

Comparative Evaluation of the Effects of Three Different Recruitment Maneuvers during Laparoscopic Bariatric Surgeries of Morbid Obese Patients on Cardiopulmonary Indices

Abstract

Background: Laparoscopic bariatric surgeries in morbid obese patients may be associated with atelectasis, hypercapnia, and hypoxemia, intra and postoperatively. Several strategies are used for the prevention of these consequences. This study aimed to examine the effects of three different recruitment maneuvers comparatively during surgery and the influence of the maneuvers on some cardiopulmonary indices. **Materials and Methods:** In a clinical trial, ninety participants of laparoscopic surgery with body mass index higher than 40 were randomly divided into three equal groups. The first group was subject to 10 cmH₂O positive end-expiratory pressure (PEEP) during surgery, the second group, after venting the pneumoperitoneum, had 5 deep breaths with a positive pressure of 40 cmH₂O, and the third group was subject to both. Some pulmonary and hemodynamic parameters were measured every 15 min and compared between three groups. **Results:** The average of peak airway pressure, plateau airway pressure, and SpO₂ static and dynamic compliance between the three groups had no meaningful differences ($P > 0.05$), but PaCO₂ in the second group was statistically higher than the other two groups ($P < 0.05$). **Conclusion:** Multiple deep breaths alone are not as effective as PEEP or PEEP plus MDB in preventing adverse pulmonary effects in laparoscopic bariatric surgeries of morbid obese patients.

Keywords: Laparoscopy, morbid obesity, recruitment maneuver

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Introduction

Morbid obesity, which is characterized by body mass index (BMI) higher than 40, has become a global health-care problem.^[1] This hygienic problem is considered multifactorial, and factors such as psychological, lifestyle, biologic, nutrition, and inactivity are influential.^[2]

One of the treatments for morbid obese patients is bariatric surgery. This surgery is often associated with intra- and post-operative pulmonary complications and respiration become highly disturbed in these patients.^[3,4] This disorder is the result of different factors including the position of patient during surgery, the prescription of muscle relaxants, and pneumoperitoneum (which results in the reduction of FRC, closing volume, and atelectasis).^[5,6]

As a result, the risk of pulmonary complications increases in the postoperative period and during hospitalization.^[7,8] Different approaches have been studied

to improve gas exchange during surgery such as using higher levels of tidal volume, more breaths or both,^[9] using positive end-expiratory pressure (PEEP)^[10] and finally putting the patient in reverse Trendelenburg position.^[11]

Application of 40 cmH₂O inspiratory pressure for 15 s followed by PEEP has been used in morbid obese patients in open bariatric surgery as a successful method for increasing oxygenation in this setting.^[12]

In another study by Almarakbi *et al.*, sixty laparoscopic gastric bounding surgeries in obese patients with BMI >30 compared for four different ventilation approaches including 10 cmH₂O PEEP, 40 cmH₂O inspiratory maneuver for 15 s, the same inspiratory maneuver plus PEEP, and the repetition of inspiratory maneuver every 10 min; they concluded that the fourth strategy has the best compliance and PaO₂ during surgeries.^[13]

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Regarding the limitations of the above-mentioned studies (not considering most of the patients as morbid obese [BMI >40], using 30% oxygen and the hemodynamic fluctuation in the group with higher compliance), this study designed to compare three ventilation approaches (recruitment maneuvers) and determine the influence of these maneuvers on cardiopulmonary indices.

Materials and Methods

This study approved by Ethics Committee of vice research of medical school of Isfahan University of medical sciences (reference number IR.MUI.REC.1394.3.670). In a randomized clinical trial, candidate morbid obese patients for laparoscopic bariatric surgery in Al-Zahra Medical Center from October 2015 to August 2016 enrolled to the study.

The including criteria were ages between 15 and 65 years old, American Society of Anesthesiologists 1 and 2 and BMI \geq 40, no smoking, normal intracranial pressure, and finally no pulmonary disease (obstructive or restrictive) and exclusion criteria were change surgery plan to open surgery and bleeding more than 10 cc/kg of the lean body weight (LBW).

After obtaining informed written consent, patients remained nil per os for 8–10 h. They took 10 cc/kg (LBW) of Ringer's solution during 90 min before surgery. Then, standard monitoring including electrocardiogram, SpO₂, and blood pressure was hooked to patients and basic vital signs were measured.

Anesthesia induced by intravenous prescription of 3 μ g/kg fentanyl (TRITTAU-Germany), 2–3 mg midazolam (Exir - Broojerd, Iran), 1.5 mg/kg propofol (Fresenius kabi Austria), and 1.5 mg/kg Cisatracurium (Daroupakhsh-Tehran Iran), and after 4 min ventilation by 100% oxygen, trachea was intubated by 7.5 internal diameter polyvinyl chloride tracheal tube. Then, patient ventilated by 10 cc/kg tidal volume and respiratory rate at 10 breaths/min. Respiratory rate adjusted every 5–10 min to kept end-tidal CO₂ (EtCO₂) between 35 and 40 mmHg.

Anesthesia was maintained by 100–200 μ g/kg/min propofol and 0.2 mg/kg of cisatracurium every 30 min. Moreover, 0.15 mg/kg (LBW) morphine (Darou Pakhsh - Tehran, Iran) was used to relief pain during the surgery. At the end of the surgery, 0.40 mg/kg of prostigmine (Caspian – Tamin, Iran) and 0.2 mg/kg atropine (Darou Pakhsh – Tehran, Iran) were used for reversing of muscle relaxant effects.

Ten minutes after inducing pneumoperitoneum (gas insufflation), the patients were divided into three groups using computerized randomization list and according to the considered group; intervention was made as follows: Group 1 or PEEP (P): patients received 10 cmH₂O PEEP from the beginning to the end of the surgery and Group 2 or multiple deep breaths (MDBs): patients were received

five breaths with positive pressure of 40 cmH₂O with 5 s of pauses and 5 s intervals as expiration at the end of surgery and after desufflation (venting) pneumoperitoneum.

Group 3 or PEEP plus MDB (PMDB): Like Group P, patients had 10 cmH₂O PEEP, and after venting the abdomen, the same MDB as group MDB was performed.

Before insufflation of gas into peritoneum, the patients were put in 15°C head down position and, after initiation of pneumoperitoneum, the patients were shifted to 30°C head up position slowly, the position was kept until the end of surgery. Intra-abdominal pressure maintained between 15 \pm 3 cmH₂O during surgery.

At the end of the surgery, infusion of propofol was stopped and the effect of muscle relaxants eliminated by reverse drugs, extubation was done after full awakening, and patients transferred to postanesthesia care unit (PACU).

During the transferring and care in PACU, the patient was maintained in 15–30 head up position and was receiving oxygen with the flow of 5–8 L/min. SpO₂, heart rate (HR), and mean arterial pressure (MAP) were measured every 15 min for 2 h in PACU.

The data were analyzed by SPSS (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp) The analyses consisted of repeated measured analysis, ANOVA, and Pearson's Chi-square test and differences considered significant at $P \leq 5\%$.

Results

The mean of demographic indexes such as age, weight, height, and BMI of the three groups had no meaningful difference ($P > 0.05$); frequency distribution of sex among the groups was the same either ($P = 0.812$), male/female were 6 (20%)/24 (80%) in Group P, 7 (23.3%)/23 (76.7%) in Group MDB, and 5 (16.7%)/25 (83.3%) in Group PMDB. The results showed no meaningful difference in surgery mean time and stay in PACU among the groups ($P > 0.05$). The comparison of the mean of SpO₂, MAP, and HR before anesthesia demonstrated that the mean of SpO₂, MAP before anesthesia had no meaningful difference between groups ($P > 0.05$), and the mean of HR before anesthesia for Group P was meaningfully lower than the other two groups ($P = 0.001 < 0.05$). The mean of total HR and the mean of arterial pressure had a meaningful difference [Table 1 and Figure 1].

Peak and plateau airway pressures and intra-abdominal pressure had no statistical meaningful difference in terms of total mean [Table 1].

Intra-abdominal pressure immediately, 60, 105, and 165 min after insufflation had a meaningful difference, in such a way that the mean intra-abdominal pressure in all the mentioned intervals was meaningfully higher in Group MDB compared with Group P.

Table 1: Total mean, standard deviation, and the statistical comparison results of hemodynamic and respiratory indices in three groups of study

Group	Mean	SD	P
Heart Rate			
P	87.2	4.1	0.037
MDB	89.8	9.1	
P+MDB	92.2	7.9	
Mean Arterial Pressure			
P	87.8	8.7	0.000
MDB	98.7	9.3	
P+MDB	87.4	13.6	
SpO ₂			
P	98.4	1.1	0.078
MDB	98.6	0.9	
P+MDB	98.7	0.8	
Peak airway pressure			
P	27.5	2.4	0.549
MDB	28.4	4.5	
P+MDB	27.7	3.1	
Pressure Plateau airway			
P	25.2	2.5	0.830
MDB	24.7	4.7	
P+MDB	25.3	3.0	
Intra-abdominal pressure			
P	14.8	0.47	0.059
MDB	15.4	0.75	
P+MDB	15.3	0.79	
Dynamic Compliance			
P	0.0224	0.004	0.510
MDB	0.0215	0.005	
P+MDB	0.0227	0.003	
Static Compliance			
P	0.0245	0.004	0.948
MDB	0.0249	0.006	
P+MDB	0.0248	0.003	
Expiratory Tidal Volume			
P	626	68	0.160
MDB	607	90	
P+MDB	646	72	
PaCO ₂ - EtCO ₂ (Before intervention)			
P	2.093	2.63	0.108
MDB	3.536	2.78	
P+MDB	2.586	2.55	
PaCO ₂ - EtCO ₂ (After intervention)			
P	2.386	1.77	0.001
MDB	5.266	4.57	
P+MDB	2.773	2.67	

P: PEEP, MDB: Multiple deep breath, PEEP: Positive end-expiratory pressure

The three groups had no statistical meaningful differences concerning the total mean of dynamic and static pulmonary compliance and expiratory tidal volume [Table 1].

Comparing the three mentioned variables, we observed no meaningful statistical difference in the intervals [Figure 1].

By comparing PaCO₂ mean and the difference between EtCO₂ and PaCO₂, 5 min after anesthesia, and 10 min after desufflation abdominal gas, it was observed that the mean of PaCO₂ 5 min after anesthesia and 10 min after venting gas had a meaningful difference among the groups ($P < 0.05$); in such a way that in the mentioned time, for Group MDB, the mean of PaCO₂ was meaningfully higher than the other two groups. The mean difference between EtCO₂ and PaCO₂ had a meaningful difference among the groups only 10 min after venting gas ($P = 0.001 < 0.05$); at this time, the difference of Group MDB was meaningfully higher than the other two groups [Table 1 and Figure 2].

Comparing the mean of SpO₂ and MAP during care in PACU showed that the mean of SpO₂ and MAP had no significant difference among the groups ($P > 0.05$) [Table 2].

By comparing the mean of urine output and the amount of used liquid for 1, 2, 3, and 4 h for the three groups, it was observed that the mean of urine output had meaningful difference only in the 1st h ($P = 0.013 < 0.05$), in such a way that the mean of urine output/hour for group PMDB was less than Group P, the mean of used liquid had no meaningful difference in the hours mentioned [Figure 3].

Discussion

The study showed that the mean of MAP for Group MDB was meaningfully higher than other groups, it can be referred to effects of PEEP (which were applied to two other groups) on decreasing preload and thereafter cardiac output and blood pressure (effects of deep breath maneuver on decreasing preload was hidden by effects of longer period of application of PEEP in other groups). The same as our results, Póvoa *et al.* claimed that MAP of group MDB is higher.^[14] However, unlike our results, Santa Cruz *et al.* reported findings, in which MAP was the same among the groups and had no significant difference.^[15]

There was no meaningful difference among the groups regarding peak airway pressure (PAP) and SpO₂ as well as EVT. Choi *et al.* found similar levels of SpO₂ in comparison of PEEP (8 cmH₂O) and recruitment maneuver (multiple deep positive pressure ventilation) followed by PEEP during one lung ventilation.^[16] While Pirrone *et al.* in their study on morbidly obese patients showed that the positive end-expiratory pressure levels of 11.6 ± 2.9 cmH₂O in comparison to recruitment plus PEEP were associated with lower oxygenation^[17] and Futier *et al.* concluded that recruitment plus PEEP improves respiratory mechanics and oxygenation during pneumoperitoneum whereas PEEP alone did not.^[18]

HR is another case of our investigation and it is clear that HR of Group PMDB was meaningfully higher than the other groups; this can be discussed by summation of

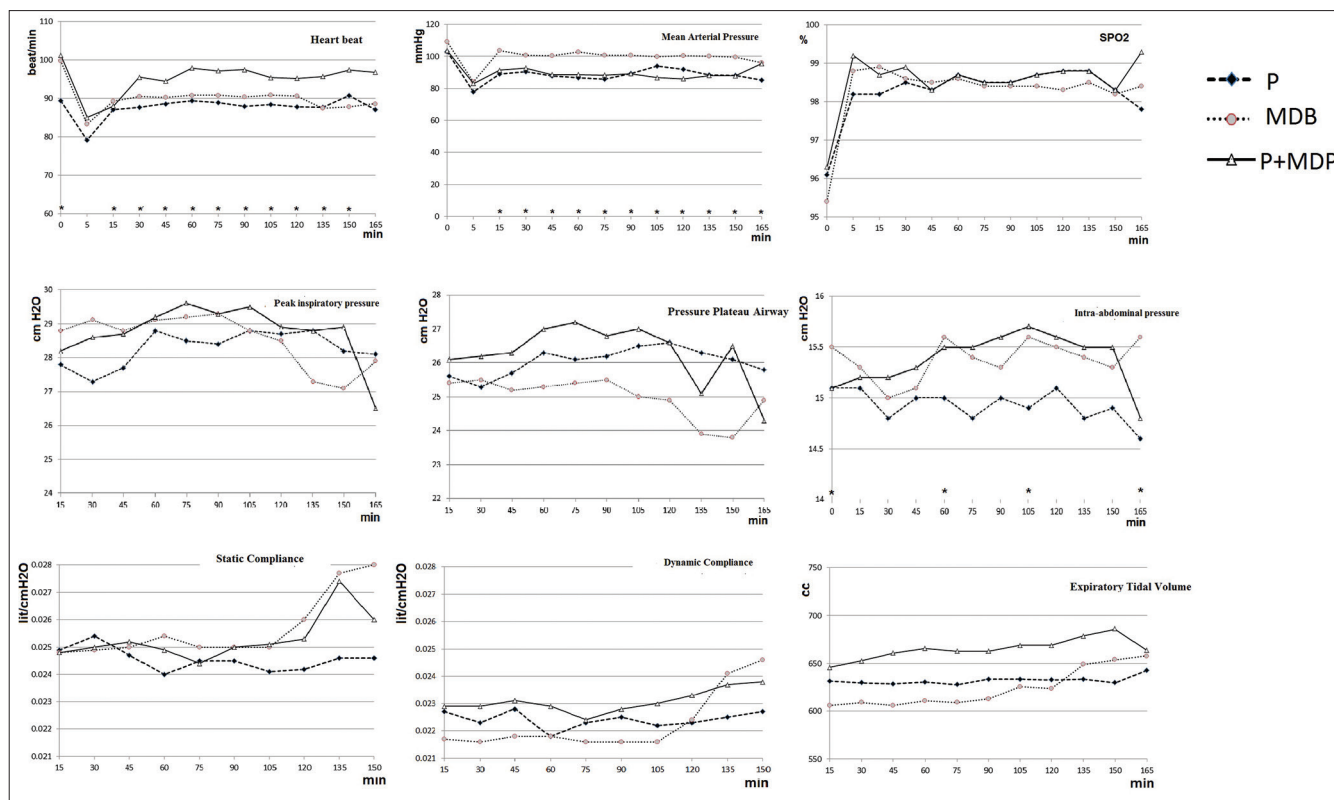


Figure 1: Diagram of changes of hemodynamic and respiratory indices during the study in three groups. (P: PEEP, MDB: Multiple deep breath, P+MDP: PEEP plus multiple breath)

Table 2: Mean, standard deviation, statistical analysis results of SpO₂, and mean arterial pressure during care in postanesthesia care unit for the groups

Group	Mean	SD	P
SpO₂			
P	92.22	2.11	0.541
MDB	91.81	3.33	
P+MDB	91.48	2.08	
MAP			
P	101.42	9.36	0.223
MDB	103.08	6.60	
P+MDB	98.84	11.49	

P: PEEP, MDB: Multiple deep breath, PEEP: Positive end-expiratory pressure

effects of PEEP and deep positive pressure breaths on decreasing preload and blood pressure and then activation of baroreceptors in this group. de Souza *et al.* in a study on adult patients with Grade III obesity who underwent bariatric surgery did not find meaningful differences in HR between patients whom treated by PEEP and recruitment maneuvers.^[19]

There were no meaningful differences between the groups concerning dynamic and static compliances while Almarakbi *et al.*^[13] showed that dynamic and static compliances of patients whom took recruitment plus PEEP (albeit with repeated recruitment) had better lung compliance in comparison to PEEP or recruitment alone.

There is a significant difference for Group MDB regarding the changes of PaCO₂-EtCo₂; this difference can show the decrease of alveolar capillary exchange level because of atelectasis although this change was not observed in SpO₂; it is probably because of ventilating of lungs by 100% oxygen.

Based on the obtained results of this study, applying PEEP (10 cmH₂O), recruitment alone (5 deep breath till PAP of 40 cmH₂O) after desufflation of intra-abdominal gas and combination of both are comparable in their effects on PAP, plateau airway pressure, (Plat AP), expiratory tidal volume (EVT), and SpO₂ and the mean of dynamic and static compliances during laparoscopic bariatric surgeries in morbid obese patients, but according to changes of PaCO₂ and EtCO₂-PaCO₂ gap, the recruitment alone is not as effective as two other strategies.

Conclusion

Recruitment alone (5 deep breath till PAP of 40 cmH₂O) after desufflation of intra-abdominal gas is not as effective as PEEP or Recruitment plus PEEP in maintaining EtCO₂-PaCO₂ gap.

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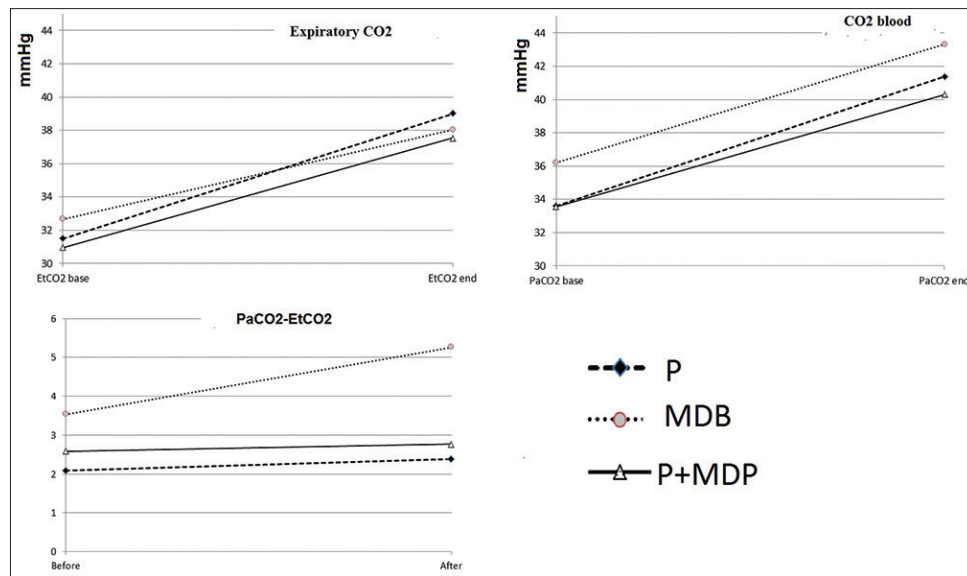


Figure 2: Diagram of changes of PaCO₂, P end-tidal CO₂ (EtCO₂) and PaCO₂-EtCO₂, before and after intervention in three groups of study (P: PEEP, MDB: Multiple deep breath, P+MDP: PEEP plus multiple breath)

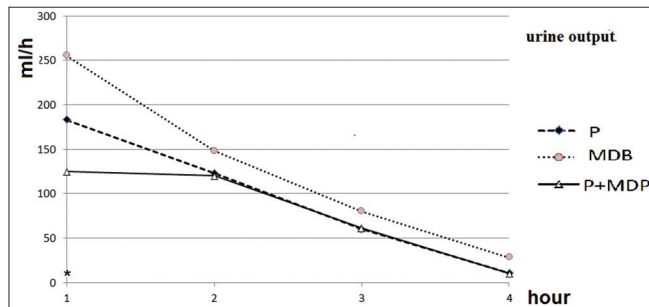


Figure 3: Diagram of urine output volume during surgery in three groups of study (P: PEEP, MDB: Multiple deep breath, P+MDP: PEEP plus multiple breath)

Conflicts of interest

There are no conflicts of interest.

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