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Comparison of the effects of room air and $N_2O + O_2$ used for ProSeal LMA cuff inflation on cuff pressure and oropharyngeal structure

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Abstract
This study aimed to evaluate the effects of different inflating gases used for ProSeal LMA (PLMA) cuff inflation on cuff pressure, oropharyngeal structure, and the incidence of sore throat. Eighty patients (American Society of Anesthesiologists; ASA I-II) were randomly divided into two groups. PLMA cuff inflation was achieved with appropriate volumes of 50% N_2O + 50% O_2 in group I and room air in group II, respectively. When the PLMA was removed, oropharyngeal examination was carried out immediately, using a rigid optical telescope. Patients were asked about sore throat symptoms postoperatively. Cuff pressures were significantly lower in group I, except at the initial pressure measurement. Cuff pressure was positively correlated with the length of the operation in group II, and negatively correlated in group I. PLMA cuff inflation with room air led to increased cuff pressure during the operation, possibly due to the diffusion of N_2O into the cuff. We consider that a PLMA cuff inflated with an N_2O-O_2 mixture is convenient, especially in operations in which N_2O has been used.

Key words PLMA · Cuff pressure · N_2O-O_2 · Room air · Rigid telescopy

The ProSeal LMA (Intravent Orthofix, Maidenhead, United Kingdom) (PLMA) is a modification of the classic laryngeal mask airway (LMA) that includes a port for a gastric drainage tube to prevent aspiration of regurgitated stomach contents [1]. The relationship between airway devices used for general anesthesia and the frequency and severity of laryngopharyngeal complications is well known [2,3]. High LMA intracuff pressures produced mild alterations in the laryngopharyngeal mucosa [4]. The pressure produced on the pharynx by the LMA when the cuff is inflated with the maximum recommended volume of air is usually higher than the mucosal capillary perfusion pressure [5,6]. Theoretically, an inflated LMA cuff could produce sufficient compression to cause a reduction in blood flow in the pharyngeal mucosa and induce direct tissue trauma, as has been reported for tracheal tubes [7]. Consequently, a sore throat may be experienced in such cases [8]. Although several studies that macroscopically investigated the trauma in the pharynx caused by LMAs and PLMAs [9–11] are available, these are technically and methodologically different from the present study. In this study, we evaluated the effects of different gases used for PLMA cuff inflation on cuff pressure, the oropharyngeal structure, and the incidence of sore throat.

Local Ethics Committee approval and written informed consent were obtained for this prospective double–blind study. Upper airway abnormality or infection, sore throat, abdominal and neck surgery, failed attempt at first insertion of an LMA, full stomach, emergencies, pregnancy, smoking, drug allergy, and lack of cooperation were accepted as exclusion criteria. Eighty adult patients, between 20 and 60 years old (American Society of Anesthesiologists [ASA] I-II) undergoing lower-extremity surgery were consecutively scheduled for general anesthesia. All patients were premedicated with midazolam IV 0.05 $mg \cdot kg^{-1}$. Anesthesia was induced with fentanyl 2 $\mu g \cdot kg^{-1}$ and propofol 2–2.5 $mg \cdot kg^{-1}$. The PLMA was appropriately deflated and lubricated with saline [2]. After the patients had become unconscious and had lost the eyelash reflex, PLMA insertions were performed by a single experienced PLMA user, with the index-finger technique according to the manufacturer's instructions. According to a randomized sequence, patients were allocated to two groups. The PLMA cuff was inflated with 50% N_2O + 50% O_2 in group I or with room air in group II. The cuff was inflated to a maximum of 60 cmH_2O or until leak of the cuff was prevented (20 ml room air for size 3

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LMA, for a small adult; 30 ml for a size 4 LMA [normal adult size]) [12]. Successful PLMA insertion was assessed by chest expansion and capnography. Anesthesia was maintained with sevoflurane 1%–1.5% in a 50% N_2O and 50% O_2 mixture and fentanyl 50 µg every 30 min. The cuff pressure was measured with an aneroid manometer (Perfect-Aneroid, Erka; Kallmeyer Medizintechnik, Bad Tölz, Germany) after the first adjustment and every 30 min afterwards. N_2O was turned off 5 mins before the operation was completed. Anesthesia depth was controlled with sevoflurane while maintaining spontaneous respiration. At the end of the operation, the PLMA was removed after the recovery of spontaneous breathing, and an oropharyngeal examination was carried out immediately, with a rigid optical telescope, by the same ear, nose, and throat (ENT) surgeon for all patients. The oropharyngeal structure was evaluated using a 0- to 2-point scale (0, lesion absent; 1, mucosal hyperemia; 2, mucosal bleeding). The patients were asked about sore throat symptoms at the first and fourth hours postoperatively. Sore throat was scored by a verbal numerical rating scale (VNRS) with scores of 0–10, and evaluated by an anesthesiologist who was blinded to the type of procedure (0, no pain; 1, pain with no analgesic requirement [VNRS ≤ 4]; and 2, pain with analgesic requirement [VNRS > 4]) [13]. Demographic data, lesions and sore throat were assessed with the χ^2 test, and age, weight, and height with Student's *t*-test. Correlations between cuff volumes, cuff pressures, operation times, sore throat, and oropharyngeal lesions were assessed with the Spearman correlation test. $P < 0.05$ was accepted as significant.

Demographic data are shown in Table 1. Differences between the groups were statistically insignificant. Cuff pressures were significantly higher in group II than in group I for all measurements except the initial pressures. There was a negative correlation (correlation coefficient, –0.34) between the operation time and cuff pressure in group I, and a positive correlation (correlation coefficient, 0.46) in group II (Fig. 1). Cuff volume, cuff pressure, operation time, sore throat, and lesion data are shown in Table 2. There were statistically insignificant differences between the groups concerning operation time, sore throat, and lesions. On comparison of the cuff pressure data within the same group, a significant difference compared with initial cuff pressure, was detected in group II at 30 min and before extubation ($P < 0.001$), but there were no significant differences in group I.

Unlike the trachea, the pharynx is a highly distensible structure that is subjected to large pressure changes under normal physiological conditions [4]. It has been reported in a histopathological study that a high LMA intracuff pressure produced mild alterations of the laryngopharyngeal mucosa in dogs [4]. While the cuff pressures were high at the beginning, a decrease at a rate of 19 %–22 % was detected in these pressures from the first minute onwards; the reason was related to the expansion of the pharyngeal muscles and their adaptation to this condition [4]. It has been reported that an increase in the temperature of an LMA cuff in the pharynx increased its compliance and may also have contributed to a decrease in the intracuff pressure [5].

It has also been reported, in another study, that the air used to inflate the LMA cuff is warmed in the pharynx from room temperature to body temperature, which consequently increases the pressure in the cuff.

Table 1. Demographic data

	Group I ($n = 40$)	Group II ($n = 40$)
Age (years)	35 ± 12	35 ± 13
Sex (M/F)	34/6	30/10
ASA I/II	34/6	34/6
Weight (kg)	74 ± 10	72 ± 11
Height (cm)	170 ± 13	168 ± 12
Body mass index ($kg \cdot m^{-2}$)	25 ± 4	25 ± 3

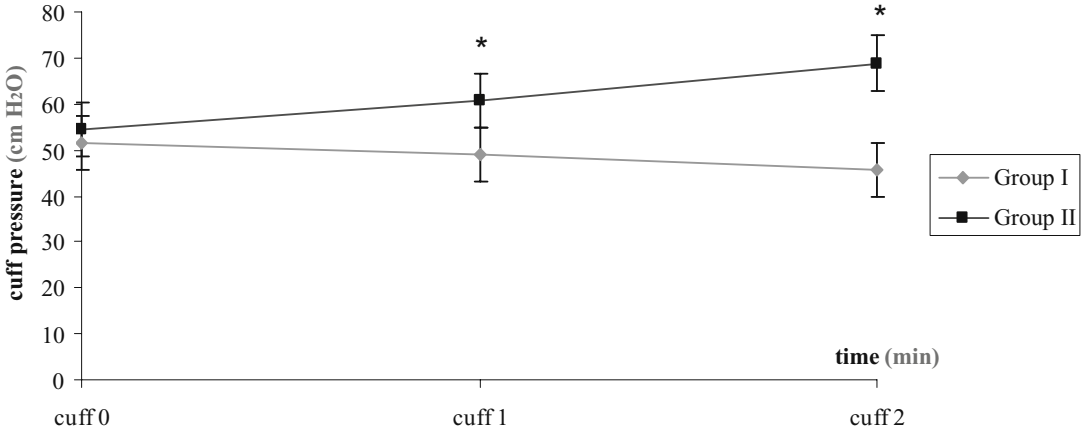

Fig. 1. Cuff pressures in groups I and II (mean ± SD). *Cuff 0*, Initial cuff pressure; *cuff 1*, cuff pressure at 30 min; *cuff 2*, cuff pressure before extubation. *$P < 0.001$

Table 2. Cuff volumes, cuff pressures, operation times, sore throat, and lesions

	Group I ($n = 40$)	Group II ($n = 40$)	P values
Operation time (min)	47 ± 13	44 ± 13	0.43
Cuff volume (ml)	18 ± 2	18 ± 3	0.48
Initial cuff pressure (cmH_2O)	52 ± 6	55 ± 6	0.1
Cuff pressure at 30 min (cmH_2O)	49 ± 7	61 ± 6*,a	0.001
Cuff pressure before extubation (cmH_2O)	46 ± 5	69 ± 6*,a,b	0.001
Score for sore throat at 1 h (0/1/2)	38/2/0	32/8/0	0.15
Score for sore throat at 4 h (0/1/2)	38/2/0	36/4/0	0.4
Lesions (0/1/2)	26/14/0	22/18/0	0.51
Size of PLMA (3/4)	6/34	6/34	1

* $P < 0.001$ between the groups; a,b $P < 0.001$ within the same group (a, vs initial cuff pressure; b, vs 30 min cuff pressure)
0, no sore throat/ no lesion; 1, slight sore throat/ hyperemia in mucosa; 2, severe sore throat/ bleeding in mucosa

However, increasing the temperature of 30 ml of gas from 20°C to 37°C will increase the cuff volume by only 1.74 ml [14]. It has also been shown in other studies that N_2O diffused into the air-filled cuffs of LMAs and PLMAs produced rises in cuff pressure and volume, and caused lesions in the oropharyngeal structures [4,14–16].

In our study, we detected a statistically significant increase over time in the cuff pressures of the cuffs inflated with room air (group II), in contrast to an insignificant decrease in those inflated with the N_2O-O_2 mixture (group I). The decrease of the cuff pressure our group I was thought be related to the warming of the PLMA in the pharynx, and the increase of the cuff pressure in group II may have been due to the diffusion of N_2O into the cuff. Insignificant mucosal changes were observed in both groups on the telescopic images.

In some studies, it was reported that increasing LMA and PLMA cuff pressures caused injuries to the lingual, hypoglossal, and recurrent laryngeal nerves, and lingual artery compression, because of strong compression of the pharyngeal structures [15,17,18]. Therefore, it was recommended not to inflate the LMA cuff to a pressure of more than 60 cmH_2O, to reduce the possibility of nerve or artery compression [18]. The incidence of postoperative sore throat with the LMA ranges between 5.8% and 34% [8,19]. The incidence of sore throat with the PLMA was reported to be 10% [19]. It has been stated that the incidence of sore throat decreases when the LMA cuff pressure is reduced to 60 cmH_2O [18]. However, Natalini et al. [20] reported that cuff pressures of over 100 cmH_2O, obtained to minimize leak fraction, did not lead to sore throat or cause pharyngeal morbidity. The mild laryngopharyngeal injuries demonstrated in a dog study [4] by light microscopic and scanning electron microscopic examination could explain some complaints after the use of the LMA in humans, such as hoarseness, dysphagia, and sore throat. In another study, it was suggested that cuff pressure changes did not lead to pharyngeal complaints such as dysphagia, hoarseness, and sore throat [21]. In our study, the lack of differences between the groups with regard to sore throat was probably due to the low cuff pressure.

In conclusion, PLMA cuff inflation with room air leads to an increased cuff pressure during operation when compared to inflation with a N_2O-O_2 mixture, possibly due to the diffusion of N_2O into the cuff inflated with room air. For this reason, we consider that a PLMA inflated with an N_2O-O_2 mixture is convenient, especially in operations in which N_2O has been used.

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