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Changes in Endotracheal Tube Cuff Pressures and Incidence of Post-operative Sore Throat While using different Inflating Agents

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Abstract:

Background & Aims: *Post-operative sore throat is one of the minor complications after general anaesthesia with endo tracheal intubation. Although short lasting and self-limiting, it creates an uncomfortable situation for patient. Diffusion of Nitrous Oxide (N_20) into endotracheal tube (ETT) cuffs and increase intra cuff pressure causes this. Different inflating agents have been studied to see the incidence of intra cuff pressure changes. This study was performed to see the post extubation tracheal mucosal changes and post-operative sore throat after using N_20 in Oxygen as ETT cuff with direct visualization of the tracheal mucosa just after tracheal extubation.*

Methods: *Institutional ethical committee approval and informed written consent were obtained, 50 patients, undergoing elective surgery under general anaesthesia, were enrolled. Patients were randomly allocated in two groups of 25. In Group A, the ETT cuff was inflated with air, in Group B, cuff was inflated with 67% N, 0 in oxygen. The cuff pressure was kept around 30 cm H, 0 and was measured every 10 minutes. The condition of the trachea was seen using fibreoptic bronchoscope and a grading was done. All the data was collected & statistical analysis performed.*

Results: *The frequencies of pain, difficulty in swallowing, and hoarseness of voice at the recovery room within the first two hours after anaesthesia were lowest in Group B than Group A and significantly reduced within 24 hours. Perioperatively cuff pressure change in group A was significantly high and in group B it was minimum. Bronchoscopic view of larynx and trachea showed 64 % normal. 22% was erythematous, 10% was oedematous in group B. In group A it was 28%, 46% and 24%.*

Conclusions: *It is evident, that N, 0 in 0, filled ETT cuff reduces the incidence of postoperative sore throat. It is proposed that the difference was produced due to no or minimum diffusion of N, 0 in N, 0 with 0, filled ETT cuff, subsequently no significant intra cuff pressure changes per operatively.*

Keywords: *ETT; cuff pressure, Inflating agents; N_2O, Bronchoscope, Larynx and trachea*

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Introduction:

ETT, commonly used during general anaesthesia to deliver anaesthetic gas and oxygen to the lungs and acts as a conduit for volatile anesthetic agents. Cuff system of ETT ensure proper seal between tracheal wall and tube to prevent aspiration of particles. Keeping the cuff inflated for long time can result in ischemia of tracheal mucosa and further complications such as postoperative sore throat[1], hoarseness of voice, tracheal ulceration, stenosis, trachea oesophageal fistula etc[2]. N20, an anaesthetic gas commonly used in conjunction with oxygen and other volatile anaesthetic agents is known to diffuse into air filled cavities including ETT cuffs leading to an increase in cuff pressure [3][6], which is transmitted to the tracheal mucosa and can cause serious sequelae. A study of blood flow in rabbit tracheal mucosa demonstrated that when a high-pressure low volume cuff pressure was inflated to >30 mm Hg, the mucosa in contact with the cuff, i.e., that covering the tracheal cartilage, become ischemic [4]. When a thin walled, low-pressure high-volume cuff was used, blood flow did not cease until intracuff pressures were in the range 80-120 mm Hg. This was thought to be due to a more even distribution

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of pressure over the mucosa covering the cartilages at pressures >30 mm of Hg. Even so, the cautious recommendation was made that intracuff pressure should be maintained at < 20 mm of Hg (26 cm of water) [4]. Several studies reported different concentration of N, 0 in the ETT cuff to provide stable cuff pressure during general anaesthesia with N, 0 [5]. This diffusion is maximum during the 1st hour of N_20 anaesthesia.

To control changes in intracuff pressure various methods have been used including automated devices [6] to prevent gas diffusion into the cuff, and cuff made of new materials with high gas barrier properties have been developed, which are effective but expensive.

The present study was performed to see the effect of increased cuff pressure on postoperative sore throat and extent of tracheal mucosal injury. The method used in the study, moreover, require no extra cost because 67% N_20 is available from a common gas outlet of every anaesthetic machineMaterials and Methods:

After getting institutional ethical committee approval and obtaining informed written consent, 50 patients, undergoing elective surgery under general anaesthesia, were enrolled. This Quasi-experimental study was carried out from January 2019 to June 2019 in the department of Anaesthesia & Pain Medicine of our hospital, which is a tertiary care, corporate run centre of excellence in Bangladesh.

The inclusion criteria included adult patients of either gender ageing 30-60 years, ASA Physical status I-II, scheduled to undergo elective surgery, under general anaesthesia with endotracheal intubation and controlled ventilation, and scheduled for surgery of more than one hour. Patients with history of hyperactive airway disease, rapid sequence intubation, difficult intubation- two or more attempts, habitual smokers and tobacco chewers and patient undergoing surgery in any position other than supine were excluded. Randomization was done using card sampling. Total of 50 cards, 25 for each group was prepared. Every patient included in the study, was allowed to choose a card. According to card number, patients were grouped in Group A (n=25), the ETT cuff was inflated with air, in Group B (n=25), the ETT cuff was inflated with gas mixture (67% N, 0 in Oxygen), taken from the common gas outlet of the anaesthetic machine.

In all cases fresh, sterile, latex free, polyvinyl chloride ETT (Curity^{TM} by Covidien^{TM}) with high volume-low pressure cuff was used. Fixed ETT size 7.5 mm in woman, 8.0 mm in men was used in every patient.

All patients underwent a prescribed anaesthetic protocol. After proper pre-oxygenation, induction was accomplished with Propofol (2-3 mg/kg), Fentanyl (1-1.5 µg/kg), Midazolam (0.04 - 0.06 mg/kg) and muscle relaxation was accomplished with rocuronium (0.6 - 0.8 mg/kg).

In Group A, the cuff was inflated with minimum amount of air by performing leak test. In Group B, the cuff was inflated with minimum amount of inhaled gas mixture composed of 67% N, 0 in Oxygen by performing leak test. For both groups, cuff was connected to manometer (Endotest CE 0124) and initial inflating pressure was maintained at < 30 cmH, 0 and every 10 minutes interval, cuff pressure was recorded without further manipulation throughout the anaesthetic procedure. Ventilation was controlled and adapted to maintain end tidal CO, at approximately 32 - 35 mmHg.

Anaesthesia was maintained with sevoflurane (1% -2% end tidal), 67 % N, 0 in oxygen, Fentanyl 0.2 - 0.5µg/kg every 30 minutes, and muscle relaxation was maintained with rocuronium 0.2µg/kg body weight. Mean arterial blood pressure (MAP) was maintained between 65 – 90 mmHg in all the patients. All patients were given Inj. Ketorolac 30 mg IV 10 minutes before tracheal extubation, and patients breathed 100% oxygen for 5 min.

Flexible fibre-optic bronchoscope (Olympus – 5 mm scope) was introduced through the tube to observe the tracheal and laryngeal condition just before extubation, then the ETT was withdrawn keeping the bronchoscope in place and after observing the tracheal wall, the bronchoscope was also withdrawn.

Postoperatively both group of patients were directly asked about presence of sore throat, cough, difficulty swallowing and change in voice. Verbal rating scale was used in both groups to assess presence and severity of sore throat in two intervals, 2 hours postoperatively and 24 hours postoperatively. All data were collected and compiled for statistical analysis. Analysis of Variance (ANOVA), students t test was performed for statistical significance. P <0.05 was considered significant.

Results:

The patient's demography showed a similar distribution. There was no difference in age & sex in between the groups (Table 1).

Preinduction and intraoperative mean arterial blood pressure is summarised in table 2. There was no significant difference between groups.

The frequencies of pain, voice changes at recovery room (after 2 hours) were lowest in the N_2O group (Group B) to air group (group A). (Table 3)

Pain, difficulty in swallowing, and hoarseness of voice were significantly absent after 24 hours in the N_2O group. 70% in the N_2O group did not complain of any pain during the entire period in comparison to 30% in air group. In the N_2O group, after 2 hours, 16% complained mild degrees of pain, and 14% complained moderate degree of pain and after 24 hours 08% complained mild degree of pain (Table 3).

In the air group, 2 hours post operatively, 10% complained moderate degree of pain. After 24 hours, the pain persisted as mild form in 32% cases and moderate form in 8% cases. Regarding dysphagia (difficult to swallow) in group B 16% complained dysphagia after 2 hours in comparison to 40% in air group. After 24 hours, it completely resolved in the N_2O group in comparison to 14% persisting in air group. 24% patients in N_20 group complained hoarseness after 2 hours in comparison to 42% in air group. After 24 hours, it was 4% in the N_2O group in comparison to 22% persisting in air group (Table 4).

Table-I

Patient Characteristics

Characteristics	Group A n =50	Group B n =50	Statistical Significance
Age; Years (Mean± SD)	40 6.7	43.88 ±6.5	NS
Sex; M: F	22: 28	21: 29	NS
Body weight; kg (Mean ± SD)	69 15.9	70 ±18.7	NS
ASA; I: II	40:10	39: 11	NS

NS: not significant P>0.05 (among two groups) for age and body weight; analysis done in ANOVA.NS: not significant P>0.05 (among two groups) for sex and ASA; analysis done by chi- squared test.

Table-II

Intraoperative mean aretrial pressure

	Before induction	5 minutes after intubation	30 minutes after intubation	1 hour after intubation	P value
Group A	83 (± 6.4)	67 (±1.2)	71 (±1.5)	73 (±1.8)	< 0.05
Group B	86 (± 2.8)	66 (±1.1)	73 (±2.1)	72 (± 2.2)	

Table-III

Evaluation of severity of pain in two groups at different time interval

Patient group	No pain	Mild Pain	Moderate Pain
Group A (n=50)At 2hours	15 (30%)	5 (10%)	30 (60%)
Group B (n=50)At 2 hours	35 (70%)	08 (16%)	07 (14%)
Group A (n=50)At 24 hours	30(60%)	16(32%)	04(08%)
Group B (n=50)At 24 hours	46(92%)	04(08%)	00(00%)

Data are in numbers with percentages in parenthesis

Cuff pressure measurements intraoperatively showed pressure changes were significantly high in group A than group B. In group A it changed from 27.7cmH, O to 113.6 cmH, 0 by 2 hours whereas in group B it changed from 28.3 to 37.8 in 2 hours (Table 5, Figure 1).

In the bronchoscopic view of larynx and trachea shows, in N_2O group 64% normal, 22% erythematous, 10% was oedematous. In the air group it was 28% normal, 46% erythematous, 24% oedematous and evidence of trauma in 2%. (Fig. 2, 3 4)

Table-IV

Comparison of Dysphagia and Hoarseness in two groups

	Group A	Group B	P
Dysphagia after 2 hours	20 (40%)	08 (16%)	0.005*
Dysphagia after 24 hours	07 (14%)	00 (00%)	0.000**
Hoarseness after 2 hours	21 (42%)	12 (24%)	0.003
Hoarseness after 24 hours	11 (22%)	02 (04%)	0.000

Data are in numbers with percentage in parenthesis.*Significant P <0.05 (among two groups): analysis done by chi-squared test**Not significant P>0.05 (among two groups)

Table-V

Comparison of cuff pressure changes in two groups

Time 10 minutes	Average Cuff Pressure (cm of water)		
Interval	Group A (n=50)	Group B (n=50)	P
Initial 0 min	27.7	28.3	0.000
10^{th} min	38.4	29.4	0.000
20^{th} min	46.9	29.4	0.000
30^{th} min	52.6	29.9	0.000
40^{th} min	64.8	30.1	0.000
50^{th} min	75.4	30.7	0.000
60^{th} min	80.6	31.3	0.000
70^{th} min	89.9	31.9	0.000
80^{th} min	98.5	32.6	0.000
90^{th} min	98.5	33.8	0.000
100^{th} min	106.3	34.6	0.000
110^{th} min	109.8	36.7	0.000
120^{th} min	113.6	37.8	0.000

Data are in numbers with percentages in parenthesis.*Not significant P >0.05 (among two groups); analysis done by chi-squared test

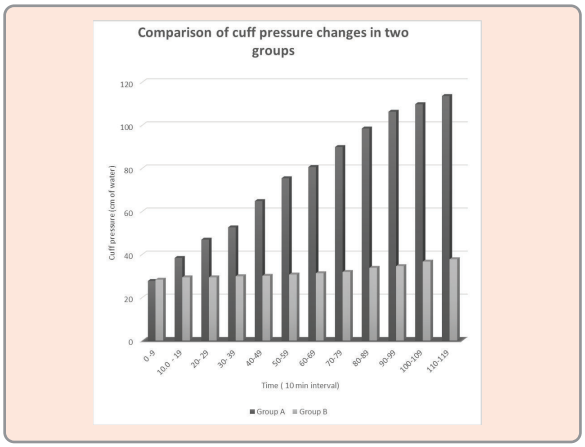

Fig.-1: *Comparison of cuff pressure changes in two groups*

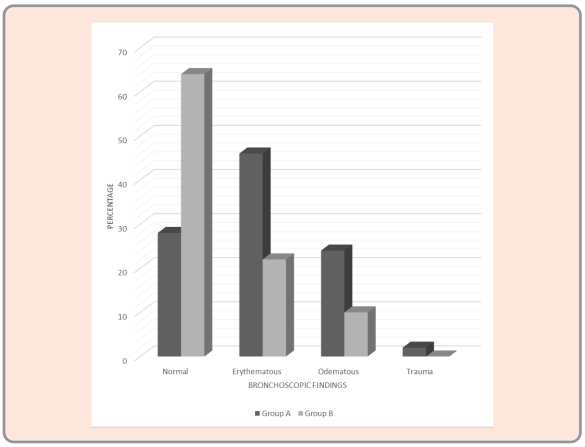

Fig.-2: *Comparison of Bronchoscopic View of Larynx and Trachea (During Extubation) In two groups*

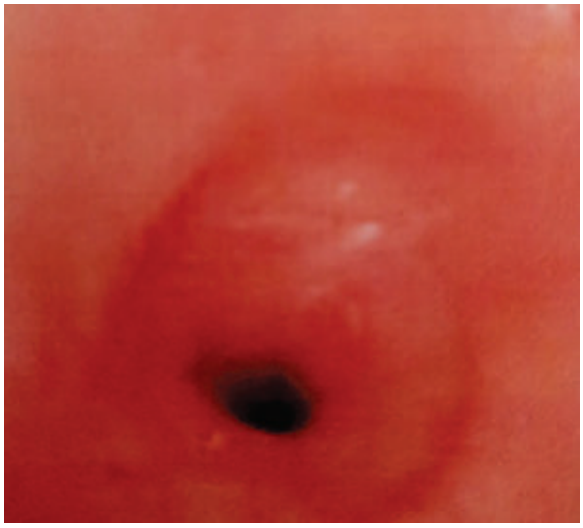

Fig.-3: *Bronchoscopic view of non erythemous trachea.*

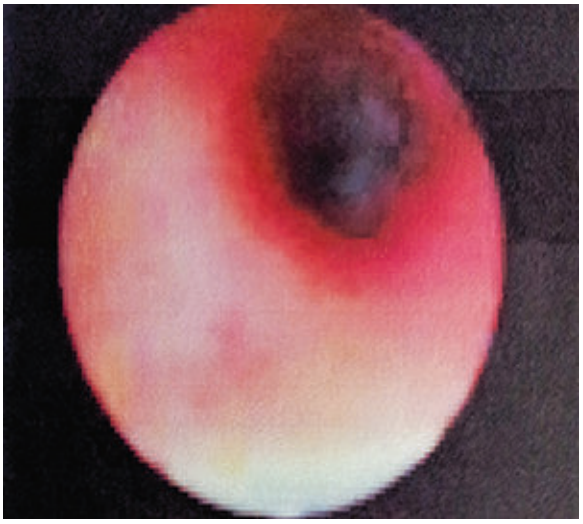

Fig.-4: *Bronchoscopic view of post extubation trachea (Erythematous) view of post extubation trachea (Erythematous)*

Discussion:

To determine whether using N_2O in O_2 instead of air to inflate the ETT cuff decreases postoperative sore throat and at the same time to see its effects on laryngotracheal mucosa, some variables typically associated with postoperative sore throat, including intubation technique, laryngoscope blade, airway placement, suctioning technique, and anaesthetic technique, were kept constant. A fresh high-volume low pressure ETT, choosing 7.5 mm for women and 8.0 mm for men thus standardizing the type and size of the tube. Patients having a history of sore throat in the last 6 months, smokers, tobacco chewers and patients with nasogastric tube in situ were excluded from the study. In intraoperative period, mean arterial pressure was kept between 65 – 90 mmHg to prevent increase in hydrostatic pressure causing cellular oedema in larynx and trachea.

In our study it was found that the incident and severity of posts operative sore throat, hoarseness and dysphagia were considerably less in the group B compared to group A. The incidence of pain was only 30% in group B compared to 70% in group A. Regarding

severity, only 16% complained of mild pain after 2 hours and 8% after 24 hours in group B compared to 60% moderate pain in 2 hours,10% mild pain after 2 hour and 8% moderate pain and 32% mild pain in 24 hours in group A.

The incidence of pain was less in group B may be due to minimal diffusion of N_20 through semipermeable membrane of ETT cuff which was manufactured by polyvinylchloride and the cuff was filled with mixed anaesthetic gas numerical (67% N_20 in oxygen) by which gaseous anaesthesia was maintained for both groups of patients.

Loessar [7]et al in 1976 compared the incident and severity is off post-operative so throat inpatients intubated with low pressure and high-pressure cuffed ETTs. They were not entirely clear why ETT cuffs that have large cuff and tracheal surfaces contact areas produced sorer throat despite lower pressure than tubes with smaller cuff tracheal surface contact areas.

Seejobin and Van Hasselt[8] in 1984 found that large volume, low-pressure ETT cuffs when over pressurised impaired mucosal blood flow. This is an important factor in tracheal morbidity associated with intubation. They also found that some damage to tracheal mucosa due to their contact between cuff material and tracheal wall is inevitable. Over expansion of cuff does not occur only during inflation but also when N_2O diffused into air-filled cuff. An air-filled ETT cuff within the trachea represents a gas filled pocket in the body. So intracuff pressure increases due to diffusion of N_20 into the air-filled cuff.

Stanley[9] et al in 1974 found that air filled cuff exposer to N_2O increased cuff gas volume and pressure in a concentration and time-dependent fashion. Their conclusion was that N2O appeared to be better cuff inflating agent than room air if room air was used, it would be important to deflate cuffs periodically.

Stanley[10] in 1975 conducted a study and observed that all ETT had significant increase in cuff volume and pressure after exposure to N_2O. This cuff over expansion during anaesthesia maybe significant cause of tracheal or laryngeal trauma and possibly also post-operative sore throat in intubated patients. They also suggested that N_2O or a sample of the inspired gas mixture may be a better inflating agent then room air.[10]

24% in the N_2O Group complained hoarseness after 2 hours in comparison to 42% in air group. After 24 hours it was 4% in the N_2O group in comparison to 22% in the air group.

Regarding this dysphagia,16% in the N_2O group complained of dysphagia after two hours in comparison to 40% in air group. After 24 hours it completely resolved in the N20 group in comparison to 14% persisting in air group.

Hoarseness and dysphagia were more common in group A because N_2O diffusers into the air-filled cuff and increase cuff pressure. Subsequently tracheal mucosa was over stretched for prolonged period, and it became oedematous which was proved by bronchoscopic view of that area during extubation. (Table 3)

On the other hand, hoarseness and dysphagia was less, in group B because no significant cuff pressure changes per operatively which was measured continuously by connecting the pilot balloon to a cuff manometer.

Our study also showed that in bronchoscopic view of sub glottis area, larynx, and trachea just before extubation, in N_20 group: 64% normal, 22% was erythematous ,10% was oedematous and evidence of trauma was 4% and in that air group it was 28% normal ,46% erythematous, 24% oedematous and evidence of trauma was 2%. (Figure 2)

For this valuable bronchoscopic findings only the responsible factor is diffusion of N_2O into air filled cuff subsequently increases the cuff pressure against the tracheal wall, tracheal mucosa become compromised. On the other hand, in group B tracheal mucosa was relatedly healthy in relation with their favourable cuff pressure entire during the operating period which was measured continuously by cuff manometer. (Figure 1)

For the time being symptoms was less persistence in group B in comparison to group A. On first post-operative day sore throat was completely resolved in group B, but in group A, in a significant number of cases symptoms were persistent in first postoperative day for a due to their tracheal mucosal injury which was documented and proved by bronchoscopy.

In group B, we also found that there was less incidence of nausea, vomiting, coughing and dysphonia after extubation, probably this is due to minimum irritation to tracheal mucosa by favourable cuff pressure in group B

versus more irritation to tracheal mucosa by high cuff pressure gained per operatively in group A.

Statistical analyses were done by Chi-squared test. Analysis was done between the two groups by ANOVA and to between each group by students unpaired t test.

Patel et el[11] in 1983 suggested an alternative inflating agent. They found that the pressure in the cuff inflated with the room there increase as more rapidly and to a higher level then pressure in the cuffs inflated with saline.

To evaluate sore throat incidents and severity, directed questions where are used, where did the answer was limited to a few possibilities. This technique has been shown to give more reliable information. A verbal rating scale on a scale of 0 to 3 graded sore throat severity.

Finally, it is evident that N_2O in O2 filled ETT cuff reduces the incidence of post-operative sore throat. It is proposed that the difference was produced due to no diffusion of N_2O in N_2O with O_2 filled ETT cuff, subsequently no significant Intracuff pressure changes per operatively.

Conclusion:

Postoperative sore throat may be one of the minor complications after general anaesthesia, but it can create an uncomfortable situation for both the patient and the anaesthesiologist. In most cases, post-operative throat complaints are short lasting and resolve spontaneously without specific treatment. In moderate to severe cases, it may be beneficial by gargling with benzylamine hydrochloride. Its prevention to some extent is possible by taking some precautions. Although many methods have been advocated in prevention of these complications, none has been completely successful. Even so, our study shows that using intra cuff N, O in O, to some extent can be effective in controlling these complications. Finally, it was evident that 67% N, O in O, filled ETT cuff reduces the incidence of postoperative sore throat.

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