Changes in Laryngeal Mask Airway Cuff Pressure under General Anesthesia with and without Nitrous Oxide

Hiroshi IWASAKI, Michiaki YAMAKAGE, Junko LEE, Yutaka YAMAZAKI, Akinori KIRITA and Akiyoshi NAMIKI

(Key words: laryngeal mask airway, cuff, nitrous oxide)

A number of reports have demonstrated that nitrous oxide diffuses into endotracheal tube cuffs in a time-related fashion, causing a significant increase in the cuff gas volume and pressure[1–3]. In air-inflated endotracheal tubes the cuff pressure varies with several factors; such as nitrous oxide concentration, exposure time to nitrous oxide, cuff thickness and cuff material. During general anesthesia[4] it has been demonstrated that the speed of nitrous oxide diffusion into silicon rubber cuffs is very fast compared with latex rubber and polyvinyl chloride cuffs of the endotracheal tube. It has been reported that the pressure of a laryngeal mask airway (LMA) cuff, which is made of silicon-based rubber, changes after exposure to nitrous oxide in vivo and in vitro studies[5]. However, there is little information about the effect of anesthetic agents on changes in the intra-cuff pressure of each size of LMA for a long period during general anesthesia.

This study was conducted to investigate the effect of nitrous oxide on LMA cuff pressure under general anesthesia. Changes in the minimum airway pressure required to cause gas leakage around the LMA in the larynx were also evaluated in adult patients.

Patients and Methods

Fifty-five ASA classification 1 or 2 patients, aged 3 months to 77 years, scheduled for elective gynecological, abdominal, plastic, or orthopedic surgical procedures were enlisted (table 1). The study was approved by our Ethics Committee. Premedication was according to the preference of each anesthesiologists, and comprised no premedication, midazolam and atropine given intramusculary or benzodiazepine administered orally, approximately 60 minutes before induction of anesthesia. Before insertion of LMA, the LMA cuff was completely deflated with a syringe. In adult patients, anesthesia was induced with 3–4 $mg \cdot kg^{-1}$ thiamylal and 1 $mg \cdot kg^{-1}$ succinylcholine or 0.1 $mg \cdot kg^{-1}$ vecuronium bromide. In small infants, anesthesia was induced with halothane and oxygen. The size of LMA was selected according to the body weight of each

Department of Anesthesiology, Sapporo Medical College and Hospital, Sapporo, Japan

Address reprint requests to Dr. Iwasaki: Department of Anesthesiology, Sapporo Medical College and Hospital, South 1, West 16, Chuo-ku, Sapporo, 060 Japan

Table 1. Demographic details of the 55 patients

Laryngeal mask airway size	Cuff inflation volume (ml)	Subject groups Anesthesia with N_2O	without N_2O
1	5	n=7 (3m–1 yr, 5–8 kg)	n=5 (3m 1 yr, 4–7 kg)
2	10	n=7 (2–5 yr, 14–24 kg)	n=7 (1–3 yr, 11–16 kg)
3	20	n=8 (28–77 yr, 48–68 kg)	n=7 (18 41 yr, 49–72 kg)
4	35	n=8 (30–77 yr, 51–82 kg)	n=6 (21–73 yr, 58 -65 kg)

Table 2. The initial intra-cuff pressure in each laryngeal mask airway before exposure to 66% of nitrous oxide in oxygen and either halothane or enflurane (with N_2O), and either halothane or enflurane in oxygen (without N_2O)

laryngeal mask airway size	initial intra-cuff pressure (mmHg) with N_2O	without N_2O
1	185.0 ± 4.6 (n=7)	188.2 ± 5.1 (n=5)
2	149.4 ± 15.0 (n=7)	143.4 ± 16.2 (n=7)
3	108.4 ± 19.2 (n=8)	98.5 ± 14.3 (n=7)
4	171.0 ± 11.1 (n=8)	175.3 ± 9.2 (n=6)

mean ± S.D.

patient. Insertion of LMA was performed either under deep neuromuscular blockade or when the gag and cough reflexes had been abolished by the anesthesia.

Immediately after insertion of LMA, the cuffs of LMA sizes 1, 2, 3 and 4 were filled with 5, 10, 20 and 35 ml of air. The cuff pressures were measured before exposure to anesthetic gases (baseline measurements) and then were measured every 10 min with a calibrated standard pressure transducer attached to the tip of the cuff inflation tube via a three-way stopcock. The patients were assigned to either a group receiving or a group not receiving nitrous oxide, as listed in the table. In the first group, anesthesia was maintained with 66% of nitrous oxide in oxygen and either 0.7–1.2% of halothane or 0.8–1.8% of enflurane anesthesia, while in the other group, anesthesia was maintained with either 0.7–1.5% of halothane or 0.9–1.9% of enflurane and oxygen and fentanyl supplements when needed.

The minimum airway pressure required to cause gas leakage around the LMA cuff in the larynx was measured at 10-minute intervals by manual compression of the reservoir bag with a closed relief valve while listening for the escape sounds of gas leaks around the larynx-to-LMA cuff in 12 adult patients who were inserted the LMA sizes 3 (n=6) and 4 (n=6). The airway pressure was measured with an aneroid gauge which had been calibrated against a water manometer.

Data were analyzed using unpaired Student's t-tests. Statistical significance was defined as a P value of less than 0.05. All values were expressed as

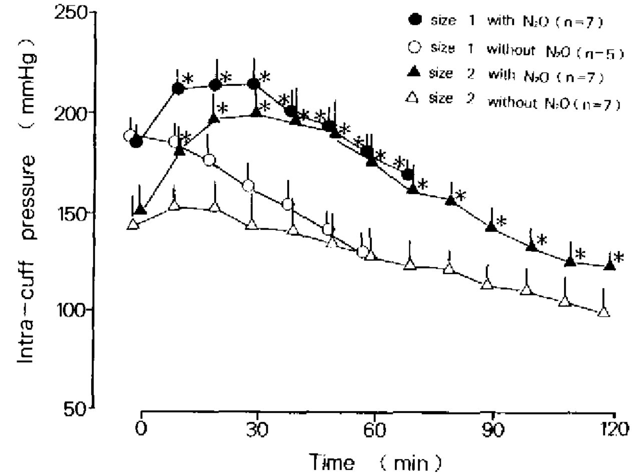

Fig. 1. Intra-cuff pressure changes in the laryngeal mask airway sizes 1 and 2 under general anesthesia with and without 66% of nitrous oxide.

All data points represent mean ± S.D.

$*P < 0.01$ compared with "without nitrous oxide" group.

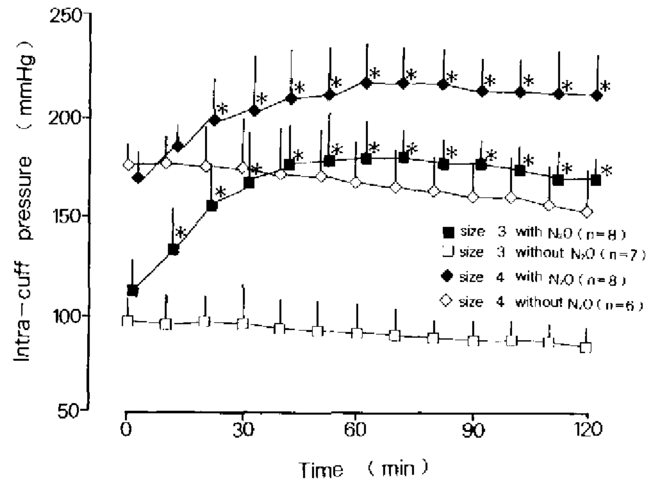

Fig. 2. Intra-cuff pressure changes in laryngeal mask airway sizes 3 and 4 cuff under general anesthesia with and without 66% of nitrous oxide.

All data points represent mean ± S.D.

$*P < 0.01$ compared with "without nitrous oxide" group.

mean ± standard deviation.

Results

Although the baseline values of the intra-cuff pressure after inflation of each volume of air were significantly different in the four sizes of LMA, no significant differences were observed in the intra-cuff pressures in each LMA size before exposure to anesthetic gases (table 2). After exposure to 66% of nitrous oxide in oxygen and either halothane or enflurane, the intra-cuff pressures of mask sizes 1 and 2 rapidly increased and then they gradually decreased. However, the intra-cuff pressures of mask sizes 3 and 4 increased slowly with time for 2 hours after the exposure to nitrous oxide. In contrast to the results obtained in LMA after exposure to nitrous oxide, the intra-cuff pressures in patients anesthetized with either halothane or enflurane and oxygen anesthesia decreased continuously with time for all mask sizes (fig. 1, 2).

Although changes in the LMA cuff pressure were observed in patients anesthetized with and without nitrous oxide anesthesia, the minimum airway pressures required to cause gas leakage around the LMA cuff in the larynx

Table 3. The minimum pressure required to cause gas leak around the laryngeal mask airway cuff during positive pressure ventilation 3, 30, 120 minutes after exposure to 66% of nitrous oxide in oxygen and either halothane or enflurane anesthesia in 12 adults patients

laryngeal mask asirway size	minimum leak pressure (cmH_2O) 3 min	30 min	120 min
3 (n=6)	24.2 ± 5.1	22.4 ± 4.2	23.1 ± 3.7
4 (n=6)	21.2 ± 6.3	23.3 ± 6.1	21.5 ± 5.6

mean ± S.D.

showed no significant change in any of the patients who had LMA sizes 3 and 4 throughout the study, even if the intra-cuff pressures decreased below the baseline values (table 3).

Discussion

Nitrous oxide and other anesthetic gases diffuse into air-filled endotracheal tube cuffs and increase volume and pressure in the cuffs unless the end of the cuff-inflating tube is open to the atmosphere. Our results demonstrated that during nitrous oxide-oxygen and either halothane or enflurane anesthesia air-filled LMA cuff pressures in the larynx of patients changes with time in all LMA sizes, and the pattern of pressure changes in the LMA cuffs differed in the LMA sizes. On the other hand, in all patients anesthetized with either halothane or enflurane and oxygen, pressures in the LMA cuff decreased continuously with time.

A cuff material of air-filled endotracheal tube cuffs is one of the important factors to determine changes in the intra-cuff pressure and volume after exposure to nitrous oxide[6]. Silicon rubber, which is the material of the LMA cuff, has a high permeability to all anesthetic gases. It has been shown that air-filled endotracheal tube cuffs made of silicon rubber, showed a biphasic pressure change in nitrous oxide; an initial increase to a maximum, followed by a decrease in pressure[4]. In the present study, pressure changes in the LMA sizes 1 and 2 showed the similar form observed in the endotracheal tube cuff in nitrous oxide; an increase in the cuff pressure within a short period followed by a gradual decline after exposure to nitrous oxide.

The diffusion rate of nitrous oxide into cuffs inflated with air is inversely proportional to the cuff thickness – thinner cuffs show a faster pressure increase and also deflate too easy. The large deviation observed in the LMA sizes 1 and 2 after exposure to nitrous oxide may be explained by thinner walls and smaller volumes of cuffs in the LMA sizes 1 and 2 than those of sizes 3 and 4. It has been reported that the LMA forms a low-pressure seal around the larynx, and the mean leak pressure is approximately 20 cm water during positive-pressure ventilation[7]. It is interesting that after insertion of LMA a large leak is observed initially, but soon disappear without an additional injection of air into the LMA cuff in clinical practice. We have speculated that the disappearance of this initial leaks might be due to expansion of the LMA cuff secondary to nitrous oxide diffusion. However, present study demonstrated that a change in LMA cuff pressure around + 30% after exposure to anesthetic gases did not compromise the function of the cuff or increase the leak. These findings suggest that cuff expansion secondary to nitrous oxide diffusion is not a main factor in the disappearance of initial leakage around the LMA in the larynx of patients.

In conclusion, our results demonstrate that the pressure of LMA cuffs inflated with air is influenced by the commonly used clinical anesthetic concentration of nitrous oxide and the pattern of the cuff pressure change differs according to the LMA size. However, the leak pressure around the LMA cuff during positive-pressure ventilation did not change in course of time.

(Received Jul. 14, 1992, accepted for publication Jan. 27, 1993)

References

1. Stanley TH: Effects of anesthetic gases on endotracheal tube cuff gas volumes. Anesth Analg 53:480–482, 1974
2. Stanley TH, Kawamura R, Graves C: Effects of nitrous oxide on volume and pressure of endotracheal tube cuffs. Anesthesiology 41:256–261, 1974
3. Patel RI, Oh TH, Epstin BS: Effects of nitrous oxide on pressure changes of tracheal tube cuffs following inflation with air and saline. Anaesthesia 38:44–46, 1983
4. Chandler M: Pressure changes in tracheal tube cuffs. Anaesthesia 41:287–293, 1986
5. Lumb AB, Wrigley MW: The effect of nitrous oxide on laryngeal mask cuff pressure. Anaesthesia 47:320–323, 1992
6. Bernhard WN, Yost L, Turndorf H, et al: Physical characteristics of and rates of nitrous oxide diffusion into tracheal tube cuffs. Anesthesiology 48:413–417, 1978
7. Brodrick PM, Webster NR, Nunn JF: The laryngeal mask airway; a study of 100 patients during spontaneous breathing. Anesthesiology 44:238–241, 1989