

Preoperative respiratory physical therapy program as a prehabilitation to improve inspiratory muscle function and quality of life in patients undergoing upper abdominal surgeries: a prospective randomized controlled trial

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Background

Respiratory complications are the most common complications after surgery.

Objective

The aim of this study was to evaluate the efficacy of preoperative respiratory physical therapy program in improving inspiratory muscle function and quality of life (QoL) in patients undergoing upper abdominal surgeries.

Patients and methods

Forty patients undergoing upper abdominal surgeries were selected from Kasr El-Aini Hospital; their ages ranged from 25 to 45 years. Patients were randomly assigned to the control or the physical therapy group. Only the physical therapy group received the preoperative chest physical therapy program. All treatment interventions were applied at a frequency of 6 days/week for 2 weeks. Outcome measures included maximum inspiratory pressure as a primary outcome measure and QoL scores as a secondary outcome measure. All outcome measures were measured for all patients 2 weeks before surgery, 24h before surgery, and 24h after surgery.

Results

Level of maximum inspiratory pressure and QoL scores were higher in the physical therapy group compared with the control group ($P < 0.05$).

Conclusion

It was concluded that preoperative respiratory physical therapy improves inspiratory muscle strength and QoL scores in patients undergoing upper abdominal surgeries.

Keywords:

prehabilitation, preoperative, upper abdominal surgeries

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Introduction

Upper abdominal surgeries are surgical procedures involving an incision above or extending above the umbilicus, including hernia repair, gall bladder removal, large bowel removal, exploratory laparotomy, and other interventions in the abdominal cavity performed by means of conventional laparotomy or laparoscopy [1]. Upper abdominal surgical procedures are associated with a high risk for postoperative pulmonary complications (PPCs). PPCs present high rates of morbidity, mortality, increased hospital costs, and prolonged hospital stay predominantly in abdominal, cardiac, and thoracic surgery [2,3].

PPCs are defined as pulmonary abnormalities occurring in the postoperative period, which produce clinically significant identifiable diseases or dysfunction that adversely affect the patient's clinical course. Pulmonary complications include atelectasis, pneumonia, bronchitis, pneumothorax, bronchospasm,

and worsening of an underlying chronic lung disease, which can occur up to 7 days after surgery [4,5]. The complication rate is higher for surgical sites closer to the diaphragm, such as the thoracic region and the upper abdomen [6].

A major decline in pulmonary function is observed on the first day after upper abdominal surgery. This decline can reduce vital and inspiratory capacity and can culminate in restrictive lung diseases that cause atelectasis, reduced diaphragm movement, and respiratory insufficiency [7]. The major causes of PPCs may be related to shallow breathing and monotonous tidal volume in postoperative patients. However, other causes such as anesthesia, opioid

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analgesia, and postoperative pain also seem to contribute to this ventilation pattern without spontaneous deep breaths that occur every 5 or 10min [8,9].

As a result, physical therapy techniques of lung re-expansion have been recommended as strategies to prevent and/or to treat the PPCs, as well as to recover the ventilatory function in the postoperative period [10,11]. Preoperative respiratory muscle training and preoperative exercise training appear to be an important strategy in the prevention of PPC after thoracic, cardiac, and abdominal surgeries [12,13].

Preoperative physical therapy before abdominal and thoracic surgery has been found to diminish postoperative radiological alterations, auscultation, blood gases, and length of hospital stay, and to improve quality of life (QoL) [14].

Inspiratory muscle training (IMT) is a technique that is designed to improve the performance of the respiratory muscles that may be impaired in a variety of conditions [15]. IMT has been shown to improve inspiratory muscle function, lung volumes, work capacity, and power output in people who are healthy [16].

Manzano et al. [17] found that preoperative IMT increased the inspiratory muscle strength [maximum inspiratory pressure (MIP)] and attenuated the negative postoperative effects of open bariatric surgery in obese women. The aim of this study was to evaluate the efficacy of preoperative respiratory physical therapy program in improving inspiratory muscle function and QoL in patients undergoing upper abdominal surgeries.

Patients and methods

A prospective, parallel-group, randomized clinical trial was conducted between February 2015 and November 2015, at Kasr El-Aini Hospital. Forty patients (13 male and 27 female) undergoing upper abdominal surgeries were enrolled into this blinded randomized controlled trial. The patients participated in the study after signing an informed consent form before data collection. Recruitment began after approval was obtained from the Ethics Committee of the Faculty of Physical Therapy, Cairo University.

Patients who underwent cholecystectomy, esophagotomy, upper abdominal tumor resection, and bariatric surgeries were included if they were clinically and medically stable.

Exclusion criteria

Exclusion criteria were as follows: presence of a malignant disease, heavy smokers, alcoholism, or presence of active tuberculosis (TB). In addition, patients were excluded if they had spent more than 24h on mechanical ventilation or had an infection postoperatively.

Patients were referred from the general surgeon. The study program started 2 weeks before the date of surgery. At first contact, the patients were asked to complete the evaluation form. Inspiratory muscle strength and QoL were evaluated for all patients. Patients were selected from Kasr El-Aini Hospital after initial evaluation. Patients were randomly divided into two equal groups (n=20), the physical therapy group and the control group.

The patients were randomly assigned to the treatment group (n=20) or the control group (n=20) by an independent person who took a sealed opaque envelope from a box following a numerical sequence; the envelope contained a letter indicating whether the patient would be allocated to the physical therapy or the control group.

Treatment procedures

The patients in the treatment group completed a preoperative 2-week exercise program consisting of IMT, deep breathing, and cough training. Preoperative physical therapy program was applied only for the physical therapy group, for 2 weeks before surgery, 6 days per each week, 1h for every session. IMT was performed using a threshold IMT device (model 64485 was manufactured in the USA). Threshold IMT devices impose a threshold or critical opening pressure that must be overcome before inspiratory flow commencing. During the task, IMT was initially performed as an isometric contraction until the threshold valve opens to allow an inspiratory flow, after which the contraction becomes isotonic in nature. Training was started with a low-intensity exercise, with 20–30% of the patient MIP load. As the inspiratory muscle became stronger, the inspiratory load was progressed to 50% of MIP over 2 weeks as tolerated. The patient was instructed to take full breath in (maximal and deep inspiration) followed by longer and slow expiration. The patient was instructed to continue this breathing pattern for 10–20 breaths and repeat for four to six times, or for about 10–15min with rest in between 30s [18].

Patients in the control group were advised to remain active and take their medications until the date of surgery.

Outcome measures

The primary measure for determining treatment outcome was respiratory muscle strength. Patients were assessed in sitting erect position with feet flat on the floor, and they were given 10min to adapt to the room condition before beginning measurement. The measurement tool was continuously sterilized with alcohol every session. Measurements were repeated three times and the best value was taken [19].

The MicroRPM respiratory pressure meter (Germany) was used. MicroRPM is a handheld portable, noninvasive instrument that features a clear digital display of the results in cmH₂O [20]. The maximal inspiratory mouth pressure (PIMAX) is an index of inspiratory muscle strength [19]. The patient was instructed to sit in an erect position with feet flat on the floor, and then the patient was asked to put the nose clips on, the mouthpiece in his or her mouth, and seal his or her lips around the mouth piece as tightly as possible. The patient was instructed to breathe air out and then breathe in as much as possible and hold the breath for at least 2s. The patient was not allowed to lean forward. Three tests were carried out and the best result from the three tests was taken. Assessment of MIP was performed for all patients at 2 weeks before surgery (pretraining), 24h before surgery (post-training 1), and 24h after surgery (post-training 2) [21].

Other outcome measures used to compare the treatment effectiveness among the groups included assessment of QoL. The WHOQOL-BREF is a shorter version of the original instrument WHOQOL-100 that may be more convenient for use in large research studies or clinical trials. This questionnaire assesses how the patient feels about his or her QoL, health, or other areas of his or her life [22].

The WHOQOL-BREF produces a profile with four domain scores and two individually scored items about the individual's professionals and is becoming an important health outcome indicator. The WHOQOL-BREF instrument comprises 26 items, which measure the following broad domains: physical health, psychological health, social relationships, and environment. The four domain scores are scaled in a positive direction, with higher scores indicating a higher QoL. Three items of the BREF must be reversed before scoring. The four domains are then scored, labeled, and transformed to a 0 to 100 scale used to interpret and compare with other validated instrument tools such as the WHOQOL-100. QoL was assessed for all patients 2 weeks before surgery (pretraining), 24 h before

surgery (post-training 1), and 24h after surgery (post-training 2) [23,24].

Sample size

Using G power (Heinrich-Hine University of Dusseldorf) program, a preliminary power analysis [power (1 α error P)=0.85, α =0.01, effect size=0.5] determined a sample size of 40 for this study. This effect size was chosen because it yielded a realistic sample size [25].

Statistical analysis

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 20.0 (SPSS 20, IBM, Armonk, NY, Chicago, USA). Differences were assumed significant at P value less than 0.05. Continuous variables were presented as mean and SD, whereas categorical variables were described as frequency and percentage. The paired t-test was used to test the differences in outcome measures within group for parametric data (MIP), whereas the Wilcoxon test was used to test the differences in outcome measures within group for nonparametric data (QoL measures). An independent t-test was used to compare data between groups for parametric data (age, weight, height, and MIP), whereas the Mann-Whitney test was used to test the differences in outcome measures between groups for nonparametric data (QoL measures).

Results

Fifty patients were initially screened. After the screening process, 40 patients were eligible to participate in the study. In total, 40 patients (100%) completed the first assessment 2 weeks before surgery (pretraining), and 40 patients (100%) completed the entire study.

Demographic and clinical characteristics of patients

In the baseline of treatment, there were no significant differences between the two groups as regards basic demographic and initial clinical characteristics (age, sex, height, weight, initial MIP, and QoL measures – physical, psychological, social, and environment domains) (Table 1).

Maximum inspiratory pressure and quality of life 2 weeks to 24h before surgery

There was a significant increase in MIP and QoL score (physical, psychological, social, and environment domains) from 2 weeks to 24h before surgery in the physical therapy group (P<0.05). On comparing both

Table 1 Baseline (pretraining) demographic and clinical characteristics of patients in the two groups

Variables	PT group (20)	C group (20)	P value
Age (years) (mean±SD)	34.10±6.62	35.40±6.58	0.537
Sex [N (%)]			
Male	5 (25)	8 (40)	0.429
Female	15 (75)	12 (60)	
Height (cm) (mean±SD)	1.66±9.7	1.67±10.16	0.705
Weight (kg) (mean±SD)	92.75±18.62	96.25±18.21	0.723
MIP (pre) (mean±SD)	82.10±4.86	81.75±4.29	0.811
QoL (pre) [physical domain (median) (range)]	43.00 (17)	39.50 (14)	0.217
QoL (pre) [psychological domain (median) (range)]	44.00 (16)	45.50 (15)	0.201
QoL (pre) [social domain (median) (range)]	35.50 (17)	35.00 (19)	0.529
QoL (pre) [environment domain (median) (range)]	42.00 (20)	39.00 (25)	0.989

C, control; MD, mean difference; MIP, maximum inspiratory pressure; PT, physical therapy; QoL, quality of life.

the physical therapy and control groups at 24h before surgery, there were highly significant differences as regards MIP and QoL measures ($P<0.05$) favoring the physical therapy group (Table 2).

Maximum inspiratory pressure and quality of life 24h after surgery

There was a significant reduction in QoL measures (physical, psychological, social, and environment domains) and MIP in the physical therapy and control groups at 24h after surgery, but on comparing the two groups at 24h after surgery, the QoL scores and MIP in the physical therapy group were higher than that in the control group ($P<0.05$) (Table 3).

Discussion

This study was designed to investigate the effect of preoperative physical therapy program as a prehabilitation in improving the inspiratory muscle strength, which results in improvement of the QoL as a postoperative outcome of patients undergoing upper abdominal surgeries.

Results of the study showed that there was a significant increase in MIP and QoL scores from 2 weeks before surgery (pre) to 24h before surgery in the physical therapy group compared with the control group ($P<0.05$).

At 24h after surgery, the level of MIP and QoL scores were decreased in the physical therapy group and the control group due to the effect of surgery. However, on comparing both the physical therapy and control group, level of MIP and QoL scores were higher in the physical therapy group compared with the control group ($P<0.05$). This reflects the efficacy of

preoperative respiratory physical therapy program as prehabilitation for improving MIP and QoL in patients undergoing upper abdominal surgeries.

The findings of this study are in agreement with those of Pehlivan *et al.* [26], who proved that preoperative prophylactic physiotherapy has been shown to be an important and effective approach in preventing or reducing postoperative complications, in addition to optimizing treatment by familiarizing the patient with the physiotherapeutic procedures. The effects of preoperative respiratory physiotherapy have been documented in the literature, but most of these studies involved hospitalized patients.

Many studies reported that high-risk patients waiting for elective coronary artery bypass graft surgery were benefitted from preoperative physical therapy programs including respiratory muscle training. A reduction in PPC and hospital stay was observed in patients undergoing respiratory muscle training compared with controls [27,28].

IMT represents one of the components of respiratory rehabilitation. The rationale behind rehabilitation using respiratory devices such as IMT and IS is the enhancement of respiratory muscle function, which can potentially reduce the severity of breathlessness and improve exercise tolerance [29]. Several previous studies [30] support the effectiveness of preoperative IMT in strengthening inspiratory muscle, decreasing postoperative pulmonary problems, and the attenuation of exercise-induced inspiratory muscle fatigue.

High-risk surgical patients who underwent preoperative IMT presented a reduction of 50% in PPCs, when compared with those who were not subjected to this training, and showed significant

Table 2 Comparative analysis of MIP and QoL measures (physical, psychological, social, and environment domains), at 2 weeks before surgery (pre) and 24 h before surgery (post 1) between the two groups

Variables	PT group (20)	C group (20)	P value between groups
MIP pre (mean±SD)	82.10±4.86	81.75±4.29	0.811
MIP post 1 (mean±SD)	96.75±5.32	82.10±3.91	0.0001*
P value – within groups	0.0001*	0.687	
QoL pre [physical domain (median) (range)]	43.00 (17)	39.50 (14)	0.217
QoL (post 1) [physical domain (median) (range)]	67.00 (15)	36.50 (12)	0.0001*
P value – within groups	0.0001*	0.211	
QoL (pre) [psychological domain (median) (range)]	44.00(16)	45.50 (15)	0.201
QoL (post 1) [psychological domain (median) (range)]	78.50 (25)	44.00 (20)	0.0001*
P value – within groups	0.0001*	0.868	
QoL pre [social domain (median) (range)]	35.50 (17)	35.00 (19)	0.529
QoL post 1 [social domain (median) (range)]	80.00 (55)	38.00 (15)	0.0001*
P value – within groups	0.0001*	0.310	
QoL pre [environment domain (median) (range)]	42.00 (25)	39.00 (25)	0.989
QoL post 1 [environment domain (median) (range)]	82.50 (55)	38.00 (20)	0.0001*
P value – within groups	0.0001*	0.360	

C, control; MD, mean difference; MIP, maximum inspiratory pressure; PT, physical therapy; QoL, quality of life. *Highly significant difference.

Table 3 Comparative analysis of QoL measures (physical, psychological, social, and environment domains), MIP at 24h before surgery (post 1) and 24h after surgery (post 2) between two groups

Variables	PT group (20)	Control group (20)	P value between groups
MIP post 1 (mean±SD)	96.75±5.32	82.10±3.91	0.0001*
MIP post 2 (mean±SD)	66.35±4.96	48.25±4.88	0.0001*
P value – within groups	0.0001*	0.0001*	
QoL post 1 [physical domain (median) (range)]	67.00 (15)	36.50 (12)	0.0001*
QoL post 2 [physical domain (median) (range)]	53.50 (23)	34.00 (8)	0.0001*
P value – within groups	0.0001*	0.011	
QoL post 1 [psychological domain (median) (range)]	78.50 (25)	44.00 (20)	0.0001*
QoL post 2 [psychological domain (median) (range)]	55.00 (27)	39.50 (16)	0.0001*
P value – within groups	0.013	0.012	
QoL post 1 [social domain (median) (range)]	80.00 (55)	38.00 (15)	0.0001*
QoL post 2 [social domain (median) (range)]	65.00 (50)	29.00 (6)	0.0001*
P value – within groups	0.0001*	0.0001*	
QoL post 1 [environment domain (median) (range)]	82.50 (55)	38.00 (20)	0.0001*
QoL post 2 [environment domain (median) (range)]	77.00 (45)	31.00 (16)	0.0001*
P value – within groups	0.001	0.011	

C, control; MD, mean difference; MIP, maximum inspiratory pressure; PT, physical therapy; QoL, quality of life. *Highly significant difference.

increases in inspiratory muscle strength and endurance after short-term preoperative IMT. Other studies demonstrated improvement in blood oxygenation, dyspnea, and MIP in patients undergoing IMT for a period of 6–8 weeks [30].

The observations in the present study are also consistent with those of Félix *et al.* [31], who found that IMT was effective in improving ventilator pattern, lung volume, respiratory muscle strength, and the health and vitality domains for QoL.

Thus, in the present study, the effectiveness of preoperative physical therapy may be attributed to

several factors : strengthening of respiratory muscle weakness, attenuation of exercise-induced inspiratory muscle fatigue, increased inspiratory muscle efficiency, improved pulmonary mechanics, increased inspiratory muscle function, increased diaphragm thickness, increased vital capacity and total lung capacity, decreased incidence of postoperative complications, and increased MIP [32,33].

Limitations of the study

A lot of effort was exerted with each patient to reduce the influence of possible errors inherent in the study. This study was limited by the following factors: physical and psychological condition of the patient during the period

of treatment, possible human error in the application of measurement or therapeutic procedures, cooperation of the patient, patient lifestyle and practicing exercises, and variability between patients and their reaction effects on the rate of recovery.

Conclusion

From the results of our study, it was concluded that preoperative respiratory physical therapy improves inspiratory muscle strength and QoL scores in patients undergoing upper abdominal surgeries.

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Conflicts of interest

There is no conflict of interest.

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