Role of endotracheal tube size on nasal and laryngeal morbidity during awake fiberoptic nasotracheal intubation: A Randomized controlled trial

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Abstract

Background and Aims: Awake fibreoptic nasotracheal intubation is associated with adverse airway and hemodynamic complications. The aim of this study was to evaluate the role of endotracheal tube size on nasal and laryngeal morbidity during awake fibreoptic-guided nasotracheal intubation.

Material and Methods: Eighty patients recruited to undergo awake fibreoptic intubation were randomly allocated to Group C (standard size endotracheal tube) and Group S (small size endotracheal tube followed by exchange to standard size using Airway Exchange Catheter under general anesthesia). Nasal morbidity was assessed by incidence of epistaxis, olfactory acuity, and mucociliary clearance. Patient discomfort during intubation was assessed using grimace score and hemodynamic parameters were recorded. Postoperatively, the incidence of nasal and laryngeal injury was recorded using nasendoscopy and telelaryngoscopy, respectively.

Results: Demographic profile between the two groups was comparable. Epistaxis was noted in 47.5% of patients in group C as compared to 12.5% in group S. Postoperative olfactory acuity was decreased [2 (1-4) vs 4 (2-5)] and saccharin clearance time was prolonged (314 s vs 134 s) in Group C as compared to Group S. (P-value <0.001) Higher grimace score [2 (1-3) vs 1 (0-2)] and increased hemodynamic response was demonstrated in Group C. (P-value <0.001) Incidence of nasal injury [2 (1-4) vs 1 (0-2)] and laryngeal injury [1 (0-2) vs 0 (0-2)] was more in Group C as compared to Group S.

Conclusion: Awake fibreoptic nasotracheal intubation with small size endotracheal tube followed by exchange to standard size under general anesthesia reduces nasal, laryngeal, and hemodynamic complications.

Keywords: Anesthesia, bronchoscopy, intubation, morbidity, nasopharynx

Introduction

Awake fibreoptic nasotracheal intubation (AFNI) is an established technique for securing the airway in patients with the potential difficult airway. But this technique is invariably associated with nasal, laryngeal, and hemodynamic complications. In order to reduce nasal complications, various measures have been proposed which include adequate topicalization of the airway, lubrication of endotracheal tube (ETT), use of vasoconstrictors, thermo softening of ETT,[1] telescoping tracheal tubes over red rubber catheters,[2] and nasopharyngeal catheters.[3]

Despite all these modifications, the incidence of nasal and laryngeal complications with AFNI is still high. Various
authors have proposed that, the use of smaller ETTs can significantly reduce these complications. However, continuing with smaller ETT throughout the intraoperative period makes them prone for kinking and narrowing, which can lead to increased peak airway pressures. So, it is prudent to use a small size ETT for AFNI, and then replace it with an appropriate size ETT after induction of anesthesia with the help of an airway exchange catheter (AEC). We hypothesized that initial awake intubation with smaller ETT followed by an exchange with a standard size ETT under general anesthesia will reduce nasal and laryngeal complications. The primary outcome was nasal morbidity, which was assessed by incidence of epistaxis, olfactory acuity, and mucociliary clearance. The secondary outcomes were laryngeal morbidity, hemodynamic disturbances, and patient acceptance.

**Material and Methods**

After obtaining institute ethics committee approval (06/01/2015, JIP/IEC/2014/9/463), this prospective randomized controlled study was registered in Clinical Trial Registry of India (CTRI/2015/10/006292) and was conducted in a tertiary care center between February 2015 and March 2017. After getting written informed consent, 80 patients aged 18–70 years belonging to American Society of Anaesthesiologists (ASA) 1 and 2 physical status scheduled to undergo surgeries under general anesthesia requiring AFNI (Oral and maxillofacial surgeries with restricted mouth opening) were included in this study. Patients with the history of obstructive sleep apnea, nasal trauma, nasal surgery, bleeding diathesis, infection of the upper airway, recently base of the skull fracture, patients on anticoagulant therapy, patients who are hypertensive, and patients in whom postoperative ventilation was anticipated were excluded from the study. Patients satisfying inclusion criteria were randomized into two groups, Group C and Group S by a computer-generated random number tables and allocation was done using a closed envelope technique by the anesthesiologist. In Group C, AFNI was done using standard size polyvinyl chloride (PVC) ETT and in Group S, AFNI was done using smaller size ETT followed by exchange to standard size ETT under general anesthesia [Figure 1].

Attending anesthesiologist did a routine pre-anesthetic assessment a day prior to surgery and an otolaryngologist evaluated the nasal and laryngeal anatomy by using anterior rhinoscopy and telelaryngoscopy, respectively. The nostril to be intubated was determined on the basis of anterior rhinoscopy findings. Mucociliary clearance was assessed by saccharin clearance test where a saccharin particle was placed on the medial surface of the inferior turbinate of the selected nostril and the patient was asked to report as soon as the taste is noted. The time from the initial placement to the perception of the sweet taste was recorded as the saccharin clearance time. Similarly, olfactory acuity was assessed by serial dilution of butanol where 4% butanol was diluted with deiodinised saline at 1:1 ratio. Patients were asked to smell the solutions through the selected nostril with the other nostril closed in the ascending order starting from the most diluted to the least diluted and a score was given accordingly i.e., 1 for the most diluted (0.0078%) and 10 for the least diluted (4%). All patients were pre-medicated with tab. diazepam 0.1 mg/kg in the night before surgery and the selected nostril was prepared with xylometazoline nasal drops in the morning of the surgery. In the operating room, after applying standard monitors, baseline heart rate and blood pressure were recorded. Injection midazolam 1 mg IV was given for sedation. Patient’s airway was anesthetized as follows: nasal cavity with lignocaine 4% soaked packs, oral cavity with 10% lignocaine spray and glottis with trans-tracheal injection of 2 ml of 4% lignocaine. In Group C, AFNI was attempted with fiberoptic bronchoscope (3.7 mm) and pre-warmed standard size polyvinyl chloride (PVC) ETT (Male 7.0 mm and Female 6.5 mm). Once tube position was confirmed, patient was induced with sevoflurane and paralyzed with vecuronium. In Group S, AFNI was attempted using a pre-warmed smaller size ETT (5.5 mm in both sexes) and once tube position was confirmed, anesthesia was induced with sevoflurane. After ensuring adequate depth of anesthesia, small size ETT was replaced with pre-warmed standard size ETT using an AEC. After confirming the tube position, the patient was paralyzed using vecuronium. After 2 mins, suctioning of oropharynx was done using 14F suction catheter and any presence of blood in the catheter was noted. Number of attempts required for both awake intubation and tube exchange was recorded. Any difficulty during intubation
like hung-up of ETT was also noted and any additional maneuvers, required to facilitate intubation like rotation of the ETT was also recorded. Patient’s acceptance of ETT during awake intubation was measured using grimace score [Table 1]. Intubation time was taken as the time from insertion of the tip of the fibreoptic bronchoscope into the nostril to the appearance of capnograph waveform. Tube exchange time was defined as the time of disconnection of the circuit from the smaller tube to the appearance of capnograph waveform with standard ETT. Any failed attempt of exchange would be managed with re-insertion of small size ETT. Tracheostomy kit and transtracheal jet ventilation was kept ready for emergency oxygenation and ventilation. At the end of surgery, all patients were extubated on-table when they were fully awake. In the postoperative period, after 1 hr, both anterior rhinoscopy and tele-laryngoscopy were repeated by the otolaryngologist, who was blinded of the intervention to record any nasal and laryngeal injury and graded as shown in Table 1. Saccharin clearance test and butanol smell test were repeated postoperatively after 4 hours.

Sample size was calculated based on the previous report of 33% incidence of epistaxis with standard size ETT.[4] Each group required 37 patients to detect a 25% difference in the incidence of epistaxis with an $\alpha$ error of 0.05 and power of 80%. To compensate for any dropouts, 40 patients in each group were recruited. Data collected were analyzed using SPSS statistical software (Statistical Package for Social Sciences SPSS Inc., Chicago, IL, version 20.0 for Windows). Parametric data of the two groups were compared and analyzed using the unpaired student’s $t$-test. The Mann-Whitney $U$-test was used to compare non-parametric data between the groups. Hemodynamic parameters were analyzed using repeated measures analysis of variance (ANOVA) and Bonferroni’s test for post-hoc significance. Unpaired Student’s $t$-test was used to measure the significance in hemodynamic response between the two groups. Time taken for intubation and number of attempts were compared using unpaired t-test. All statistical analysis tests were two-tailed and a $P$ value <0.05 was taken as significant.

**Results**

All the demographic parameters like age, sex, ASA grade and the nostril selected were comparable between the groups [Table 2]. Preoperative saccharin clearance time and olfactory acuity between Group C and Group S were also comparable. Postoperatively, saccharin clearance time increased by 314 seconds in Group C when compared to 134 seconds in Group S; $P < 0.001$. Olfactory acuity was significantly reduced in Group C (Median 4) when compared to Group S (Median 2); $P$ value <0.001 [Table 3]

All patients in both groups were intubated in the first attempt. Patients in group C had significantly higher grimace scores (Median 2) when compared to Group S (Median 1); $P$ value <0.001. Nasal injury score was found to be significantly higher in Group C (Median 2) when compared to Group S (Median 1); $P$ value <0.001. Similarly laryngeal injury score was also found to be

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### Table 1: Grading of grimace score,[15] nasal and laryngeal injury score

| Score | Definition |
|-------|------------|
| Grimace score | |
| 0 | No change in the facial expression |
| 1 | A single change in the facial expression |
| 2 | Grimacing facial expressions |
| 3 | Severe facial grimace but without reflex head movements |
| 4 | Severe facial grimace associated with discomforting head movements |
| 5 | Severe facial grimace associated with protective head and limb movements |
| Nasal injury score | |
| 0 | No injury to septum, floor or turbinates. No mucosal edema |
| 1 | Mild abrasions in septum, floor or turbinates with or without mucosal edema |
| 2 | Lacerations involving either septum or turbinates with mucosal edema and epistaxis |
| 3 | Lacerations involving septum and turbinates with mucosal edema and epistaxis |
| 4 | Avulsions of the septum or turbinates with epistaxis. |
| Laryngeal injury score | |
| 0 | No injury to glottis or supra-glottis |
| 1 | Mild abrasion in glottis or supra-glottis |
| 2 | Lacerations involving glottis or supra-glottis with mucosal edema |
| 3 | Lacerations involving glottis or supra-glottis with mucosal edema along with restricted mobility of the cords |
| 4 | Lacerations involving glottis and supra-glottis with mucosal edema, restricted mobility of the cords and inadequate glottic airway |
Table 2: Demographic characteristics of the patients

| Parameters                   | Group C (n=40) | Group S (n=40) | P       |
|------------------------------|----------------|----------------|---------|
| Age (in years)               | 32.38±11.97    | 36.03±12.63    | <0.001* |
| Sex (Male/Female)            | 38/2           | 36/4           |         |
| ASA grade (1/2)              | 37/3           | 33/7           |         |
| Nostril selected (Right/Left)| 29/11          | 24/16          |         |

Data expressed as mean±SD and numbers

Table 3: Comparison of study parameters between Group C and Group S

| Parameters                   | Group C (n=40) | Group S (n=40) | P       |
|------------------------------|----------------|----------------|---------|
| Saccharin clearance time (s) | 482.63±110.30  | 438.75±105.60  | 0.073   |
| Pre-op                       | 796.65±135.23  | 573.30±133.04  | <0.001* |
| Post-op                      |                |                |         |
| Olfactory acuity score       | 1 (1-2)        | 1 (1-2)        | 0.644   |
| Pre-op                       | 4 (2-5)        | 2 (1-4)        | <0.001* |
| Post-op                      | 2 (1-3)        | 1 (0-2)        | <0.001* |
| Grimace Score                | 2 (1-4)        | 1 (0-2)        | <0.001* |
| Nasal injury score           | 2 (1-4)        | 1 (0-2)        | <0.001* |
| Laryngeal injury score       | 1 (0-2)        | 0 (0-2)        | <0.001* |
| Epistaxis                    | 19/40 (47.5%)  | 5/40 (12.5%)   | <0.001* |
| Hung up of tube at larynx    | 10/40 (25%)    | 4/40 (10%)     | <0.001* |
| Intubation time (s)          | 139.73±38.35   | 78.40±43.35    | <0.001* |
| Exchange time (s)            | -              | 36.2±5.36      |         |
| ETCO₂ (mmHg)                 | 44.75±4.76     | 41.38±3.51     | <0.05*  |

Data expressed as median (range), mean±SD, Percentage. *P<0.05

During nasotracheal intubation, the two most common areas of resistance to passage are at the level of the turbinate and at the posterior nasopharynx. Various techniques have been established to reduce the nasal injury associated with AFNI. In our study, we used smaller ETT for awake intubation and found that the incidence of epistaxis was significantly less (12.5%) as compared to the standard ET tube (47.5%). Ahmed-Nusrath et al. suggested that endotracheal intubation through the nose follows two pathways: the inferior pathway along the floor of the nose and the upper pathway between the inferior and middle turbinate. They proposed that standard PVC tubes predominantly pass through the upper pathway and produce more nasal injury. In our study, the fiberoptic bronchoscope acted as a pathfinder for railroading the ETTs through the nose and it was free to lie along the upper or lower pathway of the nose. In group S, as the initial intubation was done with the smaller ETT, it probably took the lower pathway, which explains the decreased incidence of epistaxis. Despite the introduction of the second ETT through the nose under general anesthesia, which was expected to negate all the beneficial effects of the smaller ETT, in our study, it was found that all the beneficial effects of the smaller ETT were still preserved. This was probably due to the AEC tracing the smaller tube’s path when exchanging, thus forcing the standard size ETT to choose the lower pathway as the preferential passage despite the tube being larger.

Discussion

This study demonstrated that AFNI with smaller size tube followed by exchange to standard tube under anesthesia resulted in decreased nasal and laryngeal morbidity. Patients in the study group also had good acceptance of ETT as well as reduced hemodynamic changes as compared to the control group.

AFNI is often complicated by epistaxis, creation of false mucosal passage, avulsion of nasal polyps, rupture of ETT cuff, septal perforation, etc. Various techniques have been established to reduce the nasal injury associated with AFNI. In our study, we used smaller ETT for awake intubation and found that the incidence of epistaxis was significantly less (12.5%) as compared to the standard ET tube (47.5%). Ahmed-Nusrath et al. suggested that endotracheal intubation through the nose follows two pathways: the inferior pathway along the floor of the nose and the upper pathway between the inferior and middle turbinate. They proposed that standard PVC tubes predominantly pass through the upper pathway and produce more nasal injury. In our study, the fiberoptic bronchoscope acted as a pathfinder for railroading the ETTs through the nose and it was free to lie along the upper or lower pathway of the nose. In group S, as the initial intubation was done with the smaller ETT, it probably took the lower pathway, which explains the decreased incidence of epistaxis. Despite the introduction of the second ETT through the nose under general anesthesia, which was expected to negate all the beneficial effects of the smaller ETT, in our study, it was found that all the beneficial effects of the smaller ETT were still preserved. This was probably due to the AEC tracing the smaller tube’s path when exchanging, thus forcing the standard size ETT to choose the lower pathway as the preferential passage despite the tube being larger.

Significant increase in heart rate and mean blood pressure was noted in Group C during railroading of the ETT as compared to Group S. The hemodynamic response during the exchange of ETT was not statistically significant when compared to the baseline [Figure 2].

Intubation time was also lesser in Group S when compared to Group C. It took an average time of 78 seconds to establish the airway in Group S whereas, in Group C, it took 139 seconds for intubation. Decreased intubation time in Group S was due to the smaller size tube used during initial intubation, as there was decreased resistance at both nasal and laryngeal level.
during rail-roading of the ETT. This also led to better patient acceptance and hemodynamic stability compared to standard size ETT. Though O’Connell et al., in their study found that nasal intubation was not associated with physiological changes in the nose,[7] in our study we noted that nasal intubation affected the olfactory and mucociliary functions of the nose as shown by increased saccharin clearance time and butanol olfaction scores in both the groups. However, the increase in saccharin clearance time and olfaction acuity scores was significantly lesser in Group S as compared to Group C. This indicates the significant delay in the return of ciliary function and normal olfaction in patients intubated with standard size ETT as compared to small size ETT.

Laryngeal injury can occur during repeated attempts of AFNI and during railroading of the tube due to impingement at the level of arytenoids,[8] which in turn can lead to bleeding and edema of the laryngeal tissues.[9] Maktabi et al. reported cases of laryngeal dysfunction in the form of laryngeal edema, vocal cord dysfunction particularly when there is hung up of the ETT at the laryngeal inlet.[10] In order to reduce these complications, use of smaller tube, flexible tubes,[11] or thicker fiberscope,[12] has been proposed. The smaller the gap between the fiberscope and the ETT, the lesser is the chance of hung up. Use of larger diameter ETT leads to increased gap between the bronchoscope and tube which results in contact between the ETT bevel and laryngeal structures, increasing the risk of injury.[13] In group S, the smaller ETT ensured a smooth passage through the cords as there was no resistance to intubation at the level of the larynx. Though the smaller tube was exchanged to standard tube in this group also, there was no coughing or straining during exchange as it was performed under anesthesia. This resulted in decreased

![Figure 2: Change in heart rate and mean blood pressure during AFNI between Group C (— ■ —) and Group S (‑ ‑ ● ‑).](image-url)
incidence of laryngeal edema in the postoperative period. In our study, the incidence of hung up and the extent of laryngeal morbidity was assessed, and it was significantly less in group S as compared to the control group. The smaller ETT not only was helpful in decreasing the incidence of epistaxis but also proved to have a lesser incidence of hung up at the laryngeal inlet.

Hemodynamic responses were well-recognized hazards during AFNI. Though these effects were found to be insignificant and short lasting in healthy patients, it may cause adverse cardiovascular events in patients with cardiovascular disease.\(^\text{[14]}\) Hemodynamic responses were found to be reduced by adequate topical anesthesia of the airway. In a study done by Kundra et al., combined regional nerve block was found to be better in suppressing hemodynamic responses as compared to nebulization.\(^\text{[15]}\) So, in our study, we also used nasal packing with regional blocks over nebulization technique.

One of the limitations of this technique was the transient loss of airway during the exchange in a patient with difficult airway. In patients with difficult airway, extubation using an AEC has been proposed by various national societies and there is sufficient evidence reported in literature to have good success rate of reintubation, if required.\(^\text{[16]}\) Though there is a rare possibility of failure to railroad the standard ETT over AEC, as a safety measure, spontaneous ventilation of patients were maintained under general anesthesia as they were not paralyzed till the exchange was completed. During any untoward event, as a rescue measure, the small size ETT can be re-inserted for maintenance of oxygenation and ventilation.

Thus, awake fiberoptic intubation with small size ETT followed by exchange to standard size ETT using AEC under general anesthesia reduces nasal, laryngeal, and hemodynamic complications.

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**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Kim YC, Lee SH, Noh GJ, Cho SY, Yeom JH, Shin WJ, et al. Thermostottingen treatment of the nasotracheal tube before intubation can reduce epistaxis and nasal damage. Anesth Analg 2000;91:698–701.
2. Watt S, Pickhardt D, Lerman J, Armstrong J, Creighton PR, Feldman L. Telescoping tracheal tubes into catheters minimizes epistaxis during nasotracheal intubation in children. Anaesthesiology 2007;106:238–42.
3. Enk D, Palmes AM, Van Aken H, Westphal M. Nasotracheal intubation: A simple and effective technique to reduce nasopharyngeal trauma and tube contamination. Anesth Analg 2002;95:1432–6.
4. Elwood T, Stillions DM, Woo DW, Bradford HM, Ramamoorthy C. Nasotracheal intubation: A randomized trial of two methods. Anaesthesiology 2002;96:51–3.
5. Prasanna D, Bhat S. Nasotracheal intubation: An overview. J Maxillofac Oral Surg 2014;13:366–72.
6. Ahmed-Nusrath A, Tong JL, Smith JE. Pathways through the nose for nasal intubation: A comparison of thr. O’Connell JE, Stevenson DS, Stokes MA. Pathological changes associated with short-term nasal intubation. Anesthesiology 1996;96:347–50.
7. Johnson DM, From AM, Smith RB, From RR, Maktabi MA. Endoscopic study of mechanisms of failure of endotracheal tube advancement into the trachea during awake fiberoptic orotracheal intubation. Anaesthesiology 2005;102:910–4.
8. Heidegger T, Starzyk L, Villiger CR, Schumacher S, Studer R, Peter B, et al. Fiberoptic intubation and laryngeal morbidity: A randomized controlled trial. Anesthesiology 2007;107:585–90.
9. Maktabi MA, Hoffman H, Funk G, From RP. Laryngeal trauma during awake fiberoptic intubation. Anesth Analg 2002;95:1112–4.
10. Brull SJ, Wiklund R, Ferris C, Connelly NR, Ehrenwerth J, Silverman DG. Facilitation of fiberoptic orotracheal intubation with a flexible tracheal tube. Anesth Analg 1994;78:746–8.
11. Hakala P, Randell T, Väli H. Comparison between tracheal tubes for orotracheal fiberoptic intubation. Br J Anaesth 1999;82:135–6.
12. Kundra P, Garg R, Patwa A, Ahmed SM, Ramkumar V, Shah A, et al. All India Difficult Airway Association 2016 guidelines for the management of anticipated difficult extubation. Indian J Anaesth 2016;60:915–21.