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Research Article

Perioperative ventilatory strategies for improving arterial oxygenation and respiratory mechanics in morbidly obese patients undergoing laparoscopic bariatric surgery

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KEYWORDS

Recruitment;
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Abstract *Background:* Oxygenation impaired in morbidly obese patients undergoing bariatric surgery. We studied the safety and efficacy of recruitment maneuvers with different levels of positive end expiratory pressure (PEEP) in intraoperative and postoperative periods. The influence of post-extubation bilevel positive airway pressure (BiPAP) on oxygenation was also studied.
Methods: The study included 60 patients with body mass index (BMI) > 50 kg m^2 undergoing laparoscopic bariatric surgery. Patients were randomized into three groups; All study groups received 40 cm H_2O inspiratory pressure followed by PEEP 10 cm H_2O and O_2 postoperatively in the first group (PEEP 10 + O_2 Group), PEEP 15 cm H_2O and O_2 postoperatively in the second one (PEEP 15 + O_2 Group), and PEEP 15 and postoperative BiPAP in the third one (PEEP 15 + BiPAP Group). Primary end points were intraoperative oxygenation, ventilation, respiratory mechanics, hemodynamics, and postoperative oxygenation. Secondary end points were Vasopressor doses, length of intensive care unit (ICU) stay, and postoperative pulmonary complications.

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Results: Hemodynamics, and total vasopressor doses were comparable between groups. PaO_2/FiO_2 decreased after induction of anesthesia and pneumoperitonium and was similar between groups. After recruitment, PaO_2/FiO_2 increased significantly in PEEP 15 groups ($P < 0.05$). Static compliance decreased in all study groups 5 min after induction of pneumoperitonium, however, improved significantly after recruitment in the PEEP 15 groups ($P < 0.05$). PaO_2/FiO_2 was significantly higher in PEEP 15 groups 1 h postoperatively ($P < 0.05$). However, it was significantly increased only in PEEP 15 + BIPAP at 2, 12, 24 h postoperatively. ICU stay was significantly shorter in the PEEP + BiPAP group ($P < 0.05$). Complications were comparable between groups.

Conclusions: Recruitment maneuver followed by PEEP 15 cm H_2O improved oxygenation and respiratory mechanics during intraoperative and early postoperative periods in morbidly obese patients undergoing laparoscopic bariatric surgery. Moreover, postoperative BiPAP was essential to maintain oxygenation in these patients.

1. Introduction

General anesthesia has been reported to impair pulmonary gas exchange, and decreases blood oxygenation [1–3]. These effects are mostly due to the devolvement of pulmonary atelectasis [1,4,5] which may occur in approximately 90% of healthy adults [6,7].

Morbidly obese patients due to decreased chest wall and lung compliance, and decreased functional residual capacity, are more prone to the devolvement of pulmonary atelectasis and impaired pulmonary gas exchange with subsequent hypoxemia. These changes often occur after induction of general anesthesia [8–12], and may persist for 24 h postoperatively, resulting in increased risk for respiratory complications and prolonged hospital length of stay [13,14]. Pulmonary atelectasis is more exaggerated in morbidly obese patients undergoing laparoscopic surgery. The degree of hypoxemia has been shown to be directly related to the BMI [15,16].

Many authors reported improvement of the pulmonary gas exchange in these patients by applying recruitment maneuver in the form of an inspiratory pressure equivalent to the vital capacity maneuver [17–20], to open atelectatic alveoli with subsequent PEEP application to keep alveoli open [21]. However, these effects dissipated immediately after extubation [23].

This trial was conducted for morbidly obese patients undergoing laparoscopic bariatric surgery to study the efficacy and safety of two different levels of PEEP following the same recruitment maneuver. Moreover, we studied the efficacy of postextubation BiPAP in maintaining oxygenation in these patients.

2. Patients and methods

After approval by our local Ethics Committee and written informed consent was obtained from each patient, 60 American Society of Anesthesiologists (ASA) physical class II or III morbidly obese adult patients (BMI > 50 kg/m^2), scheduled for elective laparoscopic bariatric surgery during the period from April 2009 to October 2010 were included in this randomized prospective controlled study.

Patients were excluded if they had a [1] pregnancy [2], history of smoking [3], cardiac disease (history of coronary heart disease and New York Heart Association [NYHA] class III or IV) [4], Obstructive pulmonary disease (defined as forced expiratory volume below 80% of expected value on the preoperative spirometry) [5] If laparotomy was performed at any time [6] If peak inspiratory pressure reached 50 cm H_2O at any time [7] Persistent intraoperative hypotension unresponding to fluid boluses and/or vassopressors.

The basal pulmonary function tests (FVC, FEV1 PEFR) and chest X-ray were performed in the day before operation. Patients were fasted for at least 8 h. and premedicated with metoclopramide 10 mg IV, ranitidine 50 mg IV, and oral diazepam 5 mg 1 h before induction of anesthesia.

Standard monitoring included noninvasive arterial blood pressure, five leads electrocardiogram, capnometry, and pulse oximetry. A 20 gauge arterial (radial) and 16 gauge venous (peripheral) lines were inserted.

A fluid bolus of 20 mL/kg crystalloid solution was infused for all patients. After 3–5 min of preoxygenation, general anesthesia was induced with 1.5–2 mg/kg propofol, 2 μg/kg fentanyl, and 1.5 mg/kg succinylcholine to facilitate tracheal intubation.

For all study groups, the lungs were ventilated with volume-controlled ventilation with a mixture of 50% oxygen in air, and a tidal volume of 8–10 mL/kg based on lean body weight, inspiratory to expiratory ratio 1:2, and zero end-expiratory pressure, breathing rate was adjusted to maintain end-tidal carbon dioxide partial pressure between 30 and 35 mm Hg (Drager jullian, drager systems incorporation, USA). Anesthesia was maintained using 2% isoflurane, 0.2 mg/kg rocuronium boluses every 30 min.

Carbon dioxide was insufflated into the peritoneum to reach an intra-abdominal pressure up to 15 mm Hg, and the patient's head was elevated 30 degree afterward till the end of surgery.

Patients were randomized using a closed sealed envelope into three groups. Patients in the first group received a recruitment maneuver in the form of sustained inspiratory pressure of 40 cm H_2O for 15 s followed immediately by PEEP of 10 cm H_2O till extubation (PEEP 10 + O_2 group), the remaining two groups received recruitment maneuver in the form of sustained inspiratory pressure of 40 cm H_2O for 15 s followed immediately by PEEP of 15 cm H_2O till extubation then postoperative O_2 in one group, and BiPAP 12/8 in the other (PEEP 15 + O_2, and PEEP 15 + BiPAP groups).

In the case of intraoperative hypotension (decrease in MAP < 25% of the baseline) PEEP was discontinued, fluid bolus of 250–500 mL Ringer lactate and/or incremental doses of intravenous ephedrine (5 mg) were administered.

At the end of surgery, pneumoperitonium was released, isoflurane was discontinued, 100% oxygen was given, and muscle relaxant was reversed by neostigmine 2.5 mg and 1 mg atropine sulfate.

Tracheal extubation was performed in a semisitting position after fulfilling the criteria for extubation. Extubation criteria included a full conscious level state, hemodynamic stability, reversal of neuromuscular blockade, and the ability of head lift for 5 s.

Fully monitored patients were then transferred immediately to the ICU in a semisitting position, while receiving a high flow of oxygen. During the ICU stay, patients in the PEEP 10 + O_2, and PEEP 15 + O_2 groups received supplemental O_2 by Venturi facemask (35–60%) to achieve O_2 saturation >94%. Patients in the PEEP 15 + BiPAP group received non-invasive BiPAP by oral mask for at least 2 h out of every 3 h in the first 24 h postoperatively. Inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP) were adjusted to 12 cm H_2O and 8 cm H_2O, respectively and FiO_2 was 40% on Drager Evita 4 ventilator).

Postoperative analgesia in the first 24 h was intravenous acetylsalisilic acid and intramuscular tramal 100 mg every 12 h for all patients. Respiratory physiotherapy was initiated in the ICU for all patients in the form of respiratory exercises, assisted cough, incentive spirometry and ambulation.

Heart rate and noninvasive MAP were measured, and arterial blood gases analysis was performed just before induction of anesthesia ($T0$). Respiratory system compliance and Peak inspiratory pressure added to the previous measures were recorded at 5 min after the induction of anesthesia ($T1$), 5 min after pneumoperitonium was induced ($T2$), 5 min after recruitment ($T3$), after release of pneumoperitonium ($T4$), and just before extubation ($T5$). Arterial blood gas measures $PaCO_2$, and partial pressure of oxygen (PaO_2), then PaO_2/FiO_2 was calculated. Respiratory system compliance was calculated by dividing the exhaled tidal volume by plateau pressure after subtracting PEEP from the latter. Total doses of vasopressor used were also calculated.

During ICU stay; PaO_2/FiO_2, RR, were measured at 1, 2, 12, and 24 h from admission. Pulmonary function tests and chest X-ray were performed 12 h after ICU admission. Length of ICU stay and postoperative pulmonary complications were recorded. Complications included pulmonary embolism, barotraumas (pneumothorax, pnemomediastinum, or subcutaneous emphysema), respiratory failure requiring mechanical ventilation (defined as peripheral oxygen saturation (SPO_2) measured by pulse oximetry <90% on FiO_2 >40%, and/or respiratory rate >35 not related to reversible cause as fever or pain), pneumonia (diagnosed as new onset of fever, infiltrates on chest X-ray, leukocytosis, purulent sputum, and positive sputum culture), and atelectasis requiring intervention as bronchoscopy.

3. Statistical analysis

Data are presented as mean values with standard deviations. Data were analyzed using two way analysis of variance (ANOVA) test followed by Newman–Keuls test. $P < 0.05$ was considered for signification.

4. Results

Sixty patients were included in this prospective randomized study, 20 patients in each group, one patient from each group was excluded because of exceeding a peak airway pressure of 50 cm H_2O. One patient was excluded from the BiPAP group because he could not tolerate the oral mask. Patient's characteristics of all groups were similar. Basal pulmonary function tests showed restrictive features, and were comparable in the study groups (Table 1).

There was no significant difference between the study groups as regard hemodynamics during the study periods (Table 2).

PaO_2/FiO_2 decreased after induction of anesthesia, and was similar between the three groups. PaO_2/FiO_2 decreased more in all study groups after the induction of pneumoperitonium. After recruitment maneuver, PaO_2/FiO_2 increased in the study groups, however, patients in the PEEP 15 groups showed significant improvement when compared to PEEP10 group ($P < 0.05$). In all study groups, induction of pneumoperitonium resulted in an increase in $PaCO_2$ that decreased immediately after the recruitment maneuvers (Table 3).

Static respiratory system compliance decreased in all study groups 5 min after induction of pneumoperitonium. After lung recruitment, respiratory system compliance improved significantly in the PEEP 15 groups ($P < 0.05$) (Table 4). PIP was significantly increased in all study groups after induction of pnemopertoneum and increased more after recruitment maneuvers (Table 4).

At the end of the first hour postoperatively, PaO_2/FiO_2 was significantly higher in PEEP 15 groups ($P < 0.05$). However, there was a significant difference between PEEP 15 + BIPAP group and the other two groups as regard RR and PaO_2/FiO_2 at 2, 12, 24 h from ICU admission (Table 5).

Total vasopressor doses were comparable in the study groups. Moreover, no patients were excluded because of persistent hypotension. Length of ICU stay was significantly shorter in the PEEP + BiPAP group ($P < 0.05$). There were

Table 1 Patient characteristic.

	PEEP 10 + O_2 Group (n19)	PEEP 15 + O_2 Group (n19)	PEEP 15 + BiPAP Group (n18)
Age (year)	34 ± 4	33 ± 3	35 ± 6
Sex (male/female)	2/17	3/16	2/16
BMI (kg/m^2)	53 ± 2	54 ± 2	54 ± 3
FVC (L)	2.98 ± 0.53	2.78 ± 0.43	2.82 ± 0.46
FEV_1 (L)	2.37 ± 0.35	2.27 ± 0.32	2.28 ± 0.34
PEFR (L/min)	320 ± 50	330 ± 60	340 ± 55

PEEP = positive end expiratory pressure, BiPAP = bilevel positive airway pressure, BMI = body mass index FVC = forced vital capacity, FEV_1 = forced expiratory volume in the first second, PEFR = peak expiratory flow rate.

Table 2 Intraoperative hemodynamics.

		PEEP 10 + O_2 Group (n19)	PEEP 15 + O_2 Group (n19)	PEEP 15 + BiPAP Group (n18)
HR (b/min)	T0	88 ± 8	86 ± 7	85 ± 6
	T1	90 ± 6	89 ± 8	88 ± 7
	T2	86 ± 7	87 ± 8	87 ± 8
	T3	87 ± 8	86 ± 7	85 ± 9
	T4	89 ± 8	88 ± 9	86 ± 8
	T5	91 ± 9	92 ± 8	90 ± 8
MAP (mmHg)	T0	95 ± 8	94 ± 7	94 ± 6
	T1	85 ± 7	84 ± 6	83 ± 5
	T2	80 ± 6	78 ± 7	77 ± 6
	T3	85 ± 9	83 ± 8	85 ± 6
	T4	90 ± 7	89 ± 8	88 ± 7
	T5	95 ± 6	93 ± 7	91 ± 6

PEEP = positive end expiratory pressure, BiPAP = bilevel positive airway pressure, T0 = just before induction of anesthesia, T1 = 5 min after the induction of anesthesia, T2 = 5 min after pneumoperitoneum was established, T3 = 5 min after recruitment, T4 = after release of pneumoperitoneum, T5 = just before extubation, heart rate = HR, MAP = mean arterial pressure.

Table 3 Intraoperative oxygenation and ventilation.

		PEEP 10 + O_2 Group (n19)	PEEP 15 + O_2 Group (n19)	PEEP 15 + BiPAP Group (n18)
PaO_2/FiO_2	T0	360 ± 40	365 ± 50	366 ± 45
	T1	330 ± 44 [a]	335 ± 45 [a]	338 ± 40 [a]
	T2	300 ± 30 [a]	310 ± 35 [a]	315 ± 35 [a]
	T3	350 ± 35 [a]	386 ± 40 [a b]	388 ± 40 [a b]
	T4	365 ± 40	390 ± 35 [b]	392 ± 40 [b]
	T5	365 ± 30	385 ± 35 [b]	388 ± 30 [b]
$PaCO_2$ (Mm Hg)	T0	35 ± 3	36 ± 4	36 ± 4
	T1	34 ± 4	35 ± 4	34 ± 5
	T2	42 ± 3 [a]	42 ± 4 [a]	42 ± 3 [a]
	T3	35 ± 4 [a]	34 ± 3 [a]	34 ± 4 [a]
	T4	33 ± 4	33 ± 2	34 ± 3
	T5	35 ± 2	35 ± 3	34 ± 4

PEEP = positive end expiratory pressure BiPAP = bilevel positive airway pressure, PaO_2/FiO_2 = arterial partial pressure of oxygen/fractional inspired oxygen concentration, $PaCO_2$ = arterial partial pressure of carbon dioxide.

[a] Significant when compared with the previous reading within the same group.

[b] Significant when compared with group PEEP 10 + O_2 Group P value significant when < 0.05.

no recorded complications in PEEP 15 + BiPAP group compared with two cases of respiratory failure, one case of pneumonia, and three cases of atelectasis required bronchoscopy in the PEEP 10 + O_2 group. Two cases of respiratory failure and two cases of atelectasis required bronchoscopy in the PEEP 15 + O_2 group were also recorded. Neither, pulmonary embolism nor barotraumas were recorded in any patient in all study groups. Pulmonary function tests performed on the first postoperative day showed significant differences in the FVC, FEV1, and PEFR between PEEP 15 + BIPAP group, and the other two groups ($P < 0.05$) (Table 6).

Table 4 Intraoperative respiratory compliance.

		PEEP 10 + O_2 Group (n19)	PEEP 15 + O_2 Group (n19)	PEEP 15 + BiPAP Group (n18)
Cstat	T1	34 ± 4	35 ± 3	35 ± 2
	T2	28 ± 2 [a]	28 ± 3 [a]	28 ± 4 [a]
	T3	32 ± 3 [a]	35 ± 2 [a b]	35 ± 3 [a b]
	T4	35 ± 2 [a]	36 ± 3	36 ± 2
	T5	35 ± 3	35 ± 2	35 ± 3
PIP cm H_2O	T1	23 ± 3	23 ± 3	23 ± 2
	T2	32 ± 4 [a]	31 ± 3 [a]	32 ± 2 [a]
	T3	40 ± 2 [a]	41 ± 3 [a]	40 ± 3 [a]
	T4	30 ± 3 [a]	31 ± 2 [a]	31 ± 3 [a]
	T5	23 ± 3 [a]	23 ± 2 [a]	24 ± 2 [a]

PEEP = positive end expiratory pressure, BiPAP = bilevel positive airway pressure, Cstat = static compliance, PIP = peak inspiratory pressure, T0 = just before induction of anesthesia T1 = 5 min after the induction of anesthesia, T2 = 5 min after pneumoperitoneum was established, T3 = 5 min after recruitment, T4 = after release of pneumoperitoneum, T5 = just before extubation.

[a] Significant when compared with the previous reading within the same group.

[b] Significant when compared with group PEEP 10 + O_2 Group P value significant when < 0.05.

5. Discussion

The main finding of this study was that, for morbidly obese patients undergoing labarscopic bariatric surgery, recruitment maneuver in the form of sustained inspiratory pressure of 40 cm H_2O for 15 s followed by 15 cm H_2O of PEEP was safe, and efficacious in improving oxygenation and respiratory mechanics in the intraoperative and early postoperative periods. This was in accordance with the study of Hamid et al. who reported maximum improvement in oxygenation intraoperatively in patients undergoing Off Pump Coronary Artery Bypass surgery by repeating a recruitment maneuver of 40 cm H_2O followed by 15 cm H_2O of PEEP [23].

In the current study, respiratory system compliance, and PaO_2/FiO_2 as an indicator of oxygenation deteriorated after pneumoperitonium that was most probably due to development of atelectasis. Previous studies reported impaired respiratory mechanics and gas exchange in all study groups in both obese and non-obese individuals after pneumoperitonium [24,25]. In addition, Dumont et al. described a 31% decrease in respiratory system compliance with CO_2 insufflation in morbidly obese patients undergoing laparoscopic gastroplasty [15].

PaO_2/FiO_2 and respiratory system compliance were improved after recruitment in all study groups. However, there were significant improvement in compliance and PaO_2/FiO_2 in patients who received 15 cm H_2O PEEP compared with the PEEP 10 cm H_2O. While, intraoperative PEEP 10 was sufficient in previous studies to improve oxygenation and prevent atelectasis in obese patients with BMI lower than encountered in our study [28,29]. Maisch et al. [26] defined optimal PEEP as "the PEEP that prevents re-collapse, but avoids over-distension while optimizing lung mechanics". They found optimal PEEP to be 10 cm H_2O in their study; however they studied patients with BMI of 24 ± 4 kg/m^2 who were different from our patient populations. On the other hand, Erlandsson

Table 5 Postoperative respiratory rate and oxygenation.

		PEEP 10 + O_2 Group (*n*19)	PEEP 15 + O_2 Group (*n*19)	PEEP 15 + BiPAP Group (*n*18)
RR (breath/min)	1 h	17 ± 3	17 ± 2	14 ± 1 [b]
	2 h	16 ± 2	16 ± 3	13 ± 2 [b]
	12 h	17 ± 3	17 ± 2	14 ± 1 [b]
	24 h	17 ± 2	17 ± 2	13 ± 1 [b]
PaO_2/FiO_2	1 h	355 ± 30	380 ± 35 [b]	385 ± 30 [b]
	2 h	355 ± 35	365 ± 40 [a]	388 ± 35 [b]
	12 h	360 ± 30	360 ± 35	385 ± 35 [b]
	24 h	360 ± 35	360 ± 30	385 ± 30 [b]

PEEP = positive end expiratory pressure, BiPAP = bilevel positive airway pressure, RR = respiratory rate, PaO_2/FiO_2 = arterial partial pressure of oxygen/fractional inspired oxygen concentration.

[a] Significant when compared with the previous reading within the same group.

[b] Significant when compared with group PEEP 10 + O_2 Group *P* value significant when <0.05.

Table 6 Total vasopressors, postoperative complications, postoperative pulmonary function tests.

	PEEP 10 + O_2 Group (*n*19)	PEEP 15 + O_2 Group (*n*19)	PEEP 15 + BiPAP Group (*n*18)
Total vasspressors	10 ± 2	12 ± 3	13 ± 3
Complications			
Barotrauma	0	0	0
RF	2	2	0
Atelectasis	3	2	0
Pnemonia	1	0	0
PE	0	0	0
ICU stay (h)	48 ± 12	38 ± 10	28 ± 4 [a]
Pulmonary function tests			
FEV1 L	2.58 ± 0.43	2.63 ± 0.34	2.95 ± 0.47 [a]
FVC L	2.15 ± 0.30	2.21 ± 0.40	2.36 ± 0.35 [a]
PEFR (L/min)	310 ± 50	320 ± 40	365 ± 60 [a]

PEEP = positive end expiratory pressure, BiPAP = bilevel positive airway pressure, ICU = intensive care unit RF = respiratory failure, PE = pulmonary embolism, FEV1 = forced expiratory volume in the first second, FVC = forced vital capacity, PEFR = peak expiratory flow rate.

[a] Significant when compared with group PEEP 10 + O_2 Group *P* value significant when <0.05.

et al. [27] found a PEEP level of 15 cm H_2O as an optimal level of PEEP in morbidly obese patients where no recruitment or derecruitment had occurred using impedance tomography.

The increase in $PaCO_2$ after pneumoperitonium induction in all study groups could be explained by the CO_2 uptake secondary to CO_2 insufflation and to atelectasis formation. $PaCO_2$ returned to its normal values following recruitment most probably due to alveolar recruitment induced reduction in the ventilation/perfusion mismatch.

There was no significant reduction in the MAP and total doses of vasopressors in all study groups mostly due to adequate fluid preload. This was in accordance with Taleb et al. [29], who used a 10 cm H_2O of PEEP and same protocol of fluid preload.

At the end of the first hour postoperatively, the current study showed maintenance of the PaO_2/FiO_2 in patients of the BiPAP and PEEP 15 + O_2 groups. On the other hand, patients in the PEEP10 + O_2 group showed reduction in the PaO_2/FiO_2 than that observed in the intraoperative values. At the end of the second hour postoperatively, PaO_2/FiO_2 was maintained in the BiPAP group, however significant reduction in the PaO_2/FiO_2 was observed at that time in the other two groups. The optimal alveolar recruitment with PEEP 15 groups was the probable cause of maintained good oxygenation for 1 h post-extubation. But without BiPAP application, the effect of intraoperative recruitment was insufficient to maintain oxygenation 2 h postoperatively. Several previous studies demonstrated no beneficial effects of intraoperative recruitment strategies on postoperative oxygenation [22,30–33]. Almarakbi et al [34] showed sustained improvement in SPO_2 in patients received inspiratory maneuver repeated every 10 min into the first hour of recovery. This could be attributed to optimal alveolar recruitment and improved regional ventilation as a result of the repeated inspiratory pressure maneuver applied intraoperatively. In support of this are the results of Dyhr and colleagues [35] who reported maintenance of PaO_2 for 30 min after discontinuation of PEEP in cardiac surgical patients and improved regional lung ventilation after lung recruitment.

The recorded postoperative complications in our study were reported in the two groups who used conventional oxygen therapy. This may be explained by the role of noninvasive ventilation (NIV) in preventing alveolar derecruitment decreasing the possibility of atelectasis, pneumonia and eventually respiratory failure. This was in contrast with Talep et al. [29] who recorded no postoperative complications with PEEP 10 recruitment maneuver; however, they studied patient population with BMI lower than our patient's populations (30–50 kg/m^2).

Moreover, these reported complications may be directly attributed to the prolonged ICU stay in these two groups.

In the current study, patients who used noninvasive BiPAP demonstrated greater PaO_2 and reduction of the degree of pulmonary restrictive syndrome postoperatively than those who did not use NIV. This indicates better oxygenation levels with the use of noninvasive BiPAP, probably due to an increase in functional residual capacity. The improvement in the pulmonary function may be induced with lung inflation during IPAP, and preventing alveolar derecruitment during EPAP at the end of expiration. Previous studies [36,37] have shown that the prophylactic use of BiPAP in the first 12–24 h following a gastric bypass surgery in morbidly obese patients significantly increases the pulmonary function, when compared to a control group. NIV using BiPAP has been shown to be effective in preventing respiratory insufficiency in morbidly obese subjects if performed within 48 h of extubation in another study [38]. Liesching et al. [39] demonstrated that, the prophylactic use of the NIV postoperatively improved also gas exchange and pulmonary function, when compared to oxygen supplementation alone.

Among the limitation in the current study, we did not assess postoperative atelectasis using computerized tomography (CT) because of the difficulties encountered during positioning of these extremely obese patients.

In conclusion, Lung recruitment using inspiratory pressure of 40 cm H_2O for 15 s followed by PEEP of 15 cm H_2O improved respiratory system compliance and oxygenation in morbidly obese patients undergoing laparoscopic bariatric surgery. Moreover, postextubation BiPAP was efficient in preventing alveolar derecruitment.

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