Effect of pneumoperitoneum and Trendelenburg position on gastro-oesophageal reflux and lower oesophageal sphincter pressure

J. P. TOURNADRE, D. CHASSARD, K. R. BERRADA AND P. BOULETREAU

Summary
We have measured the effect of pneumoperitoneum and the Trendelenburg position on lower oesophageal sphincter (LOSP) and barrier pressures (BrP) in 11 anaesthetized pigs while measuring the incidence of gastro-oesophageal reflux with a pH electrode. Propofol in combination with sufentanil had no effect on LOSP or BrP. Adoption of the Trendelenburg position with a pneumoperitoneum of 15 mm Hg resulted in a significant increase in LOSP (P < 0.002) and BrP (P < 0.001). However, in two of 11 pigs who had the lowest LOSP before induction, there was regurgitation. (Br. J. Anaesth. 1996; 76: 130–132)

Key words

Factors which increase lower oesophageal sphincter pressure (LOSP) usually also increase oesophageal barrier pressure (BrP = LOSP–gastric pressure). To date, only one study found that increased intra-abdominal pressure and Trendelenburg position resulted in an increase in LOSP and it was concluded that laparoscopy did not necessarily increase the likelihood of regurgitation [1]. However, reflux was not measured and oesophageal pressures were not recorded before induction of anaesthesia. We have therefore studied in pigs the effects of anaesthesia, pneumoperitoneum and Trendelenburg position on LOSP and gastro-oesophageal reflux.

Materials and methods
After obtaining approval from our Institutional Animal Care Committee, we studied 11 pigs (weight 22–25 kg). Ketamine 8 mg kg\(^{-1}\) i.m. was given as premedication after a 12-h fast. Anaesthesia was induced with propofol 5 mg kg\(^{-1}\), sufentanil 3 μg kg\(^{-1}\) and pancuronium 0.1 mg kg\(^{-1}\) i.v. The trachea was intubated with a 6-mm cuffed tube and the lungs ventilated artificially using a MMS 107 ventilator (MMS, Pau, France) with a tidal volume of 15 ml kg\(^{-1}\) at a ventilatory frequency of 12–15 b.p.m. (normocapnia at baseline using an Engström Eliza capnograph). Anaesthesia was maintained with a continuous infusion of propofol 10 mg kg\(^{-1}\) h\(^{-1}\). Carbon dioxide was insufflated through a Veress needle inserted through a 2-cm abdominal midline incision. Intra-abdominal pressure was maintained at 15 mm Hg (Wolf, Knittlingen, Germany).

The technique of oesophageal manometry has been described previously [2, 3]. Briefly, LOSP, gastric (GP) and intraperitoneal pressures (IPP) were measured with the pig in the supine position using perfused polyethylene catheters connected to pressure transducers (Bentley Trantec, Irvine, CA, USA). Recordings of LOSP were made at end-expiration by a “pull-through” manoeuvre. Transducers were zeroed at the level of the midchest position. Before each investigation, the system was calibrated in a water column (0–50 cm H\(_2\)O) and perfused continuously using a low compliance system (SC 2000 pump, Sky Electronics). Pressures were recorded using a multiple channel recording system (Kontron Medical) before induction (T0), after induction (T1), at an intra-abdominal pressure of 15 mm Hg (T3), at a pressure of 15 mm Hg with 15° of Trendelenburg position (T4) and finally with the pig supine again (T5).

Oesophageal pH was measured continuously using a bipolar glass electrode (Ecosecur pH recorder, Tacussel). The electrode was calibrated before each set of measurements with standardized solutions of buffer at pH 3 and 7. The electrode was advanced until gastric pH was recorded. It was then withdrawn to the gastro-oesophageal junction, recognized by an abrupt increase in pH, and finally positioned 5 cm above the junction. Reflux was defined as an abrupt decrease in oesophageal pH to less than 4 [2, 4].

Statistical significance was determined using a paired Wilcoxon test. P < 0.05 was considered statistically significant.

Results
Baseline LOSP and BrP were in the normal range for pigs. LOSP was not affected by anaesthesia and BrP remained above 10 mm Hg (table 1).

The Trendelenburg position, pneumoperitoneum, or both, increased LOSP, while significant increases in BrP and LOSP were noted only after

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the combination of pneumoperitoneum and Trendelenburg position. During the Trendelenburg position, the increase in LOSP was greater than the change in IPP (LOSP: 42.6 – 16.4 = 26.2 mm Hg vs IPP = 15 mm Hg) (table 1). Two of 11 pigs exhibited prolonged gastro-oesophageal reflux during pneumoperitoneum: both had a BrP lower than 0 mm Hg (0 and -2 mm Hg) at the time of reflux. Before and after induction, BrP was lower in these two pigs with reflux than in pigs without reflux: 7 (SD 1) compared with 17.1 (8.7) mm Hg and 5 (1) compared with 14.2 (6.5) mm Hg, respectively.

When the Trendelenburg position was reversed and the pigs placed supine, gastric pressure decreased to values similar to those recorded during pneumoperitoneum.

Discussion

We have demonstrated that lower oesophageal sphincter pressure increases significantly in response to increases in intra-abdominal pressure. However, in some animals, there was gastro-oesophageal reflux.

As in humans, the musculature of the porcine distal oesophagus consists of smooth muscle fibres [5]. Recent studies have shown that the pressure at the LOS is created not only by contraction of these smooth muscles but also by the striated muscle of the crural diaphragm [6]. Previous studies have demonstrated that drugs commonly used during anaesthesia such as atropine [7], benzodiazepines [2], morphine [2], thiopentone [3] and halothane [8] can affect the competency of the lower oesophageal sphincter. In contrast, ketamine has no effect on LOSP [9]. In a clinical study, Roberts and Goodman [10] did not observe any reflux episodes in 63 patients anaesthetized with propofol and fentanyl. In our study, we demonstrated that propofol associated with sufentanil had no effect on LOSP and BrP in pigs.

After adopting the Trendelenburg position, as the increase in LOS pressure was far greater than the change in gastric pressure, BrP increased. Heijke, Smith and Key [11] showed that adoption of the Trendelenburg position alone (15° and 30°) did not change BrP in female patients during balanced anaesthesia, and Lind, Warrian and Wankling [7] found that increasing IPP resulted in an increase in BrP. Jones, Mitchell and Hindocha [1] reported that the combination of Trendelenburg 15° and IPP at 20 mm Hg resulted in an increase in BrP, results similar to our findings. Increasing intra-abdominal or intragastric pressures by straight-leg raising or abdominal compression results in a concomitant increase in LOS pressure in animals as in human volunteers [12]. During anaesthesia, this adaptive response to increases in gastric pressure has been reported to be mediated partially via a cholinergic pathway as atropine reduced LOS tone [6].

During laparoscopy, carbon dioxide insufflation increases IPP and gastric pressure. Some clinical studies have evaluated the incidence of regurgitation during laparoscopy as 2–20 % [10, 13], an incidence no greater than that during other surgical procedures [14]. We also found a 20 % incidence of reflux (two of 11 pigs). Jones, Mitchell and Hindocha [1] have shown the presence of an adaptive response in LOSP in response to peritoneal insufflation up to 30 cm H2O. Heijke, Smith and Key [11] reported a small increase in gastric pressure during 30° Trendelenburg position, but BrP was not affected. It was concluded from these manometric studies that laparoscopy does not increase the risk of regurgitation. However, these manometric studies are not conclusive as intraoperative recording of oesophageal pH was not undertaken. In contrast, our results showed that reflux may occur in some animals because the adaptive response was not always present. We noted in two pigs that BrP was lower than 0 mm Hg during episodes of reflux and that these pigs had the lowest LOSP and BrP values throughout the study. Although it is well established that there is a relationship between a decrease in LOSP and reflux [15], it is not possible at this time to define BrP or LOSP values below which reflux will occur. Any decrease in BrP during anaesthesia would be expected to increase the risk of regurgitation and this is particularly true in situations where LOSP is initially low.

From this study we suggest that in an individual patient it is not possible to predict that the adaptive response of the LOS protects against regurgitation during laparoscopy.

References


<table>
<thead>
<tr>
<th>Baseline</th>
<th>After induction</th>
<th>IPP of 15 mm Hg</th>
<th>Trendelenburg + IPP of 15 mm Hg</th>
<th>IPP of 15 mm Hg</th>
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</thead>
<tbody>
<tr>
<td>LOSP (mm Hg)</td>
<td>19.1 (9.3)</td>
<td>16.4 (7.8)</td>
<td>31.0 (14.5)**</td>
<td>42.6 (19.7)**</td>
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<td>BrP (mm Hg)</td>
<td>15.2 (8.8)</td>
<td>12.5 (8.5)</td>
<td>13.7 (12.8)</td>
<td>20.9 (17.8)**</td>
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