Comparison of the effect of incentive spirometry and deep breathing exercises on hemodynamic parameters of patients undergoing coronary artery bypass graft surgery: A Clinical Trial

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Research Article

Abstract

Background

Hemodynamic changes are among the common complications after coronary artery bypass graft (CABG) surgery. Incentive spirometry and deep breathing exercises are widely used in patients undergoing coronary artery bypass graft surgery. The aim of the present study was to compare the effect of incentive spirometry and deep breathing exercises on hemodynamic parameters of patients undergoing coronary artery bypass graft surgery.

Methods

This is a clinical trial that was performed on 40 heart patients who were candidates for coronary artery bypass graft surgery. Participants were selected using convenience sampling and then randomly divided into two groups. One day before surgery, one group was taught how to perform deep breathing exercises (DBE) and the other group was taught how to use incentive spirometry in practice. Hemodynamic indices were measured and recorded before the intervention, the first, second, and the third day after the intervention. Data analysis was carried out using SPSS ver.16 and descriptive and inferential statistical tests.

Findings:

The mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) on the first day after the intervention in patients undergoing the incentive spirometry group was significantly higher than the DBE group ($p < 0.05$). On the third day after the intervention, the mean arterial SaO2 in patients of the incentive spirometry group was significantly higher than the DBE group and the mean respiratory rate (RR) in patients in the incentive spirometry group was significantly lower than the DBE group ($p < 0.05$). However, there was no significant difference between the two groups in terms of other indices ($p > 0.05$).

Conclusion

The results showed that incentive spirometry has a greater effect on hemodynamic indices of patients undergoing CABG compared to DBE, so, it is recommended to use incentive spirometry to improve hemodynamic indices in these patients.

Trial registration:

Iranian Registry of Clinical Trials (IRCT), IRCT20191028045267N1. Registered 12 March 2020, https://www.irct.ir/trial/43365

Background

Coronary artery bypass graft (CABG) is a surgical procedure to restore normal blood flow to the heart by bypassing the blocked coronary arteries. Although surgical procedures, anesthesia, and postoperative care have improved dramatically, postoperative pulmonary complications, including atelectasis, pneumonia, and pneumothorax, have not improved significantly after CABG and remain a challenge [1]. The incidence of these complications in patients undergoing CABG surgery is significant and has been reported between 30% and 60% [2], so that pulmonary complications should be expected for any patient who undergoes CABG surgery [3]. Pulmonary complications lead to impaired oxygen delivery and gas exchanges [4].

Several measures have been proposed to reduce these complications and improve arterial blood gas parameters and hemodynamic indices [5]. However, there is no agreement on a specific method [6]. Among these methods, the use of incentive spirometry and DBEs are common methods that can be used easily and without complications for patients and are also low-cost methods [5]. Incentive spirometry, with the aim of encouraging the patient to breathe deeply and create maximum dilation in the bronchi and create an effective cough, to improve lung volume in order to improve oxygen delivery and proper ventilation through visual feedback based on tolerance, motivation, will, and cooperation of the patient [7]. DBEs encourage the patient to breathe deeply and open the collapsed alveoli. This prevents a decrease in lung function and atelectasis, which in turn improves the ventilation/perfusion ratio and ultimately improves gas exchange and oxygen delivery [8].

Various studies have been performed on the effect of each of these methods on improving pulmonary function in the field of gas exchange and oxygen delivery after CABG, which have reported different results. One study found that the use of incentive spirometry and planned DBEs were more effective in improving arterial blood gas levels than conventional breathing exercises, but both methods were not different in terms of improving arterial blood gases [9] The results of another study, however, showed that the use of incentive spirometry improves pulmonary function [10]. However, in their study, Afrasiabi et al. showed that incentive spirometry has no effect on improving the arterial blood gases levels [11]. The results of other studies have shown an improvement in the oxygen delivery status in the groups undergoing DBE and spirometry [12, 13]. Moradyan et al. showed in a study that planned breathing exercises significantly improved arterial blood gas levels on the third day after surgery, however, based on its findings, it is not possible to say which of the two methods further improves pulmonary performance, and it can only be concluded that performing these two methods improves gas exchange and oxygen delivery [14].

Overall, there is no fixed and coherent method to prevent respiratory complications after CABG in Iranian intensive care units, and depending on the patient's condition and the opinion of the physician, one or more methods of improving respiratory function may be used. Moreover, considering the different and contradictory results of relevant studies and the importance of a preferred method to prevent and

accelerate the improvement of the patient's respiratory status, the aim of the present study is to compare the effect of incentive spirometry and DBEs on hemodynamic indices in patients undergoing CABG.

Methods

This is a clinical trial that was performed on eligible 40 patients undergoing CABG surgery referred to the ICU wards of the open heart and heart surgery of Razi Hospital in Birjand/Iran in 2020. Inclusion criteria included no severe lung disease, neuromuscular and cognitive impairment, or renal impairment, no emergency surgery, mechanical ventilation<24 hours, ability to perform breathing exercises and use incentive spirometry. Exclusion criteria also included the need for reoperation due to possible complications, death or transfer of patient to another hospital, the occurrence of severe hemodynamic disorders (such as severe decrease or increase in blood pressure, shock) during the intervention, complications affecting hemodynamic changes such as bleeding and unwillingness to continue participating in the study.

The sample size was estimated 20 people per group based on a similar study [9] taking into account test power of 80% and a confidence interval of 90%. Eligible patients were gradually enrolled in the study using convenience sampling method and divided into two groups of 20 and received the desired intervention through a quadruple block with a 1: 1 allocation ratio.

Procedure

After obtaining the necessary permissions and access to the samples, the demographic form was completed for the patients and the day before the surgery, the DBE patients were taught deep breathing exercises and the patients in the incentive spirometry group were asked how to use the incentive spirometry in practice at the patient's bedside. The performance of each patient was then evaluated. This training was conducted by the second author, who has a master's degree in medical surgery nursing and has five years of experience working in the ICU.

DBEs were planned in such a way that the patient was first placed in a sitting or semi-sitting position. The patient then took deep, slow nasal breaths while placing his or her hands on his or her chest for easier breathing and pain relief, and applying gentle pressure. At the end-inhale phase, the patient was asked to hold his/her breath for three seconds and then exhale through the mouth while the lips and abdominal muscles were compressed [15]. DBEs were repeated ten times with two-hour interval when the patient woke up under the supervision of the second author.

In the incentive spirometry group, the patient was first placed in a sitting or semi-sitting position and performed the inhalation inside the device by placing an incentive spirometer tube in the mouth. At the end of the inhalation, the patient was asked to hold his/her breath for three seconds and exhale slowly through the mouth by removing the device. Patients were also instructed that they could gradually take deeper breaths with each increase in ball lifting [16]. These exercises were repeated in the form of 10 deep breaths, every two hours during awakening under the supervision of the second author.

These interventions started one hour after removal of the endotracheal tube under the supervision of the researcher and continued until three days later. Before the intervention, on the first, second and third days, hemodynamic indices, including SBP and DBP, heart rate (HR), arterial SaO2, and RR were evaluated for patients in both groups and the results were recorded in the relevant form. It should be noted that on average, respiratory physiotherapy was performed routinely in the hospital, one hour after extubation.

Data collection tools

Demographic data were collected using demographic form, including information on sex, age, level of education, marital status, smoking, history of hypertension, diabetes, and hyperlipidemia. In order to assess the content validity of the questionnaire, it was given to ten faculty members and their views were implemented.

To record hemodynamic indices, a form including information on hemodynamic indices such as SBP and DBP, HR, arterial SaO2, and RR was used. Blood pressure was measured a hand-held sphygmomanometer according to the guidelines of the World Health Organization. For this purpose, a hand-held sphygmomanometer with an armband of appropriate size was used while the patient was in semi-setting position on the bed and his hand was at the heart level. It was measured twice with 10-15 min interval and the average of two measurements was recorded as blood pressure. The first and fifth Korotkoffs were considered as SBP and DBP. Pulse oximetry was used to measure HR and arterial blood SaO2. RR was counted by observing chest movements per minute. The devices were calibrated before the research.

Data Analysis

First, the data distribution was investigated using Kolmogorov-Smirnov test, and the results showed that all research variables had a normal distribution ($p > 0.05$). Data analysis was then carried out using descriptive statistics such as mean and standard deviation and inferential statistics such as Independent t-test, chi-square or Fisher's exact test and Repeated measures ANOVA in SPSS ver. 16. P-value<0.05 was considered as the significance level in all tests.

Results

Of the 40 patients studied, 20 patients (50%) were in the DBE training group and 20 patients (50%) in the incentive spirometry group. The mean age of patients in the DBE and incentive spirometry groups was 65.4 ± 7.12 and 62.8 ± 7.22 years, respectively, but this difference was not statistically significant (p = 0.26). It should be noted that all patients in both groups were married (p = 1). Other demographic characteristics of the two groups are given in Table 1. The relative frequency of demographic variables between the two groups was homogeneous and there was no statistically significant difference (Table 1) (p > 0.05).

Table 1
Comparison of frequency distribution of demographic variables in patients in two groups

Variable		DBE N (%)	Incentive spirometry N (%)	P value
Gender	Men	15 (75)	16 (80)	1.00
	Female	5 (25)	4 (20)	
Education level	Illiterate and elementary	9 (45)	9 (45)	0.66
	Diploma	8 (40)	6 (30)	
	Associate and Bachelor's degree	3 (15)	5 (25)	
Smoking history	Yes	11 (55)	12 (60)	0.75
	No	9 (45)	8 (40)	
History of hypertension	Yes	10 (50)	10 (50)	1.00
	No	10 (50)	10 (50)	
History of diabetes	Yes	7 (35)	7 (35)	1.00
	No	13 (65)	13 (65)	
History of hyperlipidemia	Yes	9 (45)	5 (25)	0.19
	No	11 (55)	15 (75)	

As the result of independent t-test shows, the mean of pre- intervention hemodynamic indices in both DBE and incentive spirometry groups is not significantly different (p>0.05). Mean SBP and DBP on the first day after the intervention in patients in the incentive spirometry group was significantly higher than the DBE group (p<0.05). On the third day after the intervention, the mean arterial SaO2 in the incentive spirometry group was significantly higher than the DBE group and the mean RR in the incentive spirometry group was significantly lower than the DBE group (p<0.05). However, there was no significant difference between the two groups in terms of the mean arterial SaO2 and RR on the first and second days after the intervention, mean HR on the first, second and third days after the intervention and mean SBP and DBP on the second and third days after the intervention (p> 0.05) (Table 2).

Table 2
Comparison of mean hemodynamic indices before intervention and the first, second and third day after intervention in patients between the two groups

		DBE	Incentive spirometry	Independent t test	
		Mean ± SD	Mean ± SD	T	P
Pre-intervention	SBP	12.93 ± 1.54	13.64 ± 1.72	1.38	0.18
	DBP	8.11 ± 1.11	8.85 ± 0.90	1.47	0.15
	SaO2	94.35 ± 2.74	94.55 ± 1.32	0.29	0.77
	HR	79.35 ± 9.80	83.20 ± 6.94	1.43	0.16
	RR	19.05 ± 1.93	18.35 ± 1.39	1.32	0.20
First day	SBP	12.81 ± 1.42	13.73 ± 1.38	1.09	0.04*
	DBP	7.75 ± 1.18	8.65 ± 0.74	2.89	0.006**
	SaO2	94.90 ± 2.75	95.10 ± 1.25	0.30	0.77
	HR	82.15 ± 9.62	85.95 ± 7.79	1.37	0.18
	RR	19.20 ± 1.77	18.85 ± 1.81	0.62	0.54
Second day	SBP	13.01 ± 1.30	13.18 ± 1.32	0.41	0.68
	DBP	8.16 ± 1.15	8.26 ± 0.69	0.32	0.75
	SaO2	94.70 ± 2.62	95.65 ± 1.50	1.41	0.17
	HR	83.60 ± 9.73	83.35 ± 4.43	0.11	0.92
	RR	18.70 ± 2.47	17.75 ± 1.68	1.42	0.16
Third day	SBP	12.72 ± 1.28	12.93 ± 1.32	0.51	0.61
	DBP	8.35 ± 1.15	8.25 ± 0.90	0.29	0.77
	SaO2	95.20 ± 2.38	96.55 ± 1.50	2.15	0.04*
	HR	84.85 ± 8.63	81.50 ± 4.56	1.54	0.13
	RR	19.65 ± 2.32	17.30 ± 1.66	3.68	0.001**
*Correlation is significant at the 0.05 level (two-tailed).					
**Correlation is significant at the 0.01 level (two-tailed).					

As the result of ANOVA showed there was no significant difference in values of the mean SBP and DBP, arterial SaO2, and RR before the intervention, the first, second and third days after the intervention in the

DBE group (P>0.05). However, the mean HR was significantly different in at least two stages (P<0.05). Based on the results of bonferroni test, the mean HR on the second and third days after the intervention was significantly higher than before the intervention and on the third day after the intervention compared to the first day after the intervention in the DBE group (P<0.05) (Table 3).

Results of ANOVA test demonstrated that the mean of hemodynamic indices (SBP, DBP, arterial SaO2, HR and RR) before the intervention, the first, second and third days after the intervention were significantly different in patients of incentive spirometry group (P<0.05). The results of bonferroni test showed a significant decrease in the mean SBP on the second and third day after the intervention compared to before the intervention and the first day after and also on the third day compared to the second day in patients of the incentive spirometry group. Also, the mean DBP on the second and third days after the intervention in the same group was significantly lower than the first day (P<0.05). The mean arterial SaO2 on the second day after the intervention was significantly higher than before the intervention and on the third day after the intervention compared to the previous days in the above group (P<0.05). Results also showed a significant decrease in the mean HR on the first day after the intervention compared to the pre-intervention phase and also on the third day compared to the first and second days after the intervention and also the mean RR on the second day compared to the first day and on the third day compared to the previous days (P<0.05) (Table 3).

Table 3

Comparison of mean hemodynamic indices before intervention and the first, second and third day after intervention in patients in the two groups

		Pre-intervention	First day	Second day	Third day	F	P
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD		
DBE	SBP	12.93 ± 1.54	12.81 ± 1.42	13.01 ± 1.30	12.72 ± 1.28	0.35	0.79
	DBP	8.11 ± 1.11	1.75 ± 1.18	8.16 ± 1.15	8.35 ± 1.15	1.19	0.10
	SaO2	94.35 ± 2.74	94.90 ± 2.75	94.70 ± 2.62	95.20 ± 2.38	1.06	0.37
	HR	79.35 ± 9.80	82.15 ± 9.62	83.60 ± 9.73	84.85 ± 8.63	4.78	0.005*
	RR	19.05 ± 1.93	19.20 ± 1.77	18.70 ± 2.47	19.65 ± 2.32	1.17	0.33
Incentive spirometry	SBP	13.64 ± 1.72	13.73 ± 1.38	13.18 ± 1.32	12.93 ± 1.32	8.09	< 0.001**
	DBP	8.58 ± 0.90	8.65 ± 0.74	8.26 ± 0.69	8.25 ± 0.90	2.77	0.05*
	SaO2	94.55 ± 1.32	95.10 ± 1.25	95.65 ± 1.50	96.55 ± 1.50	15.47	< 0.001**
	HR	83.20 ± 6.94	85.95 ± 7.79	83.35 ± 4.43	81.50 ± 4.56	3.91	0.01*
	RR	18.35 ± 1.39	18.85 ± 1.81	17.75 ± 1.68	17.30 ± 1.66	7.33	< 0.001**

*Correlation is significant at the 0.05 level (two-tailed).

**Correlation is significant at the 0.01 level (two-tailed).

Discussion

The aim of the present study was to compare the effect of incentive spirometry and DBE on hemodynamic parameters of patients undergoing CABG.

The results of the present study showed that the mean HR in the DBE group was significantly different only in at least two stages (P < 0.05) and the mean HR in the DBE group showed a significant increase over time. With regard to other indices, this difference was not statistically significant. Consistent with the present study, Westerdahl et al., concluded that DBEs had no significant effect on arterial blood gases (arterial blood SaO2 percentage, partial pressure of carbon dioxide (PCO2), and partial pressure of oxygen

(PaO2) in patients undergoing CABG [6]; however, the results of a study by Moradyan et al. showed significantly higher arterial blood SaO2 and PaO2 in the experimental group compared to the control group on the third day after surgery. In other words, patients who performed scheduled breathing exercises had a better oxygen delivery status compared to the those received routine hospital treatment, and enjoyed faster improvement in oxygen delivery and returning to the preoperative state [14]. The results of a study by Urell et al. on the effect of deep breathing exercises on the improvement of oxygen delivery in patients undergoing CABG showed that mean arterial oxygen pressure and arterial blood SaO2 in the experimental group were significantly higher than controls on the second day after surgery. In other words, deep breathing exercises significantly increased the percentage of arterial blood SaO2 and arterial oxygen pressure [12], which are inconsistent with the results of the present study. Although in the present study, the mean postoperative arterial SaO2 had an increasing trend compared to preoperative arterial SaO2 in the DBE group, this increase was not statistically significant.

The present study also showed a significant different in the mean hemodynamic indices (SBP, DBP, arterial SaO2, HR, and RR) in patients in the incentive spirometry group, before the intervention, the first, second and third days after the intervention ($P < 0.05$). In the present study, the mean SBP in the spirometry group showed a significant improvement over time and the mean HR in the incentive spirometry group showed a significant decrease over time. Consistent with these results, the findings of another study showed a better improvement in respiratory muscle strength on the fourth day after CABG in the incentive spirometry group, but there was no significant difference in terms of postoperative pulmonary complications or length of hospital stay [1]. The results of a study by Afrasiabi et al. showed that incentive spirometry has no effect on improving arterial blood gas levels, which is inconsistent with the results of the present study. This discrepancy may be due to the fact that Afrasiabi et al. investigated the effectiveness of this method up to 6 hours after endotracheal tube removal, but it was investigated up to three days after surgery in the present study [11]. The results of another study showed that incentive spirometry is significantly effective in improving the arterial blood gas parameters [17]. Another study showed that incentive spirometry led to a significant improvement in PaO_2 and SaO_2 and a decrease in $PaCO_2$ in patients undergoing CABG [18]. The discrepancy in the findings can be related to the differences in the pattern of breathing exercises used in the studies in terms of the frequency and duration of breathing exercises; as well as combining breathing exercises with other routine respiratory care. On the other hand, the time of measuring the research variables and the sample size in different studies are different.

The results of the present study showed a significant improvement in mean arterial SaO2 and RR in patients of the incentive spirometry group compared to the DBE group on the third day after the intervention. There was also significant increase in the mean SBP and DBP on the first day after the intervention in patients of the incentive spirometry group as compared to patients in the DBE group. However, there was no difference between the two groups on the second and third day after the intervention. It should be noted that the baseline blood pressure was higher in the incentive spirometry group than the DBE group. Overall the results showed that the incentive spirometry method was more

effective than the DBE method in improving respiration and arterial SaO2. Despite these results, the findings of another study showed that the two therapies were equally effective in improving arterial blood gases, but DBEs, in particular, were more effective in improving arterial blood gases [19]. The results of another study showed that the DBEs and incentive spirometry are equally effective in reducing the incidence of postoperative chest complications [20]. Results of another study on patients CABG showed no statistically significant difference between DBE and incentive spirometry groups in terms of postoperative maximal respiratory pressures, spirometric variables, and SaO2 [5]. This discrepancy can be attributed to the difference in the research populations because some of the aforementioned studies have been performed on patients with second degree burns [19], and the elderly undergoing abdominal surgery [20].

It can be inferred that there are temporary changes in the oxygen delivery process after breathing exercises and that the blood oxygen level may return to normal after a short time. Therefore, breathing exercises are necessary to prolong the positive effects of breathing exercises [21]. Incentive spirometry is a method that enhances maximal inspiratory or maximal expiratory force and prevents alveolar collapse; therefore, it can be performed to improve oxygen delivery based on the patient's tolerance, motivation and willpower and cooperation [22].

Having a clinical trial design and no sample loss is one of the strengths of the present study. Limitations of the present study include sampling from only one medical center and small sample size. Future studies can compare the effectiveness of these two methods on a larger sample and by choosing from different treatment centers. It is also recommended to compare effectiveness of the two methods used in this study on other hemodynamic characteristics and other groups of patients in future studies.

Conclusion

The results showed that incentive spirometry has a greater effect on hemodynamic indices of patients undergoing CABG compared to deep breathing exercises, hence, it is recommended to use incentive spirometry to improve hemodynamic indices in these patients.

Abbreviations

CABG: Coronary Artery Bypass Graft, DBE: Deep Breathing Exercises, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, Sao2: Oxygen Saturation, RR: Respiratory Rate, HR: Heart Rate, PaO2: Partial pressure of oxygen, ANOVA: Analysis of variance, SD: Standard Deviation.

Declarations

Ethics approval and consent to participate

The present study has been derived from the research project approved by the Ethics Committee of Isfahan (Khorasgan) Branch, Islamic Azad University, with the code No. IR.IAU.KHUISF.REC.1398.271. The

study objectives were explained to them and written informed consent was obtained from eligible patients who agreed to participate in the study. The participants were reminded of the confidentiality of information and the voluntary nature of participating in the study. All method were carried out in accordance with relevant guidelines and regulations.

Consent for publication

The article does not contain any individual's details and consent for publication is not applicable.

Availability of data and material

The datasets generated and analyzed during the current study are not publicly available due to an agreement with the participants on the confidentiality of the data but are available from the second author on reasonable request.

Competing interests

The authors declare that they have no conflict of interests.

Authors' contributions

All authors (MB-SH and FZ) have participated in the conception and design of the study. MB-SH and FZ contributed the data collection and prepared the first draft of the manuscript. MB-SH critically revised and checked closely the proposal, the analysis and interpretation of the data and design the article. FZ carried out the analysis, interpretation of the data and drafting the manuscript. MB-SH has been involved in revising the manuscript critically. All authors read and approved the final manuscript.

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