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Effect of Preoperative Respiratory Muscle Training on Respiratory Complications after Median Sternotomy Incision

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ABSTRACT

Background: The most frequent problems following cardiothoracic surgery are postoperative pulmonary complications (PPCs), which are also the main cause of postoperative morbidity and mortality.

Aim: This study aimed to find out how preoperative respiratory muscle training affected the incidence of PPCs.

Materials & Methods: This study included thirty high-risk PPC patients awaiting elective open-heart surgery, ranging in age from 20 to 40 years. They were classified into two main groups: the control group (group I) and the study group (group II). All participants had a pulmonary function test before the study began. On the day before surgery, patients in the control group got standard care. This standard of care included a brief description of the operation's steps, potential risks, side effects, and complications, as well as postoperative chest physiotherapies techniques such as deep breathing exercises, coughing mechanisms, bed mobility, and ambulation. In addition to the usual care provided to the control group, the study group undertook preoperative respiratory muscle training twice daily for at least two weeks before the surgery.

Results: However, the findings of the current study noted that preoperative respiratory muscle training reduced the amount of time required for mechanical ventilation, ICU stays, inpatient stays, and overall postoperative hospitalization.

Conclusion: Preoperative respiratory muscle training reduced the incidence of pulmonary problems in individuals at high risk for median sternotomy incision.

Keywords: Preoperative respiratory muscle training, Postoperative pulmonary complications, Median sternotomy.

INTRODUCTION

The number of heart surgeries performed worldwide has steadily and rapidly expanded since the development of cardiac surgery in the 1950s. PPCs have a significant impact on major surgical recovery, particularly after open heart surgery. The most frequent post-abdominal or post-cardiothoracic surgery complications seen and treated are PPCs like atelectasis, pneumonia, respiratory failure, worsening of underlying chronic lung disease, or pulmonary dysfunction [1,2].

Pasteur [3] first reported postoperative PPCs and they continue to be a significant contributor to postoperative morbidity, meaning they add significantly to patient suffering, duration of hospital stays, resource utilization, and overall hospital expenditures. PPCs are defined as abnormalities in the pulmonary system that develop after surgery and result in measurable illness or dysfunction that compromises clinical outcomes. PPCs develop by alterations provoked by the surgical procedure which deteriorates the respiratory muscular function leading to respiratory dysfunction. The result of this dysfunction is a decrease in pulmonary flows and volumes, which can cause atelectasis, a less effective cough, more work for the lungs to do, and less efficiency in how the muscles of the lungs perform. The frequency of PPCs varies widely according to the type of surgery conducted, the existence of risk factors, and the diagnostic criteria employed. Rates of postoperative pancreatitis (PPC) after abdominal surgery have been reported to fall anywhere from 17 and 88 %. Multiple factors contribute to the wide range of reported occurrences of pulmonary problems following heart surgery, which sits anywhere from 8% to 79% [2,4,5,6].

Smoking, poor general health, old age, obesity (body mass index >27), COPD (FEV 1/75 percent expected, FEV 1/80 % expected, and FEV 1/FVC70 % expected), diabetes mellitus, cough, and expectoration are all patient-related risk factors that may increase the incidence of PPCs. Patients with chronic pulmonary illness are the greatest source of potential complications for PPCs [7].

Screening for and modifying risk factors, optimizing pre-operative status, patient education, intra-operative management, and postoperative pulmonary care are all effective methods for decreasing the occurrence of PPCs. Despite scant evidence for its efficacy, physiotherapy has been widely used in both pre-and post-operative care for the prevention and amelioration of PPCs following surgery since the 1960s [6].

Preoperative respiratory muscle training was recommended by some researchers; they discovered that it is well received and enjoyed by patients and appears to lower the frequency of postoperative atelectasis. The importance of preoperative optimization of cardiac and pulmonary status can be proven in specific populations undergoing high-risk surgery. Preventive physical therapy with IMT given to patients at high risk of PPCs prior to coronary artery bypass graft (CABG) surgery was related to an increase in inspiratory force, a decrease in the incidence of PPCs, and a shorter period of

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hospitalization. This has been hailed by several researchers as a crucial preoperative strategy for lowering morbidity [4,8,9].

But there is no available literature investigating its influence in high-risk patients currently facing mitral valve replacement (MVR) while in MVR it is supposed that PPCs are more than in CABG because of the increase in pulmonary venous pressure which leads to lung congestion, interstitial edema, stiff lung, and so pulmonary hypertension.

SUBJECTS, MATERIAL, AND METHODS

I- Subjects:

Thirty individuals of age ranging from 20 to 40 years old had been scheduled for primary elective open-heart surgery with median sternotomy. All patients were randomly chosen from the scheduled list of the Heart Surgery Department at Kafr El Sheikh University.

They were split into two equal groups:

1- **Group I (Control group):** 15 patients who received preoperative usual care only.
2- **Group II (Study group):** 15 patients who received preoperative respiratory muscle training in addition to the preoperative usual care.

When it came to age, height, weight, BMI, smoking, diabetes, COPD, coughing, expectorating, pulmonary function tests, and the overall number of risk factors, there was no difference between the two groups.

Inclusion criteria:

All patients were:

- Scheduled for primary elective open-heart surgery with median sternotomy and there was enough time preoperatively to conduct the preoperative procedure for group II.
- Undergone median sternotomy incision.
- High risk for postoperative pulmonary complications (PPCs) according to the pulmonary risk score system [4].
- Each patient was given a signed, written informed consent form.

Exclusion criteria:

Patients who fulfilled any of the following were not included in the study:

- Patients with cardiovascular instability at the moment of selection or throughout the study course.
- Patients with a history of using immunosuppressive medications for 30 days before surgery.
- Patients who lack the necessary physical or mental ability to carry out the activities as directed.
- Patients with exercise-induced bronchial spasm.
- Patients with various illnesses may have an impact on this study's findings.
- Patients who didn't have enough time to conduct the study.

II. Materials:

The procedures of the current study were carried out using the following instruments: -

A) Assessment Tools:

1- Pulmonary risk score system.
2- Height and weight scale: (*RTZ-120A, SHANGHAI, made in China*)
3- Spirometer: (*oxycon pro-jaeger-made in Germany*)
4- The Modified Borg Scale of Perceived Exertion:
5- The PPCs grading system

B) For treatment:

Threshold Inspiratory muscle trainer: (TIMT); *Respironics, Cedar Grove, NJ 07009-1201 (5730EU) USA*:

III. Methods:

All patients of the study were informed about the study and all risks and expected benefits were explained before signing the informed consent. All patients included in this study signed the informed consent.

1- Preoperative:

Assessment and risk stratification:

The patient's demographic data, clinical characteristics, and all medical history were obtained from the patient's file during the preoperative meetings. The preoperative assessment had been done for all patients as follows:

A- Spirometry:

All patients have undergone Spirometry which was done by the same professional in the pulmonary function laboratory in the cardiopulmonary exercise test unit as follows:

- The patients were instructed not to eat, smoke or drink tea or coffee before the test for at least 2 hours.

B-Risk stratification:

The patient's risk for PPCs was stratified at least two weeks before the surgery. It was done according to the pulmonary risk score system [4].

Treatment:

Group I (The control group): Patients in this group got only routine preoperative treatment on the day of surgery, with no additional postoperative chest physiotherapy techniques, such as (deep breathing exercises-incentive spirometer- coughing mechanism-bed mobility, and ambulation).

Group II (The study group): For proper respiratory muscle training, all patients in the study group were informed of the following instructions: with an inspiratory muscle trainer (IMT)

- Relax while seated in a comfortable position.
- Place the nasal clip on your nose and breathe exclusively through your mouth.
- Lips should be placed around the mouthpiece.
- Inhale as forcefully as possible to open the valve.
- Exhale through the mouthpiece.

- Keep breathing in and out for two minutes without taking the device out of your mouth.

Deep breathing technique:

- Patients in the deep breathing group were told to take slow, deep breaths through their noses and let them out normally through their mouths. They were also told to do 30 deep breaths once an hour. The exercise consisted of three sets of 10 deep breaths, with enough time to rest between each set.

2-Postoperative:

Until the PPCs subsided, all patients were subjected to daily monitoring and observation. In addition, a pulmonary function test was performed on each patient before they were released from the hospital, allowing for the following outcome measures to be collected and analyzed:

The first outcome:

The incidence of PPCs was daily recorded until the subsidence of the PPCs. It was scored on the PPCs grading system according to the operational definition of 10. **Kroenke *et al*.** [10].

The second outcome:

The recovery of the pulmonary functions had been recorded by postoperative pulmonary function test done on discharge in the same way as in the preoperative assessment but with asking the patient to support the site of incision during the test.

The third outcome:

The postoperative hospitalization period is classified into intensive care unit (ICU) st ay and inward stay and the total postoperative hospital stay is shown in Table (1).

Ethical consideration:

Both the Institutional Review Board [IRB] and the local committee of ethics approved the protocol of this research in the Faculty of Physical Therapy, Kafr El Sheikh University.

Statistical analysis

Statistical Package for Social Sciences (SPSS version 20.0) software was used to import the data and conduct the analysis. When the quantitative data were parametric, they were displayed as means, standard deviations, and ranges.

RESULTS

The current study was intended to find out the impact of preoperative respiratory muscle training on respiratory complications after median sternotomy incision on the surgical outcome, that is, (1) postoperative pulmonary complications as shown in table (2), (2) recovery of the pulmonary functions and as shown in tables (3&4), (3) the duration of postoperative hospitalization in high-risk patients subjected to open heart surgery with median sternotomy.

The collected data have been statistically analyzed and presented under the following items:

Table (1): Hospitalization period between both groups

Variable	Control	Study
Mechanical ventilation	6.32±4.04	4.3±2.01
Intensive care time	2.43±0.55	2.7±1.01
In-ward staying time	5.1±1.02	5.32±2.01
The total postoperative hospitalization period	11.5±2.01	7.5±1.90

Table (2): Incidence rate of some post-pulmonary complications:

	Control group N (of 24)	Study group N (of 24)
Cough and expectorations positive negative	18 6	11 13
Atelectasis positive negative	18 6	5 19
Pleural effusion positive negative	12 12	6 18
Pneumonia positive negative	10 14	4 20

Table (3): Control group, ventilatory functions:

Ventilatory	Function of the study group	
Variable	Pre-operative	Post
ERV %	114.6 ± 40.1	85.01 ± 30.12
FEF25%	60.5 ± 10.91	45.55 ± 12.7
FEF50%	70.16 ± 16.91	51.2 ± 15.6
FVC	78.96 ± 11.85	60.71 ± 7.1
FEV_1%	79.2 ± 10.1	55.7 ± 13.07

Table (4): Study group, ventilatory functions:

Variable	Pre-operative	Post
ERV %	110.01 ± 40.2	64.01 ± 34.2
FEF25%	62.02 ± 29.32	32.5 ± 14.02
FEF50%	64.22 ± 15.02	33.5 ± 10.3
FVC	82.02 ± 10.55	48.02 ± 11.01
FEV_1%	82.03 ± 12.02	45.04 ± 10.01

DISCUSSION

The significance of the current study was to find out the effect of preoperative respiratory muscle training on respiratory complications after median sternotomy incision on the surgical outcome, that is, the frequency of PPCs, the restoration of pulmonary functions, and the duration of hospital stay following open-heart surgery in high-risk patients having a median sternotomy. The current study revealed that respiratory muscle training twice daily for two weeks before open heart surgery with median sternotomy for patients who are at high risk of developing PPCs resulted in a decrease i n the incidence of PPCs. Moreover, this approach enhances pulmonary function recovery and decreases mechanical ventilation time; ICU stays, and total postoperative hospitalization period.

The present study's finding was corroborated by a previous study by **Hubzebos *et al*.** [4] who also discovered that high-risk patients benefited greatly from

preoperative physical therapy with IMT. Additionally, the frequency of PPCs decreased by 50% in patients who underwent preoperative physical therapy compared to those who underwent standard care. As a result, the patients who received IMT spent much less time in the hospital after surgery.

The current study's findings showed a statistically substantial (P<0.05) decline in the incidence rate of atelectasis in the study group when compared to the control group, which was somewhat similar to the findings of **Leguisamo *et al.*** [11], which noted that the control group's prevalence of non-ventilated areas in patients having CABG surgery in the first and sixth postoperative days was greater than that of the study group, which underwent physiotherapeutic guidance with written instructions. They also discovered that the intervention group's length of hospital stay significantly decreased. Additionally, it was discovered [9] that patients having upper abdominal surgery who had preoperative respiratory muscle training appeared to have a lower incidence of postoperative atelectasis.

After open heart surgery with median sternotomy, it was observed that participants in both groups in the current study had decreased pulmonary functioning. These were in line with the results of **Saxena *et al.*** [12], which came to the conclusion that pulmonary function declines immediately following open heart surgery and gradually improves over three months. Additionally, numerous research has looked into the function of the respiratory muscles following open heart surgery.

According to this research, postoperative respiratory muscle dysfunction and unilateral or bilateral phrenic nerve paralysis frequently occur, and both of these conditions can result in respiratory failure. Surgery-related respiratory muscle dysfunction can also impair breathing, decrease pulmonary compliance, significantly increase respiratory effort, and significantly reduce lung volumes, including vital capacity (VC), tidal volume (VT), and total lung capacity (TLC), which results in insufficient coughing. This could result in functional residual capacity (FRC) loss and atelectasis in the basal lung segments, which would then worsen the ventilation/perfusion (V/Q) mismatch and reduce the lung's ability to exchange gases [4]. Cardiopulmonary bypass (CPB) cardiac procedures identify systemic alterations that call for particular postoperative treatment. There are various causes of these systemic changes, including pulmonary origin, CPB duration, anesthetic use, postoperative discomfort, panic, the existence of risk factors, and the use of intercostal chest drains, among others [13].

In a recent study by **Ahmed** [14], it was concluded that the diaphragmatic excursion was reduced as a result of surgical intervention and that the mechanism of breathing was altered after the operation as assessed by an echocardiograph (M-mode). It was also demonstrated that the participation of the diaphragm in breathing differed from preoperative to postoperative in patients who underwent MVR, with the diaphragm becoming more participated postoperatively. Preoperative IMT was hypothesized to assist avoid or lessen this ventilatory dysfunction.

According to the current study's findings, preoperative respiratory muscle training significantly decreased pulmonary functions, which were higher in the control group than in the study group that underwent preoperative respiratory muscle training. This finding was corroborated by the study of [15,16,17]. Additionally, according to **Barros *et al.*** [13], who examined the impacts of respiratory muscle training (RMT) in CABG patients, patients who undergo cardiac surgery typically develop pulmonary dysfunction, which is characterized by a significant decrease in lung volume, impairment of respiratory function, declined pulmonary compliance, and an increase in respiratory effort. While they saw distinct behavior in the group receiving respiratory muscle training, which displayed restoration of ventilatory function upon hospital discharge, returning its parameters to the initial values noticed before surgery. From the perspective of acid-base balance, the increase in tidal volume that has been found in patients who have undergone respiratory muscle training indicates a stronger capacity for gas exchange, which may lead to better tissue oxygenation and fewer cases of respiratory or metabolic diseases. Although **Bobbio *et al.*** [18] found no difference in resting pulmonary function test (PFT) scores between patients with COPD who underwent lobectomy for non-small cell lung cancer before and after preoperative pulmonary rehabilitation, this may be due to the study's small sample size and the lack of a control group.

Our study was consistent with those of the study of **Hulzebos *et al.*** [4], which discovered that preoperative respiratory muscle training made high-risk patients for PPCs undergoing CABG more resilient to the negative effects of surgery and reduced the duration of mechanical ventilation, which was substantially longer in the usual care group. Preoperative physical therapy with respiratory muscle training may be to blame for the variation in ventilatory support duration as both groups were preoperatively matched. Additionally, **Rajendran *et al.*** [17] showed that preoperative short-term pulmonary rehabilitation in COPD cases undergoing CABG surgery reduced healthcare costs as demonstrated by shorter breathing times.

Our study showed a statistically significant (P<0.05) decrease in the total ICU staying which was relative to the results of **Felcar *et al.*** [19] who found that the use of pre and postoperative physiotherapy in pediatric cardiac surgery showed a reduction in ICU time in comparison to the group that taken only postoperative physiotherapy. Theoretically, the presence of preoperative respiratory muscle weakness will lead to postoperative complications and hinder the recovery of respiratory function indeed. While there is a contradiction concerning the correlation between

inspiratory muscle strength and PPCs. fail to find a significant correlation between respiratory muscle strength and respiratory complications after cardiac surgery but this may be due to the possible difference in the profile of patients involved in their study (CABG, valve surgeries, or ASD) and also may be due to that PPCs is multifactorial because in the study by **Hulzebous *et al.*** [(4)] looked at pulmonary complications based on risk factors before surgery. They looked at four main risk factors: being over 70 years old, having a productive cough, smoking in the eight weeks before surgery, and having diabetes mellitus. They only looked at CABG and whether cardiopulmonary bypass was used or not. They also found a link between muscle strength and PPCs. Inspiratory capacity and maximal expiratory pressure were also taken into account as protective factors for pulmonary problems when they were greater than 75% expected.

While **Hulzebos *et al.*** [(4)] apply a protocol of preoperative respiratory muscle training for at least two weeks but in the current study only one week was applied which is not enough to increase the inspiratory muscle strength but the improvement in the current study may be due to learning which is reinforced by the study of **Eastwood *et al.*** [(20)] who applied respiratory muscle training three times only and found a change in the breathing pattern which is noted as a systemic increase in the tidal volume, minute ventilation and maximum threshold pressure with the first few exposures to progressive threshold loading. These results imply improved performance, which could be due to neurophysiological adaptation to the job rather than respiratory muscle conditioning. Moreover, the breathing pattern during effort was improved which facilitated the physical activity which in term enhanced the postoperative early ambulation and may be contributed to improving physical performance in patients who received preoperative respiratory muscle training during using it and during activity. The feasibility of improvement of diaphragmatic excursion with short-term using respiratory muscle training was proved by **Zidan** [(21)] who applied two weeks of postoperative respiratory muscle training for patients undergoing valvular surgery.

CONCLUSION

Preoperative respiratory muscle training reduced the incidence of pulmonary problems in individuals at high risk for median sternotomy incision.

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