Paediatric Intensive Care Unit

Endotracheal Tube Management UHL Children's Intensive Care Guideline

Staff relevant to:	Medical and Nursing staff caring for children in the PICU
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Trust Ref:	C116/2016

Related Guidelines and Policies:	
CoMET	**Procedure for Securing an Endotracheal Tube placed Orally (Comet guideline)**
CoMET	**Procedure for Securing an Endotracheal Tube placed Nasally (Comet guideline)**
C43/2016	**The Prevention of Ventilator Associated Pneumonia**
C5/2014	**Difficult Airway UHL Neonatal Guideline**

Contents

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 standardize the use of cuffed endotracheal tube (ETT) in children's ICU and to facilitate the education of all staff groups
- Minimise the potential for subglottic injury secondary to inadvertent use of high cuff pressures or inappropriate sized uncuffed tubes.
- To standardize routine documentation of cuff pressures in all patients with cuffed Endotracheal tubes
- To assess the optimal state of sedation as well as readiness for extubation daily to minimize UE on the unit.

Definition:

Unplanned extubation (UE) is defined as premature removal of the ETT by the patient on mechanical ventilator (deliberate UE) or by staff during nursing and medical care (accidental extubation) [9]. Paediatric Intensive Care Audit network group (PICANet) defines UE as a dislodgement of the ETT from the trachea, without the intention to extubate immediately and without the presence of airway competent clinical staff in the bed space, appropriately prepared for the procedure.[23]

Why UE should be avoided?

UE may result in complications such as hypoxemia, and/or hypercarbia and these adverse events are associated with morbidity, prolonged mechanical ventilation, longer PICU stays and increased costs and rarely death.[24, 25]
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.[7]

In recent years, the rate of UE has been used to benchmark the quality of patient care in intensive care with respect to sedation, weaning, and use of restraints.[10]
Although the national average of UE rate is around 5 per 1000 days of invasive ventilation far from the recommended ideal rate of 1 per 100 ventilation days slowly and steadily UE rates are falling. Incidence of UE in Leicester Children's Hospital (PICU/CICU) still exceeds the recommended ideal rate with about an average of 17.6 UE per year over the last 5 years (as per morbidity data base).

The recommendations for the management of the ETT aim to decrease the UE incidence in our trust. Although cardiac arrest occurred in only 2% of events, UE in pediatric patients were associated with a 20% increased risk of life-threatening cardiovascular collapse with cardiopulmonary resuscitation required in up to 47% of patients.[29]

Limited data is available regarding factors that contribute to UEs and subsequent reintubation of children. Despite numerous publications on UE, very few studies have assessed the preventive strategies to avoid adverse events. Most of the studies suggest significant reduction in UE rate after implementing a robust educational program that looked at identifying high risk patients, ETT care, and protocol directed sedation.[1] Methods of securing the endotracheal tube varied across studies, and the use of physical restraints yielded conflicting findings.[2, 10]

In a multivariate analysis, risk factors for UE included

- Age < 2 years
- Male gender
- Agitation
- Inadequacy of ETT fixation
- Copious secretions as they influence stability of the ETT fixation. (Also increases risk of re-intubation in UE).
- Medical procedures / nursing cares
- Failure to assess extubation readiness
- Lack of 1:1 nursing care [2]

The following factors were **NOT** found to increase the risk of UE

- Time of the day
- Intensity of work on ITU
- Lower staffing levels at night
- Nasal vs oral intubation
- Presence of restraints[10]

(Note: Although above factors may not cause UE independently, however they may still contribute as part of multifactorial causes of UE)

Reintubation rates:

- Reintubation rates post UE range from 14-65% [28]
- Factors such as prolonged periods of ventilation (>28 days), UE during care/procedure, sedation within 2 of UE, copious secretions have contributed to various extent influencing the need for reintubation.

2. Cuffed or uncuffed ET tube

Cuffed tracheal tubes are increasingly used in current practice. With an advantage of significantly reduced leakage, cuffed tubes have shown better tidal volumes during the recruitment maneuvers on both pressure and volume-based ventilation strategies which also affects the oxygenation, monitoring parameters such as airway pressures, end-tidal CO2 and avoid risk such as aspiration.

The use of a cuffed ETT can overcome most of these issues, decreasing the need for multiple intubations, reduce costs without significant risk of adverse effects in children of all age groups.[11, 14, 20]

Literature in support of the cuffed endotracheal tubes

Despite the longstanding use and benefits of uncuffed ETT in young children, cuffed ETTs are increasingly being used with several studies over the last 20 years demonstrating its benefits. Based on plaster molds of the pediatric airway in cadaveric studies, the funnel-shaped larynx was understood to transition towards a more cylindrical adult airway around 8 years of age. Recent CT, MRI, and video laryngoscopy studies have shown that the narrowest part of the pediatric airway is actually at the infraglottic level with an elliptical form of anteroposterior greater than transverse diameter; although, the rigid cricoid ring is still functionally the narrowest part of the larynx.[31-34] The newly appreciated elliptical shaped airway at the level of the cricoid cartilage is potentially vulnerable

to damage even from a properly sealed uncuffed tube. With this, there is growing evidence that suggests uncuffed ETTs may not have better outcomes that truly offers an advantage over cuffed tubes, because the circular tube will occlude the elliptical airway only on the sides, leaving a gap in the anterior and posterior sides. The leak test done routinely to make sure that the tube is not too big, may actually show a leak, but there may be excessive pressure on the transverse walls of the trachea. [35,36]

There is growing evidence that suggests cuffed ETT have additional clinical, environmental, and economic benefits compared to uncuffed ETT. Previously, there were concerns of tracheal mucosa damage from excessive pressures, but studies have shown they provide a reliably sealed airway at pressures <= 20 cm H2O and reduce the need for tube exchanges.[12] Cuffed ETT has decreased incidences of sore throat and hoarse voice, likely from the decreased need for tube exchanges. [37] Studies have also shown no major difference in acute respiratory complications such as stridor after extubation between cuffed and uncuffed ETT [12, 38] with some showing decreased postoperative complications.[37]

In a study comparing leakage and tidal volumes in cuffed vs uncuffed ETT, cuffed ETT had significantly lower leaks and were measuring higher tidal volumes. It is assumed a majority of the leak is inspiratory due to increased intratracheal pressures. Expired tidal volume levels, which more accurately reflect true tidal volume, increased over time in the cuffed group suggesting better maintenance of lung volumes.[37] A retrospective study on neonates found that uncuffed ETT had a leak >5% in 75% of infants with a >40% leak occurring in 42.3% of infants around the third day of mechanical ventilation. Leaks were also associated with longer duration of mechanical ventilation.[39]
Although cuffed ETT are more expensive than uncuffed ETT, they are environmentally and economically beneficial due to decreased tube changes and decreased medical gas consumption. In a study looking at sevoflurane consumption, they found the uncuffed group used 16.1 mL of sevoflurane compared to 6.2 mL in the cuffed group.[40]

Recent Cochrane review looking at trials involving 2804 children under the age of 8 years 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]
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[20]
- 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[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 intubation, and possibly gastroesophageal reflux.[20]

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. Cuff pressure can be monitored using a continuous automated electronic device or intermittently by a handheld manometer. Either of the methods have been proven to be of similar efficacy.[41]
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 [11, 15, 17]. 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. [18, 19] 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 [11, 16, 19, 20]. 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. [11,16, 19]

4. Best practices recommendations

Structure

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

Process

- Staff education and training
- Patient risk identification
- Standardization of procedures such as ETT fixation, stabilization, tube suctioning physiotherapy, patient hygiene, positioning, and transport
- Standardization of routes for monitoring of ETT position
- Early recognition of patients ready for extubation

- Implementation of a protocol-directed ventilation weaning plan
- Standardization 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 downsizing 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 48-72hour
6. Assess daily for extubation and extubate at the earliest opportunity in safe and controlled environment.
7. ETT suctioning should be limited to the length of the ET tube in situ- Ideally 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® is used and hourly monitoring is not possible, in these cases please record 12 hourly (if intellicuff® 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 4th hourly utilizing 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

What will be measured to monitor compliance	How will compliance be monitored	Monitoring Lead	Frequency	Reporting arrangements

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8. Key Words

Endotracheal tube, Melbourne strapping, Microcuff, Postextubation stridor, Subglottic stenosis

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The Trust recognizes 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.

CONTACT AND REVIEW DETAILS	
Guideline Lead (Name and Title) Bedangshu Saikia - Consultant Anand Patil – PICU Consultant	**Executive Lead** **Chief Nurse**
Details of Changes made during review:	

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% O_2 (unless contraindicated)
* Optimise Position (Consider shoulder roll in <1 yr, pillow below head in >8 yr)
*Relaible 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 by1st intubator
Plan B: Next attempt by senior
Plan C: Bag Mask Ventilation
Plan D: Call Anesthetist/ENT

East Midlands Congenital Heart Centre

Leicester Children's Hospital

Size of LMA	
LMA size	weight (kg)
1	<5
1.5	5-10
2	10-20
2.5	20-30
3	30-50
4	50-70

Size of ET suction catheter
2 times ETT size

Intubation drugs (consider lower doses if risk of CVS instability)	
Drugs	Dose
Ketamine	1-2mg/kg
Fentanyl	1-2microgram/kg
Rocuronium	1 mg/kg
Atracurium	1 mg/kg

Sizes of ETT and insertion depth			
Age	Uncuffed ETT (mm ID)	Cuffed ETT (mm ID)	Length at lips (cm)
Neonate	3-3.5	3	9-10
>28 days 6 months	3.5	3-3.5	9-10
6 months-1year	3.5-4	3.5	10-12
2 years	4-4.5	4	12-13
5 years	5	4.5	14-15
8 years	5.5-6	5-5.5	16-18
10 years	6-6.5	6	17-18
12 years	6.5-7	6-6.5	18-20
15 years	7	6.5-7	20-21
18 years	7	7	20-21

Note: Rough guide

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

<u>Depth of ETT insertion</u>
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)