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COMPARISON OF MICROCUFFED ENDOTRACHEAL TUBE WITH UNCUFFED ENDOTRACHEAL TUBE IN TERMS OF EFFICACY, MORBIDITY AND SEVOFLURANE CONSUMPTION RATE FOR PEDIATRIC LAPAROSCOPIC SURGERIES.

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ABSTRACT

INTRODUCTION: Traditionally uncuffed endotracheal tubes have been used in children for half a decade. The use of cuffed endotracheal tube was considered harmful in pediatric patients. But now it is proven that pediatric cricoid is ellipsoidal in shape and uncuffed tube passing through it causing excessive pressure on the cricoid . Our aim in this study was to compare microcuff endotracheal tube with uncuffed endotracheal tube in terms of efficacy, morbidity and sevoflurane consumption rate (Dion's method) for paediatric laparoscopic surgeries.

MATERIAL AND METHODS: 60 Paediatric patients (30 patient each in microcuffed and uncuffed endotracheal tubes using groups) undergoing laparoscopic surgery under general anaesthesia were randomly selected. Written informed consents were taken from parents. After induction of anesthesia patients were intubated with either of the tube as per randomisation. Air leak pressure after intubation was tested. Depending of the air leak and inadequacy of ventilation tube was exchanged. Amount of liquid sevoflurane used was calculated according to Dion's method. Post-operative patients were assessed for stridor/hoarseness.

RESULTS: Tracheal tube exchange rate was significantly higher for uncuffed endotracheal tubes (p value 0.001). The mean for leak pressure was significantly more in uncuffed endotracheal tubes (22.03±1.25 cm of H2O) than microcuffed endotracheal tubes (10.67±1.25 cm of H2O) with p value (<0.001). There was no significant difference regarding Sevoflurane consumption and hemodynamic parameters. But incidence of airway complications was less in microcuffed tubes.

CONCLUSION: The microcuffed endotracheal tube is better than uncuffed endotracheal tube for laparoscopic pediatric surgeries in terms of lower size of tube requirement, lesser tube exchange rate, decreased leak pressure, same consumption of sevoflurane and lower morbidities such as post extubation stridor/croup, hoarseness of voice and throat pain.

KEYWORDS : Microcuffed, uncuffed , paediatrics, leak pressure

INTRODUCTION

Pediatric airway is one of the most delicate and vulnerable part of anesthesia management. So it must be handled with utmost care to allow adequate ventilation with minimal trauma to the laryngotracheal structure of our small patient.[1] Endotracheal tube provides a secure connection between the pediatric lung and the AMBU bag or ventilator. This tight and leak proof connection is must for constant minute ventilation, accurate respiratory monitoring and capnography. It helps in keeping a low fresh gas flow and prevents pulmonary aspiration.[2]

Traditionally uncuffed endotracheal tubes have been used in children for half a decade. The use of cuffed endotracheal tube was considered harmful in pediatric patients. This idea was based on the belief that the cricoid, which is the narrowest part of the pediatric airway till 8 years of age, would be a circular structure. The endotracheal tube that would fit appropriately through the cricoid and also leave an air leak at 25 cm of H_2O would be ideal choice and would give a perfect sealing.[3]

But now it is proven that pediatric cricoid is ellipsoidal in shape and uncuffed tube passing through it causing excessive pressure on the posterolateral walls of the cricoid and the air leak may be from the anterior part of the cricoid lumen.[3]

In the last decade many authors have come up with studies showing the advantage of microcuffed endotracheal tube in paediatric patient.

Microcuffed tubes have a high volume low pressure (HVLP) cuff made up of polyurethane, provides adequate sealing with a smaller diameter endotracheal tube, at a lower pressure. The chances of causing damage to the pediatric airway mucosa are very rare.[4]
So that we have planned this study to compare microcuffed tube with uncuffed tube, to see which is better for pediatric patients.

AIMS AND OBJECTIVES

To compare microcuffed endotracheal tube with uncuffed endotracheal tube in terms of efficacy, morbidity and Sevoflurane consumption rate for pediatric laparoscopic surgeries with respect to

1) Tracheal tube exchange rate
2) Sealing pressure
3) $ETCO_2$ graph, intra cuff pressure, heart rate and blood pressure at time interval of 0, 15, 30, 45, 60, 90 and 120 min interval
4) Sevoflurane consumption during the procedure
5) Postoperative Stridor, voice quality (presence of hoarseness) and throat pain.

MATERIAL AND METHODS

After institutional ethics committee approval, in this prospective randomized controlled study, 60 pediatric patients undergoing laparoscopic surgery under general anesthesia in our hospital were selected. Written informed consents were taken from parents a day prior to surgery.

INCLUSION CRITERIA:

- Children aged between 1 to 6 years
- ASA physical status I and II
- Patients posted for elective laparoscopic surgery.
- Children requiring endotracheal intubation as part of their anaesthetic care and planned controlled ventilation during the surgical procedures
- Extubation after the procedure in the operation theatre

EXCLUSION CRITERIA

- No parental written consent obtained
- Known airway anomalies (airway stenosis, including Down's syndrome)
- Known or suspected difficult intubation
- Children at risk for regurgitation
- Surgery of the larynx and/or of the trachea, neck, and/or upper oesophagus
- Pulmonary diseases (pneumonia , bronchial infection, asthma,

pulmonary malformations)
- ASA physical status III and IV.
- Planned postoperative ventilation in the ICU
- Weight and/or height percentiles , 3%/,97%

PROCEDURE

According to computer generated randomization table subjects were allocated into two groups (30 patients in each group)
(a) Microcuffed Pediatric Tracheal Tube
(b) Uncuffed ETT
After confirming adequate starvation, patients were premedicated with IV Midazolam 0.03mg/kg, IV Pentazocine 0.6 mg/kg and IV Glycopyrrolate 4µg/kg. After preoxygenation, patients were induced with IV Propofol 2mg/kg and IV Atracurium 0.5mg/kg. Then patients were intubated orally with appropriate size endotracheal tube using direct laryngoscopy according to following table:

Microcuffed endotracheal tubes

ID	AGE
3mm	Birth(>3 kg) to <8month
3.5mm	8 to <24 months
4mm	24 to <48 months
4.5mm	48 to <72 months

Table 1: size of microcuffed endotracheal tube according to age

Uncuffed endotracheal tubes
Formulas for Endotracheal Tube Selection:-[4]
(modified Cole's Formula) = 4 + Age / 4

Air leak pressure after intubation was tested with the patient supine and the head in the neutral position. An audible air leak at the patient's mouth was present at 20 cm H_2O positive inflation pressure in uncuffed endotracheal tube and in microcuffed endotracheal tube with the cuff fully deflated. If there were no air leak present at 20 cm H_2O inflation pressure, the tube were judged to be too large and were exchanged for the next smaller size (0.5 mm ID). Endotracheal tubes with excessive air leak not allowing adequate ventilation were exchanged for next larger size (0.5mm ID).

For microcuffed endotracheal tube, the cuffs were inflated with the cuff pressure manometer. Cuff pressures were limited to 20 cm H_2O with a pressure release valve. Minimal sealing pressure were assessed under steady-state ventilation conditions and maintained during the procedure. It was performed 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. Minimal cuff pressure required to seal the airway and quality of sealing were recorded. Further, leak pressure and number of endotracheal tube exchanges to find the appropriate-sized endotracheal tube were recorded.

Patients were maintained on O_2, Air (2lt/min), Inj. Atracurium and sevoflurane throughout the procedure. Sevoflurane dial concentration settings were varied according to the need. Sevoflurane consumption is calculated as[5]

Amount of liquid sevoflurane used = PFTM/2412d
Where the variables represent:

P- Vaporizer dial concentration in percent
F -Total fresh gas flow in liters/minute
T- Time for which the concentration P was set in minutes (T1=1% dial concentration for t1 min, T2=2% dial concentration for t2 min, T3=3% dial concentration for t3 min, T4=4% dial concentration for t4 min….)
M- Molecular mass of sevoflurane in grams
d- Density of liquid sevoflurane in grams/milliliter
The fixed variables used were:
F - (total fresh gas flow) set at 2 L/min (maintenance)
M- (molecular mass of sevoflurane) = 200.055 mg
d- (density of sevoflurane at 21°C) = 1.52 g/ml
The time period for each concentration was labeled as T 1, T 2, T 3 so on until T 8 in seconds for concentration of 1%, 2%, 3% till 8%.

Total liquid sevoflurane used was calculated as: .00182 (T 1 + T 2 +……)

At the end of surgery, patients were reversed with IV Neostigmine 0.05 mg/kg and IV Glycopyrrolate 8 mcg/kg and extubated after cuff deflation and oral suctioning.

Post-operative stridor/hoarseness were looked for, if present and noted.

RESULTS

Baseline characteristics and outcomes were compared using Student's t-test for normally distributed data. Mann Whitney U-test was used for non-normally distributed data and Chi square analysis for nominal data.

Out of 60 children, mean age for microcuffed endotracheal tubes was 4.23±81.76 years and 3.6± 1.84 years for the patients intubated with uncuffed endotracheal tubes. Both groups were comparable in demographic characteristics.

Among 30 patients in the Microcuffed group 19(63.3%) were males and 11(36.7%) were females and among the 30 patients of Uncuffed group 26(86.7%) were males and 4(13.3%) were females with a (P value of 0.037). The value is not significant. The gender difference is comparable between the 2 groups. Test used is Fisher's exact test.

Tracheal tube exchange rate was found significantly higher for uncuffed endotracheal tubes (p value 0.001 i.e. < 0.05).

Table 2. Comparison of endotracheal tube exchange rate.

Endotracheal tube exchange rate	N	Mean	Std. Dev	Median	IQR	Unpaired T test	p value
Microcuffed tube	30	1	0	1	0	-3.525	0.001
Uncuffed tube	30	1.3	0.47	1	1	Difference is significant	

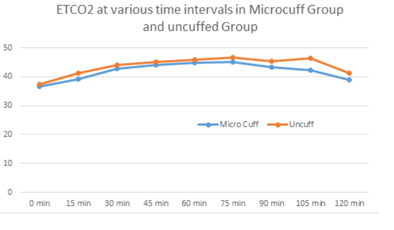
The mean for leak pressure was significantly more in uncuffed endotracheal tubes (22.03±1.25 cm of H_2O) than microcuffed endotracheal tubes (10.67±1.25 cm of H_2O) with p value (<0.001 i.e.<0.05).

Table 3: Distribution of study group as per weight (kg) and leak pressure (cm of H_2O) of endotracheal tube used in each group.

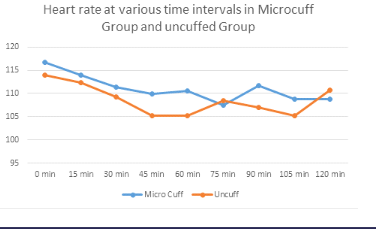
Study Parameter	Micro Cuffed	UnCuffed	Std.Dev	Unpaired T test	P Value
Weight	14.97	14.93	5.11	0.026	0.98
Leak Pressure	10.67	22.03	1.25	-43.42	<0.001

Hemodynamic parameters were monitored at 0, 15, 30, 45, 60, 75, 90, 105 and 120 minutes. Difference between mean values of ETCO2, Heart rate and MAP were not significant at all time intervals.

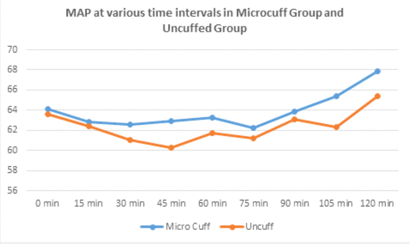
Graph 1 : ETCO2 at various time intervals in Microcuffed Group and uncuffed Group



Graph 2 : Heart rate at various time intervals in Microcuffed Group and uncuffed Group



Graph 3 : MAP at various time intervals in Microcuffed Group and Uncuffed Group



All the pediatric patients in the study group were intubated with either microcuffed or uncuff endotracheal tube. The cuff pressure (cm of H2O) values were measured at 0, 15, 30, 45, 60, 75, 90, 105 and 120 minutes. Mean values of their cuff pressure (cm of H_2O) were 11.10, 10.80, 10.60, 10.86, 10.82, 10.63, 10.62, 10.73 and 10.71 for the patients intubated with microcuffed endotracheal tubes. Cuff pressure values were 0 for Uncuffed tubes.

Study Parameter				Unpaired T test	P Value
Cuff Pressure 0 min	Microcuffed	uncuffed	Std.Dev.		
0 min	11.1	0	0		
15 min	10.8	0	0		
30 min	10.6	0	0		
45 min	10.86	0	0		
60 min	10.82	0	0		
75 min	10.63	0	0		
90 min	10.62	0	0		
105 min	10.73	0	0		
120 min	10.71	0	0		

Table 4: Comparison among study group for cuff pressure (cm of H_2O)

Sevoflurane consumption for patients intubated with microcuffed tube were 28.10±9.77 ml and for the patients intubated with uncuffed endotracheal tubes were 28.48± 8.72 ml (P value 0.874 i.e. > 0.05). Difference was not significant.

Consumption of Sevoflurane	N	Mean	Std. Dev	Median	IQR	Unpaired T test	P value
Microcuff tube	30	28.1	9.77	29.48	16.38	-0.16	0.874
Uncuff tube	30	28.48	8.72	28.94	12.01	Difference is not Significant	

Table 5: Comparison of Sevoflurane consumption (ml)

Incidence of postoperative airway complications were shown in following table. Microcuffed tubes caused less complications compared to uncuffed tubes.

Table 6: Postoperative Airway Complications

Complication	Microcuffed ETT	Uncuffed ETT	P value	Significance
Croup	3.3%	6.7%	0. 045	significant
Hoarseness	6.7%	16.7%	0.022	significant
Throat pain	6.7%	16.7%	0.022	significant

DISCUSSION

Whether to use cuffed endotracheal tubes routinely in pediatric patients has been extensively debated in the past. However the opinions and recommendations were based on personal experiences rather than on scientific evidences.

Things have changed with time, with the help of MRI; it was revealed that the cricoid lumen was not round but ellipsoidal in shape.[5]

With cuffed endotracheal tubes, the seal is obtained at the level of vocal cord by means of an appropriately positioned high volume low pressure cuff.[1]

In contrast to the cricoid ring, the tracheal rings are incomplete and thus slightly distensible, which has obvious pressure reducing effects at the level at which the airway is sealed.

To facilitate passage of the cuff through the larynx, cuffed endotracheal tubes are selected a half to one size smaller for age compared with the uncuffed tubes. This result in minimal impingement on the walls of the cricoid once the endotracheal tube is in place.[7]

Many cuffed endotracheal tubes available in markets are poorly designed and have limitation with the outer diameters, cuff position, cuff diameter and depth markings.

A satisfactory cuffed tube size in children depends on the size of both the outer tube and cuff diameter with sealing pressure of less than 20 cm of H_2O.

To address all this problems with cuffed tube, microcuff tube came into existence. Developed by Kimberly-Clark , this tube employs a patented cuff capable of sealing at a very low pressure.

The Murphy eye has been eliminated, which has allowed the cuff to be moved more distally on the tracheal tube shaft. The cuff is short, cylindrical and when inflated, it expands below the sub-glottis, providing a seal with cuff pressure <15 cm H_2O. Dullenkopf et al, found the Microcuffed endotracheal tube at a cuff pressure of 10 to 30 cm of H_2O was better than other brands in preventing fluid leakage past the cuff.[6] Mean values of their cuff pressure (cm of H_2O) were approx. 10-11 cm of H_2O.

Correct insertion depth is critical for cuffed tube so microcuffed tube have clear markings. This mark must be situated between the vocal cords and the four alerting bars, helps ensure correct positioning, without the risk of endobronchial intubation.[1] Like this study, Many studies have mentioned very low rate of reintubation and tube exchange with Microcuffed tube. (1.6-2.1%)

The phenomenal decrease in endotracheal tube exchange rate for microcuffed endotracheal tube decreases the number of reintubation and laryngoscopies as compared to uncuff endotracheal tube, thereby decreasing the chances of causing trauma to the delicate airway of our paediatric patient. Our study was comparable to the study done by M.Weiss, A. Dullenkopf, J.E.Fischer, C.Keller, A.C.Gerber et al, in 2009 where they observed a tracheal tube exchange rate of 2.1% in cuffed compared to 30.1% in uncuffed tubes.[4,7]

Dullenkopf et al, observed 500 children from birth (weighing at least 3 kg) to age 13 years, who were intubated with microcuffed endotracheal tube. He found a very low rate of tube exchange (1.6%) and decreased airway morbidity (croup requiring therapy, 0.4%).[8]

Weiss (2007) reports an intraoperative tube exchange rate of up to 28% for uncuffed tubes, which is high. This poses a risk because tubes are exchanged during the surgical procedure increasing risks such as losing the airway after extubating the original tube, laryngospasm and trauma from multiple intubations.

A large study by the Zurich group (2009) involving 2200 intubated pediatric patients revealed the tube exchange rate to be 2.1% with microcuffed endotracheal tubes, and 30.8% in uncuffed tubes (BJA, 2009). This supports earlier discussion about uncuffed tubes having a higher exchange rate, potentially leading to further complications.

The size of microcuffed endotracheal tube required to intubate and adequately ventilate in a pediatric patient is smaller compared to that required by an uncuffed endotracheal tube. The larger size of endotracheal tube used for uncuffed endotracheal tube if kept for prolonged period of time increased the risk of subglottic injury.

We observed that if microcuff paediatric endotracheal tube is used according to the recommendation with cuff pressure less than <20 cm of H_2O the chances of trauma to the delicate airway of our paediatric patients can be decreased considerably, hence the incidence of post extubation morbidity in terms of post extubation croup, hoarseness of voice and pain in throat was significantly less in Microcuffed tube comparison to uncuffed tube as contrast to the belief held till date. Our study was comparable to the study done by M.Weiss, A. Dullenkopf, J.E.Fischer, C.Keller, A.C.Gerber et al, in 2009 where they observed post extubation stridor of 2.1% in cuffed compared to 30.1% in uncuffed tubes.[4]

The sealing is good because it is made of ultra thin polyurethane.[9] So the leak pressures are on lower side with microcuffed tubes. It was well below the threshold value of 25 cm of H_2O (associated with significant increase in incidence of stridor (19%) when above this value as compared to (9%) when below this value.

In our study it was significantly less compared to uncuffed tubes. Thus, the problem that the cuff will cause airway mucosal injury, leading to sub-glottic stenosis is circumvented. [8,10]

Less no of laryngoscopies decreases the chances of airway trauma and morbidity. Fine , Dullenkoft. Suominen et al, concluded that 25 cm H_2O is the threshold where complications begin to arise.[11,12]

Deakers et al also observed that incidence of post extubation croup was low with both types of tube if pressures are kept below 25 cm of H2O.[13] With the use of uncuffed tubes there is also an increased risk of micro-aspiration around the tube as well as inaccurate capnographic tracing, spirometric tidal volume measurement and end-tidal anaesthetic measurement because the gas is escaping around the outside of the tube (Bhardwaj, 2009).[14] This gas escapes into the theatre atmosphere and thus polluting it without the ability to analyse it. Also, the leak around the tube increases the risk of micro-aspiration because if gastric contents enter the laryngopharnx, they can be aspirated into the lungs around the tube leak. In addition to this, micro-leaks increase volatile wastage which further increases the risk of airway fires, volatile costs and OR pollution.

The Microcuff endotracheal tube at a cuff pressure of 10 to 30 cm of H_2O was better than other brands in preventing fluid leakage past the cuff.

Miller et al, observed that the polyurethane cuffed endotracheal tube is associated with decreased rates of ventilator associated pneumonia.[15] However no related articles has compared hemodynamic parameters between groups intubated with uncuff and microcuff endotracheal tubes. We monitored heart rate, mean arterial pressure and $ETCO_2$ and found no significant difference in both groups. The $ETCO_2$ values were lower in microcuff endotracheal tube as compared to uncuff endotracheal tube.

Sevoflurane is now used commonly in pediatric surgeries as inhalational agent for maintenance of anesthesia. However the method of measuring sevoflurane during the operative procedures is not well validated.

Traditional method of measuring the vaporizer output has practical limitations with high error and time constraints. Very little data is available on sevoflurane consumption in pediatric surgeries.

Sevoflurane consumption depends on type of endotracheal tube cuffed or uncuffed, size and air leak around it.

Furthermore, the number of endotracheal tube exchanges decreased with improved capnography and good sealing which helped in keeping a low gas flow. This overall decreased the cost of anesthesia as well as operation theatre pollution thereby decreasing the health hazards. The Dion's method used for calculating sevoflurane consumption in microcuffed versus uncuff endotracheal tubes also showed a similar kind of consumption.[16]

We didn't find any significant difference in Sevoflurane consumption in two groups. Our results were comparable to the results obtained from other similar studies done before.

Eschertzhuber et al, studied the consumption and cost of sevoflurane and medical gases in matched groups in paediatric patients.[17] He found that the lowest possible fresh gas flow was significantly lower in the cuffed group than the uncuffed group. Khine et al, found cuffed tubes more economic for children between the ages of 2 weeks to 8 years.[18]

Cuffed endotracheal tube has additional benefits of reducing the operation theatre and environmental pollution and decrease the chances of aspiration in our pediatric patients. However in our study we have not taken these factors for comparison.

CONCLUSION

Ultimately, the type of endotracheal tube that is chosen for a pediatric patient is at the discretion of the anaesthetist, but an anaesthesiologist should be well informed about the benefits and disadvantages of all types of airways.

The microcuffed endotracheal tube is better than uncuffed endotracheal tube for laparoscopic pediatric surgeries in terms of lower size of tube requirement, lesser tube exchange rate, decreased leak pressure, same consumption of sevoflurane and lower morbidities such as post extubation stridor/croup, hoarseness of voice and throat pain.

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