

Blood Gases Response to Different Breathing Modalities in Phase I of Cardiac Rehabilitation Program after Coronary Artery Bypass Graft

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ABSTRACT

Aim: One major cause of postoperative respiratory complications is pulmonary atelectasis. Atelectasis and the associated loss of functional alveolar units has been recognized as a major pathophysiological mechanism responsible for postoperative hypoxemia after coronary artery bypass graft (CABG). The aim of this study was to determine which therapeutic breathing method from incentive spirometry (IS), non-invasive intermittent positive pressure breathing (IPPB) and continuous positive airway pressure breathing (CPAP) in addition to postoperative pulmonary physiotherapy obtain the best improvement in blood gases in phase I of cardiac rehabilitation program after CABG.

Method: Thirty six patients of both sexes who underwent CABG divided into three groups. Group (A) received breathing training with IS (5 minutes 5 times per day) in addition the chest physiotherapy program for patients after CABG and Group (B) received breathing training with CPAP (10 cmH₂O for 15 minutes once daily) in addition to the chest physiotherapy program for patients after CABG., where Group(C) received breathing training with IPPB (maximum 15 cmH₂O for 15 minutes once daily) in addition to the chest physiotherapy program for patients after CABG. Measurements of blood gases were done before the study in the first post operative day and repeated at the end of the study in the tenth postoperative day.

Result: Blood gases were improved in all groups in addition to a significant difference between IS & CPAP and IS & IPPB groups. Where there was no significant difference between CPAP & IPPB groups.

Conclusion: Incentive spirometry in addition to the usual respiratory physical therapy is recommended for patients in phase I of cardiac rehabilitation program after CABG.

Key words: Blood Gases, CPAP, incentive spirometry, NIPP, coronary artery bypass graft

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Koroner Arter Bypass Grafti Sonrası Kardiyak Rehabilitasyon Programının Faz I'inde Değişik Solunum Yöntemlerine Kan Gazı Cevabı

Amaç: Postoperatif solunumsal komplikasyonların önemli bir nedeni pulmoner atelektazidir. Atelektazi ve fonksiyonel alveolar birimin eşlik eden kaybı koroner arter bypass grefti (KABG) sonrası postoperatif hipoksemiden sorumlu önemli bir patofizyolojik mekanizma olarak kabul edilmiştir. Bu çalışmanın amacı postoperatif pulmoner fizyoterapiye ek olarak CPAP, IS ve IPPB terapötik solunum yöntemlerinden hangisinden KABG sonrası kardiyak rehabilitasyon programının faz I'indeki kan gazında en iyi düzelmeyi sağladığını tespit etmektir.

Metod: Her iki cinsiyetten KABG cerrahisi yapılan 36 hasta üç gruba bölündü. Grup (A)'ya CABG sonrası hastalar için göğüs fizyoterapi programına ek olarak IS ile solunum egzersizi (günde 5 kez 5 dakika) uygulandı. Grup (B)'ye CABG sonrası hastalar için göğüs fizyoterapi programına ek olarak CPAP ile solunum egzersizi (günde 1 kez 10 cm H₂O, 15 dakika), ve Grup (C)'ye CABG sonrası hastalar için göğüs fizyoterapi programına ek olarak IPPB ile solunum egzersizi (günde 1 kez maksimum 15 cm H₂O, 15 dakika) uygulandı. Kan gazı ölçümleri ilk post op günde çalışma öncesi yapıldı ve çalışma sonunda 10. Post op günde tekrarlandı.

Bulgular: Kan gazları bütün gruplarda IS ve CPAP, ve IS ve IPPB grupları arasında anlamlı olmak üzere düzeldi. Ancak CPAP ve IPPB grupları arasında belirgin fark saptanmadı.

Sonuç: KABG sonrası kardiyak rehabilitasyon programının faz I'indeki hastalar için genel solunumsal fizik tedaviye ek olarak insentif spirometre de önerilir.

Anahtar kelimeler: Kan gazları, insentif spirometre, NIPP, koroner arter bypas grefti

INTRODUCTION

Coronary artery bypass graft (CABG) surgery is performed daily on a worldwide basis in patients with coronary artery disease. Despite advances in anesthesia protocols, cardiopulmonary bypass techniques and pre and postoperative care, CABG is still associated with the frequent development of postoperative pulmonary complications (PPC) (1). Cardiac rehabilitation promotes the enhancement and maintenance of cardiovascular health through individualized programs designed to optimize physical, psychological, social, vocational, and emotional status of the patients as despite improvements in pharmacologic therapy and surgical interventions for the treatment of coronary artery disease (CAD), this chronic illness continues to be associated with significant mortality and morbidity. Thus, comprehensive management strategies are essential to optimize patient outcomes and decrease the disease burden associated with CAD (2). Respiratory physiotherapy after cardiothoracic surgery aims to reverse atelectasis and secretion retention, and may include deep breathing exercises, positioning, airway clearance techniques and mobilization. Intermittent, deep, prolonged inspiratory efforts are thought to re-inflate collapsed alveoli, increase pulmonary compliance and reduce regional ventilation-perfusion inequalities (3).

Incentive spirometry (IS) is currently used in the postoperative period of CABG to prevent postoperative pulmonary complications. It involves deep breathing through a device with visual feedback, can be used independently by patients and motivation. It provides low level resistive

training while minimizing the potential of fatigue to the diaphragm which is useful for patients who are resistant or unable to co-operate fully with maximal inspiratory efforts. (1,3-5). Non-invasive intermittent positive pressure breathing (IPPB) is a simple, portable, non invasive form of ventilatory support. It increases ventilation, improves the arterial blood gases and decreases the work of the respiratory muscles (6,7).

In early postoperative period continuous positive airway pressure (CPAP) is a common therapy to support pulmonary function. It increases vital capacity, reduces respiratory rate and improves arterial saturation and a decrease in work of breathing. CPAP can be recommended as a useful tool to prevent postoperative pulmonary complications in patients recovering from cardiac surgery as only 1.3% of patients (3 of 236 patients) from the study group, compared with 2.5% of patients (6 of 236 patients) from the control group were reintubated (8). Different breathing modalities and respiratory physical therapy has been proposed to improve blood gases, lung function and prevent or treat pulmonary complications after CABG. However, 2 systematic reviews concluded there is no conclusive evidence indicating that patients undergoing CABG benefit from respiratory physiotherapy (9) or incentive spirometry (10), CPAP (11) and IPPB (12) However, the past investigations in this area were typically performed in small cohorts and possessed methodological limitations such as poor control of confounding factors. In addition, most of these studies included patients at low risk for postoperative complications and did not perform

Table 1. Mean value of demographic data for participants in the three groups.

Group	Age years	Weight kg	Height cm	BMI kg/m ²
IS group	48.73±6.87	72.57±9.42	169.23±7.01	25.34±2.87
CPAP group	47.40±6.05	74.93±8.69	167.88±7.01	26.58±2.97
IPPB group	49.63±7.13	75.33±9.03	170.40±5.23	25.94±3.34

IS: Incentive spirometer, CPAP = continuous positive airway pressure, IPPB = Intermittent positive pressure breathing

adequate follow-up. Several recent, well-controlled, studies have demonstrated beneficial effects of different breathing modalities in patients after CABG (5-8). As a result of the lack of consistent positive evidence, different breathing modalities for patients undergoing CABG remains controversial. Clearly more work is needed in this area of research. To our knowledge, there are no published studies compare between IS, CPAP and IPPB despite of the extensive use of them in daily practice of them the three commonly related to use in the phase I of cardiac rehabilitation program after CABG.

Therefore, this prospective, randomized clinical trial using incentive spirometry (IS), non-invasive intermittent positive pressure breathing (IPPB) and continuous positive airway pressure breathing (CPAP) in addition to post-operative pulmonary physiotherapy was applied to detect which breathing modalities can obtain the best improvement in blood gases in phase I of cardiac rehabilitation program after CABG.

MATERIALS AND METHODS

Subjects

Thirty six consecutive patients of both sexes underwent elective coronary artery bypass graft surgery, their age ranged from 40-55 years. Participants were included into 3 equal groups; group (A) received breathing ex-

ercise training with IS in addition to the usual physical therapy program for patients after CABG up to the tenth post operative day. Group (B) received breathing exercise training with CPAP through face mask in addition to the usual physical therapy program for patients after CABG up to the tenth post operative day. Group (3) received IPPB in addition to the usual physical therapy program for patients in phase I of cardiac rehabilitation program after CABG up to the tenth post operative day. All patients electively scheduled for coronary bypass surgery were eligible to participate in the study, those who were spontaneously breathing non-intubated patients and extubated immediately following skin closure (i.e. in the operating room). Written informed consent was obtained from the patients before surgery. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki. All participants were free to withdraw from the study at any time. If any adverse effects had occurred, the experiment would have been stopped. However, no adverse effects occurred, and so the data of all the participants were available for analysis.

Evaluated parameters

Arterial blood gases

Blood gases analysis included PaO₂, PaCO₂ and pH were measured using Acid-Base Analyzer (ABL 3075R24 NB by radiometer A/S Copenhagen). Normal values of arterial

Table 2. Mean value of blood gases of the three groups before treatment.

Group	pH	PaO ₂ mmHg	PaCO ₂ mmHg
IS	7.33±0.03	63.25±2.3	43.66±3.4
CPAP	7.34±0.05	64.08±1.9	43.25±2.2
IPPB	7.33±0.04	63.33±2.3	42.75±2.2

IS: Incentive spirometer, CPAP = continuous positive airway pressure, IPPB = Intermittent positive pressure breathing

Table 3. Mean value of blood gases of the three groups after treatment.

Group	pH	PaO ₂ mmHg	PaCO ₂ mmHg
IS	7.41±0.01	82.91±2.3	39.16±2.3
CPAP	7.37±0.02	71.66±4.0	40.25±1.3
IPPB	7.36±0.02	74.50±4.8	34.75±1.6

IS: Incentive spirometer, CPAP = continuous positive airway pressure, IPPB = Intermittent positive pressure breathing

Table 4. Least significance difference of pH, PaO₂ and PaCO₂ in the 10th postoperative day in the three groups.

	pH t- value	PaCO ₂ t- value	PaO ₂ t- value
IS-IPPB	0.051 [‡]	6.09 [‡]	11.834 [‡]
IS-CPAP	0.044 [‡]	5.58 [‡]	8.084 [‡]
IPPB-CPAP	0.007 [†]	1.5 [†]	3.75 [†]

IS-IPPB : Incentive spirometer versus intermittent positive pressure breathing
 IS-CPAP : Incentive spirometer versus continuous positive airway pressure
 IPPB-CPAP: Intermittent positive pressure breathing versus continuous positive airway pressure
[‡] p<0.05, [†] p>0.05

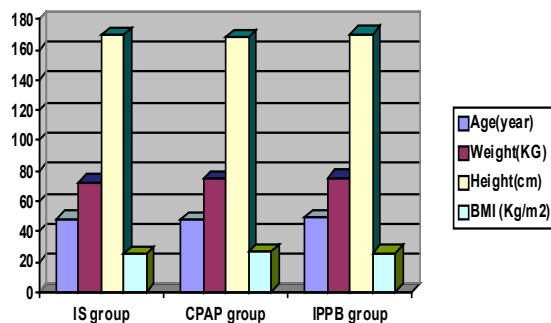


Figure 1. Mean value of demographic data for patients in the three groups

blood gases are pH (7.35-7.45), PaO₂ (80-100mmHg) and PaCO₂ (35-45mmHg) (13).

Routine chest physiotherapy program for patients after CABG

Patients of the three groups received the routine chest physiotherapy program for patients in phase I of cardiac rehabilitation program after CABG which was started on the morning of the first post operative day, a physiotherapist supervised and assisted the treatment twice a day in the first two post operative days and once a day from the third to the tenth days .During any session ,the patients performed three to five deep breaths interspersed with periods of quiet breathing followed by two or three coughs or huffs (with wound support by a pillow or his/her hands).This maneuver was carried out at least 10 times over a 15 minutes period. Additional techniques such as positioning and chest wall percussion were applied if breathing and coughing exercises alone were not effective in clearing excessive or retained pulmonary secretions. Patients were instructed to perform breathing and coughing exercise independently every hour (3).

Breathing exercise with incentive spirometry

Patients of group (A) received breathing exercise training with IS (Voldyne Volumetric manufactured by Sherwood Medical Company U.S.A.) in addition to the routine chest physiotherapy program for patients after CABG up to the tenth post operative day .Application of breathing training with incentive spirometer was applied for five minutes, five times a day (4,5).

Breathing exercise with continuous positive pressure breathing

Patients of group (B) received breathing exercise training with CPAP (RTX modes 10 Downage, respicare dragger, London) through face mask, from long sitting position with supported back. The application time was 15 minutes, and the pressure of CPAP was 10 cmH₂O every day in addition to the usual physical therapy program for patients in phase I of cardiac rehabilitation program after CABG up to the tenth post operative day (14).

Breathing exercise with intermittent positive pressure breathing

Patients of group (C) received breathing exercise training with IPPB (RTX modes 10 Downage, respicare dragger, London) and the routine physical therapy program for patients after CABG up to the tenth post operative day .The time of application of IPPB was 15 minutes/day, the percentage of inspiratory phase was 20% and the peak inspiratory airway pressure was 15 cmH₂O (15).

Statistical analysis

The mean values of PaO₂, PaCO₂ and pH were obtained before the study in the first postoperative day and at the end of the study in the tenth postoperative day for the three groups an analysis of variance was performed followed by post hoc testing with the least significance test in case of significant differences between the three groups (p<0.05).

RESULTS

The three groups were considered homogeneous regarding the demographic variables (Table 1, Figure1). Concerning the comparison between values of pH, PaO₂ and PaCO₂ before treatment for the three groups, there was no significant difference ($p > 0.05$) (Table 2). Concerning the comparison between the 10th postoperative day values of arterial blood gases for pH, PaO₂ and PaCO₂ in the three groups there was a significant improvement ($p < 0.000$, $p < 0.000$, $p < 0.000$) (Table 3). Where, the post hoc testing with the least significance test of pH, PaO₂ and PaCO₂ in the 10th postoperative day between IS group and non invasive IPPB group and between IS group and CPAP group was significant, but between non invasive IPPB and CPAP group wasn't significant (Table 4).

DISCUSSION

After coronary revascularization different breathing modalities along with chest physiotherapy improves short and long term prognosis and allows blood gases to be returned to the preoperative levels. This study was performed to determine the difference between the effect of IS, CPAP and Non-invasive IPPB on blood gases after CABG. The results obtained in the present study indicated that, there was a significant difference in blood gases (PaO₂, PaCO₂ and pH) after the use of IS, non-invasive IPPB and CPAP. There was a significant difference between IS & CPAP and IS & IPPB. Where there was no significant difference between group CPAP & IPPB. This means that the effect of IS was greater than CPAP & Non-invasive IPPB upon blood gases in phase I of cardiac rehabilitation program after CABG.

From our point of view, the improvement of blood gases after non-invasive IPPB and CPAP of treatment can be explained as a result of improvement of oxygenation, ventilation-perfusion ratio, coughing, functional residual capacity and lung compliance. While after incentive spirometry, the improvement was due to biofeedback, motivation and encouraging breathing to total lung capacity as much as the patient can, which prevent atelectasis and reduce post operative hypoxemia.

Incentive spirometry encourages patient's breath to total lung capacity and sustain that maximum inflation which opens the collapsed alveoli, to prevent atelectasis. Also postoperative hypoxemia may be reduced with

this technique (16). Physiological evidence suggests that incentive spirometry may be appropriate for lung re-expansion following major thoracic surgery. Based on sparse literature, postoperative physiotherapy regimes with, or without, the use of incentive spirometry appear to be effective following thoracic surgery compared with no physiotherapy input (17).

Non -invasive IPPB as a form of ventilatory support can increase ventilation, improve the arterial blood gases, re-expand collapsed alveoli and decrease the work of breathing (6 and 18). On the other hand a previous study applied on 17 patients admitted to the hospital to undergo elective upper abdominal surgery was randomly assigned to one of the two treatment groups: intermittent positive pressure breathing or physiotherapy. Prospective evaluation included clinical examination, whole body plethysmography and determination of arterial blood gases preoperatively and on the 3rd postoperative day. Neither of the two therapeutic modalities is more effective than the other in preventing postoperative pulmonary complications. Considering the potential hazards, chest physical therapy is clearly the preferred treatment (19).

However, fifty-two CABG patients were randomized to receive IS or IPPB in addition to conventional chest physical therapy. Slow vital capacity and peak expiratory flow readings decreased rapidly and to an equal extent in both groups after surgery, and partly recovered by the sixth postoperative day (POP). Values of PaO₂ values were similar for the groups on the first three POPs. On the POPs 2, 3, and 6, the number of chest films showing atelectases as well as the number of individual patients having atelectases revealed no statistically significant differences between the two groups. Based on the three variables studied, both devices are equal in efficiency after CABG (20). Also; forty patients after myocardial revascularization surgery were divided in two groups: one was submitted to IPPB and the other to IS. In the group submitted to IPPB, an increase in SpO₂ was observed 48 and 72 hours after surgery, when compared to the IS group. The group submitted to IS showed a significant increase in the expiratory mouth pressure 24 and 48 hours after surgery. These results indicated that for reversing hypoxemia earlier, IPPB showed to be more efficient in reversing hypoxemia when compared to IS; however, IS was more effective in improving respiratory muscle strength (21).

Values of PaO₂, PaCO₂ and SaO₂ were within normal limits and no significant differences were found between the intermittent and continuous positive airway pressure in postoperative patients undergoing CABG. Dyspnea and use of accessory muscle in postoperative assessments were found with a significantly higher frequency in patients undergoing CPAP (11). In the other hand Masouyé et al. Indicated that CPAP can safely be applied after elective cardiac surgery in patients with or without severe coronary artery disease and preoperative left ventricular ejection fractions above 40%. Furthermore, the concomitant postoperative intravenous infusion of nitroglycerin (to all 10 patients of the CABG group and to 4 patients of the AVR group) counteracted the expected beneficial effect of CPAP therapy on arterial oxygenation (22) moreover continuous positive air way pressure can restore functional residual capacity, reduce the work of breathing and unload respiratory muscles(23).

However as a contradict of the previous studies , a study on two groups of 14 patients were compared after coronary artery bypass surgery; one group received nasal continuous positive airway pressure for 1 h, the other group acted as a control. There was a significant reduction in respiratory rate from 18.3 to 16.7 breath/minute during continuous positive airway pressure. Other measured cardiorespiratory variables did not differ significantly between the groups. Visual analogue scores showed no significant difference in chest pain or mask comfort between the groups (24). Also, A randomized, prospective, controlled trial on 120 male patients underwent elective CABG, were randomly assigned to equal groups either 10 cm H₂O of CPAP , or serve as control , where the patient's lungs were vented to atmosphere during the bypass period. No differences between groups with respect to hemodynamic variables were observed at any time. So application of 10 cm H₂O CPAP does not improve lung function after cardiac surgery (25) or postoperative pulmonary gas exchange after CABG (26).

After a controlled trial of using non-invasive IPPB, incentive spirometry and deep breathing exercises aiming to prevent pulmonary complications after upper abdominal surgery, hospital stay was significantly shorter in patients received incentive spirometry than the other groups (27). During application of non invasive IPPB, the patient appeared to rely on the machine to perform the deep breathing and hence, was reluctant to actively use the respiratory muscles (17). This may explain the

lower improvement in blood gases measures in IPPB group and in CPAP group than in IS group at this study. However, the use of the incentive spirometry (IS) with expiratory positive airway pressure (EPAP) results in improved pulmonary function and 6-minute walk distance as well as a reduction in postoperative pulmonary complications (PPC) after CABG (1).

As a contradict for results of our results , a previous study was applied in order to establish the current usage of incentive spirometers (IS) for post-operative patients undergoing coronary artery bypass graft surgery a questionnaire was sent during 1997 to all physiotherapists then working in cardiac surgery centers . An 85% response rate was attained. Thirty of the 42 centers reported using IS which indicated that there was a considerable number of physical therapists that didn't support the use of IS and from this survey it is not known whether physiotherapists are aware of the evidence and choose to ignore it or are not aware of previous findings related to the benefits of IS (28).

The results from this study indicated that incentive spirometry added to the conventional physical therapy improves blood gases for patients in phase I of cardiac rehabilitation program after CABG.

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