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Research Article

ASSESSMENT OF ENDOTRACHEAL TUBE CUFF PRESSURE: FINGER PRESSURE TECHNIQUE VERSUS MINIMUM LEAK TECHNIQUE

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ABSTRACT

Objective: The purpose of this study is to compare routinely used cuff insufflation techniques to finger-pressure and minimal leak procedures for achieving safe endotracheal tube (ETT) intracuff pressures in patients undergoing endotracheal intubation.

Methods: It is a prospective observational study conducted in patients undergoing elective surgical procedures under general anaesthesia at GITAM Institute of Medical Sciences and Research, Visakhapatnam from January 2019 to June 2020. In Group FP, which includes 50 patients, the ETT cuff (ETTc) was inflated by palpating the pilot balloon between the index finger and thumb until it became taut. When this point was reached, the syringe was detached from the pilot balloon, and a cuff manometer was attached. The pressure reading on the cuff manometer is noted. In Group ML, which includes 50 patients, the ETTc was inflated fully, and then the air was withdrawn slowly from the cuff with auscultation over the trachea until a small leak was heard. When the point was reached, the syringe was detached, and a cuff manometer was attached; pressure readings were noted.

Results: Mean inflation cuff pressure in the FP group was 45.40±21.74 cm H_2O and in the ML group was 28.68±8.35 cm H_2O. In Group FP, out of 50 patients, cuff pressure in 14 (28%) patients was in the normal range; in 32 (64%) patients, the cuff was over inflated, and in 4 patients (8%) cuff was under inflated. In the group ML, 24 (48%) patients have cuff pressure within the normal range; in 18 (36%) patients, the cuff has been over inflated, and 8 (16%) patients have low cuff pressures. Cuff pressure adjustment was required in 36 patients (72%) in the FP group, whereas 26 patients (52%) in the ML group. ML group has a low incidence of postoperative complications, i.e., 10%, compared to the FP group, i.e., 18%. A positive correlation was seen between the measured cuff pressure and body mass index, Volume of air insufflated.

Conclusion: The main conclusion is to realize the need to use manometers or better-automated controllers during routine anaesthetic procedures.

Keywords: Finger pressure technique, Minimal leak technique, Endotracheal, Cuff pressure, Postoperative complications.

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INTRODUCTION

Endotracheal tube (ETT) implantation is widespread in operating rooms for providing general anaesthesia and critical care settings for securing and maintaining adequate airways and ventilating patients. The maintenance of the ETT cuff (ETTc) pressure is a crucial step in managing the airway after endotracheal intubation. The devastating implications of ETTc over-inflation and low inflation have been documented in the literature. Insufficient cuff pressure causes oropharyngeal contents to be aspirated into the lungs, while high cuff pressure reduces tracheal capillary perfusion [1-4]. The ETTc pressure must be within a range that ensures delivery of the prescribed mechanical ventilation tidal volume while also reducing the risk of aspiration of secretions that build above the cuff without jeopardizing tracheal perfusion [2-5]. A pressure range of 20–30 cm of H2O is considered optimum. Cuff pressures and post-operative airway problems have been linked [6]. A typical adverse effect of general anaesthesia is postintubation sore throat [7]. This could be related to oropharyngeal and tracheal mucosal ischemia caused by overinflating the cuff. Tracheal rupture, necrosis, stenosis, trachea-oesophageal fistula, and recurrent laryngeal nerve palsy are a few more risks of high cuff pressures [8,9]. Underinflation can result in bronchial aspiration, linked to ventilator-associated pneumonia [10,11]. In the literature, there is no standard for characterizing the process of cuff inflation, and anaesthetists utilize a variety of cuff inflation procedures. The study found that only around one-third of anaesthetic practitioners inflated the cuff within the recommended range. There are several methods for injecting air into the pilot balloon and calculating cuff pressure. The best quality level technique uses a calibrated manometer to assess cuff pressure (analogue vs. digital/intermittent vs. continuous), but it is not widely used as a standard practice. In general, low precision finger pressure (FP), minimal leak (ML) technique, minimum occlusive volume, and predefined volume technique are used to assess ETTc pressure in anaesthetic practice. A few studies compared different ETTc insufflation strategies. The goal of this study is to examine several cuff insufflation procedures that are commonly used. In order to establish safe ETT intracuff pressures in patients undergoing endotracheal intubation, researchers compared finger-pressure and ML approaches. Using cuff manometry, assess insufflation cuff pressure using two distinct ways (FP Technique [FPT] and ML Technique [MLT]) and maintain a pressure of 20–30 cm H2O, as well as assess Post-Operative problems.

MATERIALS AND METHODS

The Prospective Observational Study "Assessment of endotracheal cuff pressure: FPT versus MLT" was undertaken in patients undergoing elective surgical procedures under general anaesthesia GITAM Institute of Medical Sciences and Research, Visakhapatnam from January 2019 to June 2020. All patients have explained the procedure in detail, and written informed consent was obtained before being included in the study.

Inclusion criteria

The study includes 100 patients of both sexes between 18 and 60 years of age, under ASA grade 1 and 2, scheduled for elective surgical procedures under general anesthesia.

Exclusion criteria

Patients with anticipated difficult intubation, i.e.,

- Modified Mallampati grade III/IV
- ASA grade III, IV, V
- High risk of aspiration
- Patients with known anatomical laryngotracheal abnormalities
- Emergency intubations
- History of asthma, cardiovascular disease, smoking
- Recent respiratory infection.

The patients were randomly allocated by envelope method into two groups- 50 patients each as follows:

- GROUP FP: FPT
- GROUP ML: MLT

A routine pre-anaesthetic examination was conducted assessing:

- A detailed history of past medical diseases like Diabetes mellitus, Hypertension, Asthma, Tuberculosis, Seizure disorder
- Previous intake of medications and vices such as smoking, tobacco chewing, alcohol consumption
- The general condition of the patient
- Airway assessment by Modified Mallampati Grading
- A detailed systemic examination
- The following investigations were done for all patients.

Methodology

Haemoglobin, bleeding time, clotting time, random blood sugar, blood urea, serum creatinine, blood grouping and Rh typing, Chest X-Ray, and Electrocardiography (ECG) (if needed). All the patients were given oral Ranitidine 150 mg, Metoclopramide 10mg, Alprazolam 0.25 mg on the night before surgery. They were kept nil per oral, 6 h for solids and 2 h for clear liquids. On arrival in the operation theatre, standard non-invasive monitors, which include pulse oximetry (SPO_2), non-invasive blood pressure, and ECG, were attached, and baseline parameters such as Heart rate, systemic arterial blood pressure, and oxygen saturation were recorded. An intravenous line using 18G cannula, was secured on the non-dominant hand, infusion of Ringer Lactate was started. Pre-oxygenation was performed with 100% Oxygen for 3 min. Patients were pre-medicated with Injection. Glycopyrrolate 0.2 mg IV, Inc. Ondansetron 2 mg IV, Injection. Midazolam 0.03 mg/kg IV and Inj. Fentanyl 1 mcg/kg IV. They were induced with Injection. Thiopentone Sodium 3–5 mg/kg IV until eyelash reflex was lost. Mask ventilation was performed with 100% oxygen and Sevoflurane 0.6%. Endotracheal intubation was facilitated by Succinylcholine 1.5 mg/kg IV, and a gentle, quick laryngoscopy was done to intubate the patient. High volume, low-pressure ETT was used. Males were intubated with 8/8.5 mm internal diameter ETT, and female patients were intubated with 7/7.5 mm internal diameter ETT; the position was confirmed and secured. In Group FP, the FPT was used, and the ETTc was inflated by palpating the pilot balloon between the index finger and thumb until it became taut. When this point was reached, the syringe was detached from the pilot balloon, and a cuff manometer was attached. The pressure reading on the cuff manometer is noted.

In Group ML, MLT was used, ETTc was inflated fully, and then the air was withdrawn slowly from the cuff with auscultation over trachea until a smallleak was heard. When the point was reached, the syringe was detached, and a cuff manometer was attached; pressure readings were noted. The cuff pressures were recorded and categorized as under-inflated (<20 cm of H2O), over-inflated (higher than 30 cm of H2O), or within the range (20–30 cm of H2O. The volume of air insufflated, ASA score, type of surgical procedure, and anaesthesia time were recorded. Cuff Pressure Adjustment- Pressures out of safe range (very high and very low pressures) were adjusted immediately as per the recommendation by the ethics committee to 25 cm of H2O. At the end of the pressure measurement and recommended adjustments in both the groups, the cuff manometer was detached, the breathing circuit was attached to the ETT, and ventilation was started. Anaesthesia was maintained with Oxygen, Nitrous Oxide 3:2, Sevoflurane 0.6–1%, and IV Vecuronium Bromide at 1/5th. The induction dose was repeated at 30-min intervals or earlier if the patient showed signs of recovery from a muscle relaxant. On completion of the surgery, residual muscle relaxation was reversed with IV Neostigmine 0.05 mg/kg and Glycopyrrolate 10 mcg/kg, and extubation was performed after gentle oropharyngeal suctioning under vision. Postoperative analgesia was provided with IV Paracetamol 1gr 8th hourly. Post-operative complications such as Sore throat, Hoarseness, Odynophagia, blood-stained expectorant were monitored and recorded during the first 24 h of the post-operative period.

Statistical analysis

The sample size was calculated using the standard cuff pressure used in ETTs (20–30 cmH_2O). Prior research has determined that a 20 variation in mean cuff pressure is clinically significant. We calculated that a sample size of 43 patients per group would be necessary for a significance level of p<0.05 and a power of 90% with an expected standard deviation (SD) of 7.0 cm H_2O. We were taking into account the possibility of dropouts. In each group, 50 patients were recruited. Microsoft Excel and the Statistical Package for Social Sciences 21.0 version software are used to evaluate the study's findings. Analysis of variance, student's test and were used to compare the outcomes of this study statistically.

RESULTS

One hundred patients were divided into Group FP (FPT) and Group ML (MLT). The mean age in group FP is 43.82±13.672, and in a group, ML is 45.30±13.996 respectively, and the results of t-test analysis showed insignificant results (p=0.594). Figs. 1 and 2 showed the age-wise distribution of cases in FP and ML. The males in Group FP and ML were 24 (48%) in each group, respectively, and females in Group FP and ML were 26 in each group, respectively. The results of the t-test analysis showed insignificant results (p=0.594). The mean body mass index (BMI) in Group FP is 24.17±2.96, and Group ML i4.15±3.16, respectively, the t-test analysis results showed insignificant results (p=0.984). The mean cuff pressure in Group FP is 45.40±21.74, and in Group ML is 28.68±8.35, respectively. A statistically significant difference in mean cuff pressures was measured in both groups (p<0.01) (Fig. 3). In Group FP, number of patients with cuff pressure <20 cm H2O - 4 (8%); 20–30 cm H2O - 14 (28%) and >30 cm H2O - 32 (64%). In Group ML, number of patients with cuff pressure <20 cm H2O - 8 (16%); 20–30 cm H2O - 24 (48%) and >30 cm H2O - 18 (36%) (Table 1). The proportion of patients with cuff pressure in the safe range was 28% for FP and 48% for MLT. The mean volume of air insufflated in Group FP and Group ML was 6.87±1.20 and 5.94±0.70, respectively (Fig. 3). There is a highly statistically significant difference in the volume of air insufflated measured in both groups (p<0.01). The cuff pressure and BMI are positively correlated using Pearson's Coefficient. This shows a linear relation between cuff pressure and BMI (Table 2). The cuff pressure and volume of air insufflated are positively correlated using Pearson's Coefficient. This shows a linear relation between cuff pressure and volume of air insufflated (Table 3). As per the recommendations by the ethics committee, low pressures (<20 cmH2O) and high pressures (>30 cmH2O) were adjusted to 24 cm H2O using the manometer. The ETTc pressure was adjusted to the recommended range for 36 patients in Group FP and 26 patients in Group ML. There is a statistically significant difference in the proportion of cuff pressure adjusted between the two groups (p<0.01). Due to the adjustment of cuff pressures to the recommended range, there were minimal postoperative complications: 9 (18%) patients in Group FP, 5 (10%) patients in Group ML (Table 4). There is a statistically significant difference between the two groups regarding the presence and absence of post-operative complications in both groups.

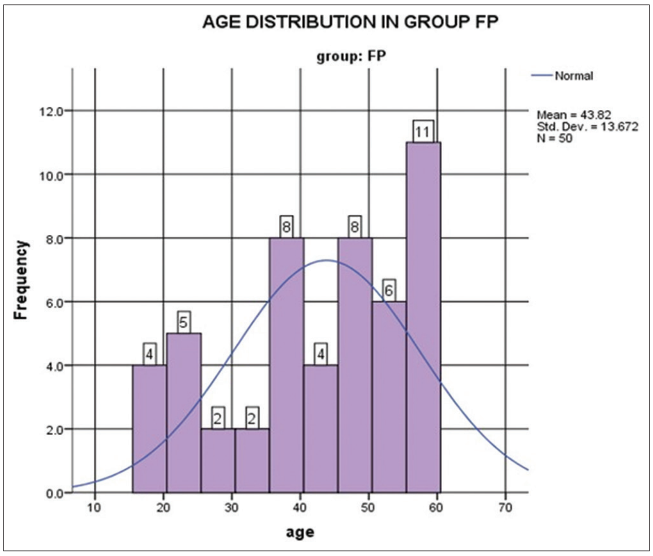

Fig. 1: Age-wise distribution of cases in group finger pressure

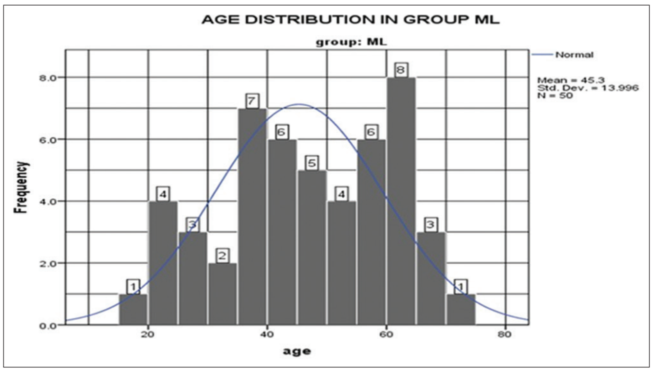

Fig. 2: Age-wise distribution of cases in group minimum leak

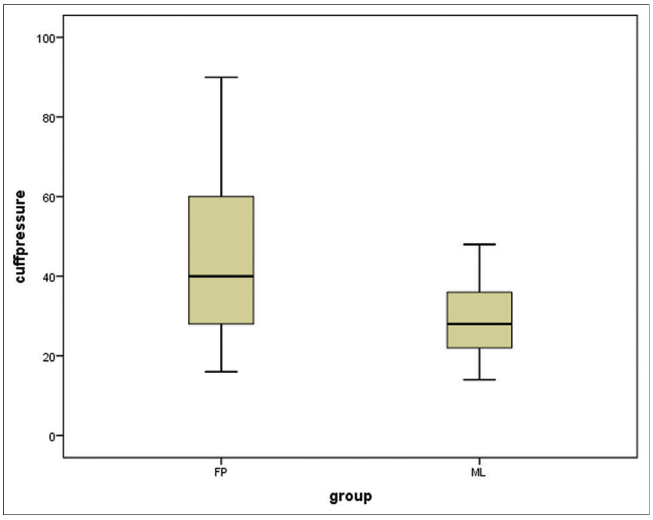

Fig. 3: Distribution of cuff pressure in both groups

Table 1: Showing cuff-pressure range in both group

Group	Number and percentage	Cuff pressure			p-value	Significance
		<20	20–30	>30		
FP	Number	4	14	32	0.019	Significant
	%	8	28	64		
ML	Number	8	24	18		
	%	16	48	36		

FP: Finger pressure, ML: Minimum leak

Table 2: Relation between BMI and cuff pressure

Groups	Variables				Pearson's correlation	Interpretation
	BMI		Cuff pressure			
	Mean	SD	Mean	SD		
FP	24.17	2.96	45.40	21.74	0.513	Positively correlated
ML	24.15	3.16	28.68	8.35	0.252	Positively correlated
Total	24.16	3.04	37.04	18.42	0.351	Positively correlated

BMI: Body mass index, FP: Finger pressure, ML: Minimum leak

Table 3: Relation between cuff pressure and volume of air insufflated

Groups	Variables				Pearson' scorrelation	Interpretation
	The volume of air inflated		Cuff pressure			
	Mean	SD	Mean	SD		
FP	6.87	1.20	45.40	21.74	0.325	Positively correlated
ML	5.94	0.70	28.68	8.35	0.267	Positively correlated
Total	6.41	1.08	37.04	18.42	0.446	Positively correlated

FP: Finger pressure, ML: Minimum leak

Table 4: Postoperative complications in both groups

Complications	Groups				p-value	Significance
	FP		ML			
	No.	%	No.	%		
No complications	41	84	45	90	0.028	Significant
With complications	9	18	5	10		
Blood-stained expectorant	2	4	1	2		
Hoarseness	1	2	0	0		
Odynophagia	3	6	2	4		
Sore throat	3	6	2	4		

FP: Finger pressure, ML: Minimum leak

DISCUSSION

A prospective observational monocenter study was undertaken at GITAM Institute of Medical Sciences and Research, Visakhapatnam. This study comprised 100 adult patients between 18 and 60 years of either sex, scheduled for elective surgery under general anaesthetic.

This study aimed to determine the optimal approach for achieving safe ETT intra cuff pressures among FPT and MLT. The best technique was assessed by comparing mean inflation pressure between two techniques and the population within the normal cuff pressure range. The incidence of postoperative complications was assessed in the first 24 h. Mean inflation cuff pressure in the FP group was 45.40±21.74 cm H_2O and in the ML group was 28.68 ±8.35 cm H_2O. In Group FP, out of 50 patients, cuff pressure in 14 (28%) patients was normal. In 32 (64%) patients, the cuff was over inflated, and in 4 patients (8%) cuff was under inflated. 24 (48%) patients have cuff pressure within the normal range in the group ML. In 18 (36%) patients cuff has been over inflated, and 8 (16%) patients have low cuff pressures. Cuff pressure adjustment was required in 36 patients (72%) in the FP group, whereas 26 patients (52%) in the ML group. ML group has a low incidence of postoperative complications, i.e., 10%, compared to the FP group, i.e., 18%. A positive correlation was seen between the measured cuff pressure and BMI, Volume of air insufflated. The standard for airway protection is high-volume low-pressure cuffed ETTs. Endotracheal cuffs are inflated to prevent gas leakage during positive pressure breathing and food or gastric fluid aspiration. The cuff's pressure on the tracheal wall is determined by the trachea's and cuff's compliance. The pressure measured at the pilot balloon of an ETTc can be used to estimate the pressure applied by the cuff on the tracheal mucosa [12]. Sengupta *et al.* [1] and Hoffman *et al.* [13] found that the measured cuff pressure and the volume of air insufflated into the cuff had a linear relationship. This association was observed by Hoffman *et al.* [13] as having a % linear correlation. The research showed no link between the measured cuff pressure and the patients' demographic parameters. The measured cuff pressure as a function of ETT size also did not differ. The pressure inside the ETTc is increased by a variety of factors, including patient position Godoy *et al.* [14], head position Brimacombe *et al.* [15], cuff position Bernhard *et al.* [16], cuff volume Sengupta *et al.* [1], temperature Atlas *et al.* [17], and nitrous oxide anaesthesia Mitchell *et al.* [18]. As a result of the contact between the ETT and the trachea during intubation, damage to the trachea is unavoidable [9]. One of the key determinants of tracheal damage is the pressure imposed on the tracheal wall [9]. Intubated patients' intracuff pressure should be sufficient to prevent air leaks and macroscopic aspiration while not obstructing mucosal blood flow [4]. Continuous lateral wall cuff pressure above 30 cm H2O has been shown to impede tracheal blood flow, while cuff pressure above 50 cm H_2O entirely obstructs blood flow [3]. According to studies, impaired blood flow for 15 min caused superficial injury to the tracheal mucosa [19], whereas more than 15 min resulted in obstructed mucosal blood flow, destruction of the columnar epithelium, and exposure of the basement membrane [16]. Excessive inflation for lengthy periods can cause ischemic necrosis, tracheal rupture, tracheoesophageal fistula, and laryngeal nerve palsy by affecting the perfusion of the tracheal mucosa. After extubation, over-inflation is more likely to cause stridor and a sore throat [5,7]. The study's major goal was to determine what percentage of cuff pressures were in the optimal range using commonly used procedures and to see if one technique might be preferred over the other for keeping cuff pressures between 20 and 30 cm H2O. This result was obtained using the initial unadjusted cuff pressures from either approach. When comparing the ML and FP groups on this primary outcome, the ML group has a much greater proportion. This adds to the growing body of data that MLT can be used to inflate cuffs. In the current investigation, ETTc pressures insufflated by MLT were within normal ranges in 48% of the cases. Despite its widespread use in anaesthesia, the FP method has repeatedly been demonstrated to provide cuff pressures outside the normal range. According to the findings after insufflation by the FPT, 28% of cuff pressures were in the ideal range. Only 25.3% of cuff pressures were in the optimal range after estimated by FPT, according to Fred Bulamba *et al.* [20], who compared the loss of resistance technique to FPT and found that only 25.3% of cuff pressures were in the optimal range after estimated by FPT. The anaesthesiologist's experience with digital balloon palpation does not match the observed ETTc pressure [9,13,19]. In this study, the incidence of post-operative problems was 18% in the FP group and 10% in the ML group, indicating that the FP group has a high rate of complications. Because cuff pressures that were out of range were restored to normal range, post-operative problems due to cuff pressure could not be studied in this study. There was no evidence of tracheomalacia, aspiration pneumonia, or tracheal injuries. It could be because the time between intubation and extubation is shorter. Das *et al.* [21] did an observational study on cardiac patients and found a higher incidence of postoperative complications. Compared to the two techniques, the MLT is better than the finger pressure technique in achieving safe ETTc pressures. Both these techniques resulted in both under-inflation and over-inflation. Hence, usage of cuff manometer is recommended.

CONCLUSION

The study concludes that the MLT method was superior to the FPT at administering pressures in the optimal range. Manual processes for determining acceptable ETTc pressure, such as palpation of the pilot balloon and ML approach, are ineffective because they frequently result in ETTc pressures that are higher or lower than the safe limit. As a result, whenever possible, we recommend using the cuff manometer. The critical takeaway is that manometers or better-automated controls should be used during routine anaesthesia treatments.

AUTHORS' CONTRIBUTION

The principal author of the study MVG had performed the work and wrote the article's first draft. Author PVSL collected the literature and performed the statistical analysis part of the work.Author ASL corrected the final version of the manuscript, managed the figures and tables.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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