Secrets of the Pediatric Intubated Patient: Evidence-Based Keys to Success

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Ranked #1 in Virginia by U.S. News & World Report

Top care
The VCU Medical Center earns No. 1 spot in the state and ranks nationally in four specialties.

VCU Medical Center
MCV Campus
VCU Total Artificial Heart Program
Objectives

- Examine pediatric endotracheal tube types
- Compare effective securement methods
- Discuss patient positioning for transport
- List possible transport complications with intubated children and develop a systematic approach to troubleshooting tube placement
The main difference in pediatric and adults patients (for most of us) is our comfort level!

- 13% of EMS Calls Peds
- Peds intubation Attempted once every 3 years
- Peds ETT Success Rate < 50%
CHILDREN ARE SCARY!!!!
The Pediatric Airway: 
The Anatomy

- Higher anterior position of glottic opening
- Large tongue
- Angle between epiglottis and laryngeal opening more acute
- Small cricothyroid membranes
- Large tonsils and adenoids
The Pediatric Airway: A Review

- Large occiputs
- Basal oxygen consumption is 2 times that of adults
- Smaller (proportionally) functional residual capacity
The Endotracheal Tube
Not All Tubes are Created Equal

CONSTRUCTION MATERIALS
DIAMETER
TUBE MARKINGS
CUFF’S
MURPHY’S EYE
Construction Materials

* Poly vinyl chloride (PVC)
  * Cheap, transparent, latex free
  * Thermoplastic
* Silicone
  * Softer – more suitable for long-term intubation
* Reinforced tubes
Construction Materials

* Radio opaque line
 Tube Diameter

* Internal diameter

* External diameter varies
ETT Sizing: Why important?

- Cricoid ring is the **narrowest** part of the airway in a child
- 1 mm of edema in the adult airway = 19% occlusion
- **1mm of edema in the peds airway = 75% occlusion**
- Using too large of an ETT has a high risk of post extubation croup

Size Determination

- Age based formulas
- Broselow tape
- Over 22 formulas available

- What does the research tell us about sizing?

ETT Depth: Why Is It Important?

* Too Deep:
  * Bronchial intubation
  * Irritation to the carina
    * Tachycardia
    * Hypertension
    * Bronchospasm
    * Hypoxemia

* Too Shallow:
  * Higher risk for extubation
  * Damage to the vocal cords

Optimal Placement = ½ way between carina & vocal cords (mid trachea)
NO INTERNATIONAL STANDARD FOR MARKINGS

Inconsistent

Variable among manufacturers
Tube Markings

- Length is measured from distal end (end inserted first in airway)
- Marked in centimeters

Inconsistent w/ Gaps in sequence

Measured From the Tip.
Tube Markings
Tube Markings
“There is no uniformity amongst the various manufacturers as to the type of guide mark – horizontal or vertical, single or multiple, and distance from the ETT tip. It will thus remain a reliable intubation depth marker but only for the discerning.”

-Goel and Lim, Paediatric Anaesthesia, 2003
Tube depth should be determined with **assessment**… not just markings!
“...variability in the tracheal length among patients makes it impossible to predict with certainty that a technique based on a formula or markers on the ETT will work in all patients.”

Tube Depth

- Direct visualization
- ETCO2?
- Chest x-ray
- Bilateral breath sounds?
- Absence of epigastric sounds
- Bilateral chest rise?
- Misting in the tube?
Is ETCO₂ Trustworthy?

- 108 Intubated Pt by EMS
- 25% improperly placed
  - 33% of those improperly placed tubes were in the hypopharynx (9 pts)
  - 56% of those (5pts) had evidence of ETCO₂ on ED arrival

DO NOT RELY ON ETCO₂ AS THE ONLY CONFIRMATION TOOL

Murphy's Eye

Murphy eye

inflated cuff
Murphy’s Eye

Bilateral breath sounds in 60% of main-stem intubations!

The ETT can be advanced up to 3.2 cm into the right bronchus of adults before breath sounds are lost on the left side.

153 Peds OR cases confirmed ETT with lung sounds...

- 18 right main stemmed
- 29 too low
- 31% error based on lung sounds alone!

Sugiyama, et al. (1999) *Does the Murphy Eye reduce the reliability of chest auscultation in detecting endobronchial intubation?* Anesthesia & Analgesia Journal

Cuff vs. Uncuffed
Uncuffed Tubes

* Oversized:
  * Multiple intubation attempts
  * Laryngeal injury

* Undersized:
  * Unreliable ventilation & oxygenation
  * Imprecise capnography & lung function tests
  * Aspiration risk
  * “children receiving uncuffed tubes were significantly more likely to demonstrate clinically significant loss of tidal volume”

Cuffed Tubes

Advantages:

- Fewer intubation attempts due to sizing issues
- Decreased risk of aspiration
- Ability to precisely control ventilation
- Able to guarantee PEEP
- Accurate monitoring of respiratory function
- Decreased anesthetic gas use
- Decreased environmental contamination of gases
- Ability to adjust for change in compliance (burns)
- Decreases post-operative pneumonia

Cuffed Tubes

Disadvantages:

- More costly
- Monitor cuff pressure
- 20 – 30 cm H2O safe zone
- Laryngeal damage risk
- Post intubation stridor risk
- Using smaller internal diameter tube with cuffed tubes
How Should You Store Your Tubes?
Storage Considerations

- Flat
- Un-kinked
- Pre-styletted
- All sizes
- All cuffed
Not all Securement Devices are Created Equal

TAPING vs. COMMERCIAL DEVICES
Thomas Tube Holder

Compared:
- Thomas Tube Holder
- Endogrip by Biomedix
- Precision Medical ETT holder
- Ergo Med Tube Tamer

Method:
- Fresh unembalmed cadavers

Results:
- The Thomas ETT holder was the only device stronger than tape.
- Other commercial devices are not as strong as tape

Clamp the ETT after the device is strapped to the patients head!

Other studies exist…but they use plastic mannequins and have unrealistic environments.
Lillehei Taping Method

Mentioned in:
- 1994 Kaplow & Bookbinder securement study
- 2007 Carlson Study

- Referenced in Clinical Procedures in Emergency Medicine as a suggested securement method.

Lillehei Taping Method
• X-rays identified the tips as:
  • Very high to Very low

• Results:
  • Tape = more likely to be “very low”
  • Neobar = most likely to be “very high” (shallow) and at risk for extubation.

Brinsmead, et al. (May 2010) *Securing endotracheal tubes: does NeoBar availability improve tube position?* Journal of Paediatric Child Health (Queensland Australia)
Transport Suggestions...

* Adult & Teen: Thomas Tube Holder
* Infant: Well practiced taping method of choice. Remove all commercial devices

- 2005 Study by Kim in Pediatric Anesthesia
- Full head extension, trachea elongated by .95 cm
- 12.1% increase in tracheal length

NO MATTER HOW THE TUBE IS SECURED (TAPE VS. COMMERCIAL METHOD), HEAD MOVEMENT CAN LEAD TO ETT DISPLACEMENT.
Tube & Head Movement

Extension of the head moves the ETT away from the carina
- Extending the neck moves the ETT 0.5 to 1.2 cm north.
- Flexing the neck moves the ETT distally 0.5 to 1.0 cm.

Flexion of the head moves the ETT toward the carina
Head Flexion

Neutral

Flexion
Recommendations for Transport
IMMOBILIZATION IS PARAMOUNT!

- Neonatal cervical manipulation significantly changes tube depth
- Immobilization prevents tube dislodgement

Consider Flexible ETT Elbows

- Allows some flexibility from BVM to ETT
- Med delivery and suction port
* (2004) PennState retrospective study
  * 10 years of PICU admissions
  * 5 years before & after PSCHSA initiated
  * PennState Children’s Hospital Sedation Algorithm
  * Before – 0.44 to 0.63 unplanned ext. per 100 admissions
  * After – 0.0 to 0.19 unplanned ext. per 100 admissions

Discussion of Paralytics

- Rooting reflex
- False ETCO₂ readings
- Pt movement
In Summary

* Know your tube
* Depth determined with assessment, not just markings
* Use multiple ETT confirmation techniques
* Considered cuffed tubes
* Remove weight from the tubes
In Summary

* Appropriate securement device
* Immobilize the whole body! (not just the c-spine)
* Sedate/Paralytics
* Assess after every move!
* TAKE YOUR TIME! DON’T RUSH!
* Secure it the right way BEFORE you leave
Questions?

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