Secrets of the Pediatric Intubated Patient:

Evidence-Based Keys to Success

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Every Day, A New Discovery.

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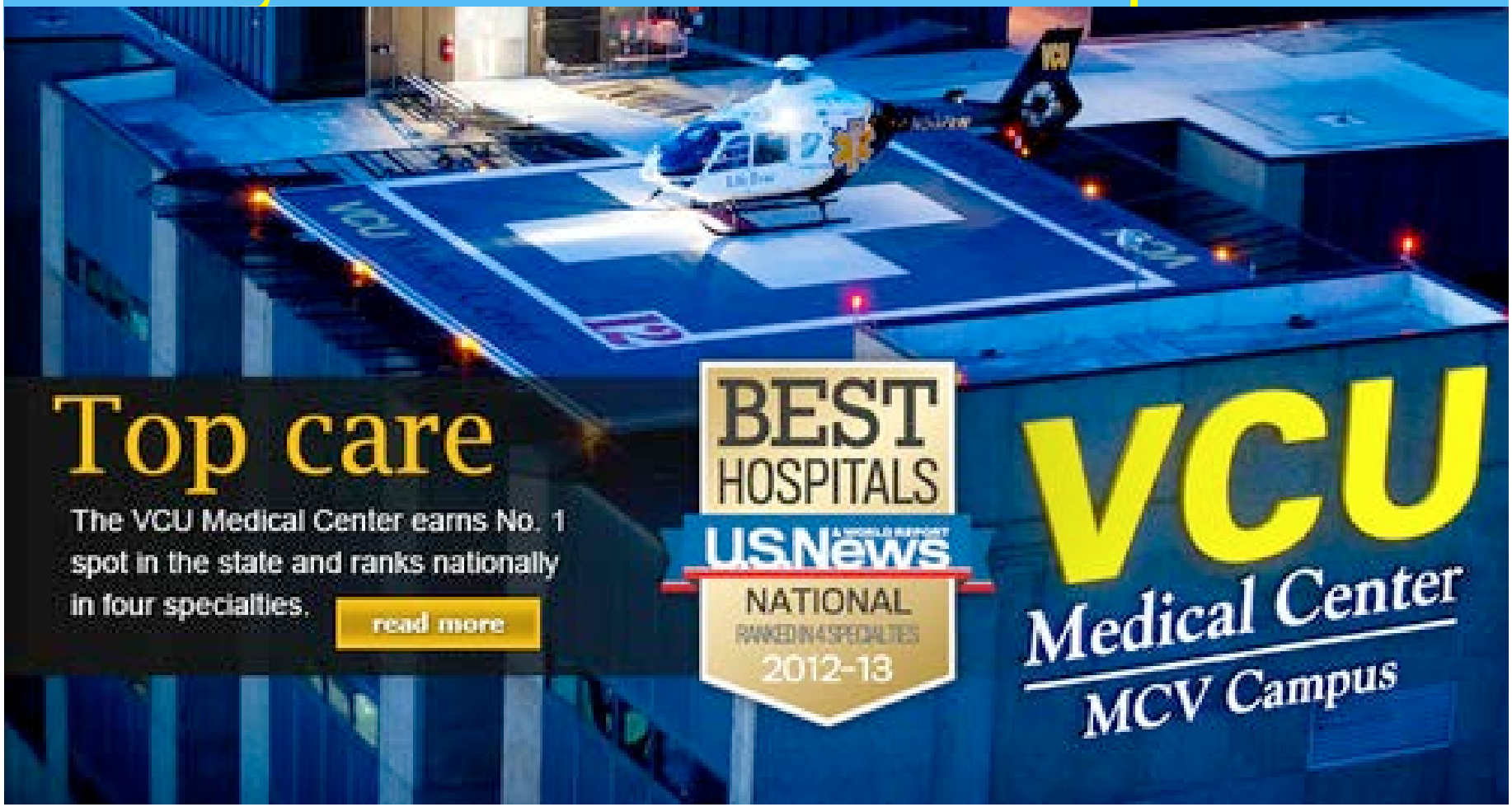
by U.S. News & World Report



VCU Total Artificial Heart Program

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N537LN

N151LN
Life Net

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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 trouble shooting tube placement

The Pediatric Airway:
A Review

The main difference in pediatric and adults patients (for most of us) is our

Comfort level!

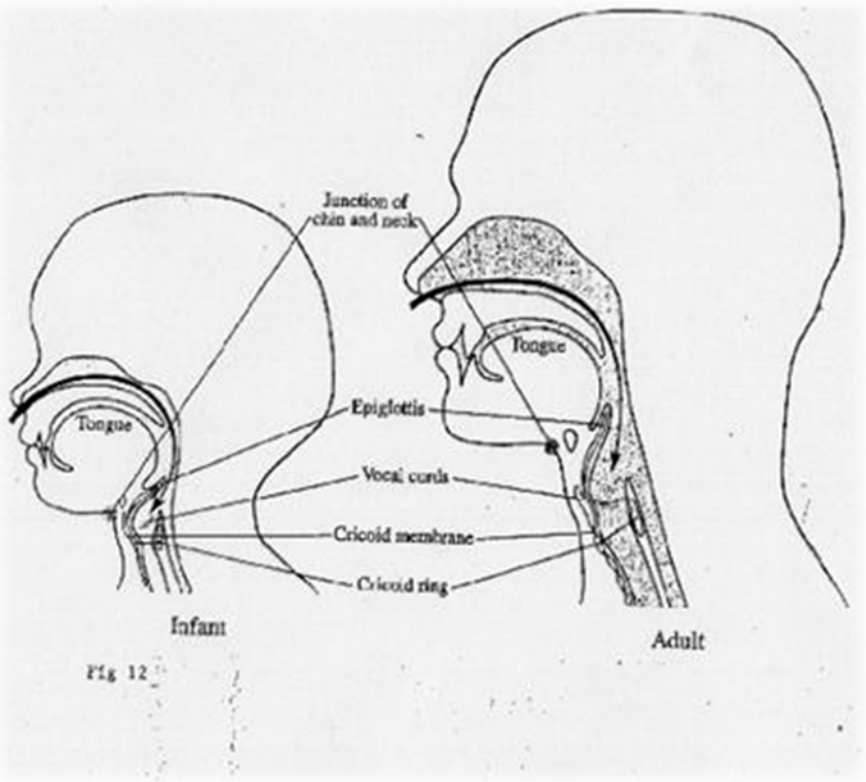
13% of EMS Calls Peds

Peds intubation Attempted once every 3 years

Peds ETT Success Rate < 50%

CHILDREN ARE SCARY!!!!

The Pediatric Airway:
The Anatomy

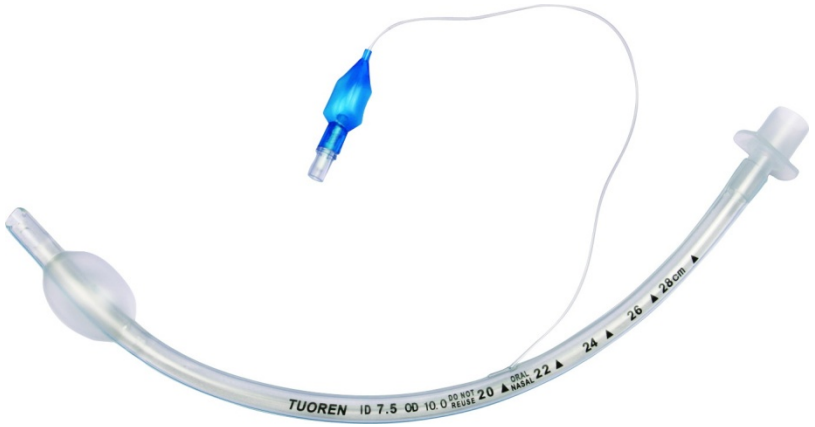


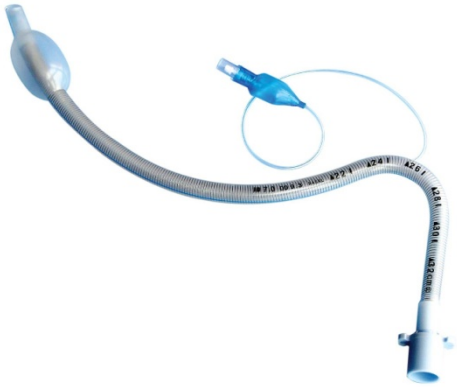
* Higher anterior position of glottic opening
* Large tongue
* Angle between epiglottis and laryngeal opening more acute
* Small cricothyroid membranes
* Large tonsils and adenoids

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

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Construction Materials

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

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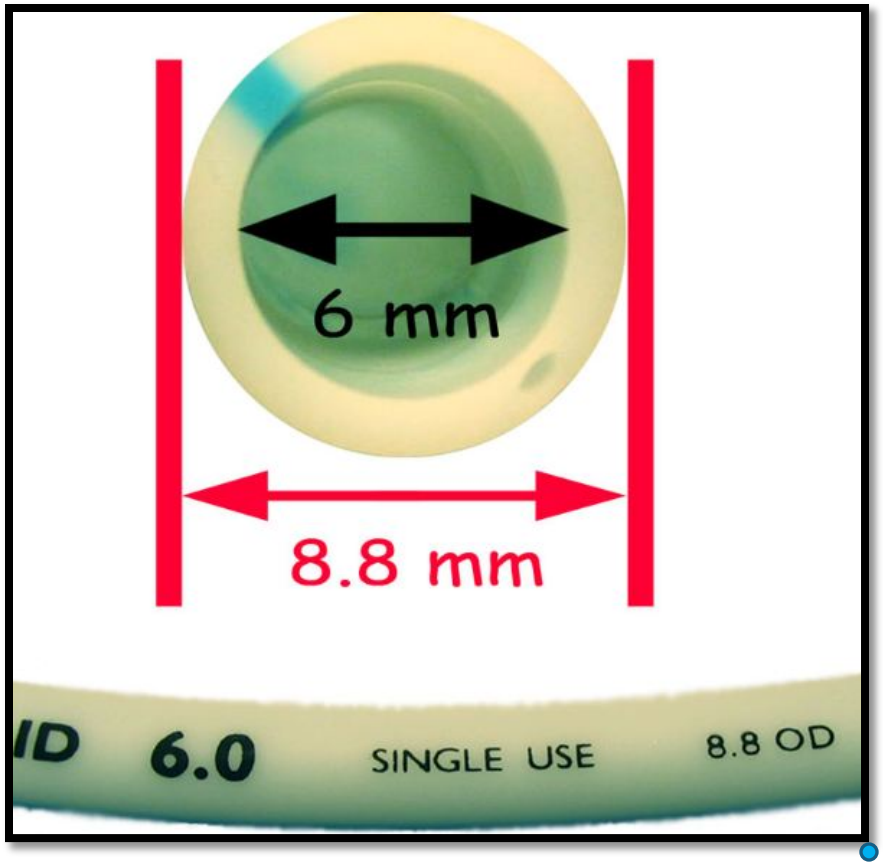
Construction Materials

* Radio opaque line

Tube Diameter

* Internal diameter
* External diameter varies



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Tube Diameter

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

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Koka, B. J. (1977). Postintubation croup in children. Anesthesia and Analgesia, 56, 501-505.

Size Determination

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

* What does the research tell us about sizing?

* Orf, J., Thomas, S., & Ahmed, W. (2000, October). Appropriateness of endotracheal tube size and insertion depth in children undergoing air medical transport. Pediatric Emergency Care, 16(5), 321-327.
* Von Rettberg, M. ; Thil, E. ; Genzwurker, H. et al. (2010, July). Endotracheal tubes in pediatric patients: Published formulas to estimate the optimal size. Anaesthesist.

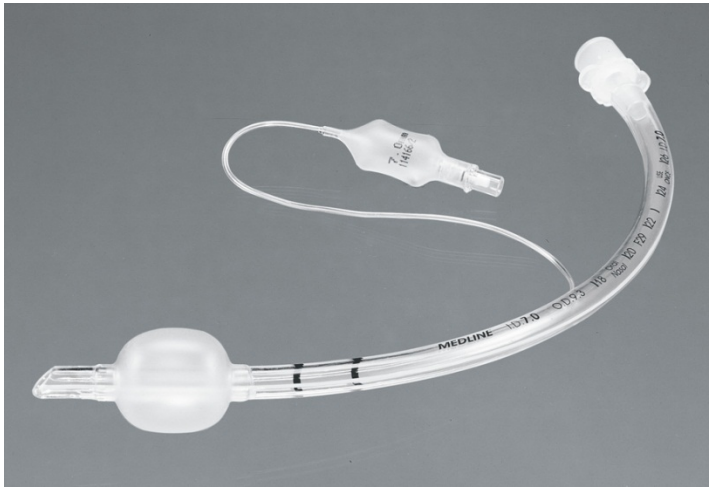
ETT Depth: Why Is It Important?

- 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)

Tube Markings

* NO INTERNATIONAL STANDARD FOR MARKINGS
* Inconsistent
* Variable among manufacturers



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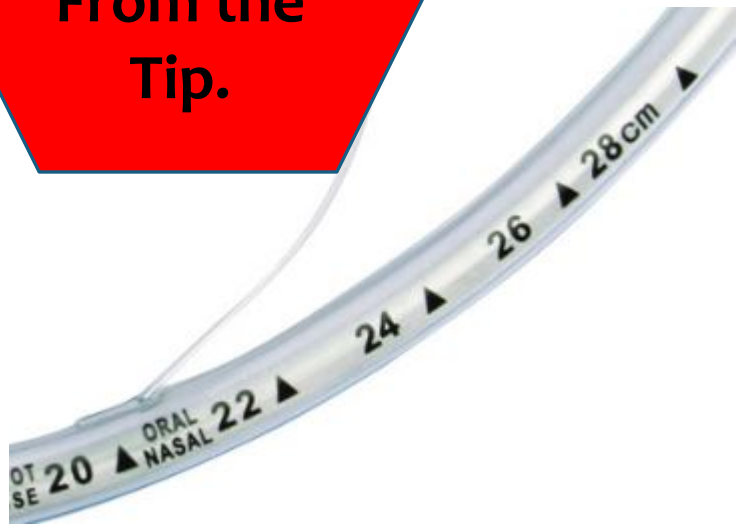
Tube Markings

Measured From the Tip.



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

Inconsistent w/ Gaps in sequence

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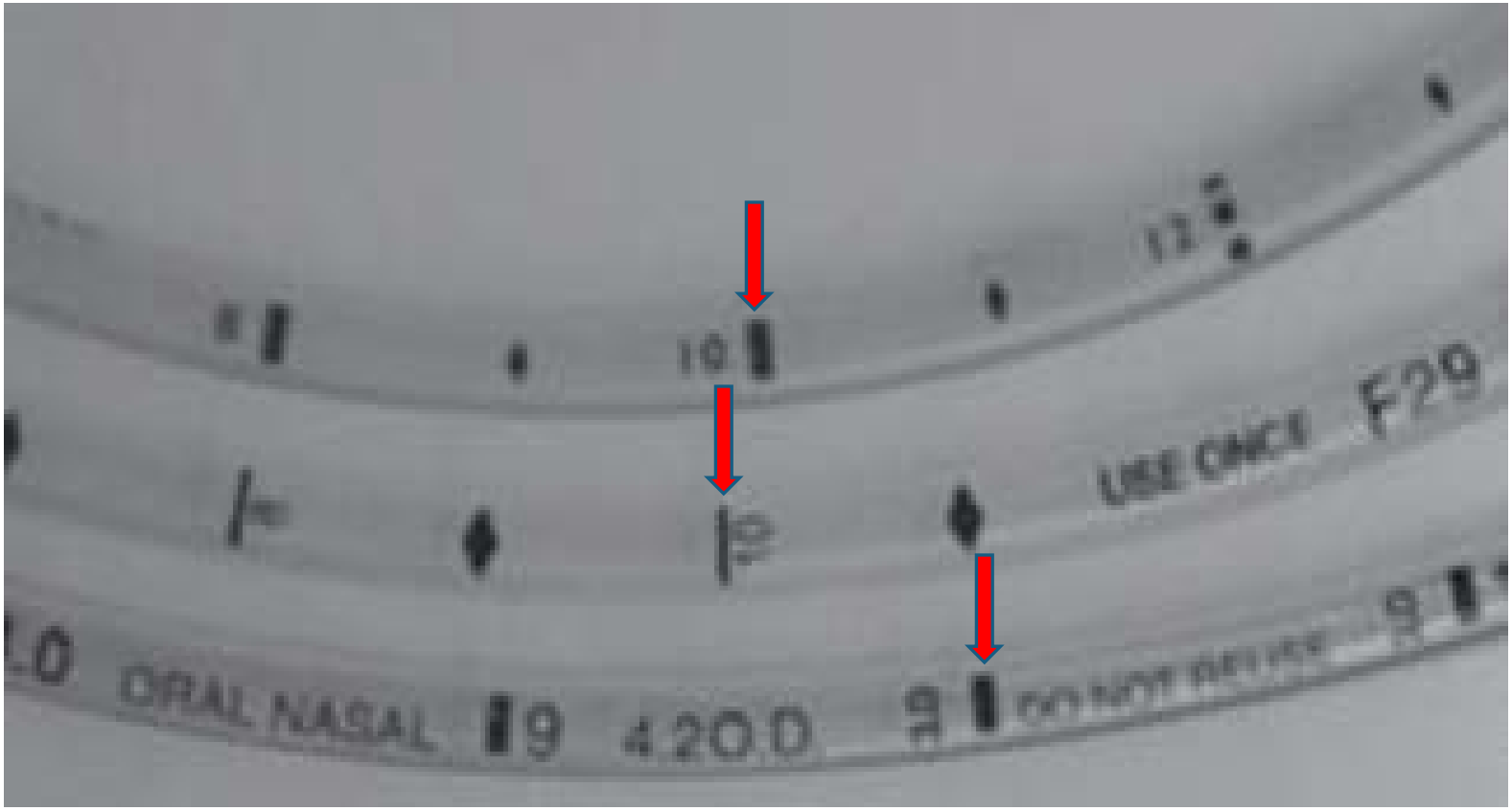
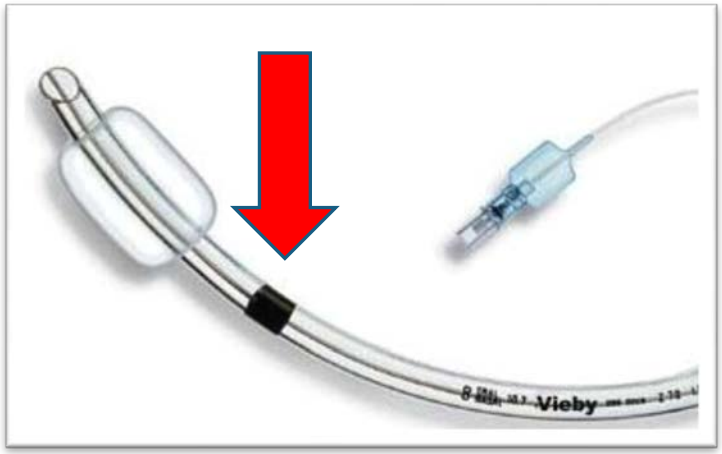
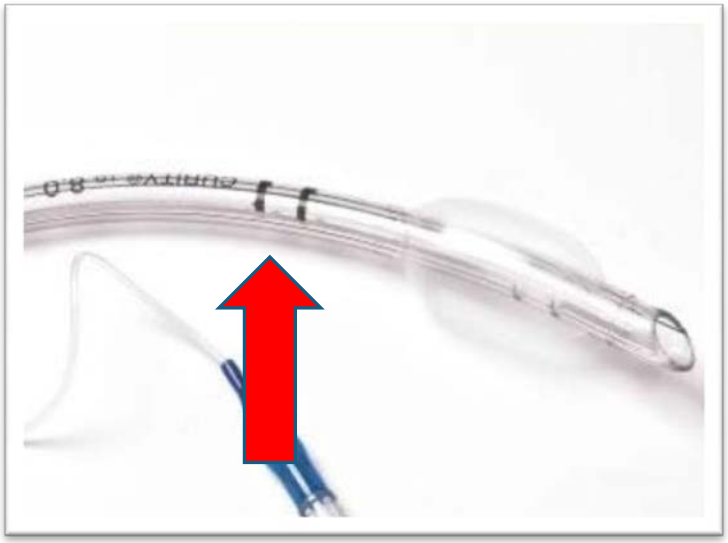
Tube Markings



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

Tube depth should be determined with **assessment**…

not just markings!

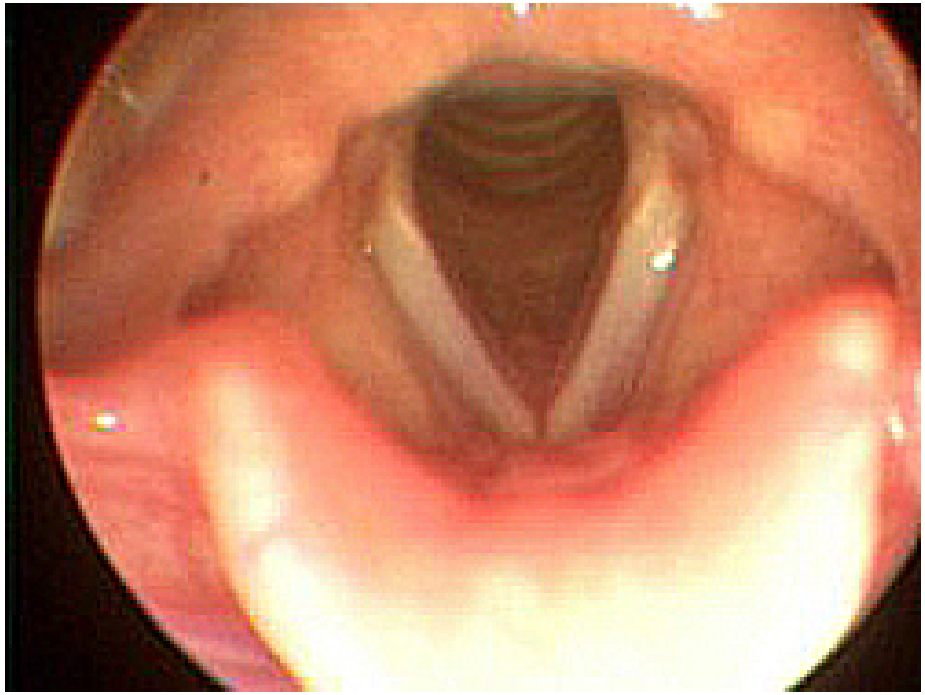
Tube Depth

"…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."

Yoo, S., Kim, J., Han, S., et al. (2007, September). A comparative study of endotracheal tube positioning methods in children; safety from neck movement. Anesthesia & Analgesia, 105, 620-625.

Tube Depth

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



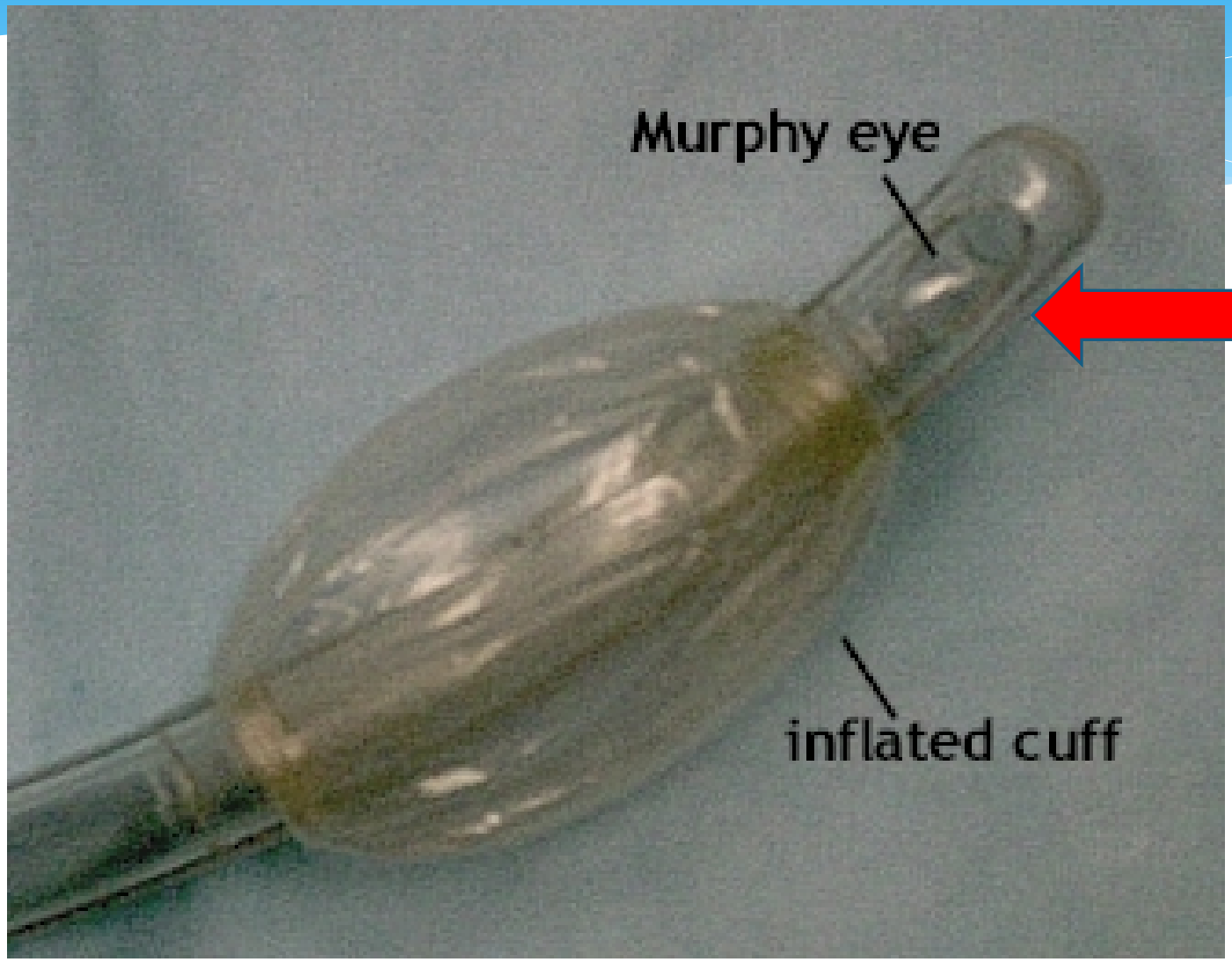
Is ETCO2 Trustworthy?

* 2001 Annals of Emergency Med Article
* 108 Intubated Pt by EMS
* 25% improperly placed
  * 33% of those improperly placed tubes were in the hypopharnyx (9 pts)
  * 56% of those (5pts) had evidence of ETCO2 on ED arrival

DO NOT RELY ON ETCO2 AS THE ONLY CONFIRMATION TOOL

Katz SH, Falk JL. Misplaced endotracheal tubes by paramedics in an urban emergency medical services system. Ann Emerg Med. January 2001;37:32-37

Murphy's Eye



Murphy's Eye

Bilateral breath sounds in

60%

of main-stem intubations!

Brune, Coleman, Schwartz, et al. (1989) *Assessment of routine chest roentgenograms and the physical examination to confirm endotracheal tube position.* CHEST: Journal of the American College of Chest Physicians.

Murphy's Eye

* 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

Verghese, et al. (2004) Auscultation of bilateral breath sounds does not rule out endobrochial intubation in children. 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"

Dorsey, D., Bowman, S., Klein, M., Archer, D., & Sharar, S. (2010). Perioperative use of cuffed endotracheal tubes is advantageous in young pediatric burn patients. *Burns (03054179)*, *36*(6), 856-860. doi:10.1016/j.burns.2009.11.011

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
  * Poelaert, J., Depuydt, P., De Wolf, A., Van de Velde, S., Herck, I., & Blot, S. (2008). Polyurethane cuffed endotracheal tubes to prevent early postoperative pneumonia after cardiac surgery: a pilot study. *The Journal Of Thoracic And Cardiovascular Surgery*, 135(4), 771-776.

Cuffed Tubes Migrate Less

Cuffed Tubes

Disadvantages:

* More costly
* Monitor cuff pressure
* 20 – 30 cm H20 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

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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!

Carlson, Mayrose, Krause, et al. (2007) Extubation force: tape versus endotracheal tube holders. Buffalo, NY.

Tape vs. Commercial Device

* 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.

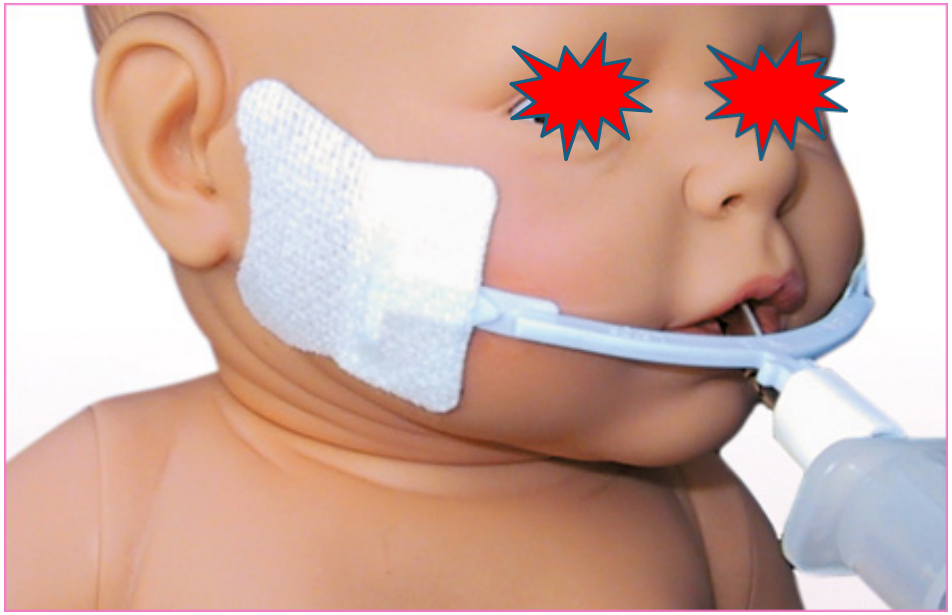
Roberts, J., & Hedges, J. (2003). Clinical Procedures in Emergency Medicine 4th ed. Philadelphia, PA: WB Saunders.

Lillehei Taping Method

NeoBar

- 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

Tracheal Elongation

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

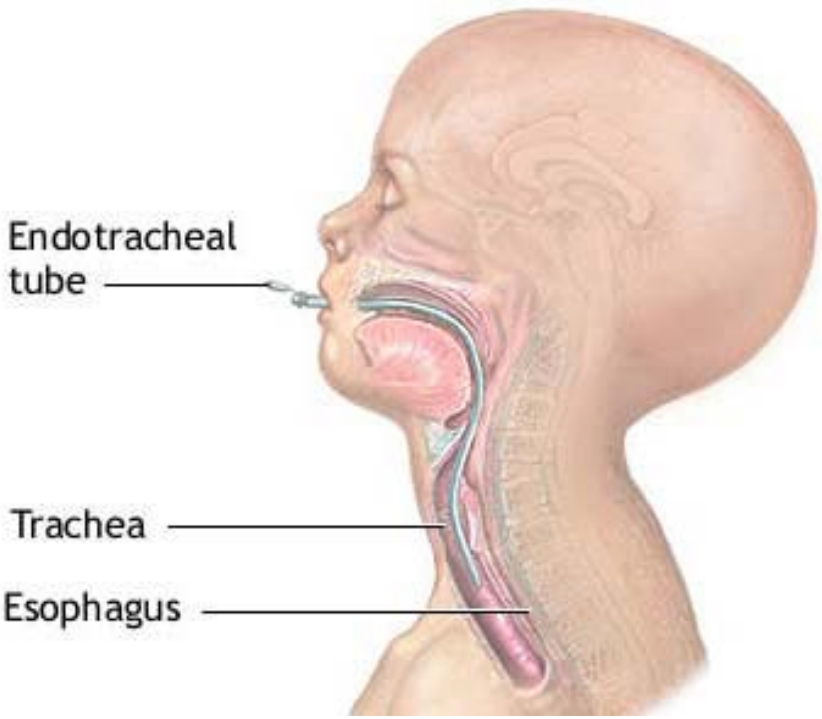
* 2005 Study by Kim in Pediatric Anesthesia
* Full head extension, trachea elongated by .95 cm
* 12.1% increase in tracheal length

Kim (2005) Elongation of the trachea during neck extension in children: implications of the safety of endotracheal tubes. Pediatric Anesthesia

Tube & Head Movement

Extension of the head moves the ETT away from the carina

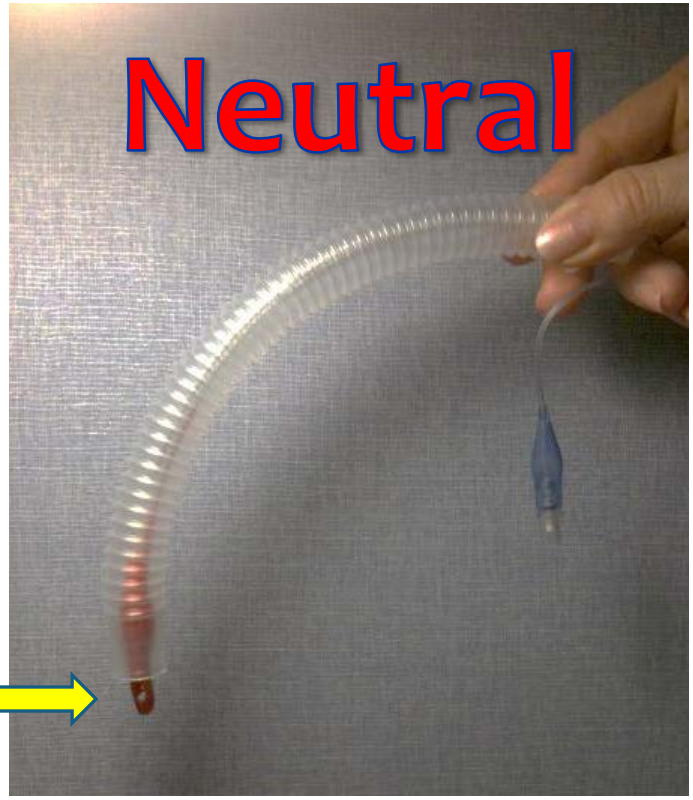
Tube & Head Movement

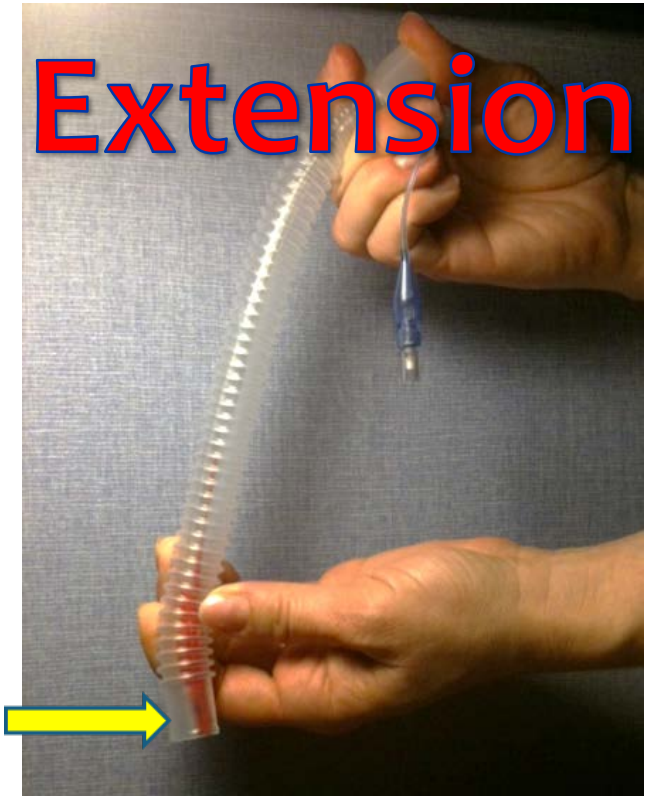


- Extending the neck moves the ETT 0.5 to 1.2 cm north.
- Flexing the neck moves the ETT distally 0.5 to 1.0 cm.

Ritz, et al. (2008) *The impact of head position on the cuff and tube tip position of preformed oral tracheal tubes in young children.* Anaesthesia.

Head Extension

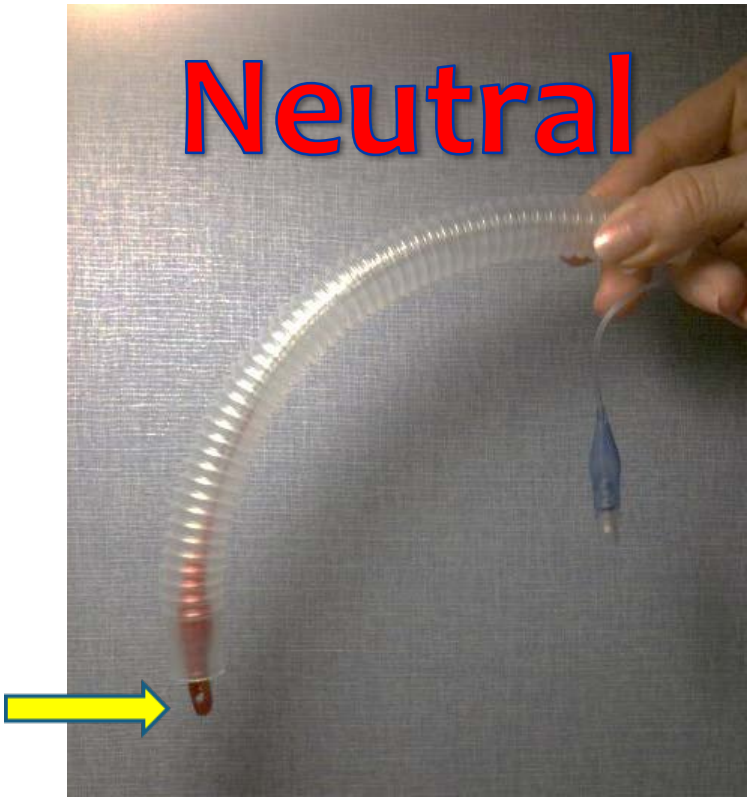


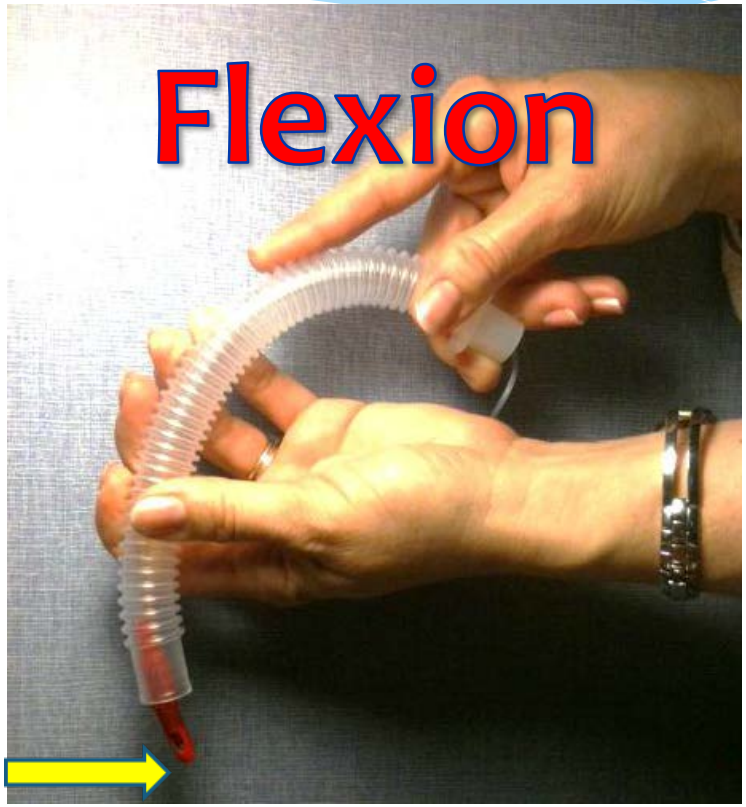


Tube & Head Movement

Flexion of the head moves the ETT toward the carina

Head Flexion

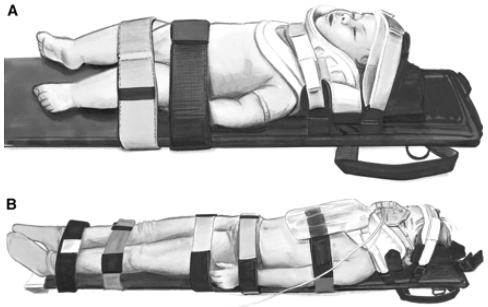




Recommendations for Transport

IMMOBILIZATION IS PARAMOUNT!

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



Kim (2009). *Head rotation, flexion, and extension alter endotracheal tube position in adults and children.* Canadian Journal of Anesthesia.

Consider Flexible ETT Elbows

* Allows some flexibility from BVM to ETT
* Med delivery and suction port

Sedation

* **(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

Popernack, M., Thomas, N., & Lucking, S. (2004, January). Decreasing unplanned extubations: utilization of the Penn State Children's Hospital Sedation Algorithm. Pediatric Critical Care Medicine, 5(1), 58-62.

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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