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Effect of Early Mobilization and Routine Chest Physiotherapy on Ventilatory Functions in Open Heart Surgery Patients

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Abstract

Background: Open heart surgery induces a sharp post-operative decrease in respiratory function, a decrease which can lead to the development of post-operative pulmonary complications which remain the most significant cause of morbidity following open heart surgery.

Aim of Study: The purpose of this study was to determine the efficacy of early mobilization on ventilatory functions in individuals undergoing open heart surgery.

Subjects and Methods: Forty patients of both sexes (31 men and 9 women) who underwent open heart surgery were enrolled in that study for ten days. Their ages ranged from 45-65 years. They were randomly assigned into two groups, twenty in each group. Group I (intervention group) received early mobilization and routine chest physiotherapy; and Group II (control group) received only routine chest physiotherapy. The frequency and duration of treatment was two sessions for the first two pre and post-operative day and once per day on the third and up to the tenth post-operative day. All of them underwent evaluation of ventilatory functions with measurement of Forced Vital Capacity (FVC), forced expiratory volume in the first second (FEV_1) and Peak Expiratory Flow (PEF) pre treatment and after ten days post-operatively.

Results: There was no significant difference were recorded between the two groups in the pre-treatment measured variables FVC, FEV_1 and PEF ($p>0.05$), while there was a significant difference when comparing pre and post-treatment mean values of all measured variables FVC, FEV_1 and PEF in each group ($p<0.01$). When comparing post mean values between both groups, the results revealed a significant improvement in favor to Group I ($p<0.01$).

Conclusions: Early mobilization is effective in improving ventilatory functions after open heart surgery.

Key Words: *Chest – Physiotherapy – Early mobilization – Ventilatory function – Open heart surgery.*

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Introduction

VENTILATORY function is commonly altered following open heart surgery as a result of general anesthesia which has been shown to reduce in total pulmonary capacities and volumes, cardiopulmonary bypass impairs gas exchange (on pump machine). The incidence of atelectasis increase with each of general anaesthesia, cardiopulmonary bypass and cardiac surgery and atelectasis itself can result in a decrease in vital capacity and lung compliance. As a result, patients undergoing cardiac surgery are at risk of developing post-operative pulmonary complications **[1]**.

A major decline in pulmonary function Forced Vital Capacity (FVC) and Forced expiratory volume in one second (FEV_1) is observed on the first day after open heart surgery. This decline can reduce vital and inspiratory capacity and can culminate in restrictive lung diseases that cause atelectasis, reduced diaphragm movement, and respi-ratory insufficiency **[2]**.

Multiple factors may be involved in diaphragmatic dysfunction, such as irritation and inflammation caused by trauma from manipulation close to diaphragm, and postoperative pain **[3]**.

Open heart surgery is associated with reductions in lung function and diminished ability by the patient to breathe deeply and cough effectively. Both the surgery and the subsequent impairments increase the risk for the development of Post-operative Pulmonary Complications (PPCs) such as pneumonia and atelectasis **[4]**.

Post-operative Pulmonary Complications (PPC) remain the most significant cause of morbidityfollowing open heart surgery [5].

The frequency of PPC after median sternotomy reported in the literature varies widely, ranging from 20% to 90% for atelectasis and 9% to 40% for post-operative pneumonia [6].

Chest physiotherapy assistance to open heart surgery aims to preserve pulmonary function and reserve physiological and/or functional changes that may occur in the post-operative period due to these complications [7].

Chest physical therapy acting with thoracic expansion exercises and diaphragmatic breathing exercises immediately after the open heart surgery appears to improve oxygenation without triggering increase in pain or other complications [8].

Another important component of care pre and post open heart surgery and one that is widely practiced is early mobilization of the patient [9].

The purpose of this study is to find out the efficacy of early mobilization on ventilatory functions post open heart surgeries.

Material and Methods

Forty patients both male and female (9 women and 31 men) undergoing open heart surgery were recruited from the Surgery Outpatient Department of the from National Heart Institute in the duration from April to September 2019. Were enrolled in that study for ten days after surgery. They were randomly assigned into two equal groups: Either the intervention group (Group I) receiving early physiotherapy-directed mobilization plus routine postoperative chest physiotherapy (deep breathing exercises and splinted coughing), or the control group (Group II) who received only routine post-operative chest physiotherapy (they were mobilized only by the third post-operative day). The frequency and duration of treatment was two sessions for the first two pre and post-operative day and once per day on the third and up to the tenth post-operative day. All of them underwent evaluation of pulmonary functions: Forced Vital Capacity (FVC), forced expiratory volume in the first second (FEV_1) and Peak Expiratory Flow (PEF) pre-treatment and 10^{th} post-operative days.

1- *Inclusive criteria:* All patients who are posted for open heart surgery with:

Age 45-65 years both male and female subjects. No history of previous surgery. Elective surgeries.

2- *Exclusion criteria:*

Patients who had met one of the following criteria were excluded from the study: Emergency open heart surgery subjects, patients who have developed hemodynamic complication (intraoperative, myocardial infarction using of an intra-aortic ballon, marked hypotension or arrhythmic or low cardiac output), neuromuscular disorders, respiratory insufficiency requiring artificial airway and patient with preoperative chest disease, hypertension, diabetes mellitus, or obesity BMI >30.

Instrumentation:

- *For assessment:*

• Computerized spirometer (ZAN 100 Handy 1 1-TB 100 E006): It was used to measure Forced Vital Capacity (FVC), forced expiratory volume in first second (FEV_1) and Peak Expiratory Flow Rate (PEFR) [10].

- *For treatment:*

• *Routine chest physiotherapy procedure:* It was consisted of deep breathing exercises (bilateral basal expansion ex) followed by splinted huff and/or cough the DBEs were performed in four series of five breaths with 3 seconds of sustained breathing [11].

• *Early mobilization:* It was commenced in the form of sit on the bed-sit out of the bed-walk 5 meter with assistance-walk 15 meter with assistance-walk 30 meter with assistance-walk 30 meter without assistance [12].

Intervention program:

Pre-operatively, patients received instructions and education concerning the effects of open heart surgery on the lungs, post-operative deep breathing exercises, coughing with wound support, the technique of spirometry, to ensure that all patients had done their best effort during the assessment and treatment phases. The patients in the early mobilization group (Group I) were taught about the post-operative early mobilization program.

Post-operative procedures:

The standardized post-operative pain regimen was the same in both groups, and consisted of diclofenac sodium, 75mg I/M 12 hourly to maintain pain at a comfortable level (score of 3 to 5). All patients had a standardized general pain regimen with no peridural catheter use. Patients quantified their incisional pain at rest using a Visual Analog Scale (VAS) which consists of a 10-cm-long horizontal line that is anchored with verbal descriptors: “No pain” and “Worst pain imaginable”. Patients

are asked to make a mark at the point that best represents the intensity of their current pain **[13]**.

Pulmonary function test:

Spirometric evaluation had been undertaken on Post-Operative Days (PODs) 1-10. The following variables were measured: Forced Vital Capacity (FVC%) and forced expiratory volume in one second (FEV_1%) and Peak Expiratory Flow (PEF%), by spirometry (ZAN 100 Handy 1 1-TB 100 E006) with the subject lying in the supine posture (with 30º head tilt upwards) as post-operative pain prevented the patients in assuming the erect posture. The patients were instructed to breathe out forcibly into the spirometer after taking a deep breath. Values were noted down after taking three readings. Data were expressed as a percentage of the predicted values for age, height, and sex **[10]**.

Treatment programs:

- *Group I (intervention group):* In this group, twenty patients underwent routine chest physiotherapy and a standardized program of early mobilization pre and post surgery they were mobilized as early as possible from the first post-operative.
- *Group II (control group):* In this group, twenty patients who had open heart surgery received only supervised routine physiotherapy treatment (deep breathing and splinted coughing exercises), they were mobilized only by 3rd post-operative day.

Routine chest physiotherapy procedure:

Patients of the two groups received the routine chest physiotherapy program 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 four series of five breaths with 3 seconds of sustained breathing interspersed with periods of quiet breathing followed by two or three coughs or huffs (with wound support by a pillow or his/her hands). Instruction and supervision from the physiotherapist focused on bilateral basal expansion, avoiding upper chest and shoulder elevation, and maximizing expansion of the lower chest diameters during inspiration, with a three second end inspiratory hold, followed by relaxed expiration. This was done with the subject in sitting on a chair or on a bed with the head end raised, with the physiotherapist providing bilateral proprioceptive feedback with the hands on the lower ribs. Patients were also encouraged to practice these DB & C exercises every waking hour by themselves **[11]**.

Early mobilization procedure:

Provided that subjects were awake (or drowsy but easily woken), had stable blood pressure and heart rate and no dyspnea at rest, and less than 8/10 pain, the following goals will be attempted in order during each treatment session: Sit on the bed-sit out of bed-walk 5 meter with assistance-walk 15 meter with assistance-walk 30 meter with assistance-walk 30 meter without assistance. The subjects were encouraged to achieve one or more goals with each treatment session, and to walk at a speed where they were taking deeper breaths than at rest, at an intensity of at least 6/10 according to the Borg 10 point scale of perceived exertion. This was intended to challenge the respiratory system sufficiently to produce an increase in minute ventilation. If subjects were not deemed fit enough to manage any distance (for example due to pain, nausea or breathlessness) they mobilized as far as safely possible. The frequency of treatment was two sessions per day on the first two pre and post-operative days and once per day on the third and up to the tenth post-operative day. Subjects permitted to also attempt the goals with relatives **[12]**.

Statistical analysis:

Descriptive statistics was done in the form of mean and standard deviation. Inferential statistics assessed Changes in CP including: Paired *t*-test was used for this variable to compare between the pre and post-treatment results for each group and the pre and post-treatment mean values of pulmonary functions between both groups post-treatment. The level of significance was established at the convention <0.05 level. All statistical analysis was conducted through the Statistical Package for Social Studies (SPSS) Version 19 for windows. (IBM SPSS, Chicago, IL, USA) **[14]**.

Results

As shown in (Table 1) there was no significant difference between the two groups in all anthropometric measurements and clinical data including; age, weight and height at the beginning of the study ($p>0.05$) and there was no significant difference were recorded between the two groups in the pre-treatment measured variables FVC, FEV_1 and PEF ($p>0.05$).

There was no significant difference ($p>0.05$) were recorded in the pre-treatment measured variables FVC, FEV_1 and PEF between the two groups, which confirm the homogeneity of the sample in both groups before administrating any treatment procedure (Table 2).

There was a significant difference when comparing pre and post mean values of all measured variables (p<0.001). Where means and standard deviations of FVC, FEV 1 and PEF of Group I increased post-treatment by 8.4, 11.49 and 18.19 respectively and the percentage of improvement in the measured variables was 17.94%, 20.41%, 18.19% respectively. Also, means and standard deviations of FVC, FEV1 and PEF of Group II increased post-treatment by 15.03, 10.92 and 6.91 respectively and the percentage of improvement in the measured variables was 13.71, 10.92 and 13.28 respectively (Table 3) and Fig. (1).

When comparing post mean values between both groups, the results revealed that there was a significant improvement spirometric indecies FVC, FEV1 and PEF of Group I compared with Group II (p<0.001), as shown in (Table 4) and Fig. (2).

Table (1): Comparison of the mean value of age (y), weight (kg), and height (cm) between Group I and II.

	Group I $\bar{X}$ ± SD	Group II $\bar{X}$ ± SD	*t*-value	*p*-value	Sig.
Age (years)	57.15±4.43	57.15±4.43	–1.05	0.29	NS
Weight (kg)	71.815±6.77	71.815±6.77	–0.91	0.36	NS
Height (cm)	165.45±3.11	165.45±3.11	–1.07	0.28	NS

$\bar{x}$: Mean. *p*-value : Probability value.
SD : Standard Deviation. *t*-value : Unpaired *t*-value.
NS : Non Significant.

Table (2): Comparison of the spirometric incidences between Group I and II pre-treatment.

Spirometric index (%)	Group I $\bar{X}$ ± SD	Group II $\bar{X}$ ± SD	*t*-value	*p*-value	Sig.
Pre-treatment:					
FVC	62.65±7.72	61.03±3.04	0.87	0.38	NS
FEV1	64.89±3.96	63.05±4.51	1.37	0.17	NS
PEF	60.74±3.54	59.1±5.72	1.08	0.28	NS

$\bar{x}$: Mean. *p*-value : Probability value.
SD : Standard Deviation. *t*-value : Unpaired *t*-value.
NS : Non Significant.

Table (3): Comparison of spirometric indices between pre and post-treatment in Group I and Group II.

Spirometric index (%)	Pre-treatment $\bar{X}$ ± SD	Post-treatment $\bar{X}$ ± SD	% of improvement	*t*-value	*p*-value
Group I:					
FVC	62.65±7.72	73.89±4.45	17.94	–8.4	0.0001
FEV1	64.89±3.96	78.14±43	20.41	–11.49	0.0001
PEF	60.74±3.54	76.9±2.17	26.6	–18.19	0.0001
Group II:					
FVC	61.03±3.04	69.4±3.47	13.71	–15.03	0.0001
FEV1	63.05±4.51	70.05±4.97	11.1	–10.92	0.0001
PEF	59.1±5.72	66.95±5.84	13.28	–6.91	0.0001

$\bar{x}$: Mean. *p*-value : Probability value.
SD : Standard Deviation. *t*-value : Unpaired *t*-value.
S : Significant.

Table (4): Comparison of spirometric indices between Group I and II post-treatment.

Spirometric index (%)	Group I $\bar{X}$ ± SD	Group II $\bar{X}$ ± SD	*t*-value	*p*-value	Sig.
Post-treatment:					
FVC	73.89±4.45	69.4±3.47	3.55	0.001	S
FEV1	78.14±4.3	70.05±4.97	5.5	0.0001	S
PEF	76.9±2.17	66.95±5.84	7.13	0.0001	S

$\bar{x}$: Mean. *p*-value : Probability value.
SD : Standard Deviation. *t*-value : Unpaired *t*-value.
S : Significant.

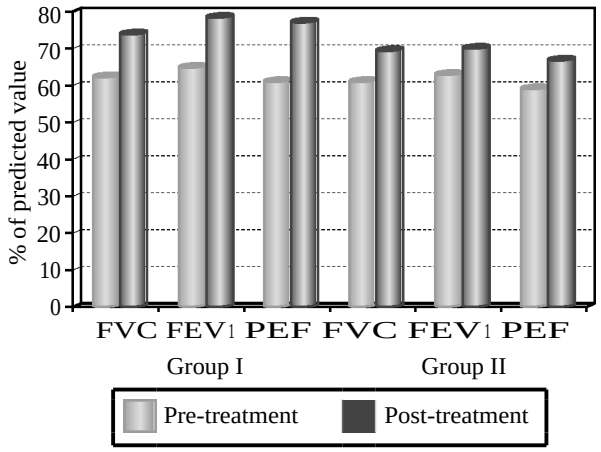

Fig. (1): Pre and post-treatment mean values of Spirometric indices in Group I and Group II.

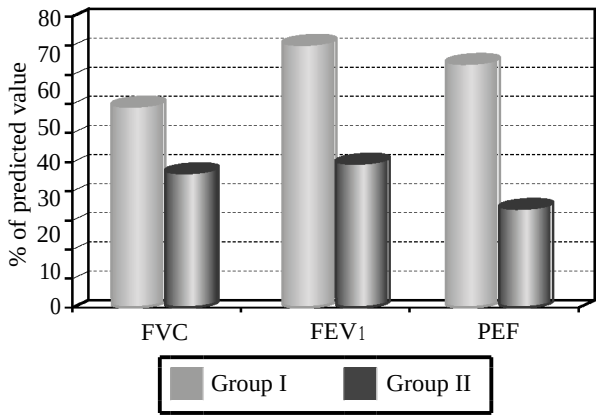

Fig. (2): Post-treatment mean values of Spirometric indices in Group I and Group II.

Discussion

The current study aimed to was to find out the efficacy of early mobilization on ventilatory functions post open heart surgeries.

Studies have reported that pulmonary function alters following open heart surgery. These functional alterations are characterized by reduction of the Vital Capacity (VC) as well as the Forced Vital Capacity (FVC) and forced expiratory volume in the first second (FEV 1) **[15]**.

Open heart surgery is associated with reductions in lung function and diminished ability by the patient to breathe deeply and cough effectively. Reduced pulmonary function (FVC, FEV 1, and PEFR) in post-operative open heart surgery subjects might be due to post-operative pain, location of surgical ports, along with anaesthetic, analgesic usage **[3]**.

Chest physical therapy acting with thoracic expansion exercises and diaphragmatic breathing exercises immediately after the surgey appears to improve oxygenation without triggering increase in pain or other complications **[8]**.

On the other hand, Agostini et al., stated that pulmonary physiotherapy was not enough for preventing pulmonary complications alone after lung resection surgery **[16]**.

Early mobilization was an important feature recommended in the approach of patients undergoing open heart after guideline implementation. It is believed that early mobilization results in increased lung volume, with consequent prevention of atelectasis **[17]**.

The findings of this study showed there was more improvement in dynamic ventilator parameter (FVC%/FEV 1/PEF) among patients who had early mobilization plus the routine chest physiotherapy compared to those who had routine chest physiotherapy exercise alone post open heart surgeries. The percentage of improvement in Group I in measured variables (FVC, FEV 1 and PEF) was 17.94%, 20.41 and 26.6 respectively and the percentage of improvement in Group II in all measured variables was 13.71%, 11.1% and 13.28% respectively. The following results demonstrate that addition of a standardized program of early mobilization to routine post-operative chest physiotherapy has a positive effect on pulmonary functions post open heart surgeries. The results of this study were consistent with the study of Samnani et al., **[18]**, recommended that in their study, pulmonary physiotherapy should be supported with mobilization.

The results of this study were consistent with the study of Brasher et al., **[11]**, have even suggested that early mobilization seems to be more effective than deep breathing exercises for the prevention of PPCs. Although the incidence of pulmonary complications has not been covered in this study, the early normalization of the pulmonary functions suggest a lower risk of further development of the most common pulmonary complications, namely atelectasis and hypoxemia **[15]**.

It was stated that mobilization implemented for the purpose of recovering pulmonary functions, supporting to the cardiovasculary system, preventing post-operative complications and improving sensation of wellness reduced the length of stay **[19]**.

These findings of this studty were supported by the findings of Browning et al., **[20]** who studied with patients undergone open heart surgery reported that daily frequency and duration of mobilisation and walking greater than 5 metres on day have a positive effects on reducing the length of stay.

Such results were supported by the findings of Neilsen et al., **[21]**. Concluded that mobilization involving an upright position is most beneficial in the early post-operative period and produces evidence of improvement in pulmonary function.

In contrast to the findings of our results Mackay et al., **[12]** and Silva et al., **[19]** suggested that the addition of DB and C to early ambulation does not significantly reduce the incidence of PPC.

Conclusion:

On basis of the current study supported by relevant literature, it can be concluded that early mobilization is effective in improving ventilatory functions after open heart surgery.

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تأثير تمارين الحركة المبكرة والعلاج الطبيعى الروتينى للصدر على وظائف الرئة ما بعد جراحات القلب المفتوح

الغرض من هذه الدراسة هو معرفة مدى تأثير الحركة المبكرة على وظائف الرئة بعد عمليات القلب المفتوح، شارك فى هذه الدراسة أربعون مريضاً من الجنسين (واحد وثلاثون ذكور وتسعة إناث) من الذين خضعوا لعمليات قلب مفتوح تم إختيارهم من معهد القلب القومى تراوحت أعمارهم بين خمسة وأربعين وخمسة وستين عاماً، تم توزيعهم بشكل عشوائى إلى مجموعتين من أعداد متساوية، المجموعة (أ) تلقت برنامج الحركة المبكرة قبل وبعد العملية بالإضافة إلى برنامج العلاج الطبيعى الروتينى للصدر والمجموعة (ب) تلقت برنامج العلاج الطبيعى الروتينى للصدر فقط وكانت معدل الجلسات مرتين يومياً خلال اليومين الأوليين قبل وبعد العملية ومرة واحدة من اليوم الثالث إلى اليوم العاشر بعد العملية، وتم تقييم وظائف التنفس لكل مريض من المجموعتين قبل وبعد عمل برنامج العلاج.

\النتائج: لم يكن هناك فرق كبير بين المجموعتين فى جميع وظائف التنفس المقاسة قبل البدء فى برنامج العلاج المحدد لكل مجموعة، بينما كان هناك إختلاف كبير عند المقارنة بين ما قبل وما بعد البرنامج العلاجى من كل المتغيرات المقاسة فى كل مجموعة، وعند المقارنة بين كل المجموعتين أظهرت النتائج تحسناً "كبيراً فى صالح المجموعة (أ).

\الخلاصة: برنامج التحريك المبكر قبل وبعد عمليات القلب المفتوح يساعد على تحسين وظائف التنفس.