1. Introduction

This guideline applies to all the intubated children in the management of ETT.
Purpose:
- Decrease the incidence of unplanned extubation (UE) in PICU/CICU
- To allow standardized use of all cuffed ETT’s (especially microcuff) in ICU 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
• Enable routine documentation of cuff pressures in all patients with cuffed ETT’s
• Aim to assess for sedation and extubation daily

Unplanned extubation (UE) is defined as premature removal of the endotracheal tube by patients on mechanical ventilator or by staff during nursing and medical care. UE in paediatric patients is associated with increased length of mechanical ventilation and length of stay in the PICU. UE may result in serious conditions such as hypoxaemia, bradycardia, aspiration pneumonia, hypotension, arrhythmias, cardiorespiratory arrest, and even death. Repeated intubations, especially those performed emergently in a less controlled scenario; increase the risk of airway injury and scarring, as well as pulmonary injury from excessive ventilation.

Incidence of UE in Leicester Children’s Hospital (PICU/CICU) exceeds the recommended ideal UE rate of less than 1 per 100 ventilator days. These recommendations for the management of the ETT aim to decrease the UE incidence in our units. Recent review article has pointed out the risks of UE and suggested methods for management and monitoring of UE.

Limited information is available regarding factors that contribute to UEs and subsequent reintubation of children. Most of the studies suggest significant reduction in UE rate after educational program implementation that identified high-risk patients for UE (younger patients) and patients who are at low risk for subsequent reintubation (weaning patients). Methods of securing the endotracheal tube varied across studies, and the use of physical restraints yielded conflicting findings.

The factors linked to higher incidences of re-intubation are accidental extubation during nursing or medical procedure, younger age, excessive secretion, night-time UE and upper airway obstruction.

The following factors were found to increase the risks of UE
• Younger patients particularly those younger than 5 years
• Agitation (UE rates 38 - 65%). Agitation within the 12 hours preceding extubation is independently associated with UE
• Inadequate ETT fixation and stabilization
• ET intubation pathway (nasal vs oral) is NOT proved to be risk factor for UE
• Copious secretions (more frequent from the mouth), influence fixation and stabilization of the ETT and secondarily increasing the risk of UE. Secretions also increase risk of re-intubation in UE.
• Performance of a patient procedure at bedside
• Weaning from the mechanical ventilation
• When nursing staff are assigned two patients rather than one

The following factors were NOT found to increase the risk of UE
• Time of the day
• Times of increased ICU activity during the day shift or during lower levels of staff activity at night
• Nasal vs oral intubation
• Presence of restraints

The above factors independently may not cause UE but may be part of the multifactorial cause of UE.
Reintubation rates:
- Reintubation rates post UE range from 14-65%
- Children are most likely to require reintubation if they are ventilated for long period (>28 days), if UE is associated with caregiver activity, if patients have received sedation within 2hrs of the UE or if patients have large amount of secretions.
- Higher reintubation rates are associated with patients requiring full ventilation at time of the incident
- Children who are weaning at the time of the UE have a lower reintubation rate

2. Cuffed or uncuffed ET tube

Uncuffed ETT was the standard of care for children under eight years old. However, uncuffed ET tubes may be associated with large air leaks, which lead to unreliable ventilation, oxygenation, airway pressure monitoring, end-tidal CO2 readings and aspiration. The use of a cuffed ETT can overcome most of these issues and decrease the need for multiple intubations, reduce costs and also has not shown to increase adverse effects in children of all ages.11, 14, 20

Literature in support of the cuffed endotracheal tubes

In studies of Murat et al and Deakers no cases of subglottic stenosis were observed. In 2006 Suominen et al studied 218 children following surgery, and found that adverse events after extubations were more likely to occur in children with an absent air leak at a pressure of 25 cm H2O. The exchange rate of cuffed tubes were actually 95% lower than uncuffed tubes and that uncuffed ETT’s had to be changed out 30% of the time in children less than 2 and 18% of the time in children over 220.

Recent Cochrane review showed two trials comparing cuffed versus uncuffed ETTs, which found no difference between the groups for post-extubation stridor. However, both trials demonstrated a statistically significant lower rate of ETT exchange in the cuffed ETT group. Cochrane concluded that large RCT of high methodological quality should be conducted to help clarify the risks and benefits of cuffed ETTs for children.14

Shortcomings in paediatric cuffed ETT:

Many commercially available paediatric cuffed ETTs are poorly designed and that this might be one of the most important sources of morbidity associated with cuffed ETTs.11, 15

Factors that might be contributing to subglottic stenosis include ETT size, movement of the tube, duration of intubation, traumatic intubation, the presence of infection during the course of intubation, and possibly gastroesophageal reflux.20

The design of endotracheal tubes used in paediatric patients

The study by Weiss et al demonstrated that the improved design of the Microcuff paediatric ETT helps to overcome important disadvantages of the use of cuffed ETTs in children.12

Microcuff ETT seals the trachea at cuff pressures that is generally considered safe to preserve tracheal mucosal perfusion pressure.13

The ‘Microcuff’ ETT cuff is made of ultra-thin material, which is softer and thinner. The cuff is more distally placed on the ETT shaft, which sits in trachea below the subglottis. In various studies, it has shown that the design of the Microcuff™ ETT is more age appropriate and therefore, superior to the design of most other commercially available paediatric ETTs.11, 20

In studies with Microcuff ET tubes showed:
very low rate of tube exchange rate and a very low rate of croup requiring therapy.
post-extubation stridor was similar (4%) in both cuffed and uncuffed tubes, but tracheal tube exchange rate was 2.1% in the cuffed and 30.8% in the uncuffed groups.
rate of epinephrine inhalation for postextubation croup and rate of successful extubation did not differ between cuffed and uncuffed groups. He concluded that children (<8 years) Microcuff ETT are the best cuffed ETT in critically ill children.

3. Cuff pressure monitoring

When using a cuffed ETT, it is mandatory to monitor the cuff pressure. Cuff pressure is traditionally monitored every hour or at least every 12 hours. Cuff pressures should be checked after ETT position changes, change in head/neck position. Animal studies have shown that airway mucosal damage can occur in as short as 15 minutes if the cuff pressure is high. Cuff pressures do change with change in head and neck position. It is therefore essential to monitor cuff pressures as part of ongoing patient safety and quality improvement initiatives. Multiple studies (Khine, Deakers, Newth) using the microcuff ETT have not shown any increase in the incidence of post-extubation stridor and long-term airway sequelae.
However, experienced paediatric ENT surgeons feel that significant airway injury is not always accompanied by stridor. The symptoms of airway injury may not present immediately after extubation and symptoms might develop weeks to months after injury when silent ulcerations of the mucosa retract to cause stenosis. Only endoscopy can evidently detect all airway injuries. Only well planned, randomized studies using well designed, standardized tracheal tubes and performing airway endoscopy before and after extubation, may answer the question which mode of intubation might be the least traumatic in children below 8 years. For clinical practice today, airway endoscopy is warranted at least in all patients developing significant stridor after extubation or any other suspicion of airway damage.

4. Best practices recommendations

Structure
- Nurse-to-patient ration of 1:1
- Continuous quality-improvement program

Process
- Staff education and training
- Patient risk identification
- Standardisation of procedures such as ETT fixation, stabilisation, tube suctioning physiotherapy, patient hygiene, positioning and transport
- Standardisation of routes for monitoring of ETT position
- Early recognition of patients ready for extubation
- Implementation of a protocol-directed ventilation weaning plan
- Standardisation of sedation practices according to sedation assessment scores
- Avoid delays in extubating in a timely fashion perhaps related to staff issues, resources and time of day
- Development of appropriate data tracking tools and data collection
Airway management:

1. Routine usage of microcuff ETT is recommended for all paediatric patients in whom high ventilator pressures are anticipated.\(^3,4\)
2. Uncuffed ETT is recommended in recent airway surgery/balloon dilatation, suspected subglottic stenosis, slide tracheoplasty patients. Consider uncuffed ETT if anticipated ventilator pressures are low, re-intubation after post-extubation stridor.
3. Consider uncuffed ETT with history of stridor in previous admission after extubation.
4. If there is no leak at a peak inspiratory pressure of 20 cm of water with cuff deflated, consider to downsize the ETT if clinical condition allows.
5. Oral versus nasal intubation
   - Oral intubation is recommended where early extubation is anticipated.
   - Nasal intubation is recommended if likely to remain ventilated for longer than 48-72 hour.
6. Assess daily for extubation and extubate at the earliest safe opportunity.
7. ETT suctioning should be limited to the end of the ET tube - Ideal ET suctioning length should be recorded on the observation chart. Oropharyngeal suction should be undertaken prior to the deflation of the cuff to minimise the risk of aspiration.
8. Aim to keep pressures less then 20cmH20 on tracheal manometer.
   - The cuff pressure should be checked every hour unless intellicuff\(^\circledR\) is used and hourly monitoring is not possible, in these cases please record 12 hourly (if intellicuff\(^\circledR\) technology is used then record hourly).
9. Consider ENT review for recurrent stridor/upper airway obstruction post extubation
10. Continuous ETCO2 monitoring is highly recommended - during endotracheal intubation and tracheostomy (all areas) -peri-operatively -for all ventilated patients in ICU -for all ventilated patients during inter-hospital or intra-hospital transfer

ETT length, position and fixation

1. Confirm correct placement of the ETT by chest XR(CXR)
   - CXR within last 24 hours if being transported out of the hospital\(^5\)
2. Length of the ETT\(^6\)
   - Recommended length of the ETT post intubation in anaesthetic department is at least 3 cm of ETT free length after strapping is applied
   - Recommended length of the ETT in ICU is at least 2 cm of ETT free length after ETT position is confirmed on CXR, and after strapping is applied.
3. Strapping of the ETT
   Melbourne strapping is recommended for securing the ETT\(^7\). Follow the CoMET (East Midlands Children’s Acute Transport) guideline for securing ETT.
4. Changing of the ETT strapping
   A bolus of sedation together with a bolus of muscle relaxant is highly recommended. Cuff should always be deflated prior to extubation or re-positioning of ETT

Sedation

1. Sedation assessment is recommended at least 4\(^{th}\) hourly utilising COMFORT scale. (target COMFORT score between 17 and 26). Follow the sedation guidelines.
2. A bolus of sedation, with or without a bolus relaxant is suggested if required during tube suctioning, physiotherapy, patient hygiene, positioning, transport and any other manipulation of the patient.

3. All patients who require mechanical ventilation during intra-hospital transfer should be sedated and muscle relaxed. Follow CoMET guidelines for further details.

**Outcome**

1. Continuous UE event monitoring with regular at least quarterly review
   - Risk for UE in PICU/CICU is targeted to be lower than 1 per 100 ventilator days

2. Surrogate marker of monthly Airway Bundle Audit
   - Target 100% compliance with interim marker of 75%
   - A patient without all bundle elements would score as ‘non-compliant’ since you need all elements to achieve compliance
   - Aim to monitor at least 10 patients per unit per month

**Review**

This guideline should be reviewed after 3 years from date of approval and following results of clinical audit and future scientific evidence. The CPM lead retains responsibility for ensuring that review takes place in partnership with the PICU/CICU.

**5. Education and Training**

None

**6. Monitoring Compliance**

None currently identified

<table>
<thead>
<tr>
<th>What will be measured to monitor compliance</th>
<th>How will compliance be monitored</th>
<th>Monitoring Lead</th>
<th>Frequency</th>
<th>Reporting arrangements</th>
</tr>
</thead>
</table>

**7. Supporting Reference**

7. [https://resus.me/securing-infant-tracheal-tubes](https://resus.me/securing-infant-tracheal-tubes)
8. Capnography guidelines.pdf
10. Sandeep Tripathi, Denise J Nunez, Chaavi Katyal, and H Michael Ushay. Plan to Have No Unplanned: A Collaborative, Hospital-Based Quality-Improvement Project to Reduce the Rate of Unplanned Extubations in the Pediatric ICU. RESPIRATORY CARE Paper in Press. Published on May 19, 2015 as DOI: 10.4187/respcare.03984

8. Key Words
Endotracheal tube, Melbourne strapping, Microcuff, Postextubation stridor, Subglottic stenosis

The Trust recognises the diversity of the local community it serves. Our aim therefore is to provide a safe environment free from discrimination and treat all individuals fairly with dignity and appropriately according to their needs.
As part of its development, this policy and its impact on equality have been reviewed and no detriment was identified.
<table>
<thead>
<tr>
<th>CONTACT AND REVIEW DETAILS</th>
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<tbody>
<tr>
<td><strong>Guideline Lead (Name and Title)</strong></td>
</tr>
<tr>
<td>Bedangshu Saikia - Consultant</td>
</tr>
<tr>
<td>Anand Patil – PICU Consultant</td>
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</table>

**Details of Changes made during review:**
- Expanded Introduction and purpose of guideline
- Added presence of restraints to factors not found to increase risk of UE
- Added section 2 – cuffed or uncuffed ET evidence
- Added section 3 – Cuff pressure monitoring background info
- Removed reference to airway care bundles & comfort scales
- Removed outcome & scope sections under best practice recommendations
- Airway management changed significantly – Red text = additional guidance

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   - Nasal intubation is recommended if likely to remain ventilated for longer than 48-72 hours.
5. Assess daily for extubation and extubate at the earliest safe opportunity
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7. The cuff pressure should be checked every hour unless intellicuff® is used and hourly monitoring is not possible, in these cases please record 12 hourly (if intellicuff® technology is used then record hourly). Aim to keep pressures less then 20cmH20 on tracheal manometer.
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Added reference to CoMET guidelines

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Added pre-intubation aide memoire and ETT size guide to appendix
Pre-Intubation “Aide memoire”
Should be read aloud when team is ready

**Prepare Equipment**

*Monitoring:*
ECG (pulse tone on)
Spo2
BP (cycle every 2 min if no arterial line)
Capnography/Color capnometer

*Airway items:*
T-piece with mask
Suction on with Yankauer
Guedel/LMA
Laryngoscope
ET tubes (correct size & 1 size below and test the cuff)
Note ETT insertion length
ET Tapes ready
Stylet/Bougie
Magill forceps if nasal intubation

*Drugs:*
Induction agents & muscle relaxant dose confirmed
(decrease dose if hypotension likely)
Emergency drugs required? (Fluid bolus, Adrenaline)

**Prepare Patient**

*History reviewed? (Previous grade of laryngoscopy, past anaesthetic problems, previous ETT size/length)*

*Airway assessment (any features of a predictably difficult airway)*

*Adequately fasted? (Consider risks/benefits of delaying intubation/RSI if not fasted)*

*Check access*

*Pre-oxygenate for 2-3 mins with 100% O2 (unless contraindicated)*

*Optimise Position (Consider shoulder roll in <1 yr, pillow below head in >8 yr)*

*Reliable access? (consider IO if difficult)*

*Hemodynamics adequate (consider fluid bolus+/peripheral vasoactive drugs pre-intubation)*

*Aspirate NG tube*

*Stethoscope*

*Family aware of the plan?*

**Prepare Team**

*Assign roles*

*Team leader*

*1st Intubator*

*2nd Intubator*

*Intubator’s assistant*

*Drug administrator*

*NGT aspiration (continuously during facemask ventilation)*

*Cricoid pressure*

*Are we in best location? (move to PICU/theatre)*

*Nurse in-charge aware?*

*Consultant aware?*

*Prepare for failure*

*Failure to intubate, CVS instability (who will deal and what should be done)*

*Any specialist team required? (Anesthetist, ENT)*

**Confirm plan**

Plan A: 2 attempts by 1st intubator
Plan B: Next attempt by senior
Plan C: Bag Mask Ventilation
Plan D: Call Anesthetist/ENT
**Intubation drugs**

<table>
<thead>
<tr>
<th>Drugs</th>
<th>Dose</th>
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<tbody>
<tr>
<td>Ketamine</td>
<td>1-2mg/kg</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>1-2microgram/kg</td>
</tr>
<tr>
<td>Rocuronium</td>
<td>1 mg/kg</td>
</tr>
<tr>
<td>Atracurium</td>
<td>1 mg/kg</td>
</tr>
</tbody>
</table>

**Sizes of LMA**

<table>
<thead>
<tr>
<th>LMA size</th>
<th>weight (kg)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>&lt;5</td>
</tr>
<tr>
<td>1.5</td>
<td>5-10</td>
</tr>
<tr>
<td>2</td>
<td>10-20</td>
</tr>
<tr>
<td>2.5</td>
<td>20-30</td>
</tr>
<tr>
<td>3</td>
<td>30-50</td>
</tr>
<tr>
<td>4</td>
<td>50-70</td>
</tr>
</tbody>
</table>

**Size of ET suction catheter**

2 times ETT size

**Sizes of ETT and insertion depth**

<table>
<thead>
<tr>
<th>Age</th>
<th>Uncuffed ETT (mm ID)</th>
<th>Cuffed ETT (mm ID)</th>
<th>Length at lips (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonate</td>
<td>3-3.5</td>
<td>3</td>
<td>9-10</td>
</tr>
<tr>
<td>&gt;28 days-6 months</td>
<td>3.5</td>
<td>3-3.5</td>
<td>9-10</td>
</tr>
<tr>
<td>6 months-1year</td>
<td>3.5</td>
<td>3.5</td>
<td>10-12</td>
</tr>
<tr>
<td>2 years</td>
<td>4-4.5</td>
<td>4</td>
<td>12-13</td>
</tr>
<tr>
<td>5 years</td>
<td>5</td>
<td>4.5</td>
<td>14-15</td>
</tr>
<tr>
<td>8 years</td>
<td>5.5-6</td>
<td>5.5-5.5</td>
<td>16-18</td>
</tr>
<tr>
<td>10 years</td>
<td>6-6.5</td>
<td>6</td>
<td>17-18</td>
</tr>
<tr>
<td>12 years</td>
<td>6.5-7</td>
<td>6-6.5</td>
<td>18-20</td>
</tr>
<tr>
<td>15 years</td>
<td>7</td>
<td>6.5-7</td>
<td>20-21</td>
</tr>
<tr>
<td>18 years</td>
<td>7</td>
<td>7</td>
<td>20-21</td>
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</tbody>
</table>

Note: Rough guide

**Size**

Uncuffed (> 1 year): Age /4 +4
Cuffed (>3 kg): Age /4+ 3.5
Neonate (under 3 kg): 2, 2.5 or 3.5 (Uncuffed)

**Depth of ETT insertion**

Neonate: 3 times ETT size
Oral: Age in yrs/2+ 12
Nasal: Age in yrs/2 + 15 (older kids)
Nasal: Age/2 + 14 (infancy and younger kids)