Effect of Two Deep Breathing Techniques on Arterial Blood Gases in Smoker and Non Smoker Patients after CABG

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ABSTRACT

Ninety male patients with age ranged from 51.5 to 53.7 years who had been operated upon for elective coronary artery bypass surgery (CABG). In intensive care unit postoperatively, they were randomly assigned into six groups according to history of smoking and applied modality (DB, IS, or both). The blood samples were withdrawn before and immediately after application, also after half an hour and two hours after completion of treatment. The results of the current study, revealed that both modalities resulted in improving arterial oxygenation with superiority of IS than DB or both. Where the non- smoker patients showed greater improvement than smokers.

Key words: *Postoperative pulmonary complications (PPCs), coronary artery bypass graft (CABG), incentive spirometry (IS), diaphragmatic breathing (DB), blood gases (PaO_2, $PaCO_2$, HCO_3 and pH).*

INTRODUCTION

It has been well established that pulmonary function decreases following open heart surgery. General anesthesia has been shown to reduce functional capacity by approximately 20%. Cardiopulmonary bypass impairs gas exchange, has a higher risk of pleural effusion and subsequent pulmonary problems[14].

The incidence of atelectasis increases with each of general anesthesia, cardiopulmonary bypass and cardiac surgery. Atelectasis itself can result in a decrease in FRC, vital capacity, and lung compliance. As a result, patients undergoing cardiac surgery are at risk of developing postoperative pulmonary complications which aggravated by the history of smoking[4].

The prevention of post operative pulmonary complications is a primary aim of physiotherapy in the early management of patients following coronary artery surgery. The physiotherapy management of these patients involves the implementation of a wide variety of techniques aimed at minimizing pathophysiological abnormalities affecting the pulmonary, cardiovascular, and musculoskeletal systems[16]. In other words, the goals of physiotherapy are to optimize oxygen transport, improve ventilation- perfusion matching, increase lung volumes, reduce work of breathing and enhance mucociliary clearance[13].

Many investigators had suggested that refractory postoperative atelectasis may best be prevented or treated by spontaneous deep breathing to improve inspiratory capacity and lung compliance with an hourly routine of at least five sequential deep breaths, each hold for five to six seconds.

Diaphragmatic breathing was described as a facilitating outward motion of the abdominal wall while reducing upper rib cage motion during inspiration[8]. Accordingly, individual skill in performing DB is assessed by observation or measurement of abdominal excursion during the respiratory cycle. Patients can be taught to perform the maneuver while maintaining abdominal muscle relaxation, a technique that ensures that inspiration begins from functional residual capacity. Alternatively, abdominal muscle contraction during expiration may has been encouraged. Theoretically, expiratory muscle activation lengthens the diaphragm and increases its force-generating capacity, the use of additional muscles during active expiration, however, may increase the energy cost of breathing[5].

Incentive spirometry (I.S) also called sustained maximum inspiration, is simply a visual and/or audio feedback device that encourages slow, deep inspiration i.e. the visual input of balls rising in chambers, colored lights, sounds, or dials reflect the degree of inspiratory effort. It provides low-level resistive training while minimizing the potential of fatigue to the diaphragm. Generally this treatment is performed frequently 10 times/hour, and its purpose is to treat and prevent atelectasis, especially in postoperative thoracic and abdominal patients[1].

The purpose of this study was conducted to investigate the efficacy of IS, DB and both on arterial blood gases for smoker and non smoker patients and which is the most effective physical therapy modality after CABG for the prevention of PPCs.

SUBJECTS, MATERIAL AND METHODS

Subjects

Ninety male patients who had been operated upon for elective coronary artery bypass surgery were participated in this study. They were selected from the intensive care unit, surgical department at National Heart Institute. Their ages ranged from 45 to 60 years with mean age (51.5 ± to 53.7 years). No patients had previous complications which might restrict their activity and interfere with the data of the results. All patients had left internal mammary artery graft (LIMA) in addition to radial graft in 25 patients and 20 patients had LIMA, radial and saphenous vein grafts. Patients were randomly assigned into six groups equal in number, according to their history of smoking (current smoker or quiet smoking since six months) and to the treatment modality they received (I.S, DB, or both) .All patients had been undergone median sternotomy and on pump procedure. Post operative prolonged ventilation (more than 24 hours), patients who had developed haemodynamic complications (e.g perioperative myocardial infarction, lung congestion, or need intra aortic balloon), arrhythmias need pacemaker or postoperative renal failure were excluded.

Procedure

Pre-operatively, the therapist instructed and assisted each patient to be acquainted with the therapeutic procedures (incentive spirometry and diaphragmatic breathing). This in order to determine the maximum inspiratory volume with incentive spirometry which used postoperatively to gain high level of co-operation. The study was started when the patient extubated from mechanical ventilation and had stable hemodynamic state in the intensive care unit (ICU) two hours after removal of the drainage tube.

The patients were in long sitting position with back supported during IS training with a volumetric DHD type. The patients were instructed to take slow maximal inspiration and to hold each breath for as long as possible. The inspired volume equal at least to 70% of pre-operative determined value. This maneuver was done at least 10 times throughout 15 minutes. During treatment, the patient was connected to oxygen supply via nasal cannula.

Diaphragmatic breathing occurs when there is a conscious appreciation of inspiring air to the lung basis with slight forward abdominal displacement. In semi- recumbent (semi-fowler) position, the patients were instructed to breath in slowly through nose and aimed at getting the air to the lower part of the lungs, remember to relax your tummy and allow the air to go under here (the investigator put his hand on the subject's subcostal region, then relax and let the air out through mouth allowing your tummy to sink gently. These procedures were done at least 3-5 times at once then repeated 10 times, where the patients took tidal breath between those bouts.

The arterial blood samples were drawn (before, immediately, half hour, and two hours) after the cessation of applied techniques (I.S, DB, and both of them). The blood samples were analyzed using acid –base analyzer for arterial oxygen, carbon dioxide pressure (PaO_2 and $PaCO_2$ respectively). Also, acid-base balance (PH) and bicarbonate were measured.

Statistical analysis

The mean, standard deviation, the median and the percentage which will be applied for all data as age, height… etc. Paired- t-test which was applied for each group to compare pre and post readings in the same group.

RESULTS

Fig. (1) smoker incentive spirometry (group1)

The mean value of PaO_2 before incentive spirometry training was 95.22±10.99 and showed significant increase immediately after 98.95±11.53 (3.91%), half an hour 103.21±12.17 (8.39%) and after two hours 107.07±12.68 (12.44%). On the other hand, the $PaCO_2$ was 37.41±1.74 before training and significantly decreased at the three time intervals 36.74±1.54, 36.29±1.58, 35.92±1.46 (-1.79%, -2.99%, -3.98% respectively). There was non statistical significant difference of mean value of H_2CO_3 immediately after (24.51±3.11, 23.95± 2.50 after half an hour and after two hours 24.48±2.38) from 24.29±2.29. There was non significant difference of pH value immediately after 7.41±3.03, after half an hour 7.44±2.90, but there was a statistical significant difference of pH after two hours 7.46±2.43 (1.08%) as compared with pre training values 7.38±3.09.

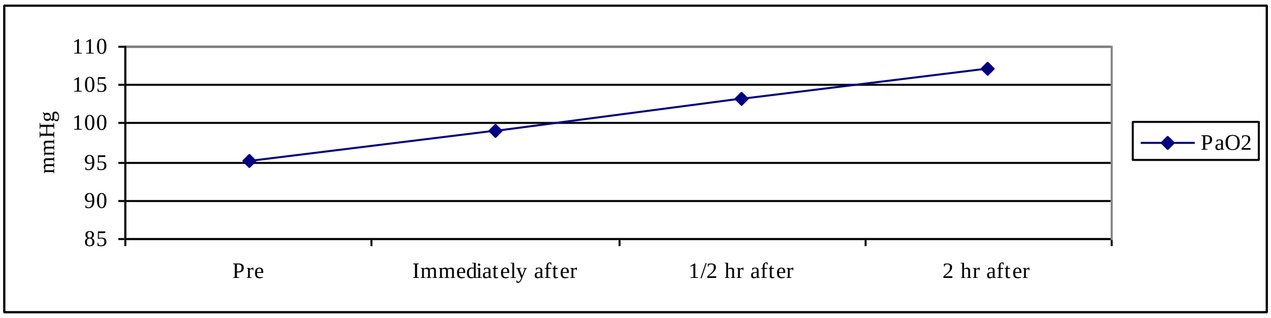

Fig. (1a): Mean value of PaO_2 (mmHg) at different time intervals.

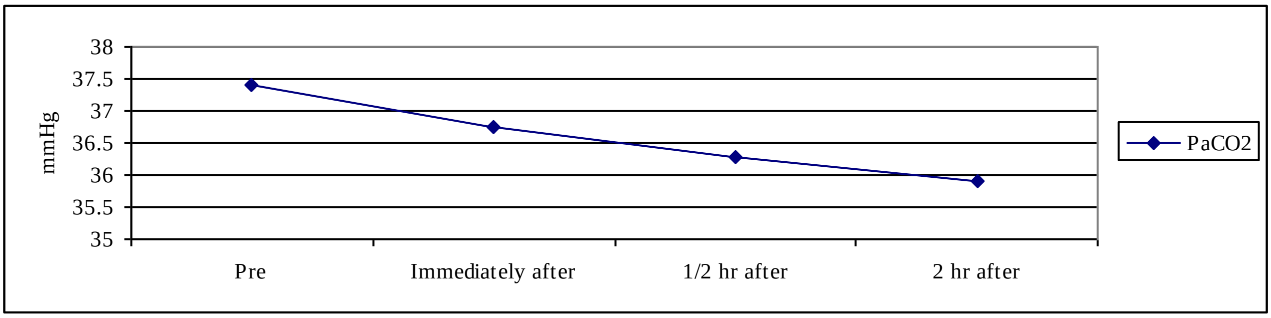

Fig. (1b): Mean value of $PaCO_2$ (mmHg) at different time intervals.

Fig. (1c): Mean value of H_2CO_3 (m Eq/L) among the different time intervals.

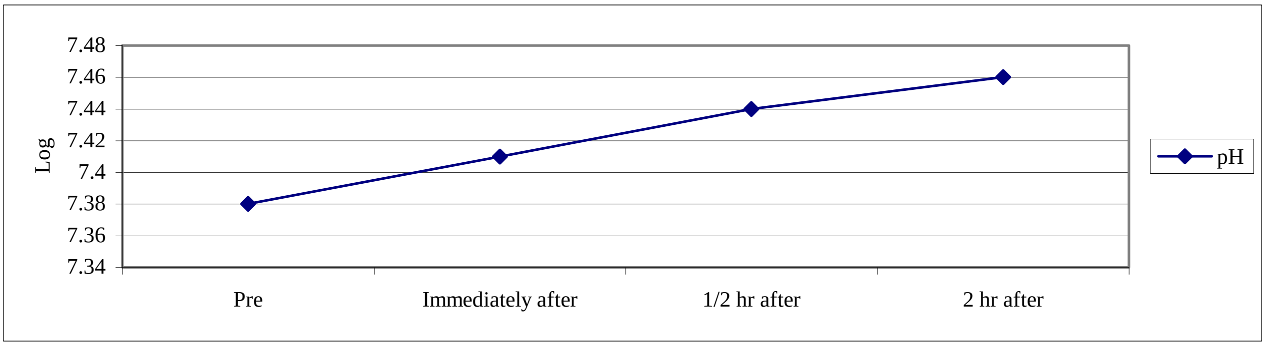

Fig. (1d): Represent the mean value of pH (Log) plotted against the different time intervals.

Fig. (2) smoker diaphragmatic breathing (group 2)

There was a non significant increase of PaO_2 immediately after diaphragmatic breathing 92.96±5.05 (1.39%) but increased significantly after half an hour 94.71±3.87 (3.3%) and two hours 96.57±3.59 (5.33%) as compared to the pre training value 91.68±5.22. The mean value of $PaCO_2$ before training was 36.86±2.70 and decreased non significantly immediately after 36.55±2.45 (0.84 %) and half an hour 36.71±2.75 (0.41%) but significantly deceased after two hours 35.99±2.56 (2.36%) of training as compared with before. There was a non significant increase of H_2CO_3 immediately after 26.87±1.64, half an hour 26.99±2.29 but significantly increase after two hours 27.28±2.09 (3.22%) as compared with before 26.43±1.32. The mean value of pH was non significantly increase immediately after from 7.4±4.05 to 7.41±3.31, two hours 7.45±3.02 but increased significantly after half an hour 7.43±2.77 (0.41%).

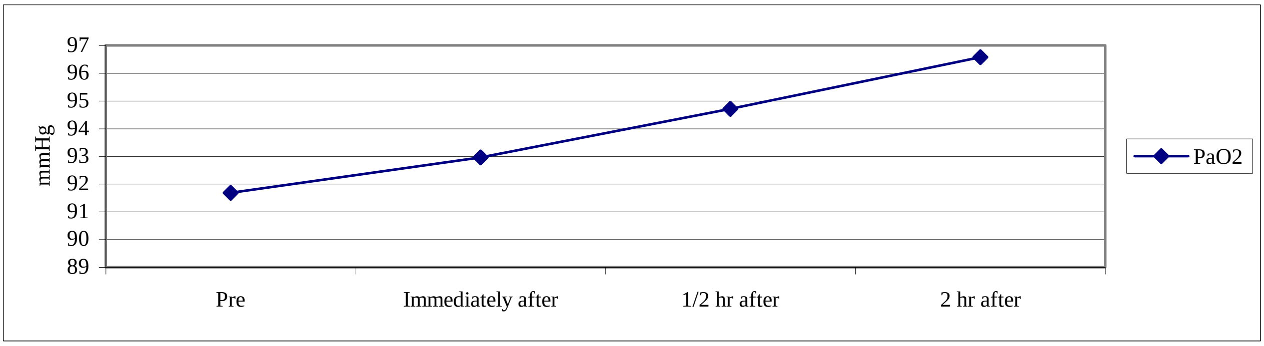

Fig. (2a): Mean value of PaO_2 (mmHg) at different time intervals.

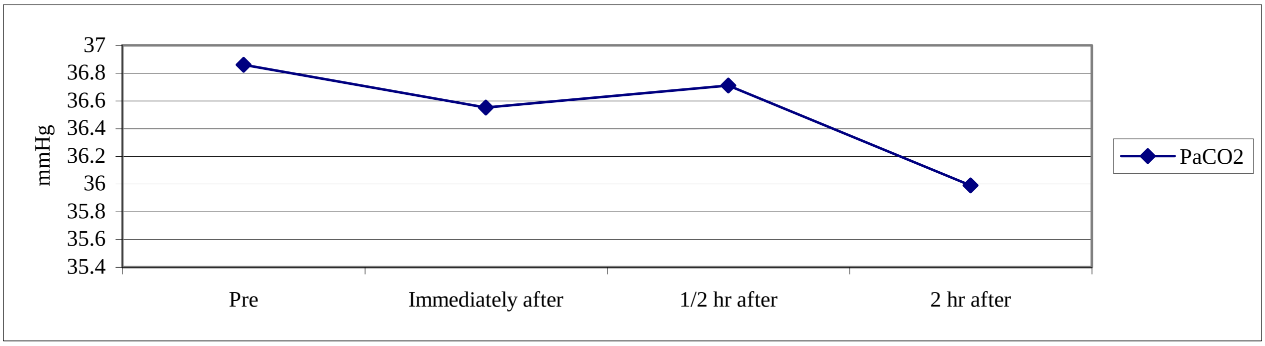

Fig. (2b): Mean value of $PaCO_2$ (mmHg) at different time intervals.

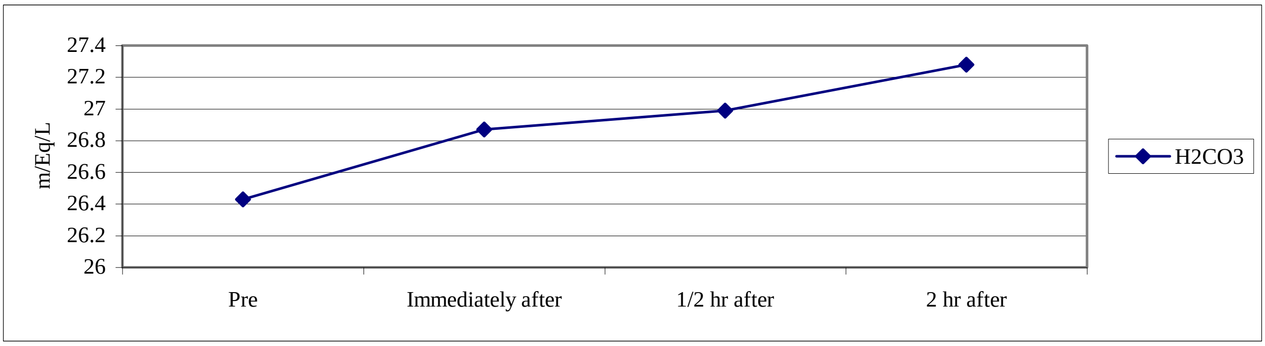

Fig. (2c): Represents the mean value of H_2CO_3 (m/Eq/L) plotted against the different time intervals.

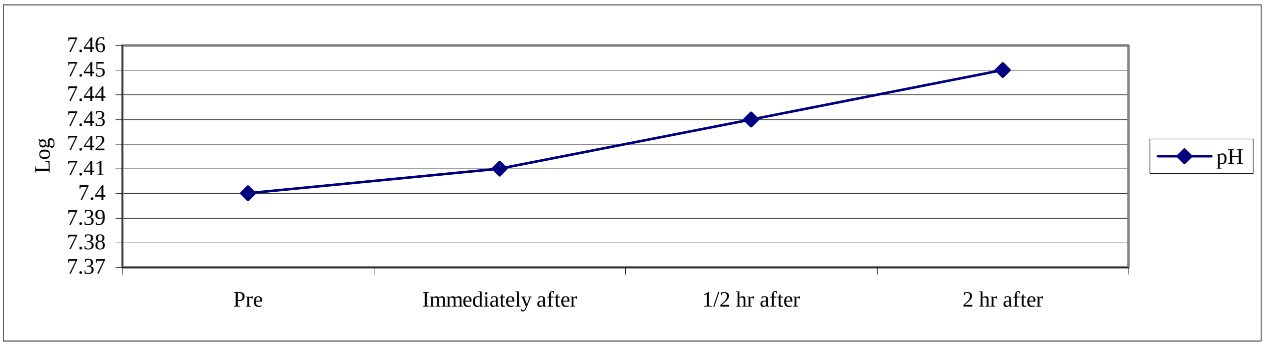

Fig. (2d): Represents the mean value of pH (Log) plotted against the different time intervals.

Fig. (3) smoker incentive spirometry + diaphragmatic breathing (group 3)

The mean value of PaO_2 before training was 95.21±9.44 and significantly increased immediately after 99.75±13.27 (4.77%), half an hour 103.73±95 (8.95%) and after two hours 106.55±14.65 (11.91%). There was a significant increase of mean value of $PaCO_2$ at all time intervals 36.89±2.89 (1.63%), 37.41±3.07 (3.06%), 37.91±2.99 (4.44%) respectively as compared to pre training value 36.30±2.9. There was non significant difference of mean value of H_2CO_3 immediately after 25.19±1.87 (9.83%), half an hour 25.84±2.55 (1.57%) and after two hours 25.74±2.59 (1.179%) as compared with before 25.44±2.09, but the mean value of pH decreased significantly at all time intervals 7.4±3.89 (0.27%), 7.37±4.11 (0.67%), 7.36±4.66 (0.81%) respectively as compared to the pre training value 7.42±3.89.

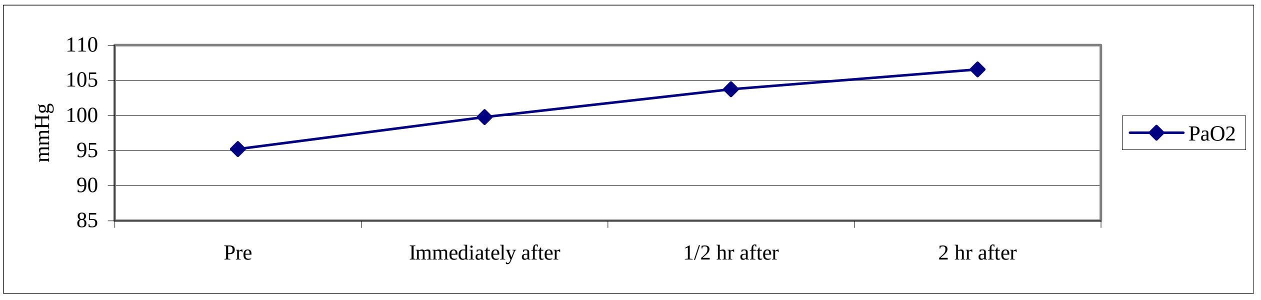

Fig. (3a): Mean values of PaO_2 (mmHg) among the different times of assessment.

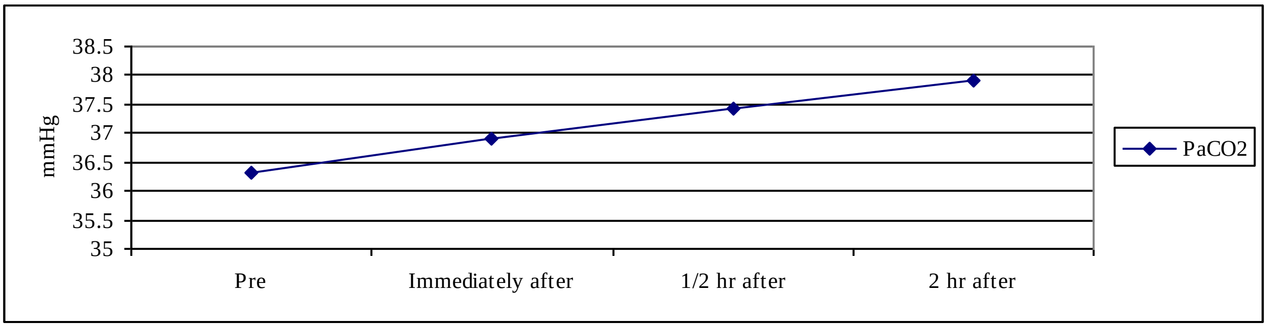

Fig. (3b): Mean values of $PaCO_2$ (mmHg) among the different times of assessment.

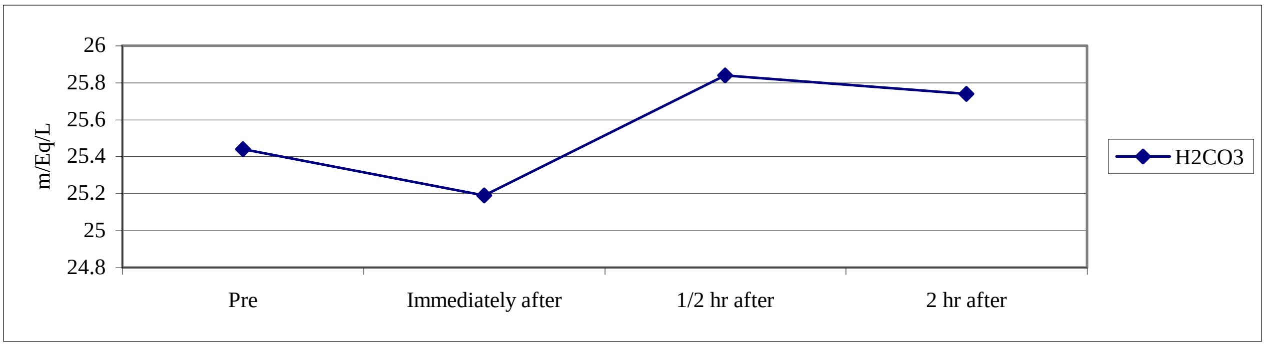

Fig. (3c): Mean values of H_2CO_3 (m/Eq/L) among the different times of assessment.

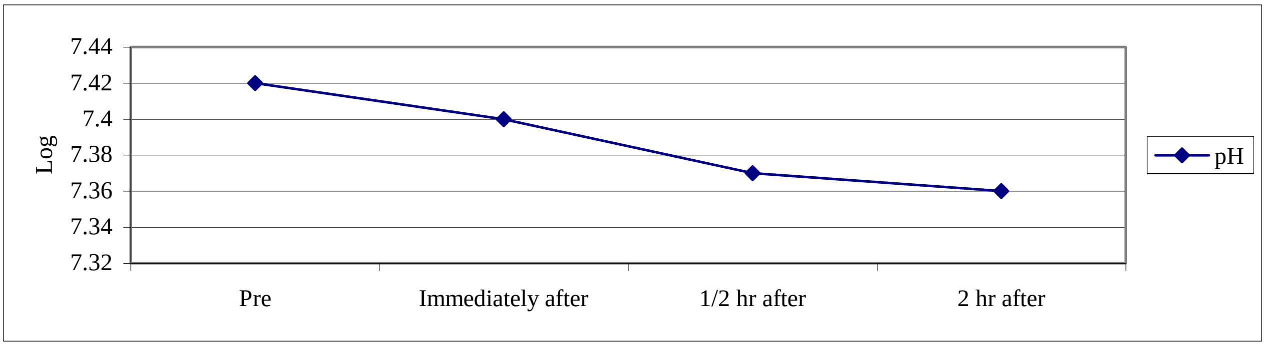

Fig. (3d): Mean values of pH (Log) among the different times of assessment.

Fig. (4) non-smoker incentive spirometry (group 4)

There was a significant increase of mean value of PaO_2 from 97.29±7.85 to 103.06±10.28 (5.93%), 107.35±12.05 (10.34%), 111.49±13.07 (14.59%) at all time intervals respectively. There was a non significant increase of $PaCO_2$ among these times from 37.68±2.52 pre treatment to 37.69±2.34 (0.026 %), 37.61±2.39 (0.185%), 37.79±2.59 (0.29 %) respectively. On the other hand, the mean value of H_2CO_3 was decreased non significantly from 25.95±1.88 to 25.89±2.01 (0.23%), 25.91±2.22 (0.15%), 25.41±2.24 (2.08%) along the time intervals. There was a non significant decrease of pH from 7.4±3.7 to immediately after 7.4±3.18 (0%) with a significant decrease after half an hour 7.39±3.55 (0.135%) and after two hours 7.39±5.79 (0.135%).

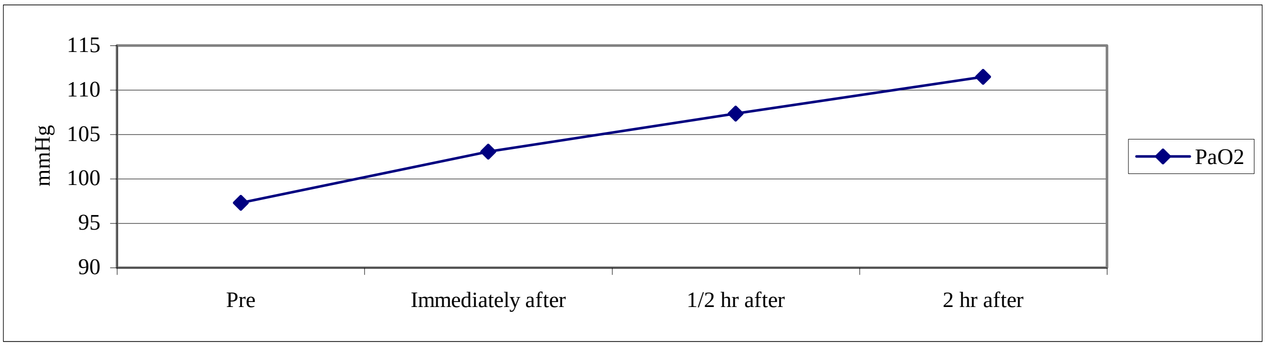

Fig. (4a): Mean values of PaO_2 (mmHg) among the different times of assessment.

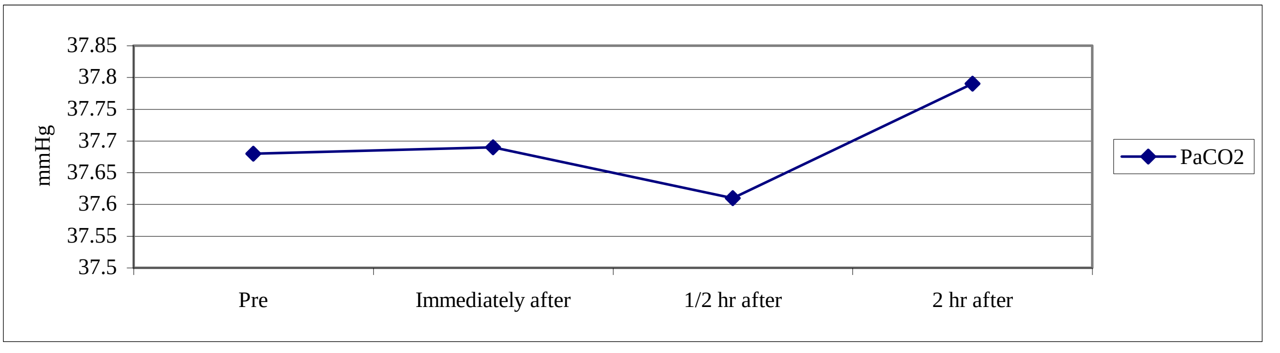

Fig. (4b): Mean values of $PaCO_2$ (mmHg) among the different times of assessment.

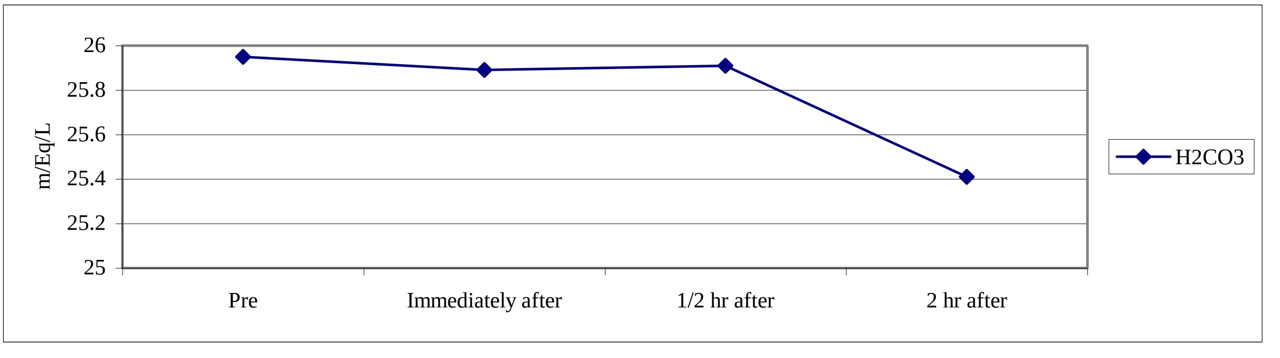

Fig. (4c): Mean value of H_2CO_3 m/Eq/l among the assessment time.

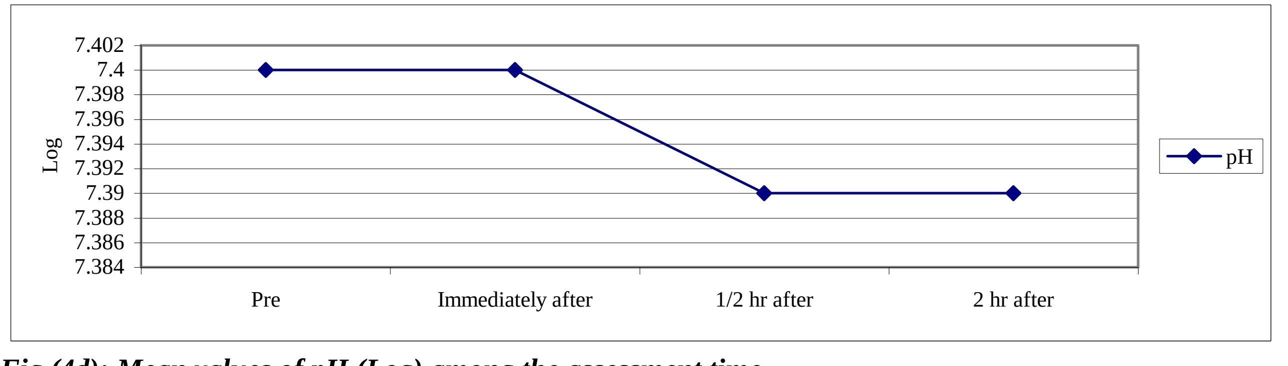

Fig.(4d): Mean values of pH (Log) among the assessment time.

Fig. (5) non-smoker diaphragmatic breathing (group 5)

The mean value of PaO_2 was significantly increased from 95.71±6.48 to 97.83±6.54 (2.22%), 100.27±7.94 (4.74%), 104.21±8.44 (8.88%) after all time of assessment with non significant difference of $PaCO_2$ from 37.45±1.89 to, 37.23±1.71 (0.587%), 37.25±2.002 (0.53%), 37.68±2.73 (0.61%) respectively. There was a non significant increase of H_2CO_3 from 25.78±2.47 to 25.83±1.87 (1.3%) immediately after, 26.17±2.83 (1.51%), after two hours with significant increase after half an hour 26.35±1.74 (2.21%). The mean value of pH significantly decreased at all time intervals from 7.41±3.44 to 7.40±3.18 (0.13%), 7.39±3.93 (0.26%), 7.38±4.29 (0.4%) respectively.

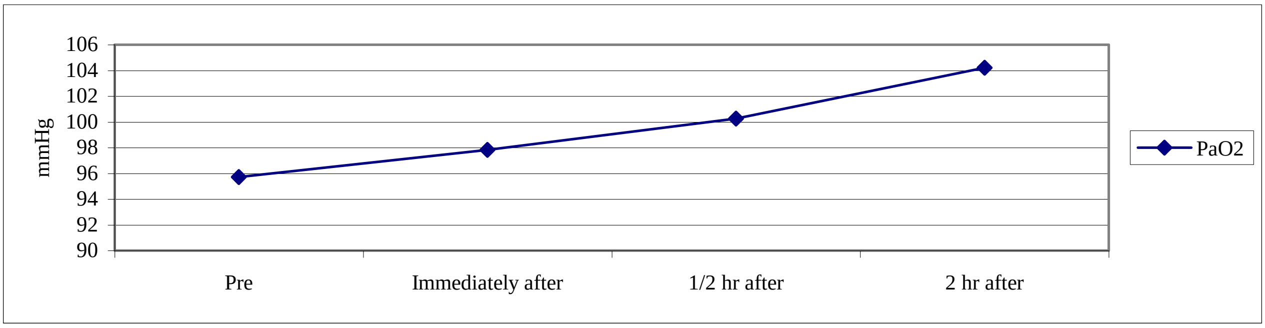

Fig. (5a): Mean values of PaO_2 (mmHg) at times of assessment.

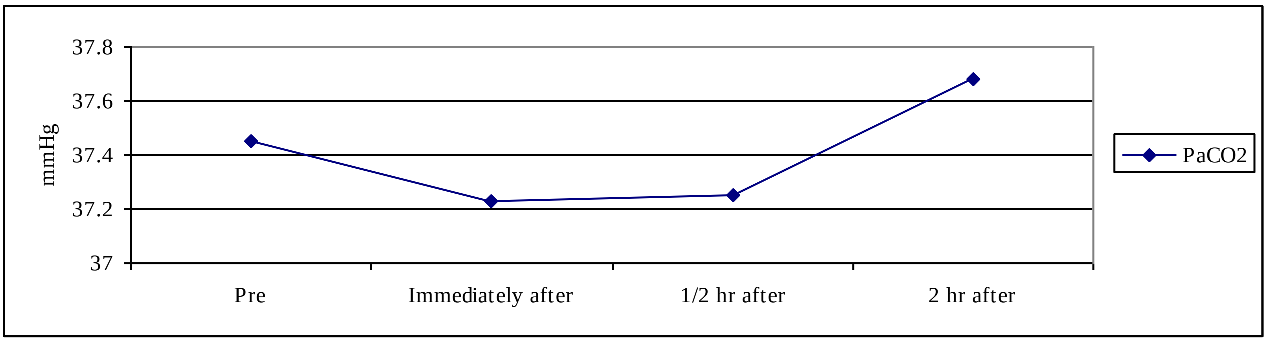

Fig. (5b): Mean values of $PaCO_2$ (mmHg) among the different times of assessment.

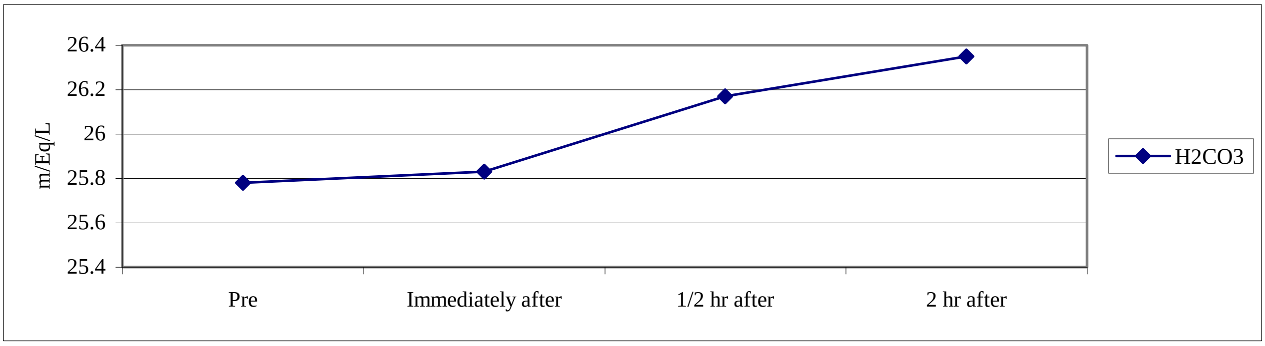

Fig. (5c): Mean values of H_2CO_3 (m/Eq/L) among the assessment time.

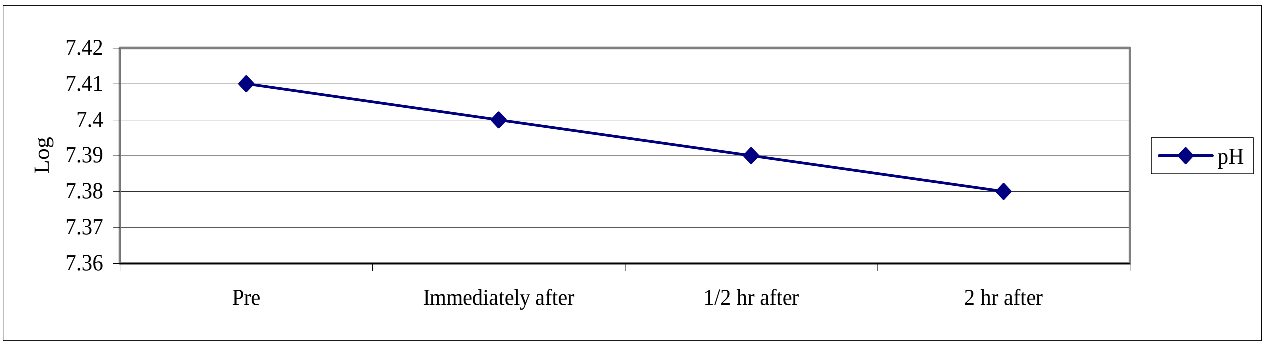

Fig.(5d): Mean values of pH (Log) among the assessment time.

Fig. (6) non-smoker IS + DB (group 6) (NSDB + IS)

The results showed that there was a statistical significant increase of PaO_2 immediately after 97.80±7.05 (2.47%) from 95.44±6.35 and half an hour after 100.47±8.46 (5.27%) with non significant increase after two hours 109.62±24.03 (14.86%). The mean value of $PaCO_2$ was none significantly differed at all time intervals 37.32±1.46 (0.78%), 37.44±1.48 (1.107%), 37.59±1.71 (1.51%) respectively as compared from before 37.03±1.47. Also, the mean value of H_2CO_3 decreased non significantly immediately after training from 26.14±1.74 to 25.38±1.82 (2.91%), while after half an hour the mean value was 25.06±1.59 (4.13%) with non significant difference $P>0.05$ and after two hours 25.38±1.85. The mean value of PH was significantly decreased at all time of assessment $P<0.05$ from 7.41±3.47 to 7.39±2.59 (0.14%) immediately after, half an hour mean value was 7.39±2.90 (0.135%) and after two hours was 7.37±4.82 (0.41%).

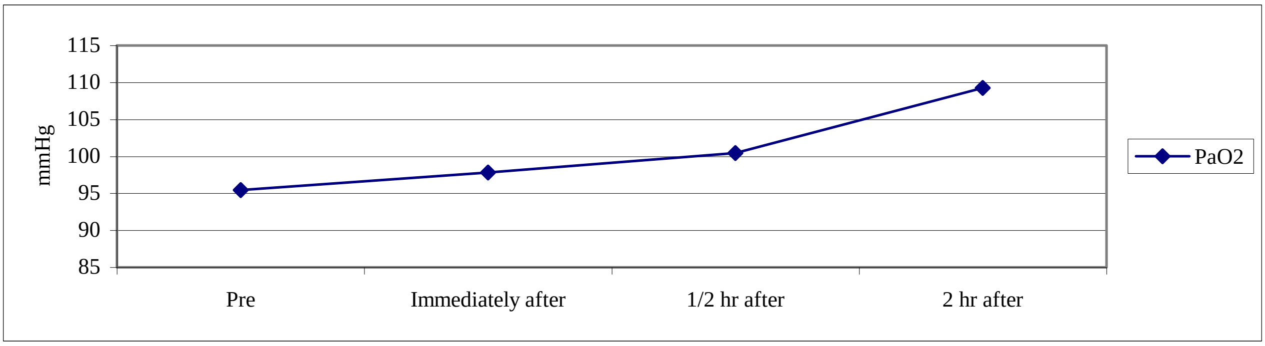

Fig. (6a): Mean values of PaO_2 (mmHg) among the different times of assessment.

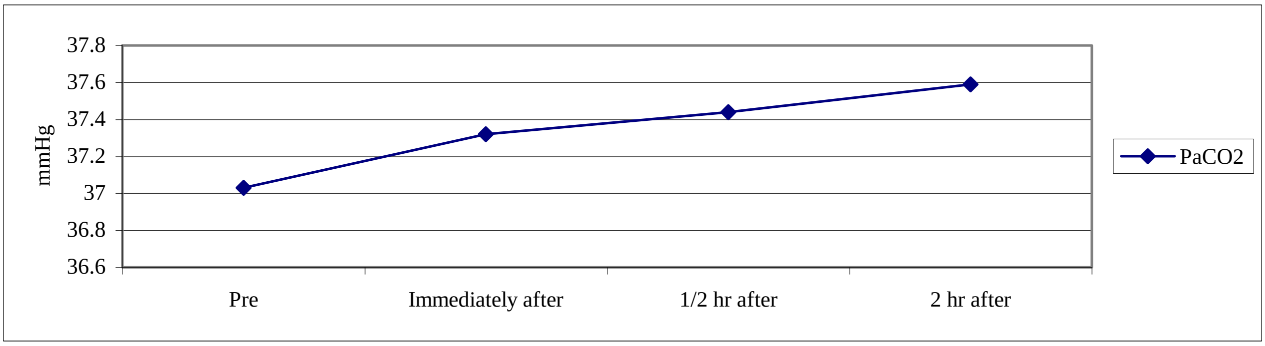

Fig. (6b): Mean values of $PaCO_2$ (mmHg) among the different times of assessment.

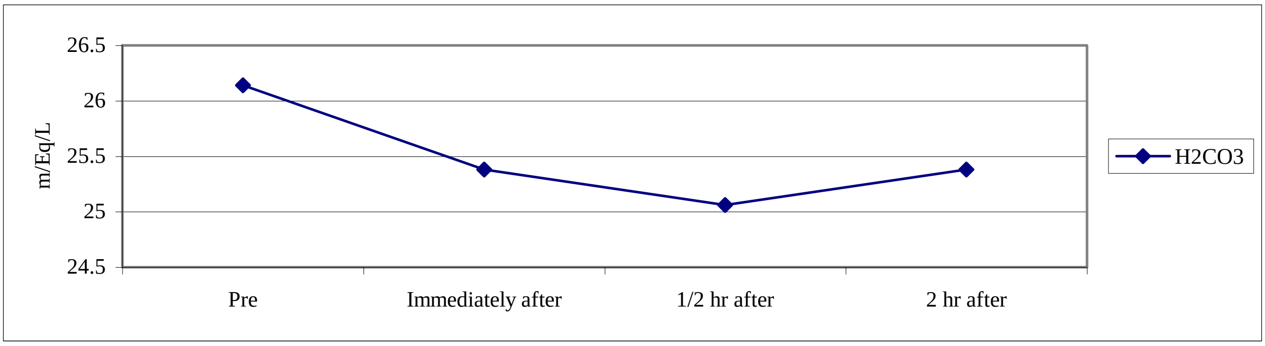

Fig. (6c): Mean values of H_2CO_3 (m/Eq/L) among the assessment time.

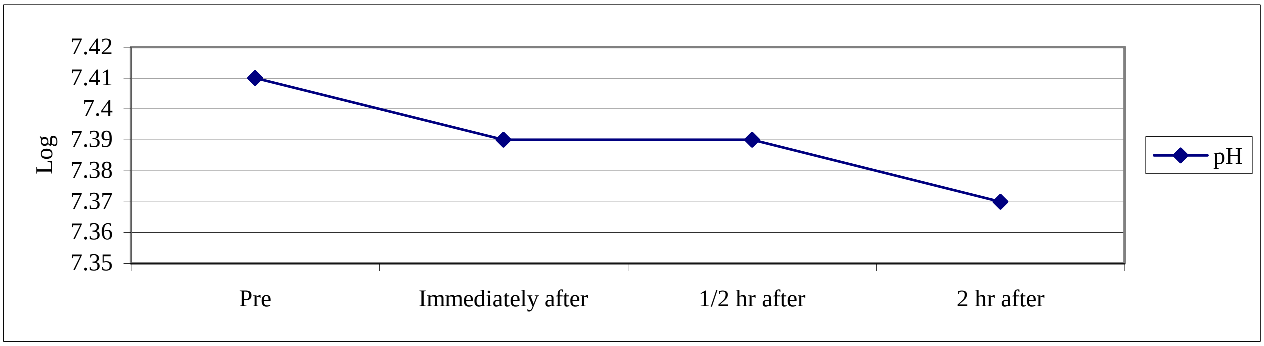

Fig.(6d): Mean values of pH (Log) among the assessment time.

DISCUSSION

The effects of diaphragmatic breathing (DB) exercise, incentive spirometry (IS) or both of them, on blood gases were investigated on the second day in smoker and non smoker patients after coronary artery bypass graft (CABG). The results of the current study revealed that both modalities resulted in improving arterial oxygenation with superiority of IS than DB. The non-smoker subjects showed greater improvement than smokers. Since, improvement might be reflected as reduction in carbon dioxide levels or improvement in arterial oxygenation. It can be suggested that DB and IS resulted in improvement of ventilation. Actually all subjects received DB, IS or both showed immediate significant improvement in PaO_2 which continue to increase up to two hours. Only smoker patients showed significant reduction of $PaCO_2$ after IS. These results were supported by findings of Dechman and Wilson[7] whom stated that with suitable instructions, the postoperative patients are able to increase the tidal excursion of the diaphragm. Some investigators have attributed benefits of DB exercises to reduced respiratory rate, increase tidal volume and improved alveolar ventilation. Indeed, DB was associated with a significant increase in tidal volume (TV) and a significant reduction in respiratory rate (RR) resulting in increased minute ventilation (VE). Diaphragmatic breathing was associated with increased TV, reduced RR and the inspiratory time divided by total respiratory cycle time (ratio) was also decreased. The smaller this ratio with a reduced RR may allow a slightly longer expiratory time which at least theoretically, should in turn favour lung emptying. It was suggested that DB was resulted in correction of the abnormal chest wall motion, decrease the work of breathing (WOB) and dyspnea; and improvement of ventilation in patients with COPD.

Vitacca et al.,[17] studied the acute effects of deep diaphragmatic breathing in patients with severe chronic obstructive pulmonary disease (COPD) and they found that DB was associated with a significant increase in transcutaneous partial pressure of oxygen (Ptc. O_2) and a significant decrease of (Ptc CO_2) with a significant increase in tidal volume and significant reduction in respiratory rate. It was concluded that in COPD patients, the DB is associated with improvement of blood gases at the expense of a greater inspiratory muscle loading. Also, it was stated that DB has been described as breathing predominantly with the diaphragm while minimizing the action of accessory muscles that may assist inspiration; so reduce the work of breathing (WOB)[5].

Jones et al.,[10] showed that DB decreased resting oxygen consumption (VO_2) by 5% in people with moderately severe COPD who were placed in the supine position. They attributed most of this change to movement of the abdominal wall. Moreover, Dechman and Wilson[7] mentioned that some subjects with COPD, showed increase in overall ventilation by 20% with DB. There was no change in minute ventilation (VE) which indicates a substantial slowing of respiratory rate. DB was associated with an average increase inspiratory time. Also, it was stated that DB was associated with an average 22% increase in VT and 25% increase inspiratory time. There is evidence compelling that DB reduces rather enhances breathing efficiency in people with severe COPD. These investigators concluded that DB contributed to inappropriate chest wall motion and decreased mechanical efficiency. Furthermore, DB has been reported to provoke post- hypervent-illation hypoxemia, this contradiction with the present finding may be attributed to difference in the studied population where the subjects participated in the current study had a post-operative restrictive airway problem.

The observed improvement in arterial oxygenation after DB in smokers and non-smoker could be attributed to alveolar ventilation (increase VT and reduce respiratory rate) and decrease work of breathing (WOB). The results of the present study demonstrate that supervised usage of IS, for a minute at the second day after CABG significantly improved arterial oxygenation up to two hours.

This may be attributed to the influence of IS which assist in lung inflation and decrease intra-pulmonary shunt[2].

Expiratory maneuvers commencing from greater lung volumes might result in similar airways clearance but differ in the energy required to produce this maneuver. It was reported that peak expiratory airflow resulting from cough and huff differed significantly (359 ± 37 L/min vs 227 ± 34 L/min respectively) suggesting variation in the muscular work required to produce these airflows. They have claimed that the forced expiration technique required less energy to be performed, and stated that a huff from a particular lung volume requires less energy than a series of coughs down to the same lung volume.

It has been shown that healthy people usually take deep breaths or sigh 9 to 10 times per hour to prevent alveolar collapse. The absence of these periodic deep breaths during post operative course, even when breathing is adequate to eliminate carbon dioxide, contributes to atelectasis and hypoxemia.

Moreover, pain and muscle spasm impair the chest wall function and decrease lung volumes, so that at functional residual capacity (FRC), significant portions of lung volume are below closing volume. The increase amount of lung below closing volume and the failure to sigh or to take deep breaths increases the likelihood of alveolar collapse, increase intrapulmonary shunt and impaired arterial oxygenation[1]. IS presumably counter-acts the effect of splinting due to pain in the postoperative patients who are unable to take deep breaths; helps to prevent the development of atelectasis; and assist in lung re-expansion.

Despite the lack of positive evidence; usage of IS for prophylaxis and treatment of post operative complications remain common and widely used. This conflicting data may be attributed to the device type and/or method of application[3].

Authors compared two incentive spirometers and found that the group using an device requiring a preset volume goal had superior results. This confirms the used procedure in the present study. Where the patients received incentive spirometry were encouraged to reach inspired volume equal at least 75% of preoperative value. Moreover they compare the efficacy of two incentive spirometers, coach (volume-oriented) and Triflo (flow-oriented) in the work of breathing in COPD patients[9]. The coach type (used in the current study) resulted in more chest expansion and less WOB than Triflo. More recently, they found that significantly higher tidal volume (TV) associated with low respiratory rate with volume-oriented than flow oriented devices. Also larger abdominal displacement with coach device[12]. The results of the current study, showed that with IS, the patient was asked to expire the air as much as he can then to inspire through IS mouth piece deeply until the ball fixed on the desired location to eliminate the influence of body position[19]. It was postulated that erect upright body position could prevent encroachment of the viscera due to the loss of the diaphragmatic barrier in these patients and thereby improve ventilation[15].

As the patients approximate the upright position, the diaphragm is displaced caudally due to a reduction in the viscera and the reduction in thoracic blood volume, which results in an increase in FRC[12].

Upright position, the rib cage assumes its greatest antero-posterior diameter, where in the inspiratory intercostal and scalene muscles are lengthend and the diaphragmatic muscle fibers are shortened due to descent and displacement of the abdominal viscera. This shortened position and the resultant decrease in force generated in this position, the neural drive to the diaphragm is increased in the upright position[6]. Based on its direct effect on FRC and diaphragmatic function, the upright position which was used during IS in the present study is the most physiologically justifiable position to affect gas exchange. Where the effect of gravity on the lung and the resultant gradient in pleural pressure (PPI) is the prime determinant of the distribution of ventilation to the dependent zones in the erect position. This enhancement in ventilation of lower lobes resulted in improving of ventilation-perfusion (V/Q) and thus improve gas exchange[20].

The loss of alveolar recoil contributes to the increase in lung compliance and impairs lung perfusion. Typically, these changes resulted from prolonged inhalation of cigarette smoke which irritates the airways thus increasing mucous production and airway resistance. Overtime, these pathophysiologic changes contribute to increase anatomical dead space in the lungs and overall total lung capacity. Consequently, hyperinflation of the lungs and the chest wall causes the hemi-diaphragms to become depressed which contributes further to breathing inefficiency and increased metabolic cost[11]. The postoperative deterioration in blood gases of smokers was statistically significant compared with non smokers. The foremention pathogenesis, may explain the less value of improving PaO_2[1].

It was suggested that maximal inflation of the lung increase production of surfactant, improve compliance and oxygenation and may assist in re-expansion of areas of atelectasis in high-risk patients after CABG The privilege of incentive spirometer than the diaphragmatic breathing may be lies in providing visual feedback which enhances the effect of deep breath in any maneuver that emphasizes inflation will increase lung volume and maintain patency of the smaller airways[15]. IS is the most widely prescribed technique for postoperative lung expansion[3]. It is characterized by active recruitment of the diaphragm and other inspiratory muscles. However its efficacy to enhance diaphragmatic excursion is still controversial[2]. The foremention may explain the superiority of IS than DB reported in the present study.

The results of the present study go hand by hand with the findings of Westerdahl et al.,[21] whom investigate the effects of deep breathing performed on the second postoperative day after CABG. Spiral computed tomography and arterial blood gas analysis were performed immediately before and after, 30 deep breaths performed without a mechanical device, with a blow bottle device or with an inspiratory resistance- positive expiratory pressure mask. Their results revealed a significant decrease in atelectatic area; increase aerated lung area. Increased PaO2 while $PaCO_2$ was unchanged in the three groups.

The results of the current study showed that postoperative atelectasis is better reduced by taking deep breath and holding it for 5 seconds than by taking multiple deep breaths or not holding a deep breath. So, it was suggested that enhancement of deep breath by DB or IS were resulted in improving arterial oxygenation with superiority of IS[18]. Breathing exercise resulted in increase tidal volume and promote an increase in airflow through collateral ventilation channels. A further mechanism by which an increase in inhaled volume is believed to move air into peripheral airways is the phenomenon of interdependent. During inspiration, the alveoli supplied by patent airways expand and exert expanding forces on adjacent alveoli. This forces may aid in the re-expansion of collapsed alveoli[21].

Conclusion

Within The limitation of the present study it would concluded that the current study revealed that both modalities resulted in improving arterial oxygenation with superiority of IS than DB. The non- smoker subjects showed greater improvement than smokers.

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الملخص العربي

تأثير طريقتين لتمرينات التنفس على غازات الدم الشرياني لدى المدخنين وغير المدخنين بعد عمليات ترقيع الشرايين التاجية

تسعون مريضا ممن اجري لهم عمليات القلب المفتوح لترقيع الشرايين التاجية تم اختيارهم عشوائيا من وحده العناية المركزة بقسم الجراحة بمعهد القلب القومي تتراوح أعمارهم بين 53.7-51.5 سنة . تم تقسيمهم إلي ستة مجموعات تبعا لتاريخ التدخين (مدخنين-غير مدخنين) وكانت طريقه العلاج الطبيعي المستخدمة لهم وهي (جهاز الحافز التنفسي-تمرينات الحجاب الحاجز وكلاهما معا) . وقد تم قياس غازات الدم الشرياني (الأكسجين ، ثاني أكسيد الكربون ، بيكربونات ودالة الحمض- القاعدة) قبل وبعد تطبيق وسيلة العلاج الطبيعي فوراً وبعد نصف ساعة وبعد ساعتين من تطبيق الوسيلة العلاجية . أوضحت نتائج البحث أنه بمقارنة المدخنين وغير المدخنين ، حدوث تحسن أفضل في الغير مدخنين وكذلك مع جهاز الحافز التنفسي أظهرت معدلات التحسن أفضل من تمرينات عضلة الحجاب الحاجز .