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Comparison of the Effect of Inhalation and Intermittent Inhalation-Exhalation Incentive Spirometry on Dyspnea Severity and Atelectasis in Patients undergoing Coronary Artery Bypass Graft

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Abstract

Background: Dyspnea and atelectasis after Coronary Artery Bypass Graft (CABG) are common and need nursing attention. Inhalation and exhalation incentive spirometry is recommended for preventing alveolar collapse and atelectasis.

Objectives: This study aimed to compare different methods of incentive spirometry on dyspnea severity and atelectasis of the patients undergoing CABG.

Methods: This randomized clinical trial study was conducted on 66 patients undergoing CABG admitted to the Intensive Care Unit (ICU) of Cardiac Surgery Department in Hamadan, Iran, in 2020. The patients were selected through convenient sampling and were divided into two groups through block permutation: inhalation incentive spirometry and intermittent inhalation-exhalation spirometry. Both groups performed incentive spirometry according to the instructions they had received for four days. Then, they were examined for dyspnea and atelectasis using the Borg scale and chest x-ray, respectively.

Results: During the intervention, dyspnea significantly decreased in the intermittent inhalation-exhalation group relative to the inhalation group ($P<0.05$). Most patients in both inhalation (63.6%) and intermittent inhalation-exhalation (65.6%) groups had atelectasis; however, no significant differences were observed between the two groups ($P=0.867$).

Conclusion: Incentive spirometry via intermittent inhalation-exhalation method was more effective on dyspnea compared to the inhalation method. Therefore, this method is recommended to patients and nurses to reduce pulmonary complications after CABG.

Keywords: Coronary artery bypass graft, Dyspnea, Pulmonary atelectasis, Spirometry

1. Background

Coronary Artery Bypass Graft (CABG) is one of the most prevalent surgeries carried out on patients with obstruction of more than two coronary arteries (1). In many cases, although CABG is the only treatment increasing the patients' life, it may have different complications. Pulmonary complications, reported to be 30-60%, are among the most common complications (2). The occurrence of these complications plays a key role in the disability and mortality of the patients leading to high costs, (3) disruption of oxygenation and gas exchange (4).

Among the measures taken to enhance pulmonary function in gas exchange and oxygenation, one can cite chest physiotherapy, deep breathing exercises, incentive spirometry, intermittent or continuous positive pressure during spontaneous breathing, using nebulizers, and early mobilization (5).

Incentive spirometry, a low-cost method, could be used easily and without complications for these patients (6). Incentive spirometers are devices used to prevent pulmonary disorders, such as atelectasis and postoperative pneumonia. Using these devices helps inflate collapsed alveoli, move secretions toward the main airways, and measure maximum exhalation force. Spirometers have various functions, some of which are set on the inhalation and some on exhalation (7). In both models, incentive spirometry encourages the patient to take a slow, deep inspiration through visual feedback (8).

In confirming the effect of incentive spirometry on increasing pulmonary function, the results of a study by Augustine and Singh indicated that using incentive spirometry by inhalation method enhances pulmonary function (9). Oei et al. concluded that inhalation incentive spirometry reduces the rate of dyspnea in patients with asthma (10). Another study by Jácome et al. showed that breathing exercises and inhalation incentive spirometry effectively reduce dyspnea among the patients with chronic obstructive pulmonary disease (11). Given the above studies, most studies have examined the effect of incentive spirometry through the inhalation method.

Nonetheless, according to reliable books and studies, incentive spirometry can be used for both inhalation and exhalation (12, 13). Few studies have examined the effect of incentive spirometry on exhalation (14,15). Rafaqat et al. compared inhalation incentive spirometry separately with balloon death, equal to exhalation incentive spirometry. They concluded that using these two methods in a similar way could enhance pulmonary function and chest dilation in patients with chest tubes (14). Moreover, Zakeri Moghadam et al. indicated that blowing in powderless latex gloves, equal to exhalation incentive spirometry, could reduce atelectasis in patients (15). Therefore, further studies are needed to be conducted to evaluate the effectiveness of incentive spirometry by exhalation along with inhalation.

2. Objectives

This research aimed to compare inhalation incentive (every 2 h up to 10 times) and intermittent inhalation-exhalation spirometry (every 2 h to 10 times intermittently for 2 h of inhalation and 2 h of exhalation) on dyspnea severity and atelectasis among the patients undergoing CABG.

3. Methods

3.1. Study Design and Study Population

This two-group randomized clinical trial study was carried out in 2020 on the patients undergoing CABG admitted to the Intensive Care Unit (ICU) of the Cardiac Surgery Department of Farshchian Cardiovascular Hospital in Hamadan, Iran. Firstly, the samples were selected by available sampling method, and then they were assigned to two groups of inhalation incentive spirometry and intermittent inhalation-exhalation spirometry, using permutation blocks.

Based on the similar study (12) and considering the confidence level of the test of 95% (1-a=0.95), the test power 80% and considering 10% possible losses, the sample size in each group is estimated least 33 people.

$$n = \frac{\left(z_{1-\frac{\alpha}{2}} + z_{1-\beta}\right)^2 \left(\sigma_1^2 + \sigma_2^2\right)}{(\mu_1 - \mu_2)^2}$$

The inclusion criteria were conscious patients undergoing CABG by cardiopulmonary bypass, the ability to use incentive spirometry, and the lack of depression or anxiety disorders, no respiratory disease, and impaired renal function. The subjects were excluded in case of patient's death, the need for reoperation, severe hemodynamic disturbances, respiratory infections, and dangerous dysrhythmias.

Participants were selected from all patients undergoing CABG surgery who were candidates for incentive spirometry (n=89). Among these patients, 11 did not meet the inclusion criteria, and seven were reluctant to participate in the study. A total of 71 patients were randomly assigned to inhalation and intermittent inhalation-exhalation incentive spirometry groups. However, five participants were excluded due to meeting exclusion criteria. Finally, 33 patients in each group completed the study (Figure 1).

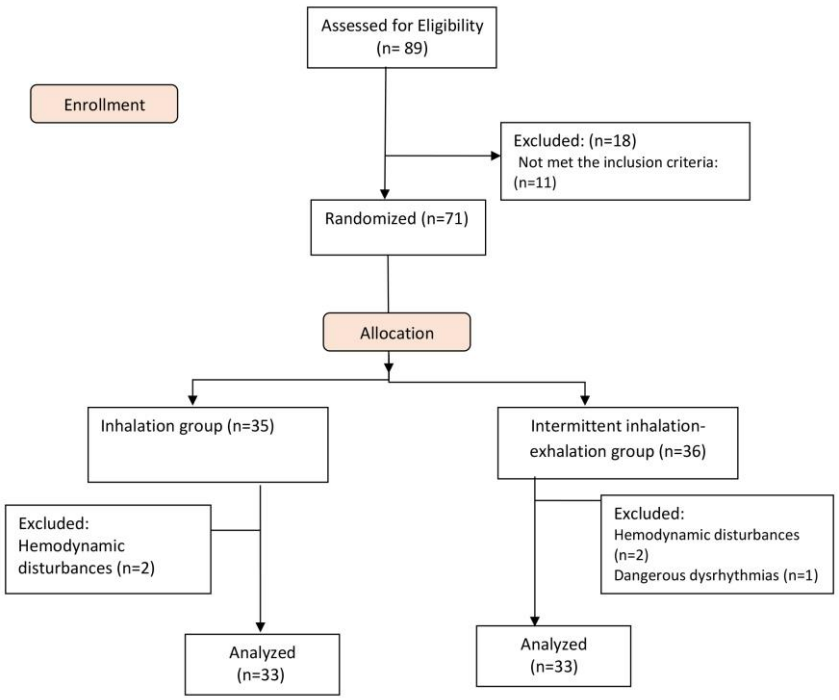

Figure 1. CONSORT Flow Diagram

3.2. Measurements

Data collection tools were demographic, a clinical information questionnaire, and a chest x-ray (CXR) to detect atelectasis. Moreover, Borg facilitated criterion (0-10 cm) was used to measure dyspnea. This scale is a standard numerical criterion stated in reference books whose reliability is calculated in Hunter's study r=0.78 (16). This scale is a 10 cm ruler where zero means no dyspnea and 10 is the maximum dyspnea where patients show their feeling of dyspnea.

3.3. Interventions

Personal and clinical information of the eligible patients was collected by the researchers with questions and answers from the patients and based on the contents of the files. Then, the patients were randomly assigned to one of the two groups of the inhalation incentive spirometry or intermittent inhalation-exhalation incentive spirometry groups to complete the number of samples.

Firstly, the researchers supervised by the treating physician and colleague, acquired the necessary training and skills regarding using incentive spirometry. The necessary training on using spirometry was given to both groups by a clinically trained researcher. The patients were then asked to perform it in practice to ensure it was done correctly. Patients undergoing incentive spirometry by inhalation method (routine ward) had been instructed that the patient should perform incentive spirometry every 2 h up to 10 times by inhalation method from 8 A.M. to 8 P.M., to perform which the patient sits or half sit-position and by placing incentive spirometry tube in the mouth the inhalation is done slowly inside the device as much as possible. After the end of the inhalation, the breath is held for three seconds, and exhalation is done slowly through the mouth by removing the device (17).

The patients undergoing intermittent inhalation-exhalation incentive spirometry were instructed to perform incentive spirometry from 8 A.M. to 8 P.M. every 2 h to 10 times intermittently for 2 h of inhalation (as above) and 2 h of exhalation. After taking a deep breath as far as possible, the patients put the pipe in their mouth and exhale slowly and were encouraged to expel the exhaled air with pressure every time they tried (3).

The researchers visited the ICU of cardiac surgery Department daily; thus, the patients meeting the inclusion criteria undergoing CABG received the necessary training and were asked to perform the trained method of spirometry from the first postoperative day to the fifth day.

To ensure that spirometry was performed, a checklist was provided to the participants, which they ticked each time they performed spirometry.

Patients in both groups were monitored daily before the intervention and for four days after the intervention at 10:00 A.M., so that the patients used the Borg facilitated criterion (0-10) to determine their degree of dyspnea. Moreover, the patients were asked to perform inhalation using an incentive spirometer. Ultimately, after four days of intervention, CXR were routinely taken from the patients and compared with CXR by a physician before the intervention in case of any atelectasis.

3.4. Ethical Consideration

After approving the project, receiving the Code of Ethics NO. IR.UMSHA.REC.1397.526 and Clinical Trial Code of IRCT20160110025929N18, and obtaining permissions from the Vice Chancellor for Research and Technology of the Hamadan University of Medical Sciences and Hospital Officials, the researchers visited the ward where there were patients who had been admitted the day before the operation. The researchers introduced themselves to the eligible patients and explained the procedure. The patients were ensured that they could leave the study if they did not wish to continue. Then, they volunteered to sign the written informed consent.

3.5. Statistical Analysis

The collected data was analyzed in SPSS (version 16) using descriptive statistics and statistical t-tests, Mann-Whitney, Chi-square, Fisher's exact test, covariance, repeated measures, adjusted Greenhouse-Geisser test, reproducible size analysis, and logistic regression at 95% confidence level. A $P<0.05$ was considered statistically significant.

4. Results

Based on the results of the demographic able, most patients in both intermittent inhalation-exhalation groups (75.8%) and in the inhalation group (60.6%) were females and married (inhalation group (84.8%) and intermittent inhalation-exhalation (90.9%)). Most patients examined in both intermittent inhalation-exhalation groups (51.5%) and inhalation (42.4%) were self-employed. According to the statistical tests performed, the patients of the two groups were similar in terms of gender, marital status, place of residence, occupation, age, and body mass index, whereas there were statistically significant differences between the two groups in terms of education level, number of chest tubes, and discharge fraction (Table 1).

The analysis of covariance was used (to moderate the heterogeneity of demographic and clinical variables in the two groups) to compare the mean severity of dyspnea among the patients of the two groups before the intervention. The findings revealed no statistically significant differences between the two groups in terms of the severity of dyspnea before the intervention (P=0.167). Thus, the two groups were similar in terms of the severity of dyspnea

Table 1. Comparison of demographic and clinical variables of the patients in inhalation and intermittent inhalation-exhalation groups

		Intermittent inhalation-exhalation group (n=33)	Inhalation group (n= 33)	*P*-value
		n (%)	n (%)	
Sex	Female	25(75.8)	20 (60.6)	0.188*
	Male	8(24.2)	13(39.4)	
Marital status	Single	2(6.1)	0(0)	0.160**
	Married	30(90.9)	28(84.8)	
	Divorced	0(0)	1(3)	
	Deceased wife	1(3)	4(12.1)	
Urbanization	Urban	23(69.7)	22(66.7)	0.792*
	Rural	10(30.3)	11(33.3)	
Educational stage	Illiterate	10(30.3)	13(39.4)	0.027**
	High school	19(57.6)	10(30.3)	
	Diploma	1(3)	8(24.28)	
	Bachelor and higher	3(9.1)	2(6.1)	
Employment	Retired	4(12.1)	1(3)	0.324**
	Employee	5(15.2)	5(15.2)	
	Housewife	7(21.2)	11(33.3)	
	Free	17(51.5)	14(42.4)	
	Unemployed	0(0)	2(6.1)	
Number of chest tubes	1	0(0)	1(3.1)	0.039**
	2	26(78.8)	16(50)	
	3	7(21.2)	14(43.8)	
	4	0(0)	1(3.1)	
		Mean±SD	Mean±SD	
Age (years)		11.05±61.15	8.78±63.78	0.287***
Body mass index (kg \ m2)		2.69±22.70	2.28±23.86	0.064***
Ejection fraction		7.88±46.39	9.96±43.5	0.031****

*Chi-square test, **Fisher exact test, *** t-test, **** Mann-Whitney test

before the intervention. The analysis of covariance (adjusting for the heterogeneity of demographic and clinical variables in the two groups) was used to compare the two groups four days after the intervention. The findings revealed that on the first, second, third, and fourth days after the intervention, the mean severity of dyspnea in the inhalation group was significantly higher than in the intermittent inhalation-exhalation group (P<0.05). Furthermore, repeated measures analysis of variance was used to evaluate the effect of the intervention on the severity of dyspnea in each group with itself before and after the intervention. The adjusted Greenhouse-Geisser test statistic was used to interpret the result of the analysis of variance with repeated measures because of the lack of sphericity default (P<0.001). Based on the results of the analysis of variance with repeated measures, a statistically significant difference was observed between the mean intensity of dyspnea in both inhalation and intermittent inhalation-exhalation groups in the five observation times (P<0.001) and a decreasing trend in the mean severity of dyspnea was seen during the observed times in both groups (Table 2).

Logistic regression (adjusting for the heterogeneity of demographic and clinical variables in the two groups) was used to compare the frequency distribution of atelectasis among the patients with inhalation and intermittent inhalation-exhalation groups. Most patients in both inhalation (63.6%) and intermittent inhalation-exhalation (65.6%) groups had atelectasis with no statistically significant differences observed between the frequency distribution of atelectasis in the two groups [P=0.800, Table 3].

Table 2. Comparison of mean severity of dyspnea among the patients with inhalation and intermittent inhalation-exhalation groups before and four days after the intervention

	severity of dyspnea		*P*-value
	Intermittent inhalation-exhalation group (n=33)	Inhalation group (n=33)	
	Mean±SD	Mean±SD	
Before intervention	1.21±7.40	4.89±9.49	0.167*
The first day after the intervention	1.24±5.50	1.03±6.84	0.001*
The second day after the intervention	1.41±3.48	1.13±5.18	<0.001*
The third day after the intervention	1.23±1.54	1.82±3.18	0.002*
The fourth day after the intervention	0.42±0.12	1.53±1.78	<0.001*
***P*-value**	<0.001**	<0.001**	

*Analysis of Covariance **Repeated measurement Analysis

Table 3. Comparison of the frequency distribution of patients' atelectasis in the inhalation and intermittent inhalation-exhalation groups after the intervention

Atelectasis	Intermittent inhalation-exhalation group (n=33) n (%)	Inhalation group (n=33) n (%)	*P*-value*
Yes	21(65.6)	21(63.6)	0.800
No	11(34.4)	12 (36.4)	

*Logistic regression

5. Discussion

This study was conducted to compare the effect of inhalation and intermittent inhalation-exhalation incentive spirometry on dyspnea severity and atelectasis among patients undergoing CABG. Based on the obtained results, the mean severity of dyspnea in patients in both groups of incentive inhalation spirometry and intermittent inhalation-exhalation on the first, second, third, and fourth days after the intervention had a decreasing trend. Consequently, exhalation can be effective in reducing dyspnea among these patients. Comparing the two methods, the results indicated that the mean severity of dyspnea in the inhalation group was higher than in the intermittent inhalation-exhalation group during the observed times after the intervention. In other words, the use of incentive spirometry by intermittent inhalation-exhalation method could reduce dyspnea in patients better than the inhalation approach. Through searching scientific databases, no studies were found to compare the two methods of inhalation and alternating inhalation-exhalation incentive spirometry. Therefore, comparison and discussion were done only with limited number of studies and some books that partially covered each of the above points.

Regarding this, Oei et al. (2011) conducted a study to investigate the effect of incentive spirometry on the respiratory indices of patients with asthma. Patients were randomly allocated to one of three groups: Group 1 had 3-monthly spirometry with medical review, Group 2 spirometry only before and after the trial, and Group 3 routine care. Results indicated that regular spirometry in group 1 with medical review led to better asthma control in patients which can be due to the proper adjustment of the drug and improved compliance (10). In the present study, similar to the study performed by Oei, both groups were under medical review, which led to improved compliance. As a result, in both groups, the severity of dyspnea decreased with spirometry.

In another study, Jácome et al. (2014) investigated the impact of pulmonary rehabilitation in subjects with mild chronic obstructive pulmonary disease (COPD). Participants enrolled in a pulmonary rehabilitation program with exercise training. It was revealed that using breathing exercises and incentive spirometry can reduce dyspnea among the patients with COPD (11). Although there are differences in the methodology, tools, and target group in the mentioned studies with our study, the results of these studies show that using incentive spirometry can affect various patients with physiological and psychological mechanisms and improve pulmonary function in these patients.

To confirm these results, Chaudhary addressed the beneficial effects of breathing exercises and incentive spirometry in reducing primary pulmonary complications through an increase in maximum expiratory flow rate and arterial blood oxygen saturation level and a decrease in dyspnea (18).

Our results revealed that no differences were found between the two methods of inhalation incentive spirometry and intermittent inhalation-exhalation in terms of atelectasis and both groups showed a similar decreasing trend in the incidence of atelectasis. Regarding this, Wang et al. (2018) found that performing respiratory exercises and incentive spirometry reduced atelectasis in lung cancer patients undergoing operation (19, 20). Moreover, in his review study, Gugnani showed that incentive spirometry is a method used to increase the expansion of the lungs, and in thoracotomy patients it increases the inspiratory capacity and improves the inspiratory muscle strength. In addition, using incentive spirometry reduces atelectasis among the patients undergoing thoracotomy (21). Oshvandi et al., (2020) investigated the effect of Respiratory Exercises on the Prevalence of Atelectasis in Patients Undergoing Coronary Artery Bypass Surgery. Their findings showed that breathing exercises, including deep breathing, effective coughing, and the use of an incentive spirometry device, are more effective in reducing atelectasis after coronary artery bypass surgery compared to the usual and routine practice performed in the hospital (22).

The results of the mentioned studies and the present study show the effect of incentive spirometry on the reduction of atelectasis in patients, although, to the best of our knowledge, there is no study comparing the inhalation and intermittent inhalation-exhalation incentive spirometry on atelectasis; therefore, more studies are needed to better generalize the findings.

This study has significant advantages in terms of dyspnea severity and atelectasis in patients undergoing CABG. Novelty of the research and comparison of the two groups are among the strengths of the present study. The random selection of samples, using various tools to examine and monitor the effects, and sufficient sample size are the strengths of this study.

5.1. Study Limitations

There were limitations in the study, the most important of which was the time limit. Therefore, the effect of these two methods on dyspnea severity and atelectasis occurred within four days. Thus, it is recommended to study the long-term effects of these two methods. Sixty-six patients were examined in this study, and to better generalize the results, it is recommended to conduct future studies with a larger sample size.

6. Conclusion

Our results indicated that using incentive spirometry with intermittent inhalation-exhalation method on dyspnea indices was more effective than using incentive spirometry with inhalation. As a result, incentive spirometry with intermittent inhalation-exhalation is recommended as a cost-effective method with no complications for patients undergoing CABG to reduce postoperative dyspnea.

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Footnotes

Conflicts of Interest: The authors declare that they had no competing interests.
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