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COMPARISON OF EFFECTS OF VOLUME INCENTIVE SPIROMETER AND FLOW INCENTIVE SPIROMETER ON PEAK EXPIRATORY FLOW RATE, OXYGEN SATURATION, CHEST EXPANSION AND QUALITY OF LIFE IN PATIENTS UNDERGOING CABG SURGERY: AN EXPERIMENTAL STUDY

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ABSTRACT

Objectives: The purpose of the study was to compare the volume and flow incentive spirometer on PEFR, SpO 2 , chest expansion, and QOL in patients undergoing CABG surgery. Patients and methods: This experimental study was performed with 50 patients (8 females, 42 males between the age group of 40-75 years). The patients were equally divided into two groups: Group 1: volume incentive spirometer along with conventional therapy (ACBT and deep breathing exercise) and Group 2: flow incentive spirometer along with conventional therapy (ACBT and deep breathing exercise). Evaluations were done at baseline, post-OP 2 nd day, post-OP 7 th day and 1 month follow up of QOL. PEFR, SpO 2 , chest expansion, and QOL were assessed. Results: No statistically significant difference observed in demographic details of patients at baseline in terms of age, BMI, and smoking history while in the case of gender, there was a significant difference observed (p=0.00*). Within group were analyzed by using repeated measures of ANOVA, the p-value at the level of p<0.001 was found to be statistically highly significant (p=0.000**) in both group at baseline, post-OP 2 nd day and post-OP 7 th day. Between groups were analyzed by using independent t-test and found that there was a highly significant difference observed in PEFR, SpO 2, and chest expansion between both groups at post-OP 7 th day ($p \leq 0.05$). Similarly, QOL also showed a highly significant level after 1-month follow-up ($p \leq 0.05$).

Conclusion: The conclusion obtained from this study was that there were improvements in PEFR, SpO 2 , chest expansion, and QOL in both intervention groups from postoperative day

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2 to postoperative day 7 when compared with preoperative values. So it was concluded that both types of spirometer were equally effective for patients of CABG.

Keywords: CABG, volume incentive spirometer, flow incentive spirometer, deep breathing exercise, active cycle of breathing technique.

INTRODUCTION

Cardiovascular diseases (CVD) have now become the leading cause of death in India. The Global Burden of Disease study estimates India's age-standardized cardiovascular death rate of 272 per 100,000 population, higher than the global average of 235 per 100,000 population.[1] Over the past few years, coronary heart disease has reached epidemic proportions in Southeast Asia, especially in India. Cardiovascular outcomes after acute coronary syndrome are unpredictable.[2] Narrative Review Coronary artery bypass grafting (CABG) is one of the widely used treatments, with over 1 million coronary artery bypass procedures performed worldwide each year.[3] According to industry sources, the annual number of CABG procedures in India was approximately 60,000 in 2010.[4] Cardiac surgery is associated with postoperative pulmonary complications (PPC), defined as any postoperative pulmonary abnormality that results in recognizable disease or dysfunction of clinical significance and that adversely affects the clinical course.[2] The risk of pulmonary complications is increased in patients undergoing coronary artery bypass grafting. The incidence ranges from 30% to 60%. These complications are the largest contributors to morbidity, mortality, and costs associated with hospitalization.[5] The most common complications of PPC include pneumonia, atelectasis or infiltration, postoperative fever, respiratory failure, and long-term mechanical ventilation, as well as pleural effusion, pneumothorax, respiratory failure, and pulmonary edema.[6]

Postoperative atelectasis is common in patients after coronary artery bypass graft surgery, with an incidence of 27–95%.[7] The cause of atelectasis is complex and may involve several factors such as general anesthesia, diaphragmatic dysfunction, abdominal distension, chest wall changes, pleural effusion, and pain.[8] After surgery, mucociliary clearance is adversely affected by the effects of general anesthesia, intubation, and analgesia. Expiratory flow rate is directly related to lung volume and therefore as lung volume decreases, coughing will be less effective in the postoperative period.[9] Insufficient breathing, lack of proper sighing mechanism and coughing technique, immobilization and poor patient cooperation can affect lung function.[10] Postoperative pain and anxiety (PO) related to changes in lung mechanics resulting from surgery influence the ability to take periodic deep breaths and cough effectively, allowing secretions to accumulate alveolar collapse, and changes in gas exchange.[7]

Chest physiotherapy was used as an alternative intervention to reduce the occurrence of loss of lung function and its complications. Postoperative chest physiotherapy began to be implemented in the early 20^{th} century. It includes breathing exercises, a motivational spirometer, an active breathing technique cycle, percussion, vibration, wheezing/coughing on a splint, positioning, and mobilization.[11]

A mechanical breathing device such as incentive spirometry (IS) has been introduced into clinical practice. Motivational spirometry encourages the patient to take a long, slow, deep breath that mimics a natural sigh and also provides visual positive feedback. Incentive spirometers based on inspiratory volume (volume-oriented) or flow rate (flow-oriented) are

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available.[12] A flow-oriented incentive spirometer (Triflow device) consists of three chambers connected in series, each containing a ball. When the patient's effort generates negative pressure above the ball, it rises in the chamber. An inspiratory flow of 600 ml/s is required to lift the first ball, an inspiratory flow of 900 ml/s is required to lift the first and second balls, and a flow of 1200 ml/s is required to lift all three balls. The volume-oriented incentive spirometer is a compact device with a capacity of 4000 mL and equipped with a one-way valve to prevent exhalation into the device. A sliding indicator indicates the prescribed inspiratory volume and an inspiratory flow indicator instructs the patient to inhale slowly.
[11-12]
ACBT is a very compelling method for improving oxygen saturation, controlling respiratory rate, and clearing the chest after major surgery. It affects chest expansion, blood gases, oxygen saturation, blood pressure, respiratory rate, and other vital parameters in patients with chronic obstructive pulmonary disease in the first phase of cardiac recovery after CABG surgery. A typical ACBT cycle includes breath control, expansion training, breath control, and huffing technique.[13-15]

Deep breathing exercises are a complementary and non-invasive treatment method that has a positive impact on insomnia, autonomic heart function, depression, anxiety, high blood pressure, and lung diseases. Patients who cannot move around the ward frequently and are at risk of atelectasis should be encouraged to perform chest expansion exercises at least once an hour, preferably with a breath hold of several seconds. Breathing exercises are used both to treat existing lung damage caused during surgery and to prevent further deterioration postoperatively.[16-18]

The number of published reports is limited to the use of different types of incentive spirometers, deep breathing exercises, and incentive spirometers in pre and post-operative effects in patients undergoing CABG. However, more research is needed to define the effectiveness of the devices of respiratory physiotherapy and their place among the current techniques available. Further very few studies have focused on the individual perception of the patient for improvement in quality of life after the treatment manoeuvres. This research will provide a base for a specific intervention-based protocol for a specific parameter and will also establish some facts for improving the overall component of rehabilitation. Therefore, the present study is designed with an aim to analyze the effect of two different types of incentive spirometer i.e. FIS and VIS combined with ACBT and DBE on lung function parameters in patients undergoing CABG.

MATERIALS AND METHODS

This was an experimental study design conducted in the College of Physiotherapy, Pt. B.D. Sharma PGIMS, Rohtak. The method of recruitment was a Random sampling method and sequencing was generated through Computer random number tables. Subjects were selected from Lala Shamlal Super Specialty Hospital, Pt. B.D. Sharma PGIMS, Rohtak.

Patients with the age group of 40-75 years of both males and females undergoing elective coronary artery bypass graft, had no history of open heart surgery, had no mechanical ventilation longer than 24 hours after surgery, no known psychological illness were included for the study and the exclusion criteria were patients with unstable hemodynamic parameters,

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uncooperative or unable to understand or use the device properly, any known pulmonary conditions, history of neurological, musculoskeletal disorder and peripheral vascular diseases. Patients were selected from L.S.L. Super Specialty Hospital, Pt. B.D. Sharma PGIMS, Rohtak to participate in the study. Patients were screened as per inclusion or exclusion criteria by using screening performa. After a comprehensive description of the study, an Informed Consent form was provided and clearly explained to the patients who participated in the study. Participants were informed that their participation was voluntary and that they could withdraw at any time.

A total number of 50 patients were randomly assigned into two groups i.e. Group A- Volume IS and conventional therapy (deep breathing exercise and active cycle of breathing technique). Group B- Flow IS and conventional therapy (deep breathing exercise and active cycle of breathing technique). The data collection tool included demographic details (age, sex, smoking history, height, weight), any previous heart surgery, and any type of neurological or pulmonary conditions. For evaluation of respiratory parameters, SpO_2 was measured through a pulse oximeter, chest expansion was measured through measuring tape, PEFR was measured through a peak flow meter and QOL was assessed by using the SF 36 questionnaire. Patients were assessed at baseline, post-OP 2^{nd} day, and post-OP 7^{th} day. A 1-month follow-up was also taken by using the SF 36 questionnaire for the assessment of QOL.

In the IS volume group, the patient was first placed in a sitting or semi-sitting position and inhalation was performed inside the device by placing the VIS tube in the mouth.[22] The patient inhaled through the breathing tube and mouthpiece connecting the patient to the breathing apparatus. flexible plastic bellows. When the patient inhales through the breathing tube, the bellows rise, indicating the volumetric displacement using an indicator on the device housing. After achieving its maximum displacement for a given breath, the patient was asked to hold the bellows in the same position for 5-10 seconds. Once the maneuver is complete, the patient removes the mouthpiece, allowing gravity to return the bellows to its original position.[12] The patient was advised to perform 3 sets of 5 repetitions of deep breaths. The patient performed this activity every 2 hours. The therapist performs the exercise once a day and the patient is instructed to do it for the rest of the day.[11]

In the flow IS, the patient was first placed in a sitting or semi-sitting position and inhaled inside the device by placing the flow IS tube in the mouth. After completing the inhalation, the patient was asked to hold his or her breath for 3 seconds and slowly exhale through the mouth by removing the device. Patients were also instructed that they could gradually take deeper breaths with each increase in lifting the ball.[19] The patient was advised to perform 3 sets of 5 repetitions of deep breaths. The patient performed this activity every 2 hours. The therapist performs the exercise once a day and the patient is instructed to do it for the rest of the day.[11]

Statistical analysis

Data were analyzed using IBM SPSS version 25.0. Categorial variables were expressed as frequency and percentages. Continuous variables were presented as mean ± SD. For between group analysis, independent t-test were used. For within group analysis, repeated measure of ANOVA followed by the Bonferroni post hoc analysis by Tukey's test was used to evaluate the change between baseline and follow-up measurements. For all statistical tests, a p-value < 0.05 was taken as a significant difference.

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RESULTS

Fifty subjects were enrolled and completed the study. Table 1 shows socio-demographic presentation of data of patients. Repeated-measures ANOVA results for both groups are explained in Table 2. Table 3 analysed SpO_2, PEFR, chest expansion and quality of life in CABG patients performing using repeated measures of ANOVA in volume and flow incentive spirometer group at baseline, post OP 2nd day and post OP 7th day in CABG patients. Table 4 describes the between-group analysis of the subjects at baseline, post OP 2nd day and post OP 7th day by using independent t-test.

Table 1: Socio-demographic presentation of data

VARIABLES	VIS	FIS	p-value
AGE, years (MEAN±SD)	57.84 ± 8.65	57.76 ± 9.47	0.97^{NS}
MALE (%)	21 (84)	21 (84)	0.00*
FEMALE (%)	4 (16)	4 (16)	
BMI, kg/m^2 (MEAN±SD)	22.75 ± 3.19	23.89 ± 2.92	0.25^{NS}
SMOKING (MEAN±SD)	0.52 ± 0.51	0.60 ± 0.50	0.58^{NS}

Table 1 shows the demographic details of patients. The mean age of volume and flow incentive spirometer group was 57.84±8.65 and 57.76±9.47 years respectively. There were 42 males and 8 females: 21 males and 4 females in each of the groups. BMI of both volume and flow incentive spirometer group of participants with an average mean was 22.75 ± 3.19 and 23.89 ± 2.92 respectively.

Table 2: Within group comparison of SpO_2, PEFR, chest expansion and quality of life at baseline, post OP 2nd day and post OP 7th day in CABG patients performing volume and flow incentive spirometer

Variables		MEAN±SD		
		Baseline	**Post OP 2nd day**	**Post OP 7th day**
SpO_2	**VIS**	94.84 ± 1.40	96.20 ± 1.15	98.32 ± 0.90
	FIS	94.80 ± 0.82	95.92 ± 0.64	96.08 ± 0.91
PEFR	**VIS**	0.18 ±0.05	0.12 ± 0.02	0.33 ± 0.06
	FIS	0.17 ± 0.04	0.12 ± 0.02	0.24 ± 0.03
Chest Expansion	**VIS**	1.30 ± 0.35	1.16 ± 0.24	2.50 ± 0.29
	FIS	1.26 ± 0.35	1.08 ± 0.20	1.94 ± 0.30
		Baseline	**After 1 month follow-up**	
Quality of life	**VIS**	10.23 ± 7.51	64.68 ± 9.22	

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	FIS	10.59 ± 10.99	49.54 ± 7.75

Table 2 shows within group comparison of SpO_2, PEFR, chest expansion and quality of life at baseline, post OP 2nd day and post OP 7th day in CABG patients performing volume and flow incentive spirometer. The mean value of SpO_2 at baseline, post OP 2nd day and post OP 7th day in volume and flow incentive spirometer group were 94.84±1.40 & 94.80±0.82, 96.20±1.15 & 95.92±0.64 and 98.32±0.90 & 96.08±0.91 respectively. Mean values of PEFR were 0.18±0.05 & 0.17±0.04, 0.12±0.02 & 0.12±0.02 and 0.33±0.06 & 0.24±0.03 respectively. In the same way, mean values of chest expansion were 1.30±0.35 & 1.26±0.35, 1.16±0.24 & 1.08±0.20 and 2.50±0.29 & 1.94±0.30 respectively. The mean values of quality of life at baseline and after 1 month follow up in volume and flow incentive spirometer group were 10.23±7.51 & 10.59±10.99 and 64.68±9.22 & 49.54±7.75 respectively.

Table 3: Analysis of SpO_2, PEFR, chest expansion and quality of life in CABG patients performing using repeated measures of ANOVA in volume and flow incentive spirometer group at baseline, post OP 2nd day and post OP 7th day in CABG patients

		Sum of Squares	df	Mean Square	F-ratio	p-value
PEFR within group	**VIS**	0.56	1.78	0.31	123.37	0.00*
	FIS	0.18	1.77	0.10	111.98	0.00*
SpO_2 within group	**VIS**	153.79	1.76	87.18	127.80	0.00*
	FIS	24.32	1.7	14.13	27.77	0.00*
Chest expansion within group	**VIS**	27.13	1.89	14.35	192.99	0.00*
	FIS	10.28	1.94	5.29	73.95	0.00*
Quality of life within group	**VIS**	37070.92	1	37070.92	695.83	0.00*
	FIS	18962.61	1	18962.61	243.65	0.00*

Table 3 shows analysis of SpO_2, PEFR, chest expansion and quality of life in CABG patients performing using repeated measures of ANOVA in volume and flow incentive spirometer group at baseline, post OP 2nd day and post OP 7th day in CABG patients. The calculated repeated measures ANOVA p value of p = 0.00* was found to be statistically highly significant at the level of $p<0.001$ in both volume and flow incentive spirometer group.

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Table 4: Between group comparison of SpO_2, PEFR, chest expansion and quality of life of participants of Volume and Flow incentive spirometer group

		MEAN±SD		t value	p value
		VIS	FIS		
PEFR	Baseline	0.18± 0.05	0.17 ± 0.04	0.89	0.38^{NS}
	Post OP 2nd day	0.12 ± 0.02	0.12 ±0.02	0.59	0.56^{NS}
	Post OP 7th day	0.31 ± 0.06	0.22 ± 0.03	6.86	0.00*
SpO_2	Baseline	94.84±1.40	94.80 ± 0.82	0.12	0.90^{NS}
	Post OP 2nd day	96.20± 1.15	95.92± 0.64	1.06	0.29^{NS}
	Post OP 7th day	98.32 ± 0.90	96.08 ± 0.91	8.76	0.00*
Chest expansion	Baseline	1.30 ± 0.35	1.26 ± 0.35	0.40	0.69^{NS}
	Post OP 2nd day	1.16 ± 0.24	1.08 ± 0.20	1.29	0.21^{NS}
	Post OP 7th day	2.50 ± 0.29	1.94 ± 0.30	6.63	0.00*
Quality of life	Baseline	10.23 ±7.51	10.59 ± 10.99	-0.14	0.89^{NS}
	After 1 month follow up	64.68 ±9.22	49.54 ± 7.76	6.28	0.00*

Table 4 shows comparison of SpO_2, PEFR, chest expansion and quality of life between volume and flow incentive spirometer group by using independent t-test. The p-values of the PEFR between volume and flow incentive spirometer group at baseline, post OP 2nd day and post OP 7th day were 0.38^{NS}, 0.56^{NS} and 0.00*. Similarly, p values of SpO_2 were 0.90^{NS}, 0.29^{NS} and 0.00* respectively. The p-values of the chest expansion between volume and flow incentive spirometer group at baseline, post OP 2nd day and post OP 7th day were 0.69^{NS}, 0.21^{NS} and 0.00* respectively. The p-values of the chest expansion between volume and flow incentive spirometer group at baseline and after 1 month follow up were 0.89^{NS} and 0.00*

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respectively. Results analysed that there was highly significant difference observed in PEFR, SpO_2 and chest expansion between volume and flow incentive spirometer at post OP 7^{th} day ($p \leq 0.05$). Similarly, quality of life showed that there was highly significant difference observed after 1 month follow-up ($p \leq 0.05$).

DISCUSSION

The main purpose of this study was to compare the volume incentive spirometer with the flow incentive spirometer on peak expiratory flow rate, oxygen saturation, chest expansion, and quality of life in patients undergoing CABG. There were 50 patients out of which 25 patients were included in each group. The outcome measures from this study depict that the volume incentive spirometer is more effective than the flow incentive spirometer. The null hypothesis is being rejected as there is a significant difference between the volume and flow incentive spirometer in patients undergoing CABG.

Peak expiratory flow rate was measured using a peak flow meter. In CABG, 88.5% of patients had PEFR lower than normal expected values.[20] In this study, PEFR values increased significantly in both groups, i.e., in the volume-flow incentive spirometer group, from baseline to day 7 after OP. A study by Zaman BA et al.[21] showed that PEFR significantly increased after incentive spirometry with EPAP was used in patients. This may be explained by the improved diaphragmatic activity and reduced work of breathing observed with the volume spirometer compared to the flow spirometer. A short, sharp inhalation activates the flow-oriented incentive spirometer with a minimal increase in tidal volume. However, in a volume spirometer, an increase in tidal volume must be achieved before the set level is reached. In a flow-oriented spirometer, air can be drawn in using accessory muscles, while a volume-oriented spirometer uses the activity of the diaphragm to draw air in. These results are consistent with the study conducted by Amin et al.[12] which compared the effectiveness of similar ventilation techniques (VS, FS, and DB) in patients who had undergone coronary artery bypass surgery. After comparison, the authors concluded that the volume-oriented incentive spirometer showed better lung function values compared to the other two techniques.

Decreased oxygenation is common in the initial period after open heart surgery. The effects of median sternotomy, hypothermia to protect the myocardium, internal thoracic artery dissection, and cardiopulmonary bypass negatively impact lung function and oxygenation.[2] The current result showed a significant increase in SpO_2 values in both the volume incentive spirometer and the flow incentive spirometer in intra- and between-group comparisons ($p \leq 0.05$). The results of one of the studies conducted by Chaudhary S et al. [2] confirm a recent study in which the effect of breathing with an incentive spirometer before and after treatment on the result of SpO_2, PEFR, and NRS was compared. SpO_2 before and after treatment, p-value ≤ 0.05 suggests a significant difference in results. The reason may be the use of motivational spirometry, which helps keep the lungs clean. Deep inhalation helps mobilize secretions and open areas of the lung that may have collapsed. Oxygen-carrying capacity increases when breathing with an incentive spirometer, which justifies the significant increase in SpO_2 levels. It also exercises your lungs, keeping them active, especially during recovery from surgery.

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This study found that there was a significant difference in thoracic expansion both within and between the flow and volume incentive spirometer groups, demonstrating that both types of incentive spirometers were effective in increasing thoracic expansion. This study is supported by one of the previous studies conducted by Wable MM et al. [22] which shows that the incentive spirometer makes a significant difference in chest enlargement. The reason may be that once the pain from the surgical incision was controlled or removed, the patient could better participate in activities such as walking and eating, which promoted his recovery. Patients were also able to sleep well, which aids the healing process, resulting in greater chest expansion.

The QOL in patients who underwent CABG is affected. The coronary artery bypass has an impact on physical and mental health status and generally in QOL.[20] This present study showed that QOL before CABG was affected very severely. When treatments were given, follow-up after 1 month showed significant differences within and between the volume and flow incentive spirometer. Both types of spirometers improve the quality of life of patients of CABG. Till now, no study has observed the effect of volume and flow incentive spirometer on quality of life. A study done by Amin R et al.[12] showed that mobilization of postoperative patients with low-intensity exercise aims at eliciting cardiopulmonary responses which enhances oxygen transport, assists in the reduction of postoperative pulmonary complications, and improves QOL.

There are two major limitations to this study. First, the duration and type of anesthesia and analgesia were not recorded and this could probably affect the outcomes. The other was the patients were provided with log books in which to make entries every time they performed the technique. This was meant to enable the researcher to check their adherence to the prescribed regimen.

The conclusion obtained from this study is that in patients undergoing CABG surgery, there is improvement in PEFR, SpO_2, chest expansion, and quality of life in both intervention groups from postoperative day 2 to postoperative day 7 when compared with preoperative values. So it concluded that both types of spirometer are equally effective for patients of CABG.

Abbreviations

IHD	Ischemic Heart Disease
CAD	Coronary Artery Disease
CVD	Coronary Vascular Disease
CABG	Coronary Artery Bypass Graft
PO	Post Operative
ACBT	Active Cycle of Breathing Technique
VIS	Volume Incentive Spirometer
FIS	Flow Incentive Spirometer
DBE	Deep Breathing Exercise
PEFR	Peak Expiratory Flow Rate
SpO_2	Oxygen Saturation
QOL	Quality of Life
ICU	Incentive Care Unit

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Ethics Committee Approval: The ethical clearance was taken from Institutional Ethical Committee of Pt. B.D. Sharma University of Health Sciences, Rohtak with reference to the letter No. BREC/23/017.

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