Effect of air, anesthetic gas mixture, saline, or 2% lignocaine used for tracheal tube cuff inflation on coughing and laryngotracheal morbidity after tracheal extubation

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Abstract

Background and Aims: Coughing and sore throat postoperatively are common clinical problems during general anesthesia which can be avoided by various methods including topicalization of airway with local anesthetics, endotracheal tube cuff (ETT) inflation with local anesthetics, use of intravenous drugs such as dexamethasone, maintaining ETT cuff pressure, intubation by an experienced anesthesiologist, etc. The aims of the study were to compare postextubation coughing response, mean number of cuff deflations required intraoperatively, and postoperative airway morbidity in terms of sore throat (2 h and 18–24 h), hoarseness of voice, and dysphagia following inflation of ETT cuff with air, anesthetic gas mixture, saline, and 2% lignocaine during general anesthesia.

Material and Methods: One hundred and four patients were randomized into 1 of 4 groups depending on whether air, anesthetic gas mixture, saline, or 2% lignocaine was used to inflate the cuff of ETT using computer-generated randomization table.

Results: There was no significant difference in the postextubation cough response among the four groups. The mean number of times the ETT cuff was deflated was significantly in favor of liquid media compared to gaseous media (P < 0.001). The incidence of sore throat at 2 h and at 18–24 h, hoarseness of voice, and dysphagia were comparable in all groups.

Conclusion: ETT cuff inflation with air, anesthetic gas mixture, 2% lignocaine, and saline are comparable in terms of incidence of postextubation cough and postoperative airway morbidity symptoms such as sore throat, hoarseness of voice, and dysphagia.

Keywords: Cough, intubation, postoperative, sore throat

Introduction

Coughing and sore throat postoperatively are common clinical problems during general anesthesia. Intracuff pressure results in irritant or stretch stimuli in trachea, which in turn results in laryngotracheal morbidity. Coughing during emergence can result in hypertension, tachycardia, increase in intraocular and intracranial pressure, myocardial ischemic changes, and bronchospasm. Coughing during extubation is significant in neurosurgical, ophthalmic, and vascular procedures. The recommended methods of preventing cough response during extubation are intravenous or topically applied local anesthetics, intravenous narcotics, or tracheal extubation during deep plane of anesthesia, each of which have their own limitations. When the lateral pressure exerted by an inflated cuff on tracheal mucosa exceeds capillary perfusion pressure, it can result in tracheal morbidity, loss of mucosal cilia, ulceration, hemorrhage, and tracheal stenosis.

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Patients may complain of sore throat, hoarseness, and dysphagia in the postoperative period.

Usually air is used for inflating the cuff of endotracheal tube (ETT) and nitrous oxide is used to maintain anesthesia with another volatile anesthetic agent, which can diffuse into the air interface of the cuff faster than nitrogen can escape, resulting in an increase in volume and pressure inside the air filled cuff. Different methods have been recommended for controlling intracuff pressure when nitrous oxide is used as a component of general anesthesia. These include regular measurement and adjustment of cuff pressure, Lanz pressure regulatory system, use of different concentration of nitrous oxide with gas mixtures, etc. Filling the ETT cuff with liquid medium, such as saline, can also be used to prevent increase in cuff pressure due to diffusion of nitrous oxide. Use of local anesthetics such as lignocaine could further benefit in addition to the use of normal saline as ETT cuff is permeable to local anesthetics and diffuses across cuff membrane. There are no studies comparing both liquid and gaseous media for cuff inflation using equated pressure measurement systems. Thus, we aimed to compare the effect of air, saline, anaesthetic gas mixture, and 2% lignocaine used for ETT cuff inflation.

Further, we planned to use anesthetic gas mixture from the sampling line of 1% isoflurane in oxygen as one of the media for cuff inflation, which has not been done before. Our primary aim was to assess the incidence of postextubation coughing among the groups. Secondary aims included the number of cuff deflations needed intraoperatively to maintain baseline cuff pressure values and postoperative laryngotracheal morbidity measured in terms of sore throat, dysphagia, and hoarseness of voice.

Material and Methods

This study was designed as a prospective, double-blind, and randomized controlled trial. Approval was obtained from the departmental dissertation committee and institutional ethics committee. Inclusion criteria were patients belonging to the American Society of Anaesthesiologists–Physical Status 1 or 2 scheduled for elective surgery below neck under general anesthesia with endotracheal intubation, age group between 18 and 60 years, estimated duration of surgery more than 60 min and less than 180 min, and body mass index (BMI) <30 kg/m². Patients with a history of smoking, laryngotracheal diseases, nasogastric tube in situ, oropharyngeal airway introduced perioperatively or more than one trial of intubation, history of increased intracranial pressure, intraocular pressure, ischemic heart disease, history of recent upper respiratory tract infection, having full stomach, history of gastric regurgitation, requiring rapid sequence induction, with anticipated difficult airway, and those undergoing laparoscopic surgeries were excluded.

Patients were evaluated the day prior to the surgery; the nature of the study and grading system was explained and informed consent was obtained from all the patients. They were kept nil per oral as per the standard guidelines (solids 6 h and clear fluids 3 h). Premedication with 0.25 mg alprazolam (if weight <50 kg) and 0.50 mg alprazolam (if weight >50 kg) was given. Patients were randomized into 1 of 4 groups depending on whether air (Group A), anesthetic gas mixture (Group G), saline (Group S), or 2% lignocaine (Group L) was used to inflate the cuff of ETT, with the use of a computer-generated randomization table. There were three observers in the study; the first observer was the anesthesia consultant who performed laryngoscopy, intubation, and assessed post extubation coughing. The second observer was the anesthesia resident who performed the preoperative evaluation, got informed consent, and inflated the cuff with air, anesthetic gas mixture, saline, or 2% lignocaine. The third observer was the postoperative ICU nurse, ward nurse, or anesthesia resident who assessed sore throat, hoarseness, and dysphagia (blinded to the study).

On the day of the surgery, after shifting to the operating room, the patients were monitored with electrocardiogram, noninvasive blood pressure monitoring, pulse oximetry, endtidal CO₂ monitoring, and intravenous access was secured. Patients were positioned with head on standard pillow and preoxygenated for 3 min with 100% oxygen. Induction sequence included IV fentanyl 2 μg/kg, and IV Propofol 2 mg/kg. Additional doses of Propofol were given as required. Ability to mask ventilate was confirmed, and patients were paralyzed with IV vecuronium bromide 0.1 mg/kg to facilitate tracheal intubation. Anesthesia was deepened with isoflurane 1% in 100% oxygen at 5 L/min. Laryngoscopy was performed by observer 1, and trachea was intubated with Portex® (Smiths Healthcare Manufacturing S.A., California, USA), PVC, soft seal, high volume, low pressure, cuffed, oral ETT of appropriate size (Males – size 8 mm internal diameter and Females – size 7.5 mm internal diameter). As per group allocation, the following interventions were done to inflate the cuff. In Group A, cuff was inflated with 4–6 ml of air using a 10-ml syringe and pressure was adjusted at ≈26 cmH₂O using aneroid manometer (baseline value). In Group G, anesthetic gas mixture of oxygen 5 L/min and isoflurane 1% similar in concentration to inspired gas mixture was obtained just prior to intubation from the inspiratory limb tubing using an heat moisture exchanger and three-way stopcock and ETT cuff was inflated with 4–6 ml of gas mixture and pressure was adjusted at ≈26 cmH₂O [Figure 1]. In Group S and Group L, the cuff was filled with 4–6 ml of normal saline and 2% lignocaine,
respectively, and cuff pressure was adjusted at the baseline value of \( \approx 18 \text{ mmHg} \) using pressure transducer kit (Figure 2). The cuff pressure measurement for liquid media was done with a saline filled pressure transducer. It was set up as follows, at one end 500 ml of 0.9% sodium chloride was connected to an IV infusion set, and to the other end, a noncompliant tubing was connected with three-way stopcock at either end. Three-way tap between the transducer and noncompliant tubing was known as T1 and three-way tap towards other end was known as T2. Entire pressure measuring unit was filled with saline up to T2. T2 was connected to the pilot balloon of appropriate size ETT. A 10-ml syringe was connected to the remaining part of T2, which was used for inflation and deflation. Zeroing was done with T1. In all groups, after inflating cuff to the baseline value, audible leak was checked around the tube when positive pressure was administered at 20 cmH\(_2\)O. Intracuff pressure was continuously monitored in all the groups and was documented every 15 min throughout the surgery. Anesthesia was maintained with isoflurane 1% and nitrous oxide (2 L/min) and oxygen (1 L/min) as 66:33 ratio on controlled mechanical ventilation and intermittent vecuronium bromide was given, as required. At the end of the surgery, once the patients made a few breathing attempts, the residual neuromuscular blockade was reversed with IV neostigmine 0.05 mg/kg and glycopyrrolate 0.01 mg/kg. Oropharyngeal suctioning was done gently to avoid any trauma to pharyngeal structures using a bite block. Once patients were fully awake, with intact gag reflex, the trachea was extubated.

We noted the following parameters: type of procedure and total duration of surgery, intubation time, which was defined as the time from the insertion of laryngoscope blade tip to the appearance of capnographic reading on the monitor. The number of times the cuff was deflated to maintain the set baseline values was also noted. Coughing was noted postextubation. Airway morbidity was measured by the parameters of sore throat, dysphagia, and hoarseness of voice. Sore throat was noted at 2 h and 18–24 h. It was graded as 0 – no sore throat, 1 – mild (scratch throat), 2 – moderate (similar to that noted with cold), 3 – severe (more severe than cold). Dysphagia was graded at 18–24 h as 0 – no dysphagia, 1 – mild (pain on swallowing solids), 2 – moderate (pain on swallowing liquids), 3 – severe (pain on swallowing saliva). Hoarseness of voice was graded at 18–24 h as Grade 0 – (none) no hoarseness of voice, Grade 1 – (mild) noted by the patient, Grade 2 – (moderate) obvious to observer, Grade 3 – (severe) aphonia, patient not able to speak.

Based on a pilot study done on 16 patients, with 4 in each group, considering a difference of 25% in the presence of cough at extubation between groups as significant, and power of study of 80% and level of significance 5%, the sample size was calculated to be 104. The study involved 26 patients in
each group. The data were analyzed using SPSS Version 16.0. SPSS Inc, Chicago, Illinois, USA. Chi-square test and analysis of variance were applied as appropriate. Student Newman Keuls test was used for intergroup comparisons. A P value of <0.05 was considered statistically significant.

Results

Demographic data and duration of surgery were comparable amongst the four groups [Table 1]. The time taken to intubate in each group was comparable. The number of times the ETT cuff had to be deflated in each group was significantly different between the groups where liquid media was used as compared to gas media being used for cuff inflation. The mean number of cuff deflations were lesser in Group S and L in comparison to Group A and G. A majority of patients coughed after extubation in all the groups but there was no significant difference between the groups. Sore throat was present at two hours in 14 out of 104 (13.5%). The incidence in Group G was highest with 5 patients developing sore throat, and least in Group L but this was statistically not significant. Eight (7.7%) patients had sore throat at 18–24 hours and the incidence was comparable in all groups [Table 2]. Sore throat, when present, was graded as Grade 1 (mild) by all patients at both points of time. None of the patients in our study had dysphagia or hoarseness of voice. None of the patients had leak around the cuff after cuff inflation with any media. There was no incidence of cuff rupture or blood staining of the ETT cuff.

Discussion

General anesthesia administered via cuffed ETT is a commonly used technique in adult patients undergoing surgery. Some complications of tracheal intubation which can be distressing to the patient include postoperative sore throat (POST), cough, hoarseness of voice, and dysphagia with an incidence varying from 40–100%. This can be attributed to trauma and nerve damage to structures in the throat.[1‑4] These symptoms are so common that, in some cases, the patients and the anesthesia staff believe that they are a natural consequence of endotracheal intubation.[5] Such symptoms can be influenced by lots of factors including sex, gender, size and pressure of ETT cuff, duration of intubation, patient position, and the anesthesiologist’s experience.[6‑9] Postextubation coughing during emergence from general anesthesia and in the postanesthesia care unit can result in

| Table 1: Demographic data |
|---------------------------|
| Demographic data          | Group A | Group G | Group S | Group L | P       |
| Age (years) Mean±SD       | 42.00±11.90 | 41.69±15.18 | 38.38±10.55 | 40.62±11.59 | 0.717  |
| Gender (n)                |         |         |         |         |         |
| Male                      | 10      | 9       | 8       | 14      |         |
| Female                    | 16      | 17      | 18      | 12      |         |
| BMI (kg/m²) Mean±SD       | 24.10±2.98 | 24.15±2.42 | 24.51±2.16 | 23.53±2.15 | 0.578  |
| Duration of surgery (min) Mean±SD | 115.38±35.69 | 100.96±28.32 | 114.81±25.08 | 113.08±29.16 | 0.261  |

SD=Standard deviation; BMI=Body mass index

| Table 2: Intubation and extubation characteristics |
|-----------------------------------------------|
| Intubation and extubation characteristics      | Group A | Group G | Group S | Group L | P       |
| Time taken for intubation (s) Mean±SD          | 19.92±2.67 | 18.62±3.07 | 20.12±3.02 | 20.81±3.18 | 0.069  |
| Number of ETT cuff deflations Mean±SD          | 2.12±1.11 | 2.38±1.02 | 0.42±1.06 | 0.35±1.02 | <0.001* |
| Number of patients who coughed after extubation n (%) | 18 (69.2%) | 17 (65.4%) | 22 (84.6%) | 20 (76.9%) | 0.399  |
| Yes                                          |         |         |         |         |         |
| No                                           | 8 (30.8) | 9 (34.6) | 4 (15.4) | 6 (23.1) |         |
| Sore throat at 2 hours post extubation n (%)   |         |         |         |         |         |
| Yes                                          | 22 (84.6%) | 21 (80.8%) | 23 (88.5%) | 24 (92.3%) | 0.648  |
| No                                           | 4 (15.4%) | 5 (19.2%) | 3 (11.5%) | 2 (7.7%) |         |
| Sore throat at 18-24 hours post extubation n n (%) | 24 (92.3%) | 23 (88.5%) | 25 (96.2%) | 24 (92.3%) | 0.781  |
| Yes                                          |         |         |         |         |         |
| No                                           | 2 (7.7%) | 3 (11.5%) | 1 (3.8%) | 2 (7.7%) |         |

*P<0.05 is statistically significant; ETT=Endotracheal tube
potentially dangerous complications such as hypertension, cardiac dysrhythmias, myocardial ischemia, surgical bleeding, bronchospasm, raised intraocular and intracranial pressure.\textsuperscript{[10]}

We used high volume low pressure cuffed ETT of standardized sizes in our study. Although the high-volume cuffs caused a greater area of damage to the tracheal mucosa, the damage was more superficial than that caused by the high-pressure cuffs.\textsuperscript{[11]} Hence, it is prudent to measure cuff pressures regularly even when high-volume cuffs are used. We, thus, used Mallinckrodt hand-held pressure manometer to measure the cuff pressure for gas media. We standardized the pressure to \( \approx 26 \text{ cmH}_2\text{O} \) as the range of safe pressures recommended by the manufacturer is 22–32 cmH\(_2\)O. For liquid media, an equivalent pressure of 18 mmH\(_g\), measured through a saline-filled pressure transducer system, was maintained. This system is sensitive and accurate for liquid media. It can be monitored continuously and stored by any anesthesia monitor that has the invasive pressure monitoring option.

In 1965, Eger and Saidman found that a gas-filled space in the body will expand if the gas within it is less soluble in blood and other body fluids than the inspired gas. They showed that nitrous oxide, a gas 34 times more soluble in blood than nitrogen when inspired, increases gas volumes over a period of time.\textsuperscript{[12]} Gas diffusion occurs along a partial pressure gradient, thus nitrous oxide also has the capacity to diffuse into the ETT cuff. This is of concern as the increase in cuff pressure may affect the tracheal mucosal perfusion. The overinflation occuring secondary to nitrous oxide diffusion may be a cause of postoperative glottic and subglottic edema and tracheal mucosal erosion. Various methods have been tried to decrease this increase in cuff pressure. Different cuff filling methods have been suggested such as 100% oxygen, anesthetic gas mixture, saline, lignocaine, and use of alkalinized lignocaine.\textsuperscript{[13–19]} Here we used two different gas media (air and anesthetic gas mixture) and two liquid media (saline and 2% lignocaine). This study demonstrates that the pressure changes in the enclosed air filled ETT cuffs exposed to nitrous oxide are similar to those occurring in enclosed gas filled spaces in the body as evidenced by the higher number of mean cuff deflations with gas media compared to liquid media. The reason for the relatively stable cuff pressure with liquid media is because liquids do not expand when gases dissolve in them. Nevertheless 4 patients in the saline group and 3 in the 2% lignocaine group had cuff pressures crossing the normal range. This may have been due to residual air being left behind in the pilot balloon cuff system.

In our study the incidence of cough in the lignocaine filled cuff group was similar to that in other groups. Sconso et al., showed that slow diffusion of lignocaine occurs via hydrophobic structures in the tube and concluded that the cuff could act as a potential reservoir for a local anaesthetic, allowing diffusion and subsequent anesthesia of the underlying mucosa.\textsuperscript{[17]} Fagan et al. found that inflating the cuff with 4% lignocaine reduced the incidence of postextubation coughing compared to air or saline.\textsuperscript{[14]} We didn’t find this effect, possibly because we used a lower 2% lignocaine solution. This was done considering the possibility of systemic toxicity, as well as the possibility of cuff damage and leakage of the local anesthetic into the bronchial tree.

Also there was evidence that inflation of the cuff with 2% lignocaine

90 min before extubation decreases incidence of sore throat.\textsuperscript{[15]} There are also studies that have demonstrated that there has been no incidence of toxic plasma concentrations of lignocaine when used for airway topicalisation or when used in ETT cuffs.\textsuperscript{[16,18]} One of the practical disadvantages noticed in our study was that the process of inflation and deflation of the cuff takes much longer when liquids are used (Group S and L). And with a small amount of saline or 2% lignocaine, the cuff pressure rises very sharply. Hence, it is preferable to adjust the cuff pressure initially before using a liquid medium for cuff inflation.

We attempted to minimize the preventable risk factors causing postoperative symptoms. For instance, laryngoscopy and intubation was done by an experienced anaesthesiologist; all cases with a history of smoking or laryngotracheal diseases were excluded and a bite block was used for suctioning instead of the oropharyngeal airway. However, our study has a few limitations, one of them being the failure to assess the incidence of possible aspiration in our patients with the cuff inflated with liquid medium. We also did not record the initial and final cuff pressures, instead the intracuff pressure was set to a preset value in each group. Further, the postoperative plasma lignocaine levels were not measured.

We conclude that different media such as air, anesthetic gas mixture, 2% lignocaine, and saline when used for ETT cuff inflation, are comparable in terms of incidence of postextubation cough, and postoperative airway morbidity symptoms such as sore throat, hoarseness of voice, and dyspagia. The mean number of cuff defaltions when liquid media is used in ETT cuff inflation during general anaesthesia involving nitrous oxide is less. This could be an advantage over gaseous media in situations where prolonged exposure to nitrous oxide is likely, as well as in situations where intracuff pressure monitoring becomes difficult such as neurosurgical or ophthalmic surgeries.
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Conflicts of interest
There are no conflicts of interest.

References

1. Agarwal A, Nath SS, Goswami D, Gupta D, Dhiraaj S, Singh PK. An evaluation of the efficacy of aspirin and benzydamine hydrochloride gargle for attenuating postoperative sore throat: A prospective, randomized, single-blind study. Anesth Analg 2006;103:1001–3.
2. Jaensson M, Gupta A, Nilsson UG. Risk factors for development of postoperative sore throat and hoarseness after endotracheal intubation in women: a secondary analysis. AANA J 2012;80:67-73.
3. Hung NK, Wu CT, Chan SM, Lu CH, Huang YS, Yeh CC. Effect on postoperative sore throat of spraying the endotracheal tube cuff with benzydamine hydrochloride, 10% lidocaine, and 2% lidocaine. Anesth Analg 2010;111:882-6.
4. Jaensson M, Olsson LL, Nilsson U. Endotracheal tube size and sore throat following surgery: A randomized-controlled study. Acta Anaesthesiol Scand 2010;54:147-53.
5. Beebe DS. Complications of tracheal intubation. Semin Anesth Perioper Med Pain 2001;20:166-72.
6. Jaensson M, Gupta A, Nilsson UG. Gender differences in risk factors for airway symptoms following tracheal intubation. Acta Anaesthesiol Scand 2012;56:1306-13.
7. Ruangsin S, Wanasuwannakul T, Patteravit N, Asin W. Effectiveness of a preoperative single dose intravenous dexamethasone in reducing the prevalence of postoperative sore throat after endotracheal intubation. J Med Assoc Thai 2012;95:657-60.
8. Biro P, Seifert B, Pasch T. Complaints of sore throat after tracheal intubation: A prospective evaluation. Eur J Anaesthesiol 2005;22:307-11.
9. Loeser EA, Orr DL 2nd, Bennett GM, Stanley TH. Endotracheal tube cuff design and postoperative sore throat. Anesthesiology 1976;45:684-7.
10. Soltani HA, Aghadavoudi O. The effect of different lidocaine application methods on postoperative cough and sore throat. J Clin Anesth 2002;14:15-8.
11. Loeser EA, Hodges M, Gliedman J, Stanley TH, Johansen RK, Yonetani D. Tracheal pathology following short term intubation with low and high pressure endotracheal tube cuffs. Anesth Analg 1978;57:577-9.
12. Saidman LJ, Eger El. Effect of Nitrous Oxide and of Narcotic Premedication on the Alveolar Concentration of Halothane Required for Anesthesia. Anesthesiology 1964;5:302-6.
13. Salman W, Shamim A, Shounthoo R, Gul S. A Comparative Study Between Intracuff Alkalized Lignocaine, Intracuff Plain Lignocaine And Intracuff Air For Decreasing Post Intubation Sore Throat And Emergence Phenomena. IOSR-JDMS 2009:14:2279-81.
14. Fagan C, Frizelle HF, Laffey J, Hannon V, Carey M. The Effects of Intracuff Lidocaine on Endotracheal-Tube-Induced Emergence Phenomena After General Anesthesia. Anesth Analg 2000;91:201-5.
15. Malhotra S, Singh M, Malhotra N. Tracheal morbidity following tracheal intubation: Comparison of air, saline and lignocaine used for inflating cuff. J Anaesthesiol Clin Pharmacol 2007;2:163-167.
16. Estebe, Jean-Pierre, Dollo, Gilles, Le Corre, Pascal, Le Naoures, Alain, Chevanne, François, Le Verge, Roger, Ecoffey, Claude. Alkalinization of Intracuff Lidocaine Improves Endotracheal Tube-Induced Emergence Phenomena. Anesth Analg 2002;94:227-30.
17. Sconzo JM, Moscicki JC, DiFazio CA. In vitro diffusion of lidocaine across endotracheal tube cuffs. Reg Anesth 1990;2:37-40.
18. Sutherland AD, Santamaria JD, Nana A. Patient comfort and plasma lignocaine concentrations during fibreoptic bronchoscopy. Anaesth Intensive Care 1985;13:370-4.
19. Rashmi N R, Shashidhar G S, Balabhaskar S, Kiranchand N. Comparison of intracuff air, lignocaine, lignocaine with sodium bicarbonate and ketamine for attenuating post operative sore throat. MedPulse Int J Anesth. 2017;3:05-8.