Original Article

Comparison of cuff inflation method with curvature control modification in thermosoftened endotracheal tubes during nasotracheal intubation - A prospective randomised controlled study

Address for correspondence:
Dr. Sukhyanti Kerai,
B3/59, Paschim Vihar,
New Delhi - 110 063, India.
E-mail: drsukhi25@gmail.com

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Prashant HT, Sukhyanti Kerai, Kirti Nath Saxena, Bharti Wadhwa, Prachi Gaba
Department of Anaesthesiology and Intensive Care, Maulana Azad Medical College and Associated Hospitals, New Delhi, India

ABSTRACT

Background and Aims: Thermosoftening of endotracheal tube (ETT) is a simple method which reduces risk of epistaxis during nasotracheal intubation (NTI). This method, however, decreases the stiffness of ETT and necessitates frequent manipulation with Magill forceps. Cuff inflation technique has been found effective for navigating ETTs during NTI. Another method is using an ETT, modified with a silk thread which can be used to control its curvature. We conducted the present study to compare the ease of navigation of thermosoftened ETT using curvature control modification with the cuff inflation technique. **Methods:** Depending on the method used for navigating thermosoftened ETT to glottis, 70 patients undergoing general anaesthesia with NTI were randomly divided into two groups. The primary outcome was ease of navigation of thermosoftened ETT. Secondary outcomes were time taken for moving tube from oropharynx to glottis and incidence of epistaxis during NTI. **Results:** Both techniques resulted in successful navigation of thermosoftened ETT in all patients with majority of cases resulting in smooth engagement to glottic inlet. The difference in ease of navigation between the groups was 7% [95% CI (−9.21% to 23.28%)] and it was not found to be statistically significant ($P = 0.395$). Cuff inflation method resulted in faster alignment to glottis compared to use of modified tube (12. 39 ± 7 Vs 18.73 ± 11.5 sec; $P = 0.003$). **Conclusion:** For thermosoftened ETT, both cuff inflation method and the technique of curvature controlled modified ETT can be used for navigation of tube to glottis with ease.

Key words: Ease of navigation, nasotracheal intubation, thermosoftening

INTRODUCTION

Thermosoftening of endotracheal tube (ETT) is a simple method shown to significantly reduce risk of epistaxis during nasotracheal intubation (NTI).[1] However, it is not without risks, as thermosoftening can distort lumen of an ETT, proportionally decreases the hardness and compromises its ability to navigate.[2] A thermosoftened tube therefore frequently requires manipulation with Magill's forceps. The use of Magill's forceps may damage its cuff, injure oropharyngeal soft tissues and make NTI more difficult.[3]

The cuff inflation technique is a simple technique in which inflation of cuff of an ETT with air, lifts it away from the posterior pharyngeal wall and facilitates its navigation from oropharynx to glottic inlet.[1] Another method for navigating ETT during NTI, controlling the curvature of a ETT with modification using a silk suture has been described in a case series

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by Naithani *et al*.[4] This technique has not been evaluated in larger groups of patients and has not been compared with other methods for navigating ETT during NTI. This modified curvature-controlled technique in thermosoftened ETTs can decrease the risk of epistaxis and improve their navigation ability during NTI.

In this study, we aimed to assess the ease of navigation of thermosoftened ETT using curvature-controlled modification to cuff inflation technique during NTI. We also evaluated the time taken for NTI, nasal bleed during procedure and postoperative complications. We hypothesised that navigation of a thermosoftened ETT using a modification with silk thread would be easier compared to cuff inflation method.

METHODS

After approval from institutional ethical committee, this prospective randomised study was conducted on patients scheduled for elective surgeries under general anaesthesia. This trial was conducted at a non-COVID set up from February to August 2020. A total of 75 patients were enroled for participation in the study and were randomised into two groups; group A (n = 38) and group B (n = 37).

Adult patients with age more than 18 years, those belonging to American Society of Anesthesiologists (ASA) physical status I–II; who were scheduled to undergo elective surgery requiring general anaesthesia were recruited. Patients with any nasal deformity, history of recurrent epistaxis, coagulopathy, recent nasal surgery or any other significant nasal pathology, pregnant patients, those with base of skull fracture and anticipated difficult airway were excluded from this study. Written informed consent for participation in the study was obtained from those found to be eligible for the study.

A detailed pre-anaesthetic check-up was carried out in all patients and simple tests like occlusion test and cold spatula test were performed to identify the patent nostril. If both nostrils were equally patent, right nostril was chosen. The anaesthetic procedure was explained to the patient in the vernacular language. On the day of surgery, 2 drops of 0.1% xylometazoline drops were instilled in each nostril at least 30 min prior to scheduled operation theatre (OT) time.

Patients were randomised using a computer-generated random table with allocation ratio of 1:1 to one of 2 groups (A or B) depending on the method used for navigating thermosoftened ETT from oropharynx to glottic inlet.

Group A: In this group, cuff inflation method was used for navigation of thermosoftened ETT.

Group B: Navigation of thermosoftened ETT from oropharynx to glottic inlet was accomplished by modifying its radius of curvature with the help of a 76 cm silk suture[4] [Figure 1].

The allocation of patient into groups was concealed in white opaque sealed envelope and on the day of surgery, it was opened by a nurse who was not involved in study. NTI intubations were performed by two experienced anaesthesiologists who had already used these two techniques in 20 patients previously.

Based on the discretion of the investigator performing NTI, polyvinylchloride ETT size 6.0 to 7.0 for a female

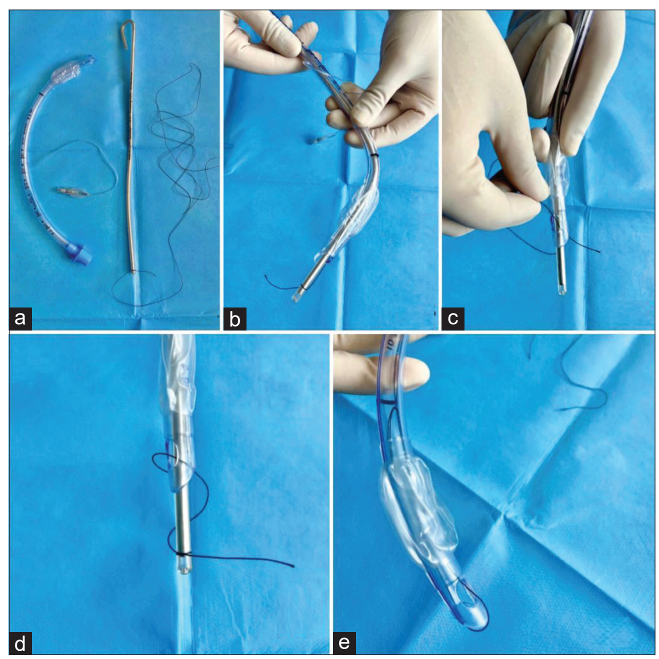

Figure 1: Preparation of endotracheal tube in Group B. (a) A long sterile silk suture was taken and is tied to the tip of a disposable stylet using a loose knot. (b) The stylet was inserted into ETT and taken out through its distal end. The knot of suture is loosened. (c) To create a loop around distal end of ETT, suture was inserted back into the lumen of tube through the Murphy's eye with its end brought out again through distal end of ETT. Now the suture is tied back to the tip of stylet. (d) The stylet with silk suture tied to its tip is then withdrawn out from lumen of ETT. Both ends of silk sutures are now protruding from proximal end of ET. (e) The loop of suture at distal end of ETT to control its curvature by gentle traction on ends of suture protruding through proximal end

patient and 7.0 to 8.0 for a male was elected. For patients in group B, threading of ETT was done prior to thermosoftening of ETT under strict asepsis in steps as shown in Figure 1.

The ETTs in both the groups were immersed in a closed water tub containing warm water (temperature 45°C) for 4–5 min for thermosoftening of the ETT. The temperature of warm water was measured continuously by dipping the tip of a nasopharyngeal temperature probe of multiparameter anaesthesia monitor in the tub.

In OT, ASA standard monitoring including continuous five lead electrocardiogram, non-invasive blood pressure and pulse oximetry were instituted. The selected nostril of the patient was then dilated using progressively larger sizes of nasopharyngeal airways with lignocaine jelly. Thereafter, each patient was preoxygenated followed by anaesthesia induction using injections fentanyl 2 μg/kg, propofol 2–2.5 mg/kg and vecuronium 0.1 mg/kg administered intravenously. Intermittent positive pressure ventilation with 100% O_2 with 1–1.5% isoflurane was done for 3 min, then NTI was performed under direct laryngoscopy as per group allocation.

The navigation of ETT from nostrils to trachea during NTI had three phases. In the first phase, the ETT was inserted through the selected nostril perpendicular to the floor of the nose till its tip was in the posterior pharynx and then advanced gently so that the tube lay in the oropharynx. In the second phase, the ETT was moved from the oropharynx to the glottic inlet under direct laryngoscopy using cuff inflation technique in one group and curvature control in the other group.

In group A, as the tip of the thermosoftened ETT reached the oropharynx, gentle laryngoscopy was performed and the cuff was inflated with 20–40 ml of air so that it aligned itself to the glottic opening. Once the tip of the ETT was in the glottic inlet, the cuff was deflated and the tube was advanced into the trachea. The amount of air used to inflate the cuff to achieve alignment with the glottic inlet was noted.

In group B, when the tip of the modified thermosoftened ETT was positioned in the oropharynx, with an assistant stabilising the part of the ETT at the nostril, its radius of curvature was reduced by pulling the ends of the suture so that the tip of the tube moved anteriorly towards the glottic opening. Once the tip of the tube was engaged at the glottic inlet, it was advanced into the trachea. The suture was taken out by simply pulling one end gently. If there was any resistance encountered while pulling out the thread, it was left in the ETT until extubation. If the ETT failed to achieve alignment to the glottic inlet, Magill's forceps were used to navigate the tube in both the groups.

The ease of insertion or navigability of ETT was noted according to the scale shown in Annexure IA.[5]

After engaging ETT at the laryngeal inlet, during the third phase of NTI, it was advanced into the trachea. In case of resistance encountered while passing the ETT, it was rotated clockwise until it was disengaged and then passed into the trachea. The ease of navigation of ETT during this phase of NTI was noted [Annexure IB][5]:

The confirmation of ETT placement was done by capnography and chest auscultation. Total time taken for insertion of ETT from nostril to trachea was noted. It consisted of time taken from nose to posterior pharynx (T1), from posterior pharynx to glottic inlet (T2) and from glottis to trachea (T3). The severity of nasal trauma during intubation [Annexure IC], any damage to cuff of tube and air required for cuff insulation in group I were also noted.

After successful intubation, controlled ventilation with O_2: N_2O (1:2) in isoflurane 1% was established. At the conclusion of surgery, anaesthetic agents were discontinued and after adequate reversal of neuromuscular block, patient was extubated. In the post-operative period, complications of NTI; nasal pain, any bleeding or nasal blockade in the patients were noted.

Sample size was determined based on a previous study by Kim *et al.*[1] With sample size of 31 patients in each group, there was 80% power at an alpha 0.05 to detect a 30% difference between two groups in the ratio of complete response. Factoring a dropout rate of approximately 5%, we calculated that 35 patients per group would be required.

Statistical testing was conducted with the statistical package for the social science system version SPSS 25.0. Continuous variables were presented as mean ± standard deviation (SD) or median if the data was unevenly distributed. Categorical variables were expressed as frequencies and percentages. The comparison of the normally distributed continuous variables between the groups were performed using Student's t test. Nominal categorical data between the groups were compared using Fisher's exact test or Chi-squared test as appropriate. Mann-Whitney U test was used for comparing non-normal distributed continuous variables. A *P* value less than 0.05 was considered to indicate a significant difference for all statistical tests.

RESULTS

All the patients completed the study; 5 patients in group A and 6 patients in group B did not required interventions investigated in this study for navigating ETT from oropharynx to glottis as tube tip aligned spontaneously to glottic inlet [Figure 2]. The demographic characteristics were similarly distributed in both the groups as shown in Table 1.

Table 1: Demographic profile

	Group A	Group B	*P*
Gender (M/F)	52.63%/47.37%	43.24%/56.76%	0.41
Age (years)	35.13±9.32	35.00±10.54	0.43
Weight (kg)	59.71±6.8	57.62±7.36	0.10
ASA Class (I/II)	92.11/7.89	89.19/10.81	0.66

ASA-American Society of Anesthesiologists

The ease of navigation of thermosoftened ETT by two methods was found to be comparable [Table 2]. The difference in ease of navigation between the groups was 7% [95% CI (−9.21% to 23.28%)] and it was not found to be statistically significant (*P* = 0.395) [Table 2]. The mean volume of air required for adequate cuff inflation in group A was 14 ± 4.7 ml. In either group, none of the patients had grade 3 ease of navigation. The difference in ease of phase 3 navigation between the groups was observed to be non-significant.

The total time taken during first phase of NTI, i.e., from nostrils to oropharynx was comparable in both the groups [Table 3]. The time taken during phase 2 involving navigation of ETT using two different methods from oropharynx to glottic inlet was significantly faster with cuff inflation technique in group A compared to use of curvature controlled modified ETT in group B (12. 39 ± 7 Vs 18.73 ± 11.5 sec; *P* = 0.003). The duration of last phase of NTI was comparable in both groups.

No difference in the incidence or severity of nasal bleed was observed in between the two groups. As shown in Table 2, 50% of patients in group A and 56.7% in group B had mild to moderate nasal bleed. None of the patients in either groups suffered severe nasal bleed. Postoperative complications of NTI such

Table 2: Ease of navigation and postoperative complications in two groups

	Group A (% of patients)	Group B (% of patients)	*P*	Difference	95% Confidence Interval	
Ease of navigation from oropharynx to glottic inlet						
Grade I	90.91%	83.87%	0.395	7.04%	−9.21%	23.28%
Grade 2	9.09%	16.13%		−7.04%	−23.28%	9.21%
Ease of navigation from glottis to trachea						
Grade I	71.05%	54.05%	0.128	17%	−4.58%	38.58%
Grade 2	28.95%	45.95%		−17%	−38.58%	4.58%
Epistaxis grade						
No epistaxis	50%	43.24%	0.558	6.76%	−15.77%	29.29%
Mild epistaxis	42.11%	35.14%	0.535	6.97%	−15.01%	28.95%
Moderate epistaxis	7.89%	21.62%	0.093	−13.73%	−29.52%	2.07%
Severe epistaxis	Nil	Nil	-	-	-	-
Postoperative complications (bleeding, nasal pain, nasal blockade)						
Yes	5.26%	2.70%	0.572	2.56%	−6.25%	11.38%
No	94.76%	97.30%		−2.56%	−11.38%	6.25%

Table 3: Time taken during NTI

	Group A (Mean±S. D.)	Group B (Mean±S. D.)	*P*
T1 (nostril to oropharynx)	10.45±4.23 sec	9.86±6.7 sec	0.326
T2 (oropharynx to glottic inlet)	12.39±7.07 sec	18.73±11.55 sec	0.003
T3 (glottic inlet to trachea)	17.37±15.6 sec	16.24±9.12 sec	0.352
Total time taken for NTI	40.21±21.27 sec	44.84±18.26 sec	0.158

NTI-Nasotracheal intubation;SD-Standard deviation

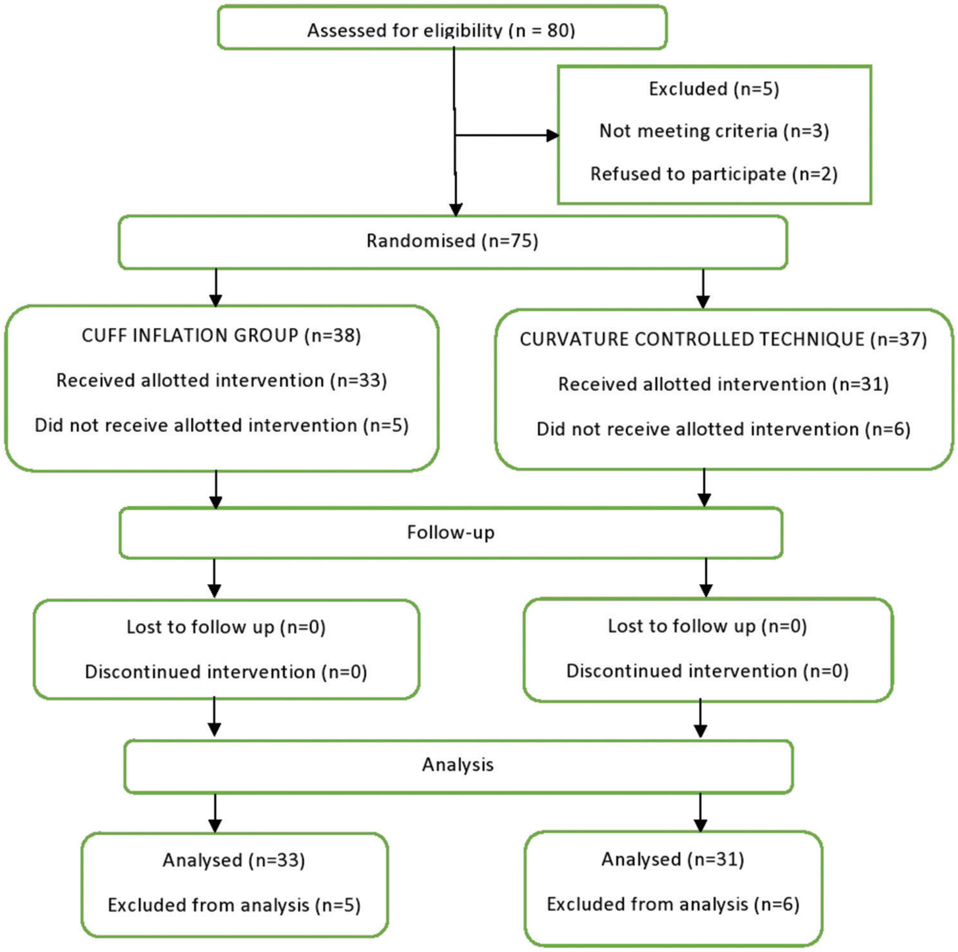

Figure 2: CONSORT Flowchart

as nasal pain, bleeding or nasal blockade were found to be comparable in both groups.

DISCUSSION

The simple thermosoftening treatment of ETT prior to NTI has shown to reduce the incidence of epistaxis and nasal damage.[6]

However, a thermosoftened ETT on exposure to ambient temperature will cool immediately and becomes stiffer. Hence if intubation is delayed, beneficial effect of ETT thermosoftening is neutralised.[2] In the present study, we therefore minimised the time elapsed from withdrawal of ETT from warm saline to start of NTI to less than 10 sec.

Another problem encountered while using thermosoftened ETT is that, above a certain temperature, ETT becomes too soft; there is alteration of its normal curvature and loss of rotational fidelity. This causes difficulty especially during second and third phase of NTI. Lu *et al.* found that a thermosoftened ETT more frequently required Magill's forceps for facilitating intubation. Shanahan *et al.* demonstrated that higher the temperature of warm saline used for thermosoftening treatment, the degree of rotation at the proximal end would result in a lesser degree of rotation of bevel of ETT.[7] We used temperature of 45°C for thermosoftening of ETT similar to the study by Kim *et al.*[1]

Cuff-inflation technique has been suggested as alternative to use of Magill's forceps for facilitating NTI. This technique has been consistently found to improve nasotracheal navigability irrespective of stiffness of different types of ETT.[5] This technique anteriorly lifts the tip of ETT from posterior pharyngeal wall towards laryngeal inlet. Naithani *et al.* utilised a modified ETT for facilitating NTI by using a silk suture creating a loop along proximal and distal ends of ETT via its Murphy's eye. They used an 80 cm long 1–0 silk thread inserted through the proximal end of a PVC ETT, taken out through the distal end, reinserted into the tube via the murphy eye, and brought out through the proximal end. When the proximal ends of the thread are pulled, it results in anterior placement of the tube tip by decrease in the curvature of ETT.[4] This modification is similar to a specialised ETT with directional tip such as Endotrol and Endoflex tube.[8,9] The silk thread used for modifying ETT runs along the entire length of tube and on pulling the proximal ends of the thread, not only the tip but the distal shaft of ETT can be moved anteriorly.

We found that cuff inflation technique resulted in faster alignment of a thermosoftened ETT into the glottic opening compared to the method of achieving alignment by decreasing the curvature of ETT using a silk thread. The inflated cuff of ETT in the pharyngeal space just above glottis, apart from causing upliftment of ETT, also minimises its chances of lateral deviation. On the other hand, we observed that although the use of curvature control modified tube effectively moves the ETT upwards, compared to cuff inflation method there are more chances of lateral migration of tube which require external laryngeal manipulations to achieve engagement of the tube at the glottis. Another important consideration with this modified ETT technique is that the silk thread acts as a lever and effective transmission of force exerted at the proximal end of tube by pulling two ends of thread to the distal end of ETT would require a fulcrum in between. Therefore, an assistant is required to hold the part of ETT lying just outside the nostrils while manipulation is done and for pushing it forward towards glottic inlet once proper alignment is achieved.

The incidence of epistaxis with thermosoftened tube in the present study was 50% in group A and 57% in group B. This is much higher compared to 7% incidence of epistaxis with tube thermosoftening reported by Kim *et al*.[1] They used thermosoftened ETT which was telescoped into a soft rubber catheter during phase 1 of NTI which could have contributed to reduction in incidence of epistaxis. Ahmed Nusrat *et al*. found that 80% of thermosoftened tubes entered the less favourable upper pathway of the nostril located above the inferior turbinate.[10] Therefore, thermosoftening treatment certainly softens them and helps in decreasing epistaxis, but this method is less effective for enhancing their flexibility which is required to enter narrow passages easily. Use of bougie or a nasogastric tube facilitates ETT passage through favourable lower pathway and hence reduces chances of epistaxis.[11,12]

There are some limitations to the present study. First, all the NTIs were performed in patients having normal airway. The most common indication for nasal intubation in clinical practice are the patients with underlying pathologies in neck or facial region. In this group of patients, nasal intubation is more difficult compared to those having normal airway. Hence the results of our study cannot be extrapolated to patients with difficult airway. Second, NTI was performed by two experienced anaesthesiologists who had previously used both techniques in 20 patients each. Therefore, the results observed may differ with inexperienced operators. Third, it was not possible to achieve blinding of operators in the study; but as all the parameters were measured objectively, there is less likelihood of operator bias in results.

CONCLUSION

Thermosoftened ETT during NTI can be successfully navigated from oropharynx to glottis using modified ETT with curvature control or by cuff inflation method. Use of either of these two techniques, obviates the need for manipulation of ETT with Magill's forceps and hence associated complications with instrument such as cuff rupture, trauma to oropharyngeal mucosa can be averted.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Annexure I: Scales used for grading ease of navigation of ETT during phase 2 (IA), phase 3 (IB) of NTI and for scaling severity of nasal bleed during NTI (IC)

IA: Ease of navigation of ETT from oropharynx to glottis

Grade I- Smooth engagement of ETT from oropharynx to glottic inlet

Grade II-ETT tip was lateral to the glottic inlet, gentle external laryngeal manipulation was done to engage tip to laryngeal inlet

Grade III- It was not possible to engage tube tip at the glottis inlet.

IB: Ease of navigation of ETT from glottic inlet to trachea

Grade I- Passage of ETT down the trachea without any resistance

Grade II- ETT abutting in anterior tracheal wall and required clockwise rotation for disengagement

Grade III- Magill's forceps were required for advancing ETT down the trachea

IC: Severity of nasal bleed during NTI

Mild-blood stains over outer surface of the ETT

Moderate-mild blood trickle present in the oropharynx.

Severe-large amount of blood in oropharynx, which obscured vision and required suctioning

ETT-Endotracheal tube; NTI-Nasotracheal intubation