Original Article

Efficacy of endotracheal tube cuff lignocaine in the prevention of postextubation cough in children undergoing elective surgeries – A randomised controlled trial

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ABSTRACT

Background and Aims: Postextubation airway complications are more common in paediatric patients than in adults. Intravenous lignocaine effectively prevents extubation response; however, data on using intracuff lignocaine in microcuff endotracheal tubes is scarce. The primary aim of this study was to compare the incidence of postextubation cough between intracuff lignocaine and intracuff air in the paediatric population during tracheal extubation. **Methods:** This randomised controlled study was conducted in 120 paediatric patients aged 1 month to 12 years who were scheduled to undergo surgeries under general anaesthesia. They were randomised to Group C (intracuff air) and Group L (intracuff 2% lignocaine). After administering general anaesthesia, the airway was secured with an age-appropriate microcuff endotracheal tube. According to groups, the cuff was inflated with air or lignocaine to achieve a cuff pressure of 10 cm H_2O. Incidences of cough, desaturation, laryngospasm, apnoea and haemodynamic changes were recorded after tracheal extubation. Categorical variables were compared using the Chi-square or Fisher's exact test, and continuous variables were compared using the Student's *t*-test or Mann–Whitney U test. Intergroup differences between the variables were analysed by a two-way repeated measure analysis of variance. **Results:** The incidence of postextubation cough was significantly higher in Group C [17 (28.3%) (confidence interval {CI} = 17.4–41.4)] when compared to Group L [8 (13.3%) (CI = 5.9–24.6)], with $P = 0.043$. One patient in Group C had laryngospasm compared to none in Group L. In Group C, there was also a significant increase in heart rate at all time points (1–5 min after extubation) from the baseline, and this increase was also significantly higher when compared to Group L ($P < 0.05$). **Conclusion:** The incidence of postextubation cough was significantly lower with intracuff lignocaine compared to that with intracuff air in paediatric patients.

Keywords: Anaesthesia, cough, intracuff, laryngospasm, lidocaine, microcuff, tracheal extubation

INTRODUCTION

Paediatric patients are at higher risk of developing postextubation airway complications (cough, laryngospasm, desaturation) than adults due to anatomical variations and hyperreactive airway reflexes.[1] Cough can result in a transient increase in airway pressure, causing spikes in intracranial and intraocular pressures and an increased risk of bleeding from friable surgical sites.[2] Apart from using multiple pharmacological means (opioids, esmolol, low-dose propofol) to suppress the adverse postextubation responses, investigators have also tried

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other techniques [extubation under deep anaesthesia, replacement of endotracheal tube (ETT) with a supraglottic airway device] to reduce extubation response.[3,4] Intravenous (IV) lignocaine is widely used to prevent adult intubation and extubation responses. ETT cuff inflation with lignocaine may permit enough diffusion across the tracheal mucosa to limit the cough response after extubation.[5] However, data are scarce on using intracuff lignocaine in microcuff ETT to reduce the incidence of postextubation adverse events in the paediatric population.

This study investigated the efficacy of intracuff lignocaine in preventing cough and haemodynamic responses in children undergoing elective surgery under general anaesthesia. The primary objective was to compare the incidence of postextubation cough between ETT-cuff lignocaine and ETT-cuff air in the paediatric population during extubation. The secondary objectives included comparison of the incidence of laryngospasm, desaturation, apnoea and haemodynamic response between the two groups. It was hypothesised that intracuff lignocaine would reduce the incidence of postextubation cough in paediatric patients during emergence from general anaesthesia.

METHODS

This randomised controlled study was conducted in paediatric patients belonging to the American Society of Anesthesiologists (ASA) physical status I and II, aged 1 month to 12 years, after obtaining approval from the Institute Ethics Committee (vide approval number JIP/IEC/2020/098, dated 9 March 2021), and was registered with the Clinical Trials Registry-India (CTRI) (vide registration number CTRI/2021 / 07/034676; https://ctri.nic.in/). This study was conducted from October 2021 to November 2022. The study was carried out using the principles of the Declaration of Helsinki, 2013, and good clinical practice. Written informed consent from parents and assent from older children for participation in the study and use of the patient data for research and educational purposes were obtained. Paediatric patients scheduled for elective surgery requiring an ETT for administering general anaesthesia were included in the study. Patients with active upper respiratory tract infections, bronchial asthma, congenital heart disease, previous laryngeal or tracheal surgery, allergies to local anaesthetics and patients undergoing cardiac, neuro, head and neck, and airway surgeries were excluded from the study.

All patients were assessed by the attending anaesthesiologist a day before the scheduled surgery. Age-appropriate premedication and nil per oral instructions were given according to departmental protocol. Patients were brought to the operating room on the day of surgery, standard monitors were connected, and baseline heart rate (HR), blood pressure and oxygen saturation (SpO_2) values were recorded. Depending on the attending anaesthesiologist's choice, induction of anaesthesia was performed either with IV propofol or sevoflurane in 100% oxygen. After administering IV vecuronium 0.1 mg/kg or atracurium 0.5 mg/kg, endotracheal intubation was done using an age-appropriate microcuff tube (formula age/4 + 3.5) by an experienced anaesthesiologist. The insertion depth was noted after the correct tracheal placement of ETT was confirmed. Patients who required multiple tracheal intubation attempts (>2 attempts) and had traumatic tracheal intubation were excluded from the study. All patients received IV fentanyl 1 μg/kg as an analgesic.

Block randomisation was performed using a computer-generated block random number table. Sequentially numbered, opaque, sealed envelopes were used for random sequence generation and concealment. Patients were randomised into two groups: Group C – cuff filled with air and Group L – cuff filled with 2% preservative-free lignocaine. In both groups, the microcuff was initially inflated with an incremental air volume. The cuff pressure was measured using a cuff pressure manometer (Ambu® Cuff pressure gauge; Ambu Inc, Columbia, MD, USA). The volume of air required to eliminate the leak around the cuff and maintain a cuff pressure of 10 cm H_2O was considered the desired volume. The microcuff was deflated and reinflated in the lignocaine group with an equal volume of 2% lignocaine solution. Anaesthesia was maintained with 2% sevoflurane in a mixture of air and oxygen (fraction of inspired oxygen 35%–40%) with a fresh gas flow rate of 2 l/min through a closed circuit. A 6–8 ml/kg tidal volume was maintained, and the respiratory rate was adjusted to maintain end-tidal carbon dioxide between 32 and 34 mmHg. At the end of the surgery, in Group L, the cuff pressure was measured, and the difference in cuff pressure from baseline values was noted. The microcuff was inflated again with air to restore the cuff pressure to baseline, and this volume was noted. Residual neuromuscular blockade was antagonised with 0.05 mg/kg of neostigmine and 0.01 mg/kg of glycopyrrolate, and tracheal extubation was performed after adequate reversal of residual neuromuscular blockade was assessed clinically by the attending anaesthesiologists.

After tracheal extubation, the following parameters were recorded for 5 min in both groups by a blinded observer: (i) cough (two or more episodes of violent coughing or an SpO_2 value that fell below 95% during the cough episode), (ii) oxygen desaturation (SpO_2 <95% for more than 30 s), (iii) laryngospasm (graded according to the 4-point scale of Tsui BCH e*t al*.[6]: Grade 0 = no laryngospasm, Grade 1 = stridor during laryngospasm, Grade 2 = complete closure of vocal cords, Grade 3 = cyanosis), iv) apnoea (cessation of breathing for more than 20 s) and v) HR and blood pressure for every minute. Patients who had desaturation, laryngospasm, apnoea and haemodynamic disturbances were managed as per the discretion of the attending anaesthesiologists.

The reported incidence of cough after extubation in paediatric patients was 40%.[7] To find a difference of 25% in the incidence of postoperative cough with a power of 80% and an alpha error of 5%, 50 patients were required in each group. To compensate for any dropouts, we recruited 120 patients, with 60 in each group. The data were analysed using Statistical Package for the Social Sciences version 21.0 (International Business Machines Corp, Armonk, NY, USA) statistical software. The normality of the data was checked using the Kolmogorov–Smirnov and Shapiro–Wilk tests of normality. Continuous variables such as age, height, weight and body mass index were summarised as mean (standard deviation) or median (interquartile range), depending on the type of distribution. Categorical variables, such as sex and ASA status, were expressed as frequency and percentage. Between the groups, categorical variables were compared using the Chi-square or Fisher's exact test and continuous variables were compared using the Student's *t*-test or Mann–Whitney U test. Intergroup differences between the variables recorded after extubation were analysed by a two-way repeated measure analysis of variance using the group as the independent samples factor and time as the repeated measurement factor. A significant group-by-time interaction was followed by tests of significance using Tukey's method to compare the two groups at various points in time. A P value of <0.05 was considered statistically significant.

RESULTS

None of the 120 patients assessed for eligibility were excluded [Figure 1]. Demographic parameters were

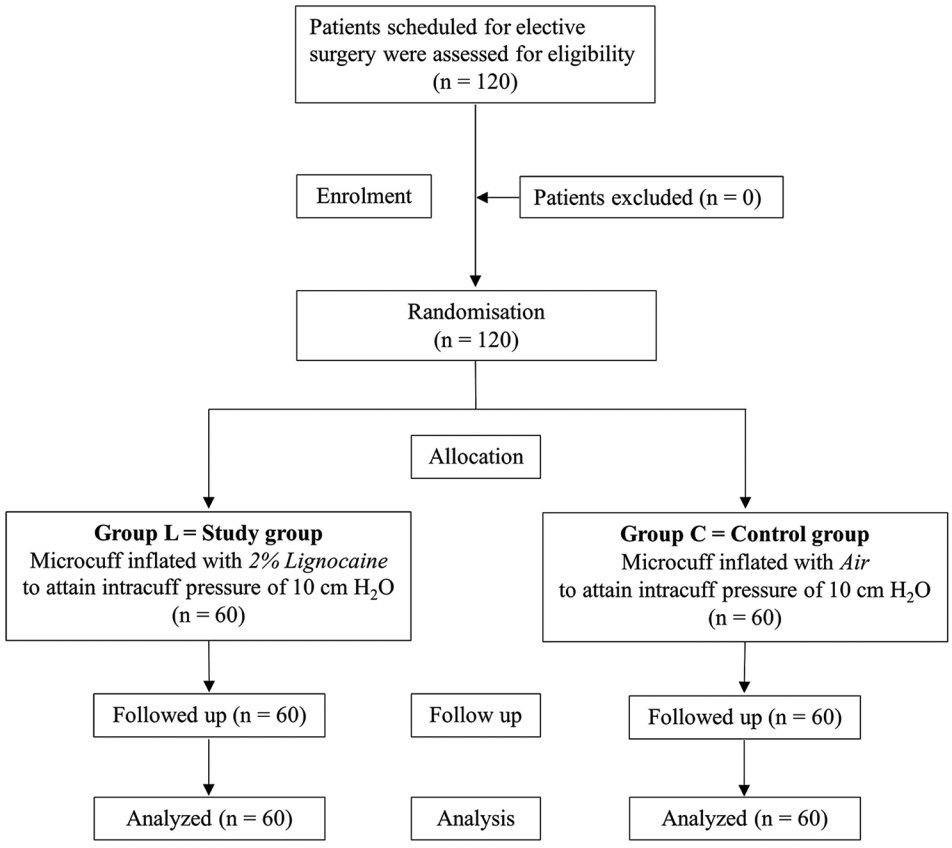

Figure 1: Consolidated standards of reporting trials (CONSORT) flow of participants. n=number of patients, Group C – cuff filled with air; Group L – cuff filled with 2% preservative-free lignocaine

comparable between the groups, and there was no significant difference in the volume of lignocaine/air used for cuff inflation with respect to the size of microcuff ETTs [Table 1]. The first-attempt success rate in Group C and Group L was 87.3% and 90.0%, respectively (P = 0.80), and none of the patients required more than two attempts for intubation. The two groups were comparable in terms of duration of surgery [Group C = median [interquartile range (IQR)] 142.5 (120–215) min and Group L = 156.5 (102.5–262.5) min], time from cuff inflation to extubation and time from last muscle relaxant to extubation.

The incidence of postextubation cough was significantly higher in Group C [17 (28.3%) (confidence interval {CI} = 17.4–41.4)] when compared to Group L [8 (13.3%) (CI = 5.9–24.6)], with P = 0.043. The incidence of laryngospasm and desaturation was comparable in both groups [Figure 2]. In Group L, the median [interquartile range (IQR)] volume of air/lignocaine required to restore the cuff pressure to the baseline value of 10 cm H_2O among different sizes of microcuff ETTs was = 0.1 ml (0–0.2) [Figure 3]. None of the patients in Group C had a fall in intracuff pressure.

In Group C, there was a significant increase in HR at all time points (1–5 min after extubation) from the baseline, and this increase in HR was also significantly higher when compared to Group L at all time points ($P < 0.05$). However, the rise in mean arterial pressure (MAP) was comparable between the two groups ($P > 0.05$) [Figure 4]. HR did not significantly increase after extubation in Group L compared to the baseline.

Subgroup analysis was performed for Group L to analyse the incidence of cough between surgeries lasting for less than 120 min and those exceeding 120 min. The incidence of cough was similar between age groups, and intubation attempts and surgery durations lasted for less than 120 min. When the surgery lasted for more than 120 min, the majority of patients had reduced cuff pressure (less than 10 cm H_2O) at the end of the surgery. The incidence of cough was significantly lower in patients with reduced end-operative cuff pressure than in those with normal cuff pressure [Table 2].

DISCUSSION

Our study demonstrates a significant reduction in postextubation cough in Group L (13.3%) compared to Group C (28.3%). Nevertheless, the incidence rates of laryngospasm and oxygen desaturation were comparable in both groups.

Our findings were in agreement with earlier reports analysing the effects of intracuff lignocaine on the emergence phenomenon in patients undergoing elective surgery.[8] The reduction in adverse events after extubation suggests the local effect of lignocaine on the tracheal mucosa. When the tracheal tube cuff is filled with lignocaine, it slowly diffuses across the cuff over time, anaesthetising the part of the tracheal mucosa in contact with the inflated cuff and contributing to tube tolerance.[9] However, the diffusion rate of lignocaine through the cuff is influenced by factors such as temperature, percentage of the uncharged drug and cuff thickness.[10]

All children in the current study underwent tracheal intubation using tracheal tubes with microcuffs

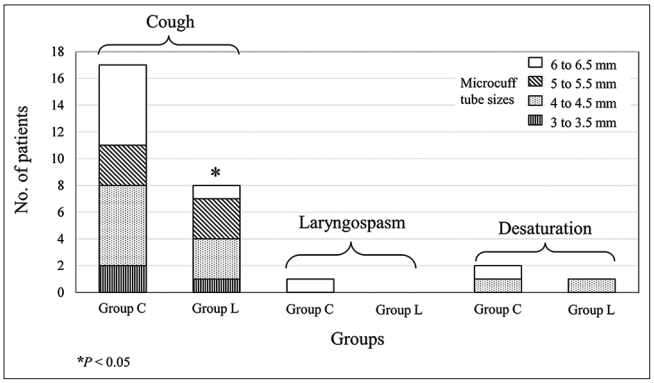

Figure 2: Postextubation events at time points from 1 to 5 min. Group C – cuff filled with air; Group L – cuff filled with 2% preservative-free lignocaine

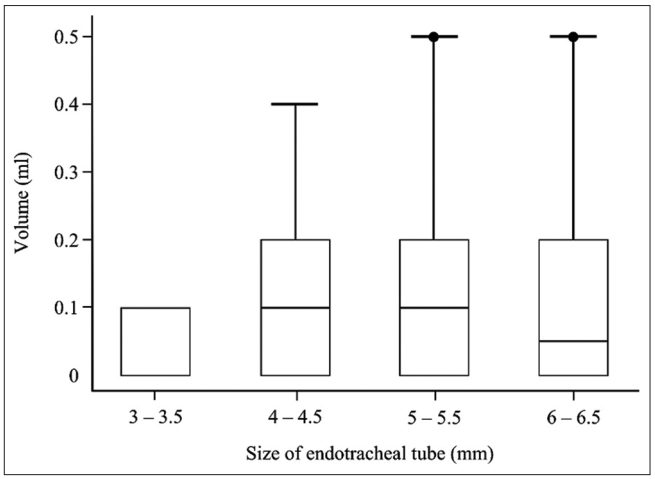

Figure 3: Volume of air required to restore the cuff pressure to baseline in Group L. Group C – cuff filled with air; Group L – cuff filled with 2% preservative-free lignocaine

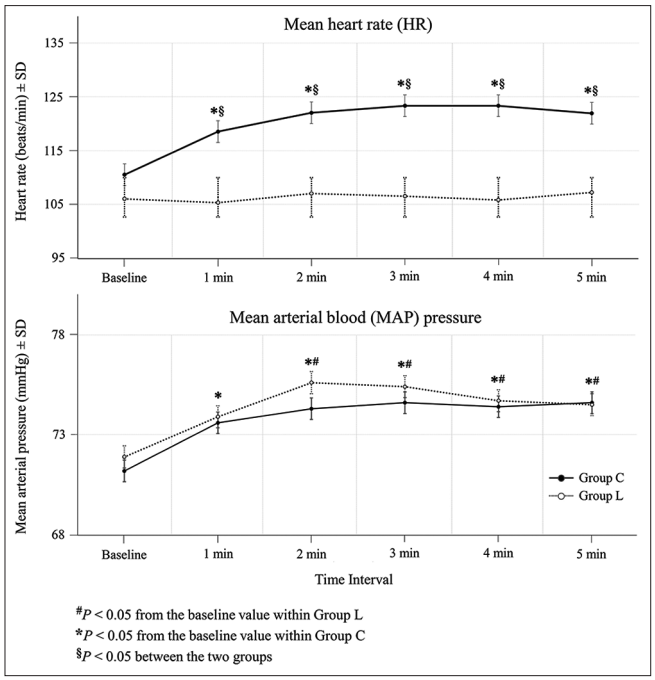

Figure 4: Comparison of mean heart rate and mean blood pressure between the two groups. SD = standard deviation, Group C – cuff filled with air; Group L – cuff filled with 2% preservative-free lignocaine

Table 1: Demographic data and volume of lignocaine/air used for cuff inflation to achieve a cuff pressure of 10 cm H_2O with respect to the size of microcuff ETT

Physical characteristics	Group C (*n*=60)	Group L (*n*=60)
Age (months)	66 (27–120)	60 (24–114)
Weight (kg)	17 (10.2–28.3)	15.3 (11–22.5)
Height (cm)	104 (82.5–131)	101 (83.5–124)
Size of microcuff ETT (mm)		
3–3.5	0.5 (0.4–0.5)	0.5 (0.5–0.5)
4–4.5	1.0 (0.8–1.0)	1.0 (0.5–1.0)
5–5.5	1.0 (1.0–2.0)	1.0 (0.8–1.3)
6–6.5	1.5 (1.2–2.0)	1.3 (1.0–1.7)

ETT=Endotracheal tube. Data is expressed as median (interquartile range). Group C – cuff filled with air; Group L – cuff filled with 2% preservative-free lignocaine, n=number of patients

Table 2: Subgroup analysis in Group L to show the relationship between duration of surgery and occurrence of cough to end-operative microcuff pressure

Duration of surgery	End-operative cuff pressure <10 cm H_2O (*n*=35)	End-operative cuff pressure=10 cm H_2O (*n*=25)	*P*
>120 min	30 (85.71%) (68.23–96.52)	10 (40%) (27.76–56.38)	<0.001
Occurrence of cough			
Cough	2 (5.7%) (1.42–12.64)	6 (24%) (14.56–40.22)	0.048

Data expressed as frequency (percentage) (95% confidence interval of percentages). Group C – cuff filled with air; Group L – cuff filled with 2% preservative-free lignocaine, n=number of patients

explicitly designed for the paediatric population. Microcuff provides a seal with a pressure of less than 15 cm H_2O, preventing cuff leaks and aspiration.[11] In our study, we maintained an upper limit for the cuff pressure at 10 cm H2O, which is much lower than that of adults at 25–30 cm H_2O.[6] This lower cuff pressure provided adequate tracheal seal in all patients in our study. This lower cuff pressure would have also contributed to the lower incidence of postextubation cough. The ultrathin nature of the polyurethane material may also offer an added advantage of better diffusion of lignocaine over conventional polyvinyl chloride. Since only 10 cm H_2O pressure is optimum to provide a tracheal seal with a microcuff tube when compared to 25–30 cm H_2O required in adults, it may lead to lesser local diffusion of lignocaine in paediatric patients when compared to adults. However, when sufficient time is given (2 h), diffusion across the microcuff in paediatric patients is enough to provide an adequate localised effect on the tracheal mucosa.

Our study found that cuff pressure at the end of surgery was lower than 10 cm H_2O in Group L patients who underwent surgery for more than 2 h. The incidence of cough was also significantly less in these patients, despite the lower cuff pressure at the end of surgery. As the duration of surgery increases, more time is available for the diffusion of lignocaine through the cuff at lower cuff pressure to produce the desired effect on the tracheal mucosa.[7] In our study, we also measured the volume of air required to restore the cuff pressure to the baseline level, and the median (IQR) air volume required to restore the cuff pressure to the baseline level was 0.1 (0–0.2) ml. We assume this volume of lignocaine diffused across the microcuff. Previous investigators have also shown that when the duration of surgery exceeds 1.5–2 h, the incidence of cough and sore throat after extubation decreases significantly with intracuff lignocaine.[12]

In addition to airway events, extubation is associated with adverse haemodynamic responses in children. A significant increase in HR was observed in Group C till 5 min after extubation, compared to a continuous stable HR in Group L. However, no significant difference was observed in MAP between the two groups until 5 min after extubation. The outcomes are in agreement with the earlier reports comparing air and saline with lignocaine.[7,13]

Our study has a few limitations. Plasma concentration of lignocaine was not assessed in the current study. It was hypothesised that the amount of air needed

to bring the cuff pressure back to its original level in Group L was equivalent to the amount of lignocaine that diffused through the cuff, which was an indirect measure of volume loss. To validate this, future investigations might be carried out by quantifying the plasma levels of lignocaine at the end of surgery. Another limitation is that we did not assess the duration of action of intracuff lignocaine on the tracheal mucosa. Lidocaine's topical anaesthetic effect may last up to 8 h, and there is an increased risk of aspiration during the first few hours after surgery. Even though none of our patients encountered this complication, vigilant monitoring is warranted in the immediate postoperative period. Another drawback is that intracuff air was used in the control group, which is the established standard of care. This led to insufficient blinding. Future research could incorporate a comparator group receiving saline to ensure proper blinding. Many authors in the past have shown that alkalinised lignocaine is more effective because of better penetration through the cuff.[7] Future research should also explore using alkalinised lignocaine as a superior option for cuff inflation in paediatric patients.

CONCLUSION

Intracuff lignocaine in microcuff endotracheal tube significantly reduces the incidence of postextubation cough when compared to intracuff air in paediatric patients undergoing surgery under general anaesthesia.

Study data availability

De-identified data may be requested with reasonable justification from the authors (email to the corresponding author) and shall be shared after approval as per the authors' institution policy.

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Conflicts of interest

There are no conflicts of interest.

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