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Original Article

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Endotracheal tube cuff pressure: need for precise measurement

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ABSTRACT

CONTEXT: High compliance endotracheal tubes cuffs are used to prevent gas leak and also pulmonary aspiration in mechanically ventilated patients. However, the use of the usual cuff inflation volumes may cause tracheal damage.
OBJECTIVE: We tested the hypothesis that endotracheal tube cuff pressures are routinely high (above 40 cmH_2O) in the Post Anesthesia Care Unit (PACU) or Intensive Care Units (ICU).
DESIGN: Cross-sectional study.
SETTING: Post anesthesia care unit and intensive care unit.
PARTICIPANTS: We measured endotracheal tubes cuff pressure in 85 adult patients, as follows: G1 (n = 31) patients from the ICU; G2 (n = 32) patients from the PACU, after anesthesia with nitrous oxide; G3 (n = 22) patients from the PACU, after anesthesia without nitrous oxide. Intracuff pressure was measured using a manometer (Mallinckrodt, USA). Gas was removed as necessary to adjust cuff pressure to 30 cmH_2O.
MAIN MEASUREMENTS: Endotracheal tube cuff pressure.
RESULTS: High cuff pressure (> 40 cmH_2O) was observed in 90.6% patients of G2, 54.8% of G1 and 45.4% of G3 ($P < 0.001$). The volume removed from the cuff in G2 was higher than G3 ($P < 0.05$).
CONCLUSION: Endotracheal tubes cuff pressures in ICU and PACU are routinely high and significant higher when nitrous oxide is used. Endotracheal tubes cuff pressure should be routinely measured to minimize tracheal trauma.
KEY WORDS: Tracheal tube. Intracuff pressure. Nitrous oxide.

INTRODUCTION

High compliance endotracheal tubes cuffs are used to prevent gas leak and also pulmonary aspiration in mechanically ventilated patients. However, the use of the usual cuff inflation volumes produces transmission of the pressure directly to the tracheal wall around the cuffs. When the cuff pressure is over 40 cmH_2O, which is the perfusion pressure of the tracheal mucosa and submucosa,[1] loss of mucosal ciliar,[2,3] ulceration, bleeding,[3] tracheal stenosis,[4] and tracheoesophageal fistula[5] may occur.

Although deleterious consequences have decreased with the routine use of high-volume, low-pressure cuffs,[6] complications such as tracheal stenosis may still occur.[5,6] During anesthesia, it should be considered that nitrous oxide, a commonly used gaseous anesthetic, diffuses easily to the endotracheal tube cuffs, increasing the cuff pressure.[7]

Endotracheal tube cuff pressures are not routinely measured[8] and previous studies have demonstrated that cuff palpation is insufficient to detect high cuff pressures.[9]

In this study, we tested the hypothesis that endotracheal tube cuff pressure is routinely high (above 40 cmH_2O) and that most professionals that work in the operating room or Intensive Care Units are unaware of the problem. We undertook a study to examine the frequency of high cuff pressures in Post Anesthesia Care Units and Intensive Care Units.

METHODS

After approval from the Ethics Committee, we measured endotracheal tube cuffs pressures in 85 patients, as follows:

Group 1: 31 patients admitted into the Intensive Care Unit (ICU);

Group 2: 32 patients admitted into the Post Anesthesia Care Unit (PACU), after anesthesia with nitrous oxide;

Group 3: 22 patients admitted into the PACU, after anesthesia without nitrous oxide.

Only adult patients that had been intubated by someone other than the authors were eligible for inclusion in the study. Patients with tracheotomies, laryngeal disease or laryngeal surgery were excluded. The sizes of the low-pressure high-compliance cuffed endotracheal tubes ranged from 7.0 to 9.0 mm in internal diameter and cuff tube inflation was under control of the anesthesiologist in the operation room, or the intensive care specialist in the ICU.

In order to measure endotracheal tube cuff pressure, a hand-held battery-operated digital manometer P-V Gauge manufactured by Mallinckrodt (USA) was used. The age, weight, height and sex of the patients, and also the internal diameter and manufacturer of the endotracheal tubes were logged. Air was removed as necessary to adjust cuff pressure to an acceptable level (30 cmH_2O) at the time of measurement.

Statistical Methods. Data obtained were compared using chi-squared test and variance analysis. The relationship between the volume of removed air and cuff pressure was also observed, by means of regression analysis. Data were reported as means, standard deviation or mode. Probability levels less than 0.05 were considered significant.

RESULTS

We found no differences among the groups according to anthropometry or sex (Table 1). High cuff pressures (> 40 cmH_2O) were found in 90.6% of patients in G2, 54.8% in G1, and 45.4% in G3 ($P < 0.001$). Endotracheal tube cuff pressure showed significant differences between the groups, with G2 > G1 = G3 ($P < 0.05$), and was higher than the tracheal capillary pressure (40 cmH_2O) in all groups (Table 2 and Figure). There was also a significant difference between the groups in relation to air removed from the cuff ($P < 0.05$). It was observed that little gas needed to be removed from endotracheal tube cuffs to reduce cuff pressure to acceptable levels (30 cmH_2O) (Table 1). The greatest volume removed from the cuff was 10 cm^3 (G1) and the least was 0.5 cm^3 (G3). There was a linear relationship between volume removed and cuff pressures in G1 (r = 0.93; P <

Table 1 - Distribution of sex and anthropometric variables and air volume removed from the cuff.

	Groups			
Data	ICU	PACU with N_2O	PACU without N_2O	P-value
Patients	31	32	22	> 0.50
Age, years	48 (18)	47 (18)	47 (19)	> 0.10
Sex (M/F)	19/12	17/15	10/12	> 0.50
Weight, kg	70 (15)	68 (13)	65 (16)	> 0.50
Height, m	1.68 (0.10)	1.66 (0.11)	1.64 (0.08)	> 0.10
Air volume removed from the cuff, cm^3	2.3 (1.9)	2.5 (2.1)	0.9 (0.7)	< 0.05

G2>G3; G1showed intermediate values; values are mean and standard deviation unless otherside indicated in parenthesis.

0.001), G2 (r = 0.74; P < 0.001), and G3 (r = 0.72; P < 0.001).

Endotracheal tube size ranged from 7.0 to 9.0 mm internal diameter (Table 3), with no significant difference among the groups (P > 0.10). It was only possible to standardize the endotracheal tubes used in OR (G2 and G3), in which high-volume, low-pressure endotracheal tubes from the same manufacturer (Rusch, Uruguay) were always employed. In ICU's (G1), endotracheal tubes from Rusch (Uruguay) were also used the most (77.4%), but high-volume low-pressure endotracheal tubes from other manufacturers were also employed.

DISCUSSION

The results of the present study showed that there was high pressure in endotracheal tube cuffs in most of G2, those patients who were submitted to nitrous oxide during anesthesia, showing the importance of fast diffusion of this gas into the air-filled cuff. The control of cuff pressure should be performed, if not continuously, at least intermittently during anesthesia.

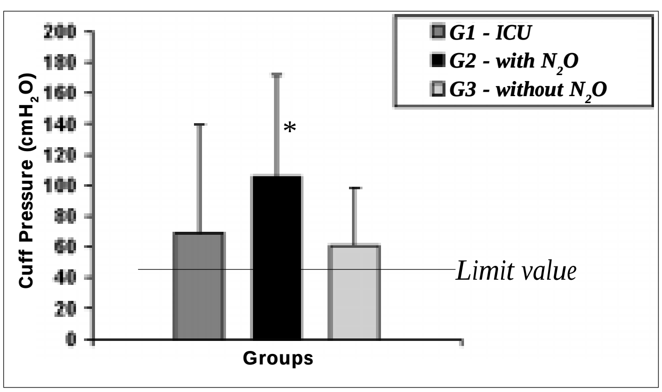

Figure - Endotracheal tube cuff pressure in the three groups: mean and standard deviation and indicative limit value for tracheal capillary pressure.
* p < 0.05:G2>(G1=G3).

On the other hand, high endotracheal tube cuff pressure was also important in ICU patients (G1) and those that did not receive nitrous oxide during anesthesia (G3), confirming the low accuracy of cuff pressure estimation by palpation, even among experienced anesthesiologists.[9]

There have been descriptions of the occurrence of tracheal sequelae, secondary to endotracheal tube cuff high pressure, since mechanical ventilation was introduced in 1950. The first endotracheal tube cuffs used were made of low-compliance latex rubber, requiring high pressure levels to seal the tracheal lumen. Since the end of the 1970's, these endotracheal tube cuffs have been replaced by ones made of high-compliance plastic. Thus, higher air volumes can be injected with only small pressure increases, decreasing the incidence of tracheal lesions.[5,10] Low-pressure endotracheal tube cuffs present wider support surfaces on the tracheal mucosa than high-pressure ones, and therefore the pressure exerted by the former is lower.[7]

Despite the use of low-pressure cuffed endotracheal tubes, post-intubation tracheal stenosis is still reported in the literature.[4]

The characteristics of tracheal mucosa, which is formed by ciliated pseudo-stratified epithelium, make it very sensitive to the endotracheal tube cuffs. Thus, pressure exerted

Table 2 - Endotracheal tube cuff pressure (cmH_2O)

Groups		
ICU	PACU with N_2O	PACU without N_2O
69(70)	106*(66)	60.5(38)
(8 to 304)	(15 to 287)	(18 to 140)

* Values are mean, standard deviation and range.
P < 0.05[G2>(G1=G3)]

Table 3 - Endotracheal tube sizes (internal diameter)

		Tube size (mm)						
Group	n	7.0	7.5	8.0	8.5	9.0	Mean	Mode
G1	31	0	9	11	7	4	8.3	8.0
G2	32	1	3	14	12	2	8.4	8.0
G3	22	0	0	11	10	1	8.2	8.0

P > 0.10

by the cuff on the tracheal mucosa seems to be the main cause of post-intubation sequelae.[1,4,5,11-13] Ischemic damage of the trachea depends on the balance between mucosal perfusion pressure and the pressure exerted by the cuff. When the cuff pressure exceeds tracheal mucosal perfusion pressure, induction of ischemia and / or necrosis will just be a question of time.[1] Tracheitis without ulceration is the initial lesion that occurs, followed by mucosal denudation and exposure of trachea cartilage.[1] Other associated factors can increase the incidence of post-intubation tracheal complications, even with cuff pressures that appear not be excessive on the tracheal mucosa. Among these factors are included the decrease in mucosal blood flow produced by hypotension, shock and anemia,[2] and low oxygen delivery to tracheal tissue, produced by hypoxemia, anemia and metabolic acidosis.[12] Additional mechanical factors, such as the placement of nasogastric tubes, seem to increase the risk of developing tracheoesophageal fistulas in patients under long-time tracheal intubation.[4]

We observed that little gas needs to be removed from endotracheal tube cuffs to reduce their pressure. This suggests that low-pressure, high-volume cuffs are filled to a low compliance point of the pressure-volume curve of the cuff, when confined within a trachea.[8] Some authors observed that high-compliance endotracheal tube cuff pressure increases very slowly, between pressures of 10 and 20 cmH_2O, after which the addition of small volumes increases the cuff pressure substantially.[8]

The demonstration of the low accuracy of finger palpation estimates for cuff pressure[9] makes it essential to measure endotracheal tubes cuff pressure frequently, by using a more objective approach. During anesthesia with nitrous oxide, cuff pressure measurements become mandatory due to the high pressure levels reached.[7]

More recently, it has been proposed that endotracheal tubes should be used that provide pressure relief valves allowing nitrous oxide diffusion when cuff pressures exceed 40 cmH_2O.[14-16] Unfortunately, the high cost of these endotracheal tubes make them impracticable for frequent use.

We recommend routine adjustment of cuff pressures to obtain the lowest pressure consistent with allowing a seal between trachea and endotracheal tubes. However, problems attributable to insufficient cuff inflation have been reported.[17] These include leaking of the tidal volume supplied by the ventilatory system and micro-aspirations of oropharyngeal secretions that could produce nosocomial pulmonary infections.[18]

CONCLUSION

Endotracheal tube cuff pressures in Intensive Care Units and Post Anesthesia Care Units are routinely high and are significantly higher when nitrous oxide is used. Endotracheal tube cuff pressures should be routinely measured by manometry to minimize trauma to the tracheal mucosa and surrounding structures.

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RESUMO

CONTEXTO: Tubos traqueais com balonete de alta complacência são utilizados para prevenção de vazamento de gás e de aspiração pulmonar em pacientes submetidos à ventilação mecânica. Entretanto, o volume de insuflação habitual gera uma pressão do balonete que se transmite diretamente à parede traqueal e pode causar lesões. **OBJETIVO:** Testar a hipótese de que as pressões no balonete do tubo traqueal geralmente estão elevadas (acima de 40 cmH_2O) na Sala de Recuperação Pós-anestésica (SRPA) ou nas Unidades de Terapia Intensiva (UTI). **TIPO DE ESTUDO:** Estudo de seção transversal. **LOCAL:** Sala de recuperação pós-anestésica e unidade de terapia intensiva. **PARTICIPANTES:** Medimos a pressão no balonete do tubo traqueal em 85 pacientes adultos, sendo: G1 (n=31) pacientes da UTI; G2 (n=32) pacientes da SRPA, após anestesia com óxido nitroso; G3 (n=2) pacientes da SRPA, após anestesia sem óxido nitroso. A pressão no balonete foi medida utilizando-se um manômetro (Mallinkrodt, USA). Quando necessário, retirou-se gás para ajustar a pressão no balonete até 30 cmH_2O. **VARIÁVEIS ESTUDADAS:** Pressão do balonete do tubo traqueal. **RESULTADOS:** Foram observadas pressões elevadas no balonete do tubo traqueal em 90,6% dos pacientes de G2, 54,8% de G1 e 45,4% de G3 ($P < 0,001$). **CONCLUSÕES:** As pressões no balonete do tubo traqueal na UTI e na SRPA estão elevadas rotineiramente e são significativamente mais altas quando se utiliza óxido nitroso. A pressão no balonete do tubo traqueal deve ser medida rotineiramente para minimizar o trauma traqueal.
PALAVRAS-CHAVE: Tubo traqueal. Pressão do balonete. Óxido nitroso.