

Original Research Article

Comparison of the endotracheal cuff inflation techniques and its postoperative laryngotracheal morbidity: an observational study

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ABSTRACT

Background: Endotracheal tubes cuffs are used to prevent gas leak and also pulmonary aspiration in mechanically ventilated patients. The commonly employed intubation techniques are the use of inflation to a constant pressure (25 cm H₂O), sealing pressure and estimation of the cuff pressure by finger palpation. However, the use of the cuff inflation volumes may cause tracheal morbidity. The aim of the present study was to compare the effective tracheal seal and the incidence of post-intubation airway complications between the three techniques.

Methods: 90 patients under N₂O free general endotracheal anaesthesia were included in the study. They were randomly allotted into three groups consisting of 30 in each. After induction of anaesthesia, endotracheal tubes size 7.0 mm for female and 8.5 mm for male were used. Constant pressure group (n=30), the cuff was inflated to a pressure of 25 cm H₂O; sealing group (n=30), the cuff was inflated to prevent air leaks at airway pressure of 20 cm H₂O and finger group (n=30), the cuff was inflated using finger estimation. Manometric cuff pressure and volume of air required to inflate the cuff, incidence of sore throat, hoarseness and dysphagia were tested.

Results: Significant differences was not observed between the three groups in case of demographic data, ASA grading, endotracheal tube size used, number of attempts to place the endotracheal tubes, duration of intubation between the three groups. On the other hand, the cuff pressure, volume of air to fill the cuff and the incidence of sore throat was significantly higher in the finger group compared to other two groups ($p \leq 0.05$). The incidence of dysphagia and hoarseness was also higher in finger palpation group but the difference is insignificant.

Conclusions: In cases of N₂O free anaesthesia, sealing cuff pressure is an easy and safe alternative technique compared to other two techniques, regarding effectiveness and low incidence of tracheal morbidities.

Keywords: Anaesthesia, Endotracheal cuff inflation techniques, Laryngotracheal morbidity

INTRODUCTION

Endotracheal cuffed tubes were used during anaesthesia to prevent gas leakage and pulmonary aspiration in patients. Excessive cuff pressure decreases tracheal capillary perfusion, and insufficient cuff pressure leads to pulmonary aspiration of oropharyngeal content.¹⁻⁴

The main indication reported after extubation was sore throat, but some also report dysphagia and hoarseness. Although the exact pathophysiology of post-intubation

airway symptoms is not fully known, mucosal damage occurring at the cuff level is believed to be an important contributing factor for tracheal indisposition.^{5,6}

The three common methods of endotracheal tube cuff inflation employed in clinical setting are the use of inflation to a precise pressure (25 cm H₂O), sealing pressure and estimation of the cuff pressure by finger palpation. However, none of them are conclusive and an intraoperative cuff pressure monitoring with manometer is recommended.

The study was conducted with the objectives to record the manometric cuff pressure and volume of air required to inflate the cuff by the three inflation methods and to assess the degree or severity of postoperative sore throat, dysphagia and hoarseness following the three endotracheal intubation methods.

METHODS

A prospective, observational open labelled study was designed and conducted with the patients admitted in Department of Anaesthesiology, Topiwala National Medical College and Hospital between the years 2013–2014. After getting approval from institutional and ethics committee and written informed consent, 90 patients were selected to undergo unilateral tympanoplasty under N₂O free general endotracheal anaesthesia with an expected surgical duration of not >150 min and ASA I & II physical status were included in this study. Patients undergoing head and neck surgery, patients with tracheotomy, laryngeal disease or laryngeal surgery, or in whom intubation will be difficult (two or more trials), or those requiring placement of a nasogastric tube were excluded from the study.

A standard protocol was followed for all the patients. Each patient was visited a day prior to surgery in the wards. A detailed history and examination was taken. Blood investigations were carried out as per the requirement of the surgery. On arrival to the operating room, standard monitors i.e. electrocardiogram, pulse oxymeter, noninvasive blood pressure monitor, capnometer were attached and baseline vital parameters were noted.

Anaesthesia technique

All patients were premedicated with 0.03 mg/kg intravenous midazolam hydrochloride and intravenous fentanyl 2 µg/kg. After preoxygenation for 3 min, anaesthesia was induced with Intravenous thiopentone sodium 5 mg/kg or intravenous propofol 2 mg/kg as per the discretion of the anaesthesiologist conducting the case.

All cases were induced by a senior anaesthesiologist. Only after confirming that the patient can be mask ventilated, neuromuscular blockade was achieved with Intravenous vecuronium bromide 0.08 mg/kg or atracurium besylate 0.5 mg/kg. Tracheal intubation was performed after 3 minutes of intravenous neuromuscular blocking agent and clinical assessment of N-M blockade i.e. adequate jaw relaxation.

Endotracheal tubes (ETT) with high residual volume, low-pressure cuff, with an inner diameter of 7.0 mm for female and 8.5 mm for male was used as per the standard protocol by the senior anaesthesiologist in our study. Patients were divided into three groups randomly consisting 30 in each group. In the constant pressure

group (Group C, n=30), ETT cuff was aspirated as much as possible and then inflated with air to achieve a cuff pressure of 25 cm H₂O on aneroid manometer (Portex). In the sealing pressure group (Group S, n=30), ETT cuff was aspirated as much as possible and then inflated with air to prevent air leaks during the inspiratory phase of mechanical ventilation of the patient when peak airway pressure of 20 cm H₂O was achieved, checking for disparity between set and delivered tidal volume using Penlon AV-S ventilator. In the finger palpation group (Group F, n=30), ETT cuff was aspirated as much as possible and then inflated to a suitable pressure by palpation of the external balloon by experienced senior anaesthesiologist conducting the case.

The volume used to fill the cuff and the cuff pressure was recorded in each patient using hand-held, Portex aneroid manometer (CE0473, for low pressure cuffs, Germany) by the senior anaesthesiologist conducting the case. Mechanical ventilation was controlled using Penlon AV-S ventilator and adapted to maintain end-tidal carbon dioxide at 30–35 mmHg and optimal saturation of >95%. Anaesthesia was maintained either by using inhalational agent or intravenous propofol as per the discretion of the conducting anaesthesiologist. N₂O was avoided. Oxygen : air (50:50) were used. Neuromuscular blockade was maintained with supplemental dosages of vecuronium (0.02 mg/kg) given at regular intervals. Fentanyl 1 mcg/kg was repeated every hour.

At the end of surgery, patient was allowed to awaken and neuromuscular block was reversed with neostigmine 0.05 mg/kg and glycopyrrolate 8 µg/kg and the pharynx was gently suctioned. Before tracheal extubation, patients were given 100% oxygen for 5 min and the ETT was removed as soon as all of the following criteria were met:

- Full reversal of neuromuscular block, spontaneous breathing for 5 mins
- Ability to follow verbal commands (hand grip or eye opening)
- Demonstration of purposeful movement (attempting self-extubation).

The duration of surgery and intubation were recorded. Intravenous paracetamol was used for postoperative analgesia. At the time of discharge from the post-anaesthesia care unit (PACU) and 24 h after tracheal extubation, patients were asked about the three laryngotracheal complaints: Sore throat, hoarseness and dysphagia by the anaesthesiologist conducting the study and were assessed for the degree of the complaint as mild, moderate, severe.

Statistical analysis

Qualitative data was represented in form of frequency and percentage. Association between qualitative variables was assessed by Chi-Square test with Continuity Correction for all 2×2 tables and Fisher's exact test for all

2×2 tables where p-value of Chi-Square test was not valid due to small counts. Adjacent row data of more than 2×2 tables was pooled and Chi-Square test reapplied in case more than 20.0% cells having expected count less than 5.

Quantitative data was represented using mean, SD and Median & IQR (Interquartile range). Analysis of Quantitative data between the two groups was done using unpaired t-test if data passes 'Normality test' and by Mann-Whitney Test if data fails 'Normality test'. Analysis of Quantitative data between a qualitative variable with more two subgroups was done using One-way ANOVA if data passes 'Normality test' and by Kruskal-Wallis test if data fails 'Normality test', with

application of appropriate Post Hoc test if P-value of ANOVA comes statistically significant.

RESULTS

There was no significant difference in the demographic data, ASA grading, endotracheal tube size used, number of attempts to place the endotracheal tubes, duration of intubation between the three groups as shown in Table 1. The cuff pressure and volume of air to fill the cuff was significantly lower in sealing group compared with other two groups ($p \leq 0.05$), however the values are significantly higher in finger group compared to other two groups ($p \leq 0.05$).

Table 1: Patient's demographic and operative data values are mean (SD) or number (proportion).

Variables	Constant pressure group (n=30)	Sealing pressure group (n=30)	Finger palpation group (n=30)	P value
Age (in years)	31.90±13.26	33.90 ±15.35	29.50±11.99±	0.408
Weight (in Kg)	58.03±8.60	56.13±9.28	55.80±9.17	0.588
Gender (M/F)	23/7	16/14	15/15	0.071
ASA grade (I/II)	22/8	24/6	24/6	0.773
ETT no. (internal diameter in mm)	8.15±0.65	7.80±0.76	7.75±0.76	0.074
No. of attempts at intubation	1.07±0.25	1.10±0.31	1.17±0.38	0.459
Total time of tube in situ (in minutes)	119.67±30.03	115.67±20.79	113.17±31.45	0.367
Pressure at manometer (cm H ₂ O)	25.00 ±0.00	39.97± 4.33	22.83 ±2.05	0.05
Volume of air (in ml)	4.19±0.36	5.23±0.57	3.98±0.34	0.05

Table 2: Comparison of laryngotracheal morbidity in the three groups.

Dependant variables	Time		Group C	Group F	Group S	P value
Dysphagia	Extubation	Moderate	1	3	2	0.4
		Mild	14	19	15	
	3 hours	Moderate	0	2	0	0.245
		Mild	1	3	3	
	24 hours	Moderate	0	0	0	0.129
		Mild	0	2	0	
Sore throat	Extubation	Moderate	1	16	0	0.0005
		Mild	18	14	14	
	3 hours	Moderate	0	1	0	0.00005
		Mild	1	21	0	
	24 hours	Moderate	0	0	0	0.002
		Mild	0	6	0	
Hoarseness	Extubation	Moderate	1	1	1	0.54
		Mild	21	24	18	
	3 hours	Moderate	0	0	0	0.585
		Mild	1	3	2	
	24 hours	Moderate	0	0	0	
		Mild	0	0	0	

Table 2 explains the laryngotracheal morbidity in the three groups after extubation postoperatively, at 3 and 24 hours. The incidences of dysphagia, sore throat and hoarseness was higher in finger group compared to constant pressure and sealing group after extubation and even after 24 hours. Their severities at different time intervals were comparable in all the three groups.

DISCUSSION

The cuff of an endotracheal tube is used to prevent gas leak and pulmonary aspiration in intubated patients.⁷ Despite the use of high-volume, low-pressure cuffs, certain patients remain at risk for cuff-induced laryngotracheal morbidity, even with short-duration anaesthesia. This has produced a growing interest in monitoring endotracheal tube cuff pressure intraoperatively and studying laryngotracheal morbidity as related to endotracheal cuff overinflation.

Although palpation of the ET tube pilot balloon is a common practice, several studies have demonstrated the inability of intensive care physicians, anaesthetists, prehospital emergency physicians and critical care nursing staff to accurately determine ET tube cuff pressure by palpation alone.⁸⁻¹¹ So measuring pressure in the ET tube cuff with a small aneroid cuff pressure manometer has been tried and advocated in our institute.

The three common methods of endotracheal tube cuff inflation used in our clinical setting are the use of sealing pressure, inflation to a precise pressure (25 cm H₂O), or estimation of the cuff pressure by finger palpation of the pilot balloon. However, there is not enough supportive data as to which of technique is superior.

In our study, there is no significant difference observed in the demographic data between the three groups. This was similar with the previous studies done by Al-metwalli et al.¹²

In this study, we used ETT with internal diameter of size 7 in females and size 8.5 in males. Stout et al demonstrated that the incidence of laryngotracheal morbidity is lower when ETT size 7.5 is used for males and 6.5 is used for females.¹³

It was also observed that there is no significant variation between the three groups in terms of number of attempts at intubation and total time of ETT intubation. This comparison was similar with the results obtained by Al-metwalli et al.¹²

In our study, the difference in manometric pressure measured at the endotracheal tube cuff was statistically significant in all the three groups. The lowest pressure was recorded in the sealing pressure group and this was statistically lower than the other 2 groups. This could be explained by the high compliance of the high-volume, low-pressure cuff which allow the pressure to increase

slowly between the pressures of 10 and 20 cm H₂O, after which the addition of small volumes increases the cuff pressure significantly.¹⁴ The highest cuff pressure was recorded in finger palpation group and found to be significant when each group was compared to the other. This was similar with the observations made by Al-metwalli et al.¹²

It was noted that the difference in volume of air used to inflate the endotracheal tube cuff in finger group was statistically higher than the other two groups. The lowest volume of air required was recorded in the sealing pressure group. This was compared with the findings of Hoffman et al. In his study, he showed the correlation of volume and pressure of 97%, showing nearly perfect relationship. However, the volume necessary to achieve a cuff pressure of 20 to 30 cm H₂O varies considerably between patients, regardless of tube size and patient morphometric characteristics. Measuring cuff pressures therefore is still necessary.¹⁵

Many studies had evaluated the relationship between ETT cuff pressure and the occurrence of laryngotracheal complaints with contradictory results.¹⁶⁻¹⁸ In the current study, the main symptom reported after tracheal intubation is sore throat, but patients also report hoarseness and dysphagia. This finding have been supported by other investigators, who claimed the high tracheal cuff pressure as an important factor in the development of tracheal mucosal ulcerations whose severity was correlated to postoperative sore throat incidence. While other postoperative symptoms, principally hoarseness and dysphagia, were related to tracheal intubation and airway management, explaining their similar incidence in all groups.¹⁹

CONCLUSION

Of all the three endotracheal intubation anesthetic techniques, the sealing pressure method results in lowest manometric cuff pressure and postoperative laryngotracheal morbidity as compared to finger palpation method and constant pressure method. It is more convenient and reliable method regarding prevention of the air leak.

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