A systematic review considering the use of cuffed vs uncuffed endotracheal tubes in children

Daniel Crankshaw

The use of cuffed endotracheal tubes in paediatric patients is a controversial topic. This paper aims to investigate whether cuffed or uncuffed tubes should be used in children under the age of eight years. Currently, there are no guidelines on this topic. Daniel is a fourth-year medical student at Lancaster Medical School.

INTRODUCTION

Traditionally the use of uncuffed endotracheal tubes in children has been the accepted practice. This is, however, an area of controversy, with the practice of cuffed tubes becoming accepted for use in children over the age of eight, but not for those younger.^(1,2)

The traditional teaching for paediatric anaesthesia suggests that as the cricoid cartilage is the narrowest part of the airway, the utilisation of an uncuffed tube that fits and seals within the cricoids cartilage makes a cuff unnecessary.^(3,4) However, there is a belief that it is difficult to find the correct size of uncuffed tube for each patient. Evidence suggests that this can lead to an excessive number of tube changes, almost 30%.⁽⁵⁾ A difficult choice then has to be made – to use a tube that is too small for the patient, or one that is too large, each causing their own problems. A tube that is too large is known to produce damage to the larynx. Deciding to use a tube that is too small, however, will mean that air can leak from the tube and cause interference with efficient ventilation, wastage of anaesthetic volatile agent, and environmental pollution.⁽¹⁾ Using a smaller tube also carries the risk of pulmonary aspiration; this is a rare complication, but carries with it extremely serious consequences.⁽³⁾

Anaesthetists use uncuffed tubes in paediatric patients for fear of damaging the airway mucosa when inserting a cuffed tube. Damage can be caused in a number of ways:

- oversized outer tube diameters
- poorly designed cuffs
- wrongly positioned tubes
- overinflating of the cuff, resulting in post-extubation stridor^(1,3)

Newly designed cuffed tubes are now available; these tubes aim to combat the problems noted above. The tubes are, however, more expensive than uncuffed alternatives.⁽²⁾ It is believed that by using these cuffed tubes, indirect savings can be made (ie decreasing the oxygen and anaesthetic gases used within the surgery). They are also better for patients and reduce environmental pollution.^(2,3)

This systematic review aims to analyse the current evidence base on the use of both cuffed and uncuffed endotracheal tubes in young children and provide information on when each of the tubes should be used, as there is currently no guidance in this area.

METHOD

There were two phases to the literature search: an initial one, which identified 43 potential papers in the English language; and a subsequent review of each, to establish that the subjects studied were under the age of ten. Five papers were identified for detailed review.

Kihne *et al* (1997)⁽⁶⁾

A controlled study that compared the use of cuffed versus uncuffed tubes in children who were aged 0-8 years old requiring general anaesthesia. It included 251 patients in the cuffed group and 237 patients in the uncuffed group. The null hypothesis of this study was that there would be no change in: the number of tubes needed to get the appropriate size of endotracheal tube; ability to ventilate the lungs adequately; ability to use low fresh gas flows; anaesthetic gas concentration in operating theatre; and the incidence of post-extubation stridor.

This study refers to their allocation of patients receiving cuffed or uncuffed tubes as random. However, this process was simply based on the patient's hospital number; with odd numbers receiving cuffed and even numbers receiving uncuffed. Despite this, the confounders of each study group were comparable as shown in table 1.

	Cuffed tube	Uncuffed tube	P-value
Total patients	251	237	
Age (yr)	3.3 ±2.4	2.9 ±2.2	0.05
Weight (kg)	15.1 ±7.4	14.3 ±7.7	0.09
Duration of intubation (min)	55	60	0.13
Patients needing tube changes	3 (1.2)	54 (23)	<0.001
Patients needing >2l of oxygen / minute gas flow	3 (1.2)	26 (11)	<0.001

Table 1 Confounders and effect of tube type on number of changes and fresh gas flow rate

The study was not blinded. Patients' ages were rounded up to their next birthday; for example, if they had passed their first birthday, they would be considered to be two years' old. As the formulas for both the cuffed and uncuffed groups require the age of the patient to work out the appropriate size of tube, the rounding should not have affected the results.

The cuffed tubes were appropriately sized for 99% of patients, with only three patients (aged three, four and six) requiring a change of tube. All of which required a tube one size larger. Only 77% of the patients were given an appropriate sized uncuffed tube in the first instance, 13 patients required a smaller one, and 41 patients required a larger tube, whose average ages were 4.5 and 1.9 years respectively. A greater number of uncuffed patients also required a greater fresh gas flow. These results were all statically significant to $p<0.001$ and are summarised in table 1.

The study also produced relevant results with regards to the concentration of nitrous oxide in the operating theatre and the amount of patients that suffered with post-extubation stridor. The nitrous oxide concentration for the room was statistically significantly less in the cuffed group – $p < 0.001$. As the gas levels were taken at 24 inches away from the patient's mouth this was deemed to be in the zone of the breathing of the anaesthetist, therefore they would be inhaling less nitrous oxide from the environment around them.

The results of the study also showed that there was no difference in the rate of post-extubation stridor. Three in each group were treated with racemic epinephrine and none of them had to be re-intubated. More information on any longterm implications of using a cuffed tube and the incidence of post-extubation stridor and types of airway damage caused by the tubes would have been a useful addition to the study. The sample size for this study was relatively small and further information and trends may be seen with a larger sample.

Weiss et al (2009)⁽¹⁾

This multicentre prospective randomised controlled trial from birth (over 3kg) to five years enrolled 2,246 children, and aimed to find the rate of post-extubation stridor and the number of tube changes to find the correct sized tube in both groups.

A standard cuffed tube was used throughout the study – the Microcuff PET. Allocation of the correct tube size for each patient was sent to all locations. The study protocol allowed anaesthetists to choose uncuffed tubes as per local guidelines.

The randomisation process of the study ensured an even spread of possible confounders across the groups. The potential confounders noted patient's age, weight, gender, prior croup, ASA score, procedure type or route and the induction procedure used.

The results for post-extubation stridor were not significantly different in either group, with 4.4% in the cuffed group and 4.7% of the uncuffed group showing symptoms. The results for the exchange rate did show significant results, with an exchange rate of 2.1% in the cuffed group and 30.8% in the uncuffed group. These results are shown in table 2, along with their p-values.

	Cuffed tubes (1,119)	Uncuffed tubes (1,127)
Tube exchange	24 (2.1%)	347 (30.8%)

Table 2 Tube exchange rate, $p < 0.0001$

A difficulty of this study is that due to a manufacturing change in the cuffed tubes during the study, the tubes began to kink. This resulted in the trial ending several months early. It is of interest that the manufacturer of the faulty tubes provided the equipment free of charge, and two of the authors of this paper were involved in the development of this particular tube. It is recognised, however, the cost of randomised control trials can be vast and therefore funding is often supported by interested parties.

Newth et al (2004)⁽⁶⁾

A prospective cohort study examined 597 intensive care patients. The study demographic can be seen in table 3. The main aim of the study was to assess a potential difference in the rate of post-extubation stridor in the two groups and the amount of patients with the complication of subglottic oedema. The children who required racemic epinephrine after extubation were said to have subglottic oedema. The authors of the study set no specific guidelines for this; it was the choice of the physician in charge as to whether to administer this drug.

Variable	Total	Extubation success	Extubation failure
Total intubations	860	797 (92.7%)	63 (7.3%)
Median age (yr)	1.5	1.5	0.5
<1 month	79	72 (91.1%)	7 (8.9%)
1 mo-1yr	310	282 (91%)	28 (9%)
1-5yr	208	192 (92.3%)	16 (7.7%)
5-8yr	71	65 (91.6%)	6 (8.4%)
>8yr	192	186 (96.9%)	6 (3.1%)
Duration of ventilation (d)	1.85	1.69	3.94

Table 3 Demographic of study population

The choice of tube size was set by the modified Cole's formula ($\text{age [y]} / 4 + 4 \text{ mm ID}$) for uncuffed tubes, whilst those in the cuffed group received half a size smaller with the exception of the 3.0mm tubes. Children under the age of two years who were intubated with the cuffed tubes spent significantly more days intubated ($13.5:8.5$ $p < 0.01$) and those under the age of two were more critically ill at time of intubation. A three-week-old was intubated with a cuffed tube for 103 days and required no racemic epinephrine after a successful extubation. No longterm effects were seen as a result of being intubated with either tube. Interestingly, the results show a pattern that the anaesthetist in charge was more likely to opt for a cuffed tube in those who were more ill and those who would spend longer intubated.

Age of child	≤1mo	>1,≤24mo	>2,≤5y	>5,≤8y	>8y	Total
Type of tube						
Uncuffed	115	208	64	27	8	422
Cuffed	27	126	57	44	184	438
Intubation duration (d)						
Uncuffed	5.9	1.2	1.1	1.1	0.8	1.9
Cuffed	6.6	4.8	1.1	1.3	0.9	1.8
Uncuffed (max days)	93.3	79.4	0	45.2		
Cuffed (max days)	103.6	98.4	35.1	42.6		
Racemic epinephrine use (No. %)						
Uncuffed	7	14	6	1	1	29
Cuffed	2	12	5	0	2	21
Failed extubations (No. %)						
Uncuffed	11	12	4	2	0	29
Cuffed	2	16	6	4	6	34
Failed extubations (per 100 days)						
Uncuffed	1.23	1.49	3.29	1.95	0.00	1.49
Cuffed	0.42	1.1	3.01	1.93	1.02	1.14

Table 4 Duration of intubation, use of racemic epinephrine, and failed extubation rates in relation to age and endotracheal tube type

Dorsey et al (2009)⁽⁷⁾

Paediatric burn patients have unique problems and in view of airway oedema are special cases during ventilation.⁽⁷⁻⁹⁾ Table 5 shows that, predictably and sadly, most of the patients in this study were under the age of four:

	Cuffed (111)	Uncuffed (117)	P-value
Female	24.3%	37.6%	0.03
Age (mean years)	4.6	2.7	<0.001
<1	3.6%	23.1%	
1-4	53.2%	53%	
5-10	43.2%	23.9%	
Mean TBSA	22.1	14.4	<0.001
TBSA <20%	48.7%	75.2%	
TBSA 20-49.9%	35.1%	18.8%	
TBSA ≥50%	16.2%	6%	
Facial burn present	35.1%	35%	NS
Smoke inhalation present	5.4%	3.5%	NS
Any immediate re-intubation required	7.2%	37.6%	<0.001
Air leak	1.8%	23.1%	<0.001
Year of intubation			<0.001
1998-2002	29.4%	77.9%	
2003-2007	70.6%	22.1%	

Table 5 Patient and burn characteristics

Over the ten years, 287 intubation events were included, with a tendency to use cuffed tubes in the later years of the study: 111 cuffed and 117 uncuffed. The authors used multivariable logistic regression to control factors such as age, gender, total body surface area burnt, year of intubation and presence of burn to the patient's face.

There were no statistically significant outcomes when comparing adverse effects, including post-extubation stridor, self-extubation aspiration and failed extubations, which can be seen in table 6.

	Cuffed	Uncuffed
Post-extubation stridor	7.2%	4.3%
Self-extubation	0.9%	0.9%
Aspiration	0%	0%
Failed extubation	1.8%	3.4%

Table 6 Comparison of adverse effects

The study did demonstrate significant results relating to re-intubation and significant air leak in favour of the cuffed tubes. Whilst there were only two (1.8%) significant air leaks in the cuffed group, there were 27 (23.1%) noted in the uncuffed group, leaving a p-value of 0.03. Similar results were also seen in results specific to children aged under two, with more re-intubations in the uncuffed group and 13 air leaks in the uncuffed group compared to none in the cuffed.

Eschertzhuber et al (2010)⁽²⁾

A randomised control trial to assess the difference in, and economic benefit of, anaesthetic gas, sevoflurane, when using cuffed or uncuffed tubes in 70 children aged 0 (>3kg) to five years.

The minimum fresh gas flow to maintain ventilator bellow was determined. The variables measured, from final positioning until end of surgery included: oxygen; air; nitrous-oxide flow; and inspiratory sevoflurane concentration flow. Prices of each of the gases used and the tubes can be found in table 7.

Amount	Item	Cost (€)
0.001L	Sevoflurane	0.8
1L	Oxygen	0.004
1L	Nitrous oxide	0.0024
1L	Medical air	0.004
1	Uncuffed tracheal tube	1.7
1	Cuffed tracheal tube	9.5

Table 7 Cost for sevoflurane, medical gases and tracheal tubes

When comparing the results, no significant differences could be found when comparing age, weight or sevoflurane concentrations. A difference was found in both the fresh gas flow and the sevoflurane consumption per patient, being significantly less in the cuffed group. These results, along with medical gas consumption and the cost of the medical gases, can be seen in table 8. These results show that the extra costs accrued by using the cuffed tube are outweighed by the cost of the gases used when the time of surgery reaches 49 minutes. The findings also do not demonstrate, however, the possible benefit of reducing the gas delivery to the child and the reduced air leak to the environment and the anaesthetist.

	Uncuffed	Cuffed	P-value
No. patients (n)	35	35	—
Patients' age (yr)	1.75	1.65	
Patients' weight (kg)	9.8	12	
Duration (min)	56	57	0.787
FGF (l/min)	2.0	1.0	<0.001
Sevoflurane consumption/patient (l)	16.1	6.2	0.003
Medical gas consumption/patient (l)	129	46	<0.001
Cost for sevoflurane/patient (€)	12.9	5	<0.001
Cost for medical gases/patient (€)	0.62	0.17	<0.001
Cost of sevoflurane and gases/patient (€)	13.4	5.2	<0.001
Cost for sevoflurane and medical gases/patient/min (€)	0.25	0.09	<0.001

Table 8 Epidemiological, measured and calculated data (data are median)

DISCUSSION

Each of the studies reviewed had varying outcomes that were measured to assess whether cuffed or uncuffed endotracheal tubes should be used in paediatric anaesthesia. The results of the first four studies reviewed show significant results in favour of use of a cuffed endotracheal tube and a change in current practice. None of the studies reviewed showed that patients were more likely to suffer injury as a result of using a cuffed tube. This is important as the review covers a variety of patients, including those undergoing elective operations, burn patients and those who are critically ill. All of the studies reviewed demonstrated potential benefits of introducing cuffed tubes into practice as they reduced exchange rate, failed extubations, air leaks and the costs associated with the anaesthetic gases used.

The reduction of incidence of multiple intubations and the environmental advantage without any suggestion of an increased risk of complications support the introduction of cuffed tubes. However, from my own experiences it is not just a case of choosing one tube over the other. Paediatric cuffed tubes may not be readily available. Cuffed tubes are over five times more expensive than uncuffed ones. This cost is offset with any surgery lasting over 49 minutes, as gas flow delivery can be easily reduced with a cuffed tube. Although no direct figures can be shown, it can be assumed that with a much lower exchange rate, as shown in the early studies, that this would also reduce the costs associated with using a cuffed tube. More conclusive evidence is needed in certain areas, with a need for more randomised control trials with larger sample sizes.

In conclusion, cuffed tubes are shown to decrease the need for multiple intubations, reduce costs and are not shown to increase adverse effects in children of all ages.

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