Effect of the laryngeal mask airway on oesophageal pH: influence of the volume and pressure inside the cuff

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We studied gastro-oesophageal reflux (GOR) with a face mask and laryngeal mask airway (LMA), and the effects of inflation pressure and volume of the LMA cuff on oesophageal pH, in 60 patients. Patients were managed with either a face mask (group I) or LMA inflated to obtain a seal in the anaesthesia circuit at 7 cm H2O (group II) or 15 cm H2O (group III). A pH-sensitive probe with two electrodes, 10 cm apart, was placed in the oesophagus during anaesthesia and recordings were made continuously until patients awakened. There was a significant difference in the incidence of GOR between the face mask (group I) and the LMA (groups II–III) (P<0.05) in the lower oesophagus but there was no difference in the mid-oesophagus. No correlation was found between pressure and volume inside the cuff and variations in oesophageal pH. We conclude that LMA use was associated with increased reflux in the low oesophagus but oesophageal pH was not influenced by variations in pressure or volume inside the LMA cuff.

Keywords: anaesthesia, general; equipment, masks anaesthesia; complications, gastro-oesophageal reflux; gastrointestinal tract, pH; gastrointestinal tract, reflux

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Since its introduction in 1983,1 the laryngeal mask airway (LMA) has become an alternative to tracheal intubation or the face mask for the management of the airway during general anaesthesia. It has a small haemodynamic effect,2 avoids vocal cord trauma associated with intubation3 and is well tolerated, even when anaesthesia is superficial.4 However, its use may be associated with an increased incidence of gastro-oesophageal reflux (GOR),5–6 from loss of lower oesophageal sphincter activity caused by the LMA.7 The reason for this disruption at the level of the gastro-oesophageal junction is unclear, although it could be a result of a reflex from distension of the pharynx by the LMA cuff.7

We undertook a prospective, randomized study to compare the incidence of GOR related to the use of both the face mask and LMA, by measuring oesophageal pH in the lower and mid-oesophagus, and assessed the effects of cuff inflation pressure and volume of the LMA cuff on GOR.

Patients and methods

After obtaining approval from our Hospital Research and Ethics Committee and informed written consent, we studied 60 adults (ASA I, II) undergoing short elective surgery under general anaesthesia. Patients were allocated randomly to one of three groups (n=20). Randomization was by sealed envelope; the number inside identified the study group. Exclusion criteria included obesity (BMI >30 kg m–2), history or symptoms suggesting a diagnosis of GOR and use of ulcer medication or medications that could affect intestinal transit. All patients fasted for at least 6 h before surgery.

The pH monitoring apparatus consisted of two monocrystalline antimony pH electrodes (Synectics Medical, Stockholm, Sweden) enclosed, 10 cm apart, in a plastic tube (pH probe). The electrodes were calibrated using standardized buffer solutions before each case (precision and stability of 0.1 unit of pH over 100 h). After arrival in the operating room and commencing standard monitoring, anaesthesia was induced in all participants with midazolam 0.02 mg kg–1, propofol 2–3 mg kg–1 and fentanyl 1 µg kg–1 while breathing oxygen via a face mask. After loss of consciousness, a 2-mm diameter pH probe was introduced gently into the oesophagus, via a 14F suction catheter, using a laryngoscope. The probe was connected to a portable two-channel recorder (Digitrapper Synectics Medical, Stockholm, Sweden) for continuous recording of pH at both electrodes. The pH probe was inserted until a pH <4.0 was obtained at the distal electrode,
which meant it had just entered the stomach. It was then pulled back slowly, in order to observe the increase in pH, indicating return to the oesophagus. The catheter was then pulled back an extra 2 cm and secured firmly with tape (Fig. 1).

Anaesthesia was maintained throughout the study with propofol 100–300 mg kg⁻¹ min⁻¹ together with bolus doses of propofol 0.5 mg kg⁻¹ and/or fentanyl 0.5 μg kg⁻¹, as needed. Both drugs were titrated to allow spontaneous ventilation while avoiding movement and cough. The only respiratory gas administered during the course of the study was oxygen. Four minutes after insertion of the pH probe, pH recording began and, 1 min later, management of the airway was modified according to the treatment the patient was allocated. In group I, an oropharyngeal airway was inserted before continuing with the face mask throughout surgery. In groups II and III, an LMA (size 3 for women and 4 for men) (Intavent, Henley-on-Thames, UK) was inserted. The LMA cuff was inflated with the minimum amount of air so that no leak could be heard when the pressure in the anaesthesia circuit was maintained at 7 cm H₂O (group II) or 15 cm H₂O (group III). Immediately after inflation of the cuff, the exhaust valve of the anaesthesia circuit was opened to allow the pressure to return close to 0 cm H₂O for the remainder of the study. One minute after

### Table 1: Patient data (mean (SD or range) or number). *P*<0.05 compared with group I (ANOVA)

<table>
<thead>
<tr>
<th></th>
<th>Group I (n=20)</th>
<th>Group II (n=20)</th>
<th>Group III (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>47 (19–66)</td>
<td>40 (18–67)</td>
<td>36 (18–54)*</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64 (12)</td>
<td>65 (9)</td>
<td>64 (13)</td>
</tr>
<tr>
<td>Duration of surgery (min)</td>
<td>23 (14)</td>
<td>27 (26)</td>
<td>32 (20)</td>
</tr>
<tr>
<td>Propofol (mg)</td>
<td>648 (241)</td>
<td>784 (502)</td>
<td>964 (420)</td>
</tr>
<tr>
<td>Fentanyl (μg)</td>
<td>109 (36)</td>
<td>124 (73)</td>
<td>135 (50)</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>4/16</td>
<td>6/14</td>
<td>9/11</td>
</tr>
<tr>
<td>Position (litho/supine)</td>
<td>8/12</td>
<td>10/10</td>
<td>6/14</td>
</tr>
</tbody>
</table>

### Table 2: Surgical procedures

<table>
<thead>
<tr>
<th></th>
<th>Group I (n=20)</th>
<th>Group II (n=20)</th>
<th>Group III (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor breast surgery</td>
<td>7</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Limb surgery</td>
<td>5</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Minor gynaecological surgery</td>
<td>0</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Minor urological surgery</td>
<td>7</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

inflation, a pressure transducer system (Cobe Canada, Ltd) was attached to the LMA valve and the pressure inside the cuff was measured. The two-level recording of oesophageal pH was maintained until the patient was awake after surgery. The LMA (groups II and III) or the oropharyngeal airway (group I), together with the pH probe, were then removed and the volume of air withdrawn from the LMA cuff was recorded.

pH measurements were analysed and printed using Gastrosoft Version 5.51 software (Digitrapper and OesopHogram; Synectics Medical). A episode of reflux was defined as pH <4.0. An episode of reflux was attributed to the insertion procedure if it occurred within 1 min. Variables with normal distributions were compared between the three groups using one-way ANOVA followed, if appropriate, by the Tukey test. Variables showing non-normal distribution were analysed using the Kruskal–Wallis test followed, if necessary, by Dunn’s test. Qualitative variables were compared using the chi-square test. Comparisons applying only to groups II and III were performed using the t and Fisher’s tests. Linear regression was used to correlate the volume or pressure recorded inside the LMA cuff and GOR. Data are presented as mean (SD). *P*<0.05 was considered significant.

### Results

There was no difference between groups in weight, doses of propofol and fentanyl administered, sex, positioning of patients (lithotomy/supine position), or type and duration of surgery. However, patients in group I were older than those in group III (Table 1). Types of surgical procedures are reported in Table 2. Reflux at the inferior electrode level (low oesophagus) throughout the study was greater in groups II (50%) and III (65%) compared with group I.
The LMA offers many advantages for the management of the airway during surgery. A meta-analysis suggested that the single disadvantage associated with the LMA compared with tracheal intubation or a face mask is increased susceptibility to GOR. Valentine, Stakes and Bellamy and Owens and colleagues studied oesophageal pH in patients whose airways were managed with either the LMA or a face mask and found an association between the LMA and GOR. Both studies reported an incidence of GOR superior to 50% associated with the LMA. Barker and colleagues also observed a high incidence of GOR in patients with the LMA. They noted in seven of 28 patients managed with the LMA that methylene blue was present inside the mask towards the end of surgery (methylene blue had been swallowed 10 min before induction of anaesthesia). None of the 28 patients managed with a face mask had methylene blue in the pharynx at a similar time (inspected by direct laryngoscopy).

The clinical relevance of GOR associated with the LMA is unclear. In a prospective study of 2359 patients, only two cases of regurgitation (0.08%) were noted by anaesthetists who used no particular monitoring apparatus. Neither case had adverse consequences for the patient. Moreover, the LMA was used without any major incident in 100 patients undergoing gynaecological laparoscopy, which included obese (BMI >30 kg m\(^{-2}\)) and morbidly obese (BMI >35 kg m\(^{-2}\)) patients (n=6). Joshi and colleagues found no episodes of regurgitation, detected with a pH electrode at the pharyngeal level, in an ambulatory population. The main goal of our study was not to measure the clinical impact of GOR associated with the use of the LMA but rather to confirm its existence and to determine the effects of pressure and volume used to inflate the LMA cuff. Our results confirmed the association between the LMA and GOR, but this association was observed only at the lower oesophageal, which is clinically reassuring. Rabey and colleagues studied barrier pressure of the lower oesophageal sphincter and found that the LMA was associated with lowering of the mean obstruction pressure of the sphincter by 3.6 cm H\(_2\)O. Interestingly, using the face mask provoked a 2.2-cm H\(_2\)O increase in the pressure of the lower oesophageal sphincter. Inflating a balloon in the oesophagus can induce some relaxation at the lower oesophageal sphincter level. A similar mechanism, triggered from the pharynx, could explain the effects of the LMA. Such a reflex has been shown in awake patients swallowing a food bolus at the pharyngeal level. Therefore, it is possible that the size of the cuff in the pharynx and the pressure exerted by it could affect the lower oesophageal sphincter and, consequently, GOR. This could explain the greater incidence of GOR observed in groups II and III (LMA) compared with group I (oropharyngeal airway) at the time of insertion. Absence of a difference between groups II and III regarding the incidence of GOR (Fig. 2, Table 3) and the lack of correlation between the volume or pressure within the LMA

### Discussion

Our results confirmed that the use of the LMA was associated with a higher incidence of GOR compared with the face mask and an oropharyngeal airway. We found no correlation between the pressure or volume inside the cuff of the LMA and indices of GOR.

### Table 3 pH values at the lower (inferior electrode) and mid-oesophageal (superior electrode). *P<0.05 between groups (ANOVA or Kruskal–Wallis) (only group I was different from the other groups)

<table>
<thead>
<tr>
<th>Electrode</th>
<th>Group I (n=20)</th>
<th>Group II (n=20)</th>
<th>Group III (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean pH</td>
<td>Inf. 6.1 (0.7) 5.6 (0.8) 5.6 (1.1)</td>
<td>Sup. 6.0 (0.6) 5.7 (0.7) 5.7 (0.6)</td>
<td>Sup. 6.0 (0.6) 5.7 (0.7) 5.7 (0.6)</td>
</tr>
<tr>
<td>% time pH&lt;4.0</td>
<td>Inf. 3.5 (5.6) 6.2 (15.9) 8.6 (21.8)</td>
<td>Sup. 0.3 (1.0) 3.0 (12.3) 0.5 (2.4)</td>
<td>Sup. 0.3 (1.0) 3.0 (12.3) 0.5 (2.4)</td>
</tr>
<tr>
<td>Minimum pH</td>
<td>Inf. 4.8 (1.2) 3.6 (1.6) 3.0 (1.3)</td>
<td>Sup. 4.9 (0.9) 4.9 (0.7) 4.7 (0.9)</td>
<td>Sup. 4.9 (0.9) 4.9 (0.7) 4.7 (0.9)</td>
</tr>
</tbody>
</table>

(15%) (P<0.05) (Fig. 2). There was no difference between groups in the incidence of GOR at the superior electrode level (mid-oesophagus) during the study (group I 10%; group II 10%; group III 5%) (Fig. 2). The incidence of GOR at the inferior electrode was greater when the insertion procedure with the LMA (groups II and III combined 0.35) than with the oropharyngeal airway (group I 0%) (P<0.05). There was no difference in the incidence of reflux at the level of the superior electrode during the insertion procedure (groups II and III combined 5%; group I 0%).

There was no difference between groups in mean pH at the inferior electrode. However, there were differences between groups in minimal pH and percentage of time when pH was less than 4.0 (% time pH<4.0) (Table 3). No difference in mean pH, minimum pH or % time pH <4.0 was observed between the three groups at the level of the superior electrode (Table 3).

The volume of air held in the cuff of the LMA in group II (15 (8) ml) was less than that in group III (34 (8) ml) (P<0.05). Pressure in the cuff of the LMA in group II (132 (100) mm Hg) was less than that in group III (303 (51) mm Hg) (P<0.05). Pressure inside the cuff could not be related to mean pH, minimum pH or % time pH <4.0 at the inferior electrode (Fig. 3). The volume of air contained in the cuff could not be related to these same variables (Fig. 4).

### Fig 2 Incidence of gastro-oesophageal reflux at both electrodes (low and mid-oesophagus). *P<0.05 vs between groups (chi-square).

### Table 3 pH values at the lower (inferior electrode) and mid-oesophageal (superior electrode). *P<0.05 between groups (ANOVA or Kruskal–Wallis) (only group I was different from the other groups)
cuff and pH measurements (Figs 3, 4) does not, however, support this theory. Perhaps stimulation at the pharyngeal level by insertion of the LMA had a maximum response that was not increased by additional cuff inflation.

Several factors can influence the characteristics of GOR. These include sex, age, medications used, mode of ventilation and the position of the patient. Of these, only age differed between the participants in our study: patients in group I were, on average, 11 yr older than those of group III. However, for correlation between pH measurements and the characteristics of the LMA cuff, only patients from groups II and III were included. We did not use nitrous oxide to avoid modifications of the pressure or volume inside the LMA cuff during surgery.

In summary, we have confirmed the association between the use of the LMA and a greater incidence of GOR. The incidence and characteristics of GOR were not, however, influenced by the volume of the LMA cuff or the pressure inside it.

Acknowledgement
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