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Original Article

Contrast of cuff pressure of two common endotracheal tubes in thyroid surgery and association with post-operative sore throat and dry throat

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Abstract: We aimed to explore the mechanism of postoperative sore throat and dry throat by monitoring cuff pressure of two endotracheal tubes in thyroid surgery. Fifty patients who underwent thyroidectomy surgery were included. They were randomly divided into the NIM group and Rusch group. Patients in the NIM group were assigned with the Medtronic Xomed NIM endotracheal tube and the Rusch enhanced endotracheal tube for the Rusch group. After induction of general anesthesia and endotracheal intubation, cuff pressure was raised up to 20 mmHg (28 cm H_2O) by inflation. Cuff pressure was recorded per 5 minutes until extubation. Throat complaints of sore throat and dry throat were assessed and graded 24 h later. The NIM group showed higher cuff pressure compared with the Rusch group (31.1 ± 9.5 mmHg *vs.* 23.0 ± 8.5 mmHg, $P < 0.001$). The NIM group got higher sore throat score than the Rusch group (4.0 ± 2.0 *vs*. 2.6 ± 1.4, $P < 0.01$). Multiple linear regression model analysis suggested that cuff pressure had obvious effect on sore throat ($\beta = 0.391$, SE = 0.162, $P < 0.05$). There was no significant difference in the dry throat classification of the two groups in nonparametric test ($P > 0.05$). However, the rates of dry throat events of I and II grades of NIM group were lower than those in Rusch group [grade I: 6 cases (22.2%) *vs.* 8 cases (34.8%); grade II: 3 cases (11.1%) *vs*. 8 cases (34.8%)]. The rates of dry throat events of grades III and IV in NIM group were higher than those in the Rusch group [grade III: 6 cases (22.2%) *vs.* 3 cases (13.0%); grade IV: 12 cases (44.4%) *vs*. 4 cases (17.4%)]. Decision tree model analysis suggested when cuff pressure < 24.1 mmHg, the risk of dry throat of grade I was higher; when 24.1 mmHg ≤ cuff pressure < 28.4 mmHg, the risk of dry throat of grade III was higher; when cuff pressure ≥ 28.4 mmHg, the risk of dry throat of grade IV was higher. Compared with the Rusch group, the NIM group had higher cuff pressure and the postoperative sore throat among patients was more severe. Sore throat VAS score was associated with the mean cuff pressure, but dry throat grade was not associated with mean cuff pressure.

Keywords: Cuff pressure, dynamic monitoring, thyroid surgery, sore throat, dry throat

Introduction

Sore throat and dry throat are common complications developed after tracheal intubation in general anesthesia (especially for thyroid surgery), with high prevalence of 14%-65% [1]. These are the major postoperative complications besides wound pain [2]. Sore throat and dry throat reduce satisfaction of patients with surgery and adversely influence the normal life of patients after surgery [3]. Previous studies have shown that cuff pressure is associated with tracheal tube related complications after general anesthesia surgery, thus controlling cuff pressure may effectively reduce development of these complications [4]. Our hospital had introduced a newly-developed tube, recurrent laryngeal nerve monitoring tube, which can realize recurrent laryngeal nerve monitor during surgery and reduce recurrent laryngeal nerve impairment. In the present study, we investigated the association between cuff pressure and post-operative sore throat and dry throat, by continuously monitoring cuff pressure of two tubes.

Material and methods

Ethics statement

The present study had been approved by Ethics Committee of Tongji Medical School of Hua

Table 1. Comparison of main status of patients between two groups (n = 50)

Group	Gendre Ratio (m/f)	Age (years)	BMI (kg ± m^2)	Anesthesia duration (min)	Peak airway pressure (cm H_2O)
NIM group	4/23	46.4 ± 12.1	23.0 ± 2.8	132.4 ± 1.6	12.9 ± 2.5
Rusch group	4/19	46.6 ± 12.4	22.7 ± 2.9	135.4 ± 32.0	12.9 ± 2.4

Table 2. Contrast of inflation volume needed for certain cuff pressure after tracheal intubation by two tubes

Groups	Cuff pressure 16 mmHg inflation volume	Cuff pressure 20 mmHg inflation volume	Cuff pressure 24 mmHg inflation volume
NIM group	3.0 ± 1.0[a]	3.3 ± 1.0[a]	3.5 ± 1.1[a]
Rusch group	6.3 ± 0.9	6.5 ± 0.9	6.9 ± 1.0

Notes: Compared with Rusch group, [a]$P < 0.05$.

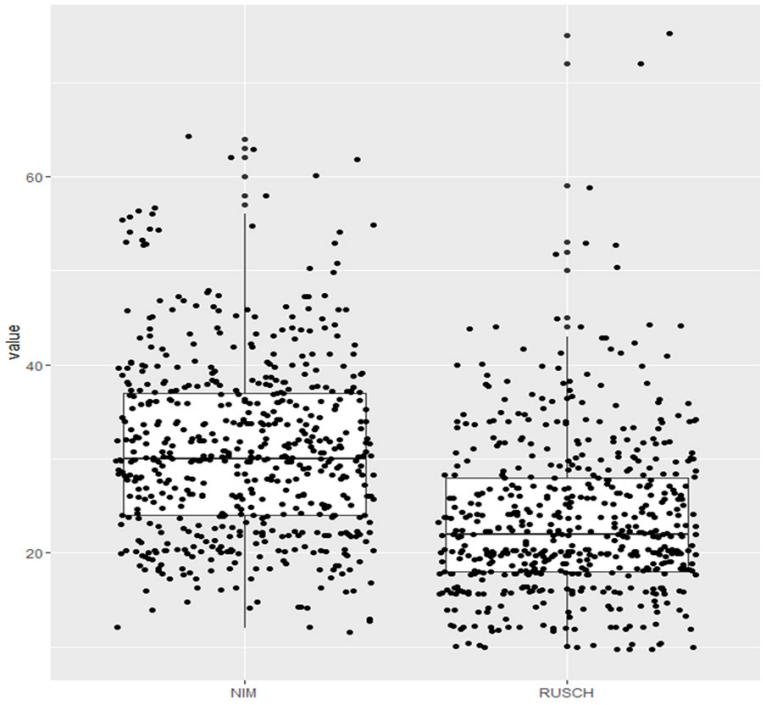

Figure 1. Contrast of cuff pressure of two groups (Mixed model).

Zhong Technology University and informed consent was given by all patients enrolled. This study included 50 patients to receive thyroid surgery, with age of 18-60 years, ASA grade I or II, BMI 18-30 kg/m^2, Mallampati grade I-II and tubulization time of 120-180 min. Exclusion criteria: confirmed cardiovascular diseases; known difficult airway or unsuccessful intubation for the first time; chronic diseases inducing sore throat and dry throat; throat surgery or traumatic history. According to a random number table, the patients were randomly divided into the NIM group and the Rusch group. Patients in the NIM group were assigned with the Medtronic Xomed NIM recurrent laryngeal nerve monitor tube and patients in the Rusch group with a Rusch enhanced endotracheal tube.

Surgical operation

No premeditation was administered among patients. Mask oxygen-inspiration was given, peripheral venous circuit was established, noninvasive blood pressure, pulse oxygen saturation and electrocardiogram (ECG) were routinely monitored after inter-room. Anesthetic induction: intravenous injection with sufentanil 0.5 μg/kg, etomidate 0.4 mg/kg, and rocuronium 1 mg/kg. After induction, endotracheal intubation was performed by a senior anesthesiologist. Patients in the NIM group were assigned with the Medtronic Xomed NIM recurrent laryngeal nerve monitor tube (Medtronic Inc, USA) and the Rusch group with a Rusch enhanced endotracheal tube (Teleflex, USA). Cuff pressure gauge (Wyeth, USA) was adopted to inflate cuff till pressure reached 20 mmHg. After confirmation of no air leakage, pressure sensor was connected (SCW Medicath LTD, CHN). Mindray Monitor (Mindray, China) was adopted to monitor tracheal cuff pressure, with unit of mmHg. After oral tracheal intuba-

Table 3. Contrast of cuff pressure of two groups

Groups	Cuff pressure
NIM group	31.1 ± 9.5[a]
Rusch group	23.7 ± 8.5

Notes: Compared with Rusch group, [a]$P < 0.05$.

Table 4. Contrast of VAS scores for sore throat of two groups

Groups	VAS scores
NIM group	4.0 ± 2.0[a]
Rusch group	2.6 ± 1.4

Notes: Compared with Rusch, [a]$P < 0.05$.

tion, mechanical ventilation was given with tidal volume of 6-10 ml/kg, inspiratory/expiratory time ratios (I/E) of 1:2, ventilation frequency of 10-12/min, $PETCO_2$ maintained within 35-45 mmHg, and airway pressure of 9-20 cm H_2O. Anesthesia maintenance: inhalation of 0.8%-2% sevoflurane, intravenous injection of propofol 50-150 $\mu g \cdot kg^{-1} \cdot min^{-1}$ and remifentanil 0.05-0.15 $\mu g \cdot kg\text{-}1 \cdot min^{-1}$, and maintenance of stable arterial pressure and heart rate with fluctuation amplitude of less than 20% of preoperation level.

Postoperative follow-up

Patients were followed up 24 hours after surgery. Visual analogue scale (VAS) was adopted to assess sore throat. The discomfort (not pain) with dry throat as major manifestation was assessed with the following classification standard [5]: A, grade I: normal. The patients felt no difference with the time of pre-intubation, and no symptom of dry throat; B, grade II: mild discomfort. Patients felt difference with the time of pre-intubation, with mild symptom of dry throat, no sensation of fullness and/or constriction and foreign body sensation; C, grade III: moderate discomfort. Patients felt dry throat, with sensation of fullness and/or constriction. Patients felt symptom slight and no foreign body sensation, with occasional but not habitual throat clearing. D, grade IV: severe discomfort. Patients constantly made habitual throat clearing to insure throat comfort, with obvious sensation of fullness and/or constriction. Patients felt reduction of mucous secretion of throat and obvious foreign body sensation.

Statistical analysis

SPSS 21.0 software was used for statistical analyses. Measurement data of normal distribution are presented as mean ± standard deviation. T test was conducted for comparison between groups. Enumeration data are presented with case number or percentage (%). X^2 test was conducted for comparison between groups. Rank-sum test was conducted to compare ranked data. Mix model was selected for comparing difference of cuff pressure between groups. Influence factors of sore throat were analyzed with Pearson test and multiple linear regression; influence factors of dry throat were analyzed with decision tree model. Differences were considered statistically significant when $P < 0.05$.

Result

There is no difference in the gender ratio, age, BMI, duration of anesthesia, peak airway pressure between the two groups ($P > 0.05$, **Table 1**). The inflation volume required to reach certain cuff pressure after trachea intubation was less in the NIM group than that of the Rusch group (**Table 2**). The mean cuff pressure during surgery in the NIM group was higher than that of the Rusch group ($P < 0.05$, **Figure 1** and **Table 3**). VAS score for the post-surgery sore throat in the NIM group was higher ($P < 0.05$, **Table 4**). VAS score of sore throat was associated with mean cuff pressure ($\beta = 0.391$, SE = 0.162, $P < 0.05$; **Table 5**). Non-parametric test for the rate of dry throat of different grades between the NIM group and the Rusch group did not show a significant difference (**Table 6**). The rate of grades I and II dry throat in the Rusch group was larger than that of the NIM group; the rate of grades III and IV dry throat in the NIM group was larger than that of the Rusch group (**Table 6**). Results of single factor analysis for a group of individual influence factors (gender, age, BMI, allocation, mean cuff pressure) demonstrated that there was no significant difference in each factor between subgroups divided by dry throat grade ($P > 0.05$, **Table 7**). Moreover, gender, age, BMI, allocation, and mean cuff pressure did not influence the dry throat severity significantly.

In CART arithmetic, the maximum growth depth was set as 4 level, the minimum node sample size was 20, and the minimum node sample

Table 5. Association between VAS scores for post-surgery sore throat and influence factors

Factors	Standard partial regression coefficient	Standard Error	*t*	*p*
Intercept	0.33 [-0.372,1.032]	0.348	0.949	0.348
Gender/female	-0.276 [-1.02,0.467]	0.368	-0.751	0.457
Age	0.006 [-0.272,0.284]	0.138	0.044	0.965
BMI	0.023 [-0.266,0.312]	0.143	0.159	0.874
Anesthesia duration	0.203 [-0.055,0.461]	0.128	1.591	0.119
Mean cuff pressure	0.391 [0.064,0.718]	0.162	2.416	0.020[a]
RUSCH	-0.295 [-0.916,0.325]	0.308	-0.960	0.342

Notes: [a]$P < 0.05$.

Table 6. Rate of dry throat of different grades in two experimental groups

Groups	Dry throat classification			
	I	II	III	IV
NIM group	6 (22.2%)	3 (11.1%)	6 (22.2%)	12 (44.4%)
Rusch group	8 (34.9%)	8 (34.8%)	3 (13.0%)	4 (17.4%)

size was 7. Cuff pressure was finally obtained. When cuff pressure < 24.06 mmHg, risk of I grade dry throat was the highest; 24.06 ≤ cuff pressure < 28.35 mmHg, risk of III grade dry throat was the highest; when cuff pressure ≥ 28.35 mmHg, the risk of IV grade dry throat was the highest (**Figure 2**).

Discussion

The results of the present study demonstrate obvious differences between the two tubes and the Rusch tube was superior in some aspects. The cuff volumes of the two tubes were different as indicated by different inflation volume. The cuff of the Rusch tube had a larger volume and a lower pressure, which resulted in larger buffering capacity. The cuff wall of the Rusch tube was transparent, thin, soft, and extensible. In comparison, the cuff wall of the NIM tube was thicker and harder. The Rusch tube was superior to NIM tube in respect to the properties above. However, according to the result, small alterations of inflation volume could lead to cuff pressure rising out of normal range for both tubes, therefore we recommend a cuff gauge should be routinely adopted to inflate the cuff [6], although it is not widely popular due to expense involved.

Cuff pressure is such an important factor in thyroid surgery that we recommended a routine monitor on cuff pressure be applied. Tracheal tube cuff pressure of more than 30 mmHg may lead to compression of tracheal wall, and further to ischemia, necrosis, and abscission of local tracheal mucous. In severe cases, a local ulcer may occur and a circular scar may develop after healing, which may lead to tracheal stenosis [7, 8]. The thyroid is close to the trachea. Adopted surgery position required the patient's neck to hyperextend, which will lead to stretching of the trachea and increase the stretching force of the tracheal wall, thereby the traction of surgery physicians will influence the cuff pressure significantly (high as more than 80 mmHg as indicated in results). This problem could be easily neglected without continuous monitoring of cuff pressure. Therefore, application of continuous cuff pressure monitor is very important in thyroid surgery. Furthermore, adopting continuous cuff pressure monitor can not only avoid severe post-surgery complication resulting from tracheal intubation, such as tracheal mucosal damage [9] and constriction [10], but can also improve comfort and refinement of the anesthesia target [11]. Therefore, it shall be listed as routine monitoring. From an economic consideration, it is affordable as no extra expense is needed.

Consistent with results of previous other studies [6, 12], we have also found an association between cuff pressure and post-surgery sore throat. The results in the present study that the mean cuff pressure and VAS scores for post-surgery sore throat in the NIM group were higher than those of the Rusch group further support this conclusion.

The non-parametric test for rate of dry throat of different grades between the two groups, and the single factor analysis for influence factors did not show a significant difference. However, the negative result may due to a relatively small sample size. The occurrence distribution classified by dry throat grade demonstrated that the occurrence rate of grade I and II dry

Table 7. Single factor analysis of influence factors between subgroups divided by dry throat grades

Dry throat grades	I (N = 14)	II (N = 11)	III (N = 9)	IV (N = 16)	*p*
Gendre					0.092
Male	5 (35.714%)	0 (0.000%)	1 (11.111%)	2 (12.500%)	
Female	9 (64.286%)	11 (100.000%)	8 (88.889%)	14 (87.500%)	
Age	46.571 ± 11.175	46.364 ± 13.589	43.667 ± 12.865	48.125 ± 12.468	0.863
BMI	23.244 ± 2.361	22.905 ± 3.862	22.790 ± 2.720	22.554 ± 2.735	0.935
Anaesthesia duration	120.571 ± 27.160	147.364 ± 36.451	134.778 ± 31.511	135.438 ± 29.696	0.208
Group					0.063
NIM	6 (42.857%)	3 (27.273%)	6 (66.667%)	12 (75.000%)	
RUSCH	8 (57.143%)	8 (72.727%)	3 (33.333%)	4 (25.000%)	
Mean cuff pressure	24.877 ± 6.395	25.544 ± 7.322	29.692 ± 5.282	30.503 ± 5.690	0.054

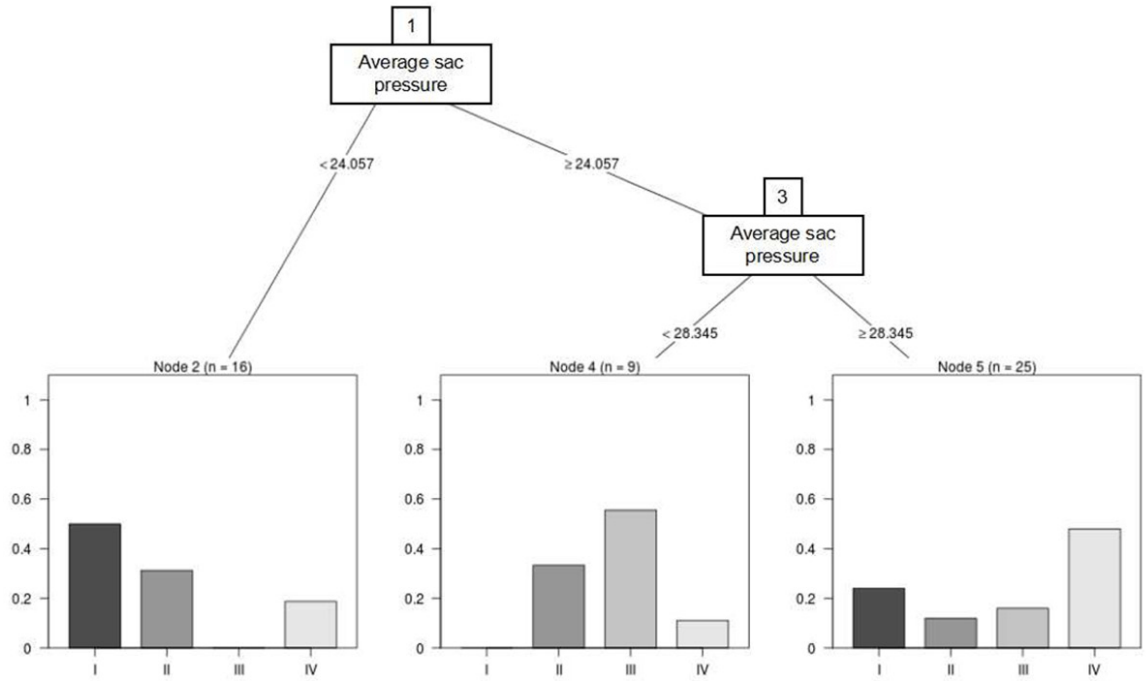

Figure 2. Decision tree model of dry throat classification.

throat in the NIM group was lower than that of the Rusch group, but the rate of grade III and IV dry throat of the NIM group was higher. It may be attributed to a different mean cuff pressure of the two groups. The decision tree model analysis result demonstrated that the risk of grade I dry throat was the largest with a cuff pressure < 24.06 mmHg, the risk of grade III dry throat was the largest with 24.06 ≤ cuff pressure < 28.35 mmHg, and the risk of grade IV dry throat was the largest when cuff pressure ≥ 28.35 mmHg. These findings suggest that a higher cuff pressure is associated with more severe dry throat. However, further and larger studies are needed to make a conclusion.

In conclusion, sore throat and dry throat are common complications among patients after thyroid surgery, which are mainly attributed to the special surgery site. Cuff pressure was associated with sore throat, but might not be associated with dry throat. We recommended to adopt continuous cuff presssure monitoring to scientifically establish and maintain the cuff pressure during thyroid surgery. This will lead to improved anesthesia quality and benefit to patients.

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