Paediatric Intensive Care Unit (PICU)

Guideline on the use of
Cuffed Endotracheal Tubes
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1. **Introduction**

Traditional teaching suggests that in children under 8-10 years of age requiring intubation uncuffed tracheal tubes should be used. These should pass through the cricoid portion of the upper airway easily and a leak should be evident at a pressure of around 20 cm H$_2$O. Practically, it is often difficult to find an appropriately sized tube which produces adequate seal for ventilation and an acceptable leak minimising undue pressure on the laryngeal mucosa and surrounding structures. The search for this perfect balance can result in a dilemma: whether to accept large air leak or to insert an oversized tracheal tube.

The background for this practice lies with the understanding that there are fundamental anatomical differences between the airway of an adult and infant. Previously the infant’s airway was thought to be funnel shaped with the narrowest portion at cricoid cartilage being round in shape. However Litman et al report that the cricoid cartilage is in fact ellipsoidal and that the uncuffed tube rests on the posterolateral aspects of this area. This can cause excessive pressure on the adjacent mucosa yet a leak can still occur through the anterior aspect of the cricoid area.

Uncuffed tubes are sealed by the encircling cricoid ring which is called “cricoid sealing”, whereas the cuffed tubes provide tracheal sealing by cuff inflation below the cricoid ring. An appropriate sized circular ETT should fit through this portion without causing a significant leak at modest inspiratory pressures (up to 20cmH2O) or too much mucosal pressure resulting in pressure necrosis. In the past concerns have been raised regarding cuffed tubes in that although the ability to ventilate the patient may be enhanced the pressure in the balloon portion may be too high causing pressure necrosis of the surrounding fragile epithelium potentially resulting in permanent upper airway damage such as subglottic stenosis. In a study involving 80 children aged 2-4 years it was found that Microcuff paediatric endotracheal cuffed tubes required significantly lower sealing pressures of 11 cmH$_2$O when compared to other cuffed endotracheal tubes such as the Mallinckrodt, Ruesch, Portex or Sheridan varieties. In a study assessing the Microcuff ETT, 95% of patients achieved a tracheal seal with cuff pressure of less than 15 cmH$_2$O (see figure 1). In view of these low sealing pressures there was a greater safety margin between this level and higher unsafe limits of more than 25 cm water. A maximum cuff pressure of 20 cmH$_2$O is suggested in this paper though the evidence for this is limited. Further studies may inform our target pressures.

Re-intubation because of excessive air leak has been shown to be a risk factor for the occurrence of airway injury and this is more common when uncuffed ETT’s are utilised.
In a recent survey undertaken in the UK only 7% of the lead anaesthetists and 5% of the lead paediatric intensivists in the 30 UK centres with a level 3 PICU routinely used a cuffed tube as a first line ETT in children under 8 years of age.

Newth et al undertook a prospective observational study of 860 children aged 1 month to 12 years requiring long term intubation admitted to their general and cardiac ICU. The children were intubated with cuffed or uncuffed tube depending on the preference of the physician who intubated. This group used primarily the Malinckrodt ETT’s. They used modified Cole formula ([Age in years/4] + 4) for choosing uncuffed tubes and one half size down for the cuffed tube. Cuff pressures were monitored every 8 hours and maintained at pressures just enough to obliterate the leak at peak inspiratory pressure or up to a maximum of 25 cmH₂O. They found no difference in the use of racemic epinephrine, rate of successful extubation or need for tracheostomy between those who were intubated with cuffed and uncuffed endotracheal tube in any age group.

Early paediatric cuffed tube designs had problems with a small margin for error when positioning them which made it relatively easy to have the cuff too proximal to the glottis, hence increasing the risk of glottic damage or the tip of the tube too low resulting in endobronchial intubation. Weiss et al studied the placement of Microcuff paediatric endotracheal tubes with the intubation depth marker as a guide. This allowed adequate placing of the tube with cuff free of the subglottic zone and without risk for endobronchial intubation in children from birth to adolescence. However the evidence for relying on the depth marker has been questioned.

Locally we have the portex and microcuff cuffed endotracheal tubes available for use. This guideline is pertinent to the use of all cuffed endotracheal tubes.

A recent study assessed the ETT cuff pressures in 300 patients aged 4 to 92 years who required inter-hospital transport and found that they had a median cuff pressure of 40 cmH₂O (range 10-80 cmH₂O) with 64.7% of patients having a pressure of greater than 30 cmH₂O. This should be used as a warning to the retrieval team who may be transporting patients with a cuffed ETT sited by the referring centre as mucosal damage has been shown to occur in as short a space of time as 15 minutes in animal models. Currently there is no cuff pressure manometer in the transport bags and staff should be cogniscent of cuff pressures when siting cuffed ETT’s in a distal centre.
There is good evidence from recent studies that manual palpation of the pilot balloon in patients intubated with a cuffed ETT is unreliable in assessing cuff pressures with preponderance for a large over-estimation of the pressures generated with pressures over 100 cmH₂O recorded in some studies. We have also shown in a bench model using a Laerdel Infant mannequin and microcuffed tubes (3.0/3.5/4.0) that as little as 0.2-0.4mls of air is required to generate 20 cmH₂O and correlates poorly with manual palpation of the pilot balloon (unpublished data). Most observers greatly under-estimated the pressures generated in the cuffed ETT.

It is therefore essential to monitor ETT cuff pressures for optimal care as part of ongoing patient safety and quality improvement initiatives.

**Ideal properties of cuffed paediatric endotracheal tube**
- ETT size calculated easily.
- Good outer to inner diameter ratio.
- Low pressure cuff design.
- Cuff distally placed.

**Advantages of cuffed endotracheal tube**
- Reduced gas leak
- Reduction in the requirement to change the tube
- Improved efficiency of ventilation with minimal air leak
- Reduced risk of aspiration
- Improved accuracy of end-tidal carbon dioxide monitoring
- Greater reliability of spirometry monitoring including tidal volume and lung compliance
- Reduced incidence of autotrigerring of ventilator in the flow trigger mode.
- Decreased atmospheric pollution if inhalational anaesthetic in use
- Decreased use of oversized uncuffed tubes in order to avoid leak, which is the main cause of subglottic mucosal ischaemia and ulcerations

**Disadvantages of cuffed endotracheal tube:**
- Risk of inadvertent cuff over-inflation, which can leak to mucosal ischemia and post-extubation morbidity
- A smaller internal diameter ETT is used, compared with uncuffed tubes, which can increase work of breathing in a spontaneously breathing child
- Currently more expensive
- Changes in head/neck position can affect the cuff pressure (Kako H, Krishna SG. The relationship between head and neck position and endotracheal cuff pressure in the pediatric population. Pediatr Anaesthe 2014:24(3); 316-21
2. **Rationale/Purpose/Objective**

- To allow standardized use of all cuffed ETT’s in PICU and to facilitate the education of all staff groups.
- Minimise the potential for subglottic injury secondary to inadvertent high cuff pressures or inadvertent oversized uncuffed ETT’s being sited.
- Enable routine documentation of cuff pressures in all patients with cuffed ETT’s in place and allow us to audit and monitor our adverse events and outcomes.

3. **Scope**

- This guideline applies to any patient being ventilated via a cuffed ETT in PICU.

4. **Roles and responsibilities**

- All healthcare professionals in paediatric critical care involved in the care of ventilated children should be familiar with this guideline.
5. Procedure

Portex cuffed ETT sizing guide

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<tr>
<th>Internal diameter</th>
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<tr>
<td>5.5</td>
<td>4-5 yrs</td>
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<tr>
<td>6.0</td>
<td>6-7 yrs</td>
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Recommended sizing guide for Microcuff ETT (Kimberly Clark):

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When using a cuffed endotracheal tube **it is mandatory that cuff pressure is monitored if inflated**. The cuff pressure is traditionally monitored every 6 hours or at least every 12 hours. Some units in addition to monitoring the cuff pressure use a safety device such as “cufflator” or cuff pressure “pop-off” valve so that the cuff pressure never exceeds the set limit. We do not currently use these devices. Cuff pressures should be checked after ETT position changes where the cuff will need to be deflated for safe ETT re-positioning. Rarely a cuffed ETT may not be inflated for example when a patient is oscillated to maximize CO2 removal; the cuff pressure need not to be monitored in the cuff is deflated.

**How to set up for monitoring of cuff pressure**

**Equipment needed:**

1. Lectrocath pressure cabling 15cm (See figure 2) (Ref 1155.01)
2. Tracoe Cuff pressure monitor (see figure 2)
   - Stored at each bedspace in bedside trolley, each with a unique identifier
   - Spare Tracoe cuff pressure monitors are available on shelving in the intubation trolleys
   - Please label any faulty equipment and place on the trolley in the Equipment Store Room for Bioengineering to collect and review.
Procedure for cuffed ETT intubation and checking of cuff pressure

1. Intubation should be undertaken with the cuff in fully deflated position. Cuff should be checked for a leak prior to intubation.

2. It should be possible to produce a leak at a maximum inspiratory pressure of 20 cm water with the cuff fully deflated. If there is no leak at a peak inspiratory pressure of 20 cm water, then it is important to downsize the ETT.

3. The cuff is inflated gradually, using the bedside “tracoe” cuff pressure device with a closed valve (see figure 2) until there is no leak at the lowest cuff sealing pressure (maximum ETT cuff pressure of 20 cmH₂O should be used). If a cuff pressure of greater than 20 cmH₂o is required then this indicates that the ETT and its cuff are too small, requiring excessive cuff inflation and the ETT should be upsized.

4. Fill in CIS intubation procedure form documenting whether tube is cuffed or uncuffed and whether cuff inflated or not and at what pressure cuff is inflated.

5. This should be undertaken for all cuffed ETT’s where the cuff is inflated.

6. The cuff pressure should be checked **every 6 hours** at least. Oropharyngeal suction should be undertaken prior to the deflation of the ETT cuff to minimise risk of aspiration. If the cuff pressure is greater than 20 then release air from cuff via valve on left of “tracoe” device (see figure 2).

7. Cuff pressures should be routinely documented on the respiratory chart in CIS (figure 4).

8. Cleaning of Tracoe cuff pressure monitor should be undertaken as directed by the “GG&G Decontamination Policy and the Standard Operating Procedure for the Cleaning of Near Patient Healthcare Equipment” for most circumstances detergent wipes are satisfactory. For equipment used with a patient in source isolation, including cohort patients 1,000ppm, “Actichlor plus” should be used.

9. A cuffed ETT with a burst cuff may need to be changed for a new cuffed ETT. Please fill in a Datix form if this occurs.

Valve to allow air in/out
Pressure dial (cmH2O)
Sphygmomanometer to inflate ETT cuff
Lectrocath 15cm pressure cable

Attaching Lectrocath to Tracoe cuff pressure device

Figure 2.
Lectrocath to attach to Tracoe device and cuffed ETT
Figure 3.

Recording ETT cuff pressure on CIS
Figure 4.

Quick guide (see ready reckoner)

- Cuffed ETT’s should always be placed with cuff fully deflated (unless deflated when patient
  oscillated to maximize CO2 removal)
- On intubation inflate cuff to max pressure of 20cmH2O to minimize leak around ETT (unless the
  patient is oscillated, in which case the cuff can be deflated to maximize CO2 removal)
- Record cuff P on intubation record and on CIS “respiratory” page (see fig 4)
- Check cuff P by attaching Tracoe cuff pressure device as shown in figure 3 to ETT cuff pilot
  balloon
  - Connect Lectrocath to Tracoe cuff P device and ETT cuff valve (fig 3)
  - Close valve
  - Inflate cuff to max pressure of 20cmH2O
  - If Cuff P >20cmH2O then release air from cuff using valve (fig 2)
  - Disconnect Lectrocath from cuffed ETT between cuff P checks.
- Check Cuff pressure every 6 hours and document on CIS “Respiratory” page
- Cuff should always be deflated prior to extubation or re-positioning of ETT
6. **Review**

This guideline should be reviewed within 3 years from date of approval and following results of clinical audit and future scientific evidence. The Lead Manager retains responsibility for ensuring that review takes place in partnership with the Critical Care Forum.

7. **References**

Medline search Jan 2011 to obtain best levels of evidence including expert opinion.

A  Communication and Implementation  Plan

Groups informed prior to implementation:
  - PICU Consultant Group
  - PICU Charge Nurse Group
  - PICU Education Team
  - Clinical Effectiveness Office (Yorkhill Hospital)

Implementation Plan:
  - Education and training for nursing staff
  - Competency for nursing staff
  - Patient care plan

B  Monitoring

In line with clinical governance, audit will be utilised to provide a means by which to assess the efficacy and impact of this guideline. Adverse events will be identified through the established local incident reporting infra-structure

C  Impact Assessment

Risk assessment and EQIA were not deemed necessary for this guideline.
Cuffed ETT pressure monitoring ready reckoner

- Cuffed ETT’s should always be placed with cuff fully deflated (unless deflated when patient oscillated to maximize CO2 removal)
- On intubation inflate cuff to max pressure of 20cmH2O to minimize leak around ETT
- Record cuff P on intubation record and on CIS “respiratory” page (see fig 3)
- Check cuff P by attaching Tracoe cuff pressure device as shown in figure 2 to ETT cuff pilot balloon
  - Connect Lectrocath to Tracoe cuff P device and ETT cuff valve (fig 2)
  - Close valve
  - Inflate cuff to max pressure of 20cmH2O
  - If Cuff P >20cmH2O then release air from cuff using valve (fig 1)
  - Disconnect Lectrocath from cuffed ETT between cuff P checks.
- Check Cuff pressure every 6 hours and document on CIS “Respiratory” page
- Always deflate cuff prior to extubation or re-positioning of ETT

Fig.1  Tracoe cuff pressure monitoring device  Fig 2. Tracoe cuff pressure device on cuffed ETT

Fig 3.  Recording of ETT cuff pressure on CIS respiratory page
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