Pre and Post Operative Physiotherapeutic Management in Open Heart Surgery

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ABSTRACT

This work was conducted to study the effect of the application of pre and post-operative diaphragmatic breathing exercises on pulmonary functions and the rate incidence of pulmonary complications in patients undergoing open heart surgery. Thirty patients participated in this study and were divided into two equal groups. The patients of both groups were instructed to practice diaphragmatic breathing exercise. The patients in the first group were instructed to practice this exercise at the forth day post-operatively twice a day (morning and evining) for 15 minutes. While the patients in the second group practiced this technique twice a day for one week pre-operatively and were instructed to perform it by themselves in the intensive care unit every two hours in additon to the program given to the first group. The obtained data of this investigation indicated the following alterations: there was an increased ability of patients to perform the previously learned exercise smoothly, with more confidence and remarkable co-operation post-operatively. There was also a significant reduction in the incidence of pulmonary complications and atelectasis in the trained patients, with a significant increase in the pulmonary functions and a significant decrease in post-operative hospitalization period, sputum volume, respiratory and heart rates. The conclusion drived from this study, suggested that the application of pre operative diaphragmatic breathing exercise for one week, lead to remarkable improvement in the pulmonary functions and reduced the rate of incidence of pulmonary complications in comparison to open heart surgery patients who did not receive such training program.

INTRODUCTION

Deep breathing techniques such as diaphragmatic and/or pursed lip breathing have been used to control dyspnea[1], increase ventilation to the lung basis[4,5], increase the efficiency of the respiratory muscles[13], improve arterial oxygen saturation[9,12,18,19,23,28] and decrease the respiratory rate[28]. Diaphragmatic breathing exercises have been administrated to eliminate accessory muscle activity, strengthen the dia-phragm[20] and promote normal alveolar ventilation[6]. They are also used to retrain a normal pattern of breathing to mobilize the costovertaberal, costotransverse, costochondral and chondrosternal joints and to increase the venous return to the heart[15]. Diaphragmatic breathing exercise is now widely used after abdominal and heart surgeries to prevent secondary pathology in the lungs and to improve the physical condition of the patients[17]. The opportunity to work with patient pre operatively provides benefit for both the patient

and therapist. The goals of pre operative meeting with the patient are to inform him with the importance of his chest physical therapy program and by demonstration to familiarize him with the techniques he will use post operatively[11]. Changes in the mechanics of breathing, lung volumes and gas exchange have been noted to occur after thoracotomy and sternotomy. These changes are attributable to a decrease in the respiratory drive from general anesthesia, narcotics and a decrease in thoracic expansion from pain and accompanying muscle spasm. Persistence of these abnormal changes facilitate alveolar collapse and after hours may result in gross atelectasis[2]. This may result in decreased lung capacity and compliance, thereby, increasing the work of breathing. In order to reverse such processes, breathing exercises specially the diaphragmatic breathing has been recommended pre and post-operatively for patients undergoing open heart surgery[14,24].

The main aim of this study was to evaluate the degree of improvement in pulmonary functions, as a result of pre-operative diaphragmatic breathing exercise and in post-operative conditions. The second aim of this study was to measure the trend of reduction of pulmonary complications after open heart surgery in response to breathing exercise. The third aim of this study was to evaluate the changes in treatment time and hospitalization period in these post-operative conditions as a result of breathing exercise program.

METHODS

Thirty patients of both sexes with open heart surgeries participated in this study. They were assigned randomly into two groups. The first group (control): consisted of 15 patients (3 females and 12 males) with age ranged from 18 to 51 years and a mean value of 25.87 years. This group was treated with diaphragmatic breathing exercise only at the fourth day post-operatively for two weeks. The second group (study): consisted of 15 patients (3 females and 12 males) ranging in age from 18 to 58 years and a mean value of 29.67 years. This group was trained and instructed with diaphragmatic breathing exercise for one week pre-operatively, in addition to the same technique given to the first group at the fourth day post-operatively for two weeks.

PROCEDURES

Each patient was asked to sit in the bed with his or her back completely supported, with hips and knees semiflexed, placing both hands over the midrectus abdominis area. The patient was directed to inhale slowly through the nose, then, he/she was instructed to watch the hands as inspiration continue. He/she was encouraged to direct the air so that both hands gradually rises as inspiration continued. The patient was instructed to avoid excessive movement of the sternum. Firm counter pressure was applied over the patient's hands just before directing the patient to inhale. Each patient was instructed to inhale so as to lessen the counter pressure as inspiration continues. This exercise was practiced until the patient requires no assistance. The exercise was applied at the fourth day post-operatively, twice a day (morning and evening) for 15 minutes, over two weeks for both groups by the physiotherapist. The study group practiced this technique, also twice a day for one week preoperatively. They were instructed to perform it by themselves in the intensive care unit every two hours. Also, all the patients of both groups were instructed to practice another breathing exercise every two hours post operatively as follows: deep diaphragmatic breathing five

times successifuly, followed by normal breathing for two minutes. This process was repeated for at least 25 minutes[20].

The pulmonary functions concerning vital capacity (VC), forced vital capacity (FVC), forced expiratory volume at first second (FEV_1) and maximum voluntary ventilation (MVV) of the control and study groups were obtained daily in the morning before and after application of diaphragmatic breathing exercise at the fourth day post-operatively and for two weeks, using the microprocessor controlled spirometer model MS-11.

The pulseminder model 8329, was used daily to measure heart rate before and after treatment, while respiratory rate was measured manually. Sputum volume expectorated during each day for each patient was collected in the graduated cylinder (sputum mug, 250 ml) containing 30 cc of chloroform. The difference in graduation represents sputum volume.

RESULTS

Vital Capacity (VC) :

The mean value of VC in the control group was 0.83 ± 0.15 L and 0.95 ± 0.17 L, before and after treatment respectively (table1) and (fig.1) with a mean difference of 0.11 L, about 14.02 % of the original value (table 4). While in the study group the mean value of VC was 1.44 ± 0.19 L and 1.65 ± 0.25 L before and after treatment respectively (table1), with a mean difference of 0.20 L, about 14.42% of the original value (table 3) and (fig. 2).

Forced Vital Capacity (FVC) :

The mean value of FVC in the control group was 0.95 ± 0.18 L and 1.12 ± 0.24 L before and after treatment respectively (table1) and (fig.1) with a mean difference of 0.14 L, about 14.12 % of the original value (table 4). In the study group the mean value of FVC was 1.71 ± 0.22L and 1.94 ± 0.29L before and after treatment respectively (table 1), with a mean difference of 0.23 L, about 13.66 % of the original value (table 4) and (fig. 2).

Forced Expiratory Volume-first second (FEV_1):

The mean value of FEV_1 in the control group was 0.64 ± 0.11 L and 0.79 ± 0.16 L before and after treatment respectively (table1) and (fig. 1) with a mean difference of 0.15 L, about 23.30 % of the original value (table 4). In the study group the mean value of FEV_1 was 1.37 ± 0.18 L and 1.68 ± 0.22 L before and after treatment respectively (table 1) and (fig.2) with a mean difference of 0.30 L, about 22 % of the original value (table 4).

Table (1): Mean, standard deviation and standard error for VC, FVC and FEV_1 of the control and study groups.

Control Group						
	VC (Liter)		FVC (Liter)		FEV_1 (Liter)	
	B	A	B	A	B	A
Mean	0.83	0.95	0.95	1.12	0.64	0.79
S.D.	0.15	0.17	0.18	0.24	0.11	0.16
S.E	0.04	0.04	0.05	0.06	0.03	0.04
Study Group						
	VC (Liter)		FVC (Liter)		FEV_1 (Liter)	
	B	A	B	A	B	A
Mean	1.44	1.65*	1.71	1.94*	1.37	1.68*
S.D.	0.19	0.25	0.22	0.29	0.18	0.22
S.E	0.05	0.06	0.06	0.07	0.05	0.06

B : Before treatment * *: Significant ($P < 0.05$)*
A : After treatment

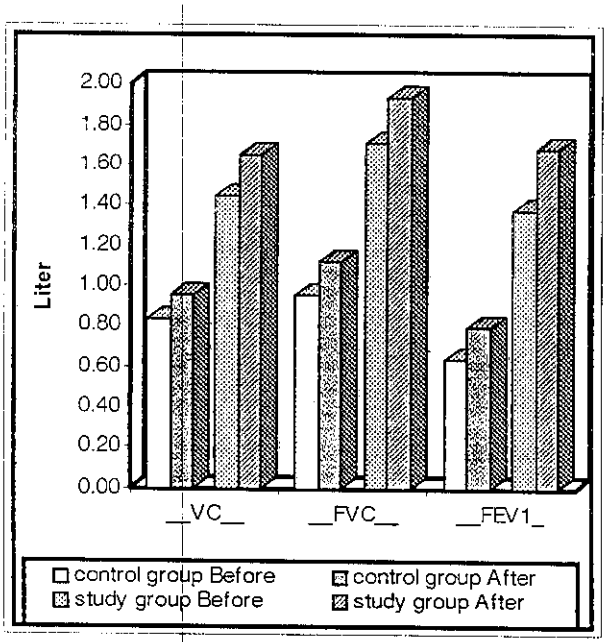

Fig. (1) : Mean values of VC, FVC and FEV_1 for control and study groups, before and after treatment.

Maximum Voluntary Ventilation (MVV) :

The mean value of MVV in the control group was 30.92 ± 7.69 l/min. and 36.78±9.96 l/min. before and after treatment respectivaly (table 2) and (fig. 2) with a mean difference of 5.86 l/min., about 18.95% of the original value (table 4). While in the study group it was 53.41±9.17 l/min. and 62.78±10.28 l/min. before and after treatment respectively (table2) and (fig. 3) with a mean difference of 9.37 l/min., about 17.54% of the original value (table 4).

Changes in the pulmonary function concerning (VC, FVC, FEV_1 and MVV) of the control group were found to be statistically non-significant. In the study group the values were found to be statisticaly significant ($P<0.02$) for VC, FVC, MVV and ($P<0.001$) for FEV_1 .

Table (2): Mean, standard deviation and standard error for MVV, RR and HR of the control and study groups.

Control Group						
St.	MVV (Liter/min)		RR (breath/min)		HR (beat/min)	
	B	A	B	A	B	A
Mean	30.92	36.78	31.22	29.30	101.39	99.29
S.D.	7.69	9.96	3.86	4.04	9.66	9.83
S.E	1.99	2.57	1.00	1.04	2.50	2.54
Study Group						
St.	MVV (Liter/min)		RR (breath/min)		HR (beat/min)	
	B	A	B	A	B	A
Mean	53.41	62.78*	25.64	22.68*	96.09	91.59*
S.D.	9.17	10.28	3.20	2.49	6.80	6.57
S.E	2.37	2.66	0.78	0.64	1.76	1.70

B : Before treatment
A : After treatment
* : *Significant (P<0.01)*

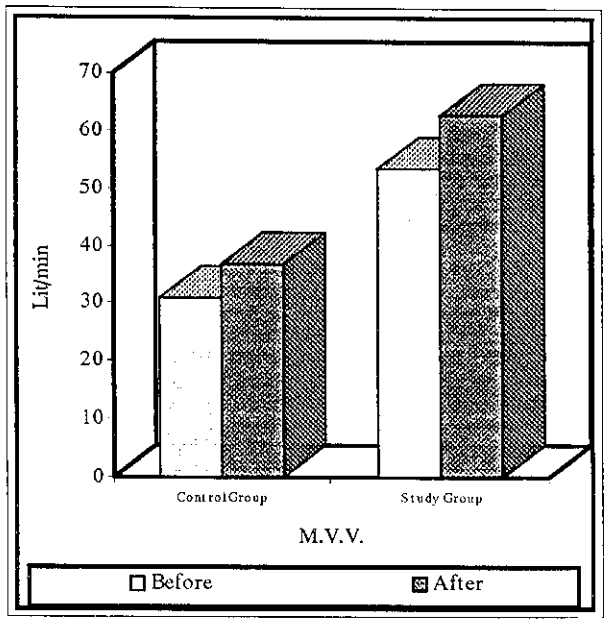

Fig. (2) : Mean of changes in M.V.V. for the both control gruop and study group, before and after treatment.

Respiratory Rate (RR) :

The mean value in RR of the control group was 31.22 ± 3.86 breath/min. and 29.30 ± 4.04 breath/min. before and after treatment respectivaly (table 3) and (fig. 4) with a mean difference of 1.92 breath/min, about 6.15 % of the original value (table 4). In the study group it was 25.64 ± 3.20 breath/min and 22.68 ± 2.49 breath/min. before and after treatment (table 3) and (fig. 4), with a mean difference of 2.96 breath/min, about 11.54 % of the original value (table 4). These changes were found to be statistically non-significant in the control group while it was significant in the study group ($P < 0.01$).

Heart Rate (HR) :

The mean value of HR in the control group was 101.39 ± 9.66 bpm and 99.29 ± 9.83 bpm before and after treatment respecitively (table 3) and (fig. 5) with a mean difference of 2.10 bpm, about 2.07 % of the original value (table 4). In the study group it was 96.09 ± 6.80 bpm and 91.59 ± 6.57 bpm before and after treatment (table 3) and (fig. 5), with a mean difference of 4.5 bpm, about 4.68% of the original value (table 4). These changes were found to be statistically non-significant in both groups.

Sputum Volume:

The mean value of the sputum volume in the control group was 46.53 ± 15.51 cc while it was 6.93 ± 3.00 cc in the study group (table 5) and (fig. 6). Significant decrease in the sputum volume ($P<0.001$) was found when a comparison was done between the control and the study groups.

Concerning the difference in the mean values between the control and study groups the data in table (5) indicate that changes in sputum volume, FEV1, RR and HR were found to be statistically significant ($P < 0.01$).

Chest complications:

In the control group, two patients were infected with bronchitis, one with right lower lobe pleural effusion, and the other with sternal infection and another two suffered from left lower lobe atelectasis. While in the study group two patients were infected with bronchitis and one complained from infection at the incisional part of the right upper thigh, after coronary artery by pass (table 6).

Percentage of chest complications :

Concerning the chest complications in the control group, 4 patients had been infected and complained from chest diseases, this result represents about 80% of the original value. While in the study group two patients had been infected only, this represents about 40% of the original value (table 6).

Table (3): Percentage of changes in VC, FVC, FEV_1, MVV, RR and HR of the control and study groups.

Control Group				
	Befor	After	Difference	%
VC	0.83	0.95	0.11	14.02
FVC	0.95	1.12	0.14	14.12
FEV1	0.64	0.79	0.15	23.30
MVV	30.92	36.78	5.86	18.95
RR	31.22	29.30	1.92	6.15
HR	101.39	99.29	2.10	2.07
Study Group				
	Befor	After	Difference	%
VC	1.44	1.65	0.20	14.42
FVC	1.71	1.94	0.23	13.66
FEV1	1.37	1.68	0.30	22.00
MVV	53.41	62.78	9.37	17.54
RR	25.64	22.68	2.96	11.54
HR	96.09	91.59	4.50	4.68

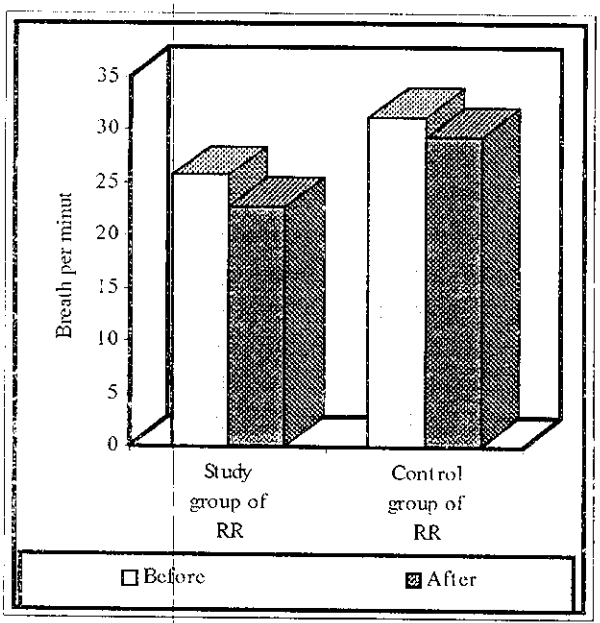

Fig. (3): Mean values of RR for both study and control groups before and after treatment.

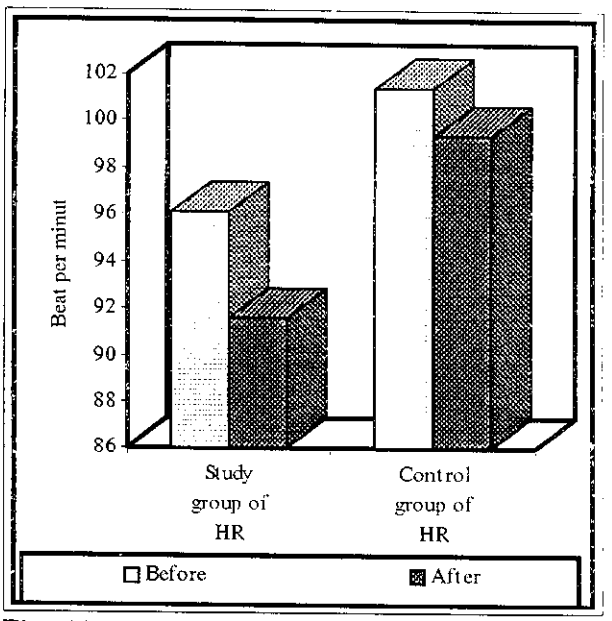

Fig. (4): Mean values of HR for both study and control groups before and after treatment.

Hospitalization Period :

The mean value of post-operative hospitalization period of the control group was 14.7 ± 2.85 day, while in the study group it was 11.5 ± 7.78 day. These changes were found to be statistically significant ($P < 0.001$) (table 6).

Table (4): Mean difference, S.D. and S.E. of VC, FVC, FEV1, MVV, RR, HR and sputum volume for the both control and study groups.

		Mean D.	S.D.	S.E.
VC	C	0.11	0.04	0.02
	S	0.20**	0.08	0.02
FVC	C	0.14	0.09	0.02
	S	0.23**	0.09	0.02
FEV_1	C	0.15	0.07	0.02
	S	0.30**	0.09	0.02
MVV	C	5.86	4.60	1.19
	S	9.37**	2.58	0.66
RR	C	1.92	0.77	0.20
	S	2.96**	0.91	0.24
HR	C	2.10	0.68	0.18
	S	4.50°	1.38	0.36
Sputum	C	46.53	15.51	4.01
	S	6.93°	3.00	0.77

C : Control group.
S : Study group.
** : *Significant increase (P<0.01).*
° : *Significant decrease (P>0. 01)*

Table (5): The distribution of chest complications, mean and standard deviation of hospitalization period for both control and study groups.

Patient's number	Control group	Days	Study group	Days
1	No	12	Bronchitis and three days fever.	15
2	Bronchitis and four days fever.	15+	four days fever.	15
3	Left lower lobe atelectasis.	15+	No.	9
4	four days fever.	15+	No.	10
5	Left lower lobe atelectasis.	15+	No.	11
6	Bronchitis	15	No.	9
7	Bronchitis	15	No.	10
8	Right pleural effusion.	15+	No.	12
9	Sternal infection and bronchitis.	15+	Infection of the right upper thigh(coronary by pass graft).	15+
10	No.	15	No.	9
11	No.	12	No.	12
12	Right pleurizy	15+	No.	11
13	No.	15	No.	15
14	Bronchitis and four days fever.	15+	Bronchitis	11
15	No.	15	No. No.	11
Mean S.D.		14.60 1.06		11.00 3.77

+ : The hospitalization period was more than 15 days, post-operatively
- : significant in the post-operative hospitalization period, (P<0.001).

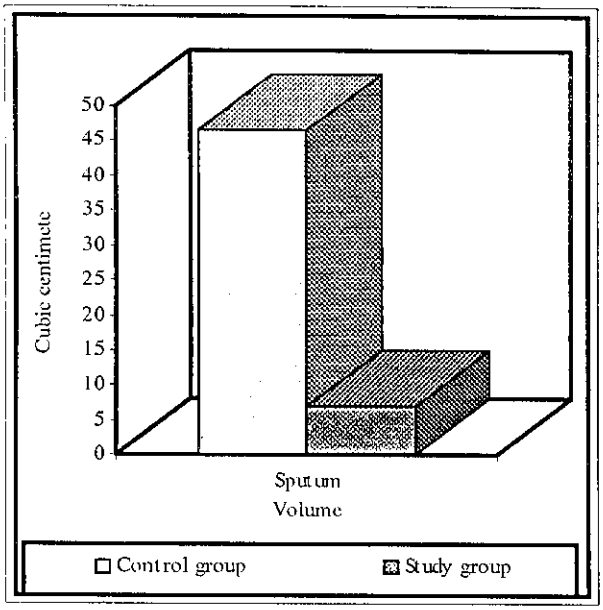

Fig. (5) : Mean values of sputum volume (cc) for both control and study groups.

DISCUSSION

Decrease compliance of the lungs and decreased diaphragmatic excursion have been found to be reduced during the first 3 days postoperatively, putting patients at a risk of developing atelectasis and/or pneumonia[21], also a considerable reduction in lung volume in the early post-operative period had been observed[3]. Ventilatory muscle training, has been shown to improve the strength and endurance of ventilatory muscles[10], these training produce an increase in (VC)[16]. Pre-operative patient education can strongly influence course[24], and the vast majority of patients are remarkably co-operative[15,30]. Thirty patients with open heart surgeries were subjected to this study, 15 patients were kept as a control group, treated with diaphragmatic breathing exercise for two weeks post-operatively, whereas 15 patients considered as study group, were treated similarly as the control one, in addition to practicing the same technique for one week preoperatively. The results of this study indicated that the mean difference of (VC) in the control group was 0.11 ± 0.04 L, whereas, in the study group it was 0.20±0.08 L and it was found to be statistically significant. This finding was consistent with those reported by Joan[15],Leith and Bradbeg[16].

Training effects on pulmonary ventilation are associated with an increase in (FVC)[25]. The mean difference of FVC in the control group was 0.14 ± 0.09 L, whereas in the study it was 0.23 ± 0.09 L, with highly significant increase. When a comparison was done between the two groups, it was consistent with that observed with Sinclair and Ingram[25]. Forced expiratory volume at first second (FEV_1) provides an indication of expiratory power and overall resistance to air movement in the lungs[31]. In this study (FEV_1), of the control group, showed that the mean difference was 0.15 ± 0.07L, while in the study group, it was 0.30 ± 0.09L. This increase was found to be statistically significant, when it was compared with the control group. This impro-vement was consistent with that reported by William et al[31]. Concerning MVV, the mean difference increase value of the control group was 5.86 ± 4.60 l/min., while in the study one it was 9.37 ± 2.58 l/min.. This change was found to be statistically signifi-cant, when a comparison was done between the two groups. This result indicates a considerable impro-vement in the endurance of the respiratory muscles of the study group and it is consistent with that reported by Leith[16] and Pardy[22].

Patients undergoing thoracotomy, experience severe postoperative pain and marked respiratory impairment[8]. In addition, the patient's coughing mechanism may be inhibited due to pain, anaesthesia, and narcotics, causing retained secretions[7], predisposing them to mucus plugging and atelectasis[32]. The

present study indicated that the mean value of sputum volume of the control group, was 46.53 ± 15.51 cc. while it was 6.93 ± 3.00 cc. in the study group, which was found to be statistically significant, when a comparison was done between the two groups. The mean difference in respiratory rate of the control group was -1.92 ± 0.77 B/min., while in the study group it was 2.96 ± 0.91 B/min. These changes were found to be statistically significant. Decrease in respiratory rate had been reported after using deep breathing technique[28]. Concerning the heart rate of the control group, the mean difference was 2.10 ± 0.68 bpm, but in the study group it was 4.5 ± 1.38 bpm. These changes were found to be statistically significant, when a comparison was done between the two groups. In this study, the percentage of the chest complications post-operatively for the control group was 80% as compared to a 20% for the study group. The decrease in the percentage of chest complication in the study group come in agreiment with the results of Stein[26], Tarhan[27] and Thoren[29]. Patients with value surgeries treated with pre-operative breathing exercise were discharged 8 days sooner than counter parts who were not treated preoperatively[24]. So, in this study the mean difference value of the hospitalization period post-operatively for the control group was 14.60 ± 1.06 day, but it was 11.00 ± 3.77 day in the study group, with significant decrease.

CONCLUSION

Our results suggested the following conclusions:

- Patients who received preoperative instructions and training with diaphragmatic breathing exercise, were able to perform previously learned exercise, smoothly, without difficulty, with more confidence and remarkable co-operation post-operatively.
- Pre and post-operative diaphragmatic breathing exercises, were more effective in improving pulmonary functions than post-operative exercises only.
- Also, this technique documented the decrease incidence of post-operative pulmonary complications and atelectasis in the study group.
- The post-operative decrease in sputum volume was specially associated with the improvement of FEV_1, and this may be due to the pre-operative training and instructions applied to the study group.
- Decreasing in both respiratory and heart rates, in the study group, are due to the improvement observed in the vital capacity.
- Severe chest problems, which were reported concerning untrained patients, were due to the latency period for understanding the application of the right way of the diaphragmatic movements, during both, inspiration and expiration.

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الملخص العربي

دور العلاج الطبيعي قبل وبعد عمليات جراحة القلب المفتوح

تم إجراء هذه الدراسة لمعرفة أثر تطبيق تمرين تنفس الحجاب الحاجز قبل وبعد الاجراء الجراحي ـ بهدف تحسين وظائف الرئة وتقليل معدل حدوث المضاعفات الرئوية لمرضى جراحة القلب المفتوح.
ثلاثون مريض تطوعوا فى هذه الدراسة وقد تم تقسيمهم الى مجموعتين متساويتين ومتماثلتين (ضابطة وتجريبية). المجموعة الاولى (الضابطة) تكونت من خمسة عشر مريض (٣ أناث و١٢ رجال) وتراوحت اعمارهم بين ١٨-٥٨ سنة وعولجت بتمرين تنفس الحجاب الحاجز فى اليوم الرابع بعد العملية لمدة اسبوعين. أما المجموعة الثانية (التجريبية) فقد تكونت من خمسة عشر مريض (٣ أناث و١٢ رجال) وتراوحت اعمارهم بين ١٨-٥٨ سنة وقد تم معاملتها تماما مثل المجموعة الضابطة بالاضافة الى تطبيق نفس التمرين لمدة أسبوع واحد قبل الاجراء الجراحى.
وقد تم قياس الوظائف الرئوية المختلفة يوميا قبل وبعد التمرين لكل من المجموعتين مع استخدام جهاز Microprocessor respirometer وكذلك تسجيل حجم البصاق ومعدل التنفس ومعدل ضربات القلب والمضاعفات الرئوية وفترة الاقامة بالمستشفى بعد الجراحة.
وقد توصلت الدراسة بأن تطبيق تمرين التنفس بالحجاب الحاجز قبل إجراء الجراحة لمدة أسبوع وبعد الاجراء الجراحى يؤدى الى تحسن فى وظائف الرئة ويقلل من معدل حدوث المضاعفات الرئوية.