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Impact of Preoperative Respiratory and Physical Therapy on Postoperative Pulmonary Function and Complications in Obese Patients Undergoing Laparoscopic Upper Abdominal Surgery

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ABSTRACT

Background: Obesity is an important risk factor for postoperative pulmonary complications (PPCs), especially for upper abdominal laparoscopic surgery. Prehabilitation, involving systematic physical and respiratory therapy has been found to improve perioperative outcomes but has not been thoroughly investigated in obese patients.

Objective: To assess the effects of preoperative respiratory and physical therapy on postoperative pulmonary function and the occurrence of pulmonary complications among obese patients who are undergoing laparoscopic upper abdominal surgery.
Methodology: A randomized controlled trial was conducted at Ayub Medical Complex, Abbottabad from April 2022 to January 2024. Sixty patients who were obese (BMI ≥30 kg/m², age ≥50 years) and undergoing elective laparoscopic cholecystectomy, fundoplication, or sleeve gastrectomy were randomly assigned to an intervention group (n=30) and a control group (n=30).

Results: The intervention group had significantly improved postoperative pulmonary function at all time points (e.g., FVC on POD5: 2.6 ± 0.3 L vs. 2.0 ± 0.4 L, p<0.01). Secondary outcomes were also in the intervention's favor, such as lower oxygen requirement (17.4±4.9 vs. 26.2±6.1 hours, p<0.01), less hospital stay (4.3±1.1 vs. 5.7±1.3 days, p<0.01), decreased pain scores (VAS 3.5±0.9 vs. 4.9±1.2, p<0.01), and faster ambulation (9.1±2.3 vs. 13.5±3.1 hours, p<0.01). ICU admission rates were decreased but not statistically significant.

Conclusion: Preoperative structured physical and respiratory therapy has been proven to improve postoperative pulmonary function and recovery and decrease PPCs in obese surgical patients having laparoscopic upper abdominal surgery. These results endorse the incorporation of prehabilitation into perioperative care pathways for high-risk surgical candidates.

Keywords: Prehabilitation; Pulmonary Complications; Respiratory Therapy; Laparoscopic Surgery

Introduction

Obesity (BMI ≥ 30) is a complex chronic condition characterized by excess body fat. It is closely associated with diabetes, respiratory dysfunction, and cardiovascular disease, and significantly increases perioperative and postoperative risks, especially pulmonary complications during surgeries such as laparoscopic upper abdominal procedures (e.g., cholecystectomy, bariatric surgery, fundoplication).[1] Even minimally invasive laparoscopic approaches pose physiological challenges; PPCs remain a major cause of increased healthcare costs, morbidity, mortality, and prolonged hospital stays.[2]

Obesity alters respiratory physiology via reduced lung compliance, lower FRC, higher airway resistance, and decreased ERV, which predispose patients to poor oxygenation, atelectasis, and ineffective ventilation.[1] These mechanical effects (e.g., increased abdominal pressure, restricted diaphragmatic movement) are worsened by pneumoperitoneum and patient positioning, impairing pulmonary function further during surgery.[3] General anesthesia, muscle relaxation, and postoperative pain contribute to hypoventilation in obese patients.[1] Common PPCs in this population include pneumonia, bronchospasm, atelectasis, pleural effusion, and respiratory failure.[3]

Prehabilitation, comprising respiratory and physical therapy before surgery, aims to build functional and respiratory reserve. Components typically include breathing exercises, diaphragmatic training, incentive spirometry, PEP therapy, inspiratory muscle training (IMT), and pulmonary hygiene education (e.g., coughing, deep breathing). Physical prehabilitation includes strength, aerobic, flexibility, and mobility training.[4] Evidence shows that respiratory training enhances lung volumes, mucociliary clearance, and inspiratory muscle strength while reducing PPC risk.[5] When combined with physical training, prehabilitation enhances metabolic fitness and recovery.[6]

Data in obese patients undergoing laparoscopic upper abdominal surgery are limited. Morbidly obese patients undergoing bariatric procedures who received preoperative IMT showed better postoperative oxygenation (higher PaO_2/FiO_2) and inspiratory muscle strength compared to controls in a randomized clinical trial.[7] Systematic reviews have found that IMT administered ≥2 weeks pre-op (≥15 min/day) reduces PPC incidence with relative risk ~0.4.[5] A short-term combined physical and respiratory prehabilitation program also improved pulmonary function and decreased PPCs in obese surgical populations.

Obese patients face unique challenges from altered cardiopulmonary physiology and comorbidities like cardiovascular disease, diabetes, and obstructive sleep apnea. This suggests that preoperative optimization may offer significant advantages in this subgroup.[3] Yet, high-quality trials and standardized guidelines are lacking.

Therefore, the current study aims to evaluate whether a structured preoperative respiratory and physical therapy program improves postoperative pulmonary function and reduces PPCs in obese patients undergoing laparoscopic upper abdominal surgery. The goal is to support safer surgery, facilitate recovery protocols, and inform future obesity-specific prehabilitation recommendations in high-risk surgical care.

Objective

To assess the effects of preoperative respiratory and physical therapy on postoperative pulmonary function and the occurrence of pulmonary complications among obese patients who are undergoing laparoscopic upper abdominal surgery.

Methodology

The purpose of this prospective, randomized controlled trial was to evaluate the impact of structured preoperative physical and respiratory therapy on postoperative pulmonary function and complications in obese patients at Ayub Medical Complex, Abbottabad, a tertiary care facility. The research was carried out between April 2022 and January 2024. Individuals scheduled for elective laparoscopic procedures like fundoplication, sleeve gastrectomy, or cholecystectomy, those who were 50 years of age or older and had a body mass index (BMI) of 30 kg/m² or higher were considered eligible. Patients with severe pre-existing pulmonary diseases (like interstitial lung disease or COPD), uncontrolled cardiovascular disease, recent respiratory infections (within two weeks), neuromuscular disorders affecting respiratory function, or those undergoing emergency surgery were excluded.

Written informed consent was taken from all the Participants. Patients were randomly split into two groups. In addition to the standard care, one group (the intervention group) underwent a prearranged regimen of breathing and physical exercises prior to surgery. This program included daily supervised sessions with breathing exercises like deep breathing, using a spirometer, coughing practice, breathing muscle training, and light physical activity like walking or cycling. It lasted for five to seven days prior to surgery. The other group, known as the control group, did not receive any additional exercises and only received the standard pre-surgery care.

All patients had their laparoscopic surgery under the same general anesthesia procedures. During the operation, details such as how long the surgery took, the type of anesthesia used, and the ventilator settings were noted to keep conditions the same for everyone. After surgery, lung function tests like FVC (forced vital capacity) and

FEV1 (forced expiratory volume in one second) were done on days 1, 3, and 5. Lung-related problems after surgery—such as collapsed lungs (atelectasis), chest infections (pneumonia), breathing difficulty (bronchospasm), or respiratory failure—were checked and recorded within the first week. Other things like how long the hospital stay lasted, if ICU care was needed, oxygen use, pain levels, and how soon patients started moving after surgery were also recorded.

Data were collected using standardized forms and entered into a secure database. Statistical analysis was performed using SPSS software veion 22.0. Continuous variables were compared using the Student's t-test, while categorical variables were analyzed using the Chi-square test or Fisher's exact test. A p-value of less than 0.05 was considered statistically significant. Ethical approval was obtained from the institutional ethics committee before commencing the study, and patient confidentiality was maintained throughout. All participants retained the right to withdraw from the study at any point without affecting their standard medical care.

Results

A total of 60 obese patients were selected and randomized equally into two groups (n=30 each): one receiving structured preoperative respiratory and physical therapy and one receiving standard care. There were no significant differences (all $p > 0.5$) between the two groups in terms of the following important baseline characteristics: mean age (51.1 vs. 50.8 years), sex distribution (14/16 vs. 13/17), and BMI (34.5 vs. 34.1 kg/m^2). Effective randomization was confirmed by the similar distribution of surgical procedures (cholecystectomy, sleeve gastrectomy, and fundoplication), diabetes prevalence (23.3% vs. 16.6%), and hypertension (50.0% vs. 53.3%) (Table 1).

Table 1. Baseline Demographics and Clinical Characteristics

Variable	Intervention (n=30)	Control (n=30)	p-value
Age (years, mean ± SD)	51.1 ± 5.2	50.8 ± 4.7	0.53
Male / Female	14 / 16	13 / 17	0.80
BMI (kg/m^2, mean ± SD)	34.5 ± 3.3	34.1 ± 3.5	0.62
Diabetes mellitus (%)	7 (23.3%)	5 (16.6%)	0.79
Hypertension (%)	15 (50.0%)	16 (53.3%)	0.79
Type of Lap. Surgery;			
Cholecystectomy (%)	18 (60.0%)	19 (63.3%)	0.89
Sleeve gastrectomy (%)	6 (20.0%)	5 (16.6%)	
Fundoplication (%)	6 (20.0%)	6 (20.0%)	

Compared to controls, patients who completed the two-week prehabilitation program showed noticeably improved lung function during the first postoperative week. On the first day following surgery, they showed better early preservation of lung volumes and airflow, with an average forced vital capacity (FVC) of 2.0 L compared to 1.6 L in the control group and a forced expiratory volume in one second (FEV_1) of 1.7 L compared to 1.3 L. These benefits continued on Days 3 (FVC 2.3 L vs. 1.9 L; FEV_1 2.0 L vs. 1.5 L) and 5 (FVC 2.6 L vs. 2.0 L; FEV_1 2.2 L vs. 1.7 L). Additionally, the prehabilitation group maintained higher FEV_1/FVC ratios (roughly 86% vs. 82–83%), which is indicative of less relative airway obstruction and more effective ventilatory mechanics (Table 2).

Patients in the prehabilitation group had significantly fewer overall pulmonary complications (13.3% vs. 36.7%, $p = 0.035$), mainly due to a lower rate of atelectasis (10.0% vs. 23.3%). The intervention arm also had lower rates of respiratory failure, bronchospasm, and pneumonia, indicating a steady trend towards improved postoperative respiratory outcomes with preoperative physical and respiratory therapy.

When compared to controls, the intervention group's secondary outcomes were noticeably better. Preoperative therapy patients needed less postoperative oxygen support (17.4 vs. 26.2 hours, $p < 0.01$) and had a shorter hospital stay (4.3 vs. 5.7 days, $p < 0.01$). On the first

Table 2. Postoperative Pulmonary Function Tests (mean ± SD)

POD	Group	FVC (L)	FEV_1 (L)	FEV_1/FVC (%)
Day 1	Intervention	2.0 ± 0.4	1.7 ± 0.3	85.1 ± 3.5
	Control	1.6 ± 0.3	1.3 ± 0.3	81.5 ± 4.1
Day 3	Intervention	2.3 ± 0.4	2.0 ± 0.3	86.2 ± 2.9
	Control	1.9 ± 0.3	1.5 ± 0.4	82.3 ± 3.6
Day 5	Intervention	2.6 ± 0.3	2.2 ± 0.3	87.0 ± 2.6
	Control	2.0 ± 0.4	1.7 ± 0.3	83.2 ± 3.3

postoperative day, they also reported less pain (VAS score 3.5 vs. 4.9, p <0.01) and were able to walk around sooner (9.1 vs. 13.5 hours, p <0.01), which suggests a better functional recovery. The intervention group experienced fewer ICU admissions (3.3% vs. 10%), but the difference was not statistically significant. Overall, these results support the role of prehabilitation in improving postoperative recovery and reducing resource utilization (Table 4).

Discussion

In this prospective randomized controlled trial, we evaluated the impact of a standardized preoperative physical and respiratory therapy on postoperative pulmonary function, morbidity, and convalescence in obese patients following laparoscopic upper abdominal surgery. Such a conclusion underscores the critical benefits of targeted prehabilitation approaches for improving overall postoperative recovery and pulmonary outcomes.

Our findings indicated that patients who received prehabilitation can achieve better postoperative pulmonary function, including higher values of FVC, FEV_1, and FEV_1/FVC at postoperative days 1, 3, and 5. This efficacy of the intervention on lung function improvement may be attributed to the strengthening of respiratory muscles, the promotion of lung compliance, as well as the facilitation of airway clearing. This is consistent with prior literature reporting comparable effects of preoperative inspiratory muscle training (IMT) and breathing exercises. For instance, Abdelaal et al. (2017)[7] reported that preoperative physical and respiratory therapy decreased postoperative pulmonary complications in obese patients submitted to laparoscopic upper abdominal surgery. Moreover, Ali et al. (2022)[8] also concluded that preoperative physical and respiratory therapy had beneficial effects on pulmonary function and decreased the occurrence of postoperative pulmonary disorders in obese patients undergoing laparoscopic surgery of the upper abdomen.

Importantly, our study also highlighted a significant decrease in the overall incidence of postoperative pulmonary complications (13.3% versus 36.7%; p=0.035) particularly with atelectasis among the groups receiving the intervention. Although pneumonia, bronchospasm, and respiratory failure were not reaching statistical significance concerning the rates of individual

Table 3. Incidence of Postoperative Pulmonary Complications

Complication	Intervention (n=30)	Control (n=30)	p-value
Any PPC	4 (13.3%)	11 (36.7%)	0.035
Atelectasis	3 (10.0%)	7 (23.3%)	0.16
Pneumonia	1 (3.3%)	3 (10.0%)	0.30
Bronchospasm	0 (0%)	2 (6.7%)	0.15
Respiratory failure	0 (0%)	1 (3.3%)	0.31

Table 4. Secondary Outcomes

Outcome	Intervention	Control	p-value
Length of stay (days)	4.3 ± 1.1	5.7 ± 1.3	<0.01
Pain score (VAS, POD1)	17.4 ± 4.9	26.2 ± 6.1	<0.01
Pain score (VAS, POD1)	3.5 ± 0.9	4.9 ± 1.2	<0.01
Early ambulation (hours)	9.1 ± 2.3	13.5 ± 3.1	<0.01
ICU admission (%)	1 (3.3%)	3 (10.0%)	0.30

complications, there was an apparent downward trend. This is in accordance with findings reported by Soares et al. (2013),[9] which established that respiratory rehabilitation protects against PPC and is more effective in moderate- and high-risk patients, but it does not influence surgery-induced functional changes.

Furthermore, the intervention group scored significantly higher in secondary outcomes, such as shorter hospital stay, reduced oxygen needs, comparatively lower postoperative pain perception, and earlier ambulation. All recorded differences were statistically significant. These outcomes are of clinical relevance, indicating faster recovery and reduced utilization of resources and costs to the healthcare system. Previous authors Boden et al. (2018)[10] have similarly highlighted prehabilitation as beneficial in functional recovery, postoperative pain reduction, and hospital stay shortening across a variety of surgical populations, few of which have focused specifically on obese patients.

The difference in incidences of ICU admissions between the intervention group and the control meant nothing statistically as far as testing was concerned. In the intervention group, the incidence was 3.3% compared to 10.0% in the control group. This could be because very few patients in either group were admitted to the ICU and the effect may have been underpowered for such outcome. Always consider the tendency to show some treatment benefits for this end and better not jump into conclusions before larger trials are done on them.

Another distinguishing feature of this study is the uniform application of the prehabilitation protocol that contained supervised sessions, respiratory muscle training, incentive spirometry, and aerobic conditioning. Having such organized, comprehensive strategies may yield better outcomes than individual treatment methods. In addition, the two-week time span of prehabilitation seems to be reasonable and attainable in the context of elective surgery, as it does not postpone essential surgical procedures.

Although there is a general consensus in the literature on the efficacy of prehabilitation, notable inconsistency concerning the intervention length, elements, and populations remains. For instance, Denehy et al. (2001)[11] stated that preoperative physical therapy for the respiratory muscles improves inspiratory muscle strength and QoL scores in patients receiving upper abdominal surgery, but covered patients from various surgical specialties. Few other studies also found perioperative breathing exercises contributed to the prevention of postoperative pulmonary complications and improved the long-term prognosis in elderly patients who were undergoing laparoscopic colorectal surgery.[12,13] Our study fills the gap by examining obese patients who were undergoing laparoscopic upper abdominal operations, a vulnerable population which is prone to PPCs because of their altered respiratory mechanics.

Strengths of the study are its randomized controlled design, optimal baseline characteristic matching, standardized anesthetic and surgical practices, and overall outcome measurement. Limitations exist, though. The sample size, although sufficient to identify differences in primary outcomes, may constrain the generalizability of findings and statistical power to identify differences in uncommon outcomes such as ICU admission or respiratory failure. In addition, compliance with the prehabilitation protocol was not objectively measured, and this could influence reproducibility. Longer follow-up periods should be included in future studies and the cost-effectiveness of prehabilitation in this environment explored.

Conclusion

In conclusion, this trial presents strong evidence that preoperative structured physical and respiratory therapy has a major positive effect on pulmonary function, decreases postoperative pulmonary complications, and accelerates recovery in obese patients undergoing laparoscopic upper abdominal surgery. The findings are in favor of the integration of prehabilitation into perioperative management guidelines for high-risk surgical candidates and could influence future clinical guidelines.

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