	22.65±102.08	0.119
	Follow-up and discharge	43.09±58.19	<0.001*
B	Pre-operative and discharge	−1.72±92.73	0.896
	Follow-up and discharge	36.60±78.76	0.002*

Independent samples test, Level of significance *P*<0.05, 6 MWT: 6 minute walk test

Table 4 shows that the measurement of IS is not statistical significance difference between the Groups A and B at "preoperative," "at discharge," and "at follow-up."

DISCUSSION

In this study, all patients posted for open heart surgery, that is, CABG and valve replacement or both at B and M Patel Cardiac Centre, Karamsad were screened. Out of 282, a total of 112 patients recruited for the present study as per inclusion and exclusion criteria. 102 patients continued in the study, while ten left due to various reasons such as major

Table 3: Difference of 6 MWT in pre-operative, discharged and follow-up between the groups comparison

Difference of 6 MWT	Group	Mean±SD	Sig. (two-tailed)
Discharge and preoperative	A	−22.65±102.08	0.212
	B	1.72±92.72	
Follow-up and discharge	A	43.09±58.19	0.636
	B	36.00±78.75	

Independent samples test, Level of significance $P<0.05$, 6 MWT: 6 minute walk test

Table 4: Comparison of IS in pre-operative, discharged and follow-up between the groups

Incentive spirometer (cc)	Group	Mean±SD	Sig. (two-tailed)
Pre-operative	A	669.23±152.80	0.607
	B	654.00±144.58	
Discharge	A	702.88±151.60	0.647
	B	717.00±158.31	
Follow-up	A	781.73±180.15	0.149
	B	833.30±177.56	

Level of significance $P<0.05$. IS: Incentive spirometry

postoperative complications, non-cooperation, and lost to follow-up. The basic demographic details of both groups were age- and BMI-matched and history of smoking too. The functional status was assessed by 6 MWT where the distance walked during 6 min is taken and along with vital parameters before and after walking. The 6 MWT is helpful to know the functional status as submaximal exercises test bur few studies have been shown its importance in rehabilitation after heart surgery.[17] In the study, it was found that mean distance of 6 MWT difference in both groups was statistically significant seen "at discharge" and "at follow-up" within the group.

The research by Foroncewicz *et al*. (2011), they had assessed the capacity of exercises for liver transplantation patients using the 6 MWT. The patients were checked on the 7th and 14th days after surgery and mentioned that the distance walked was more on the 14th day than the 7th day and said that the 6 MWT is beneficial, cost-effective, and satisfactory for measuring capacity of exercise.[18] In the present study, not much improvement was noted in the 6 MWT distance walked at the discharge. This might be attributed to, or apprehension, and incisional pain/discomfort of the patient following the cardiac surgery. Fiorina *et al*. studied on the 6 MWT after surgery of the heart and its reference values in regard to rehabilitation. In which 1370 patients, sequentially admitted for rehabilitation after heart surgeries, undertook 6 MWT at 15 days after various surgery of heart. They said that 6 MWT is practicable and well accepted in adult as well as elder patients soon after uncomplicated surgery of heart.[12] The reference value was mentioned by Opasich *et al*. in 2004, by studied the distance walked in 6 MWT soon after cardiac surgery, that is, on the 4th day after cardiac surgery was 296 ± 111 meters which was similar to that seen in the present study. They also mentioned that reference values depend on age, gender, vital stability, surgery, as well as rehabilitation.[19] Locke *et al*. had studied on mechanics of thoracic cage following sternotomy and measured the volumes of lung and thoracic cage movements at before, 1 week and 3 months after the cardiac surgery. They concluded that diminished and uncoordinated thoracic cage expansion following median sternotomy, gives to the ventilatory weakness mainly restrictive pattern.[20] Regarding the assessment of functional capacity using IS, similar improvement was seen during discharge, and follow-up in between groups from "pre-operative" but which was statistically not significant. The reason behind not achieving much improvement in respiratory functions after surgery of heart can be multifactorial, for example, diminished lung expansion, and uncoordinated thoracic wall movements, diaphragmatic dysfunction as a result of phrenic nerve damage, pleural effusion, as well as lung collapse at basal area. In addition to that a reduction in pulmonary function could also be due to the dysfunction of respiratory muscles.[7,16,21] For consider the works on cardiac surgery, Freitas *et al*. (2007) had done a review of literature for patients after CABG on IS and were found 4 randomized controlled trials which showed not much improvements in decreasing the incidence of respiratory problems because of the modest numbers of participants, the limitations in methodology, and the adjunctive procedure of other therapeutic treatments in those patients. On the other hand, these trials were helpful to make decisions on usage of IS.[22] The significance of IS after surgery of heart by Gale, and Sanders did research on 109 patients after heart surgery who were treated through intermittent positive pressure breathing (IPPB) and (IS), which showed that the practice of the IS 4 times/daily was more beneficial than IPPB. training, for prevention of lung collapse after operation of heart.[23]

Hence, muscle dysfunction of pulmonary system should be given due consideration after the operation in the patients with cardiothoracic surgeries. Consequently, the training of inspiratory muscle and function appears as basic strategy in moving back weakness of muscle after open heart surgery. From the present study, though we did not find much improvement in IMT group than the CP group; improvement was seen in both the groups from the pre-operative to discharge and discharge to follow-up within the groups. Thus, further studies are recommended to appreciate effect of exercise training of inspiratory muscles on recovery of functional status in long-term follow-up of patients.

CONCLUSION

The 6 MWT and IS measurements were not demonstration any statistically significant change among the two groups even though they had incremental changes in both groups. The functional capacity in the form of 6 MWT showed

significant improvement within the groups "at discharge" and "at follow-up."

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CONFLICTS OF INTEREST

The Maximum Inspiratory Pressure measuring by the Capsule Sensing Pressure Gauge-V was donated by Gauges Bourdon Pvt. Ltd., India, for the present research study.

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