

The effect of cuffed endotracheal tube on respiratory complication following adenotonsillectomy in children

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Abstract

Background: Uncuffed endotracheal tube (ETT) were considered for children less than 8 years. Meanwhile, aspiration around ETT in patients undergoing adenotonsillectomy is concerned. We compared cuffed versus uncuffed ETT regarding respiratory complications following adenotonsillectomy.

Methods: 128 children aged 2-8 yr were divided to two groups of 64 each. Uncuffed and cuffed tubes were used respectively in the uncuffed (UG) and cuffed (CG) groups. Anesthesia was routinely performed in an identical pattern in all patients. The number of attempts to reach the appropriate tube size was recorded. After extubation, the patients observed for the occurrence of cough, hypoxemia, and stridor.

Results: Less reintubation attempts were needed in the CG (p -value=0.002). In the UG, 31.3% and in the CG 10.9% had some respiratory complications (P -value=0.009). The change of the initial tube had significant effect on the occurrence of croup and stridor (P -value=0.000).

Conclusion: The use of cuffed tube in 2-8 yr, could lower the incidence of respiratory complications following adenotonsillectomy. It also decreases the number of intubation attempts needed to reach the appropriate tube size.

Keywords: Adenotonsillectomy, tracheal intubation, cough, hypoxemia, stridor, endotracheal tube, cuff, postoperative.

Introduction

Adenotonsillectomy is commonly required for treatment of recurrent infections or for obstructive hypertrophy hyperplasia [1]. The operation is performed under general anesthesia and oral intubation considered a preferred technique for maintaining airway protection as the larynx exposed to profuse bloody secretions during the whole operation [1].

Historically, pediatric anesthesiologists have refrained from using cuffed tubes (CT) in children younger than 8 years or even 10 years [2,3,4], because of the anatomical particularities of their airways [5], and thus the increased

risk of postintubation tracheal damage [2,6]. It is also stated that the use of cuffed tube with a smaller internal diameter, leads to high respiratory airway pressure and increased work of breathing in the patient breathing spontaneously [2, 3]; and cuffs are not necessary because appropriately sized uncuffed tubes seal well at the cricoid ring where the lumen is narrowest in children [7] and permit mechanical ventilation without excessive air leakage [2].

Research over the years has shown that many factors contribute to the complication of endotracheal tube (ETT) use in children and that properly sized cuffed ETTs of modern design can provide safe ventilation and may be prefer-

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able for most airway management situations in children [3,8,9]. The use of cuffed ETT may have some advantages. Because the fit of a cuffed-ETT can be adjusted, it may allow fewer laryngoscopies to replace ill-fitted ETT that is an independent risk factor for trauma related to intubation [10, 11]. Also the reliable presence of a soft seal may reduce the risk of aspiration [12], improve the reliability of end tidal gas monitoring, xreduce contamination of the operating room environment[10] and are more economical because one may use a lower fresh gas flow compared with uncuffed ETTs [3].

Official bodies such as the American Heart Association (AHA) and the International Liaison Committee on Resuscitation (ILCOR) state in their 2005 guidelines for pediatric resuscitation, that the use of cuffed tubes in infants and children is now an accepted alternative to uncuffed tubes [13,14].

The use of cuffed ETT in ENT surgery has been reported previously [15], but there are no controlled trial comparing the use of cuffed and uncuffed ETTs in children undergoing adenotonsillectomy. We therefore conducted this clinical trial to compare these two ETTs.

Our null hypothesis were based on weathere the choice of cuffed or uncuffed ETT would not affect the number of ETT changes needed to place appropriately sized ETT, the incidence of blood aspiration around the ETT during adenotonsillectomy, with respiratory complications (cough, croup, stridor and hypoxemia) and the need to treat respiratory complications after adenotonsillectomy.

Methods

The study was approved by the research review and ethic committee of Shiraz medical school and informed consent was obtained from the patient's parents. This prospective, randomized clinical trial included 128 children aged 2-8 yrs of both sexes with ASA= I, scheduled for elective adenotonsillectomy. Children were randomized by a computer generated

table to two groups of 64 each, the cuffed ETT (CG) and uncuffed ETT (UG) groups. Children with a history or physical evidence of intrinsic or extrinsic airway obstruction, prior tracheal sequale, common cold, asthma, and allergy or any other respiratory disorders and difficult intubations were excluded. The study was not a blinded one.

Routine monitoring and general anesthesia were established as follows. After denitrogenation, induction was given with sodium thiopental(5-7 mg/kg) and succinylcholine(1.5 mg/kg) and oral intubation was performed. After induction and intubation, fentanyl 2 g/kg and ondansetrone 0.15 mg/kg were used intravenously for pain management and the prevention of postoperative nausea and vomiting.

Patients in the CG were tracheally intubated with low pressure high volume ETT (Mallinkrodt, NY, USA). The tube cuffs were inflated and checked by inspection prior to intubation. The cuffed-ETT size was selected based on khine formula [10].

Hence the Cuffed ETT size (mm internal diameter) = (age/4) + 3.

If there was resistance to passage of the tube into the trachea, one smaller tube size (0.5mm) was placed. The cuff was inflated using a cuff pressure gauge(VBM, Sulz, Germany) to prevent air leakage as indicated by the disappearance of audible sounds at mouth and palpable crepitation on trachea, with an upper limit of 20cm H₂O (16mmHg). The cuff pressure was monitored through out the intubation period.

Table 1. Patients parameters and factors involved in study.

	UG	CG	p.value
AGE(yrs)	5.95±1.29	5.88±1.35	0.765
WEIGHT(kg)	19.04±3.82	18.5±3.91	0.426
OP.TIM(min)	19.65±4.59	20.68±4.73	0.213
AN.DUR(min)	37.39±6.91	38.35±7.61	0.453
SEX(F/M)	29/35	30/34	1.000

Table 2. Details of information gathered from patients.

	UG group No (%)	CG group No (%)	P.value
Bloody Aspirate	6(9.4%)	1(1.6%)	0.057
Protracted cough	8(12.5%)	3(4.7%)	0.103
Croupy cough	7(10.9%)	3(4.7%)	0.162
Stridor	5(7.8%)	2(3.1%)	0.220
Hypoxemia	7(10.9%)	2(3.1%)	0.082
Smaller ETT needed	9(14.1%)	2(3.1%)	0.027**
Larger ETT needed	5(7.8%)	0(0.0%)	0.029**
ETT change needed	14(21.9%)	2(3.1%)	0.002**

When a leak occurred at a lung inflation pressure less than 10cm H₂O, the tube was changed to a larger tube size. The appropriate position of the ETT cuff was checked by palpation of the cuff between the level of cricoid cartilage and sternal notch.

Patients in the uncuffed-ETT group were tracheally intubated with the size based on the commonly used modification of cole's formula [16,17]: Uncuffed ETT size (mm internal diameter) = (age/4) + 4

If there was resistance to passage of the initial tube into the trachea or in absence of an audible leak when the lungs were inflated to a pressure of 20 cm H₂O, a one size smaller tube was placed. If a leak occurred at an inflation pressure less than 10cm water, the tube was replaced by one size larger tube.

An attending anesthesiologist who was not participated in other part of the study using a makintosh laryngoscope conducted all intubation attempts. Correct tube position was con-

firmed by capnography and auscultation of the lungs in both groups.

The number of ETT changes needed to arrive at the final size was recorded. Anesthesia was maintained with isoflurane (0.8-1.5%) and nitrous oxide (60-70%) in oxygen. Mapleson F circuit was used in patients having spontaneous ventilation with a fresh gas flow rate of 150ml/kg/min.

All the operations were performed by an attending otorhinolargologist, using Davis gag.

At the end of operation, gentle tracheal suction was performed for aspiration of secretion and to detect possible bleeding. Then 1-2cc normal saline was installed into the ETT and tracheal suctioning was repeated. The presence of visible bloody secretion of the tracheal aspirate was recorded. Oral cavity was suctioned gently and thoroughly. When adequate spontaneous normal ventilation was achieved and the child awaked enough to demonstrate recovery of protective airway reflexes, extubation achieved af-

Table 3. Tubiana's grade and associated factors

	Without cough No (%)	With cough No (%)	Total No (%)
Without bloody aspirate	114(94.2%)	7(5.8%)	121(100%)
With bloody aspirate	3(42.9%)	4(57.1%)	7(100%)
Total	117(91.4%)	11(8.6%)	128(100%)

ter a full inspiration. The child was positioned in lateral decubitus position and transferred to postanesthesia care unit (PACU). The duration of anesthesia and operation were recorded. In the PACU, arterial saturation of oxygen (SpO₂) was monitored and oxygen was administered by mask for 5 minutes when SpO₂ dropped below 92%. Patients were observed for evidence of croupy cough, protracted cough and stridor during their PACU period (90 minutes after extubation) and hospital stay (one day postoperative). The need for treatment, reintubation and unplanned prolonged hospital stay for croup were also recorded. Data in the PACU and ward were recorded by observer unaware of the type of ETT used.

According to a pilot study, we assumed that respiratory complication will occur in 30% of the uncuffed tube and 9% of the cuffed tube group. With an $\alpha = 0.05$ and $1 - \beta = 80\%$, we computed comparison formula for 64 patient in each group with two-population proportion.

Age, weight, operation time and anesthesia duration were compared by independent samples t-test, and Sex distribution of the patients compared by chi-square tests.

Chi-Square Tests and Fisher's exact Test were used to compare the two groups regarding the occurrence of bloody secretions in the tracheal aspirate, cough, hypoxemia, stridor, croupy cough, and also the need to change the initial tube. Laminar by laminar correlation with Goodman & Kruskal tau method was used to evaluate the correlation between bloody aspirate from ETT and the occurrence of cough.

Results

Age, weight, sex distribution, duration of

Table 4. Association of bloody aspirate in the ETT with the duration of anesthesia and operation.

	Number	Mean±SD	P.value
Op. Duration without blood	121	20.32±4.69	0.131
With blood	7	17.57±3.73	
An. Duration without blood	121	38.05±7.19	0.238
With blood	7	34.71±8.30	

(Op:operation, An:anesthesia)

anesthesia and surgery were comparable for the two groups ($p \leq 0.01$)(Table 1).

Only two patients in the CG required a change of ETT, requiring a tube one size smaller than predicted. But in the UG, a total of 14 ETT replacements (21.9%) were required, 5 patients needed a larger tube and 9 patients a smaller one. None of the patients in the two groups need a third attempt to replace an appropriate ETT.

In the CG, only one patient (1.6%), whereas 6 of the 64 patients (9.4%) in the UG had a bloody secretion aspirated from the ETT. We found no significant difference between the two groups ($P = 0.057$).

The occurrence of protracted cough, croupy cough, stridor and hypoxemia were not different between the two groups (Table 2). Protracted cough without croup, resolved during PACU stay and no treatment was needed.

Croupy cough occurred in 7 and 3 patients of the UG and CG respectively. One patient in the CG was treated with racemic epinephrine for croup. There was no need for reintubation, corticotherapy or hospital admission for croup in the Cuffed group. In the Uncuffed group, two patients needed treatment with racemic epinephrine, while one had to stay in the hospital for another day.

Table 5. The effect of changing the initial ETT on the occurrence of croupy cough and stridor.

	Stridor	Croupy Cough
No ETT change	1/112(0.9%)	3/112(2.7%)
Changed the initial ETT to a Smaller one	6/11(55%)	7/11(64%)
Changed the initial tube to a Larger one	0/5(0%)	0/5(0%)
Total	7/128(5.5%)	10/128(7.8%)

The occurrence of hypoxemia ($\text{SPO}_2 < 92\%$) during their PACU stay was not different between the two groups ($P = 0.082$). 5 patients of the UG and 2 in the CG had stridor during recovery. Inspiratory stridor resolved spontaneously in the cuffed group, but three patients in the uncuffed group needed corticoid nebulization. None of the patients in the two groups required reintubation for the management of respiratory complications.

In overall, more patients in the uncuffed group had a respiratory problem of any type as compared with cuffed group. Seven (10.9%) patients in the CG and 20 (31.3%) patients in the UG had some respiratory complications ($P = 0.009$).

The association between bloody aspirate from ETT and protracted cough was significant ($P = 0.001$) as 5.85% of the patients without and 57.1% of those with bloody aspirate developed protracted cough during recovery (Table 3).

The occurrence of blood aspiration had no correlation with the duration of anesthesia and operation (Table 4).

The change of the ETT to a smaller size was related to the occurrence of croup and stridor. But, In the case of the change of the initial tube to a larger one, we found no association with the occurrence of either croup or stridor (Table 5).

Finally, the change of the ETT (either to a smaller or larger one), had significant effect on the occurrence of both croup and stridor in the postoperative period ($P = 0.000$).

Discussion

Despite technical and pharmacologic advances, the problems presented in the anesthetic management of tonsil or adenoid surgery are complicated by the shared airway and bleeding [18]. An artificial airway must protect the larynx and trachea from contamination with blood and surgical debris [19].

Tracheal intubation and laryngeal mask airway (LMA) are routine methods for providing artificial airways in this type of surgery

[1,18,20]. Previously comparison were made regarding the use of laryngeal mask airway and tracheal intubation for adenotonsillectomy [21,22]. The use of cuffed ETT for tonsillectomy had been reported previously since they were concerned for the risk of blood aspiration [15]. But some think the anatomic subglottic narrowing present in infants and children may protect from aspiration and did not use cuffed ETT in children under the age of 8 years [12].

Data from the present study demonstrated a lesser need to change the initial tube and overall less respiratory complication in the pediatric adenotonsillectomy patients intubated with cuffed endotracheal tubes. We found less need to change an ill fitting ETT in the CG as compared with the UG patients. This is the same as found previously [10,11].

Pediatric anesthesiologists routinely change uncuffed ETT to achieve an appropriate fit [12,23]. This is necessary because of the normal variations in laryngeal dimensions and the fixed outer diameter of the uncuffed tubes [23]. Because this claim is difficult to fulfill in daily practice, many different formulas for tube size selection have been put forward and despite these a high tube exchange rate to find an appropriately 'fitting' tube is usual [5]. When a correct sized tube cannot be found, anesthetists have the dilemma to accept an uncuffed tube with a large gas leak or to insert an oversized tracheal tube. Also it is probable that a significant number of children may have an oversized uncuffed ETT inserted [1]. Oversized uncuffed tracheal tubes exert undue pressure on the laryngeal structures and are well known to be a main cause of laryngeal injury from tracheal intubation [2,24].

By using protocol-defined choice of initial tube and reintubation criteria's, we demonstrated that the use of cuffed ETT with an adjustable outer diameter and shape, almost eliminated the need to replace the initial tube. Multiple intubation attempts could be a risk factor for intubation related injury.

Low tube exchange rates and a sealed airway without the use of an oversized tracheal tube are the main proven benefits of cuffed tracheal tubes in children. If the cuff pressure is held no higher than 20 cm H₂O and the tube cuff is positioned in the trachea, there is no increased airway morbidity [25]. Wiess et al reported that the use of cuffed ETTs in small children provides a reliably sealed airway at cuff pressures of ≤ 20 cm H₂O, reduces the need for TT exchanges, and does not increase the risk for post-extubation stridor compared with uncuffed TTs [26].

The occurrence of croupy cough was noted as an indication of laryngotracheal injury and a marker for subglottic edema [10]. In our study, we found a lower rate of croupy cough in both groups (CG and UG) as previously reported [10,27]. This could be explained by two factors: 1) the newer design of endotracheal tube (especially the shape of the cuff); 2) shorter duration of intubation in our study as compared with the previous studies. We considered the importance of the markers of laryngotracheal injury because it was suggested that the use of cuffed ETT may predispose children to airway injury [12,16]. A comparable rate of croupy cough in the two groups signify the safety of cuffed tube for intubation in children by using protocol-defined choice.

The rate of occurrence of stridor was not so much difference between the UG and CG. As the occurrence of inspiratory stridor suggests vocal cord injury, it means that no difference in the rate of this complication should be observed by the use of cuff. This is in accordance to data from Deuker's et al that cuffed ETT intubation in children is not associated with an increased risk of postintubation stridor or significant long-term sequels in pediatric intensive care patients [28].

In the present study we found a strong association between the need to change the initial tube and the occurrence of cough and stridor. Therefore, the use of cuffed tube would be more ap-

propriate to reduce the need to replace the endotracheal tube for the purpose of providing an acceptable fit.

Aspiration of blood was detected with a higher percentage in the UG in comparison with the CG, although not significant statistically ($P = 0.057$). This is in concordance with previous studies [12,29], although with a lower percentage in both groups. This difference between our study and the previous ones could be attributed to variation in the method used for detecting aspiration. Browning used Evan's blue [12] and Reali-Forster contemplated the use of methylen blue [29] for confirmation of aspiration around the ETT. In the current setup of the study we were imposed by the surgeon not to use any dye, as it may interfere with the careful hemostasis needed in this type of surgery. Also we tried to use fiberoptic bronchoscopy for this purpose but it was not possible due to the bloody field around the larynx and ETT. Overall our finding could confirm a comparable (or even greater) protection to blood aspiration that the use of cuffed ETT could provide during adenotonsillectomy as compared with the use of uncuffed ETT.

Non-croupy protracted cough was comparable in the UG and CG. Cough could be a consequence of the irritation of the trachea by aspirated blood, since we found a positive correlation between bloody aspirate in tracheal tube and protracted cough (Table 3). For this reason, some anesthesiologist may attempt to reduce the air leak around an uncuffed ETT (a prognostic factor to the occurrence of silent aspiration) by packing the throat with gauze. This practice is not ideal, especially for prolonged periods of intubation, and a cuffed tube would be more satisfactory [3, 4].

Golden proposed that cuffed tube could be suitable from size internal diameter size of 4.0 mm and larger for children and cuffed tracheal tubes are preferred in patients at risk of pulmonary aspiration, with low lung compliance (including laparoscopy, thoracoscopy, car-

diopulmonary bypass) and in whom precise ventilation and CO₂ control is important [30].

In the meantime, evidence has accumulated that cuffed tracheal tubes can be used safely in children and they have proven benefits over uncuffed tracheal tubes [10,25,31]. Even more clinical situations are now highlighted, where uncuffed tracheal tube should no longer be used [32]. Several large pediatric centers have routinely used cuffed tracheal tubes in infants and children for many years without increased airway morbidity [15].

Because active overinflation or overexpansion by nitrous oxide diffusion may cause laryngeal damage, continuous and precise control and regulation of cuff pressure is mandatory. Anesthetists who are not yet willing to do so should not use cuffed tubes [33]. Only correctly designed cuffed tubes with a definite intubation depth mark, a short high-volume low-pressure cuff and a reliable size selection recommendation should be used. When using such a cuffed tracheal tube, cuff pressure must be monitored and adjusted.

A limitation of our study was the method for confirming the occurrence of blood aspiration around the ETT. Also we consider the occurrence of respiratory complication as a whole for estimation of the sample size. We might find significant difference regarding the occurrence of specific respiratory problem with a larger sample. This should be investigated in further study.

Overall, data from the present study demonstrated less need to change the initial ETT and lower incidence of respiratory complication of any type in the CG. The change of ETT was significantly associated with the occurrence of cough and stridor ($P = 0.000$). Also, there was association between bloody aspiration and protracted non-croupy cough.

Conclusion

The use of cuffed endotracheal tube is a safe practice in patients undergoing adenotonsillectomy.

This practice reduces the incidence of any respiratory complications during recovery period in patients undergoing adenotonsillectomy. There is also less need to change the initial ETT to obtain the suitable tube size

Therefore we recommend the use of cuffed ETT for tracheal intubation in 2-8 year pediatric patients undergoing adenotonsillectomy operations.

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