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Changes in Intracuff Pressure of Microcuff Endotracheal Tube During Prolonged Anaesthesia with Nitrous Oxide and Air in Paediatric Patients

Hithesh[1], Thrivikram Shenoy[2]

ABSTRACT

Introduction: Introduction of micro cuff endotracheal tubes for pediatric intubations with improved designs are attractive innovation in pediatric anesthesia. In spite of exciting properties, hyperinflation with prolonged anesthesia with N_2O is an everlasting problem. The current study was focused on monitoring and comparing intra cuff pressure changes with N_2O and Air in children intubated with micro cuff endotracheal tubes and its overall effect on ventilation during prolonged anesthesia.

Material and Methods: In this prospective, observational study of randomized convenient sampling of 60 pediatric patients, were divided into two groups. Group 'N' received general anesthesia with nitrous oxide and Group A with air. The intracuff pressures were recorded every 15 min for the first 1 hour, and every 30 min thereafter throughout procedure.

Results: The baseline average pressure of 16.13 cm of H_2O decreasing in a linear fashion to 11.3 at the end of the surgery in the group N and similarly from 17 cm of H_2O to 11.67 in group A. The airway pressure decline were highly significant between the two groups at baseline and at every stipulated duration except at the 60th minute till the end of the surgery with a p-value<0.001

Conclusion: Significant changes in cuff pressures occur during prolonged general anaesthesia using microcuff ET tubes irrespective of using N_2O or air rendering the need for cuff pressure monitoring.

Keywords: Intracuff Pressure, Microcuff Endotracheal Tube, Prolonged Anaesthesia, Nitrous Oxide, Paediatric Patients

INTRODUCTION

Endotracheal intubations in children before 1940 was considered as a potentially lethal and traumatic invasive procedure. The introduction of Polyvinyl chloride incorporated uncuffed endotracheal tubes in 1960 made paediatric intubations under the age of 8 years suitable for both short and long term needs. Traditionally, cuffed endotracheal tubes were not used in paediatric patients for the fear of subglottic damage due to ischaemia of the tracheal mucosa when the cuff pressures exceeded 20 cms of H_2O. But there has been a recent change with a transition to the use of cuffed endotracheal tubes instead of cuffed ones as the advantages being a reduced incidence of the need to change the ETT, better airway seal and least risk of pulmonary aspiration, more reliable constant oxygenation and ventilation in spite of change in lung compliance. It also facilitated a more accurate analysis of end-tidal carbon dioxide tracing with reduced consumption and as well as monitoring of end tidal inhalational anaesthetic agents.[1] However, the risk of over-inflation of a high pressure and low volume cuff still existed with intra cuff pressures being not maintained within the recommended range resulting in compromised tracheal mucosal blood flow and the subsequent development of tracheal and subglottic complications. Moreover the possibilities of design errors regarding depth as well as too longer tips were pitfalls in the manufacture of these tubes.

An interesting innovation in 2004 was the introduction of a novel microcuff endotracheal tube by Kimberly-Clark (Dallas TX) with a specialized cuff made of an ultrathin polyurethane.

The intra cuff pressure with safer limits of less than 20 cms of H_2O could be checked initially following the cuff inflation after endotracheal intubation with cheaper and easily available devices like manual aneroid manometers and pop-off valves safer than the expensive automated ones. The intracuff pressure being an universal problem at all ages, changed dynamically throughout the procedure especially significant during prolonged anaesthesia because of the various factors including changes in the head and neck position, body temperature, and the composition of the inhaled gases.[1] There are currently no data in the paediatric population regarding comparison of changes in the intracuff pressure of Microcuff endotracheal tube when using nitrous oxide to that of air. This current study was aimed to do so by prospectively and continuously assessing the changes and comparison of intracuff pressures during prolonged (more than 3 h) anaesthesia with N_2O and Air and its overall effect on overall ventilation.

MATERIAL AND METHODS

The present study following approval by the institutional ethical committee entrusted 60 paediatric patients scheduled for prolonged major surgeries lasting 3 hours belonging to

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ASA 1 admitted in KMC Hospital Attaver, KMC Hospital Ambedkar circle and Regional Advanced Paediatric Care Centre Govt Wenlock Hospital Hospital, Mangalore between September 2015 and July 2017.

Randomization was done by convenient sampling and the design was an Observational study.

With 95% confidence level and 80% power[1] the sample size was fixed to 60 paediatric patients who were divided into two groups: Group N and Group A. The Group N consisted of 30 children who received general anaesthesia with Nitrous oxide and Group A consisted of the remaining 30 patients who received general anaesthesia with Air.

The study included patients under the age of 5 years of American Society of Anaesthesiology (ASA) physical status I, undergoing elective surgeries under general anaesthesia with administration of either Nitrous oxide or Air. Patients with co morbid conditions and those parents who refused to participate were excluded from the study.

All patients received 0.05mg/kg and 1 mcg/kg of Midazolam and Fentanyl respectively depending on the presence of cannula before or after induction of anaesthesia.

Anaesthesia was induced after with inhalational or intravenous agents based on the presence of indwelling cannula and preference of the attending anaesthesiologist. All the patients received 0.1 mg /kg of vecuronium for endo tracheal intubation. Endotracheal intubation was performed using Microcuff ET tube (Kimberley Clark) of appropriate size adopting Khine formula with cuff fully deflated and the cuff was inflated by the anaesthesia provider with a cuff manometer and inflator 2ml syringe only after intubation. The cuff was inflated to a pressure of 15cm H_2O till it prevented any air leak. The average volume of cuff inflated varied between 0.2 to 0.5 ml.

The Children in Group 'N' were maintained with oxygen and nitrous oxide and the rest of the patients in Group 'A' were maintained with oxygen and air.

All patients were maintained on 2% sevoflurane and received analgesia with appropriate repeat doses of fentanyl. Some of the patients undergoing infra umbilical surgeries received continual regional anaesthesia through caudal or lumbar epidural catheters.

After inflation of the cuff, the intracuff pressure was continuously monitored using the same cuff manometer. The intracuff pressures were recorded initially and every 15 min for the first 1 hour, and then every 30 min thereafter throughout the surgical procedure.

STATISTICAL ANALYSIS

The Data was analysed using Students Unpaired 't' test. Timewise comparison was done by ANOVA with Bonferroni 't' test. P < 0.05 was considered to be significant. P< 0.005 was considered to be highly significant

RESULTS

The figure 1 shows the average cuff pressures in cm of H_2O from the beginning of inflation of cuff to every 15 mins till the end of the procedure.

Anova test (F) suggested the changes in mean pressure at different time intervals in both groups were very highly significant with p values less than 0.001 at the 180th min. When an interperiod group comparison was done in group N and A utilizing the Bonferroni test, the mean pressures were not significant in the first 15 minutes just significant at 30th min and highly significant thereafter till the end.

The table 1 and figure 2 shows the changes in mean pressure between the two groups are significant at base 15, 30, 45 and 90th minutes with P values less than 0.05 but not significant

Time	group	N	Mean	Std. Devi-ation	t
	Group N	30	16.133	1.167	2.48900
Base					
	Group A	30	17.000	1.509	p=0.016 sig
	Group N	30	15.767	1.165	2.65300
15 min					
	Group A	30	16.700	1.535	p=0.01 H sig
	Group N	30	15.000	1.017	2.36300
30 min					
	Group A	30	15.733	1.363	p=0.022 sig
	Group N	30	14.400	1.070	2.17800
45 min					
	Group A	30	15.100	1.398	p=0.034 sig
	Group N	30	13.633	2.076	1.94600
60 min					
	Group A	30	14.600	1.476	P=0.057 NS
	Group N	30	13.200	1.215	2.00400
90 min					
	Group A	30	13.867	1.358	p=0.05 sig
	Group N	30	12.667	1.322	1.56500
120 min					
	Group A	30	13.233	1.478	P=0.122 NS
	Group N	30	11.967	1.586	.47700
150 min					
	Group A	30	12.167	1.663	P=0.635 NS
	Group N	30	11.300	1.512	.83200
180 min					
	Group A	30	11.667	1.882	P=0.409 NS

Table-1: Comparison of mean Pressure between the groups

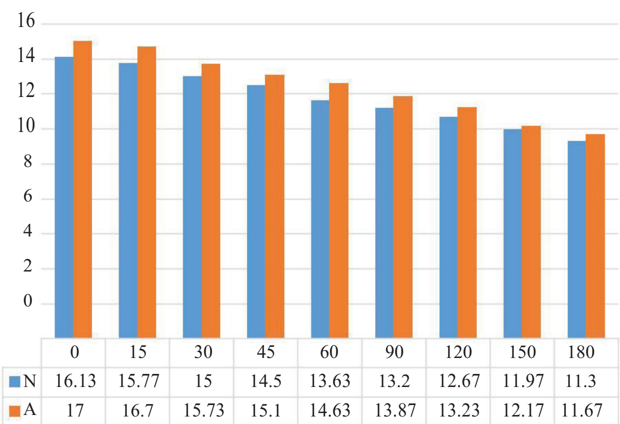
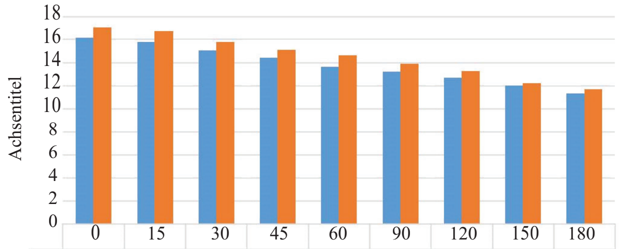


Figure-1: Average cuff pressures in cms of H_2O



	0	15	30	45	60	90	120	150	180
N	16.133	15.767	15	14.4	13.633	13.2	12.667	11.967	11.3
A	17	16.7	15.733	15.1	14.6	13.867	13.233	12.167	11.667

Figure-2: Comparison of mean pressure between the groups

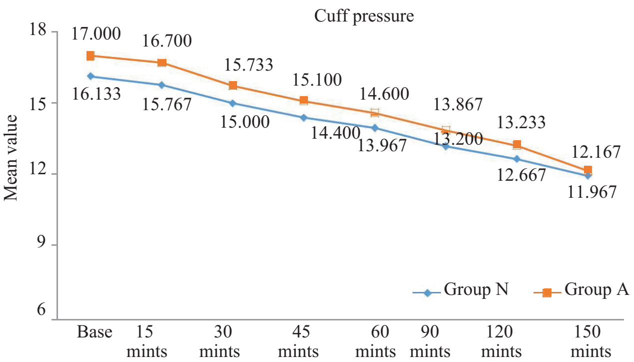


Figure-3: Cuff pressure

at the 60th min and there after between 120th and 180th min. Both the groups exhibited a linear trend of fall in the mean intracuff pressures with no additional advantage over each other.

The figure 3 shows the graphical representation of fall in endotracheal cuff pressures with time in both the groups N and A

DISCUSSION

Endotracheal intubation is an integral part of paediatric anaesthetic techniques and paediatric critical care units for airway isolation, protection and ventilation. The controversy of the use of cuffed tube below 8 years of age was in vogue for the past four decades lacked any guidelines. Achieving an appropriate fit using standard formula was not reliable with uncuffed endotracheal tubes due to aberrations in laryngeal measurements, resulted in frequent reintubations due to a faulty choice of an unusually large or a smaller tube producing significant leaks ultimately resulting in inadequate ventilation, risk of aspiration and theatre pollution with N_2O. Prolonged general anaesthesia in children intubated with cuffed portex endotracheal tubes with use of nitrous oxide resulted in raise in intracuff pressure. Diffusion of N_2O through the permeable polyvinyl chloride cuffs were directly dependant to its permeability coefficient and inversely proportional to its thickness of the cuff walls. Although the mechanisms regarding the permeability and diffusion of N_2O were unclear but the pressures were sufficient to damage the tracheal epithelium. Alternative methods of inflating the cuff with air or saline along with anaesthetic gas mixture were tried but considering the properties and advantages of N_2O over ruled the possibilities of stopping its use in current anaesthetic practice, and frequent cuff pressure monitoring particularly maintaining it below peak inspiratory pressure was justifiable.

Invention of more safer tubes in relation to the anatomical perspectives of larynx in children particularly concerning the cuffs, led to the invention of high volume low pressure microcuff endotracheal tubes in 2004 to procure a seal 20cm of H_2O in children. The size selections were based on khine s formula with clear insertion depth marks with good margin of safety for accidental endobronchial intubation and extubation against movement of head. The cuff were made of tissue compatible ultrathin (10 micro m) polyurethane with superior sealing properties at very low pressures less than 10 cm of water.

The cuff pressure measurement is a top order procedure to prevent and minimize the complications associated with endotracheal intubation during prolonged surgery or in intensive care. Various devices are available to measure and regulate cuff pressures from simple pop off valves and manometers to expensive automated pressure.

Revenas etal (1976) noticed during general anesthesia, the pressure of the endotracheal tube cuff may have to be changed frequently in particular, the use of N_2O during anesthesia results

in increased cuff pressure due to the diffusion of N_2O into the cuff.[2-6]

Gerber et al (2009) in their study in 2246 children up to 5 years of age a observed a minimal cuff pressure of 10.6 cm of H_2O of water to seal the tracheal mucosa with the use of Microcuff (PET) tracheal tubes with an average duration of surgery of 93.5 min. They concluded that a

minimum cuff pressure less than 20 cm of H_2O was adequate for a good tracheal seal with less

significant need for tracheal tube exchanges and incidence of sore throat.[7,8]

Hiromi Kako et al (2015) conducted a study of changes in intracuff pressures using microcuff endotracheal tubes during general anaesthesia in 30 paediatric patients undergoing prolonged surgery of more than 4 hrs. The cuffs were inflated utilizing an air leak test with a CPAP of 20cms of H_2O in the anesthesia circuit and the inflating port of the pilot balloon were connected to an invasive pressure monitoring transducer and the cuff pressures measurements were recorded every 15 minutes up to 1 hour and thereafter every 30 min till the conclusion of the surgery. The study was conducted on 30 children aged between 1.2 to 17.6 years and weighing from 9.4 to 113.4 kg. The size of the microcuffed tubes ranged from 3.5 mm to 8.0 mm ID and the baseline intracuff pressures measured at the time of inflation was 17.6 ± 8.8 cm H_2O. The absolute change in the intraoperative intracuff pressure when compared to the baseline intracuff pressure ranged from -25.8 to +16.3 cm H_2O. In 9 patients (30%), the decrease of the intracuff pressure was more than 10 cm H_2O. In 6 patients (20%), the increase of the intracuff pressure was more than 10 cmH_2O. In 5 of 30 patients (17%), the absolute intracuff pressure was greater than 30 cm H_2O at least once intraoperatively and in no patient, did the intracuff pressure remain the same as the baseline throughout the procedure. They concluded that significant variations in the intracuff pressures occured during prolonged surgical procedures.[1] These unintended changes, both increases and decreases, could impact the perioperative course of patients and stressed the need for continuously monitoring intracuff pressure if a cuffed ETT is used in children for prolonged surgical procedures.[9-14]

Sultan et al. have shown that several factors influenced the variation of the cuff pressure, as a change in tracheal muscles tonus, hypothermia, the patient head position (Griffin 2016) reduced the cuff reinforcing the need for frequent monitoring and adjustment of cuff pressure.[13,14]

Kako, Krishna etal (2014) noticed a linear decrease in cuff pressures in children undergoing cardiac surgeries during CPB returning to the base line level as the temperature normalized.[15]

In the present observational study involving 60 pediatric patients, were divided into two groups N maintained on N_2O and oxygen and group A on air and oxygen using block randomization. All children aged between 6 months and 5 years were intubated with micro cuffed tubes of sizes varying between 3.5 and 5 using the khine and standard formulations provided by the Kimberly clark. The cuffs were inflated to a pressure of 15 cm of H_2O using an Ambu pressure guage to prevent any air leak with a volume varying between 0.2 to 0.5 ml. In both the groups the intracuff pressures were monitored immediately as baseline and thereafter every 15 mins till the first hour followed by every 30 minutes till the end of the surgery. The present study was comparable to that conducted by the khako et al in 2013 and we noticed an average baseline average pressure of 16.13 cm of H_2O decreasing in a linear fashion to 11.3 at the end of the surgery in the group N and similarly from 17 cm of H_2O to 11.67 in group A.[1] These findings were also comparable to the study conducted by Gerber etal in 2009, who conducted a comparative study of uncuffed and micro cuffed tubes in children.[8] The airway pressure decline were highly significant in between the two groups at baseline as well as at every stipulated duration except at the 60th minute till the end of the surgery with a p-value<0.001. Anova test (F) suggested that the changes in mean pressure at different time intervals in both groups are very highly significant with p values less than 0.001 at the 180th min.[16-21]

When an interperiod group comparison was done in group N and A utilizing the Bonferroni test, the mean pressures were not significant in the first 15 minutes just significant at 30th min and highly significant thereafter till the end. Ultimately a significant fall in cuff pressure were seen at the end of the procedure seen in the current study not supported by Dullenkopf et al where the cuff pressures never recorded below 20 cm of H_2O.[16] We do not attribute this to hypothermia as the operating tables were equipped with warmer. The cuff pressures in our study remained critically as low as less than 10 cm of H_2O at the end of the surgery in few patients but reinflation was not considered as the patients were extubated immediately. We attribute this to shortened high volume low pressure ultrathin polyurethane cuff allowing adequate seal at very low cuff pressures.

CONCLUSION

In the present study of changes in intracuff pressure of microcuff endotracheal tube during prolonged anaesthesia with nitrous oxide and air in paediatric patients conducted in the year 2015 to 2017 at KMC hospitals Attaver, Ambedker circle and RAPCC Government Wenlock hospitals we come to following conclusion.

1. Microcuff endotracheal tubes are useful innovations in anaesthetic armamentarium at all ages starting from newborn to adolescents, significant changes in cuff pressures occur during prolonged general anaesthesia using micro cuff endotracheal tubes irrespective of using N_2O or air along with inhalational agents so that the cuff pressure monitoring is mandatory to keep it below 20 cm of H_2O. Simple hand made gauges like AMBU can be safely used to evaluate the cuff pressures. In the present study the cuff pressures were critically low at the end of the surgery with adequate seal, but may be a concern in ICU patients when retained for more than 48 hours for the fear of occurrence of VAP.[18] No significant advantage was seen with air over N_2O with a linear fall of Mean cuff pressures in both the groups.
2. They ensure safe seal, adequate ventilation and permits economy of fresh gases and expensive inhalational agents reducing cost but not particularly applicable to microcuff tubes only. But they are quite expensive compared to other conventional endotracheal tubes.
3. Airway trauma is rare as the intubations are smooth due to ultrathin microcuffs placed sufficiently below the laryngeal structures. Avoids an oversized tube selection and compensates adequately with inadvertent intubations with smaller tubes particularly during rapid sequence intubation.
4. AHA and its European counterpart have recommended microcuff tubes in the 2005 guidelines.
5. Cuff pressures can be affected by usage of N_2O, hypothermia, head and neck position which were not conclusive in our study.

REFERENCES

1. Hiromi Kako, Anatoliy Goykhman, Archana S. Ramesh, Senthil G. Krishna, Joseph D. Tobias Changes in intracuff pressure of a cuffed endotracheal tube during prolonged surgical procedures. / International Journal of Pediatric Otorhinolaryngology 2015;76– 79.
2. S. Eschertzhuber, B. Salgo, A. Schmitz, W. Roth, A. Frotzler, C.H. Keller, et al., Cuffed endotracheal tubes in children reduce sevoflurane and medical gas consumption and related costs, Acta Anaesthesiol. Scand. 2010;54:855–858.
3. Part 12: Pediatric Advanced Life Support. Circulation

2005;112:167 – 187.
4. Timmerman and JM Thomas, Endotracheal tubes in paediatric anaesthesia:the cuffed versus uncuffed debate. SAJA 2010;16:3, 88-91.
5. Dr L. Ford, Ms J Ballard, Dr M Davidson, Guideline on the use of Cuffed Endotracheal Tubes, PICU guideline group, March 2016.
6. Revenas B, Lindholm CE. Pressure and volume changes in tracheal tube cuffs during anaesthesia. Acta Anaesthesiol Scand 1976; 20: 321-326.
7. Stanley TH, Kawamura R, Graves C, Effects of nitrous oxide on volume and pressure of endotracheal tube cuffs. Anesthesiology 1974; 41: 256-262.
8. M. Weiss, A. Dullenkopf, J.E. Fischer, C. Keller, A.C. Gerber, Prospective randomized controlled multi-centre trial of cuffed or uncuffed endotracheal tubes in small children. European Paediatric Endotracheal Intubation Study Group, Br. J. Anaesth 2009;103:867–873.
9. Mukul Kumar Jain and Chander Bushan Tripathi, Endotracheal tube cuff pressure monitoring during neurosurgery - Manual vs. automatic method, Journal of Anaesthesiology, Clinical Pharmacology, Jul-Sep 2011; 27: 358–361.
10. V.Bernet,A. Dullenkopf, P.Maino,M. Weiss,Outer diameter and shape of paediatric tracheal tube cuffs at higher inflation, Anaesthesia, November 2005; 60: 1123– 1128.
11. Roshdi Al-Metwalli, S.Sadek,Safety and reliability of the sealing cuff pressure of the Microcuff pediatric tracheal tube for prevention of post-extubation morbidity in children: A comparative study, Saudi Journal of Anesthesia 2014;8(4).
12. Senthil G. Krishna, and Mumin Hakim, and Rob Sebastian, Heather L. Dellinger, Dmitry Tumin, and Joseph. D. Tobias. Cuffed endotracheal tubes in children: The effect of the size of the cuffed endotracheal tube on intracuff pressure. Pediatric Anesthesia 2017; 27:494–500.
13. Sultan P, Carvalho B, Rose BO, Cregg R. Endotracheal tube cuff pressure monitoring: a review of the evidence. J Perioper Pract. 2011; 21:379-86.
14. Griffin H. Olsen, Senthil G. Krishna, Kris R. Jatana, Charles A. Elmaraghy, James M. Ruda, Joseph D. Tobias, Changes in intracuff pressure of cuffed endotracheal tubes while positioning for adenotonsillectomy in children, Pediatric Anesthesia 2016; 26: 500–503.
15. Hiromi Kako, and Omar Alkhatib, and Senthil G Krishna, Sarah Khan, Aymen Naguib, and Joseph. D Tobias. Changes in intracuff pressure of a cuffed endotracheal tube during surgery for congenital heart disease using cardiopulmonary bypass. Paediatric anaesthesia. 25,(2015).
16. Dullenkopf, A. C. Gerber and M. Weiss, Fit and seal characteristics of a new paediatric tracheal tube with high volume–low pressure polyurethane cuff, Acta Anaesthesiologica Scandinavica 2005;49:232–237.
17. Madhankumar Sathyamoorthy, Jerrold Lerman, Satyan Lakshminrusimha and Doron Feldman. Inspiratory Stridor after Tracheal Intubation with a MicroCuff (R) Tracheal Tube in Three Young Infants. Anesthesiology,2013; 118.
18. Augustyn B. Ventilator-associated pneumonia – risk factors and prevention. Crit Care Nurse 2007; 27: 32-36.
19. Tu H Nguyen, Saidi N, Leiutaud T, Bensaid S, Menival V, Duvaldestin P, Nitrous oxide increases endotracheal cuff pressure and the incidence of tracheal lesions in anesthetized patients,Anesth Analg. 1999;89:187-90.
20. Ahmad NL, Norsidah AM, Change in endotracheal tube cuff pressure during nitrous oxide anaesthesia: a comparison between air and distilled water cuff inflation, Anaesth Intensive Care. 2001;29:510-4.
21. S. Gopalakrishnan, N. Barry, J. Rice, J.D. Tobias, Cuffed endotracheal tubes in infants and children: a technique to continuously measure the intracuff pressure, Int. J. Pediatr. Otorhinolaryngol. 2013;77:1135–1138.

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