Original Article

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Effect of Aerobika® Device in Sputum Induction, Pulmonary Function and Thoracic Expansion in Phase One Cardiac Rehabilitation for Post CABG Subjects: A Randomized Prospective Controlled Trial

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Abstract

Background: Patients who undergo coronary artery bypass graft (CABG) surgery frequently ex-perienced pulmonary complications shortly after the procedure due to reduced lung function and a weakened cough reflex. The recent study aimed to determine and evaluate the effects of Aerobika® device on sputum induction, pulmonary function and thoracic expansion in phase one cardiac rehabilitation for post CABG subjects.

Methods: A Randomized prospective controlled trail was conducted on 36 participants with me-dian sternotomy. Participants were assigned to either Group A (n=18) or Group B (n=18) . The session was carried for 30 minutes twice a day for a week. Outcome measures in the present study were sputum volume, thoracic expansion measurements, peak expiratory flow meter and maximal inspiratory pressure. The outcome measures were evaluated on daily basis i.e., pre and post of every session.

Statistical analysis used:Statistical analysis was done using SPSS 23. Wilcoxon test was used for within group pre test and post test comparison whereas Mann Whitney Test was used for between the group comparison. The level of significance was set at 5%.

Results: Within-group analysis indicated that both groups demonstrated statistically significant improvements in all parameters individually (p-value = 0.001< 0.05). Between group comparison demonstrated that the experimental group was more effective in enhancing secretion clearance, thoracic expansion, maximal inspiratory pressure and peak expiratory flow meter as evidenced by significant differences (p-value = 0.001<0.05).

Conclusion: The study concluded that phase one cardiac rehabilitation along with the use of Aerobika® device are effective in improving the sputum induction, pulmonary function and tho-racic expansion of the lung.

Keywords: Phase one cardiac rehabilitation, CABG surgeries.

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Introduction

Coronary artery disease involves impairment of blood flow through the coronary arteries, most commonly by theromas. Clinical presentations include silent ischemia, angina pectoris, acute coronary syndromes and sudden cardiac death.Coronary artery disease is a leading cause of mor-tality and morbidity around the world[1]. According to recent estimates from epidemiological studies conducted across India, the prevalence of CAD is between 2%- 7% in rural and 7%-13% in urban[2].The average age for people who have CABG surgery is around 66 years old. About 72% of the people who undergo it are men.

CABG is most commonly used procedure for CAD. CABG surgery restores blood flow to areas of heart that are not getting enough blood circulation. Due to median sternotomy patient often develop pulmonary complication in the post-operative period as result of decreased lung function and impaired cough[3]. Acute respiratory failure, pneumonia, atelectasis, and pulmonary edema are typical postoperative pulmonary consequences, especially following abdominal and thoracic surgery. The length of hospital stay and greater morbidity are linked to postoperative pneumo-nia.Acute respiratory failure, pneumonia, atelectasis, and pulmonary edema are typical postopera-tive pulmonary consequences, especially following abdominal and thoracic surgery. The length of hospital stay and greater morbidity are linked to postoperative pneumonia. Acute respiratory fail-ure is a potentially fatal pulmonary condition that calls for the use of mechanical ventilation, ad-mission to an intensive care unit, and a higher risk of infection linked to ventilator use[4]. After surgery, patients often avoid coughing due to extended anesthesia and pain at the site of surgery, causing cough to build in the bronchial tree. Cardiac rehabilitation reduces mortality , mobility and avoidable hospital admissions while improving exercise capacity, quality of life and mental health.Inpatient cardiac rehabilitation, sometimes referred to as Phase 1 program which is utilized after heart surgeries to promote early mobility and enhance post-operative care[5,6].

Oscillatory positive expiratory pressure(OPEP) devices have been used as an additional therapy to traditional chest physiotherapy(CPT) to enhance the clearance of respiratory secretion in indi-vidual with reduced coughing skills[7]. OPEP device increase in pressure is transmitted to airways creating back pressure stenting them during exhalation, preventing premature airway closure and reducing gas trapping .The Aerobika® device has an innovative pressure-oscillation mechanism that creates positive pressure pulses when patient exhales .The positive pressure created can assist with opening weak and collapsed airways[8]. The Aerobika® device a drug-free portable oscillat-ing positive expiratory pressure (OPEP) device developed to help people remove mucus from the lungs, open airways, boost lung function and improve QoL and function[9].The oscillations or vibrations produced in the airway can help to thin and loosen mucus, naturally moving it to the upper airways where it can be coughed out easily[10].

Method

Present study was conducted in Intensive Thoracic Unit of tertiary care hospital, in Belagavi city from December 2024 to May 2024 . An ethical clearance from institutional ethical committee was obtained.

A Randomized controlled trial was conducted on 36 subjects who had undergone CABG surgery. Participants were assigned to either Group A (n=18) received traditional chest physiotherapy or Group B (n=18) received aerobic device with traditional chest physiotherapy. The participants were randomly alloted in the experimental and control group through an opaque envelop method.Participants were screened for inclusion and exclusion criteria. Following the screening , eligible and willing participants were included in the study and consent form was signed before commencement of the study. The study was a single- blinded study. The statistician involved for this study was blinded to the intervention and control group to ensure unbiased data analysis. Demographic data , pre and post assessment of the outcome measure were noted on a daily basis.

Participants

Inclusion criteria: Participants aged between 40-65 years of age of both the genders. Participants who are oriented, conscious, co-operative and willing to participate were included.

Exclusion criteria: Participants who are uncooperative. Participants who can not understand how to use the device. Participants who are hemodynamically unstable, fragile and participants who had systemic illness were excluded.

Intervention

Similar post-operative medical treatment, nebulizer(budecort 0.5mg, duolin nebulizer solution), chest binder and incentive spirometer (800 cc/sec) were administered to all the participants. The treatment was started on POD2 for both the groups. Same therapist had given treatment for both the groups.Each participant was given demonstration and instructions about the intervention. Par-ticipants were randomly allotted in Group A (control) or Group B (experimental) through envelope method. Intervention lasted for 30 minutes twice a day, for a week in both the groups.

Control group:(Group A)

The treatment included standardized protocol of phase 1 cardiac rehabilitation.

Step 1 : diaphragmatic breathing exercises. (5 repetitions, 3sets), Active assisted ROM bilateral upper limb and lower limb (5repetitions, 3 sets) Ankle toe movements(5 repetitions, 3 sets), tho-racic mobility exercises (5 repetitions, 3 sets)

Step 2 : repeat step 1, sitting on the edge of the bed, active range of motion bilateral upper limb (shoulder abduction were limited to below 90 degree) and lower limb (5 repetitions, 4 sets)

Step 3 : repeat step1, repeat step 2, supported room ambulation.

Step 4 : repeat step1, repeat step 2, repeat step 3, trunk mobility exercises (5 repetitions, 3 sets), and unsupported ward ambulation (2 rounds)

Step 5 : repeat step 4 and downstairs 2-flight (2 times/day), progression of ambulation10[21] .

Interventional group:(Group B)

In interventional group participants were treated with Aerobika® device and standardized protocol that is used in phase 1 cardiac

rehabilitation.The participant were seated in long sitting position on bed.The participant were asked to hold the device via the mouthpiece. Participant was asked to breath in through the mouthpiece and hold the breath for 2-3 seconds and steadily blow out into the mouthpiece. The process was repeated for 10-20 times followed by huffing and coughing for 5-6 times. During huffing and coughing participant should wear the chest binder and place both the hands placed over the binder and cough slowly so that the sutures are se-cured.To help maintain the 4 seconds expiratory time, resistance was changed accordingly.

Outcome measures

The study utilized pre and post data collection through various methods to evaluate respiratory function and capacity in subjects. Baseline scores were taken on day one i.e., before the interven-tion and on day 7th post completion intervention.

Peak expiratory flow rate

The participant were seated comfortably in a chair or in long sitting position on bed.The partici-pate was instructed to inhale as deeply as possible and blow out into the mouthpiece as rapidly as possible. This method was carried out three times for accurate measurements, and the average of the three was calculated(for each session/day[11,12].

Sputum volume

Sputum was collected in a sputum container to indicate the volume of sputum expectorated dur-ing the procedure(for each session/day[13,6].

Thoracic expansion measurements

The participant were in comfortable upright sitting position and the readings were taken at the three levels that is axillary, nipple and xiphisternum were marked.They were instructed to take a few normal breaths first and then asked for full exhalation, followed by a full inhalation.

Maximal inspiratory pressure

The participant were asked to sit either on the chair or in long sitting position.The participants were asked to hold the mouthpiece through lip and were asked to inhale as quickly as possible after a maximal expiration.This method was carried out three times for accurate measurements, and the average of the three was calculated(for each session/day).

Statistical Analysis

The various statistical measures such as mean, standard deviation,Mann-Whitney, normality test using Shapiro-Wilk were required.Within group outcome measures like thoracic expansion meas-urements, peak flow meter, maximal inspiratory pressure and sputum volume was done using Paired sample Wilcoxon test and for between group it was done by independent test like Sample Mann Whitney test.

Results

We aimed to include 36 participants for our study, in which either groups that is Group A had 18 participants and Group B had 18 participants. These 36 participants met the inclusion and exclusion criteria of the study.Baseline scores were taken on day one i.e., before the intervention and on day 7th post completion intervention.

Table 1 shows the age, height, weight and BMI of the participants in both the groups. There was no significant difference seen in the demographic data.

In Table 2 within group analysis of outcome measures chest expansion , peak flow rate , maximal inspiratory pressure and sputum volume.Both the groups showed significant difference in all out-come measures, but Group B was more significant then the Group A.

In Table 3 it is observed that between groups analysis is not significant for Chest expansion, Peak Expiratory Flow meter, Maximum Inspiratory Pressure and Sputum Volume at 5% level signifi-cance as the p-value is more than 5%. It shows non-significant differences between the groups. From the Table 3 it is observed that between groups analysis is significant for Chest expansion, Peak Expiratory Flow meter, Maximum Inspiratory Pressure and Sputum Volume at 5% level significance as the p-value is less than 5%. It shows significant differences between the groups.

Table 1: Comparison of Groups with Mann Whitney test

Variable	Group	Mean	SD	z-value	p-value
Age	Grp-A	60.44	4.57	0.986	0.324
	Grp-B	57.50	7.21		
Height	Grp-A	162.89	7.84	1.431	0.152
	Grp-B	158.72	8.48		
Weight	Grp-A	63.39	5.96	0.974	0.330
	Grp-B	60.33	8.55		
BMI	Grp-A	23.97	2.00	0.032	0.975
	Grp-B	23.96	2.21		

Table 2: Within group Analysis of Chest expansion, Peak Expiratory Flow Rate, Maximum In-spiratory Pressure, Sputum Volume, using paired sample Wilcoxon test

Chest Expansion at Axillary Level								
Groups	Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	z-value	p-value
Group A	Pre	1.09	0.10	0.57	0.08	6.74	3.804	0.001*
	Post	1.66	0.16					
Group B	Pre	1.06	0.11	0.91	0.10	8.91	3.839	0.001
	Post	103.79	18.66					
Chest Expansion at T4 Level								
Groups	Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	z-value	p-value
Group A	Pre	1.24	0.05	1.08	0.22	4.87	3.762	0.001
	Post	2.32	0.24					
Group B	Pre	1.33	0.14	1.13	0.17	6.48	3.760	0.001
	Post	2.47	0.08					
Chest Expansion at Xiphisternal Level								
Groups	Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	z-value	p-value
Group A	Pre	1.07	0.40	1.15	0.26	4.39	3.771	0.001
	Post	2.22	0.44					
Group B	Pre	1.51	0.09	1.02	0.12	8.84	3.942	0.001
	Post	2.52	0.07					
Peak Expiratory Flow Rate								
Groups	Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	z-value	p-value
Group A	Pre	104.33	0.69	3.72	1.18	3.16	3.754	0.001
	Post	108.06	1.43					
Group B	Pre	104.89	1.02	12.00	3.01	3.99	3.748	0.001
	Post	116.89	3.05					
Maximum Inspiratory Pressure								
Groups	Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	z-value	p-value
Group A	Pre	-8.67	3.43	3.39	1.82	1.86	3.767	0.001
	Post	-12.06	2.58					
Group B	Pre	-3.17	1.29	8.22	1.83	4.49	3.734	0.001
	Post	-11.39	1.09					
Sputum Volume								
Groups	Times	Mean	SD	Mean Diff.	SD Diff.	Effect size	z-value	p-value
Group A	Pre	2.61	0.50	2.08	0.65	3.22	3.805	0.001
	Post	0.53	0.50					
Group B	Pre	5.50	1.20	5.28	1.18	4.48	3.745	0.001
	Post	0.22	0.35					

*p-value= 0.001<0.05

Table 3: Between group Analysis of Chest expansion, Peak Expiratory Flow Rate, Maximum In-spiratory Pressure, Sputum Volume, using Mann Whitney Test

Variable	Time	Group	Mean	SD	z-value	p-value
Chest Expansion Axillary	Pre	Group A	1.09	0.10	3.162	0.002
		Group B	1.00	0.00		
	Post	Group A	1.66	0.16	4.125	0.001
		Group B	1.91	0.10		
T4	Pre	Group A	1.24	0.05	1.588	0.112
		Group B	1.33	0.14		
	Post	Group A	2.32	0.24	1.811	0.070
		Group B	2.47	0.08		
Xiphoid	Pre	Group A	1.07	0.40	3.420	0.001
		Group B	1.51	0.09		
	Post	Group A	2.22	0.44	2.224	0.026
		Group B	2.52	0.07		
Peak Expiaratory Flow Rate	Pre	Group A	104.33	0.69	1.905	0.057
		Group B	104.89	1.02		
	Post	Group A	108.06	1.43	5.117	0.001
		Group B	116.89	3.05		
Maximum Inspiratory Pressure	Pre	Group A	-8.67	3.43	4.658	0.001
		Group B	-3.17	1.29		
	Post	Group A	-12.06	2.58	1.468	0.142
		Group B	-11.39	1.09		
Sputum Volume	Pre	Group A	2.61	0.50	5.250	0.001
		Group B	5.50	1.20		
	Post	Group A	0.53	0.50	1.877	0.060
		Group B	0.22	0.35		

*p-value= 0.001<0.05

Discussion

The present study was undertaken to evaluate and comparative the effectiveness of Aerobika® device with conventional cardiac rehabilitation on sputum volume, peak flow rate , thoracic ex-pansion and maximal inspiratory pressure in phase one cardiac rehabilitation. Total number of participants recruited in the study were (n=36) in phase one cardiac rehabilitation with median sternotomy incision. The experimental group was treated for twice a day for 7 consecutive days, followed by conventional physiotherapy exercises it showed a significant improvement in reduc-tion of sputum, chest expansion measurements, peak expiratory flow rate and maximal inspirato-ry pressure.

Siti N.S et, al research stated that administration of Aerobika® device in COPD subjects showed significant improvement in sputum clearance in these subjects. In our recent study carried out on CABG subjects in phase one cardiac rehabilitation showed that using Aerobika® device along with conventional physiotherapy showed a significant difference in sputum clearance[14].

Coughing becomes less effective when lung volumes are lowered in the post-operative period be-cause expiratory flow rate is directly proportional to lung capacity. The Aerobika® device im-proves peak expiratory flow rate by raising intrapulmonary pressure, resulting in an increase in functional residual capacity. Peak expiratory flow rate increased as a result of the recreation being cleared from the lungs, which increases the lung volume[15]. This supports the findings in both the groups, which showed a considerable increase in peak expiratory flow rate following interven-tion in conjunction with conventional physiotherapy activities[16].

In our study, a significant improvement was seen in both groups. But maximal inspiratory pres-sure in group B, it may be due to the exposure of inspiratory muscle to being attributed to load of resistance with 1 to 5 pressure setting in which Aerobika® provides gradual rise in pressure fol-lowed by a sudden drop by rapid onset of high velocity airflow , which is regularly repeated for 10 times with huffing and coughing in between, so that there is increase in sarcomere, expansion of muscular mass and strength generating capacity of the muscle[17]. Furthermore , the improve-ment in inspiratory muscle strength might be related to physiological adaptations generated by Aerobika® which may have increased the aerobic capacity of respiratory[18].

In the current study, Group B (interventional group) showed a significant improvement in thorac-ic expansion, possibly because the thoracic expansion exercises activated the collateral ventilato-ry system, allowing air to pass distal to mucus plugs in the peripheral airway[19]. This might be explained by a decrease in rib cage muscle tension and an improvement in mechanical character-istics brought about by rib cage movement[17]. The underlying mechanism of Aerobika® has proven useful in enhancing lung expansion because it is connected with peak force experienced at the mucus surface caused by continually changing air pressure, which overcomes the adhesive bindings between the mucus layer and afflicted airways[20].

Conclusion

The randomized controlled study investigated the effective of conventional physiotherapy exer-cises with combination of both Aerobika ®and conventional therapy on various health parameters in subjects who had undergone CABG surgeries. The results indicated that the use of Aerobika ® device along with standard cardiac rehabilitation significantly improved outcomes that includes thoracic expansion, peak expiratory flow rate ,better maximal inspiratory pressure more effective sputum clearance. Overall administration of Aerobika® device to the standard cardiac rehabilita-tion provides a better improvement in management of CABG patients in phase one of cardiac re-habilitation.

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