Incentive Spirometry Versus non-invasive Intermittent Positive Pressure Breathing after Coronary Artery Bypass Grafting

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ABSTRACT

Background and purpose: *Prevention of pulmonary complications immediately following coronary artery bypass grafting (CABG) reduces morbidity and mortality. The purpose of this study was to determine whether the addition of either incentive spirometry (IS) or non-invasive intermittent positive pressure breathing (IPPB) to postoperative pulmonary physiotherapy is more effective than physiotherapy alone in improvement of cardiopulmonary function after CABG.*
Subjects and methods: *Thirty patients of both sexes who underwent CABG divided into three groups. Group (1) received the chest physiotherapy program for patients after CABG, Group (2) received thee chest physiotherapy program for patients after CABG in addition to breathing training with incentive spirometry received thee chest physiotherapy program for patients after CABG in addition to breathing training with incentive spirometry, where Group (3) received the chest physiotherapy program for patients after CABG in addition to non-invasive IPPB. Measurements of inspiratory capacity (IC), arterial oxygen saturation (SaO_2) and heart rate (HR) were done before the study in the first post-operative day and repeated at the end of the study in the tenth postoperative day.*
Results: *The results of this study indicated a significant increase in IC and SaO_2 and decrease in HR in the three groups. While there was a significant difference only between group (1) received thee chest physiotherapy program for patients after CABG and Group (2) received thee chest physiotherapy program for patients after CABG in addition to breathing training with incentive spirometry.*

INTRODUCTION

Coronary artery bypass graft (CABG) surgery improves survival for patients with sever coronary artery disease. Patients with less sever disease often elect to undergo coronary revascularization to reduce their angina and to improve their quality of life[1].

Recovery from major surgery is primarily enlarged by postoperative pulmonary complications e.g. atelectasis, pneumonia or pulmonary dysfunction which remain the major causes of postoperative morbidity and mortality[12].

The basic mechanism of postoperative pulmonary complications is lack of lung inflation that occurs because of change in breathing to shallow, prolonged recumbant positioning and temporary diaphragmatic dysfunction. Mucociliary clearance also is impaired postoperatively, which along with the decreased cough effectiveness and increases risks associated with retained pulmonary secretion[6].

Incentive spirometry is simply a visual and/or audiovisual device that encourages slow, deep inspiration i.e. visual input of balls rising in chambers, coloured 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 which is useful for patients who are resistant or unable to co-operate fully with maximal inspiratory efforts, it remains a widely used technique for the prophylaxis and treatment off respiratory complications in post surgical patients and can be used independently by patients[4,6].

Non-invasive intermittent positive pressure breathing (IPPB) is a simple, portable, non-invasive form of ventilatory support and suitable for use in home, general word and incentive care unit. It increases ventilation, improves the arterial blood gases and decreases the work of the respiratory muscles[3,11].

Breathing exercises have been used to increase lung volume, improve gas exchange and ventilation distribution. Diaphragmatic, segmental and costal respiratory exercise may alleviant surgically induced alterations such as diminished diaphragmatic mobility and restrictive pulmonary changes through increase diaphragmatic mobility and decrease basal atelectasis[2,8].

As determination of the effective therapy off post operative respiratory disorder in patients who have had cardiac surgery, the aim of this study was to detect if incentive spirometry or non-invasive IPPB offered a therapeutic advantage over the routine physical therapy in patients who had undergone CABG.

SUBJECTS, MATERIAL AND METHODS

Subjects

Forty five consecutive patients of both sexes underwent elective coronary artery bypass graft surgery who gave informed written consent form, their age ranged from 45-58 years. All the participants were chosen randomly from the physical therapy department in the National Heart Institute. After obtaining consent, patients were randomly allocated by means of a random numbers table to one of three equal groups.

Equipments and measurements

1- Pulse oximeter (Model8500, Nonin Medical) an earlobe sensor was used to measure heart rate (HR) and arterial oxygen saturation (SaO_2) nonivasivly.
2- Incentive spirometry (Voldyne Volumetric manufactured by Sherwood Medical Company U.S.A.): It is a respiratory therapy device that provides visual feedback in term of volumetric success as a patient performs a deep breath. Incentive spirometer consider as a guideline for progression of treatment. Also incentive spirometer was used in measurement of inspiratory capacity (IC).
3- Non-invasive intermittent positive pressure breathing (RTX modes, Respiratory Care Drager, London) it is a pressure cycle ventilator that triggered by a patients inhalation to deliver ambient air or oxygen to the patient until a preset pressure (15-20cmH_2O) is reached through fase mask.

Procedures

Patients were divided into three equal groups:

Group (1): Patients in this group received the usual chest physiotherapy program for patients after CABG. This 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 used 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.

Group (2): Patients in this group received the same previous exercises during the first four days after the surgery, then all patients in this group were given breathing exercise training with incentive spirometry in addition to the usual physical therapy 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.

Group (3): Patients in this group received the same previous exercises during the first four days after the surgery, then all patients in this group were given Non-invasive intermittent positive pressure breathing (IPPB) in addition to the usual 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 equal 20% and the peak inspiratory airway pressure equal1 5 cmH_2O to provide a sufficient widening of thoracic cage diameter.

Measurements of heart rate (HR), inspiratory capacity (IC) and arterial oxygen saturation (SaO_2) were taken at the first postoperative day before the study and repeated at the tenth postoperative day at the end of the study.

Statistical analysis

The mean values of HR, IC and Sao_2 were measured and calculated before the study in the first postoperative day and at the end of the study in the tenth postoperative day for the three groups, then the results were compared using the paired -t- test to determined the level of significance. comparison between groups were done using the independent t-test ($P<0.05$).

RESULTS

Table (1): Shows the difference between the pre and post values of HR, IC and SaO_2 in group (1).

	Mean ± SD		**t value**	**Significance**
	Pre	**Post**		
HR (Beat/Min.)	102.51 ± 4.357	82.12 ± 4.389	-3.285	Sig.
SaO_2(%)	85.47±3.823	93.73±3.172	2.76	Sig.
IC(L.)	420.31±70.795	1520.67±130.24	3.582	Sig.

SD: Standard deviation
Beat/Min: Beat/Minute
L: Liter
Sig.: Significant

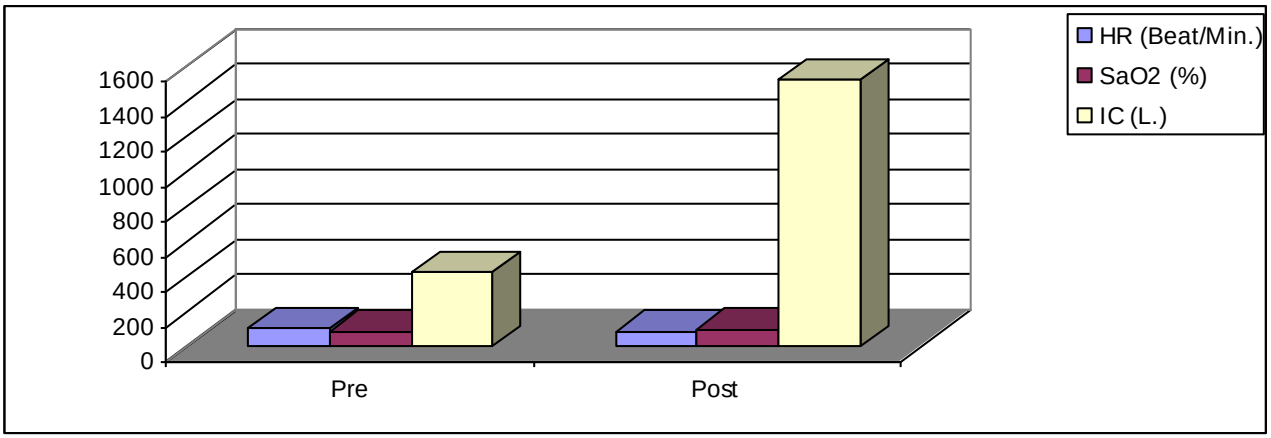

Fig. (1): Shows the difference between the pre and post values of HR, IC and SaO_2 in group (1).

Table (2): Shows the difference between the pre and post values of HR, IC and SaO_2 in group (2).

	Mean ± S.D.		t-value	Significance
	Pre	Post		
HR (Beat/Min.)	103.67±3.981	75.85±3.792	-4.176	Sig.
SaO_2 (%)	86.32±3.651	98.15±2.815	3.45	Sig.
IC (L.)	415.83±68.34	1759.83±160.25	4.63	Sig.

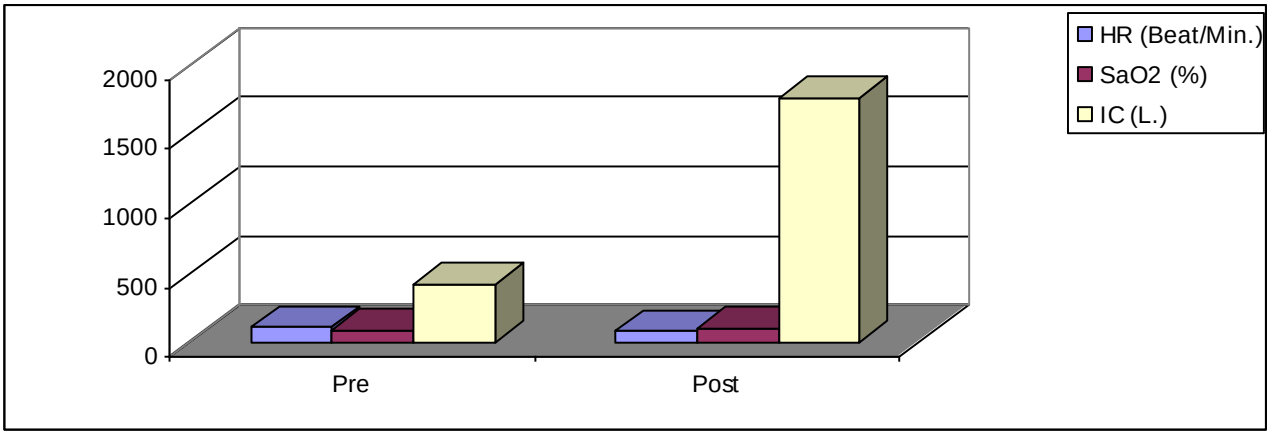

Fig. (2): Shows the difference between the pre and post values of HR, IC and SaO_2 in group (2).

Table (3): Shows the difference between the pre and post values of HR, IC and SaO_2 in group (3).

	Mean ± SD		t-value	Significance
	pre	Post		
HR (Beat/Min.)	103.58±4.152	81.23±3.975	-3.428	Sig.
SaO_2 (%)	85.89±3.370	94.14±3.115	2.88	Sig.
IC (L.)	422.45±72.641	1545.72±138.52	3.827	Sig.

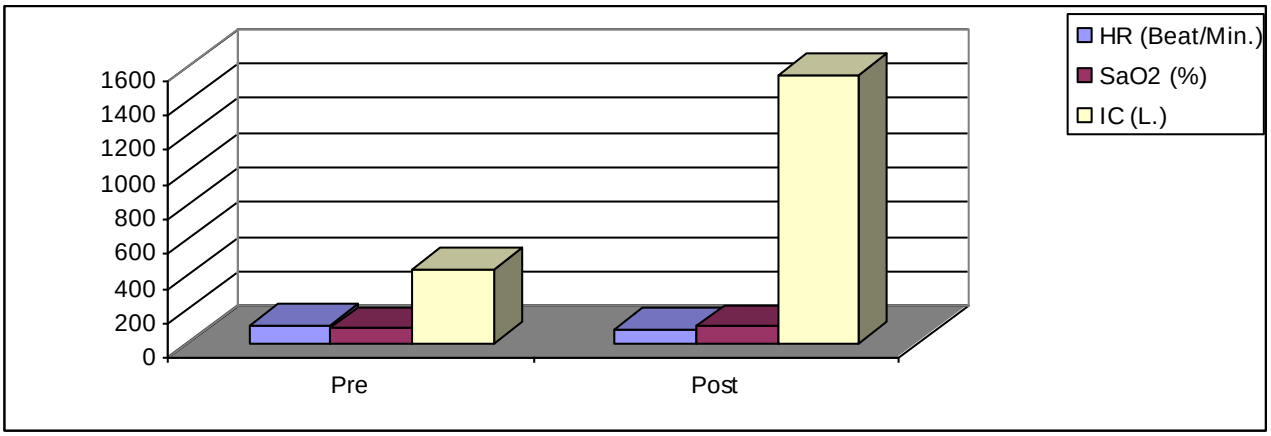

Fig. (3): Shows the difference between the pre and post values of HR, IC and SaO_2 in group (3).

Table (4): Shows the difference between group (1) and group (2) in HR, IC and SaO_2 at the end of the study.

	Mean ± SD		t-value	Significance
	Group (1)	Group (2)		
HR (Beat/Min.)	82.12±4.389	75.85±3.792	2.424	Sig.
SaO_2 (%)	93.73±3.172	98.35±2.815	2.440	Sig.
IC (L.)	1520.67±130.24	1759.83±160.25	2.603	Sig.

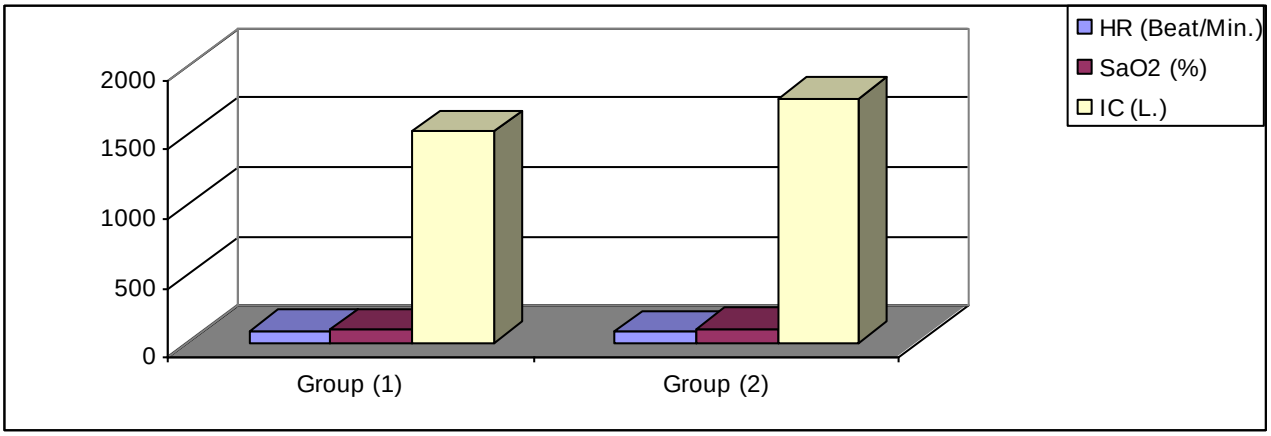

Fig. (4): Shows the difference between group (1) and group (2) in HR, IC and SaO_2 at the end of the study.

Table (5): Shows the difference between group (1) and group (3) in HR, IC and SaO_2 at the end of the study.

	Mean ± SD		t-value	Significance
	Group (1)	Group (3)		
HR (Beat/Min.)	82.12±4.389	81.23±3.975	0.714	Non Sig.
SaO_2 (%)	93.73±3.172	94.14±3.115	0.206	Non Sig.
IC (L.)	1520.67±130.24	1545.72±138.52	0.295	Non Sig.

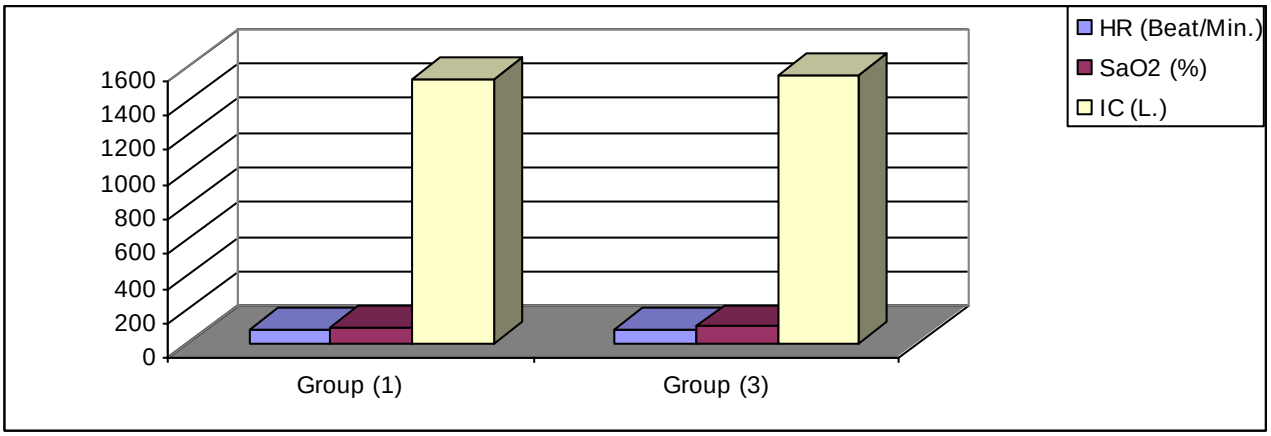

Fig. (5): Shows the difference between group (1) and group (3) in HR, IC and SaO_2 at the end of the study.

Table (6): Shows the difference between group (2) and group (3) in HR, IC and SaO_2 at the end of the study.

	Mean ± SD		t-value	significance
	Group (2)	Group (3)		
HR (Beat/Min.)	75.85±3.792	81.23±3.975	2.597	Sig.
SaO_2 (%)	98.35±2.815	94.14±3.115	2.245	Sig.
IC (L.)	1759.83±160.25	1545.72±138.52	2.266	Sig.

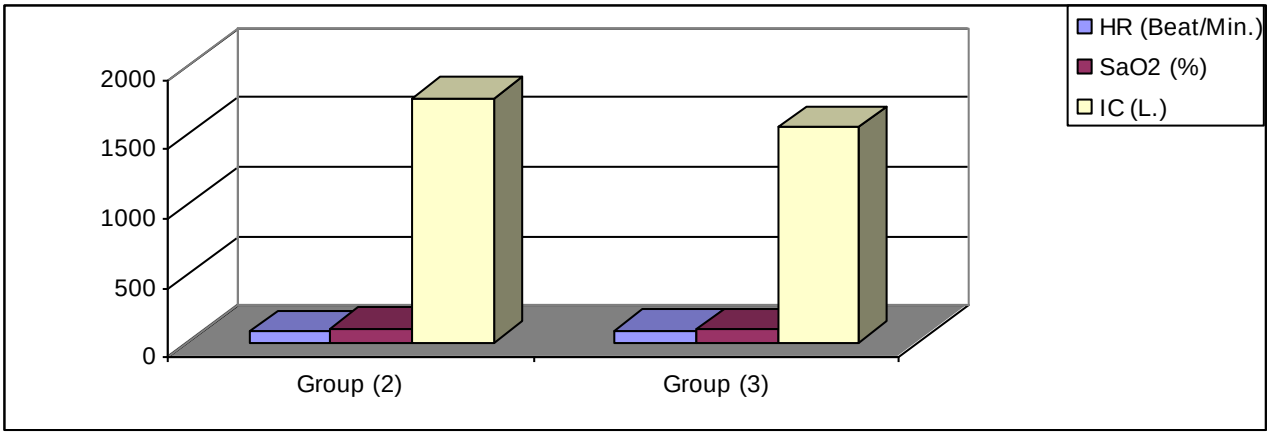

Fig. (6): Shows the difference between group (2) and group (3) in HR, IC and SaO_2 at the end of the study.

DISCUSSION

Chest physiotherapy facilitates physical, psychological and emotional recovery for patients following coronary revascularization and evidence suggests that it improves short and long term prognosis and allow pulmonary function to return to an increased rate to preoperative levels. This study was performed to determine the difference between the effect of incentive spirometry and Non-invasive intermittent positive pressure breathing on

cardiopulmonary response following coronary artery bypass surgery.

The results of this study indicated a significant improvement in cardiopulmonary response in the three groups. While, then was a significant difference only the group (1) received the usual chest physiotherapy and group (2) who received the usual physiotherapy in addition to the incentive spirometry.

Incentive spirometry (IS) was proposed on the theoretical basis of encouraging patients to breathe to total lung capacity, to sustain that inflation and by opening collapsed alveoli to prevent atelectasis, postoperative hypoxemia may be reduced with this technique. It is characterized by active recruitment of the diaphragm and other inspiratory muscles. Also, it reported better elimination of pulmonary secretions and decreased risk of chest infection[12].

Non-invasive IPPB as a form of ventilatory support play a role in improving ventilatory function after open heart surgery. It increases ventilation, improving arterial blood gases and decreases the work of breathing. It can aid in removal of retained secretions, reduces the incidence of postoperative atelectasis and pneumonia as well as re-expanding collapsed alveoli[5,10].

Application of breathing exercises, coughing, incentive spirometry, Non-invasive IPPB and periodic application of continuous positive air way pressure after coronary artery surgery were compared. No treatment was found to superior to any other in the prevention of postoperative pulmonary complications[7].

In comparing incentive spirometry, non-invasive IPPB and deep breathing exercises, it was concluded that they are equally effective in preventing pulmonary complications after abdominal surgery, although incentive spirometry may be the treatment of choice in upper abdominal procedures, because there are no complications of this treatment and it appears to shorten the length of hospitalization.

Non-invasive IPPB provides mechanical ventilation assistance. This positive pressure ventilation is opposite to normal physiological ventilation in that normal ventilation occurs when negative pressure created by contraction of the diaphragm causes air to enter the lungs. Inspiration occurs by pulling air into the lungs, whereas ventilators push air into the lungs. This is important as the thoracic cavity becomes an area of higher pressure which may creates adverse cardiovascular homodynamic events[3].

Patients receives ventilation assistance by non-invasive IPPB appear to relay on the machine to perform the deep breathing and hence, is reluctant to actively use the respiratory muscles, presumably because of greater incisional pain associated with active muscular contraction as opposed to passive muscular movements[11].

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الملخص العربي

جهاز الحافز التنفسي مقابل جهاز ضغط التنفس المتقطع الموجب الغير تداخلي بعد الترقيع التوصيلي للشريان التاجي جراحيا

يلعب العلاج الطبيعي دور كبير في تأهيل مر يض القلب بعد عمليات تحويل الشريان التاجي لذلك كان هدف هده الدراسة هو تقيم فائدة إضافة تدريبات التنفس بجهاز الحافز التنفسي وكذلك جهاز ضغط التنفس المتقطع الموجب الغير تداخلي علي الاستجابة الدورية التنفسية بعد عمليات تحويل الشريان التاجي وقد تم اختبار ثلاثين مريضا من الجنسين تتراوح أعمارهم بين 45-58 سنه وقد قسمت العينه إلى ثلاث مجموعات تجريبية تلقت المجموعة الأولى العلاج الطبيعي المعتاد للجهاز التنفسي بعد عمليات تحويل الشريان التاجي وتلقت المجموعة الثانية نفس العلاج في المجموعة الأولى بالاضافه إلى تدريبات التنفس بجهاز الحافز التنفسي في حين تلقت المجموعة الثالثة نفس ا لعلاج في المجموعة الأولى بالاضافه إلى جهاز ضغط التنفس المتقطع الموجب الغير تداخلي . تم قياس السعه التنفسية ومعدل ضربات القلب ودرجة تشبع الدم بالأكسجين قبل بدء البرنام ج في اليوم الأول بعد الجراحة ثم أعيدت القياسات مره أخرى بعد انتهاء البرنامج في اليوم العاشر للجراحه .أظهرت النتائج تحسن في جميع القياسات في الثلاثة مجموعات وبمقارنة القياسات وجد هناك فرق ذو مغزى إحصائي بين المجموعة الأولي والمجموعة الثانية فقط لذلك يوصى بإضافة تدريبات التنفس بجهاز الحافز التنفسي إلى العلاج الطبيعي المعتاد للجهاز التنفسي بعد عمليات تحويل الشريان التاجي .