Ventilation during laparoscopic-assisted bariatric surgery: volume-controlled, pressure-controlled or volume-guaranteed pressure-regulated modes?

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Abstract

Background: Pressure-controlled ventilation, volume-guaranteed (PCV-VG) is an alternative to pressure (PC) or volume (VC) controlled ventilation. We hypothesized that PCV-VG ventilation would improve oxygenation and ventilation with lower peak inflating pressures (PIP) than PC or VC ventilation in obese adolescents and young adults undergoing laparoscopic-assisted bariatric surgery.

Methods: This prospective, randomized, cross-over trial evaluated the effects of PC, VC and PCV-VG ventilation modes on PIP, ventilation, and oxygenation during bariatric surgery. Each patient received the 3 modes of ventilation for 20 minutes during the laparoscopic portion of the procedure. Ventilatory, hemodynamic and anesthetic parameters, and arterial blood gases were regularly documented.

Results: PCV-VG and PC ventilation both resulted in significantly lower PIP (cmH2O) than VC ventilation (30.5 ± 3.0, 31.6 ± 4.9, and 36.3 ± 3.4 mmHg respectively; p<0.01 for PCV-VG vs. PC and VC vs. VC). There was no difference in oxygenation (PaO2, PaCO2) or hemodynamic variables using any of the three ventilation modes.

Conclusions: In adolescents and young adults undergoing laparoscopic-assisted bariatric surgery, PCV-VG and PC ventilation were superior to VC ventilation in their ability to provide ventilation with the lowest PIP.

Methods

Study Design: Prospective, randomized, cross-over trial.

Cohort: 20 adolescents/young adults (BMI ≥ 40 kg/m²) presenting for laparoscopic-assisted bariatric surgery.

Anesthetic technique:
- Premedication, induction and endotracheal intubation standardized.
- Maintenance with desflurane titrated to a bispectral index of 40-60.
- Dexametomidine (0.2-0.25 µg/kg/ hour) and remifentanil infusions.

Ventilation Management: 3 ventilation modes provided for 20 minutes each: PC, VC and PCV-VG ventilation: set tidal volume of 6-8 mL/kg
- PC ventilation: PIP adjusted to deliver tidal volume of 6-8 mL/kg
- Held constant: I:E ratio 1:2-3, PEEP 5 cmH2O, FIO2 0.5, inspiratory time (T-insp) 1.5 seconds, respiratory rate (R-rate) to maintain normocarbia.

If a PIP ≥ 40 cmH2O was required to achieve the desired tidal volume, T-insp was first increased. If ineffective, that ventilation mode was terminated for another mode of ventilation.

Data Collection: Documentation of ventilatory, hemodynamic and anesthetic parameters, and arterial blood gases. Data were analyzed using paired t-tests.

Results

Table 1: Demographic data

<table>
<thead>
<tr>
<th>Number of patients</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years)</td>
<td>17.2 ± 2.3</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>128.8 ± 26</td>
</tr>
<tr>
<td>Body Mass Index (BMI) (kg/m²)</td>
<td>49.3 ± 9.3</td>
</tr>
<tr>
<td>Gender (male-female)</td>
<td>3:17</td>
</tr>
</tbody>
</table>

Table 2: Arterial blood gas and ventilation parameters by mode of ventilation

<table>
<thead>
<tr>
<th>Mode of Ventilation</th>
<th>VC</th>
<th>PC</th>
<th>PCV-VG</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIP (cmH2O)</td>
<td>36.5 ± 5.0</td>
<td>31.6 ± 5.5</td>
<td>30.6 ± 3.4</td>
</tr>
<tr>
<td>PaCO2 (mmHg)</td>
<td>161 ± 45</td>
<td>169 ± 47</td>
<td>166 ± 52</td>
</tr>
<tr>
<td>pH</td>
<td>7.32 ± 0.04</td>
<td>7.33 ± 0.05</td>
<td>7.34 ± 0.03</td>
</tr>
<tr>
<td>PaO2 (mmHg)</td>
<td>40.9 ± 3.3</td>
<td>40.2 ± 3.7</td>
<td>38.8 ± 4.1</td>
</tr>
<tr>
<td>Resp. rate (breaths/min)</td>
<td>9.2 ± 2.1</td>
<td>9.4 ± 2.2</td>
<td>9.2 ± 2.1</td>
</tr>
<tr>
<td>Exhaled tidal volume (mL)</td>
<td>760 ± 124</td>
<td>737 ± 135</td>
<td>750 ± 121</td>
</tr>
</tbody>
</table>

The data are listed as the mean ± SD; *p<0.001 for PCV-VG vs. VC and **p<0.001 for PC vs. VC

Table 3: Arterial blood gas and ventilation parameters by mode of ventilation

<table>
<thead>
<tr>
<th>Hemodynamic variable</th>
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<tr>
<td>Heart rate (beats/minute)</td>
<td>77 ± 10</td>
<td>73 ± 11</td>
<td>71 ± 11</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>99 ± 10</td>
<td>98 ± 11</td>
<td>96 ± 16</td>
</tr>
<tr>
<td>Mean arterial pressure (mmHg)</td>
<td>62 ± 8</td>
<td>60 ± 11</td>
<td>59 ± 11</td>
</tr>
</tbody>
</table>

The data are listed as the mean ± SD; P=NS for all variables in Tables 3 and 4, and each mode of ventilation.

Discussion

- During VC ventilation, 4 patients required adjustments to the T-insp to maintain a PIP ≤ 40 cmH2O, and 1 patient could not be ventilated (PIP ≥40 cmH2O) thus VC mode was abandoned.
- PCV-VG and PC ventilation were superior to VC ventilation in the ability to mechanically ventilate with the lowest PIP.
- No significant differences were noted between any mode of ventilation when considering oxygenation, ventilation, hemodynamic variables, and intraoperative anesthetic requirements.

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Table 4: Hemodynamic parameters by mode of ventilation

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The data are listed as the mean ± SD; P=NS for all variables in Tables 3 and 4, and each mode of ventilation.

- Peak inspiratory pressure (mmHg) dependent on the type of ventilation.
- The peak inspiratory pressure was significantly less during pressure control and pressure-control ventilation, volume guaranteed when compared to volume control.

Figure 1: Mean peak inspiratory pressures by ventilation mode

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