The Lanz® endotracheal tube decreases tracheal injury in dogs

[L'usage du tube endotrachéal Lanz® réduit les lésions de la trachée chez les chiens]

Tania Mara Vilela Abud MD PhD,* José Reinaldo Cerqueira Braz MD PhD,* Regina Helena Garcia Martins MD PhD,† Elisa Aparecida Gregório PhD,‡ João Carlos Saldanha MD,§ Ana Carolina Pasquini Raiza MD*

Purpose: To determine, in dogs anesthetized with nitrous oxide (N_2O), whether the endotracheal tube (ETT) cuffed with a Lanz® pressure regulating valve decreases the tracheal consequences of tracheal intubation.

Methods: Sixteen mixed-breed dogs were allocated to two groups according to the ETT used: Control group ($n = 8$) - Rüsch ETT, and Lanz group ($n = 8$) - ETT with Lanz® pressure regulating valve. The ETT cuffs in both groups were inflated with air to an intracuff pressure of 30 cm H_2O. Anesthesia was induced and maintained with pentobarbitone and N_2O (1.5 $L{\cdot}min^{-1}$) and O_2 (1 $L{\cdot}min^{-1}$). ETT cuff pressures were measured before (control) and 60, 120, and 180 min during N_2O administration. The dogs were sacrificed, and biopsy specimens from four predetermined areas of the tracheal mucosa in contact with the ETT were collected for light and scanning electron microscopy (SM) examination.

Results: Cuff pressures in the Control group were higher than in the Lanz group at all time points studied ($P < 0.001$), with an increase over time only in the Control group ($P < 0.001$). Median neutrophilic inflammatory infiltration values of the epithelial surface, and in the subepithelial layer in contact with the cuff, were higher in the Control group as compared to the Lanz group (3.0 *vs* 1.0 and 3.0 *vs* 1.5 respectively) ($P < 0.05$). On SM examination, median histological grades were higher in the Control group compared to Lanz group (2.9 *vs* 1.9 respectively), ($P < 0.05$).

Conclusions: The Lanz® ETT decreases tracheal mucosal injury in dogs.

Objectif : *Déterminer, chez des chiens anesthésiés avec du protoxyde d'azote (N_2O), si le tube endotrachéal (TET) muni d'un ballonnet avec manodétenteur Lanz® permet de diminuer les lésions de la trachée lors de l'intubation endotrachéale.*

Méthode : *Seize chiens de race mêlée ont été répartis en deux groupes selon le TET utilisé : groupe témoin ($n = 8$) - TET Rüsch, groupe Lanz ($n = 8$) - TET avec manodétenteur Lanz®. Les ballonnets des TET ont été gonflés à l'air à une pression interne de 30 cm H_2O. L'anesthésie a été induite et maintenue avec du pentobarbital et du N_2O (1,5 $L{\cdot}min^{-1}$) dans de l'O_2(1 $L{\cdot}min^{-1}$). Les pressions des ballonnets ont été mesurées avant (témoin) et pendant l'administration de N_2O à 60, 120 et 180 min. Les chiens ont été sacrifiés et des spécimens de biopsie ont été prélevés à partir de quatre sites prédéterminés de la muqueuse trachéale en contact avec le TET pour un examen au microscope classique ou électronique à balayage (MB).*

Résultats : *Les pressions de ballonnet témoins ont été plus élevées que celles du groupe Lanz à tous les temps de mesure ($P < 0,001$), avec une augmentation dans le temps dans le groupe témoin seulement ($P < 0,001$). Les valeurs médianes de l'infiltration inflammatoire neutrophile de la surface épithéliale et de la couche sous-épithéliale en contact avec le ballonnet ont été plus élevées dans le groupe témoin que dans le groupe Lanz (3,0 vs 1,0 et 3,0 vs 1,5 respectivement) ($P < 0,05$). À l'examen MB, les grades histologiques médians ont été plus élevés dans le groupe témoin que dans le groupe Lanz (2,9 vs 1,9 respectivement) ($P < 0,05$).*

Conclusion : *L'usage du TET Lanz® diminue les lésions de la muqueuse trachéale chez les chiens.*

From the Departments of Anesthesiology,* and Otorhinolaryngology, Ophthalmology and Head and Neck Surgery,† School of Medicine, University of São Paulo State (UNESP); the Department of Morphology, Institute of Bioscience,‡ UNESP, Botucatu, São Paulo; and the Department of Pathology,§ School of Medicine, Federal University of Triangulo Mineiro, Uberaba, Minas Gerais, Brazil.

Address correspondence to: Dr. José Reinaldo Cerqueira Braz, Department of Anesthesiology, School of Medicine, UNESP, District of Rubião Júnior - P.O. Box 530, Zip Code 18618-970 - Botucatu, SP - Brazil. Phone: 55-14-3811-6222; Fax: 55-14-3815-9015; E-mail: jbraz@fmb.unesp.br

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THE use of nitrous oxide (N_2O) during anesthesia, which is well-known to diffuse into the endotracheal tube (ETT) cuff, is the most important of factors that contribute to the incidence of high intracuff pressures during this period.[1,2] Tracheal arterial capillary 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.[3]

An ETT with the Lanz® pressure regulating valve, which has a large pilot balloon, effectively limits to 30 cm H_2O the increase in cuff pressure caused by excessive volume inflated in the pilot balloon, or N_2O diffusion into the ETT cuff.[4] However, there is a lack of data assessing whether the Lanz® ETT attenuates tracheal mucosal injury after N_2O anesthesia. In dogs anesthetized with N_2O, we hypothesized that the Lanz® ETT would avoid high intracuff pressure, and decrease the extent of tracheal mucosal injury associated with tracheal intubation.

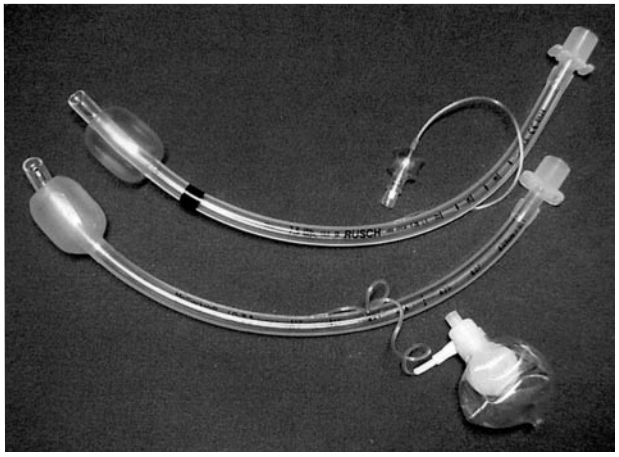

FIGURE 1 A standard endotracheal tube (from Rüsch, Rüschlit model, Montevideo, Uruguay [top]) and a Lanz® endotracheal tube (from Mallinckrodt Medical, St. Louis, MO, USA [bottom]). The latter has a large pilot balloon (with a clear protective cover). Both cuffs have a similar volume.

Methods

The trial was approved by the University Ethical Commission on Research in Animals. Sixteen mixed-breed dogs weighing from 12 to 17 kg were studied. In order to measure continuously ETT cuff pressure, a digital manometer (manufactured by Mallinckrodt Medical, St. Louis, MO, USA) was connected to the ETT pilot balloon. Before anesthesia, the dogs were randomly allocated (via a sealed envelope) to two groups according to the ETT with high residual volume, low-pressure cuff used: Control group (n = 8) - ETT from Rüsch (Uruguay) and Lanz group (n = 8) - ETT from Mallinckrodt Medical, with a Lanz® pressure regulating valve (Figure 1).

Anesthesia was induced and maintained with pentobarbitone (bolus injection of 25 $mg \cdot kg^{-1}$ and infusion of 25 $mg \cdot kg^{-1} \cdot min^{-1}$ *iv*), cisatracurium bensilate (bolus of 0.150 $mg \cdot kg^{-1}$ *iv* and infusion of 2 $\mu g \cdot kg^{-1} \cdot min^{-1}$), and N_2O (1.5 $L \cdot min^{-1}$) in O_2 (1.0 $L \cdot min^{-1}$). ETT with an inner diameter of 8.0 mm for female and 8.5 mm for male dogs were used. In both groups, the ETT cuff was inflated with air until intracuff pressure reached 30 cm H_2O.

Standard clinical monitoring was performed: electrocardiography (D_{II} lead), peripheral oxygen saturation of oxyhemoglobin, end-tidal carbon dioxide, and inspired fractions of O_2 and N_2O were measured. The animals were ventilated in a volume-controlled mode (Ohmeda, model 7900, Madison, WI, USA). A 20-G catheter was placed in the right femoral artery to measure mean arterial blood pressure (MAP; AS3, Datex-Engstron, Helsinki, Finland). An 18-G catheter was placed in the right jugular vein for infusion of 5 $mL \cdot kg^{-1} \cdot hr^{-1}$ of lactated Ringer's solution. Measurement of MAP and intracuff pressures were performed before and 60, 120, and 180 min during N_2O administration.

At the end of the experiment, the dogs were sacrificed with an excessive dose of pentobarbitone. Trachea removal was preceded by its transfixation to the ETT, to prevent ETT displacement. Biopsies of the tracheal mucosa were taken from four areas in contact with the cuff (anterior, posterior, right lateral and left lateral regions). For scanning electron microscopy (SM) and light microscopy (LM) studies, specimens were prepared according to a previous study.[5]

All LM and SM evaluations were conducted by a single pathologist blinded to the treatment group. In the LM analysis the following characteristics were evaluated: epithelial surface (erosion and neutrophilic inflammatory infiltration - NII) and subepithelial layer (congestion, hemorrhage, and NII). The analysis was semiquantitative with scoring from 0 to 3 (without, mild, moderate, or severe injury, respectively). In the SM analysis, severity of mucus, cilia and epithelial cell changes were graded from 0 to 4, as follows: 0 - lack of mucus, ciliary or epithelial cell changes; 1 - evidence of mucus drying and clustered cilia, and lack of epithelial cell changes; 2 - signs of mucus drying, mild ciliary loss and lack of epithelial cell changes; 3 - signs

TABLE Cuff pressures in the two groups during nitrous oxide anesthesia

	Time (min)			
Groups	*0*	*60*	*120*	*180*
Control	30 [30;30]	42.5 [40;44]#*	57 [56;64.5]#*	69[65.5;73.5]#*
Lanz	30 [28.5;31]	30.5 [28.5;31.5]	32.5 [28;33.5]	33 [27.5;34.5]

Data are medians [25th and 75th percentiles]. #$P < 0.001$: intracuff pressures different from Lanz® (by Mann-Whitney test). *$P < 0.001$: intracuff pressures different from T = 0 (by Friedman test).

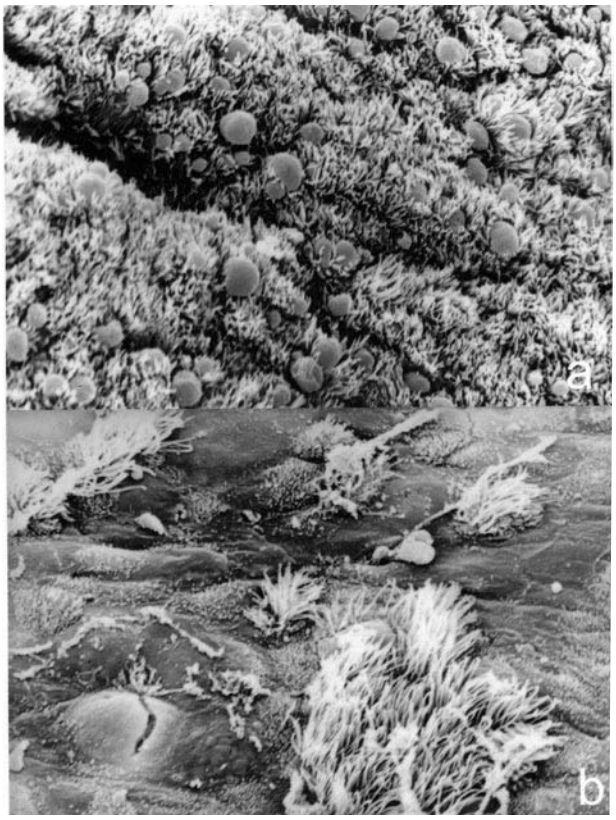

FIGURE 2 Scanning electron microscopy of a segment of tracheal mucosa in contact with cuff, showing: a) Lanz group. Clustered cilia and mucus droplets with wrinkling on the surface (1860x), characterizing histological evaluation grade 1. b) Control group. Important ciliary loss and clustered cilia, and epithelium rupture (1860x), characterizing histological evaluation grade 3.

of mucus drying, major ciliary rarefaction associated with epithelial rupture; 4 - tracheal epithelium rupture with disorganization and cell loss.

A Student t test was used for statistical comparison of the anthropometric variables and MAP values. Sexes were compared by Chi-square test. The non-parametric Mann-Whitney test was used to compare intracuff pressures and tracheal-mucosa-area values between groups, and the Friedman test was used to investigate differences over time in each group. A P value less than 0.05 was considered significant.

Results

Groups were homogenous in anthropometric and gender distribution. MAP values were not significantly different between the groups. The cuff pressures were significantly different between groups ($P < 0.001$), with a significant increase over time only in the Control group ($P < 0.001$), (Table).

LM findings showed from 1 to 2 grades of the epithelial area eroded, and moderate congestion in the subepithelial surface without significant differences between the groups ($P > 0.10$). No hemorrhage was detected in either group. However, the median neutrophilic inflammatory infiltration values in the epithelial surface and subepithelial layer of the tracheal mucosa in contact with the cuff were significantly higher in the Control group (3.0 and 3.0 respectively) as compared to the Lanz group (1.0 and 1.5 respectively), ($P < 0.05$).

The median histological grade of the tracheal mucosa area assessed by SM was significantly higher in the Control group (2.9) as compared to the Lanz group (1.9), ($P < 0.05$). The few histological changes demonstrated by SM in the Lanz group are shown in Figure 2a, while the important histological changes in the Control group are shown in Figures 2b, 3a and 3b.

Discussion

Our study shows that during N_2O anesthesia, use of an ETT cuffed with a Lanz® pressure regulating valve results in stable intracuff pressures and minor microscopic tracheal lesions (Figure 2a). On the other hand, the use of standard type ETT during N_2O anesthesia results in high intracuff pressures and a higher incidence of microscopic tracheal lesions (Figures 2b and 3). Accordingly, during anesthesia with N_2O, cuff pressure measurements and adjustment of cuff pressure should be considered, due to the high intracuff pressures attained.[1,2] As N_2O diffuses more rapidly into

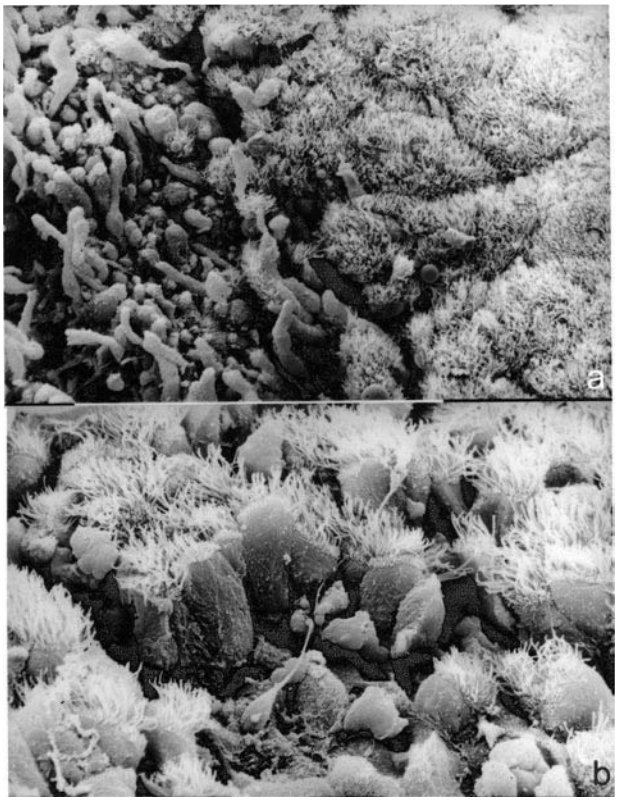

FIGURE 3 Control group. Scanning electron microscopy of tracheal mucosa in contact with cuff, showing: a) transitional area with clustered cilia, characterizing histological evaluation grade 1, and epithelial rupture, dried mucus droplets and cell debris (x890), characterizing histological evaluation grade 4. b) epithelial rupture, ciliary devastation, disorganization and "loose" cells (x1860), characterizing histological evaluation grade 4.

the cuff than nitrogen diffuses out, augmentation of cuff pressure occurs, a well-known phenomenon.[1,6,7] This tendency is opposed by barometric pressure build up in the cuff. When the diffusion pressure is equal to the barometric pressure, the diffusion stops. Pressure does not build up in the ETT cuffed with the Lanz® valve, as the volume expansion accompanying the equilibration of N_2O expands the high compliance pilot balloon.

Considering our results and higher cost of the Lanz® ETT, what should be recommended regarding the use of the Lanz® ETT during anesthesia? When equipment is available to monitor cuff pressure during anesthesia, the method for the prevention of increased cuff pressure is a moot point, as adjustments in cuff volume can be made according to an objective measurement. When it is difficult or impossible to monitor the cuff pressure, such as head and neck surgeries carried out with the use of N_2O, preference should be given to using a Lanz® ETT. Other techniques have been proposed to minimize high intracuff pressure during N_2O anesthesia. Each technique has an advantages and potential limitations. Filling the cuff with isotonic saline[7] or lidocaine[8] is associated with the risk of cuff rupture and fluid release to the trachea. Filling the cuff with N_2O/O_2 gas mixture in concentrations similar to those used during anesthesia has been tried,[9] although large variations in inspired N_2O concentration induce rapid changes in cuff volume, resulting in either overinflation or deflation.[6] Finally, a new ETT has been developed with a cuff impervious to N_2O.[10]

We conclude that tracheal mucosal injury resulting from increases in ETT cuff pressure begins after one hour of N_2O administration. The Lanz® ETT maintains a constant cuff pressure, and decreases tracheal mucosal injury in dogs.

References

1 *Stanley TH, Kawamura R, Graves C.* Effects of nitrous oxide on volume and pressure of endotracheal tube cuffs. Anesthesiology 1974; 41: 256–62.

2 *Braz JR, Navarro LH, Takata IH, Nascimento Junior P.* Endotracheal tube cuff pressure: need for precise measurement. São Paulo Med J 1999; 117: 243–7.

3 *Nordin U.* The trachea and cuff-induced tracheal injury. An experimental study on causative factors and prevention. Acta Otolaryngol 1977; 345(Suppl.): 1–71.

4 *Navarro LH, Braz JR, Pletsch AK, Amorim RB, Modolo NS.* Comparative study of tracheal tube cuff pressures with or without Lanz® pressure regulation system. Rev Bras Anestesiol 2001; 51: 17–27.

5 *Barra Bisinotto FM, Braz JR, Martins RH, Gregorio EA, Abud TM.* Tracheobronchial consequences of the use of heat and moisture exchangers in dogs. Can J Anesth 1999; 46: 897–903.

6 *Tu HN, Saidi N, Leiutaud T, Bensaid S, Menival V, Duvaldestin P.* Nitrous oxide increases endotracheal cuff pressure and the incidence of tracheal lesions in anesthetized patients. Anesth Analg 1999; 89: 187–90.

7 *Combes X, Schauvliege F, Peyrouset O, et al.* Intracuff pressure and tracheal morbidity: influence of filling with saline during nitrous oxide anesthesia. Anesthesiology 2001; 95: 1120–4.

8 *Soltani HA, Aghadavoudi O.* The effect of different lidocaine application methods on postoperative cough and sore throat. J Clin Anesth 2002; 14: 15–8.

9 *Karasawa F, Tokunaga M, Aramaki Y, Shizukuishi M,*

Satoh T. An assessment of a method of inflating cuffs with a nitrous oxide gas mixture to prevent an increase in intracuff pressure in five different tracheal tube designs apparatus. Anaesthesia 2001; 56: 155–9.

10 *Fujiwara M, Mizoguchi H, Kawamura J, et al.* A new endotracheal tube with a cuff impervious to nitrous oxide: constancy of cuff pressure and volume. Anesth Analg 1995; 81: 1084–6.