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Response of Diaphragmatic Excursion to Inspiratory Muscle Trainer Post Thoracotomy

H. M. Haytham, E. A. Azza, E.S. Mohamed, E. G. Nesreen

***Abstract*—**Thoracotomy is a great surgery that has serious pulmonary complications, so purpose of this study was to determine the response of diaphragmatic excursion to inspiratory muscle trainer post thoracotomy. Thirty patients of both sexes (16 men and 14 women) with age ranged from 20 to 40 years old had done thoracotomy participated in this study. The practical work was done in cardiothoracic department, Kasr-El-Aini hospital at faculty of medicine for individuals 3 days Post operatively. Patients were assigned into two groups: group A (study group) included 15 patients (8 men and 7 women) who received inspiratory muscle training by using inspiratory muscle trainer for 20 minutes and routine chest physiotherapy (deep breathing, cough and early ambulation) twice daily, 3 days per week for one month. Group B (control group) included 15 patients (8 men and 7 women) who received the routine chest physiotherapy only (deep breathing, cough and early ambulation) twice daily, 3 days per week for one month. Ultrasonography was used to evaluate the changes in diaphragmatic excursion before and after training program. Statistical analysis revealed a significant increase in diaphragmatic excursion in the study group (59.52%) more than control group (18.66%) after using inspiratory muscle trainer post operatively in patients post thoracotomy. It was concluded that the inspiratory muscle training device increases diaphragmatic excursion in patients post thoracotomy through improving inspiratory muscle strength and improving mechanics of breathing and using of inspiratory muscle trainer as a method of physical therapy rehabilitation to reduce post-operative pulmonary complications post thoracotomy.

***Keywords*—**Diaphragmatic excursion, inspiratory muscle trainer, ultrasonography, thoracotomy.

I. Introduction

THORACIC surgeries may cause reduced respiratory function, pulmonary complications and increased risk of mortality, morbidity. The risk of post-operative pulmonary complications is relatively high following thoracic surgery; rates have been recorded at between 19% and 59%, compared with only 16% and 17% for upper abdominal surgery and 0% and 5% for lower abdominal surgery. Post-operative physiotherapy aims to reverse atelectasis and secretion retention, and may include deep, and prolonged inspiratory efforts that are thought to reinflate collapsed alveoli, increase pulmonary compliance and reduces regional ventilation–perfusion inequalities [1].

H. M. Haytham, E. A. Azza and E. G. Nesreen are with the Faculty of Physical Therapy, Cardiovascular/Respiratory Disorders and Geriatric Department, Cairo University, Egypt (phone: 00201097002274; e-mail: hythmhamed@yahoo.com).

E.S. Mohamed is with Cardiothoracic Surgery Department, Faculty of Medicine, Cairo University, Egypt (phone: 00201002227242; e-mail: nesreen_2512@yahoo.com).

Patients undergoing thoracotomy associated with lung resection are thought to be at high risk for the development of post-operative pulmonary complications (PPCs) during the post-operative period, and these complications may lead to serious morbidity [2].

Respiratory muscles are the only skeletal muscles vital to life. Surgical procedures can affect the respiratory muscles by a number of pathophysiological mechanisms including thoracoabdominal mechanics, reflexes, neuromechanical coupling, and loss of muscular integrity. Impairment of respiratory muscle function after surgery may lead to post-operative complications such as hypoventilation, hypoxia, atelectasis, and infections, some of which may be life threatening [3].

Only 2 hours of thoracic surgeries causes marked, and selective, diaphragm muscle fiber weakness. In all patients, the force-generating capacity of diaphragm muscle fibers was significantly reduced [4].

Dysfunction of the respiratory muscles is considered as the main cause of post-operative pulmonary complications, and can cause alveolar collapse that contributes to the formation of atelectasis leading to pulmonary infections. Inspiratory muscle training (IMT) appears to be an alternative to prevent these complications [5]. Inspiratory muscle training (IM training) is a technique that is designed to improve the performance of the respiratory muscles (RMs) that may be impaired in a variety of conditions [6]. Inspiratory muscle training (IMT) has been shown to improve inspiratory muscle function, lung volumes, work capacity, and power output in people who are healthy [7].

II. Materials and Methods

The study was conducted on 30 patients of both sexes (16 men and 14 women) after 3 days from thoracic surgery through thoracotomy. The patients were recruited from cardiothoracic department, Kasr –EL-Aini hospital at faculty of medicine, Cairo University. Clinically and medically stable patients with age of 20-40 years were included. Patients with a history of malignant disease, infection, medically unstable and other physical disorders may affect the result as obesity and smoking were excluded. The study was explained to the patients and their signed informed consent was taken. Patients were randomized into the following two groups: study group who received inspiratory muscle training in addition to postoperative routine chest physiotherapy in form of (deep breathing, coughing and early ambulation) (3 sessions per week twice daily for 1month) and control group who received postoperative routine chest physiotherapy in form of (deep

breathing, coughing and early ambulation) (3 sessions per week twice daily for 1month).

Diaphragmatic excursion (the movement of the diaphragm during breathing) was measured during deep breathing while the patient in semi-recumbent position on a comfortable bed using ultrasonography by an ultrasound expert radiologist, postoperatively and also immediately at the end of the training program. Diaphragmatic excursion represents the distance difference between the same leading edge of the diaphragm at end expiration and end inspiration is calculated by M-mode tracing.

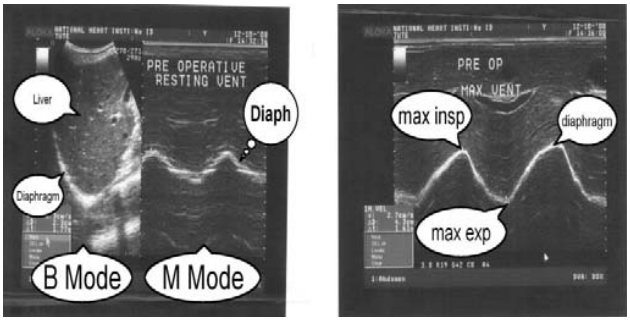

Fig. 1 Pre-operative left and post-operative right U/S showing the liver and diaphragm in the MCL with sub costal approach, toggled with M-mode of the same scanned media showing diaphragmatic motion (thick white line)

The control knob on the top of the inspiratory muscle training device was turned to align the red edge of the pressure indicator to the setting prescribed. The maximum training load was set; the patient identified the load at which they could successfully execute ten breaths at maximum resistance depending on the patient's rate of perceived exertion. Training was started with a load equal to 30% of the patient's maximum inspiratory effort. This individualized load increase progressively as the inspiratory muscle became stronger and the recommended pressure load determined by the 30% maximum 10-repitition method by using IMT device [8].

The mouthpiece was attached to the device and put the nose clip on the patient's nose so that all of the breathing was done through the mouth and making sure the lips were sealed around the mouthpiece and the tongue not occlude it. The Patient was asked taking full breath in (maximal and deep inspiration) then longer and slow expiration through mouthpiece and continues this breathing pattern for 10-20 breath by inhalation and exhalation done through mouthpiece. The duration of treatment session was 10-15minutes with rest in between 30 second. The session was repeated three times/week twice daily for four weeks [9]. Group A and B received the traditional physical therapy program which includes deep breathing, cough and early ambulation [9].

III. Results

The collected data were statistically analyzed using descriptive statistics (the mean and standard deviation). Descriptive statistics and t-test for comparison of the mean age of both groups, the paired t test was used to determine the significance level between pre and post physical therapy treatment. The unpaired t test was used to compare between both groups after treatment. The level of significance for all statistical tests was set at $p < 0.05$. All statistical measures were performed through the statistical package for social studies (SPSS) version 19 for windows.

Basic characteristic in form of age was gathered for each patient to calculate mean and standard deviation. The study group consisted of fifteen patients (8 men and 7 women), with an average age (29.53±5.26). On the other hand, the control group also consisted of fifteen patients (8 men and 7 women), with an average age (28.8±4.31) years old.

The result of this study has shown that diaphragmatic excursion in post thoracotomy patients significantly improved in the study group (A) post treatment in comparison with the control group (B) as shown in Table I.

Baseline clinical and demographic data were presented in Fig. 2. Of the variables presented, no pretreatment differences were observed between the two groups.

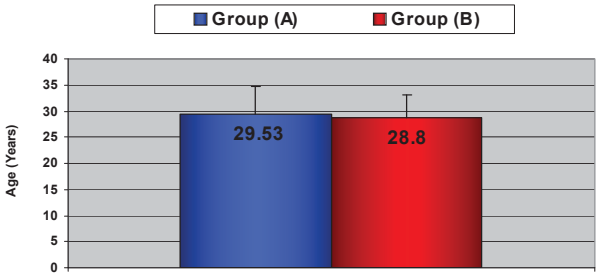

Fig. 2 Mean values of patients' the mean and ±SD of the age for group A and group B

As observed in Fig. 3, there was statistical significant improvement in mean value of patients for post-diaphragmatic excursion in study group A compared with Post- diaphragmatic excursion in control group B at entry of the study. The percentage of improvement in the study group post treatment was 59.52 % while for the control group was 18.66 % ($P<0.05$).

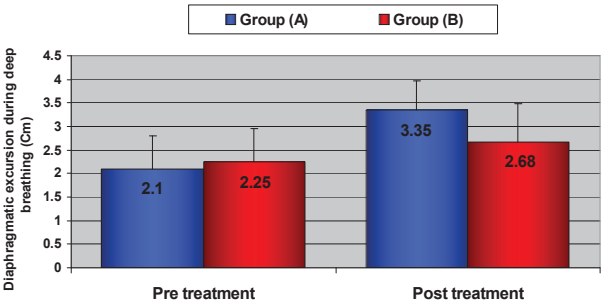

Fig. 3 Mean values of patient's diaphragmatic excursion of pre and post treatment for study group A and control group B

As observed in Fig. 4, there was no statistical significant difference in mean value of patient's post- diaphragmatic

excursion between men and women in group A but there was statistical significant improvement in mean value of patients for post- diaphragmatic excursion compared with pre-diaphragmatic excursion in group A at entry of the study (P<0.05)

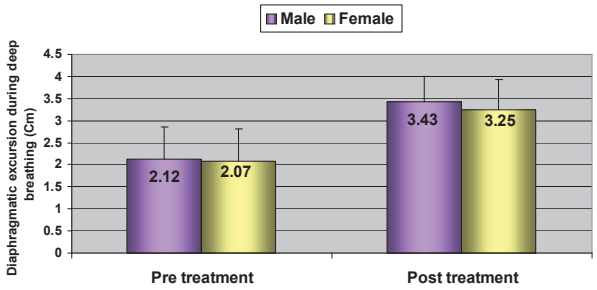

Fig. 4 Mean values of patient's diaphragmatic excursion of pre and post treatment for men and women in group (A)

As observed in Fig. 5, there was no statistically significant difference in mean value of patient's post-diaphragmatic excursion between men and women in Group B but there was statistical significant improvement in mean value of patient's post-diaphragmatic excursion compared with pre-diaphragmatic excursion in group B at entry of the study (P<0.05)

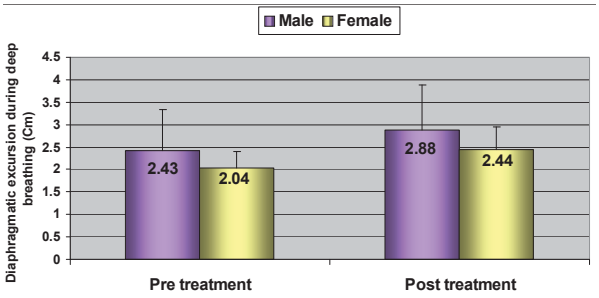

Fig. 5 Mean values of patient's diaphragmatic excursion of pre and post treatment for men and women in group (B)

TABLE I
MEANS, STANDARD DEVIATION AND PAIRED T-TEST FOR STUDY AND CONTROL GROUPS

Groups	Diaphragmatic Excursion			
	Pre	Post	**T-Value**	**P-Value**
Study group	2.1±0.71	3.35±0.61	19.39	0.0001
Control group	2.25±0.75	2.68±0.85	7.92	0.0001

IV. DISCUSSION

Contrary to our hypothesis, we found that inspiratory muscle training has a significant effect on diaphragmatic excursion in post-thoracotomy patients in addition to improvement of mechanics of breathing which in turn help to reduce the severity of postoperative diaphragmatic dysfunctions. The analysis of the results of the current study showed that diaphragmatic excursion in post thoracotomy patients significantly improved in the study group (A) post treatment in comparison with the control group (B). This improvement in diaphragmatic excursion may be due to improvement of diaphragm mechanics, power and inspiratory muscle strength. Statistical significance was established at the conventional 0.05 level.

A controlled trial of IMT (pressure threshold) in 35 lung resection patients was taken. The IMT group (n=25) training for 20 minute per day, six times per weeks for one week pre-operative and 3 weeks post-operative, started with load of 30% MIP, exhibited a significant improvement in inspiratory muscle strength (70.36%) and reduction of post-operative atelectasis in study group more than control group [10].

Previous study revealed that IMT intervention improves exercise capacity and quality of life, particularly in patients with inspiratory muscle weakness. Some benefit from IMT may be accounted for by the attenuation of the inspiratory muscle metabolic reflex. Moreover, IMT results in improved cardiovascular responses to exercise and to those obtained with standard aerobic training. [11].

In agreement with the results of the current study, it showed that most patients experience a reduction in inspiratory muscle function post-operative lobectomy, as well as a decline in lung function. They tested the hypothesis that IMT enhance inspiratory muscle strength and lung function both pre and post-operative. This improvement was also associated with significantly better lung function test results as compared with those in the control group of patients who were not given training [12].

The results of this study are coincided with result that examined effect of IMT on inspiratory muscle strength and post-operative pneumonia for patients undergoing pulmonary resection (n=40), training group (n=20) 15 minute daily, six time per week, training for 2 weeks pre-operative and 2 weeks post-operative, started by (20-30%) of MIP. Observed significantly increased in inspiratory muscle strength (67.39%) and reduce incidence of post-operative pneumonia in the training group more than control group [13].

The results of this study coincided results of a study found that six months of inspiratory threshold loading training, added to general exercise reconditioning, markedly improved inspiratory muscle strength and endurance, as well as exercise tolerance, in patients with COPD subjected to surgery, and that the improvement in this group of patients was significantly greater than that achieved with general exercise reconditioning alone [14].

It was approved that IMT device improve inspiratory muscle strength and endurance and account for an earlier recovery of pulmonary airflows in patients submitted to bariatric surgery [15].

V. CONCLUSION

Our conclusion is to inspiratory muscle training has positive effects on diaphragmatic excursion in post-thoracotomy patients and IMT helps to restore inspiratory muscles strength which in turn helping of increase exercise tolerance.

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