Research Paper

Running title: *Cuff Pressure: Air vs Lignocaine*

A Comparative Study of Cuff Pressure Between Air and Alkalinized Lignocaine in General Anaesthesia

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ABSTRACT

Background and Aims

Nitrous oxide (N_2O) diffuses into air-filled endotracheal tube cuffs, increasing intracuff pressure beyond safe limits (>30 cm H_2O) and causing tracheal ischaemia, mucosal damage, and postoperative complications. This study aimed to compare intracuff pressure changes when inflated with air versus alkalinized lignocaine during general anaesthesia with N_2O.

Methods

A prospective, randomised clinical trial was conducted on 50 adult patients (ASA I–II), aged 18–65 years, undergoing elective surgery. Patients were randomised into two groups: Group A received cuff inflation with air (n=25) and Group L received alkalinized lignocaine (19:1 dilution of 2% lignocaine and sodium bicarbonate, n=25), both to 20 cm H_2O baseline pressure. Intracuff pressures were recorded before N_2O administration and thereafter every 30 minutes. Intraoperative haemodynamics, tube tolerance, and postoperative complications (sore throat, cough, hoarseness) were assessed.

Results

Intracuff pressure increased significantly in Group A (31.56±1.64 cm H_2O at end of surgery) compared to Group L (21.21±0.93 cm H_2O), $p<0.0001$. Group L demonstrated better endotracheal tube tolerance at extubation (72% without agitation vs. 40% in Group A, $p=0.045$). Volume deflated from the cuff was significantly higher in Group A (12.30±2.30 ml vs. 8.57±1.96 ml, $p<0.0001$). Postoperative sore throat at 24 hours was significantly lower in Group L (8% vs. 36%, $p=0.04$). Haemodynamic parameters remained comparable between groups. Cough and hoarseness showed no statistically significant differences.

Conclusion

Alkalinized lignocaine cuff inflation effectively prevents excessive cuff pressure rise during N_2O anaesthesia, reduces airway trauma, improves tube tolerance, and decreases postoperative sore throat incidence compared to air inflation.

Keywords: Intubation, Lignocaine, Nitrous oxide, Pharyngitis, Postoperative complications.

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INTRODUCTION

Endotracheal intubation is an essential technique for maintaining airway patency and facilitating mechanical ventilation during general anaesthesia. The cuffed endotracheal tube, introduced in the mid-20th century, provides a seal between the tube and tracheal mucosa to prevent gas leakage and aspiration of gastric contents.[1] However, excessive intracuff pressure causes ischaemia of the tracheal mucosa, particularly when pressure exceeds the capillary perfusion pressure of 30 cm H_2O.[2]

Nitrous oxide, a commonly used volatile anaesthetic, readily diffuses across the semipermeable membrane of polyvinyl chloride (PVC) cuffs due to its high blood solubility. This diffusion causes a progressive increase in intracuff pressure and volume, particularly in prolonged procedures.[3] The continuous rise in cuff pressure leads to tracheal mucosal ischaemia, manifest as inflammation, ulceration, haemorrhage, and ultimately tracheal stenosis or tracheo-oesophageal fistula in severe cases.[1,4]

The resulting complications include postoperative sore throat, cough, and hoarseness — the most common side effects reported after extubation.[5] These complications occur in 15–90% of intubated patients, depending on study design, tube characteristics, and technique.[6] The morbidity associated with postoperative sore throat, though often considered minor, significantly impacts patient satisfaction and recovery quality.

Lignocaine, a local anaesthetic agent, when infiltrated into the endotracheal tube cuff, diffuses through the cuff membrane and anaesthetises the adjacent tracheal mucosa. This reduces airway irritation, cough reflex, and haemodynamic responses to intubation and extubation. The addition of sodium bicarbonate increases the non-ionised form of lignocaine, facilitating enhanced diffusion across the cuff membrane while reducing the required dosage.[7]

Recent studies have demonstrated that alkalinized lignocaine-filled cuffs significantly reduce postoperative airway complications compared to saline or air inflation.[7,8] However, comparative data on cuff pressure dynamics and clinical outcomes in Indian patient populations are limited. This study was designed to evaluate the efficacy of alkalinized lignocaine in preventing cuff pressure escalation during N_2O anaesthesia and assess its impact on patient morbidity.

METHODS

A prospective, randomised, comparative study was conducted at the Surgical Gastroenterology Operation Theatre from February 2022 to September 2022. Fifty adult patients aged 18 to 65 years with American Society of Anesthesiologists (ASA) physical status I or II undergoing elective surgery under general anaesthesia were enrolled after obtaining written informed consent. Institutional Ethics Committee approval was obtained prior to the commencement of the study.

Patients were excluded if they had an ASA status of III or higher, were critically ill, or had a known allergy to local anaesthetics. Additionally, the study excluded patients with a history of smoking, those requiring a nasogastric tube or tracheostomy, and cases of difficult intubation requiring more than one attempt. Patients with severe cardiovascular, hepatic, respiratory, endocrine, or psychiatric illnesses were also excluded to minimise confounding variables.

The sample size was calculated based on a previous study by Jayachandran et al.[7] where the mean difference in cuff pressure between the air and alkalinized lignocaine groups was significant. Assuming a power of 80% and a type I error (alpha) of 0.05, it was estimated that a minimum of 22 patients per group would be required to detect a clinically significant difference of 5 cm H_2O in intracuff pressure. To account for potential dropouts, a sample size of 25 patients per group was selected (total n = 50).

Patients were randomised into two groups: Group A (n=25), where the tracheal cuff was inflated with air to 20 cm H_2O, and Group L (n=25), where the tracheal cuff was inflated with alkalinized lignocaine (2% lignocaine and 7.5% sodium bicarbonate in 19:1 dilution) to 20 cm H_2O. This was a single-blind study where the participants were blinded to the group allocation; however, the anaesthesiologist administering the intervention and recording the data was aware of the group assignment due to the nature of the intervention.

Standard anaesthesia monitors (electrocardiography, non-invasive blood pressure, pulse oximetry, end-tidal CO_2, and cuff pressure monitor) were applied, and baseline vital parameters were recorded. After 3 minutes of preoxygenation with 100% oxygen, patients received intravenous glycopyrrolate (4 µg/kg), fentanyl (2 µg/kg), and propofol (2 mg/kg) for induction. Atracurium (0.5 mg/kg) facilitated tracheal intubation with appropriate-sized cuffed endotracheal tubes (7.5 mm for females, 8.0 mm

for males). Cuff inflation was performed to achieve a baseline pressure of 20 cm H_2O in both groups. The baseline cuff pressure before N_2O administration was documented, and subsequent measurements were recorded every 30 minutes until the end of surgery. Anaesthesia was maintained with 50% nitrous oxide, 50% oxygen, and controlled mechanical ventilation with fentanyl (1 µg/kg every 45 minutes) and intermittent atracurium (0.1 mg/kg).

The primary outcome was the assessment of changes in intracuff pressure during and after the administration of nitrous oxide. Secondary outcomes included monitoring of intraoperative haemodynamic changes (heart rate, systolic and diastolic blood pressure, mean arterial pressure, end-tidal carbon dioxide, and oxygen saturation), endotracheal tube tolerance at extubation, cuff volume changes, and postoperative complications (sore throat, cough, and hoarseness) assessed at 30 minutes and 24 hours after the procedure. Data were analysed using SPSS (version 21.0). Results are presented as mean±standard deviation for quantitative variables. Independent t-test was used for comparison of quantitative variables between groups, while Fisher's exact test was used for categorical variables. A p-value <0.05 was considered statistically significant.

RESULTS

Fifty patients (25 in each group) successfully completed the study. The demographic characteristics were comparable between the two groups with no statistically significant differences. The mean age was 39.68±12.78 years in Group A and 39.28±13.04 years in Group L ($p=0.91$), while the mean weight was 64.48±6.80 kg and 65.16±7.69 kg respectively ($p=0.74$). The distribution of gender ($p=0.78$) and ASA physical status ($p=0.57$) was similar, with 58% of patients classified as PS-I and 42% as PS-II overall. The mean duration of anaesthesia was also comparable (135.76±16.13 min in Group A vs 133.40±10.56 min in Group L, $p=0.54$). Baseline haemodynamic parameters were similar between groups ($p>0.05$).

Intraoperative monitoring revealed no statistically significant differences in heart rate, systolic and diastolic blood pressure, mean arterial pressure, end-tidal CO_2, or oxygen saturation at any time point ($p>0.05$). Regarding the primary outcome, intracuff pressure increased progressively and significantly in Group A, reaching 31.56±1.64 cm H_2O by the end of surgery, exceeding safe limits. In contrast, Group L maintained stable pressure near baseline levels (21.21±0.93 cm H_2O), demonstrating effective prevention of pressure escalation (Table 1).

Endotracheal tube tolerance at extubation was significantly better in Group L ($p=0.045$), with 72% of patients showing no agitation compared to only 40% in Group A (Table 2). Although the initial cuff inflation volumes were comparable ($p=0.29$), the volume deflated at extubation was significantly higher in Group A (12.30±2.30 ml) compared to Group L (8.57±1.96 ml) ($p<0.0001$), indicating excessive pressure and volume accumulation due to N_2O diffusion into the air-filled cuff (Table 3).

The incidence of sore throat at 24 hours was significantly lower in Group L (8%) compared to Group A (36%) ($p=0.04$). The incidence of cough and hoarseness showed no statistically significant differences between the groups (Table 4).

DISCUSSION

The management of endotracheal tube cuff pressure is critical for preventing postoperative airway complications. This study demonstrates that alkalinized lignocaine significantly prevents cuff pressure escalation during general anaesthesia with nitrous oxide, compared to air inflation.[9] Nitrous oxide, with a molecular weight of 44 and high blood solubility, diffuses readily across the PVC membrane of endotracheal tube cuffs. The driving force for this diffusion is the partial pressure gradient between the alveolar space and the cuff lumen. Unlike nitrogen, which is poorly soluble in blood, N_2O crosses the cuff membrane easily, causing volume and pressure expansion.[3,10] This phenomenon was clearly demonstrated in Group A, where cuff pressure increased by 11.56 cm H_2O (58% increase) by the end of surgery.

In contrast, Group L maintained stable cuff pressure throughout the procedure. The mechanism relates to the diffusion of alkalinized lignocaine across the cuff membrane. Lignocaine, being lipophilic and in its non-ionised form when alkalinized with sodium bicarbonate, readily diffuses through the PVC membrane and anaesthetises the tracheal mucosa. This explains the superior performance of alkalinized lignocaine in pressure control.[11]

The capillary perfusion pressure of the tracheal mucosa is approximately 18–25 mm Hg (24–34 cm H_2O).[12] Cuff pressures exceeding this threshold cause mucosal ischaemia, leading to ciliary dysfunction, inflammation, ulceration, and haemorrhage.[13] In our study, Group A achieved end-of-surgery pressures of 31.56 cm

H_2O, exceeding recommended safe limits. The European Society of Anaesthesiology and Intensive Care recommends maintaining cuff pressures between 20–30 cm H_2O.[16] Our study demonstrates that alkalinized lignocaine maintains pressures at the lower end of the safe range (21.21 cm H_2O), providing a substantial safety margin.

The significantly better tube tolerance observed in Group L (72% without agitation vs. 40% in Group A) reflects the anaesthetic effect of diffused lignocaine on the tracheal mucosa. Rapid stretch receptors in the tracheal epithelium trigger cough and patient agitation when distended by high-pressure cuffs.[15] Alkalinized lignocaine depresses these receptors' activity through local anaesthesia, resulting in smoother extubation and better patient cooperation.[16]

The lower volume deflated from Group L cuffs at extubation (8.57 ml vs. 12.30 ml) further confirms that excessive pressure did not develop, as cuff volume expansion directly correlates with pressure elevation. This is clinically significant, as large volume changes during deflation can cause mucosal injury through shear forces. The significantly lower sore throat incidence in Group L at 24 hours (8% vs. 36%, p=0.04) is the most clinically meaningful finding. Postoperative sore throat affects 36–100% of intubated patients and causes significant discomfort.[17,18] It results from mucosal damage caused by direct intubation trauma, ischaemic mucosal injury from excessive cuff pressure, mucosal drying from inhalational anaesthetics, and airway inflammation and oedema.

By maintaining optimal cuff pressure and providing local anaesthesia, alkalinized lignocaine addresses multiple pathogenic mechanisms. The local anaesthetic effect reduces pain perception from mucosal damage, while pressure control prevents ongoing ischaemic injury. The absence of significant haemodynamic differences between groups is reassuring and demonstrates that alkalinized lignocaine has no adverse cardiovascular effects. Previous studies have shown that lignocaine absorption through the tracheal epithelium is minimal (<1% of the administered dose), resulting in negligible systemic toxicity.[19] This single-centre study was conducted in a controlled surgical setting with relatively short anaesthesia durations (mean 135 minutes). The simple, safe, and cost-effective nature of alkalinized lignocaine makes it an attractive intervention for routine clinical practice.

CONCLUSION

Alkalinized lignocaine cuff inflation effectively prevents excessive intracuff pressure rise during nitrous oxide anaesthesia compared to air inflation, maintaining pressures within safe limits. This approach significantly reduces postoperative sore throat incidence and improves endotracheal tube tolerance at extubation without affecting haemodynamic stability. Alkalinized lignocaine should be considered as a routine cuff inflation agent in patients undergoing general anaesthesia with nitrous oxide.

Data Availability Statement: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

REFERENCES

1. Tobin MJ. Principles and Practice of Mechanical Ventilation. 3rd ed. New York: McGraw-Hill; 2013.
2. Seegobin RD, van Hasselt GL. Endotracheal cuff pressure and tracheal mucosal blood flow: endoscopic study of effects of four large volume cuffs. Br Med J (Clin Res Ed) 1984;288:965–8.
3. Lumb AB. Nunn's Applied Respiratory Physiology. 8th ed. Edinburgh: Elsevier; 2016.
4. Rashkin MC, Davis T. Acute complications associated with endotracheal tubes. Chest 1986;89:165–71.
5. Moulder ZJ, Nissen L, Sweeny A, et al. Postoperative sore throat: a systematic review. Anaesthesia 2024;79:1–12.
6. Christensen AM, Willemoes-Larsen H, Lundby L, Jakobsen KB. Postoperative throat complaints after tracheal intubation. Br J Anaesth 1994;73:786–7.
7. Jayachandran VV, Venkatraman R, Joseph JV. Effect of alkalinized lignocaine instillation in the endotracheal tube on postoperative sore throat. Indian J Anaesth 2009;53:40–5.
8. Kaur N, Sarna R, Sen IM, Yaddanapudi S. Intracuff alkalinized 2% lignocaine versus air for endotracheal tube induced postoperative sore throat and other laryngotracheal morbidities-A randomized, controlled trial. Trends in Anaesthesia and Critical Care. 2024 Dec 1;59:101500.
9. Mu G, Zhang Y, Wang X. Reevaluating 30 cmH_2O endotracheal tube cuff pressure: implications for mucosal safety. Crit Care 2024;28:342.
10. Bhatia N, Kumar A. Endotracheal tube cuff pressure monitoring: a review of current

evidence. J Anaesthesiol Clin Pharmacol 2021;37:23–9.
11. Gropper MA, editor. Miller's Anesthesia. 9th ed. Philadelphia: Elsevier; 2020.
12. Singh A, Gupta A. Endotracheal cuff pressure changes during laparoscopic surgery: a comparative study. Indian J Anaesth 2022;66:210–5.
13. Dollo G, Estebe JP, Boet S, et al. In vitro assessment of lidocaine diffusion from endotracheal tube cuffs. Anesth Analg 2003;96:1331–5.
14. Bagshaw O. Tracheal stenosis following endotracheal intubation. Int Anesthesiol Clin 1971;9:263–83.
15. Nordin U. Histologic injury to the trachea, carina and mainstem bronchi following prolonged cuffed oral intubation. Acta Otolaryngol 1977;345:1–71.
16. European Society of Anaesthesiology and Intensive Care. Guidelines for management of tracheal intubation in critically ill adults. Eur J Anaesthesiol 2023;40:1–24.
17. Mazzone SB, McGarvey L. Mechanisms of cough and cough reflex sensitivity. Lancet 2013;381:779–85.
18. Sharma S, Mishra S. Postoperative sore throat: a comparative study of magnesium sulphate vs ketamine gargle. Indian J Anaesth 2023;67:345–50.
19. Venkatesan T, Ramachandran S, Ravi M, et al. A comparative study of methods to prevent postoperative sore throat. Indian J Anaesth 2010;54:413–9.

Table 1: Comparison of intracuff pressure (cm H_2O) at different time intervals

Time Point	Group A (cm H_2O)	Group L (cm H_2O)	p-value
Before N_2O	20.00±0.00	20.00±0.00	—
30 minutes	22.68±1.64	20.32±0.48	<0.0001
60 minutes	25.36±2.27	20.88±0.67	<0.0001
90 minutes	27.60±1.96	20.92±0.86	<0.0001
120 minutes	29.72±2.28	20.80±0.96	<0.0001
End of Surgery	31.56±1.64	21.21±0.93	<0.0001

Abbreviations: N_2O, nitrous oxide; cm H_2O, centimetres of water. Group A: air inflation (n=25); Group L: alkalinized lignocaine inflation (n=25). Data presented as mean ± SD.

Table 2: Endotracheal tube tolerance at extubation

Parameter	Group A	Group L	p-value
With agitation	15 (60%)	7 (28%)	0.045
Without agitation	10 (40%)	18 (72%)	—

Group A: air inflation (n=25); Group L: alkalinized lignocaine inflation (n=25). Fisher's exact test used. *p<0.05 is statistically significant.

Table 3: Cuff volume parameters

Parameter	Group A	Group L	p-value
Volume inflated (ml)	9.96±2.07	9.36±1.89	0.29
Duration of anaesthesia (min)	135.76±16.13	133.40±10.56	1.0
Volume deflated (ml)	12.30±2.30	8.57±1.96	<0.0001

Data presented as mean ± SD. Independent t-test used. **p<0.0001 highly significant.

Table 4: Postoperative complications at 30 minutes and 24 hours

Complication	Group A	Group L	p-value
Sore throat – 30 min	4/25 (16%)	2/25 (8%)	0.67
Sore throat – 24 hrs	9/25 (36%)	2/25 (8%)	0.04*
Cough – 30 min	6/25 (24%)	4/25 (16%)	0.72
Cough – 24 hrs	0/25 (0%)	0/25 (0%)	—
Hoarseness – 30 min	9/25 (36%)	6/25 (24%)	0.54
Hoarseness – 24 hrs	11/25 (44%)	8/25 (32%)	0.56

*p<0.05 statistically significant. Fisher's exact test used. Group A: air inflation (n=25); Group L: alkalinized lignocaine inflation (n=25).