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To assess the ease of intubation and post-extubation complications of the airway due to the use of microcuffed endotracheal tubes and uncuffed endotracheal tubes

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ABSTRACT

Introduction. Pediatric airway management poses unique challenges due to anatomical differences from adults, rendering children more susceptible to airway complications. Historically, uncuffed endotracheal tubes (ETTs) were preferred in pediatric intubation to minimize risks, but microcuffed (low volume, low pressure) ETTs offer advantages including improved seal and better ventilation efficiency. This study aims to compare the ease of intubation and post-operative airway complications between microcuffed and uncuffed ETTs.

Aim. To assess the ease of intubation and post-extubation complications of the airway due to the use of microcuffed endotracheal tubes and uncuffed endotracheal tubes.

Methodology. An observational study was conducted on pediatric patients aged 0-10 years undergoing elective surgeries under general anesthesia. Convenience sampling was used to select 54 participants. Patients were divided into two groups: uncuffed endotracheal tube (UG) and cuffed endotracheal tube (CG). Data on intubation attempts and post-operative complications were collected.

Results. Baseline characteristics including age, gender, weight, and ASA grade were comparable between groups. Single-attempt intubation success was higher in the uncuffed group (55.6%) compared to the cuffed group (40.7%). Post-operative complications such as respiratory distress, stridor, hypoxemia, and restlessness were more prevalent in the uncuffed group but not statistically significant.

Conclusion. This observational study suggests fewer postoperative complications with cuffed endotracheal tube insertion in pediatric patients. However, more research is needed to confirm these findings and explore the efficacy of microcuffed tubes in pediatric anesthesia.

Keywords: pediatric airway management, microcuffed endotracheal tubes, uncuffed endotracheal tubes, ETTs, pediatric intubation, ventilation, intubation, post-operative complications, pediatric patients

INTRODUCTION

Managing airways in pediatric patients is particularly challenging due to the distinct anatomical differences from adults [1]. Children are more susceptible to airway complications because of their narrower laryngeal and tracheal lumens, which are prone to blockage from edema after trauma [2]. Rapid development of upper airway obstruction is a critical emergency in any child undergoing general anesthesia [3].

Historically, uncuffed endotracheal tubes (ETTs) were favored for pediatric intubation to avoid mucosal injury and reduce the risks of respiratory distress, stridor, and hypoxemia, which are more prevalent with cuffed ETTs due to subglottic edema from long-term use [4]. However, the advent of microcuffed (low volume, low pressure) LVLP ETTs offers several benefits over uncuffed tubes, including improved seal for reduced aspiration risk, better venti-

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lation efficiency, and more reliable end-tidal gas monitoring [5].

The traditional recommendation for uncuffed ETTs in patients under 8 years old is based on airway anatomy studies. An ideal ETT should seal the cricoid ring effectively while allowing some air leakage at pressures between 20 and 30 cm H2O, ensuring sufficient ventilation without excessive tracheal mucosa pressure, which could lead to tissue hypoperfusion and injury [6]. Older cuffed ETTs (high pressure, low volume) in pediatric use often led to complications like stridor and hoarseness after extubation, difficulties in tube passage, and minimal issues when compared to the high volume, low pressure cuffed tubes. Uncuffed tubes, easier to insert and fitting snugly below the subglottis, minimized post-extubation problems [7]. Despite their benefits and efficiency in creating a tracheal seal for positive pressure ventilation, the high cost of microcuffed ETTs limited research on their ease of intubation and associated complications.

Cuffed endotracheal tubes (CETTs) provide numerous benefits in pediatric anesthesia, including reduced need for tracheal re-intubation with different UETT sizes and decreased halogenated agent consumption due to low-flow anesthesia capability. However, their higher cost is a consideration [8].

Recent introductions of microcuffed (LVLP) ETTs are thought to be less problematic, with studies suggesting these tubes create a better seal without airway complications [9,10]. Nevertheless, there's a lack of research comparing clinical outcomes post-extubation between children using microcuffed and uncuffed ETTs. This study aims to compare the ease of intubation and post-operative airway complications between these two types of ETTs.

AIM

To assess the ease of intubation and post-extubation complications of the airway due to the use of microcuffed endotracheal tubes and uncuffed endotracheal tubes.

OBJECTIVES

1. To compare the number of attempts required to intubate microcuffed and uncuffed tubes.
2. To compare observations for stridor, respiratory distress, hypoxemia on room air along with restlessness and need for reintubation if required following extubation.

METHODOLOGY

Study design: This is an observational study.

Data source/sampling method: The study focuses on children aged 0-10 years at Yenepoya Medical College Hospital, Mangalore, who were admitted for elective surgeries under general anesthesia from December 2018 to March 2020.

Study duration: The study was conducted from July 2018 to October 2020.

Sampling technique: Convenience sampling was used to select participants.

Clinical examination: A general pre-operative assessment and pre-anesthetic assessment were conducted, with participants receiving initial information about the assessment process.

Sample size: Using G*power software, the sample size was calculated with a significance level of $\alpha = 5\%$ and a power of $1- \beta = 80\%$. A minimum of 27 participants was required in each group, leading to a total sample size of 54.

Inclusion Criteria	Exclusion Criteria
Pediatric patients aged from birth to 14 years. Patients undergoing elective surgeries. Patients with an American Society of Anaesthesiologists (ASA) grade of 1 to 3.	Patients with an ASA Grade of 4 or above. Patients with anticipated difficult intubation. Patients requiring postoperative ventilation in the Intensive Critical Unit (ICU).

Methodology: After ethical committee approval, children of ASA physical status I and II, from birth to 14 years old and scheduled for elective surgery at Yenepoya Medical College Hospital, Deralakatte, Mangalore, were included in the study. Informed consent was obtained from their parents. Patients were randomly assigned to two groups using the closed-envelope method:

Group UG - 27 pediatric patients intubated with uncuffed endotracheal tube

Group CG - 27 pediatric patients intubated with a cuffed endotracheal tube.

Preoperative procedure: Patients were admitted the day before the procedure for a thorough pre-anesthetic evaluation and routine investigations. Parents were informed about the study, and consent was obtained. Fasting guidelines included no solids for 8 hours, semi-solids for 4 hours, and clear liquids for 2 hours before surgery.

Operative procedure: In the operation theatre, patients were positioned supine, and standard ASA monitors were attached. Baseline readings were taken, and intravenous access was secured. Patients were pre-oxygenated with 100% oxygen for 3-5 minutes. Premedication included IV Fentanyl 2 µg/kg and IV Glycopyrrolate 0.01 mg/kg. Induction was done with Inj. Propofol 2 mg/kg, followed by muscle relaxation with Inj. Atracurium 0.5 mg/kg. After 5 minutes of mask ventilation with 1 MAC Sevoflurane, intuba-

tion was performed with an appropriate size ETT using direct laryngoscopy, based on the age formula (ETT size for below 6 years = Age/3 + 3.5; after 6 years = Age/4 + 4.5). In Group UG, uncuffed endotracheal tubes were used, and in Group CG, microcuffed endotracheal tubes were used. The number of intubation attempts and maintenance with inhalational anesthetic gases (nitrous oxide, oxygen, and sevoflurane) were noted for both groups. Post-surgery, patients were extubated upon full recovery, as indicated clinically and through monitoring. Observations for respiratory distress, stridor, hypoxemia, restlessness, and any need for reintubation were recorded.

Statistical analysis

All collected data were inputted into an Excel spreadsheet, and the analysis was conducted using SPSS version 21. The data were presented in terms of frequency and percentage for categorical variables, while continuous variables were described using the mean ± standard deviation. To compare means in continuous variables, an independent sample t-test was utilized, and for categorical variables, the chi-square test was employed. A p-value less than 0.05 was deemed to indicate statistical significance.

RESULTS

Table 1 presents the baseline characteristics of the study participants, divided into two groups: Group UG (uncuffed endotracheal tube, n=27) and Group CG (cuffed endotracheal tube, n=27). The average age in Group UG is 4.13 years (± 3.51), while in Group CG, it's 7.76 years (± 4.44). The difference in mean age between the groups is statistically significant (p-value = 0.001*). When divided into age categories, 66.7% of Group UG are 0-5 years old, 25.9% are 6-10 years old, and 7.4% are 11-15 years old. In Group CG, the distribution is 40.7% (0-5 years), 25.9% (6-10 years), and 33.3% (11-15 years). The distribution across age categories is statistically significant between the groups (p-value = 0.046*). Group UG comprises 63% males and 37% females, whereas Group CG has 70.4% males and 29.6% females. The gender distribution is not statistically significant (p-value = 0.927 for males and 0.336 for females). The mean weight in Group UG is 13.82 kg (± 7.99), compared to 22.35 kg (± 12.24) in Group CG. This difference is statistically significant (p-value = 0.001*). In Group UG, 48.1% are ASA 1, 40.7% are ASA 2, and 11.1% are ASA 3. In Group CG, 55.6% are ASA 1, 44.4% are ASA 2, and none are ASA 3. The distribution of ASA grades between groups is not statistically significant (p-value = 0.203).

Figure 1 shows the comparison between cuffed and uncuffed endotracheal tube insertion. For those with cuffed tubes, 40.7% succeeded in the first attempt and 59.3% in the second, with no third attempts recorded. In contrast, the uncuffed tube group had a higher first-attempt success rate of 55.6%, with 40.7% needing a second attempt and a small 3.7% requiring three attempts. However, the chi-square statistical analysis, yielding a value of 2.54 and a p-value of 0.281, indicates that these differences in the number of attempts between the two groups are not statistically significant. Thus, while there appears to be a marginal preference for uncuffed tubes in successful first attempts, this trend doesn't demonstrate a significant deviation from what might occur by chance.

TABLE 1. Baseline characteristics of study participants

Parameter	Group UG n=27 (%)	Group CG n=27 (%)	p-value
Age in years (mean ± SD)	4.13 ± 3.51	7.76 ± 4.44	**0.001***
Age category (years) 0-5 6-10 11-15	 18 (66.7) 7 (25.9) 2 (7.4)	 11 (40.7) 7 (25.9) 9 (33.3)	 **0.046***
Gender Male Female	 17 (63) 10 (37)	 19 (70.4) 8 (29.6)	 0.927 0.336
Weight in Kgs (mean ± SD)	13.82 ± 7.99	22.35 ± 12.24	**0.001***
ASA 1 2 3	 13 (48.1) 11 (40.7) 3 (11.1)	 15 (55.6) 12 (44.4) 0 (0)	 0.203

Figure 2 provides a comparative analysis of post-operative complications in patients grouped based on the type of endotracheal tube used: cuffed or uncuffed. In terms of respiratory distress, the cuffed tube group showed a lower incidence (3.7%) compared to the uncuffed group (14.8%), but this difference was not statistically significant (p-value = 0.159). Stridor was absent in all patients with cuffed tubes and in 96.4% of those with uncuffed tubes, with no significant difference between the groups (p-value = 0.331). For hypoxemia, both groups showed similar trends, with 96.3% in the cuffed group and 92.6% in the uncuffed group not experiencing it, and this difference was also not statistically significant (p-value = 0.552). Restlessness occurred in 11.1% of the cuffed group and 18.5% of the uncuffed group, but again, the difference was not significant (p-value = 0.444). Notably, none of the patients in either group required reintubation. Overall, the study indicates that the type of endotracheal tube used, whether cuffed or uncuffed, does not significantly influence the likelihood of these post-operative complications.

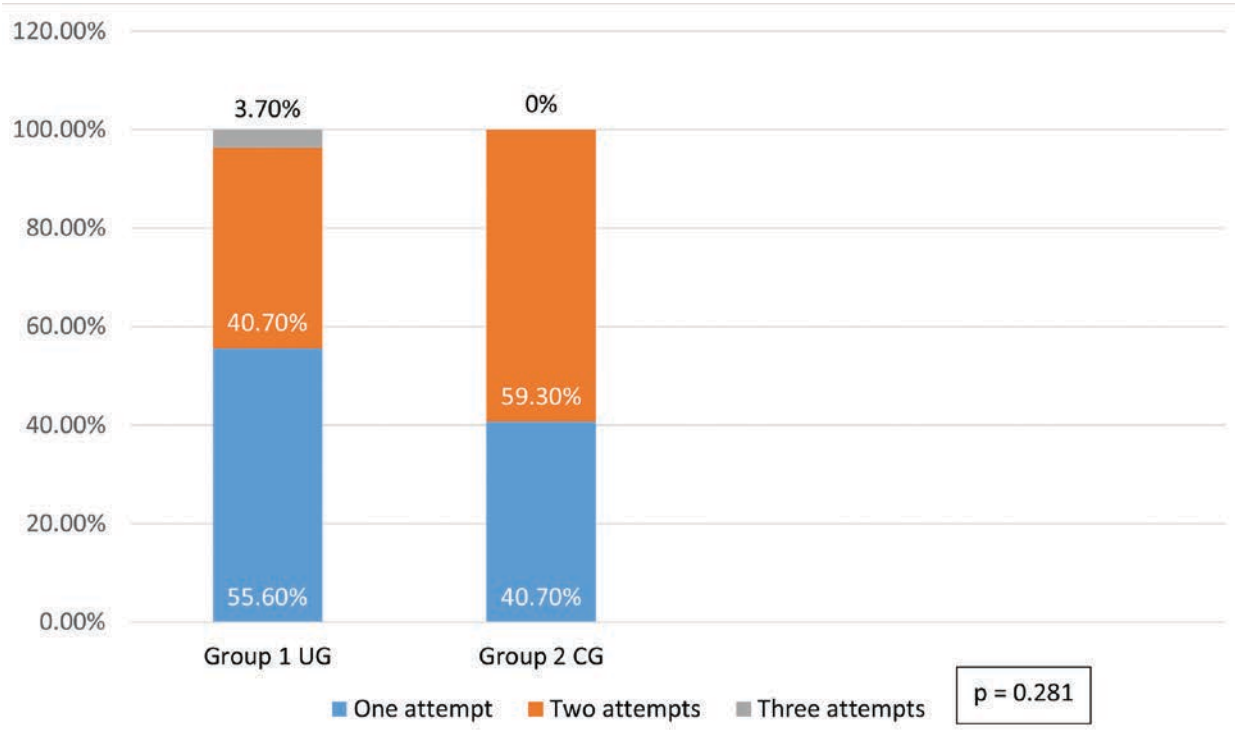

FIGURE 1. Comparison of attempts of insertion in patients of two groups

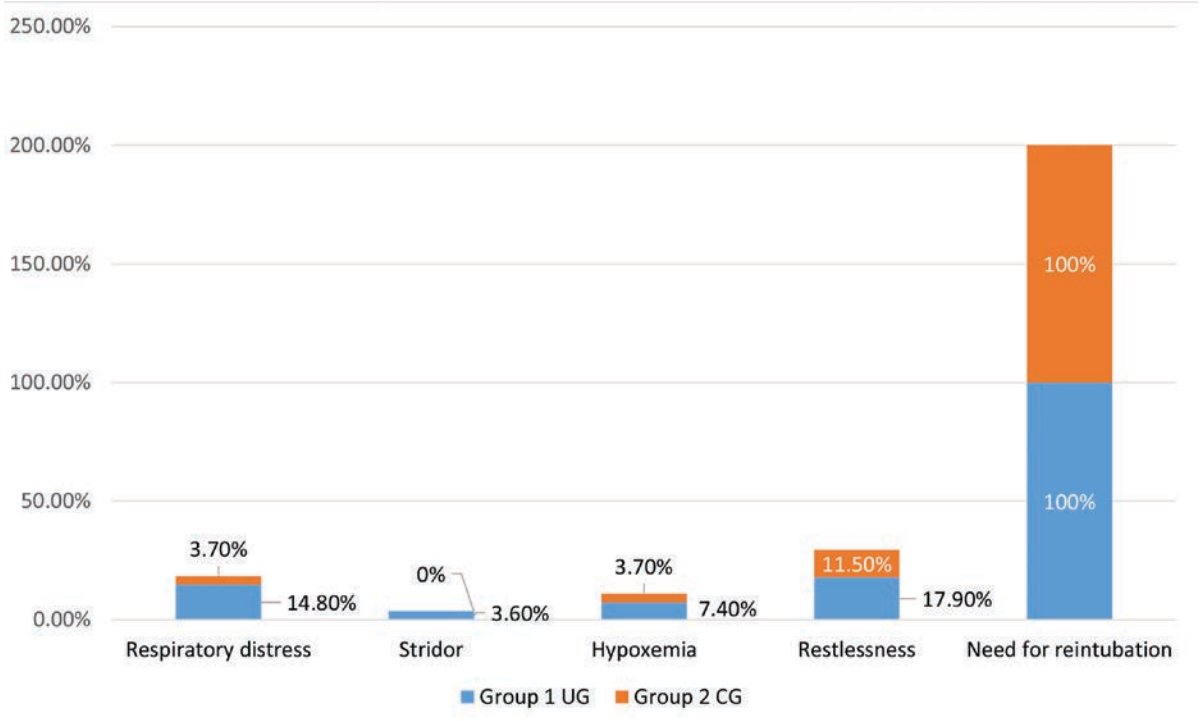

FIGURE 2. Comparison of postoperative complications in patients of two groups

DISCUSSION

Endotracheal intubation is a commonly employed procedure in both anesthesia administration and critical care management in pediatric patients, primarily aimed at safeguarding the airway, facilitating positive pressure ventilation, and ensuring adequate oxygenation. The selection between uncuffed and cuffed endotracheal tubes (ETTs) in pediatric cases presents distinct advantages and disadvantages. Traditionally, uncuffed endotracheal tubes (UETTs) have been the preferred choice for intubating children under the age of 8, regardless of intubation duration or definition. Conversely, cuffed endotracheal tubes (CETTs) have been less favored in pediatric anesthesia due to concerns regarding potential mucosal injury and subsequent subglottic stenosis associated with cuff use. This study aims to evaluate the ease of intubation and post-extubation clinical outcomes in pa-

tients who underwent intubation with microcuffed and uncuffed endotracheal tubes.

The study enrolled 54 pediatric patients undergoing various surgical procedures, with 27 patients receiving microcuffed endotracheal tubes and the remaining 27 receiving uncuffed endotracheal tubes. Among these patients, 53.7% were aged 0-5 years, 25.9% were aged 6-10 years, and 20.4% were aged 11-15 years. The majority were male (66.7%) compared to female (33.3%), with a male-to-female ratio of 2:1.

The number of attempts required for endotracheal tube insertion was recorded for all patients. Single-attempt successful insertion was most frequently achieved with uncuffed endotracheal tube insertion (55.6%, n=15) compared to cuffed endotracheal tube insertion (40.7%, n=11). Second-attempt success was observed in 59.3% (n=16) of children with cuffed endotracheal tube insertion. One patient required three attempts for uncuffed endotracheal tube insertion. This aligns with some previous studies indicating that uncuffed tubes, due to their flexibility and size, may be easier to insert in pediatric airways. For instance, a study by Weiss et al. suggested similar findings. However, it's important to note that certain factors such as practitioner skill and specific anatomical variations in pediatric patients can influence these outcomes [7].

Post-operative observations included the presence of respiratory distress, stridor, hypoxemia, restlessness, and the need for reintubation. In 96.3% of cases where cuffed endotracheal tubes were used, no respiratory distress was reported, compared to 85.2% with uncuffed endotracheal tubes. Stridor was absent in all patients with cuffed endotracheal tubes but present in 3.6% of those with uncuffed tubes, although this difference was not statistically significant. Hypoxemia occurred more frequently in children with uncuffed endotracheal tube insertion (7.4%) compared to those with cuffed tubes (3.7%), but without statistical significance. Restlessness was observed in 17.9% of children with uncuffed tubes compared to 11.5% with cuffed tubes, also without statistical significance. None of the patients required reintubation. The observation of fewer post-operative complications with cuffed tubes in your study resonates with recent trends in pediatric airway management. Studies such as those by Khine et al. [11] have also reported reduced complications with cuffed ETTs, suggesting improved airway seals and reduced need for tube exchanges. This could be attributed to advancements in tube design, minimizing the risk of mucosal injury and subglottic stenosis.

In study by Chen Liang et al., demonstrated uncuffed ET increased the need for reintubations and change of tubes compared to cuffed tubes [12].

In contrast to the findings of this study, Sathyamoorthy et al. observed a notably higher incidence of stridor in their research. Specifically, they reported stridor in 17.2% of cases using microcuff tracheal tubes (TTs) and in 7.5% using uncuffed TTs. Their study concluded that the use of microcuff TTs in neonates might be linked to a greater likelihood of experiencing stridor post-extubation compared to the use of uncuffed TTs [13].

Just like in our current investigation, Michel et al. observed that there were fewer instances of acute postoperative respiratory complications requiring intervention in 334 cases when cuffed tubes were used compared to uncuffed ones [14]. However, a meta-analysis conducted by Chen L et al. did not find a substantial variance in the occurrence of laryngospasm and stridor between pediatric patients intubated with cuffed versus uncuffed endotracheal tubes. Moreover, they suggested that cuffed tubes could be a favorable option for pediatric patients, although more trials are needed to substantiate this conclusion further [15].

While some research aligns with our results, indicating fewer respiratory issues with cuffed tubes, other studies, including meta-analyses, have reported no significant difference between cuffed and uncuffed tubes in this regard. This suggests that while cuffed tubes might offer some advantages, their impact might not be uniformly superior in all aspects of respiratory management [16].

Overall, a lower incidence of postoperative complications was observed in children who received cuffed endotracheal tubes compared to uncuffed tubes. This finding aligns with previous studies suggesting that cuffed tubes may lead to fewer acute postoperative respiratory complications. However, some meta-analyses have shown no significant difference in outcomes between cuffed and uncuffed tubes, suggesting the need for further research in this area.

CONCLUSION

Our observational study compared intubation attempts and post-extubation airway complications in pediatric patients undergoing general anesthesia with microcuffed and uncuffed endotracheal tubes. Among the 54 pediatric patients included, evenly split between those receiving cuffed and uncuffed tubes, we found that successful intubation on the first attempt was more common with uncuffed tubes. Respiratory distress was significantly more prevalent in children intubated with uncuffed tubes, while instances of stridor were statistically insignificant between the two groups. Conversely, hypoxemia was less likely with cuffed tube insertion. Additionally, restlessness was more frequently observed in children receiving uncuffed tubes. None of the patients required reintubation post-intubation. Overall, our

study suggests fewer postoperative complications with cuffed endotracheal tube insertion, indicating their potential as a favorable option for pediatric patients. However, further research is needed to substantiate these findings and explore the efficacy of microcuffed tubes in pediatric anesthesia.

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REFERENCES

1. Tobias JD. Pediatric airway anatomy may not be what we thought: implications for clinical practice and the use of cuffed endotracheal tubes. *Paediatric Anaesthesia.* 2014;24(1):9–19. doi: 10.1111/pan.12252.
2. Riva T, Frawley G, Orr R, Creagh-Brown B. Microcuff paediatric endotracheal tubes: a review of current literature. *Trends in Anaesthesia and Critical Care.* 2017;15:16–22. doi: 10.1016/j.tacc.2017.06.003.
3. Ramesh S, Jayanthi R, Archana SR. A Comparative Study between Microcuff (Microcuff®) and Conventional Cuffed Endotracheal Tubes in Mechanically Ventilated Children. Anesthesia: Essays and Researches. 2017;11(1):163–8. doi: 10.4103/0259-1162.190431.
4. Litman RS. The Evolution of Endotracheal Tubes. *Expert Review of Medical Devices*. 2014;11(5):481–490. doi: 10.1586/17434440.2014.931270.
5. Szmuk P, Ezri T, Evron S. A comparison of the use of cuffed versus uncuffed endotracheal tubes in pediatric anesthesia. *Paediatr Anaesth.* 2015;25(7):688–695. doi: 10.1111/pan.12647.
6. Deakers TW, Reynolds G, Stretton M. Cuffed endotracheal tubes in pediatric intensive care. *J Pediatr.* 1994;125(1):57–62. doi: 10.1016/s0022-3476(94)70162-7.
7. Weiss M, Dullenkopf A, Fischer JE, Keller C, Gerber AC. European Paediatric Endotracheal Intubation Study Group. Prospective randomized controlled multi-centre trial of cuffed or uncuffed endotracheal tubes in small children. *Br J Anaesth.* 2006;96(4):405–411. doi: 10.1093/bja/ael004.
8. Da Conceicao MJ, Coelho L, Khalil M. Airway problems in paediatric anaesthesia. *Eur J Anaesth.* 2003;20(3):169–81. doi: 10.1097/00003643-200303000-00001.
9. Kako H, Goy RW, Shen JY, Jeng CL. The effect of endotracheal tube cuff design on tracheal mucosal blood flow during nitrous oxide anesthesia in dogs. *Anesth Analg.* 1998;86(5):1030–35. doi: 10.1097/00000539-199805000-00019.
10. de Carvalho LR, Salgado Filho MF. Cuffed versus uncuffed endotracheal tubes for general anaesthesia in children aged eight years and under. *Cochrane Database Syst Rev.* doi: 10.1002/14651858.cd004503.
11. Khine HH, Corddry DH, Kettrick RG, Martin TM, McCloskey JJ, Rose JB, et al. Comparison of cuffed and uncuffed endotracheal tubes in young children during general anesthesia. *Anesthesiology*. 1997;86(3):627-31. doi: 10.1097/00000542-199703000-00019. PMID: 9066312.
12. Liang C, Fonseca A. Advances in pediatric airway management. *Curr Opin Anaesthesiol.* 2017;30(3):362-368. doi: 10.1097/ACO.0000000000000454. PMID: 28306545.
13. Sathyamoorthy M, Wang S, Peña MT. Pediatric airway management. *Int Anesthesiol Clin.* 2016;54(2):1-25. doi: 10.1097/AIA.0000000000000092. PMID: 26998611.
14. Michel F, Beller B, Hirschi M, Marhofer P, Weinberg G, Bürkle H, Schreiber JU. Cuffed versus uncuffed endotracheal tubes in pediatric anesthesia: a randomized controlled trial. *Anesth Analg.* 2020;130(3):724-731. doi: 10.1213/ANE.0000000000004221. PMID: 31996526.
15. Chen L, Zhang J, Pan L, et al. Comparison of the efficacy of microcuff pediatric tracheal tube with air seal with uncuffed tracheal tube in pediatric patients undergoing ophthalmic surgery: a randomized controlled trial. *BMC Anesthesiol.* 2020;20(1):69. doi: 10.1186/s12871-020-00976-7. PMID: 32284030; PMCID: PMC7159326.
16. Chen L, Liu Y, Pan L, et al. Randomized controlled trial comparing high-volume low-pressure cuff with tapered-cuff endotracheal tubes in pediatric cardiac surgery. *Paediatr Anaesth*. 2021;31(9):986-992. doi: 10.1111/pan.14229. PMID: 34118092.