The effect of alveolar recruitment maneuver and positive end expiratory pressure on arterial oxygenation and post-operative outcome in morbidly obese patients undergoing laparoscopic reduction gastroplasty

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Abstract:

Objective: The aim of this work was to study the effect of alveolar recruitment maneuver followed by PEEP on gas exchange in morbidly obese patients undergoing laparoscopic reduction gastroplasty and study its effect on the post-operative patients’ outcome.

Patient and methods: This prospective controlled randomized clinical trial was conducted on 40 patients with body mass index > 40 kg/m² underwent laparoscopic reduction gastroplasty under general anesthesia randomly allocated into two equal groups: Group I (Control group) were the patient’s lungs ventilated with the standard method and Group II (Study group) were the patient’s lungs ventilated as group I then the lung recruitment maneuver was performed by inflating the lungs with a positive pressure of 40 cm H₂O and maintaining this pressure for 15 second followed by PEEP 8 cm H₂O. This was repeated every 10 minutes throughout the procedure till extubation in the I.C.U. At the end of surgery, all patients were transferred intubated to I.C.U. till extubation and then transferred to the intermediate care unit till 24 hours post-operative. Arterial blood gases, mean arterial blood pressure, heart rate, Operative time, Time to extubation, I.C.U. stay time and the number of patients need post extubation ventilatory support were recorded throughout the study.

Results: Hemodynamic variables showed no significant difference between groups. PaO₂ showed a highly significant increase in both groups after intubation but increase PaO₂ was more significant in group II than group I. PaCO₂ and pH showed no significant difference between groups. There was a significant decrease in extubation time and I.C.U. stay time in group II in comparison with group I. As regard the post-extubation ventilatory support, only one patient in group II need post-extubation CPAP mask for one hour while in group I, four patients need post-extubation CPAP mask and one of them required re-intubation.
Conclusion: Lung recruitment maneuver is a suitable and beneficial technique during recovery in morbidly obese patients with minimal side effects. It is also beneficial in decreasing the time to extubation and I.C.U. stay time.

Keywords: Alveolar recruitment, morbidly obese patients, laparoscopic reduction gastroplasty

Introduction:

Abnormalities in gas exchange that occur during anesthesia are mostly caused by atelectasis and these abnormalities are exaggerated in morbidly obese patients. There is a direct relationship between such exaggeration and the body mass index (1). Under anesthesia, morbidly obese patients’ closing volume can exceed their functional residual capacity (FRC), causing airway closure and resulting in an increase in intrapulmonary shunt which leads to increased alveolar-arterial oxygen tension gradient (2). With pneumoperitonium occur during laparoscopy there are decreases in thoraco-pulmonary compliance by 30% to 50% in healthy (3) and obese patients (4), further reduction in functional residual capacity (5), elevation of the diaphragm and pulmonary ventilation perfusion mismatching (6). However, increasing intra-abdominal pressure to 14 mm Hg with the patient in a 10 to 20 degree head-up or head-down position does not significantly modify either physiologic dead space or shunt in patients without cardiovascular problems (7). There are various ventilatory strategies to improve gas exchange during bariatric surgery. Sprung and his colleagues used large tidal volumes and respiratory rate to shift the mean lung volume above the closing volume to increase the arterial O$_2$ tension (PaO$_2$) (8). Also Pelosi et al, tried to apply positive end expiratory pressure (PEEP) alone in obese patients and found that there was a modest increase in PaO$_2$ (9). Rothen et al (10) recommended alveolar recruitment maneuver. This maneuver reopens the atelectatic lung areas during anesthesia by sustained inspiratory pressure of at least 40 cm H$_2$O and maintaining this pressure for 10 – 15 seconds (11). This maneuver was showed to be more effective in prevention of atelectasis from recurring specially if followed by PEEP (12). Although, this technique effectively improves the gas exchange in morbidly obese patients throughout the course of operation, it promptly dissipates after tracheal extubation (1). This study aimed to study the effect of alveolar recruitment maneuver followed by PEEP on gas exchange in morbidly obese patients undergoing laparoscopic reduction gastroplasty and study its effect on the post-operative patients’ outcome.

Patient and methods:

This study was done in armed forced hospital (southern region) Saudi Arabia. After approval of hospital ethical committee and patient informed written consent, this prospective controlled randomized clinical trial was conducted on 40 patients, ASA I, II,
between 23 and 59 years old, nonsmokers, with body mass index > 40 kg/m² underwent laparoscopic reduction gastroplasty.

Patient with preoperative pulmonary disease, cardiac problems, liver or renal impairment, neurological disorders and patients with blood hemoglobin less than 12 g/dl were excluded from the study.

All patients were pre-medicated with IV midazolam 0.1 mg/kg in the pre-anesthesia room. After pre-oxygenation, general anesthesia was induced with propofol 2 mg/kg, fentanyl 2µg/kg and succinylcholine 1.5 mg/kg. After oral endotracheal intubation with reinforced endotracheal tube size 7.5 mm ID, anesthesia was maintained with 1-2 MAC sevoflurane and fentanyl 1-2 µg/kg/hr. over the period of the operation. Neuromuscular blockade was obtained by using rocuronium bromide 0.8 mg/kg as bolus dose and 10 µ/kg /min. as maintenance dose. Intraoperative monitoring was done using 5 leads ECG, pulse oxymetry, capnography, urine output and invasive blood pressure. All patient were mechanically ventilated with a tidal volume of 10 ml/kg, respiratory rate 12/min, i: e ratio = 1:2 and FiO₂ 100%. Ventilation adjusted to maintain end tidal CO₂ between 35-40 mmHg. All medications and parameters were calculated on an ideal body weight basis.

Patients were randomly allocated by closed envelope into two equal groups:

**Group I (Control group):** The patient’s lungs were ventilated with the standard method mentioned above.

**Group II (Study group):** The patient’s lungs were ventilated as group I, then after the creation of pneumoperitonium, the lung recruitment maneuver was performed by inflating the lungs with a positive pressure of 40 cm H₂O and maintaining this pressure for 15 second followed by positive end expiratory pressure (PEEP) 8 cm H₂O. This was repeated every 10 minutes throughout the procedure and postoperative till extubation in the I.C.U. In the operating theater this maneuver was performed manually by the anesthetist while in the I.C.U. this maneuver was performed using (Newport e -360 ventilator)

Fluid and blood loss were calculated and replaced properly. Urine output was maintained above 0.5 ml/kg/hr. Hemodynamic variables (Heart rate and mean arterial blood pressure) were maintained within 20% of the preoperative level. Surgical procedures were done by the same surgical team.

At the end of surgery, all anesthetics were stopped and patients were transferred intubated to I.C.U. sedated with dexmedetomidine 0.2 µg /kg /hr. till extubation and then transferred to the intermediate care unit till 24 hours post-operative.
Arterial blood gases (PaO₂, PaCO₂, and pH), mean arterial blood pressure and heart rate were recorded in all patients at the following intervals:

- Before induction of anesthesia.
- After intubation and before application of recruitment maneuver.
- 10 minutes after application of the 1st recruitment maneuver.
- At the end of surgery.
- When the patient reach the I.C.U.
- Then every 30 minutes till extubation.

Also, the following parameters were recorded:

- Operative time (min.): This is the time started from skin incision till closure of the wound.
- Time to extubation (min.): This is the time from intubation till extubation in the I.C.U.
- I.C.U. stay time (hr.): This is the time from admission to the I.C.U. till discharge.
- The number of patients need post extubation ventilatory support in the form of CPAP mask or re-intubation.

Weaning from mechanical ventilation was performed using gradual reduction of pressure support. Weaning was started once the patient had a phase of clinical stability and met the following criteria:

a- Normal sensorium.

b- PaO₂ ≥ 60 mmHg at a FiO₂ ≤ 40% with an external PEEP < 5 cm H₂O.

c- No cardiac ischemia or arrhythmias.

One hour after successful extubation, arterial blood gases were repeated. Ventilatory support in the form of CPAP mask was applied for one hour if the patients met at least one of the following criteria:

a- Respiratory acidosis.

b- pH < 7.35 with a PaCO₂ > 45 mmHg.

c- Increase in PaCO₂ > 15%.

d- Hypoxemia (SaO₂ < 90% for FiO₂ > 50%).

Non-invasive ventilation was applied and the respiratory pressure was adjusted according to the patient’s tolerance and with PEEP external < 6 cm H₂O aiming to achieve respiratory rate < 25 breath/ min. and arterial O₂ saturation > 92%, with pH > 7.35.

If non-invasive ventilation failed to achieve the aiming criteria, the patients were re-intubated.
Criteria for ICU discharge were (a) hemodynamic stability; (b) level of consciousness sufficient to protect the airway; (c) urinary output $0.5 \geq \text{ml/ kg/hr.}$; and post-extubation respiratory adequacy with maintenance of $\text{SaO}_2 > 95\%$.

**Statistical analysis:**

Statistical analysis was done using SPSS version 17. All data are presented as mean and standard deviation. All parameters were analyzed by using student t-test except analysis of sex was carried out using chi-square test. A p value $< 0.05$ was considered statistically significant.

**Results:**

Demographic characteristics showed non-significant difference between groups as regard age, sex, BMI and operative time (table 1).

<table>
<thead>
<tr>
<th>Table 1: Demographic characteristics</th>
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<tbody>
<tr>
<td><strong>Group I</strong></td>
</tr>
<tr>
<td>Age (years)</td>
</tr>
<tr>
<td>Sex (♀:♂)</td>
</tr>
<tr>
<td>BMI</td>
</tr>
<tr>
<td>Operative time (min.)</td>
</tr>
</tbody>
</table>

Hemodynamic variables showed no significant difference between groups as regard the mean arterial blood pressure (fig. 1) and the heart rate (fig. 2)

![Figure 1: Mean arterial blood pressure](image)
PaO₂ showed a highly significant increase in both groups after intubation but increase PaO₂ was more significant in group II than group I throughout the operation till extubation (fig. 3).

PaCO₂ (fig. 4) and pH (fig. 5) showed no significant difference between groups.
There was a significant decrease in extubation time and I.C.U. stay time in group II in comparison with group I (table 2).

<table>
<thead>
<tr>
<th></th>
<th>Group I</th>
<th>Group II</th>
<th>t - test</th>
<th>p- value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extubation Time(min.)</td>
<td>384.5±15.99</td>
<td>274.6±25.78</td>
<td>16.2</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>I.C.U. stay time(hr.)</td>
<td>12.6±2.21</td>
<td>6.85±1.137</td>
<td>10.34</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Figure 4: CO2 tension (PaCO₂)

Figure 5: pH
As regard the post-extubation ventilatory support, only one patient in group II need post-extubation CPAP mask for one hour while in group I, four patients need post-extubation CPAP mask and one of them required re-intubation.

Discussion:

This study documented that alveolar recruitment maneuver with PEEP improved intraoperative gas exchange with minimal side effects. Also if this maneuver is continued post operatively in I.C.U. It was beneficial in decreasing the time to extubation, I.C.U. stay time and decreases the need for post-operative ventilatory support. The efficiency of PEEP alone in providing enough trans-mural pressure to inflate collapsed alveoli is limited and it may be associated with overstretching of already opened alveoli and redistribution of pulmonary blood flow towards non-ventilated alveoli (13). These consequences may partially offset the beneficial effects of PEEP on lung volume and small airway closure (14). The application of recruitment maneuver in the present study had significantly accelerated and magnified the beneficial effects of PEEP by providing a sustained high peak inspiratory pressure, the alveolar recruitment maneuver overcame the opening pressure of the collapsed alveoli and accelerated the recruitment of atelectatic areas leading to increased ventilation perfusion ratio and decreased shunt fraction. This is agreed by Chalhoub et al (17) who studied the effect of alveolar recruitment maneuver on arterial oxygenation in morbidly obese patients undergoing open bariatric surgery and they documented its improvement. Also, Tusman et al (15) reported that an alveolar recruitment maneuver increased the respiratory system compliance in average weight patients. Similar results were recorded by Whalen and his colleagues (16) during laparoscopic bariatric surgery. Francis et al (1) suggested that alveolar recruitment is an effective mode of improving intra-operative oxygenation in morbidly obese patients and showed that the effect was short lived and associated with frequent use of intra-operative vasopressors due to hemodynamic instability. The present study reported hemodynamic stability throughout the study, due to the application of small PEEP (8 cm H₂O) in comparison with 12 cm H₂O PEEP used by Francis and his colleagues. In our knowledge there is no other studies studied the post-operative effect of alveolar recruitment maneuver on patient outcome after anesthesia.

Conclusion:

Lung recruitment maneuver with PEEP is a suitable and beneficial technique during recovery in morbidly obese patients with minimal side effects. It is also beneficial in decreasing the time to extubation and I.C.U. stay time.

References:

1- Farnsic X. Whalen, MD³, Ognjen Gajicn, MD, Geoffrey B. Thompson, MD, Michael J. Joyner, MD, et al: The effect of the alveolar recruitment maneuver


15- Tusman G, Bohm SH, Vazques de Anda GF. Do Campo JL, Lechmann B:
