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Original Paper

Effect of Adding Continuous Positive Airway Pressure via Mask on Respiratory Indices During Cardiac Rehabilitation After Coronary Artery Bypass Grafting

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ABSTRACT

Introduction: Coronary artery bypass graft (CABG) is the primary surgical process to reduce mortality in patients with coronary artery disease. Atelectasis, as the most important pulmonary complication, postpones the recovery period. One of the most innovative methods for preventing atelectasis is continuous positive airway pressure (CPAP).

Objective: The present study evaluated the effect of adding CPAP to the cardiac rehabilitation program after CABG on exercise and respiratory parameters.

Materials and Methods: This research was a randomized clinical trial conducted on 40 patients of two intervention groups (20 patients) and control (20 patients) after CABG. They were randomly assigned with four block randomizations to receive CPAP mask besides incentive spirometry (IS) in the intervention group or only IS in the control group. Data collection tools were demographic information, modified Borg scale 10, exercise, and respiratory parameters. Participants were assessed from the first to the fourth days of the study. The repeated measures analysis of covariance, t-test, Mann-Whitney test, and multivariate analysis of covariance were used for data analysis.

Results: There were 17 men and 3 women in the intervention group and 12 men and 8 women in the control group. Their Mean±SD age was 59.80±9.54 years in the intervention and 54.45±11.32 years in the control group. From the first to the third day, the values of dyspnea (P=0.001), leg effort (P=0.001(, walking time (P=0.001), and peripheral oxygen saturation before and after walking (P=0.001) were statistically significant in both groups. Considering the group effect, dyspnea (P=0.002), leg effort (P=0.001), walking time (P=0.001), and peripheral oxygen saturation before and after walking (P=0.001) were significant between the two groups. Considering the group and time effect, the tidal volume (P=0.001), minute ventilation (P=0.006), forced vital capacity (P=0.001), forced expiratory volume in one second (P=0.001), and peak expiratory flow (P=0.001) were significant.

Conclusion: Adding a ventilation assist gadget featuring CPAP to cardiac rehabilitation programs may improve the exercise and respiratory parameters after CABG.

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Highlights

• Currently, incentive spirometry (IS) is used to prevent atelectasis. However, modern methods like continuous positive airway pressure (CPAP) could be effective.

• Considering the group effect, amounts of dyspnea, leg effort, walking time, and peripheral oxygen saturation before and after walking were significant between the two studied groups who received routine IS or CPAP mask besides IS.

• Adding a ventilation assist gadget featuring CPAP to cardiac rehabilitation programs may improve the exercise and respiratory parameters after cardiac surgery.

Plain Language Summary

Atelectasis is one of the most important pulmonary complications after coronary artery bypass graft (CABG), reported in 95%-100% of all patients after this surgery. Several rehabilitation strategies have been applied to minimize or prevent postoperative pulmonary complications. Chest physiotherapy and regular incentive spirometry (IS) are used to maintain airway patency and prevent or reverse alveolar atelectasis. In typical methods, the patient should be very active in performing breathing exercises and spirometry after the operation. However, most of them neglect these exercises due to their old age, fatigue after the operation, or pain in the sternum. On the other hand, the situation is more difficult due to the lack of proper supervision of the rehabilitation of the clients. Continuous positive airway pressure (CPAP) encourages the client to do it due to the lack of constant monitoring and the patient's passiveness. Thereupon, another method of atelectasis prevention is the use of noninvasive positive pressure ventilation, especially CPAP. In this method, all respiratory parameters improve by alveolar re-opening and increasing oxygenation. This study showed that adding a ventilation assistant gadget featuring CPAP to IS in cardiac rehabilitation programs improved the exercise and respiratory parameters after CABG.

Introduction

Coronary artery disease (CAD) is the most prevalent cardiovascular disease [1, 2] and the leading cause of mortality worldwide, with up to 17.3 million deaths every year [3]. According to official data provided by the Ministry of Health and Medical Education in Iran, 33% to 38% of deaths are due to CAD, especially acute myocardial infarction [4]. The mortality rate is controlled or prevented by appropriate treatments [5]. Coronary artery bypass graft (CABG) is the choice of treatment for these patients, which may cause complications [6].

Pulmonary complications are among the most important complications that postpone recovery [7, 8]. Atelectasis is one of the serious pulmonary complications after CABG that usually occurs in the lower lobe of the lungs close to the heart [9]. The incidence of atelectasis has been reported to be 95%-100% in all patients undergoing CABG on the first and second postoperative days [10]. Several rehabilitation strategies have been applied to minimize or prevent postoperative pulmonary complications [8].

Chest physiotherapy, concentrating on deep breathing and encouraging coughing, can treat postoperative atelectasis. Regular incentive spirometry (IS) is used to maintain airway patency and prevent or reverse alveolar atelectasis. However, several publications have not revealed any evidence that IS therapy can prevent pulmonary complications after cardiac surgery. A new meta-analysis conducted by Sullivan et al. reveals that IS alone has little effect in reducing mortality from postoperative pulmonary complications and length of hospital stay [10]. Evidence-based studies show no benefit for IS in preventing postoperative pulmonary complications [9-11]. Noncompliance of most patients with cardiac rehabilitation programs, especially IS (due to time-consuming, postoperative fatigue, and the probability of staff supervision deficiency because of a high number of patients and additional workload), has encouraged researchers to adopt new methods in the cardiac rehabilitation process. Another method of atelectasis prevention is using noninvasive positive pressure ventilation mode, especially continuous positive airway pressure (CPAP) [12].

Studies show no evidence of a reduction in pulmonary complaints after using IS after cardiac surgery. The use of CPAP during inhalation and exhalation periods in the cardiac rehabilitation program of hospitalized patients after CABG has improved the relevant clinical results. Continuous positive airway pressure increases walking time and ventilatory performance and improves respiratory pattern [8]. Since atelectasis is an essential pulmonary complication after cardiac surgery, resulting in pneumonia and acute respiratory failure [8, 13, 14], using a method that can help reduce the severity of these complications after cardiac surgery can help the patient recover faster and the medical service delivery systems to save costs. Therefore, this study evaluated the effect of adding CPAP to the cardiac rehabilitation program after CABG on exercise and respiratory parameters in admitted patients.

Materials and Methods

The current study is a randomized controlled trial performed on 40 patients undergoing CABG in one of the educational and remedial centers, Guilan University of Medical Sciences, Guilan Province, Iran, from September to November 2018 for 50 consecutive days. The sample size was estimated as 20 people in each group with 95% confidence and 10% type II error based on the results of Pantoni et al.'s study (Mean±SD were 90.2±2.8 and 92.8±2.3 in the control and intervention groups, respectively) and using the oxygen saturation index of the peripheral blood in the two-domain test [8]. Samples were entered into this study based on the inclusion criteria. First, they were randomly allocated by flipping the coin to determine intervention or control, and then, with four block randomizations, defined the sequences of the intervention (20 patients) and control (20 patients) groups.

The inclusion criteria were elective CABG with cardiopulmonary bypass, sternotomy incision and use of saphenous vein, internal mamillary artery or radial vein graft, ability to perform an exercise, no previous cardiac surgery, non-use of intra-aortic balloon pump, no permanent pacemaker, no valvular heart disease, and no chronic obstructive pulmonary disease (COPD) history based on the medical record (Figure 1).

In this study, all information was obtained from the registered medical records of the patients and the researcher's observations, which consisted of three general sections. The first part included demographic information: Age, gender, and body mass index (BMI). The second part involved extraction of non-spirometry results consisting of dyspnea-using modified Borg scale 10 for dyspnea score (16), leg effort-using rate of perceived exertion (RPE) scale, walking time, SpO_2 before walking, and SpO_2 after walking from the first to the third day of study that measured with calibrated pulse oximeter accurate model. This research divides the Borg scale into two sections: Modified CR-10 and RPE. Modified CR-10 is used to assess the degree of dyspnea, rated from 0 to 10. Zero means nothing at all, 0.5=extremely slight, 1=very slight, 2=slight, 3=moderate, 4=somewhat severe, 5=severe, 7=very severe, 9=extremely severe (al-

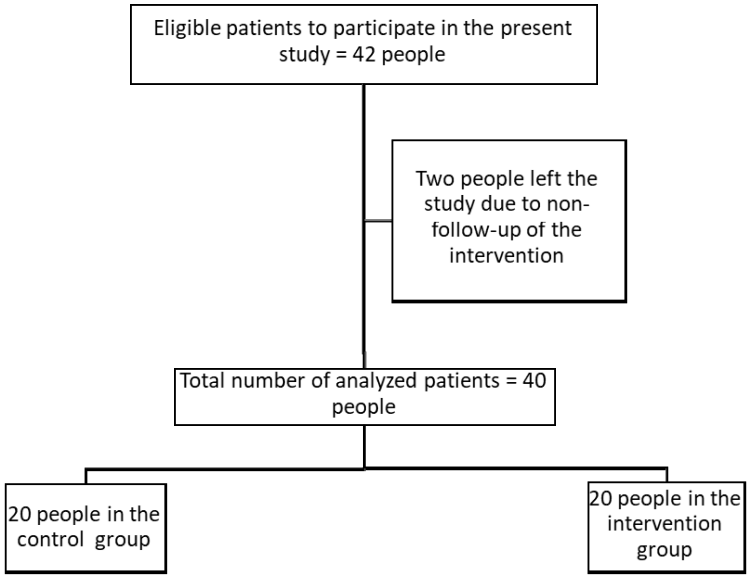

Figure 1. CONSORT study flowchart

most maximal). RPE is used to measure the perceived exertion during a patient's activity, which is rated from 6 to 20. Six means no exertion at all (no muscle fatigue, breathlessness, or difficulty in breathing), 7=extremely light (very, very light), 9=very light (like walking slowly for a short while and very easy to talk), 11=light (like alight exercise at patient own pace), 12=moderate, 13=somewhat hard (fairly strenuous and breathless and not so easy to talk), 15=hard (heavy and strenuous and upper limit for fitness training as when running or walking fast, 17=very hard (very strenuous and patient is very tired and breathless, very difficult to talk), 19=extremely hard (the most strenuous effort that patient has ever experienced, 20=maximal exertion (maximal heaviness). There are not explanation for items 6, 8 in CR – 10 and for items 8, 14, 16 in RPE inn original version of scale [16]. These two sections are illustrated as two separate checklists. It is noticeable that the researcher recorded the total time of physical activity and the amounts of SpO_2 right before and after physical activity. The third part contained extracting spirometry results using a computed spirometry test consisting of tidal volume (VT), respiratory rate (RR), minute ventilation (VE), forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), FVC/FEV_1, and peak expiratory flow (PEF) on the fourth day of study. One person did all spirometry tests for all samples. The walking time was recorded based on the researcher's observation.

Patients in the control group received routine IS, and patients in the intervention group received CPAP mask with controlled pressure set 3-5 cm H_2O besides IS as prescriptive cardiac rehabilitation for three days (8). Two masks (made by Vygon Co., France) were used in this study. The masks were disinfected with ethylene oxide gas after use for each patient. At the time of this intervention, the samples of the intervention and control groups were separated from each other in two different rooms to prevent sensitivity to the change in the routine method. In our research environment, patients undergoing CABG were admitted to open heart ICU for two days after surgery. Then, on the third day after surgery, the patient is transferred to an open-heart ward and monitored for four more days. After studying the patient's medical record and reviewing the inclusion criteria, the researcher provided a complete description of the study process, the non-use of any invasive procedure, and the confidentiality of personal information. Then, agreement consent was signed, and the researcher completed the questionnaire.

In the cardiac rehabilitation program, 48 hours after the operation, the patients in the control group received a routine program, including using IS and deep breathing exercises for half an hour before starting to walk. In addition to receiving routine IS for 30 minutes, patients in the intervention group were used to apply continuous positive airway pressure with balanced airway pressure in the inhalation and exhalation periods of 4-6 cm H_2O according to the patient's tolerance. Then, two hours after applying continuous positive airway pressure with balanced airway pressure during inhalation and exhalation periods, active physical exercises in the form of walking for 5 to 10 minutes on the first day (depending on the patient's tolerance), 10 to 15 minutes on the second day, and 15 minutes and more on the third day, were done. The control group also had the same amount of activity due to the possibility of the patient's intolerance to this mask; the researcher was present throughout the intervention.

The findings of this study were analyzed by SPSS software, version 16 after coding. Before analyzing data, the Shapiro-Wilks test was used to determine the normal distribution of data. Non-spirometry variables were analyzed using descriptive statistics such as Mean±SD, time effect, group effect, and interaction between group and time using repeated measure analysis of variance. The spirometry variables were analyzed using descriptive statistics such as mean, standard deviation, first and third quartile. Finally, repeated measures analysis of covariance, t-test, Mann-Whitney test, and multivariate analysis of covariance were used to analyze the relationship and significance of dependent and independent variables in non-spirometry and spirometry parameters as multivariate. The statistical tests were considered significant when $P<0.05$.

Results

There were 17 men and 3 women in the intervention group and 12 men and 8 women in the control group. Their mean age was 59.80±9.54 years in the intervention and 54.45±11.32 years in the control group. Their mean BMI was 27.24±2.55 kg/m^2 in the intervention group and 27.56±3.62 kg/m^2 in the control group. The statistical test showed that age, gender, and BMI had a normal distribution. No significant differences were observed between groups regarding gender, age, and BMI (Table 1).

The two groups' spirometry and non-spirometry variables were different, presenting lower values for dyspnea and leg effort and higher values for walking time and SpO_2 before and after walking in the intervention group. Dyspnea and leg effort had similar decreasing

Table 1. Demographic indicators of samples in the intervention and control groups (n=20)

Group / Variables		No. (%)/Mean±SD		P
		Intervention	Control	
Sex	Female	3(15)	8(40)	0.155*
	Male	17(85)	12(60)	
Age		59.80±9.54	54.45±11.32	0.114**
Body mass index (kg/m^2)		27.56±3.62	27.24±2.55	0.748 **

*The chi-square test, **The Independent t-test.

trends during three days, and walking time increased in the intervention group. SpO_2 before and after walking had increasing trends in the intervention group but fixed in the control group. Although the group effect was statistically significant in all non-spirometry variables, interactions between group and time were insignificant in dyspnea and leg effort variables (Table 2).

Comparison of means and standard deviations of spirometry parameters on the fourth day in the intervention and control groups indicated that values like VT,

Table 2. Comparing non-spirometry variables from the first to the third days considering time, group, and group×time effects

Variables	Day	Mean±SD		P			
				Time Effect*		Group Effect*	Interaction Between Group and Time*
		Intervention (n=20)	Control (n=20)	Intervention	Control		
Dyspnea	1st	1.200±0.784	2.050±1.645	0.001	0.001	0.001	0.153
	2nd	0.325±0.494	1.725±1.508				
	3rd	0.050±0.153	1.078±0.889				
Leg effort	1st	8.95±1.504	12.20±3.071	0.001	0.001	0.001	0.428
	2nd	7.30±0.979	11.15±3.345				
	3rd	6.45±0.510	9.70±2.774				
Walking time	1st	424.55±75.586	277.70±120.496	0.001	0.001	0.001	0.001
	2nd	825.05±92.482	519.20±182.434				
	3rd	1316.30±384.728	698.65±261.124				
SpO_2 before walking	1st	93.70±1.380	92.95±1.432	0.001	0.096	0.001	0.001
	2nd	95.30±1.418	93.15±1.785				
	3rd	97.10±1.021	93.80±1.936				
SpO_2 after walking	1st	95.40±1.536	92.55±2.14	0.001	0.114	0.001	0.048
	2nd	96.80±1.704	93.15±2.519				
	3rd	98.50±0.607	93.85±2.498				

*Repeated measures analysis of variance.

Table 3. Comparing spirometry indices on the fourth day in the intervention and control groups

Variables*	Group	Mean±SD	Median (Interquartile Range)	P
VT (mL)	Intervention	484.40±34.614	496.50 (475.00-507.75)	0.001*
	Control	406.65±52.443	407.00 (368.25-433.00)	
RR (min)	Intervention	16.25±2.403	16.00 (14.00-18.00)	0.462**
	Control	16.85±2.700	17.00 (14.25-19.00)	
VE (L/min)	Intervention	7854.80±1192.476	7894.00 (6734.50-8899.00)	0.020**
	Control	6855.15±14070775	6725.50 (5403.00-8182.25)	
VC (L)	Intervention	2.441±0.718	2.220 (1.897-3.142)	0.001**
	Control	1.504±0.504	1.605 (1.040-1.862)	
FEV_1 (L)	Intervention	2.187±0.619	2.070 (1.715-2.510)	0.001**
	Control	1.300±0.444	1.390 (0.792-1.617)	
FVC/FEV_1	Intervention	90.369±9.770	93.285 (85.707-96.815)	0.372*
	Control	86.807±12.196	87.755 (81.092-96.787)	
PEF (L/min)	Intervention	5.652±1.976	5.195 (3.972-7.577)	0.001**
	Control	3.003±1.129		

Abbreviations: VT: Tidal Volume; RR: Respiratory rate; VE, Minute ventilation; FEV_1: Forced expiratory volume in one second; FVC: Forced vital capacity; PEF: Peak expiratory flow.

*The Mann-Whitney U test, ** The Independent t-test.

VE, FVC, FEV_1, and PEF in the intervention group were higher than in the control group. Significant statistical differences were seen between groups in VT (P=0.001), VE (P=0.020), FVC (P=0.001), FEV_1 (P=0.001), and PEF (P=0.001), but none in RR and FVC/FEV_1 (Table 3).

The study showed that non-spirometry variables were higher in the intervention group. The effect of age was significant just in dyspnea. Gender and BMI did not affect any non-spirometry variables. In addition, all non-spirometry parameters affected the group (Table 4).

A comparison of the two groups showed that the mean values of all spirometry parameters in the intervention group were higher than those in the control group. Regarding the relationship between dependent variables in spirometry parameters and independent variables in both groups simultaneously and controlling the additional and continuous effect of independent variables demonstrated that age significantly affected VT (P=0.001), FVC (P=0.001), and FEV_1 (P=0.001), and impact of gender was significant just in FVC (P=0.017). Also, BMI was significantly effective in FVC (P=0.004) and PEF (P=0.008). Besides, the effect of group in the intervention group was significantly different from the control group in VT (P=0.001), VE (P=0.006), FVC (P=0.001), and FEV_1(P=0.001). These results were shown in Table 5. Comparing mean values of spirometry parameters on the fourth day of study considering age, gender, and BMI effectiveness indicated that all spirometry variables were higher in the intervention group except FVC/FEV_1.

Discussion

The current study's findings indicate that using CPAP and routine cardiac rehabilitation positively improves non-spirometry and spirometry parameters. This study showed a significant difference in dyspnea between the two groups on the days under investigation. So, all these days, the amount of dyspnea in the intervention group was always lower than in the control group. In a study conducted by Kamisaka et al. to determine the effect of ventilation aids on reducing dyspnea while walking, especially in patients with cardiac and pulmonary dysfunction after cardiovascular surgery in Japan, the rate of dyspnea after using the ventilation aids, there was a significant difference compared to the previous session [14].

Table 4. Analysis of covariance based on the effect of age, gender, BMI, and group in the intervention and control groups

Variables	Day	Mean±SD				P			
		Intervention		Control					
		Female	Male	Female	Male	Effect of Age*	Effect of Gender*	Effect of BMI*	Effect of Group*
Dyspnea	1st	1.648±0.706	0.962±0.303	2.196±0.443	2.178±0.355	0.040	0.769	0.281	0.002
	2nd	0.480±0.626	0.176±0.268	1.946±0.393	1.748±0.314				
	3rd	0.169±0.372	0.027±0.160	1.158±0.234	1.103±0.187				
Leg effort	1st	10.011±1.395	8.548±0.598	12.723±0.876	12.155±0.701	0.349	0.549	0.564	0.001
	2nd	6.989±1.390	7.080±0.596	12.02±0.873	10.964±0.699				
	3rd	6.684±1.109	6.235±0.476	10.926±0.696	9.128±0.558				
Walking time	1st	386.200±59.355	437.601±25.452	255.652±37.260	283.325±29.829	0.301	0.169	0.111	0.001
	2nd	869.712±84.814	822.564±306.369	537.265±53.242	499.513±42.624				
	3rd	1272.273±183.698	1353.206±78.772	517.849±115.318	777.906±92.319				
SpO_2 before walking	1st	93.350±0.819	93.810±0.351	93.466±0.514	92.538±0.411	0.548	0.131	0.514	0.001
	2nd	96.018±0.932	95.304±0.400	92.970±0.585	93.084±0.468				
	3rd	96.329±0.906	97.319±0.388	93.240±0.569	94.056±0.455				
SpO_2 after walking	1st	94.705±1.060	95.642±0.455	92.409±0.666	92.475±0.533	0.933	0.796	0.433	0.001
	2nd	97.019±1.280	96.852±0.549	92.531±0.803	93.434±0.643				
	3rd	98.664±1.007	98.593±0.432	92.560±0.320	94.537±0.506				

BMI: Body mass index.* P are based on repeated measures analysis of covariance.

Table 5. Multivariate analysis of covariance based on the effect of age, gender, BMI, and group in the intervention and control groups

Variables	Group	Gender	Mean±SD	95% CI		P			
				Lower	Upper	Effect of Age*	Effect of Gender**	Effect of BMI*	Effect of Group*
VT (mL)	Intervention	Female	472.522±24.677	422.373	522.671	0.034	0.448	0.171	0.001
		Male	491.720±10.582	470.216	513.225				
	Control	Female	398.296±15.491	366.815	429.778				
		Male	404.818±12.401	379.615	430.020				
RR (min)	Intervention	Female	17.968±1.495	14.930	21.005	0.716	0.571	0.306	0.782
		Male	16.020±0.664	14.717	17.322				
	Control	Female	16.316±0.938	14.409	18.223				
		Male	17.102±0.751	15.576	18.629				
VE (L/min)	Intervention	Female	8467.742±730.829	6982.519	9952.965	0.142	0.834	0.085	0.006
		Male	7862.090±313.388	7225.210	8498.971				
	Control	Female	6519.488±458.782	5587.130	7451.846				
		Male	6915.362±367.283	6168.953	7661.770				
FVC (L)	Intervention	Female	2.173±0.278	1.608	2.739	0.001	0.017	0.004	0.001
		Male	2.597±0.119	2.355	2.840				
	Control	Female	1.098±0.175	0.743	1.453				
		Male	1.621±0.140	1.337	1.906				
FEV_1 (L)	Intervention	Female	2.078±0.252	1.566	2.591	0.001	0.111	0.005	0.001
		Male	2.299±0.108	2.079	2.519				
	Control	Female	1.017±0.158	0.696	1.339				
		Male	1.357±0.127	1.100	1.615				
FVC/FEV_1	Intervention	Female	96.178±6.375	83.221	109.134	0.607	0.086	0.378	0.294
		Male	88.966±2.734	83.410	94.522				
	Control	Female	91.980±4.002	83.846	100.113				
		Male	83.895±3.204	77.384	90.406				
PEF (L/min)	Intervention	Female	5.699±0.838	3.995	7.403	0.059	0.320	0.008	0.001
		Male	5.823±0.359	5.093	6.554				
	Control	Female	2.235±0.526	1.166	3.305				
		Male	3.260±0.421	2.404	4.117				

Abbreviations: VT: Tidal volume; RR: Respiratory rate; VE: Minute ventilation; FVC: Forced vital capacity; FEV_1: Forced expiratory volume in one second; PEF: Peak expiratory flow.

**P on multivariate analysis of covariance.

Also, the findings showed that the leg effort was significantly different between the two groups. So, all these days, the leg effort in the intervention group was lower than in the control group. In this regard, research by Ferreira et al. to determine the effect of IS and CPAP during exhalation simultaneously in preventing pulmonary complications showed that the amount of leg effort by the patient during the 6-minute walking test in the control group was significantly more than that in the intervention group [5].

On the fourth day of the study, VT, VE, FVC, FEV_1, and PEF as spirometry variables were higher in the intervention group. In addition, dyspnea was just influenced by age and group. Besides, the group influenced the other non-spirometry parameters, too. Also, VT was influenced by age and group, and VE was just affected by group, but no independent variables influenced RR.

In this regard, the study by Kamisaka et al. using ventilatory assistant gadgets in patients with cardiopulmonary dysfunctions after CABG showed a significant difference in the dyspnea group compared before using ventilatory assistant gadgets [14]. Additionally, Ferreira et al. proved that using CPAP and IS together significantly reduced dyspnea score and perceived effort sensation [5]. Previously, Pantoni et al. indicated that walking time was significantly different between groups by 43.4 s. Although Olper et al. although this study showed that CPAP increased lung capacity [8], Al-Mutairi did not report a significant difference between the IS group and 4-h CPAP. Of course, 2-h CPAP was statistically significant [9]. On the other hand, when using noninvasive ventilation, Preisig et al. did not mention any significant difference between the intervention and control groups [16]. In this context, we demonstrated that CPAP and IS reduce dyspnea and leg effort. The findings of our study showed that the walking time and SpO_2 improved after the intervention. A possible mechanism for the results of the present study may be related to CPAP decreasing the physiologic work of breathing, thereby unloading the respiratory musculature and reducing the likelihood of fatigue. It may have decreased the presence of hypoxia during walking and potentially contributed to the observed improvement in walking time.

Using plethysmography during walking, Pantoni et al. showed significant differences in VT and VE between the two groups [8]. Also, Al-Mutairi et al. demonstrated no significant difference in RR among all study groups [9]. Age, BMI, and group variables did not affect FVC and FEV_1, but gender influenced FVC. Contrary to the results obtained in this study, Bittencourt et al., in a randomized controlled trial, proved that no difference was seen between the two groups in amounts of FVC and FEV_1 before and after cardiac rehabilitation [17]. Perhaps different research communities and the duration of rehabilitation programs caused this variation in the results of the two studies. Additionally, Guimarães et al. demonstrated no significant difference in FVC and FEV_1 between the two groups in the 1st, 2nd, and 24th hours after the operation [18]. A low sample size and different research communities led to these diversities among the above two studies. Therefore, FVC/FEV_1 was not influenced by any independent variables, including age, gender, BMI, and group, but PEF was affected by BMI and group. On the other hand, Ferriera et al. indicated no significant differences in FVC, FEV_1, and PEF variables in two control and intervention groups before and 18 months after the operation periods [5]. Probably, different methods applied in their study and measuring these variables before and after intervention yielded different results.

Findings of this study indicate that values of VT, FVC, FEV_1, and PEF were statistically significant between the two groups, while RR, VE, and FVC/FEV_1 were not. It seems that because of adequate ventilation in the intervention group and prevention of pulmonary endothelial dysfunction and due to the increase of alveolar stability, atelectasis is prevented, and oxygenation is improved. However, appropriate pulmonary muscles and diaphragm function were effective. They caused significant differences in spirometry parameters in the two studied groups. Since most of the spirometry parameters such as VT, VE, FVC, FEV_1, and PEF were influenced by the group significantly and due to the researcher's intervention, applying a ventilator assistant instrument featuring CPAP along with routine cardiac rehabilitation, it seems that increased pulmonary capacity is associated with this respiratory assistant procedure. It appears that in the intervention group, due to the proper establishment of ventilation, pulmonary endothelial dysfunction is prevented, and by increasing the stability of the alveoli, the amount of atelectasis decreases and improves oxygenation. In addition, the proper functioning of the lung and diaphragm muscles is also effective in improving the patient's respiratory condition [19, 20, 21].

Placing a bulky mask of CPAP on the face of patients can cause anxiety, and this change can affect physiological parameters, including cardiovascular and respiratory function.

The study shows that adding a ventilation assistant gadget featuring CPAP to IS in cardiac rehabilitation programs improves the exercise and respiratory parameters

after CABG, which can be considered in patients undergoing cardiac surgery. Usage of CPAP may cause alveolar re-opening and increase oxygenation, leading to non-spirometry and spirometry parameters (i.e. VT, VE, FVC, FEV_1, and PEF) improvement after CABG. Therefore, it is recommended that a ventilatory assistant instrument featuring CPAP as a simple and modern tool to improve exercise and respiratory parameters should be applied. It can also be suggested to policymakers for rehabilitation programs after coronary artery bypass surgery.

Ethical Considerations

Compliance with ethical guidelines

This study was supported by the Deputy of Research and Technology and the Ethics Committee of the Guilan University of Medical Sciences (Code: IR.GUMS.REC.1397.007) and Iranian Registry of Clinical Trials (IRCT) (Code: IRCT20101019004971N5).

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Authors' contributions

Prepare the initial proposal, collect data, and write the manuscript: Fatemeh Roknishirazi; Technical consultant in the research process: Nazila Javadi-Pashaki; Statistical analysis: Ehsan Kazemnejad Lili; Clinical consultant in the research field: Mehrzad Ghasemzade; Corresponding author. Research supervisor and last version manuscript approval: Mohammad Taghi Moghadamnia; Approved the final version of manuscript: All authors.

Conflict of interest

The authors declared no conflict of interest.

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References

[1] Hinkle JL, Cheever KH. Brunner and suddarth's textbook of medical - surgical nursing. Punjab: Wolters kluwer india Pvt Ltd; 2018.

[2] Pourshaikhian M, Moghadamnia MT, Yekaninejad MS, Ghanbari A, Rashti AS, Afraz Kamachli S. The effects of meteorological variables on ambulance attendance for cardiovascular diseases in Rasht, Iran. J Therm Biol. 2019; 83:150-6. [DOI:10.1016/j.jtherbio.2019.05.002] [PMID]

[3] Kachur S, Chongthammakun V, Lavie CJ, DeSchutter A, Arena R, Milani RV, et al. Impact of cardiac rehabilitation and exercise training programs in coronary heart disease. Prog Cardiovasc Dis. 2017; 60(1):103-14. [DOI:10.1016/j.pcad.2017.07.002] [PMID]

[4] Ghiasmand M, Moghadamnia MT, Pourshaikhian M, Kazemnejad Lili E. Acute triggers of myocardial infarction: A case-crossover study. Egypt Heart J. 2017; 69(4):223-8. [DOI:10.1016/j.ehj.2017.03.003] [PMID]

[5] Ferreira GM, Haeffner MP, Barreto SS, Dall'Ago P. Incentive spirometry with expiratory positive airway pressure brings benefits after myocardial revascularization. Arq Bras Cardiol. 2010; 94(2):230-5. [DOI:10.1590/s0066-782x2010000200017] [PMID]

[6] Andersen DK, Brunicardi CF. Schwartz's principles of surgery. New York: Mc GrawHill; 2015.

[7] Paryad E. [Nursing care in open heart Intensive Care Unit (Persian)]. Rasht: Guilan University of Medical Sciences; 2012.

[8] Pantoni CB, Di Thommazo-Luporini L, Mendes RG, Caruso FC, Mezzalira D, Arena R, et al. Continuous positive airway pressure during exercise improves walking time in patients undergoing inpatient cardiac rehabilitation after coronary artery bypass graft surgery: A randomized controlled trial. J Cardiopulm Rehabil Prev. 2016; 36(1):20-7. [DOI:10.1097/HCR.0000000000000144] [PMID]

[9] Al-Mutairi FH, Fallows SJ, Abukhudair WA, Islam BB, Morris MM. Difference between continuous positive airway pressure via mask therapy and incentive spirometry to treat or prevent post-surgical atelectasis. Saudi Med J. 2012; 33(11):1190-5. [PMID]

[10] Sullivan KA, Churchill IF, Hylton DA, Hanna WC. Use of incentive spirometry in adults following cardiac, thoracic, and upper abdominal surgery to prevent postoperative pulmonary complications: A systematic review and meta-analysis. Respiration. 2021; 100(11):1114-27. [DOI:10.1159/000517012] [PMID]

[11] Odor PM, Bampoe S, Gilhooly D, Creagh-Brown B, Moonesinghe SR. Perioperative interventions for prevention of postoperative pulmonary complications: Systematic review and meta-analysis. BMJ. 2020; 368:m540. [DOI:10.1136/bmj.m540] [PMID]

[12] Sadahiro M. Cardiopulmonary rehabilitation using adaptive servo-ventilation after cardiac surgery. Circ J. 2015; 79(6):1204-5. [DOI:10.1253/circj.CJ-15-0407] [PMID]

[13] Cordeiro ALL, Gruska CA, Ysla P, Queiroz A, Nogueira SCO, Leite MC, et al. Effect of different levels of peep on oxygenation during noninvasive ventilation in patients submitted to CABG surgery: Randomized clinical trial. Braz J Cardiovasc Surg. 2017; 32(4):295-300. [DOI:10.21470/1678-9741-2016-0038] [PMID]

[14] Kamisaka K, Sakui D, Hagiwara Y, Kamiya K, Adachi T, Iida J, et al. Mechanical ventilatory assistance may reduce dyspnea during walking especially in patients with impaired cardiopulmonary function early after cardiovascular surgery. J Cardiol. 2016; 67(6):560-6. [DOI:10.1016/j.jjcc.2015.08.003] [PMID]

[15] Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982; 14(5):377-81. [PMID]

[16] Verlaine Balzan L, Vinícius Lovatto A, Fernando Nataniel V, Eraldo de Azevedo L, Laura Jurema S, et al. Ventilação não Invasiva após Cirurgia Cardiovascular: Um En- saio Clínico Randomizado / Non-invasive ventilation after cardiovascular surgery: A randomized clinical trial. Revista da Associação Médica Brasileira. 2014; 27(1):43-52. [Link]

[17] Portal Regional da BVS. VHL Regional Portal: Information and Knowledge for Health. Available from: [Link]

[18] Bittencourt HS, Cruz CG, David BC, Rodrigues E Jr, Abade CM, Junior RA, et al. Addition of noninvasive ventilatory support to combined aerobic and resistance training improves dyspnea and quality of life in heart failure patients: A randomized controlled trial. Clin Rehabil. 2017; 31(11):1508-15. [DOI:10.1177/0269215517704269] [PMID]

[19] Guimarães J, Pinho D, Nunes CS, Cavaleiro CS, Machado HS. Effect of Boussignac continuous positive airway pressure ventilation on PaO2 and PaO2/FIO2 ratio immediately after extubation in morbidly obese patients undergoing bariatric surgery: A randomized controlled trial. J Clin Anesth. 2016; 34:562-70. [DOI:10.1016/j.jclinane.2016.06.024] [PMID]

[20] Bolukçu A, İlhan S, Topçu AC, Günay R, Kayacıoğlu İ. Causes of dyspnea after cardiac surgery. Turk Thorac J. 2018; 19(4):165-9. [DOI:10.5152/TurkThoracJ.2018.17084] [PMID]

[21] Treschan TA, Schaefer M, Kemper J, Bastin B, Kienbaum P, Pannen B, et al. Ventilation with high versus low peep levels during general anaesthesia for open abdominal surgery does not affect postoperative spirometry. Eur J Anaesthesiol. 2017; 34(8):534-43. [DOI:10.1097/EJA.0000000000000626] [PMID]