The effect of nitrous oxide on laryngeal mask cuff pressure

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During general anesthesia with the laryngeal mask airway (LMA), a significant increase in cuff pressure due to diffusion of nitrous oxide through the cuff wall occurs. This descriptive clinical study was conducted in a university teaching hospital ambulatory surgical center with 100 patients (ASA physical status, I-III; age, 5 months to 76 years; weight, 5.8-146.3 kg) undergoing general anesthesia with an LMA. The airway pressure at which the LMA seal was broken (leak pressure) was determined immediately after the insertion of the LMA. The LMA leak pressure was determined by closing the circuit pop-off valve and recording with a stethoscope at the neck the pressure at which the gas was first heard to escape around the LMA. The LMA cuff pressure was determined by connecting the check valve of the LMA pilot balloon to a sphygmomanometer. The mean LMA cuff pressure increased $16 \pm 8.2$ mm Hg (1- to 30-minute group), $38.11 \pm 15.87$ mm Hg (31- to 60-minute group), $39.53 \pm 16.9$ mm Hg (61- to 90-minute group), $42.63 \pm 20.36$ mm Hg (91- to 120-minute group), and $44.25 \pm 14.03$ mm Hg (120- to 350-minute group).

This study demonstrated that there was a gradual increase in the cuff pressure well over a 3-hour period during nitrous oxide and oxygen anesthesia.

Key words: Cuff pressure, laryngeal mask airway, nitrous oxide.

Introduction

The laryngeal mask airway (LMA) is used to maintain a reliable airway for many types of anesthesia. The cuff of the LMA is manufactured from silicone-based rubber, a substance known to permit the rapid diffusion of volatile anesthetics and nitrous oxide. The LMA cuff is therefore highly permeable to nitrous oxide through the cuff wall. During general anesthesia, nitrous oxide is expected to diffuse into the air-filled cuff of the LMA more rapidly than the nitrogen in air can diffuse out. Thus, logically, cuff volume and pressure would be expected to temporarily increase during nitrous oxide anesthesia similar to the increase seen in the cuff pressure of an endotracheal tube. Several studies have established that during anesthesia with the LMA, a significant increase in cuff pressure due to diffusion of nitrous oxide through the cuff wall occurs during the first 45
minutes. However, the extent of the pressure rise has not been systematically studied for procedures lasting more than 2 hours.

The initial cuff pressure achieved after filling the cuff with the recommended volumes is inappropriately high in most patients. The pressure exerted by the LMA can be transferred onto the pharyngeal mucosa, causing a concomitant decrease of pharyngeal perfusion and postoperative complications, which include sore throat, decreased carotid blood flow, dysphonia, and nerve damage. One study found that cuff pressures of the LMA were self-limiting over a 1- to 2-hour period and did not cause excessive pressure on the hypopharynx or displacement of the LMA. The authors of that study concluded that there is no evidence that cuff pressure limitations are necessary during LMA anesthesia. However, other authors recommend measurement and control of intracuff pressures.

The present study, therefore investigated the effect of nitrous oxide on the cuff of the LMA and the extent of increased cuff pressures over a period up to 350 minutes.

Materials and methods

Following institutional approval, 100 patients who were ASA physical status I to III, ages 5 months to 76 years, and weighing 5.8 to 146.3 kg, were studied during general anesthesia with an LMA. General anesthesia was induced in the pediatric patients with sevoflurane, nitrous oxide, and oxygen by face mask. Induction for adults consisted of lidocaine, 1 mg/kg; propofol, 2.0 to 2.5 mg/kg; and fentanyl, 1 to 2 µg/kg, intravenously.

The LMA was inserted following recommended guidelines for placing and securing the device. Proper placement of the LMA was validated by auscultating the chest, listening at the neck, examining the capnogram, and applying manual ventilation. After securing the LMA with tape, the LMA sealing pressure (leak test) was measured by closing the circuit pop-off valve and recording with a stethoscope at the neck the pressure at which gas was first heard escaping around the LMA.

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Table 1. Laryngeal mask airway (LMA) sealing pressure and cuff volume*

<table>
<thead>
<tr>
<th>LMA size</th>
<th>Amount of air (mL)</th>
<th>Leak pressure (mm of water)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>2½</td>
<td>5-10</td>
<td>20-21</td>
</tr>
<tr>
<td>3</td>
<td>12-20</td>
<td>20-28</td>
</tr>
<tr>
<td>4</td>
<td>5-38</td>
<td>20-38</td>
</tr>
<tr>
<td>5</td>
<td>20-35</td>
<td>20-46</td>
</tr>
</tbody>
</table>

* Amount of air used to inflate the LMA cuff to maintain the sealing pressure. Leak pressure was determined by closing the circuit pop-off valve and recording with a stethoscope at the neck the pressure at which gas was first heard escaping around the LMA.

Results

The sizes of the LMA used were as follows: 1, 1 case; 2, 1 case; 2½, 2 cases; 3, 4 cases; 4, 80 cases; and 5, 12 cases. The duration of the LMA insertion was 20 to 350 minutes. The LMA sealing pressure was measured, and the amount of air to inflate the cuff was adjusted to maintain the sealing pressure at a minimum of 20 cm water (Table 1). LMA cuff pressures were continuously monitored and charted with the starting and ending pressures (Figure 1). The mean LMA cuff pressure increase in LMA use was recorded in 30-minute groups (Table 2 and Figure 2). The cuff pressure continued to increase evenly over 3 hours.

Discussion

To date, no absolute relationship between cuff pressure and laryngeal morbidity has been established. Although there is anecdotal evidence that transient hypoglossal nerve paralysis, lingual nerve palsy, and tongue cyanosis may occur with the LMAs, this probably represents a malposition of the cuff, tube, or bite block and/or overinflation. The incidence of sore throat from the use of the LMA is approximately 10%, but it varies between 0% and 70%. It is usually mild and is generally less than that reported for the endotracheal tube. The only factor that has been clearly shown to reduce the incidence of sore throat is

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cuff pressure control.\textsuperscript{7} Lumb and Wrigley\textsuperscript{2} suggested that damage might occur by compression of part of the pharynx against surrounding tissues, such as the hyoid bone or cervical vertebrae. In a study of 200 patients, Burgard et al\textsuperscript{7} demonstrated that reducing cuff pressure to the minimum required for an adequate seal significantly reduced the incidence of sore throat. Lacroix et al\textsuperscript{11} also demonstrated that sore throat decreased significantly if cuff pressure increased only 23%, instead of more than 50%.

In the present study, the leak test was therefore done to reduce the amount of air needed to “just seal” the LMA and to determine how much positive pressure could be administered if needed for assisted ventilation or use of positive-pressure ventilation without breaking the seal and subjecting the patient to gastric insufflation. The results of the study clearly demonstrated that the cuff pressure did not stabilize within 15 minutes as Gursoy et al\textsuperscript{16} reported, but continued to increase beyond a 3-hour period. The initial pressure
increased significantly within the first 30 minutes, just as reported by Lumb and Wrigley, but it was not self-limiting as reported by Brimacombe and Berry. Of note, in the case that extended to 350 minutes, the cuff pressure hit a plateau at 200 mm Hg at 290 minutes and then began to decrease, to an end pressure of 120 mm Hg.

No follow-up on pharyngeal morbidity was conducted in this study. Further studies should consider whether there is a link between high cuff pressure and patient morbidity and attempt to identify the safest and simplest method of dealing with the problem.

In summary, the present study found a gradual increase in the cuff pressure over a period of more than 3 hours during nitrous oxide–oxygen anesthesia. Until it can be demonstrated that the increase in cuff pressures does not cause a decrease in hypopharyngeal perfusion or damage to surrounding tissues, continuous monitoring of the cuff pressures is empirically recommended with periodic deflation to maintain reasonable cuff pressure during nitrous oxide–based anesthesia.

REFERENCES

AUTHOR
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