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RESEARCH ARTICLE

COMPARATIVE STUDY BETWEEN DIFFERENT PULMONARY REHABILITATION PROGRAMS IN PATIENTS UNDERGOING CORONARY ARTERY BYPASS GRAFT

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ABSTRACT

Background: Coronary artery bypass graft (CABG) is still associated with frequent development of postoperative pulmonary complications, which are particularly concerning given its link to increased patient morbidity and mortality and resource utilization.
Aim of the work: The aim of this study was to compare between the effects of different rehabilitation programs post coronary artery bypass graft.
Subjects and Methodology: Forty-five patients of both sexes (22 women and 23 men) who underwent coronary artery bypass graft were enrolled in that study for five days while inpatient period. Their ages ranged from 45-55 years. They were assigned into three groups with equal numbers (control group, Buteyko breathing technique group and incentive spirometer group). Arterial blood gases (PaO_2, PH, Hco_3 and $PaCO_2$) were measured for the three groups at the beginning of the study (1st day postoperative) and after the end of training (5th day postoperative).
Results: There was significant improvement in arterial blood gases including an increase in PaO_2 and PH, while there was significant decrease in $PaCO_2$ and Hco_3 ($P<0.05$) for three groups. Significant difference was noted between three groups postoperatively, in favor of incentive spirometer group.
Conclusion: Both Buteyko breathing technique and incentive spirometer induce significant improvement in arterial blood gases after Coronary Artery Bypass Graft surgery, in favor of incentive spirometer.

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INTRODUCTION

Coronary Artery Bypass Graft (CABG) is a surgical procedure performed to relieve angina and to reduce the risk of death from coronary artery disease. Arteries or veins from elsewhere in the patient's body are grafted to the coronary arteries to bypass atherosclerotic narrowing and to improve the blood supply to the coronary circulation supplying the myocardium (Sabik and Josephh, 2001). Postoperative pulmonary impairment is common in the early period after cardiac surgery. Chest physiotherapy is widely used in postoperative care to prevent pulmonary complications such as decreased lung volumes, atelectasis, decreased oxygenation and pneumonia (Herdy *et al.*, 2008). Incentive Spirometry (IS) combined with physical therapy is more effective than postoperative physical therapy alone in reducing postoperative complications after CABG surgery (Agostini and Singh, 2009). The benefits attributed to IS include the amelioration of atelectasis and improved coughing mechanism due to improved inspiratory capacity and a strengthening of the diaphragm. The patient can assume responsibility for their own treatment, thus reducing the amount of direct patient contact time with the therapist (Rafea *et al.*, 2009). The Buteyko method is a series of reduced-breathing exercises, although variations exist among teachers of the technique in different countries, the three core principles of Buteyko remain the same nasal-breathing, breath-holding and relaxation. The Buteyko method was designed to teach asthmatics to breathe less. The goal is to retrain breathing to a normal pattern (Courtney and Cohen, 2008). A number of clinical trials indicate that it is a successful treatment for asthma; however, there is little support for the CO_2 theory that

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underpins the Buteyko Method. There are, however, many other possible reasons that the breathing techniques used by the Buteyko Method work. These reasons include change in symptom perception and improved sense of control, improved biomechanics of breathing, beneficial effects of low-volume breathing, altered nitric oxide (NO) levels, and resetting of respiratory rhythm generation by breath-holding techniques (Courtney, 2008). Previous studies have shown the effect of IS on post operative pulmonary complications (PPCs) of CABG. The aim of this work was to evaluate the additive effect of Buteyko breathing technique to post-operative rehabilitation program and compare its effects versusincentive spirometer on arterial blood gasesafter CABG.

MATERIALS AND METHODS

Participants

Forty-five patients of both sexes (22 women and 23 men), their ages ranged from 45-55 years who underwent CABG and were selected randomly from National Heart Institute where the study was conducted. Patient's demographic data, clinical characteristic and all medical history was collected from theadmission sheets to ensure that all patients were clinically and medically stable. Their Body mass index (25: 29.9 kg/m^2). Post operative pain was controlled medically. They were assigned into three groups with equal numbers: control group, Buteyko Breathing Technique (BBT) group and Incentive Spirometer (IS) group.

Exclusion criteria

Patients who had met one of the following criteria were excluded from the study:Obese patients (BMI $\geq$ 30 Kg/m^2), patients who had developed hemodynamic complications (e.g. preoperative myocardial infarction, lung congestion or patients on Intra-aortic balloon), Post-operative renal failure or arrhythmia needed for a pacemaker, post-operative mechanical ventilation (more than 24 hours) and history of smoking.

Instrumentation

1) For assessment

Arterial blood gases analyzer: It was used to measure arterial blood gases via arterial blood sample. This was done for each patient before starting the program of training (1st day postoperative) and was measured also after five days of the training program. Arterial blood gases included PaO2, $PaCO_2$, PH and HCO_3.

2) For treatment

Flow-oriented Incentive Spirometer: Triflow II type (RESPIPROGRAM) was used. It is one type of flow-centered incentive spirometer.

Intervention program

Pre operative procedures

All patients who were involved in this study had been attended the preoperative meeting and they signed a consent form. All patients had been instructed and taught about the traditional post - operative physical therapy modalities including (deep breathing exercises, teach the patient right way of cough mechanism, bed mobility and ambulation exercises). The patients in the BBT group were taught about the post operative training program (Buteyko breathing technique) and the patients in IS group had received instructions for proper use of IS.

Post operative procedures

Postoperative physical therapy program started when the patient was extubated from mechanical ventilation and hemodynamically stable in the first day postoperatively and continued after discharge from the ICU for five days postoperative. The patient's incisional pain had been controlled medically by analgesics if it was intolerable before the assessment. The arterial blood gasses were evaluated before the training program.

Treatmentprograms

The patient had been asked to remember the instructions that had been informed during the pre operative meeting.

- The three groups trained on traditional post-operative physical therapy modalities including (deep breathing exercises, teach the patient right way of cough mechanism, bed mobility and ambulation exercise training).
- Control group: patients in this group underwent the traditional post-operative physical therapy only
- BBT group: In addition to the traditional post-operative physiotherapy, the patients received the designed BBT for 15 minutes, two times per day (Coopers *et al*., 2003).
- IS group: In addition to the traditional post-operative physiotherapy, the patient received IStraining for 15 minutes, two times per day (Christine *et al*., 2005).

Buteyko Breathing Technique

a. The patient was sitting upright and adapts a good posture with relaxed shoulders and rested lower back.
b. She/he didn't change breathing before taking control pause (CP). Patient was asked to take a small breath in (inspire two sec.) and a small breath out (expire three sec.) hold nose on the 'out' breath, with empty lungs but not too empty until feeling the first need to breathe in. Release nose and breathe in through it (Mckeown, 2008).

Step 2: Shallow Breathing

- To monitor the amount of air flowing through his/her nostrils, his/her finger was placing under the nose in a horizontal position.
- Then, to breathe air slightly into the tip of his/her nostrils. For example, just take enough air to fill the nostrils and no more. Breathe in a flicker of air with each breath.
- The patient was asked to exhale that to pretend that his/her finger is a feather, and to breathe out gently onto his/her finger so that the feather does not move.
- Breathe out and to concentrate on calming his/her breath to reduce the amount of warm air he/she feel on the finger.

- As the patient reduces the amount of warm air onto his/her finger, the patient will begin to feel a need or want for air. (Mckeown, 2008)

Step 3: Putting it together

- Take CP
- Reduced breathing for 3 min.
- Take CP
- Reduced breathing for 3 min.
- Take CP
- Reduced breathing for 3min.
- Take CP
- Reduced breathing for 3 min.
- Take CP
- Reduced breathing for 3 min. **(**Mckeown, 2008**)**

Incentive spirometer training

- Patient was asked to sit and relax quietly for a few min. and pay attention to their present breathing. Then he/she hold the spirometer by one hand and the tube, mouthpiece by the other hand.
- Take three to four slow, easy breaths and maximally exhale with the fourth breath.
- Then, he/she was asked to place the IS in his/her mouth and maximally inhale through the spirometer to try to raise the white piston (column) in the chamber as high as he can, then hold the inspiration for 2-3 sec. before exhaling normally. These steps were repeated for a total of four to five times, and then he /she was instructed to stop and rest for 60 sec. This sequence was repeated for 15 min. (Christine *et al*., 2005).

Statistical Analysis

Descriptive statistics was done in the form of mean and standard deviation. Inferential statistics assessed Changes in arterial blood gases including: Paired t-test was used for each variable to compare between the pre and post treatment results for each group, analysis of variance (ANOVA) was used for each variable to compare between the pre and post treatment results for the three groups together, Least significance difference (LSD) to show the statistical difference between the three groups post treatment. Statistical significance was established at the convention < 0.05 level. Analysis was done using SPSS version 18 and percentage of change was calculated according to:

$$\text{Relatives changes percentage} = \frac{\text{post}-\text{pre}}{\text{pre}}\times 100$$

RESULTS

No significant differences were recorded in all anthropometric measurements and clinical data including; age, weight, height and body mass indexat the beginning of the study (P > 0.05), as Table (1). The pretreatment results of this study showed that there were no significant differences in all measured parameters among three groups of patients in the blood gases (P > 0.05) before treatment suggesting proper sample subdivision, as Table (2). There were significant differences in all measured parameters of the blood gases for the control group in comparison of the pre and post treatment mean values (P < 0.05). The percentages of improvement were 0.14% and 3.1% increase in PH and PaO_2 respectively while 7.04%and8.95% reduction in $PaCO_2$ and HCO_3 respectively, as shown in Table (3).

Table 1. Descriptive data of the three groups

Item	Control group mean± SD	BBT group mean± SD	IS group mean± SD	F value	*p*-value
Age (yrs)	49.8± 3.61	49.87 ±3.25	49.6 ± 3.92	0.02	>0.05
Height(cm)	171.2 ± 4.06	171.27 ±3.95	171.27 ±3.95	0.00	>0.05
Weight (kg)	83.11 ± 4.38	83.13 ±4.34	83.1 ± 4.39	0.00	>.0.05
BMI (Kg/m$^{2)}$	28.26 ±0.27	28.23 ± 0.30	28.24±0.30	0.03	>0.05

BMI=Body mass index SD=Standard deviation P. value= level of significance

Table 2. ANOVA test of arterial blood gases, pre treatment, among the three groups

Item	Control group mean± SD	BBT group mean± SD	IS group mean± SD	F ratio	*p*-value
PH	7.34 ±0.03	7.35±0.02	7.34 ± 0.03	0.72	>0.05
PaO_2	72.26 ±0.02	72.25±0.02	72.25±0.02	1.52	>0.05
$PaCO_2$	43.32 ±0.14	43.3±0.08	43.31±0.13	0.11	>.0.05
HCO_3	25.81 ±0.30	25.81±0.09	25.79±0.14	0.06	>0.05

SD=Standard deviation P. value= level of significance

Table 3. Statistical analysis of arterial blood gases, pre and post treatment, for the control group

Item	Pre mean± SD	Post mean± SD	*MD*	*% of improvement*	*t*-value	*p*-value
PH	7.34 ± 0.03	7.35 ± 0.02	0.01	0.14%↑	-5.94	<0.05*
PaO_2	72.26± 0.02	74.50± 0.02	2.24	3.1%↑	-1.02	<0.05*
$PaCO_2$	43.32 ± 0.14	40.27 ± 0.09	3.05	7.04%↓	83.35	<0.05*
HCO_3	25.81 ± 0.30	23.50 ± 0.15	2.31	8.95%↓	34.26	<0.05*

SD=Standard deviation P. value= level of significance *significant at p-value < 0.05 MD= Mean difference
%=Percentage ↑=Increase ↓=Decrease

Table 4. Statistical analysis of arterial blood gases, pre and post treatment, for BBT group

Item	Pre mean± SD	Post mean± SD	*MD*	*% of improvement*	*t*-value	*p*-value
PH	7.35 ± 0.02	7.39 ± 0.01	0.04	0.54%↑	-6.25	<0.05*
PaO_2	72.25± 0.02	78.7± 2.39	6.45	8.2 %↑	-10.50	<0.05*
$PaCO_2$	43.3 ± 0.08	40.09 ± 0.15	3.21	7.41%↓	75.91	<0.05*
HCO_3	25.81 ± 0.09	23.31± 0.19	2.5	9.69%↓	38.90	<0.05*

SD=Standard deviation P. value= level of significanc *significant at p-value < 0.05 MD= Mean difference
%=Percentage ↑=Increase ↓=Decrease

Table 5. Statistical analysis of arterial blood gases, pre and post treatment, for IS group

Item	Pre mean± SD	Post mean± SD	*MD*	*% of improvement*	*t*-value	*p*-value
PH	7.34 ± 0.03	7.43 ± 0.02	0.09	1.23%↑	-8.38	<0.05*
PaO_2	72.25± 0.02	82.42± 0.02	10.17	14.1%↑	-3814.75	<0.05*
$PaCO_2$	43.31 ± 0.13	36.71 ± 0.12	6.6	15.24%↓	-186.50	<0.05*
HCO_3	25.79 ± 0.14	22.20± 0.12	2.31	13.92%↓	-80.10	<0.05*

SD=Standard deviation P. value= level of significance
*significant at p-value < 0.05
MD= Mean difference %=Percentage ↑=Increase ↓=Decrease

Table 6. ANOVA test of arterial blood gases, post treatment, among the three groups

Item	Control group mean± SD	BBT group mean± SD	IS group mean± SD	F ratio	*p*-value
PH	7.35 ± 0.02	7.39 ± 0.01	7.43 ± 0.02	58.88	<0.05*
PaO_2	74.50± 0.02	78.7± 2.39	82.42± 0.02	124.24	<0.05*
$PaCO_2$	40.27 ± 0.09	40.09 ± 0.15	36.71 ± 0.12	3928.43	<.0.05*
HCO_3	23.50 ± 0.15	23.31± 0.19	22.20± 0.12	300.93	<0.05*

SD=Standard deviation
P. value= level of significance*significant at p-value < 0.05

There were significant differences in all measured parameters of the blood gases for BBT group in comparison of the pre and post treatment mean values (P < 0.05). The percentages of improvement were 0.54% and 8.2% increase in PH and PaO_2 respectively while 7.41% and 9.69% reductionin $PaCO_2$andHCO_3respectively, as Table (4). There were significant differences in all measured parameters of the blood gases for IS group in comparison of the pre and post treatment mean values (P < 0.05). The percentages of improvement were 1.23% and 14.1% increase in PH and PaO_2 respectively while 15.24%and 13.92% reduction in $PaCO_2$andHCO_3respectively, as Table (5). There were significant differences in post treatment mean values of all measured values between three groups in favor of IS group, as Table (6) and Figures from (1-4).

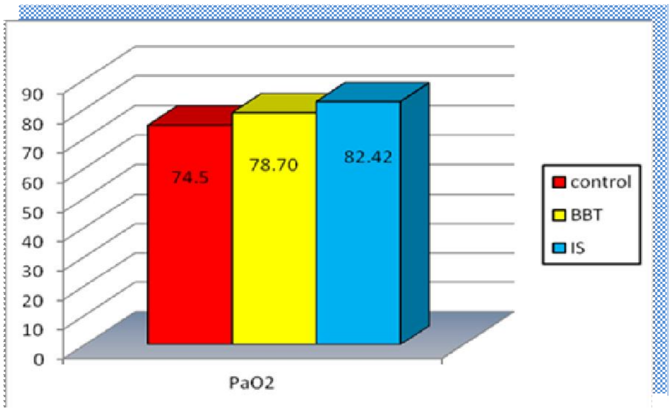

Fig. 2. Mean values ofPaO$_2$, post treatment, among the three groups

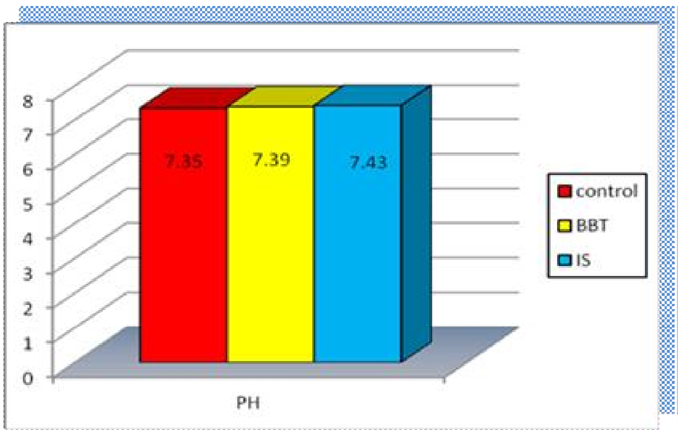

Fig. 1. Mean values of PH, post treatment, among the three groups

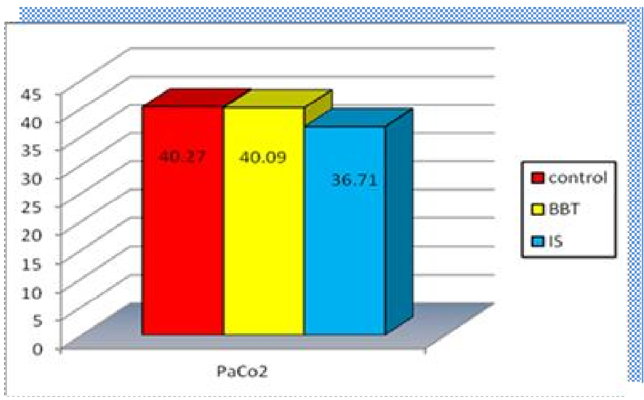

Fig. 3. Mean values ofPaCO$_2$, post treatment, among the three groups

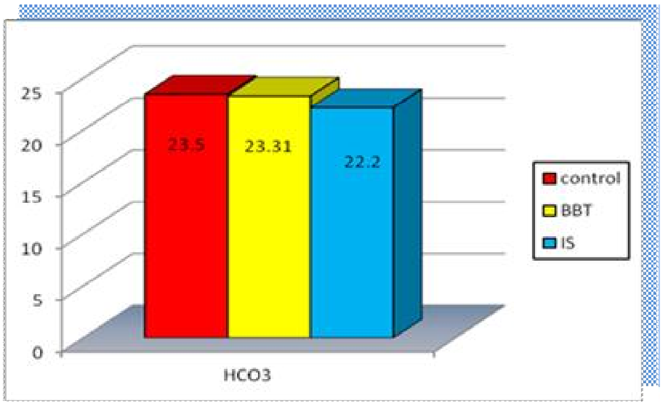

Fig. 4. Mean values ofHCO_3, post treatment, among the three groups

DISCUSSION

Coronary artery bypass graft surgery is performed daily on a worldwide basis in patients with coronary artery disease. Despite advances in anesthesia protocols, (Myles and Mcilroy, 2005) cardiopulmonary bypass techniques (Staton *et al*., 2005) and preand postoperative care (goksin *et al*., 2006), CABG is still associated with thef requent development of PPC (Ng *et al*., 2002). The incidence of postoperative pulmonary complications (PPC) will most likely continue to remain problem aticsecondary to CABG procedures being more frequently performed in patientswith multiple comorbidities (Scott *et al*., 2005). In addition, preoperative factors such as the reduction in functional residualcapacity, (Ferguson, 1999) pulmonary gas exchange, (Groeneveld *et al*., 2007) and cough strength as well as the increase in pleural effusion, pain with breathing, and retention of secretions all contribute to increased PPC risk (Wynne and Botti, 2004). Respiratory physiotherapy has been proposed to improve lung function and prevent or treat pulmonary complications in the postoperative period of CABG. Incentive spirometry (IS) is currently used with the intention to PPC prevention. To the best of our knowledge, this is the first clinical trial assessing the efficiency of BBT post CABG. This study aimed also to compare between the effect of BBT and the spirometric training on arterial blood gases after CABG. The main results of the present study is the demonstration that the use of IS and BBT are effective in improving arterial blood gases but IS is superior to BBT at inpatient period after CABG.

The change in all measured variables in post-treatment results of the control group comes in agreement with (lamari *et al*., 2006) who reported that conventional chest physiotherapy was effective in bronchial hygiene due to the increased velocity of mucous transportation, the gas exchange and improvement in the pulmonary function. The current study reflected that improvement of the ABGs in BBT group which was better than conventional physiotherapy intervention only could be explained by several possible neurological, biochemicals, and biomechanical pathways that may also explain the Buteyko effect. One possible biochemical mechanism of Buteyko may be through its influence on NO. Nitric oxide is involved in a large number of physiological responses including bronchodilation, vasodilatation, tissue permeability, immune response, oxygen transport, neurotransmission, insulin response, memory, mood, and learning. Buteyko practitioners' insistence on nasal breathing at all times is likely to affect NO levels, as a large percentage of the body's NO levels are made in the paranasal sinuses (Lundberg and Weitzbergb, 1999). The work of breathing is most efficient when coordinated contribution from the diaphragm, abdominal muscles, and rib cage muscles results in balanced motion between the upper rib cage and the lower rib cage and abdomen. Unevenness of motion of the chest wall where the upper rib cage movement dominates and lower rib cage expansion is impaired can indicate biomechanically induced dysfunctional breathing that result in hyperinflation and contributes to breathing symptoms such as Dyspnea. People practicing the Buteyko Method are taught to reduce their volume of breathing by using a combination of increased abdominal muscle tone and relaxation of all the other muscles of breathing, particularly the shoulders and chest (O'donnell, 2006). It was proposed that altered breathing pattern could contribute to breathing symptoms such as dyspnea and that breathing therapies such as BBT might influence symptoms by improving the efficiency of the biomechanics of breathing (Courtney and Cohen, 2008).

The significant improvement in all measured variables in IS group could be explained byrespiratory muscle training which enhances lung expansion and inspiratory muscle strength; increases production of surfactant which leads to reducing surface tension, increasing lung compliance, decreasing the work of breathing and better aeration of the alveoli. The improvement of total lung and thoracic compliance may be contributed to increase PaO2 and SaO2 (Abd el-kader and Abdullah, 2010). Incentive spirometer allows slow maximal inspiratory (SMI). During inspiration, there is the elevation of balls, which encourages the patient, through a visual feedback, to perform slow and deep inspirations. This pattern determines the increase of inspiratory volumes, increase of transpulmonary pressure, improvement of the performance of inspiratory muscles, thus reestablishing the pattern of pulmonary expansion (Ferreira *et al*., 2010). There was significant difference between the effect of IS and BBT, in favor of IS. Incentive spirometer provides deep breathing exercises. (Westerdahl *et al*., 2003) mentioned that a mechanical device could help patients to remember to carry out the respiratory exercises, and that patients find these devices both useful and motivating. As previously mentioned, in our case the patients used a flow-based IS and carried out 30 SMI maneuvers, as well as a daily deep breathing exercises. They found immediate effects of deep breathing performed on the second post-operative day after cardiac surgery, and concluded that there was a significant decrease of the atelectic area, increase in aerated lung area and a small increase in PO2 after performance of 30 deep breathing.

The results are supported by (Roy, 2013), who conducted a study to compare between the effect of deep breathing technique and BBT in patients with upper abdominal surgeries. She concluded that the patients in deep breathing technique (DBT) group showed more improvement after a single session of treatment. The chances of PPCs were reduced. As a result, the patient who underwent the intervention involving DBT demonstrates a better result than the group of patients who received BBT.

Conclusion and Recommendations

The results obtained in the present study revealed that, BBT and IS in addition to routine post-operative physiotherapy program in the form of deep breathing, bed mobility, coughing and early ambulation induce significant improvement in arterial blood gases (PaO_2, $PaCO_2$, PH and HCO_3) of patients after CABG. Also, there was super effect of IS in comparison with the effect of BBT. A limitation of the present study was short duration which showed incomplete effect of the intervention.

It is recommended to add Buteyko breathing technique to the rehabilitation program for patients underwent CABG surgery. More researches are needed to study the effect of BBT on CABG at home and to show its effect on other heart surgeries. Further studies are needed to compare between the effect of BBT and PEEP device after CABG surgery. In future, a large study with a follow-up should be conducted to determine the long term effect of the treatment.

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