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Preoperative Continuous Positive Airway Pressure Versus Incentive Spirometer in Morbidly Obese Patients Undergoing Bariatric Surgeries: Randomized Comparative Study

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ABSTRACT

Background: Morbidly obese patients have high risk to develop postoperative pulmonary complications, 80% of them have obstructive sleep apnea and obesity hypoventilation syndrome. Patients with sleep breathing issues often use continuous positive airway pressure (CPAP) machines, which employ mild air pressure to keep the airways open. Incentive spirometry encourages cases to take slow, deep breaths, triggering natural sighs.

Aim: to compare preoperative CPAP and incentive spirometer on postoperative pulmonary complications incidence in morbidly obese cases post laparoscopic bariatric surgeries.

Patients and method: 52 morbidly obese patients underwent general anesthesia for laparoscopic bariatric surgery were randomly allocated either received CPAP or incentive spirometry before the day of surgery, patients were assessed for postoperative pulmonary complications, changes in pulmonary function, lung mechanics and postoperative hypoxia incidence.

Results: there was no significant change among both groups in the context of postoperative respiratory complications: atelectasis was the most common complications (61.5% and 46.2% in CPAP and spirometry respectively). Better postoperative pulmonary function profile and lung mechanics was noted in spirometry group.

Conclusion: Preoperative application of CPAP and incentive spirometer have comparable result as regard incidence of postoperative pulmonary complications. However, incentive spirometer improves intraoperative lung mechanics and postoperative pulmonary functions.

Keywords: Bariatric, Continuous positive airway pressure, Incentive spirometry, Pulmonary complications.

INTRODUCTION

The incidence of various diseases increases with obesity, especially cardiovascular diseases (CVS), type II diabetes mellitus (DM), obstructive sleep apnea (OSA), many forms of malignant tumours, osteoarthritis, and depression[1].

The link between obesity and pulmonary dysfunction is becoming more apparent[2]. Pneumoperitoneum is produced during laparoscopic surgery. In this procedure, a gas (typically carbon dioxide) is insufflated into the peritoneal cavity. There was an increase in intra-abdominal pressure. The use of laparoscopic surgery is becoming commonplace as it reduces pain postoperatively, has highest cosmetic result, reduces hospital stay and complies patients satisfaction[3].

Patients with sleep breathing issues often use continuous positive airway pressure machines, which employ mild air pressure to keep the airways open[4]. Incentive spirometry is a type of spirometry that encourages patients to take slow, deep breathes from their functional residual capacity (FRC) up to their complete lung capacity, then hold for 5 seconds[5].

Pulmonary problems after surgery are prevalent, expensive, and increase patient mortality. On induction of general anesthesia, alterations to the respiratory system begin immediately; respiratory drive and muscle function are altered, lung capacities are lowered, and atelectasis develops in more than 75% of patients taking neuromuscular medications. It could take up to 6 weeks for the respiratory system to recover to its pre-surgery state. Respiratory infections, respiratory failure, pleural effusion, atelectasis, pneumothorax, bronchospasm, pneumonia, acute respiratory distress syndrome (ARDS), tracheobronchitis, pulmonary edema, pulmonary embolism, and mortality are all postoperative pulmonary problems[6].

The aim of the present study was to compare between the effects of utilizing CPAP or incentive spirometer preoperatively on postoperative pulmonary complications in morbidly obese cases post laparoscopic bariatric surgeries. The primary end point was the achievement of less postoperative pulmonary complications, while improvement of respiratory mechanics, oxygenation index and postoperative pulmonary functions were the secondary outcomes.

PATIENTS AND METHODS

Any morbidly obese patients whose BMI > 30 kg/m^2 with American Society of Anesthesiologists (ASA cases physical status II-III of both genders, aged between 18-60 years, scheduled for laparoscopic bariatric surgeries were included in this study.

We excluded patients with major cardiac impairment with ejection fraction less than 40%, cases with major hepatic (Child B and C), patients with renal problems (renal failure according to RIFFLE criteria), patients converted to open surgery, patients with OSAS on active treatment by CPAP, patients enrolled in other studies, and patients who refused to be included in this study.

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Fifty-two patients were randomly allocated using computer generated program and closed envelop method into two groups. **Group CPAP** (26 patients) patients were subjected to continuous airway pressure 10 cm H_2O for 10 minutes every 2 hours on the day before operation till the time of surgery, while **group IS** (26 patients) patients were instructed to use spirometry one day before operation by inhaling as slowly and deeply as possible in a set of 10 times and repeat the process every 2 hours till the time of surgery. Full detailed medical and surgical history was taken from all patients including common comorbidities associated with obesity as metabolic syndrome, OSA, and obesity hypoventilation syndrome (OHS). All patients were routinely examined. Routine laboratory investigations, ECG, echocardiography and pulmonary function tests were done.

Routine monitoring, including an electrocardiogram, non-invasive blood pressure, and pulse oximetry, were attached when the patient arrived in the operation room. The baseline values were recorded. A cannula for intravenous administration was placed. After preoxygenation with 100 percent oxygen mask for 5 minutes, all patients received 1-2 μg fentanyl, 2 mg/kg propofol slowly IV till loss of verbal contact, and atracurium 0.5 mg/kg to assist correct installation of endotracheal tube.

All patients were mechanically ventilated by utilizing volume control mode, with a tidal volume of 6 mL/kg, PEEP of 5 cm H_2O, and a respiratory rate was regulated to keep end tidal carbon dioxide of 30-35 mmHg. All patients were kept anaesthetized with 1-1.2 MAC isoflurane in O_2 air mixture with FiO_2 (0.4) and a 0.15 mg kg atracurium incremental dose.

Pneumoperitoneum was conducted by surgical team by CO_2 insufflation to keep intra-abdominal pressure between 12-14 mmHg. If there was intraoperative hypoxia (O_2 saturation <92%), rescue maneuver was followed: first increase PEEP in 2 cm H_2O increment provided that plateau pressure remained below 30 mmHg, second step was to increase FiO_2 in 10% increment, if persistent hypoxemia, the surgeon was asked to deflate the abdomen. All patients received intravenous ringer acetate 2-4 ml.kg.h.

Peak airway pressure (Ppeak), plateau pressure (Pplat), PaO_2/FiO_2 ratio, PEEP and driving pressure were recorded at (basal, 10 minutes, 30 minutes, one hour after intubation and just before return to spontaneous ventilation).

Before end of anesthesia lungs were recruited through manual application of continuous pressure of 30 cm H_2O for 15 seconds. Neuromuscular block was reversed using neostigmine (0.04 mg/kg) and atropine (0.02 mg/kg). Fully recovered protective airway reflexes, proper respirations, and full muscle strength were assured prior to extubation. Patients were monitored in post anesthesia care unit (PACU) for postoperative hypoxemia for 4 hours after operation.

Screening of postoperative pulmonary complications lasted for 5 days which comprised: respiratory infections, respiratory failure, pleural effusion, atelectasis, pneumothorax, pneumonia, ARDS, pulmonary edema and embolism. Follow up was done by clinical symptoms, X-ray and CT chest if needed. Pulmonary function test was done 24 hours following surgery. Forced vital capacity (FVC), forced expiratory volume in first second (FEV_1), (FEV_1/FVC) were recorded.

Sample size

Using pilot study incidence of postsurgical pulmonary adverse events was 26%. Assuming alfa error 0.05 and beta error 0.2 (power 0.8) and using X^2 test 23 patients were needed to decrease postoperative pulmonary complications to 15% in CPAP group; allowing 10% dropout 26 patients were needed in each group.

Ethical approval

The study was approved by the Institutional Research Board; approval number MS 20.07.1203, Mansoura Faculty of Medicine. Informed written consent was taken from each participant in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

The Statistical Package for the Social Sciences (SPSS, IBM, Inc., Chicago, USA) version 26 for Windows was used for data collection, tabulation, and analysis. Quantitative data was recorded as mean and standard deviation (SD). Percentage and frequency were used to express categorical data. Intergroup comparison of parametric and nonparametric continuous data was done using independent-sample t- and Mann–Whitney tests, respectively.

For pair-wise comparison of data, the follow-up values were compared to their corresponding basal value using paired samples T test, Wilcoxon matched pairs signed ranks test or related-samples.

In terms of comparing two or more groups of categorical data, chi^2 test was utilized. It was statistically significant if the probability (P) was less than 0.05.

RESULTS

62 patients were assessed for eligibility, 10 patients were excluded as shown in flow chart in figure **(A)**. There was no significant difference among the two groups in terms of demographic data, comorbid diseases and sleep disorders (Table 1).

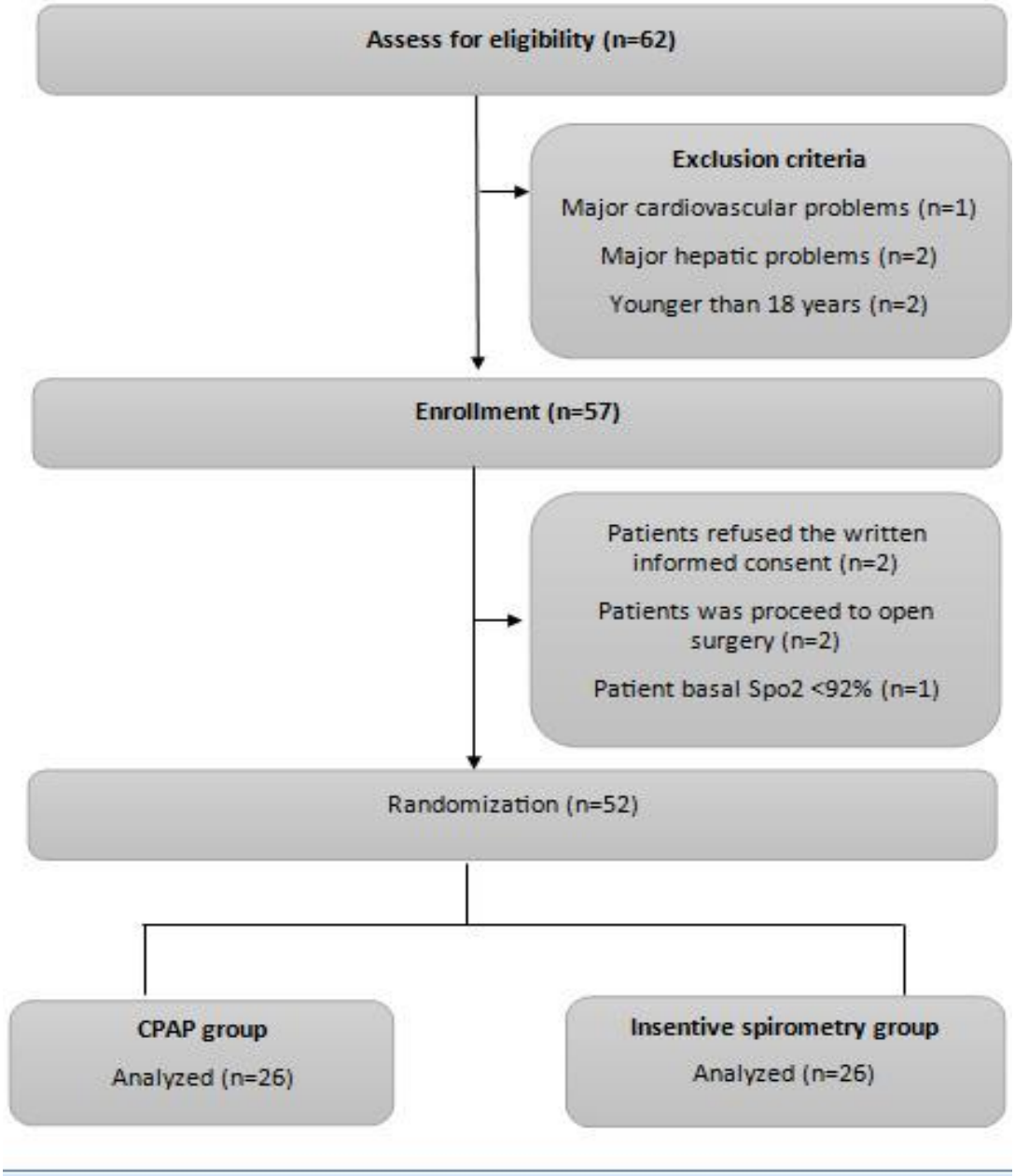

Figure A: Consort flow of cases of clinical trial

Table (1): Demographic features of the studied groups

		CPAP group (n= 26)	Spirometer group (n= 26)	P
Age		35.31 ± 13.873	37.73 ± 14.415	0.589
Gender	**Male**	38.5% (10)	30.8% (8)	0.560
	Female	61.5% (16)	69.2% (18)	
Weight		137.00 ± 17.256	129.73 ± 16.026	0.122
Height		166.58 ± 6.048	164.92 ± 7.353	0.380
BMI		49.44 ± 6.268	48.01 ± 7.652	0.464
DM		50.0% (13)	34.6% (9)	0.262
HTN		50.0% (13)	30.8% (8)	0.158
Duration of surgery		109 ± 18	114 ± 21	0.097
Sleep disorders	**OSAS**	42.3% (11)	19.2% (5)	0.146
	OHS	7.7% (2)	19.2% (5)	

The mean and standard deviation of the data, as well as the percentage and frequency of the data, are used. BMI: Body Mass Index; DM: Diabetes Mellitus; HTN: Hypertension; OSAS: Obstructive Sleep Apnea Syndrome; OHS: Obesity Hypoventilation Syndrome

As regard incidence of postoperative pulmonary complications there was no significant change among both groups. Atelectasis was the most common complication (Figure B)

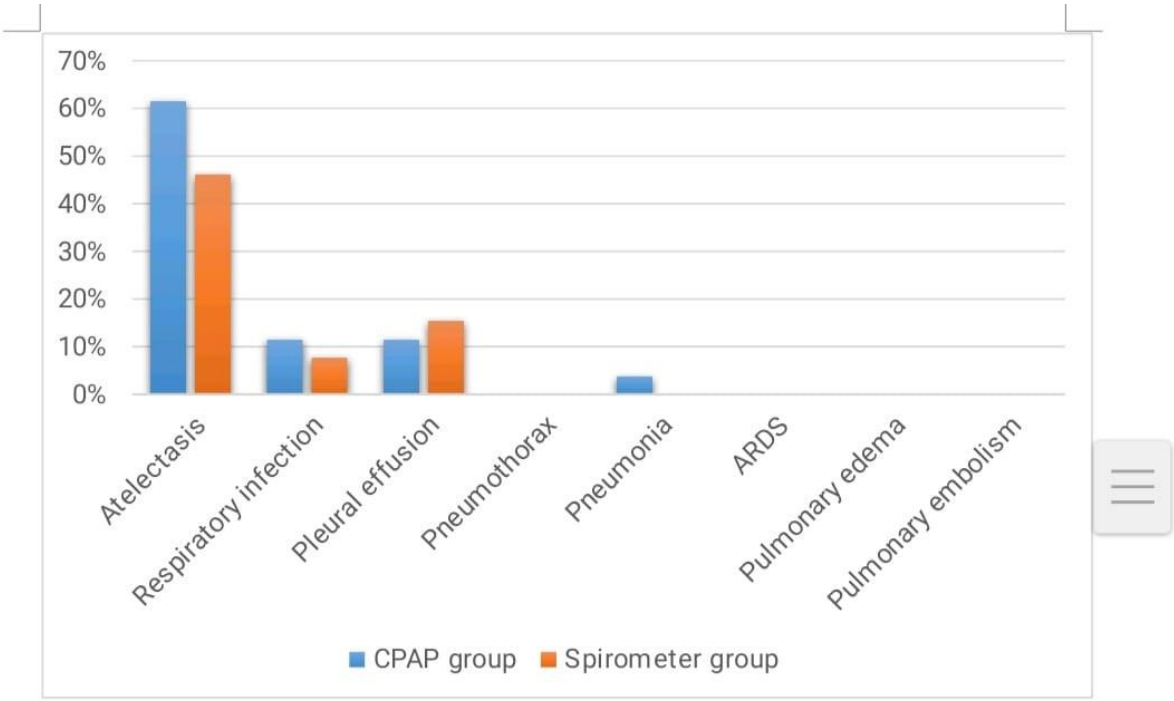

Figure B: Postoperative respiratory complications of the studied groups

There was no significant change among both groups in base line FVC, FEV_1, FEV_1\FVC. Postoperatively, there was significant reduction in pulmonary functions from base line in both groups. The mean postoperative FEV_1 was statistically significantly lower than mean baseline FEV_1 in CPAP group. The mean postoperative FEV_1 in spirometer group was statistically significantly higher than mean postoperative FEV_1 in CPAP group. The mean postoperative FEV_1\FVC was statistically significantly lower than mean baseline FEV/FVC in CPAP group. The mean postoperative FEV_1\FVC in spirometer group was statistically significantly higher than mean postoperative FEV_1/FVC in CPAP group (Table 2).

Table 2: Pre-and postoperative assessment of the pulmonary function of the studied groups

		Baseline	Postoperative	P
FVC	**CPAP group (n= 26)**	2.99 ± 0.707	2.18 ± 0.695	**< 0.001**
	Spirometer group (n= 26)	2.77 ± 0.472	2.63 ± 0.441	**< 0.001**
	P	0.180	**0.009**	-
FEV1	**CPAP group (n= 26)**	2.75 ± 0.924	1.77 ± 0.922	**< 0.001**
	Spirometer group (n= 26)	2.41 ± 0.589	2.32 ± 0.605	0.139
	P	0.122	**0.004**	-
FEV1/FVC	**CPAP group (n= 26)**	89.85 ± 9.962	76.96 ± 16.360	**< 0.001**
	Spirometer group (n= 26)	86.92 ± 10.769	87.88 ± 11.684	0.298
	P	0.315	**0.008**	-

Data are expressed as mean and standard deviation. FVC: Forced Vital Capacity: FEV_1, Forced Expiratory Volume in first second

Regarding the respiratory mechanics and P/F ratio follow-up of the studied groups, there was no statistically significant difference among both groups regarding peak airway pressure at any time. Regarding plateau airway pressure, it was found that the mean plateau airway pressure in spirometry group was statistically significantly lower than CPAP group, at 10, 30, and 60 minutes, and before extubation. Regarding PEEP, it was found that its mean value in CPAP group was statistically significantly higher than spirometer group, at 10, 30, and 60 minutes, and before extubation. Regarding driving pressure, it was found that its mean value in CPAP group was statistically significantly higher than spirometer group, at 10, 30, and 60 minutes, and before extubation. There was no significant difference in P/F ratio between both groups at any time (Table 3).

Table 3: Respiratory mechanics and P/F ratio follow-up of the studied groups

		10 minutes	30 minutes	60 minutes	Before extubation
Peak airway pressure	**CPAP group (n= 26)**	25.54 ± 3.849	28.73 ± 4.133*	29.31 ± 3.917*	26.27 ± 5.363
	Spirometer group (n= 26)	26.27 ± 4.788	27.50 ± 4.743	29.27 ± 5.064*	28.00 ± 3.098
	P	0.547	0.323	0.976	0.160
Plateau airway pressure	**CPAP group (n= 26)**	18.31 ± 5.058	20.54 ± 5.209	21.23 ± 7.901	18.85 ± 6.117
	Spirometer group (n= 26)	13.85 ± 4.722	15.88 ± 5.125	15.58 ± 5.537	14.00 ± 4.079
	P	**0.001**	**0.003**	**0.002**	**0.002**
PEEP	**CPAP group (n= 26)**	5.92 ± 0.628	5.88 ± 0.766	6.15 ± 0.613	5.92 ± 0.628
	Spirometer group (n= 26)	4.81 ± 0.634	5.08 ± 0.796	5.00 ± 0.800	4.69 ± 0.679
	P	**< 0.001**	**0.002**	**< 0.001**	**< 0.001**
Driving pressure	**CPAP group (n= 26)**	12.38 ± 5.013	14.65 ± 5.253	15.08 ± 8.079	12.92 ± 6.190
	Spirometer group (n= 26)	9.04 ± 4.845	10.81 ± 4.891	10.58 ± 5.665	9.31 ± 3.937
	P	**0.017**	**0.007**	**0.013**	**0.017**
PaO_2/FiO_2 ratio	**CPAP group (n= 26)**	222 ± 30	219 ± 50	207 ± 29	228 ± 49
	Spirometer group (n= 26)	225 ± 69	217 ± 31	229 ± 43	209 ± 24
	P	0.570	0.964	0.069	0.131

Data are expressed as mean and standard deviation. PEEP: Positive End Expiratory Pressure. * indicates significant difference between a reading and its respective baseline value.

Regarding the postoperative hypoxia of the studied groups, it was noted in 46.2% (12) of CPAP group, and 38.5% (10) of spirometer group (p 0.575)

DISCUSSION

Obese people are more likely to have lung collapse in dependent lung regions, particularly under general anesthesia. Since the diaphragm is mechanically connected to the abdominal wall, any rise in abdominal pressure during laparoscopic surgery might cause the diaphragm to cranially move, reducing the function residual capacity [7].

Application of CPAP or incentive spirometry can serve a protective strategy for improving oxygenation and lung mechanics. The aim of this study was to assess the effect of preoperative usage of CPAP or incentive spirometer among the obese patients undergoing laparoscopic bariatric surgeries.

The current study demonstrated that CPAP is comparable to incentive spirometry. As regard postoperative pulmonary complications, which were lower in incentive spirometry group but without significant difference.

The most common postoperative pulmonary complications were atelectasis (61.5% (16 patients) in CPAP group, 46.2% (12 patients) in incentive spirometry), respiratory infection (11.5% (3 patients) in CPAP group, 7.7% (2 patients) in incentive spirometry), pleural effusion (11.5% (3 patients) in CPAP group, 15.4% (4 patients) in incentive spirometry group), and pneumonia (3.8% (one patient) in CPAP group, 0% in incentive spirometry group).

Our study demonstrated the reduction in pulmonary functions (FVC, FEV1 and ratio) in incentive spirometry group was significantly lower than in CPAP group.

In terms of postoperative pulmonary problems, it was revealed that roughly 30% of bariatric surgery patients experienced pulmonary dysfunction. Preoperative spirometry showed that pulmonary dysfunction might predict postoperative pulmonary problems. Patients above the age of 40 and those who are superobese have a greater risk of lung dysfunction and developing pulmonary problems following bariatric surgery [8].

Benoît[9] and his colleagues validated it, demonstrating that in PACU patients, atelectasis is still present. In a short trial of 30 cases undergoing peripheral surgery under GA, CT scans were taken 20 minutes following extubation and indicated extensive

regions of atelectasis, which was much worse if the patient had gotten 100 percent oxygen during emergence

According to **Yang *et al.*** [10] 5.8% of cases who had major abdominal surgery (pneumonia 3.2 percent, extended ventilator support 48 hours 3.0 percent, and unexpected intubation 2.8 percent) had pneumonia. On multivariate analysis, esophagectomy, advanced ASA Classification System, dependent functional condition, longer surgical duration, age 80, severe COPD, presurgical shock, ascites, and smoking are all significant predictors of overall and individual postoperative pulmonary complications (PPCs). Obesity was not found to be a risk factor in this study. Female sex was found to be protective of PPCs.

In patients with rib fractures, they found that using an incentive spirometer (IS) decreased pulmonary consequences including atelectasis and hemothorax, as well as the need for further procedures like a tube thoracotomy. Furthermore, individuals who utilized an IS had substantial improvements in percent FVC and percent FEV1. The IS device has no effect on the duration of stay in the hospital or the intensity of chest discomfort. These devices are simple to use and show therapeutic advantages for individuals with rib fractures. They also have no negative side effects [11].

This result was consistent with the findings of **Bilyy *et al.*** [12]. Postoperative pulmonary difficulties were more common in the group without a preoperative incentive spirometer (24.4 percent vs. 5.9 percent, respectively, p = 0.045). Daily repetitions, balls per repetition, and proper incentive spirometer technique were all higher in the preoperative incentive spirometer arm (p = 0.002, p 0.001, and p = 0.034, respectively). The number of balls increased every repetition and the number of repetitions daily (p 0.032 and 0.021, correspondingly) indicated postoperative pulmonary issues. Postoperative pulmonary issues were also linked to less than 5 repetitions per day (sensitivity 93 percent, specificity 77 percent, p 0.001) and less than 2 balls each repetition (sensitivity 93 percent, specificity 77 percent, p 0.001).

According to **Jo and Shin** [13] the experimental group's compliance rate with breathing exercises was considerably greater than the control group's compliance rate with breathing exercises utilizing an incentive spirometer. After meals, the experimental group did a daily breathing exercise utilizing pan flutes for 30 minutes. In the following time, the experimental group had no lung infections, but the control group had a greater risk of pulmonary infections. Furthermore, the experimental group's life satisfaction score climbed dramatically.

According to the prospective cohort study of **Toor *et al.*** [14] the research involved 48 patients, 21 females and 27 males, with a median age of 58 years. Prior to exercise, the maximum inspiratory capacity of research members was 1885.4 mL, with a consequent increase in lung capacity reported in all subjects. The average maximum inspiratory volume was 2235.4 mL at the conclusion of week four of the research. The difference between baseline (1885.4) ml and maximum (2235.4) ml volumes was significant (t=-4.59, p 0.0001). ANOVA revealed no significant change in the week 1-4 averages (F=1.08, p 0.36). During the 30-day period, none of the individuals recorded any manifestations (fever, cough, and shortness of breath) or COVID-19 infection. None of the individuals said they had contacted their primary care doctors.

Sah *et al.* [15] agreed with our findings, stating that incentive spirometry and CPAP have comparable impacts on FVC levels. In all groups, postoperative 30 minute FEV1 values were statistically substantially lower than baseline (p 0.0001). In the groups IS and CPAP, FEV1 values were statistically substantially higher after 24 hours after surgery compared to 30 minutes after surgery (p 0.0001).

Stock *et al.* [16] on the other hand, contrasted the use of CPAP and incentive spirometry with a regimen of coughing and deep breathing to see which encouraged the fastest recovery of pulmonary function following upper abdomen surgeries in 65 individuals. FRC of patients in all groups was comparable postoperatively compared to preoperative values. When compared to the values obtained during surgery, the mean FRC of patients who got CPAP rose more quickly than the mean FRC of those who underwent cough and deep breathing (p 0.05). FRC was not increased any more by incentive spirometry than by CPAP. Atelectasis was detected 72 hours after surgery in 23 percent of CPAP patients (five of 22), 42 percent of CDB patients (eight of 19), and 41 percent of IS patients (nine of 22). Pneumonia struck two individuals (3 percent). After upper abdominal procedures, the frequency and monitoring of respiratory treatment may be more significant than the kind of therapy provided. Mask CPAP has the benefit of requiring no effort from the patient and not being painful.

The mean causes of difference with our result were different types of surgery, non-compliant patients in cough and deep breathing and IS groups, timing of use of active therapy as they used it postoperative, however, we used active therapy before operation. Active respiratory exercise using IS can strengthen inspiratory muscles, improve lung capacity and compliance, thus prevent postoperative pulmonary complications.

Surgical patients were screened for OSA in a preoperative consultation and given CPAP therapy in a previous study. Those who used CPAP treatment had better sleep quality, less fatigue throughout the day, and used fewer medications for relevant medical conditions [17].

CPAP has been shown to have positive effects on postoperative adverse outcomes [18]. In a case study by **Rennotte *et al.*** [19] two patients with OSA who did not get CPAP experienced postoperative complications, one of whom died, whereas 14 patients with OSA who received CPAP had a smooth recovery.

Patients with OSA who did not use CPAP had more postoperative difficulties (44 percent vs 27 percent, P 0.02) than patients with OSA who used CPAP. Patients with OSA who did not get continuous positive airway pressure treatment had more unplanned ICU transfers, and their duration of stay was one day longer [20].

Gobindrac *et al.* [21] agree with our work by using of CPAP on morbid obese patients who were with moderate to severe risk of OSA, those who were compliant to perioperative CPAP revealed a drop on cardiopulmonary adverse events.

Current study revealed comparable results as number of patients developed postoperative hypoxemia.

In a prospective cohort experiment, 132 patients were separated into CPAP using and non-using groups, with CPAP using significantly improving oxygen desaturation index (p 0.001). When comparing the CPAP using group to the non-using group, the need of supplemental oxygen treatment was significantly reduced (9.88 percent vs 46.5 percent, p 0.001) [22].

Furthermore, the findings of **Alam *et al.*** [23] agree with ours. In this study, they compared the effects of incentive spirometry and Acapella on blood gases. The average partial pressure of oxygen (PaO_2) determined by incentive spirometry after extubation and three days was 58.12.31 and 67.23.24, respectively. Acapella's PaO_2 was 56.33.43 and 66.43.54 after extubation and three days, correspondingly. The average PCO_2 assessed by incentive spirometry after extubation and 3 days was 41.43.326 and 36.12.11, respectively. Acapella's partial pressure of carbon dioxide (PCO_2) was 39.42.55 and 37.53.58 following extubation and three days, correspondingly. The differences were statistically significant at a p-value of 0.05. Acapella and incentive spirometry therapy were demonstrated to improve blood gases after a coronary artery bypass graft.

Our study has several limitations. Firstly, there was a defect in categorization of different types of bariatric surgery. Second, limited duration of active treatment. Lastly lack of frequent postoperative monitoring of blood gases, postoperative lung ultrasound and electric impedance tomography, which is a sure diagnostic tool for atelectasis.

CONCLUSION

Our results demonstrated that either preoperative application of CPAP or incentive spirometer has comparable results as regard incidence of postoperative pulmonary complications. However, incentive spirometer improved intraoperative lung mechanics and postoperative pulmonary functions.

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