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Intubation outcome of microcuff versus uncuffed endotracheal tube in children undergoing elective surgeries

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Abstract:
Background*: Previously uncuffed endotracheal tubes have been the gold standard for intubation in under 8 years age children. The aim of our study was to compare the safe use of Microcuff tubes with uncuffed tubes in children in terms of tube exchange rate, consumption of sevoflurane and post operative stridor*
Materials and Methods*: A total of 32 patients of ASA grade I and II , from newborn to 5 years posted for elective surgery who gave consent for intervention were included in group A (Microcuff tube) . Appropriate age matched controls were selected in group B (Uncuffed tube) We studied post-extubation stridor, TT exchange rates and consumption of inhalational agents as primary outcome . Secondary outcome variables included ventilation at low flow, airway sealing pressure and adverse effects.*
Results*: A total of 64 children were studied. Tracheal tube exchange rate was significantly higher in group B (28.1% vs 3.1%) as compared to group A. (p = 0.006). Main reason was excessive air leak. Consumption of sevoflurane in group A was 6.56 ± 4.75 ml and in group B was 15.81± 9.81 ml (p = 0.00). Minimal cuff pressure required to seal the trachea was 11 ±1.91 cm H2O. Incidence of post extubation stridor was found to be similar in both the groups (3.1% ; p = 1.11).*
Conclusion: *Microcuff tubes can be safely used in children if size selection recommendations are followed and cuff pressure is strictly monitored without any increase in the incidence of post extubation stridor.*
Key Word*: Microcuff endotracheal tube, Paediatric airway*

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I. Introduction

Airway management is the art of securing a patent airway and is a cornerstone of anaesthetic practice. Paediatric airway management is crucial for clinical anaesthesiologist as it is vulnerable to iatrogenic injury.[1] For more than 50 years, uncuffed endotracheal tubes have been the gold standard for intubation in children under 8 years of age except in certain situations where cuffed tubes were used.[1],[2] This was attributed to the non-availability of the cuffed tubes in very small sizes and the fear of airway mucosa injury from high pressure low volume cuffs that were used in the past.[3]

Now with the availability of cuffed paediatric tracheal tubes (Microcuff) in all sizes featuring a high volume low pressure cuff with ultra-thin polyurethane membrane, many clinical trials have shown the advantages of Microcuff endotracheal tubes (ETT) in paediatric anaesthesia[4] viz., less gas leakage around the tube cuff, with improved efficacy of ventilation,[5], reduced environmental pollution, more reliable end-tidal gas monitoring, less aspiration , the possibility for low-flow anaesthesia , economy of anaesthetic agents with no increased risk of laryngotracheal morbidity as these conform to the airway anatomy well.

Only few studies comparing the use of Microcuff and uncuffed ETTs in neonatal age group are available [6],[7],[8]. So we conducted this study in 0-5 years age group in Indian children to compare Microcuff tube with the traditionally used uncuffed tubes in terms of post extubation stridor, tracheal tube exchange rate, consumption of inhalational agents as primary outcome variables. Other parameters noted were minimal sealing pressure and efficacy of ventilation at low flows.

II. Material And Methods

This prospective comparative study was conducted at a tertiary Care Centre, after obtaining approval from the Institutional Ethics Committee and Research Review Board (Ref.No. 2405 /MC/EC/2016) and written informed consent from all parents. A total of 32 patients of American Society of Anesthesiologists (ASA) grade I and II, from newborn to 5 years scheduled for elective open abdominal surgery under general anaesthesia who gave consent for intervention were included in this study. Appropriate age matched controls were selected after their informed consent. Patients with any known airway anomaly, suspected difficult intubation or need for post-operative ventilation were excluded from the study.

Pre-anaesthetic checkup was done one day prior to surgery .Patients who gave consent for intervention were placed in Group A and their age matched controls in Group B. Written informed consent was taken from both Group parents. Patients in Group A were intubated with appropriate size Microcuff endotracheal tube and Group B were intubated with routinely used uncuffed endotracheal tube. On arrival in operation theatre, multipara monitoring was established. After pre-oxygenation with 100% oxygen, premedication was given in the form of inj. glycopyrrolate 0.005mg/kg, and inj. fentanyl 1 micro gm/kg through already secured iv line as per hospital protocol. Induction was done with inj. propofol 2.5-3.0mg/kg i.v. and inj. atracurium 0.6mg/kg i.v .After IPPV with 100% oxygen for 90-120 seconds oral endotracheal intubation was performed under direct laryngoscopy according to the group assigned.

For Microcuff endotracheal tubes size selection was done according to the following chart

ID(Internal Diameter)	**AGE**
3mm	Birth(>3 kg) to <8month
3.5mm	8 to 18 months
4mm	18 to <36 months
4.5mm	36 to <60 months

For uncuffed ETT, size selection was done according to Modified Coles formula
age < 6 yrs. = age in yrs. / 4 + 4[6]. ETT insertion depth was selected according to institutional guidelines in uncuffed ETT (12+ age/2) and according to depth marking in Microcuff ETTs. Bilateral breath sounds were checked by auscultation and confirmed by capnography.

Air leak after intubation was checked with the patient in supine position at 20 cm H2O positive inflation pressure in uncuffed ETT and in Microcuff ETT with the cuff fully deflated by audible air leak method. If no air leak was observed at 20 cm H2O inflation pressure, the tube is judged to be too large and was exchanged for one smaller size (-0.5 mm ID). Uncuffed tracheal tubes with excessive air leak not allowing adequate ventilation,absence of proper capnograph tracing and persistent leak even at pressure greater than 30 cm H2O were exchanged for next larger size (+ 0.5mm ID).

For Microcuff ETTs, the cuff was inflated using cuff pressure manometer just above the minimal sealing pressure. Minimal sealing pressure was determined by slowly reducing the cuff pressure until an audible leak appeared at the patient's mouth and then the pressure was increased until leak disappeared under steady-state ventilation conditions and maintained throughout the procedure . Number of ET exchanges to find the appropriate-sized tube and the final ETT size selected for intubation (cuffed or uncuffed) and minimal seal pressure for Microcuff tube was recorded.

Lowest fresh gas flow (FGF) required for filling the ventilator bellows (minimum 1 l /min) was assessed and maintained at steady level during controlled ventilation. We also recorded inspiratory sevoflurane concentration till the completion of surgery. The amount of liquid sevoflurane and FGF used was calculated using the following formula[21]

Calculation of volume of liquid sevoflurane used per hour:
A= C x FGF x 60 / 20
Where:
A= Amount of liquid volatile used (ml/h)
C = Concentration of volatile agent (%)
FGF= Fresh gas flow (l/min)
60= Conversion factor for minutes to provide hourly consumption, and

20= Conversion factor for approximation of vapour to liquid volume*

Calculation of volume of medical gases used:
V= FGF x D
Where:
V = Volume of medical gases used (l)
FGF = Fresh gas flow (l/min)(separate for oxygen, nitrous oxide and air), and
D = Duration (min)

At the end of surgery reversal of neuromuscular blockade was done with inj. neostigmine 0.06mg/kg and inj. Glycopyrrolate 0.008mg/kg. Patients were extubated awake after performing oral suctioning and cuff deflation. The child was observed for laryngospasm, post extubation stridor and the need for reintubation. If no airway complication was observed, the child was shifted to recovery room and monitored till 1 hour after extubation.

Sample size was calculated 32 subjects in each of two groups at α error 0.05 and study power 80%, to verify the expected difference of 28.7% in tube exchange rate in both study group (2.1% versus 30.8%).

Data were summarized at the end of the study using Microsoft Excel and analyzed with the help of SPSS (Statistical Package for Social Sciences) software version 20. The results of quantitative variables were reported as mean± SD and of qualitative variables were reported as percentages. Comparison of the means of the quantitative variables between two study groups was done using the independent t test. Percentages of qualitative variables between two groups were compared using chi –square test. For all statistical tests done, the level of significance was fixed at the 5% level. A p-value> 0.05 indicates no significant difference. A p-value <0.05 indicates significant difference.

III. Result

There was no significant difference between two groups in terms of age, weight, gender and ASA physical status. Demographic profile is shown in Table 1.

Table 1: Age wise distribution of study subjects (N=64)

variable	Microcuff tube (N=32)		Uncuffed tube (N=32)		p value(by independent t test)
	Mean	Standard Deviation	Mean	Standard Deviation	
Age of patients (in months)	23.81	21.70	25.56	21.37	**0.746**
Weight of patients (kg)	11.44	6.20	11.44	6.02	**0.625**

Tracheal tube exchange rate was significantly higher (p =0.006) in Group B (28.1%) as compared to (3.1%) in Group A . Main reason for tube exchange in group B was excessive air leak. (Table 2).

Table 2: Distribution of tube exchange and related variables among study subjects (N=64)

variable	Microcuff tube (N=32)		Uncuffed tube (N=32)		P value(by Chi-Square test)
	Frequency	Percentage	Frequency	Percentage	
No tube exchange	31	96.9%	23	71.9%	**0.006**
Tube exchange	1	3.1%	9	28.1%	
Tube exchange rate	**3.1%**		**28.1 %**		
Patient with >1 tube exchanges	0	0.0%	2	6.25%	**0.003**
Total number of tube exchanges	1	3.1%	11	34.4%	**0.000**

Consumption of fresh gas was significantly less in group A (1.06 ml) as compared to Group B(2.25ml) (p = 0.000). Consumption of sevoflurane was 6.56 ml in Group A while 15.81 ml in Group B (p = 0.000). (Table 3)

Table 3: Distribution of Reasons Of Tube Exchange among study subjects (N=64)

variable	Microcuff tube (N=32)		Uncuffed tube (N=32)		p value (by chi-square test)
	Frequency	Percentage	Frequency	Percentage	
Resistance to pass the tube	0	0.0%	2	6.2%	**0.492**
No air leak at 20 cm H2O	1	3.1%	3	9.4%	**0.613**
Excessive air leak at IPPV	0	0.0%	5	15.6%	**0.020**

Minimal sealing pressure was found to be 11 cm H_2O in the Microcuff group. One case in each group had post extubation stridor.

Table 4 : Consumption of gases among study subjects(N=64)

Variable	Microcuff tube (n=32)		Uncuffed tube (n=32)		p value(by independent t test)
	Mean	Standard Deviation	Mean	Standard Deviation	
Fresh gas flow(ml)	1.06	0.246	2.25	0.440	0.000
Consumption of sevoflurane (ml)	6.56	4.75	15.81	9.81	0.000

IV. Discussion

Determination of "best fit" endotracheal tube is important in children to provide optimum ventilation without causing any laryngotracheal morbidity[9]. This is necessary when using uncuffed endotracheal tubes because of the normal variations in laryngeal dimensions[10] and the fixed outer diameter of these tubes. Using the protocol-defined choice of initial tube and reintubation criteria, we demonstrated that use of Microcuff endotracheal tubes, which have an adjustable outer dimension and shape, almost eliminates the need to replace the initial tube.

Microcuff endotracheal tubes are specially designed tubes with cuff made up of ultrathin polyurethane material (10 micron) that permits a true high volume, low pressure (HVLP) cuff to reduce cuff pressure. It seals at an average cuff pressure of 11 cm H_2O which is below the commonly presumed capillary perfusion pressure of paediatric population thus diminishing the risk to mucosal damage. It has a short cylindrical cuff placed near the tube tip that fits in the trachea and not in the pressure sensitive subglottis which is the narrowest portion of the airway. Murphy eye is absent. It has correctly placed depth markings ensuring optimal tube placement [11],[12],[13] and reducing the chances of endo-bronchial intubation.

In our study we observed that the tracheal tube exchange rate was significantly less in the Microcuff tube group as compared to the uncuffed tubes (3.1% % Vs 28.1%). Similar results were obtained in a multicentre trial conducted by Weiss et al (2009)[7] in 2246 patients from birth to 5 years comparing Microcuff tubes with uncuffed tubes (2.1% Vs 30.8%). Other studies also observed similar results. [6], [14], [15]

Main reason for tube exchange in uncuffed group was excessive air leak in 15.6%. Other reasons for tube exchange included resistance to pass the tube (6.2% in the uncuffed group and none in the microcuff group) and no air leak at 20 cm H_2O (3.1% in Microcuff group and 9.4% in the uncuffed group). A study conducted in paediatric burn patients also found that it was difficult to ventilate the patients adequately due to excessive air leak in the uncuffed TT group (23.1%) as compared to the cuffed tube group (1.8%)[16]. Hence significant number of tube exchanges were needed in the uncuffed group to combat for excessive air leak. Another study by Park in 2013 [17] demonstrated that the age-based formula for uncuffed ET tube size selection has low specificity. They concluded that age-based formula usually assesses one size smaller ET tube (65% cases) as required for adequate seal hence leading to excessive air leak. Several other studies support our result of excessive air leak leading to high tube exchange rate in uncuffed group.[6],[7]

We observed that chances of finding an appropriate size tracheal tube in single attempt were 96.9% in the Microcuff group and 69.4% in the uncuffed group. Our results were consistent with a multicentre trial by Weiss[7], which demonstrated appropriate tracheal tube size selection in 97.9% in Microcuff group as compared to 69.5% in uncuffed group.

We observed, no significant difference in post extubation stridor between the two groups (p =1.11). Cuff stabilizes the tube and allows it to maintain a more central position, thereby potentially reducing the risk of airway trauma. Our results were consistent with other studies.[6],[18],[19],[20]

Laryngospasm occurred in 1 patient in the uncuffed group while no incidence was reported in the Microcuff group. It was relieved by bag and mask ventilation. None of the patient in both the groups required reintubation for stridor. Our results are consistent with the study of **Khine et al[6]**.

The consumption of fresh gas and sevoflurane was significantly less in Microcuff tube group as adequate ventilation was achieved at low flow rates. Our results were in accordance to other studies[21],[22]. High flows are required with the uncuffed tubes because of the leakage. Hence the higher cost of Microcuff tubes is compensated by decrease in the wastage of medical gases, inhalational agents and reduced ambient environmental pollution.

Minimal sealing pressure in the Microcuff group was 11 cm H_2O. Other studies [23],[24] also demonstrated that Microcuff tubes have minimal sealing pressure when compared with the other cuffed tubes. No exact data is available regarding perfusion pressures of the tracheal mucous membrane in children. So, it is believed that low cuff pressure would possibly be safe for children

V. Conclusion

Microcuff tubes can be safely used in children if size selection recommendations are followed and cuff pressure is strictly monitored without any increase in the incidence of post extubation stridor.

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