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Does Lanz® Endotracheal Tube Offer Advantage in Nitrous Oxide Anesthesia?

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Aim: Increasing intracuff pressure and postoperative laryngotracheal complications are the important issues in nitrous oxide anesthesia. The Lanz® endotracheal tube is a new kind of tube with a pressure-regulating valve. We aimed to investigate whether or not this tube may be useful in nitrous oxide anesthesia in terms of postoperative laryngotracheal complications.

Materials and Methods: The study included 70 female patients, aged 18-60 years. Patients were intubated with the standard endotracheal tube in Group S (n = 35) and the Lanz® endotracheal tube in Group M (n = 35). The intracuff pressures were monitored with a manometer during general anesthesia. Postoperative laryngotracheal complications were recorded after tracheal extubation, at the time of discharge from the Post-Anesthesia Care Unit and 24 hours after extubation.

Results: There was a statistically significant increase in the intracuff pressures in Group S over time ($P < 0.001$), while the P0 values were maintained constantly at approximately 30 cm H_2O in Group M ($P > 0.05$). However, intensity and incidence of postoperative laryngotracheal complications were not significantly different between the two groups.

Conclusions: The Lanz® endotracheal tube works properly and limits the increase in intracuff pressure but offers no advantage with respect to reduction in the intensity and incidence of postoperative laryngotracheal complications after nitrous oxide anesthesia lasting approximately two hours.

Key Words: Complications, tracheal tube, cuff pressure, nitrous oxide

Lanz® Endotrakeal Tüp Nitröz Oksit Anestezisinde Avantaj Sağlar mı?

Amaç: Artan kaf-içi basıncı ve postoperatif laringotrakeal komplikasyonlar, nitröz oksit anestezisinde önemli sorunlardır. Lanz® endotrakeal tüp, basınç düzenleyici valvi olan yeni bir tüptür. Biz, bu tüpün nitröz oksit anestezisinde postoperatif laringotrakeal komplikasyonlar açısından faydalı olup olamayacağını araştırmayı amaçladık.

Yöntem ve Gereç: Bu çalışma 18-60 yaş arasında olan, 70 bayan hasta üzerinde yürütüldü. Grup S deki (n = 35) hastalar, standart endotrakeal tüp ile, Grup M deki (n = 35) hastalar ise Lanz® endotrakeal tüp ile entübe edildiler. Kaf-içi basınçlar, genel anestezi sırasında bir manometre ile takip edildi. Trakeal ekstübasyondan hemen sonra, PACU dan çıkış sırasında ve ekstübasyondan 24 saat sonra postoperatif laringotrakeal komplikasyonlar kaydedildi.

Bulgular: Grup S de kaf-içi basınçlarda zamanla istatistiksel olarak anlamlı artış gözlendi ($P < 0.001$). Grup M de P0 değerleri yaklaşık 30 cm H_2O seviyesinde sabit olarak devam etti ($P > 0.05$), ancak postoperatif laringotrakeal komplikasyonların şiddeti ve sıklığı bakımından iki grup arasında anlamlı farklılık gözlenmedi.

Sonuç: Lanz® endotrakeal tüp, uygun şekilde çalışır ve kaf-içi basıncının artmasını sınırlar, fakat yaklaşık 2 saat süreli nitröz oksit anestezisini takiben, postoperatif laringotrakeal komplikasyonların şiddetini ve sıklığını azaltmak açısından bir avantaj sağlamaz.

Anahtar Sözcükler: Komplikasyonlar, trakeal tüp, kaf basıncı, nitröz oksit.

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Introduction

The cuff of an endotracheal tube (ETT) must permit maintenance of airway positive pressure during mechanical ventilation and prevent aspiration of pharyngeal content. However, tracheal arterial pressure decreases when the cuff exerts pressure greater than 30 cm H_2O, causing tracheal ischemia proportional to the pressure exerted by the cuff and the time of exposure. An increase in cuff pressure is seen during anesthesia incorporating nitrous oxide (N_2O) if air is used to inflate the cuff. N_2O diffuses more rapidly into the cuff than nitrogen diffuses out of the cuff, thus creating excessive pressure even when the initial sealing pressure is satisfactory (1,2).

Although deleterious consequences have decreased with the routine use of high-volume, low-pressure cuffs, postoperative laryngotracheal complications can still occur (3). Intracuff pressure higher than 30 cm H_2O causes laryngotracheal complications; on the other hand, incidence of postintubation throat complaints varies widely (14-75%) (4), and there is sometimes no significant difference in the incidence of sore throat and hoarseness after short- term operations even if the intracuff pressure is below 30 cm H_2O (5).

In addition, there are some results suggesting that manual estimation is an unacceptable method to monitor cuff pressure, mostly because of the physical properties of the tubes and the variability of the observers. The manometers introduced to measure cuff pressure can be used as a basic tool in the care of intubated patients (6). Although this practice has been recommended, continuous monitoring of the cuff pressure is not widely used (7).

The Lanz® ETT features a high volume, low pressure cuff and a Lanz Pressure Regulating Valve with inflatable balloon and clear protective cover (Figure 1). Pressure does not build up in the Lanz ETT cuff, as the volume expansion accompanying the equilibration of N_2O expands the high compliance pilot balloon (8). However, there is a lack of data assessing whether the Lanz® ETT attenuates postoperative laryngotracheal complications.

In our study, we aimed to compare the standard ETT used in practice and the Lanz® ETT with respect to maintenance of proper cuff pressure during N_2O administration and reduction in the incidence and intensity of postoperative laryngotracheal complications.

Materials and Methods

This was a prospective, randomized, blinded study. After obtaining the approval of the Ethics Committee of Ankara Training and Research Hospital and the patients' informed consent, 70 female patients, aged 18-60 years with American Society of Anesthesiologists' (ASA) physical status I and II who were scheduled for elective abdominal surgery requiring tracheal intubation and lasting at least 120 minutes were included in this study over a period of three months. Patients with tracheotomy, laryngeal disease or laryngeal surgery, difficult intubation (two or more trials), or who smoked cigarettes were excluded from the study.

Patients were premedicated with diazepam 10 mg orally 60 minutes before surgery. On arrival in the operating room, a 20-gauge intravenous (i.v.) cannula was inserted and ECG, pulse oximetry, end-tidal carbon dioxide and non-invasive arterial pressure (PM 8060 Vitara, Drager, Lübeck, Germany) were monitored. Ringer's lactate infusion was started at 5 ml kg^{-1} h^{-1}.

After 3 min preoxygenation, anesthesia was induced with fentanyl 1.5 µg kg^{-1} and thiopental sodium 5-6 mg kg^{-1} until the eyelash reflex had been abolished, then vecuronium 0.1 mg kg^{-1} was given. Tracheal intubation was always performed by an experienced anesthesiologist 3 min after vecuronium was given. The interval between the onset of laryngoscopy and completion of tracheal

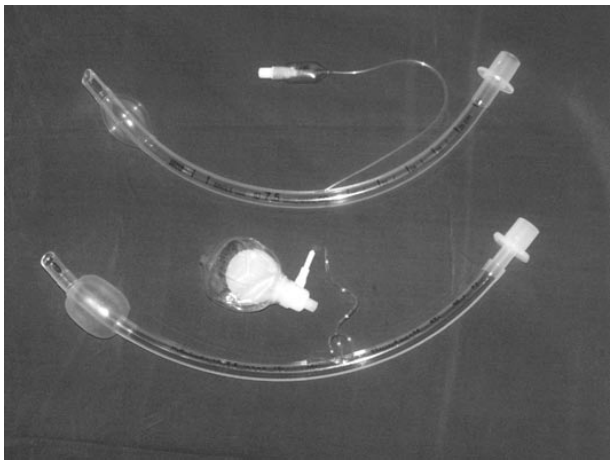

Figure 1. A standard endotracheal tube (from Saviour, Guangdong, China [top]) and the Lanz® endotracheal tube (from Mallinckrodt, Athlone, Ireland [bottom]). The latter has a large pilot balloon with a clear protective cover.

intubation was recorded (intubation time). The intubating conditions were graded using a score described by Viby-Mogensen and colleagues (9). The patients whose scores were excellent (1) or good (2) were included into the study (Table 1).

We calculated that 32 patients were required in each group to detect 35% differences in postoperative hoarseness between the two groups for 80% power and a = 0.05. We then added five patients in each group in the event that any of the patients experienced unexpected difficult intubation or poor intubation condition score requiring exclusion from the study. Patients were randomly allocated via sealed envelope assignment to two groups for tracheal intubation as Group S (standard endotracheal tube) and Group M (Lanz® endotracheal tube). Two patients in Group S were excluded from the study due to difficult intubation and two patients in Group M due to poor intubation score. Patients in Group S were intubated with ETT (Saviour, Guangdong, China), which has a high residual volume, low pressure cuff, and inner diameter of 7.5 mm (n = 35). The ETT cuff was inflated with the lowest volume of air that would not leak when the end-inspiratory plateau pressure was 20 cm H_2O and the sealing pressure was achieved. The volume used to fill the cuff (V_1) and the initial cuff pressure (P_0) were recorded. In Group M (n = 35), the Lanz® ETT (Mallinckrodt, Athlone, Ireland) with pressure regulating valve and inner diameter of 7.5 mm was used. The ETT cuff was inflated with 30-40 ml air until intracuff pressure reached 30 cm H_2O as described in the directions for use, then P_0 was recorded. The pilot balloon of the tested tube cuffs were connected to a cuff pressure manometer (Mallinckrodt, Athlone, Ireland) using a three-way stopcock. The end-expiratory intracuff pressures were measured every 30 min during the N_2O administration. Anesthesia was maintained with 50% N_2O in oxygen and sevoflurane at 1-1.2 MAC. The lungs were ventilated mechanically and end-tidal carbon dioxide was maintained within the physiologically normal range.

At the end of surgery, neuromuscular block was reversed with neostigmine (0.03 mg kg^{-1}) and atropine (0.015 mg kg^{-1}) and 5 min after reversal of neuromuscular block, administration of N_2O was terminated. The oropharynx was aspirated gently, the cuff deflated and the tracheal tube was removed in a deep plane of anesthesia. The volume of air aspirated from the cuff was recorded in Group S (V_2). After extubation, breath holding, coughing, laryngospasm, desaturation and wheezing were recorded. The patients with spontaneous, adequate respiration, the ability to follow verbal commands and hemodynamic stability were transferred to the Post-Anesthesia Care Unit (PACU).

The patients were discharged from PACU when Modified Aldrete Score was 9-10. At the time of discharge from PACU and 24 hours after tracheal extubation, patients were asked about sore throat, hoarseness and dysphagia. Patients assessed the intensity of their symptoms on a visual analog scale (VAS; where 0 mm = no discomfort and 100 mm = worst discomfort possible). These measurements were recorded by an investigator who was unaware of the type of endotracheal tube used. Fifteen minutes before the end of the operation, 1.5 mg kg^{-1} tramadol i.v. was administered and intramuscular (i.m.) diclofenac sodium (75 mg 2 times a day) was used for postoperative analgesia on the first postoperative day.

Table 1. Demographic and perioperative data in the two groups.

	Group S (n=35)	Group M (n=35)	P
Age (yr)	41.11 ± 10.47	41.48 ± 10.96	0.885
BMI (kg m^{-2})	25.61 ± 2.85	26.12 ± 3.02	0.476
ASA (I-II)	26 / 9	25 / 10	0.788
Intubation time (s)	10.77 ± 3.08	10.60 ± 2.22	0.791
Intubation score (1/2)	32/3	33/2	0.500
Duration of surgery (min)	131.57 ± 21.82	128.42 ± 26.22	0.588
Duration of intubation (min)	143.28 ± 22.48	140.14 ± 27.47	0.602

S: Saviour. M: Mallinckrodt. BMI: Body mass index. ASA: American Society of Anesthesiologists. Data are presented as means ± standard deviation.

All data were analyzed with SPSS 11.5 (SPSS Inc., Chicago, IL, USA) software. Descriptives were quoted as mean ± SD and incidence (%). The Student's t test was used for statistical comparisons of the demographic and perioperative data. The chi-square test was used to compare the ASA classification and intubation scores between the two groups. The Fisher exact test was used to analyze breath holding, coughing, laryngospasm, desaturation and wheezing after extubation. The repeated measurements of two way ANOVA were used to compare intracuff pressure values between groups and the paired t test was used to investigate differences over time in each group. The chi-square test was used to compare the incidence of the complaints and the Mann-Whitney U test to compare the intensity of the complaints between the two groups. Bonferroni test was used as post-hoc test. Pearson correlation analysis was used to analyze the volume of air injected and then aspirated from the cuff in Group S. Statistical significance was set at the $P < 0.05$ level.

Results

There were no significant differences between the two groups with respect to age, body mass index (BMI), ASA classification, intubation time, intubation score, duration of surgery and duration of intubation ($P > 0.05$) (Table 1). The baseline intracuff pressures (P_0) were 24.51 ± 3.60 cm H_2O in Group S and 30.00 ± 0.00 cm H_2O in Group M ($P < 0.001$). There was a statistically significant increase in the intracuff pressures in Group S over time ($P < 0.001$) but the P_0 values remained constant at approximately 30 cm H_2O in Group M ($P > 0.05$). When compared to Group M, the increase in the intracuff pressures in Group S was significantly different from P_0 at all times recorded ($P < 0.001$). We observed that the increases in the intracuff pressures in Group S were significantly higher than those in Group M at 60, 90 and 120 minutes. It was seen that the intracuff pressures of Group S exceeded the critical pressure of 30 cm H_2O after 60 minutes (Table 2). The aspirated air volumes from the cuff (6.78 ± 1.13 ml) were higher than the initial volumes of the cuff (4.48 ± 0.63 ml) in Group S ($P < 0.001$). In Group S, breath holding, laryngospasm, desaturation and coughing were observed in 5, 1, 2 and 1 patients, respectively, while in Group M, breath holding, laryngospasm and desaturation were observed in 3, 1 and 1 patients, respectively. There were no statistically significant differences between the two groups with respect to the incidence of sore throat, hoarseness and dysphagia at the time of discharge from PACU and at the postoperative 24th hour ($P > 0.05$) (Table 3). When we compared the VAS values of the patients with complaints (sore throat, hoarseness and dysphagia) in the two groups, we observed that the intensity of hoarseness at the postoperative 24th hour was lower in Group M than in Group S ($P < 0.025$) (Table 4). On the other hand, when we considered the intensity of the other complaints measured at the times described above and the incidences of all complaints, there were no significant differences between the two groups with respect to postoperative laryngotracheal complaints ($P > 0.05$) (Tables 3, 4).

Table 2. Changes in intracuff pressures over time in the two groups.

Time	Pressures (cm H_2O)				
	P_0	P_{30}	P_{60}	P_{90}	P_{120}
Group S	24.51 ± 3.60*	30.62 ± 5.92†	35.25 ± 7.90*†	39.62 ± 9.74*†	44.40 ± 11.23*†
Group M	30.00 ± 0.00	30.05 ± 0.33	30.22 ± 0.64	30.40 ± 0.81	30.62 ± 1.16

S: Saviour. M. Mallinckrodt. Data are presented as means ± standard deviation.

*$P < 0.001$: Intracuff pressures different from Group M.

† $P < 0.001$: Intracuff pressures different from P_0.

Table 3. Incidence of sore throat, hoarseness and dysphagia in the two groups at the time of discharge from PACU (1) and at 24 h (24).

	Incidence (%)					
	Sore Throat		Hoarseness		Dysphagia	
	1	24	1	24	1	24
Group S	40.00	20.00	20.00	17.14	31.42	17.14
Group M	34.28	11.42	22.85	14.28	25.71	8.57
P	0.621	0.324	0.771	0.743	0.597	0.239

PACU: Post-Anesthesia Care Unit. S: Saviour. M: Mallinckrodt. Data are incidences (%).

Table 4. Patient assessment of complaints on a visual analog scale (0-100 mm) at the time of discharge from PACU (1) and at 24 h (24) in the two groups.

	Sore Throat		Hoarseness		Dysphagia	
	1	24	1	24	1	24
Group	32.85 ± 19.77 (n = 14)	30.00 ± 16.32 (n = 7)	38.57 ± 21.15 (n = 7)	31.66 ± 17.22 (n = 6)	32.72 ± 21.01 (n = 11)	26.66 ± 12.11 (n = 6)
GroupM	18.33 ± 11.14 (n = 12)	12.50 ± 5.00 (n = 4)	22.50 ± 14.88 (n = 8)	10.00 ± 0.00 (n = 5)	17.77 ± 16.41 (n = 9)	20.00 ± 17.32 (n =3)
P	0.036	0.109	0.189	0.017*	0.046	0.548

PACU: Post-Anesthesia Care Unit. S: Saviour. M: Mallinckrodt. Data are presented as means ± standard deviation.
n: Number of patients with complaints.
*P < 0.025: A significant difference between the two groups.

Discussion

This study shows that the Lanz® ETT limits the increase in intracuff pressure, but it does not significantly decrease the incidence and severity of laryngotracheal complications after N_2O administration lasting 120 minutes.

Abud et al. (8) concluded in their study that the Lanz® ETT maintains a constant cuff pressure and decreases tracheal mucosal injury in dogs. In their study, the period of N_2O administration was longer (180 minutes) than that of our study. We do not know the pathological changes in our patients' tracheae but the incidence of postoperative laryngotracheal complications was less but not statistically significant in Group M when compared to Group S.

In our study, we did not adjust the initial cuff volumes at the same pressure in the Lanz® ETT and standard ETT because in clinical practice we usually fill the cuff until the leaking sound is terminated (sealing pressure) and when the standard ETT is used during N_2O administration, the initial cuff pressure of 30 cm H_2O is the borderline pressure with respect to the maintenance of tracheal arterial capillary pressure. We preferred to achieve the sealing pressure and observe the changes in intracuff pressure over time and the time at which the cuff pressure of the standard ETT would exceed the intracuff pressure of the Lanz® ETT. After 60 minutes, the intracuff pressure of the standard tube exceeded the intracuff pressure of the Lanz® ETT. The volume filled (V_1) and then aspirated (V_2) from the cuff was not recorded in Group M. It would not be meaningful to record the filled and aspirated volumes from the Lanz® ETT cuff because its pressure regulating valve changed and regulated the volume in the cuff continuously.

Monitoring of the intracuff pressures using a manometer during N_2O administration is an advisable method but this is not a common application. In our study, the mean duration of surgery was approximately two

hours. Tracheal ischemia is proportional to the pressure exerted by the cuff and the time of exposure. Considering that the intracuff pressures were maintained constantly at approximately 30 cm H_2O in Group M, it is possible that the advantage of the Lanz® ETT with respect to postoperative laryngotracheal complications after N_2O anesthesia may be statistically significant if this tube is used during operations lasting longer than those in this study. On the other hand, the higher cost of the Lanz® ETT limits its use. When it is possible to monitor the cuff pressure, preference should be given to using a standard ETT. The sealing cuff pressure can prevent the occurrence of high cuff pressure, especially during the first 60 minutes of N_2O administration (10). When it is difficult or impossible to monitor the cuff pressure, such as during head and neck surgeries lasting longer than two hours, preference should be given to using the Lanz® ETT.

There are some techniques used to minimize high intracuff pressure during N_2O administration. Filling the cuff with isotonic saline or lidocaine is associated with the risk of cuff rupture and fluid release to the trachea (11,12). Some investigators have filled the cuff with N_2O/O_2 gas mixture in concentrations similar to those used during anesthesia (13), but Mitchell et al. (14) have shown that intracuff pressure decreased and the risk of aspiration increased when gas mixture was used. The ETT with a cuff that is impervious to N_2O or the ETT with Brandt™ system are the other alternative tubes, but their cost limits their use as with the Lanz® ETT (15). Cost considerations are mandatory when new techniques are introduced into general clinical practice.

In conclusion, the Lanz® ETT works properly and limits the increase in intracuff pressure, but it offers no significant advantage with respect to postoperative laryngotracheal complications after N_2O anesthesia lasting approximately two hours. Thus, we suggest that there is no need to use the Lanz® ETT for operations lasting two hours or less.

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