Challenging Pediatric Intubations

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Objectives

- Kids are not little adults – differences in respiratory anatomy and physiology
- Assessment of respiratory status
- Recognition of respiratory compromise
- Airway management
- Challenging pediatric airways

Kids are not little adults!!

Why be aggressive in Pediatric Airway Management?

- Children have limited ability to compensate for respiratory compromise.
- Early recognition of any dysfunction and anticipation of respiratory failure is essential.

How is Pediatric Airway Management Different?

- Anatomy/Physiology
- Etiology of airway problems
- Equipment
- Frequency with which many practitioners encounter true pediatric airway problems means less experience available

Predisposition to Respiratory Failure

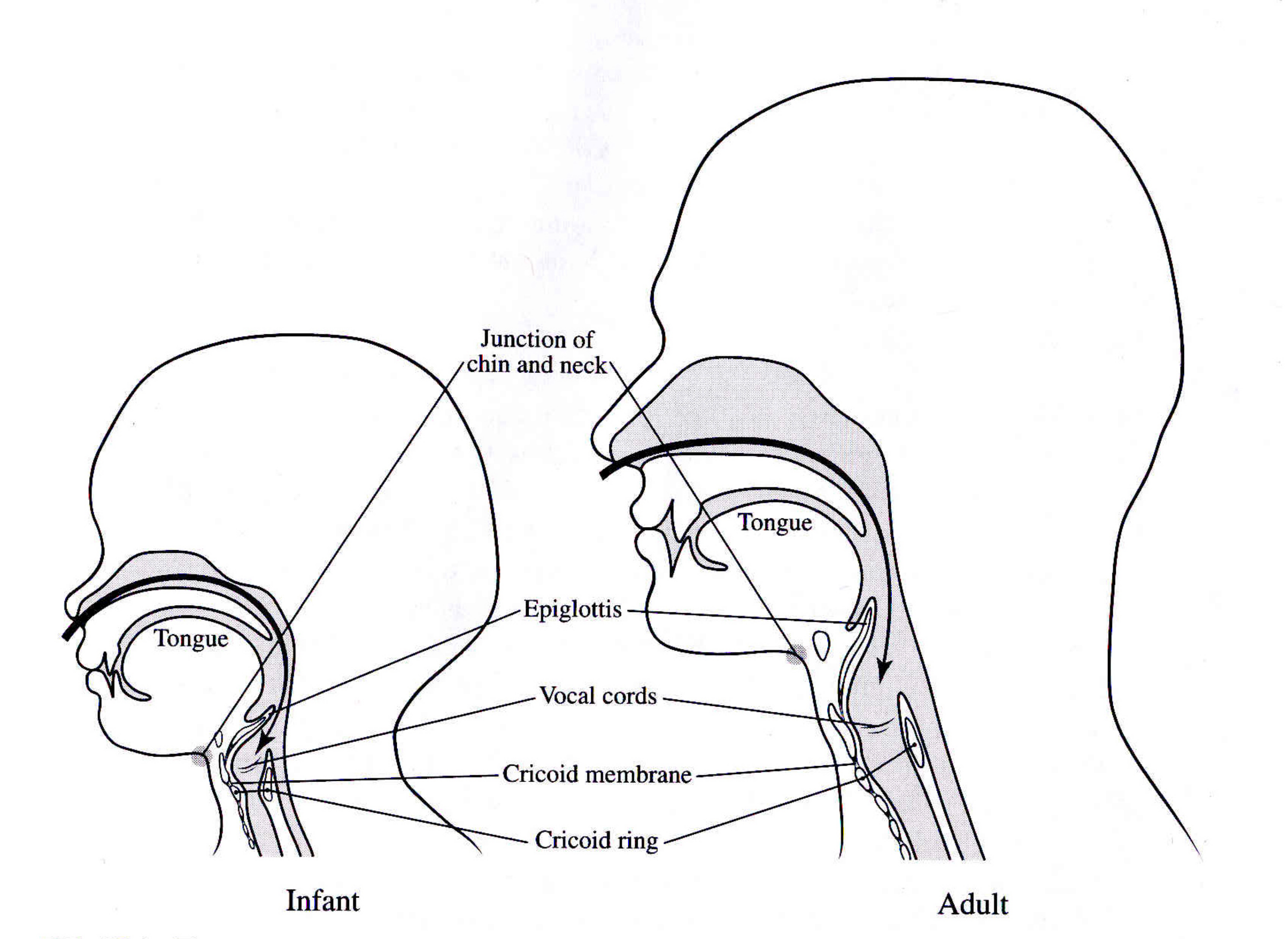
- Anatomic Factors
- Mechanical Factors
- Physiologic Factors

Anatomic Factors

TABLE 3-1 Comparison of Infant and Adult Airways[1–3]

	Infant	Adult
Head	Large prominent occiput resulting in sniffing position	Flat occiput
Tongue	Relatively larger	Relatively smaller
Larynx	Cephalad position, opposite C2 and C3 vertebrae	Opposite C4 to C6
Epiglottis	Ω shaped, soft	Flat, flexible
Vocal cords	Short, concave	Horizontal
Smallest diameter	Cricoid ring, below cords	Vocal cords
Cartilage	Soft, less calcified	Firm, calcified
Lower airway	Smaller, less developed	Larger, more cartilage

Comparative Anatomy



Larynx Anatomy

- Opposite c2-c3
- Larynx more anterior and cephalad
  - angle between tongue and glottic opening more acute
  - cords harder to see

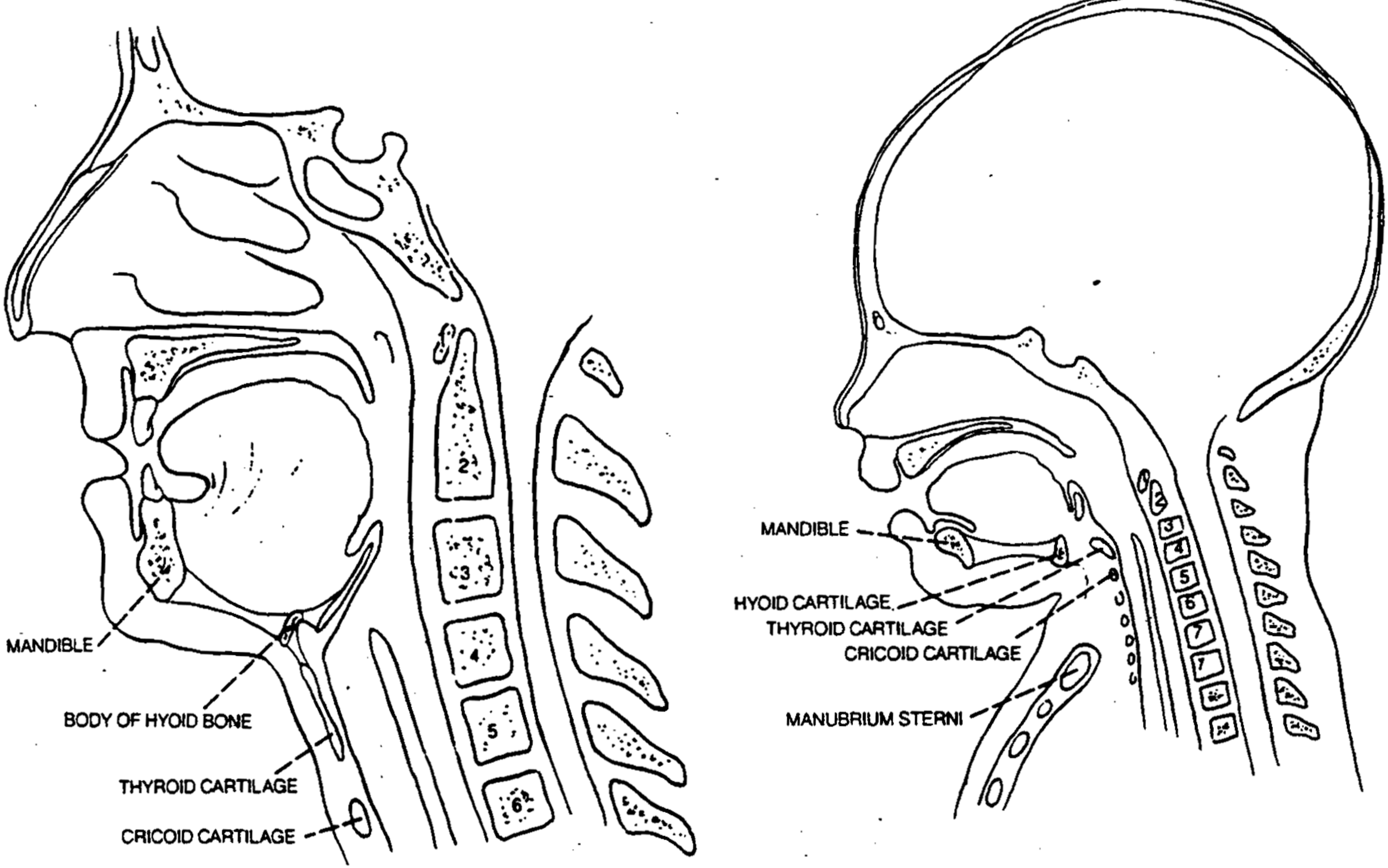
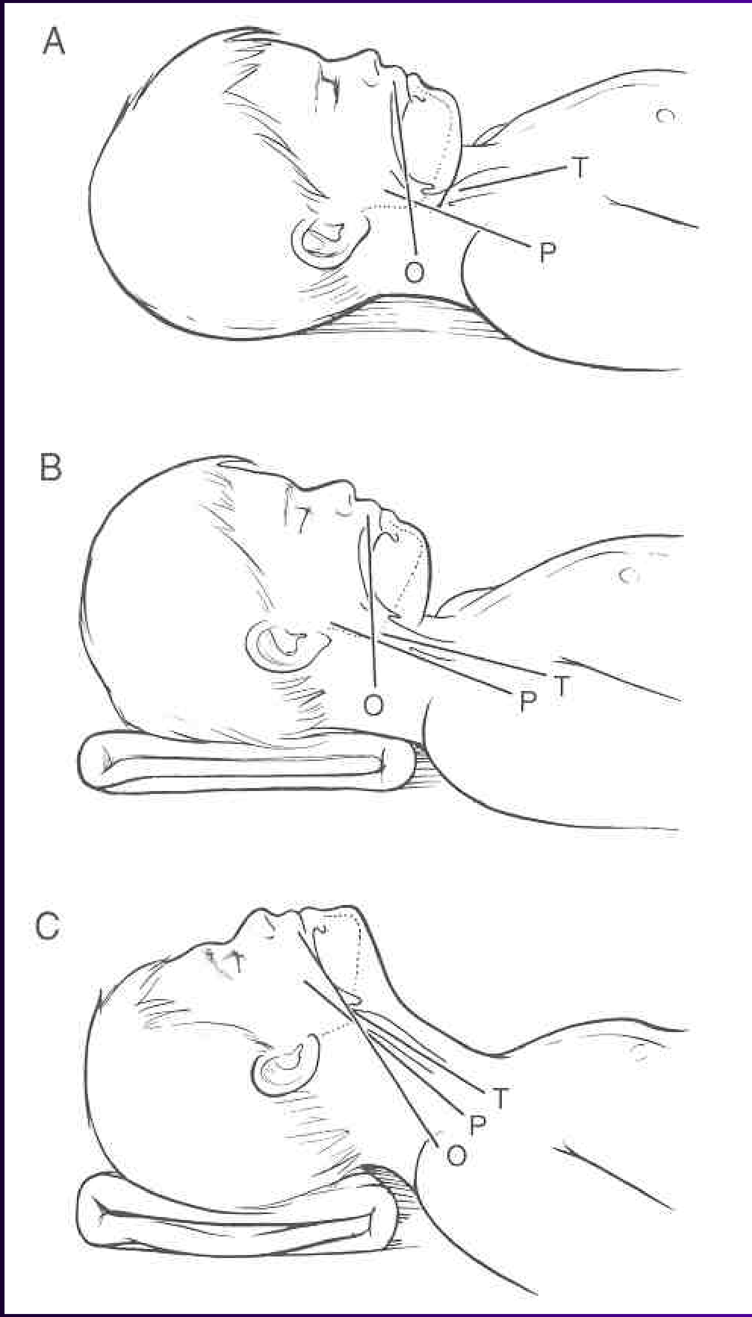


Figure 44–1. Sagittal section of the adult *(A)* and infant *(B)* airway. (Reproduced, with permission, from Snell RS, Katz J: *Clinical Anatomy for Anesthesiologists.* Appleton & Lange, 1988.)



Align the oral (O), pharyngeal (P) and tracheal (T) planes:

Elevate the occiput and extend the head.

Looking from side, note the ear anterior to the shoulder—sniffing rose position.

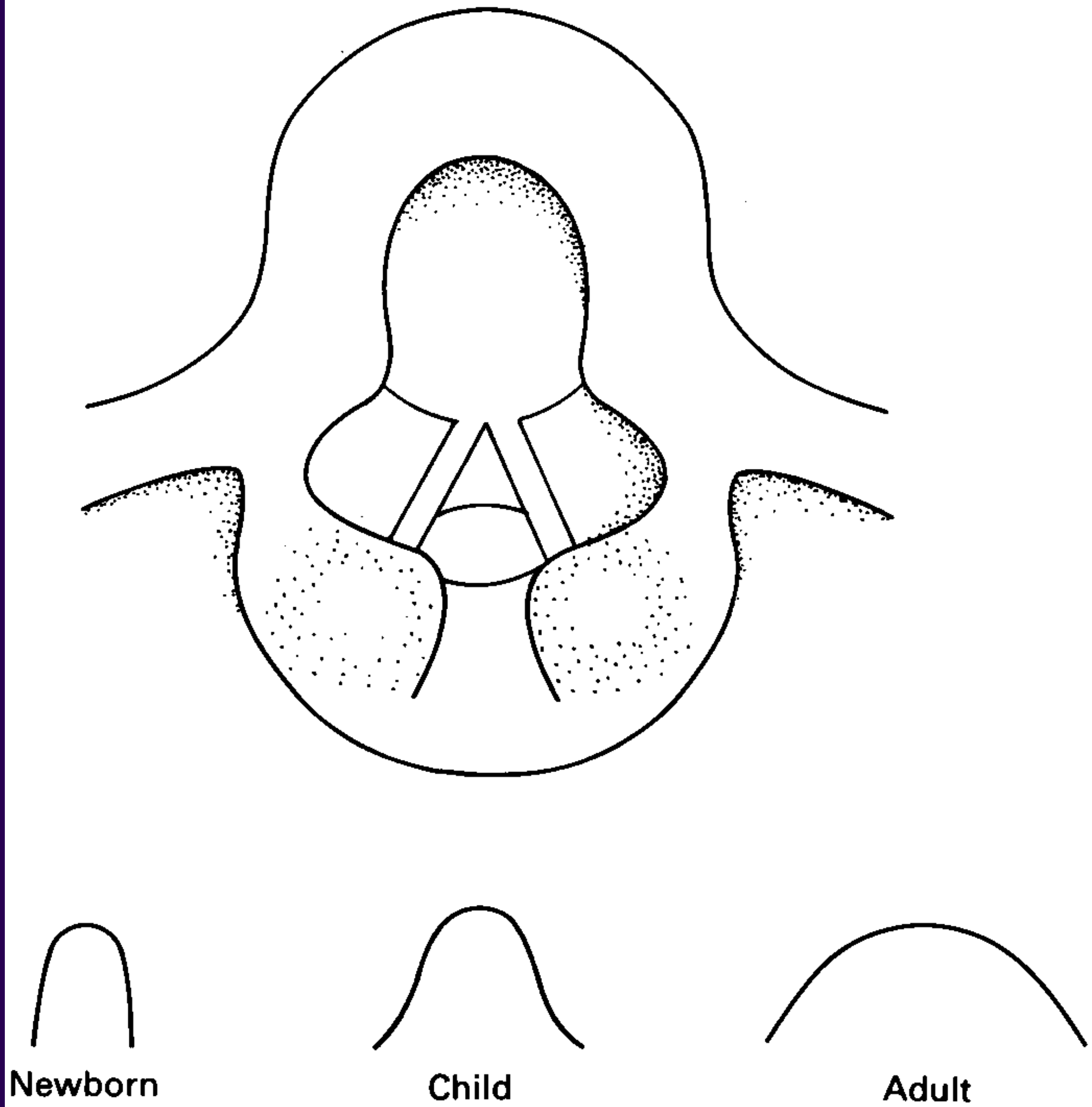
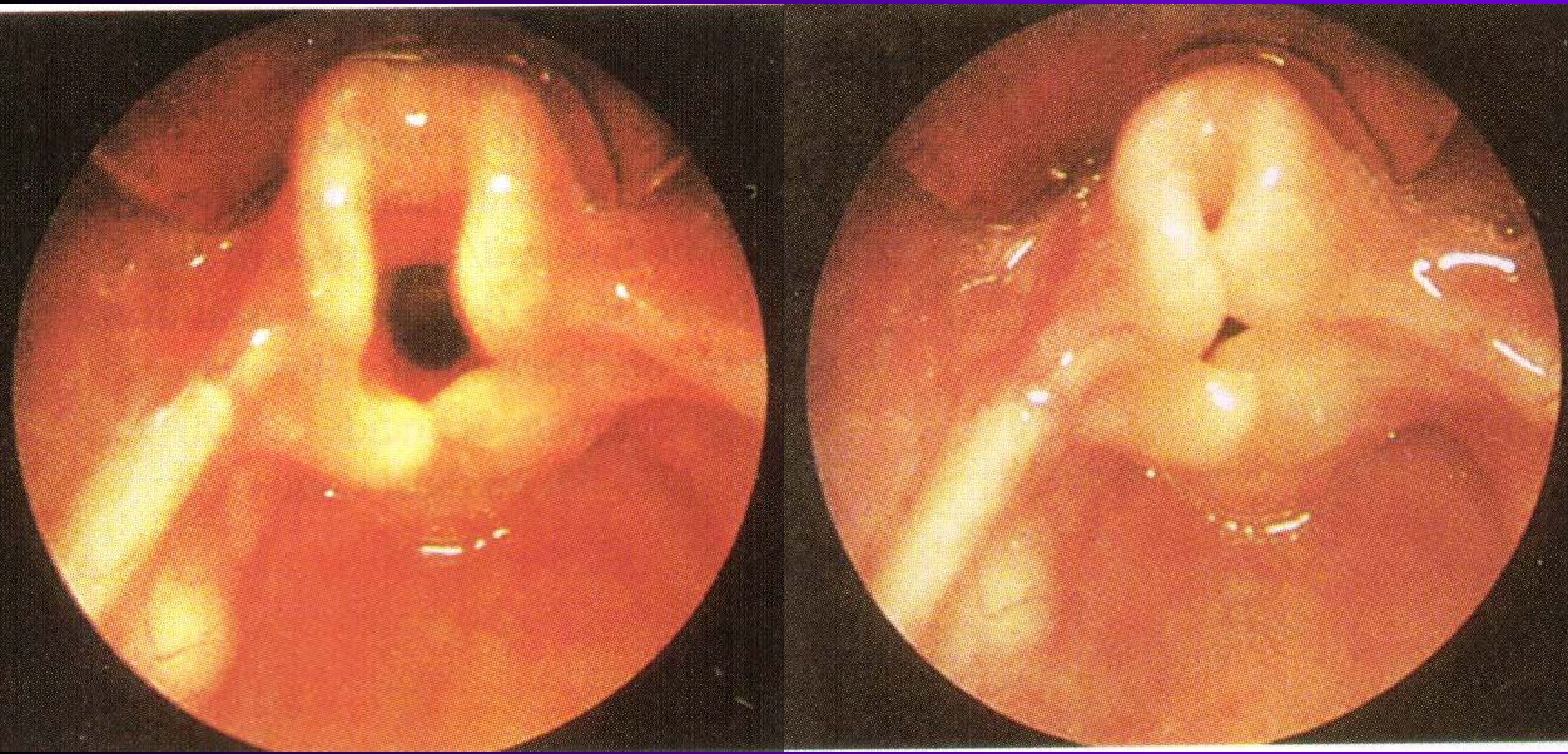


Fig. 1.1 The epiglottis is relatively larger and more U-shaped in the neonate.



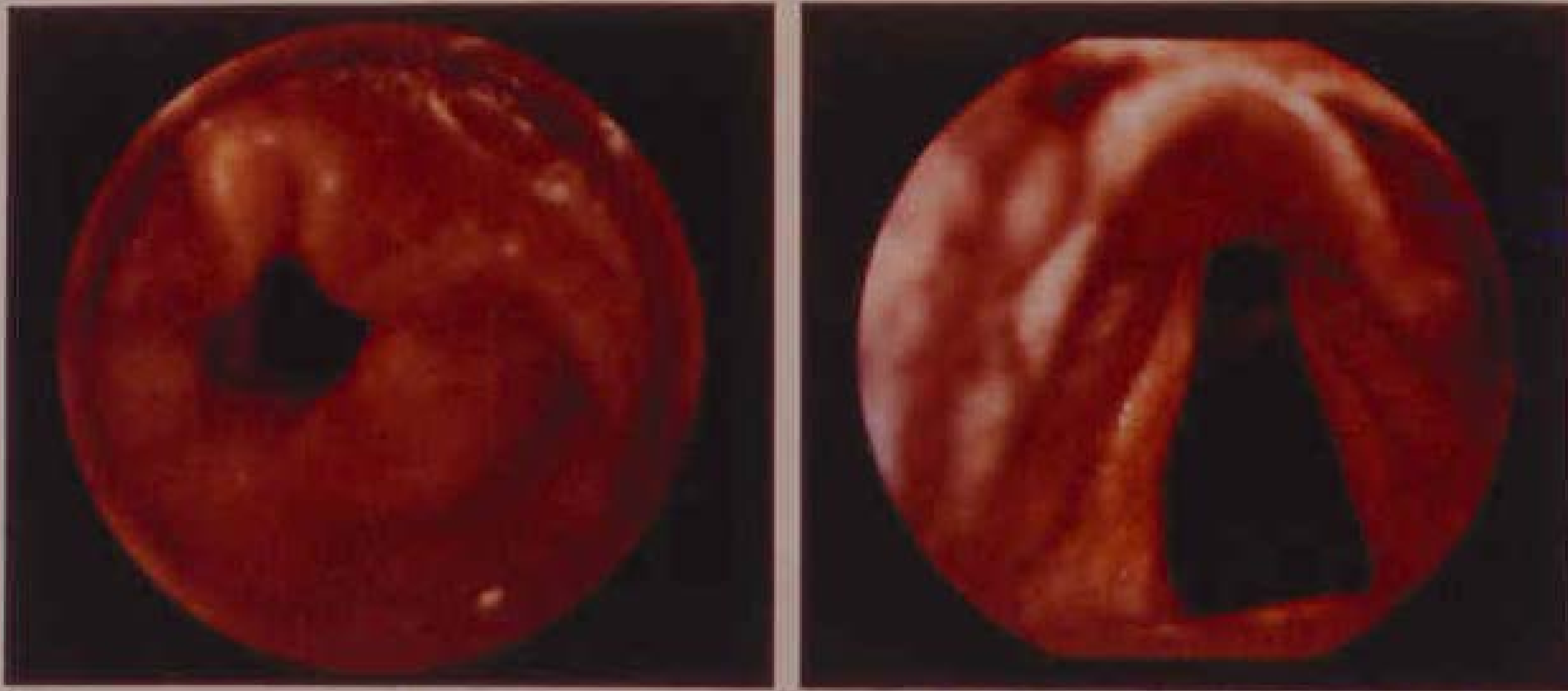


Fig. 9-3. A, Infant glottis, magnified $\times 6$, and, B, adult glottis, $\times 2$. Note soft, edematous appea ance of infant tissues and folded gamma (Ω) shape of epiglottis. (Courtesy Dr. Paul Hollinge Chicago, Ill.)

Mechanical Factors

- Airway size and compliance
- Rib orientation
- Chest wall configuration and compliance
- Diaphragm position/function
- Type I vs. Type 2 muscle fibers

Chest Wall Mechanics

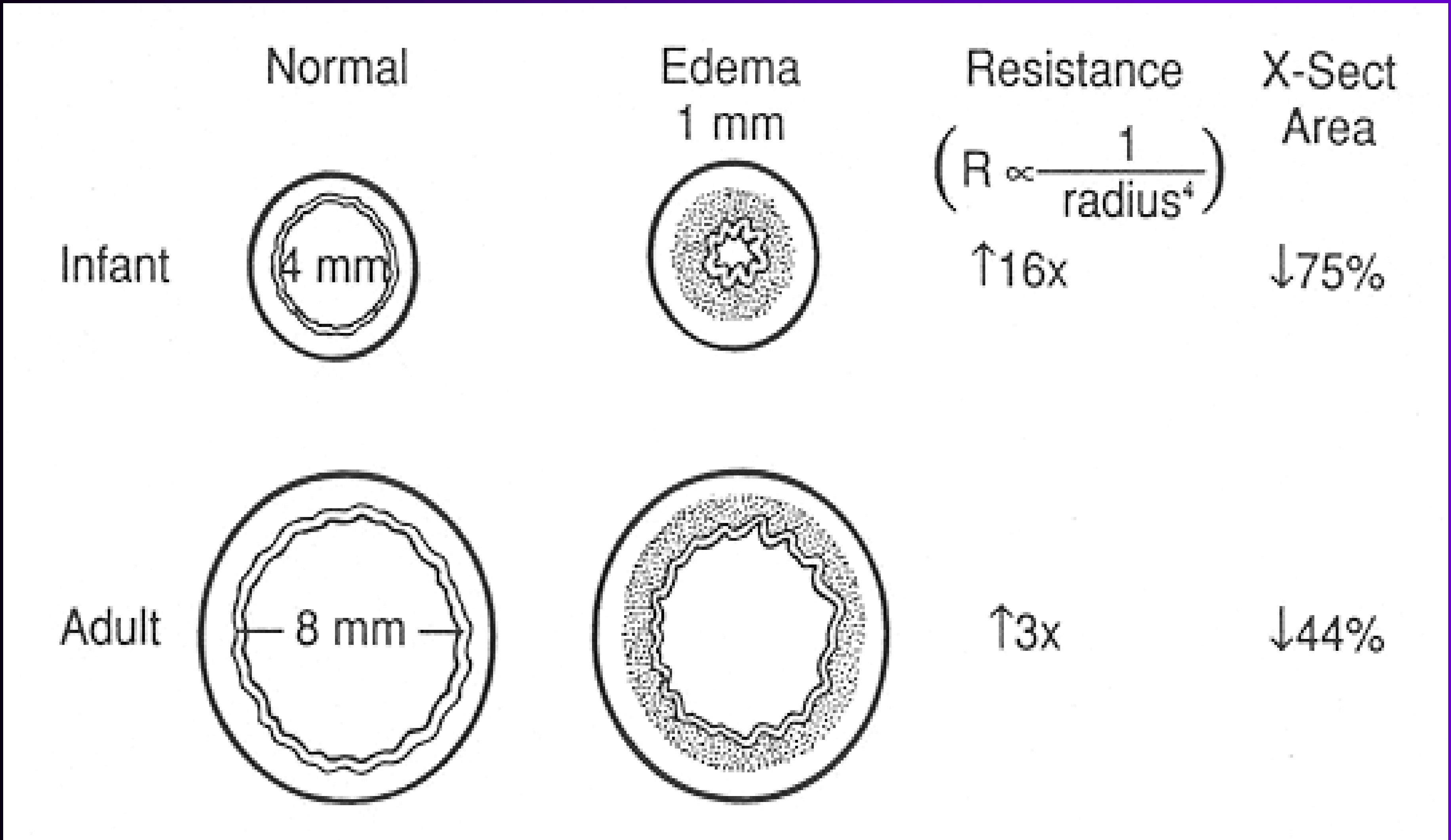
- Type 1 respiratory muscle fibers are responsible for sustained muscle activity
- Type 2 fibers are responsible for bursts of muscle activity

Chest Wall Mechanics

- Infants have higher % of Type 2 fibers.
- Conditions that cause increased work of breathing will result in fatigue and respiratory failure sooner than in adults and older children.

Physiologic Factors

- Respiratory arrest most common cause of cardiac arrest
- Decreased lung compliance
- Airways are smaller with increased resistance
- Metabolic demand



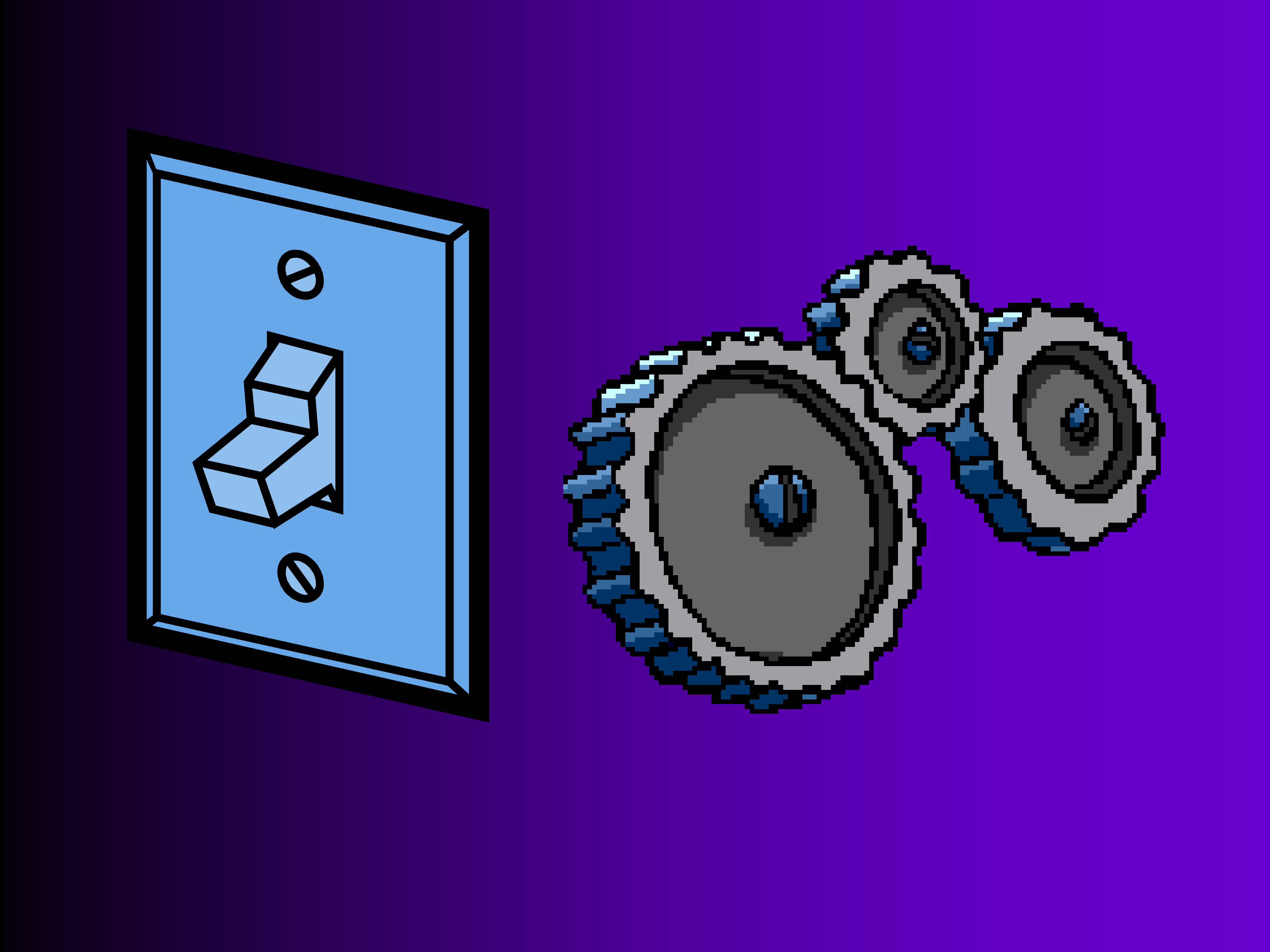
Normal
Edema
1 mm
Resistance
$\left(R \propto \frac{1}{\text{radius}^4}\right)$
X-Sect
Area
Infant
4 mm
↑16x
↓75%
Adult
8 mm
↑3x
↓44%

Physiologic Factors

- Metabolic Demand
  - Oxygen consumption 2X that of adults due to higher metabolic rate
  - Less cardiopulmonary reserve
  - Hypoxia will develop more rapidly

Bottom line!!

- Airway management in a pediatric patient is challenging due to the anatomy, mechanics and physiology.
- Kids have less reserve and may deteriorate rapidly so think quickly and be as aggressive as necessary without doing harm!



Assessment of Respiratory Status

- Level of Consciousness
- Work of breathing, respiratory rate
- Color
- Mechanics: grunting, flaring, retractions
- Breath sounds and aeration

Normal Respiratory Rates

• Infant	30-60
• Toddler	24-40
• Preschool	20-30
• School-age	12-25
• Adolescent	12-16

Physical Exam—Observation

- Respiratory rate
  - Periodic breathing in infants
  - Inaccurate while crying
- Respiratory pattern
  - Inspiratory to expiratory ratio
  - Normal is less than 1 to 1
- Retractions
  - Subcostal or “belly breathing”
  - Intercostal
  - Suprasternal

Physical Exam—Auscultation

- Wheezing
- Stridor
- Crackles
- Transmitted Upper Airway Sounds

Wheezing

- Whistling noise thru constricted bronchioles
- Noise typically is heard during a prolonged expiratory phase
- Varying degrees of respiratory distress
- Frequently confused for transmitted upper airway noises

- Examples: Asthma, Bronchiolitis

Stridor

- High-pitched noise
- Usually heard in inspiration
- May also see suprasternal retractions
- Often anxious appearing

- Examples: Croup, Bacterial Tracheitis, Epiglottitis

Stridor at Rest

Crackles

- Sounds like velcro or Rice Krispies
- Difficult to hear in a noisy environment
- Characterize as focal or diffuse
- Varying degrees of respiratory distress

- Examples: Pneumonia, Congestive Heart Failure

Transmitted Upper Airway Noise

- Sources include:
  - Nasal, upper airway mucous
  - Relaxed hypo pharyngeal tissues
- Changes with respiration
- Frequently mistaken for wheezing

- Examples: URI, neurologically impaired patients

Tricks to Improving Your Exam

- Changing position, lying vs. sitting
- Distraction techniques
- Have patient cough
- Have patient breathe through mouth
- Have patient blow nose
- Decrease ambient noise
- Have them “blow out the candle”.

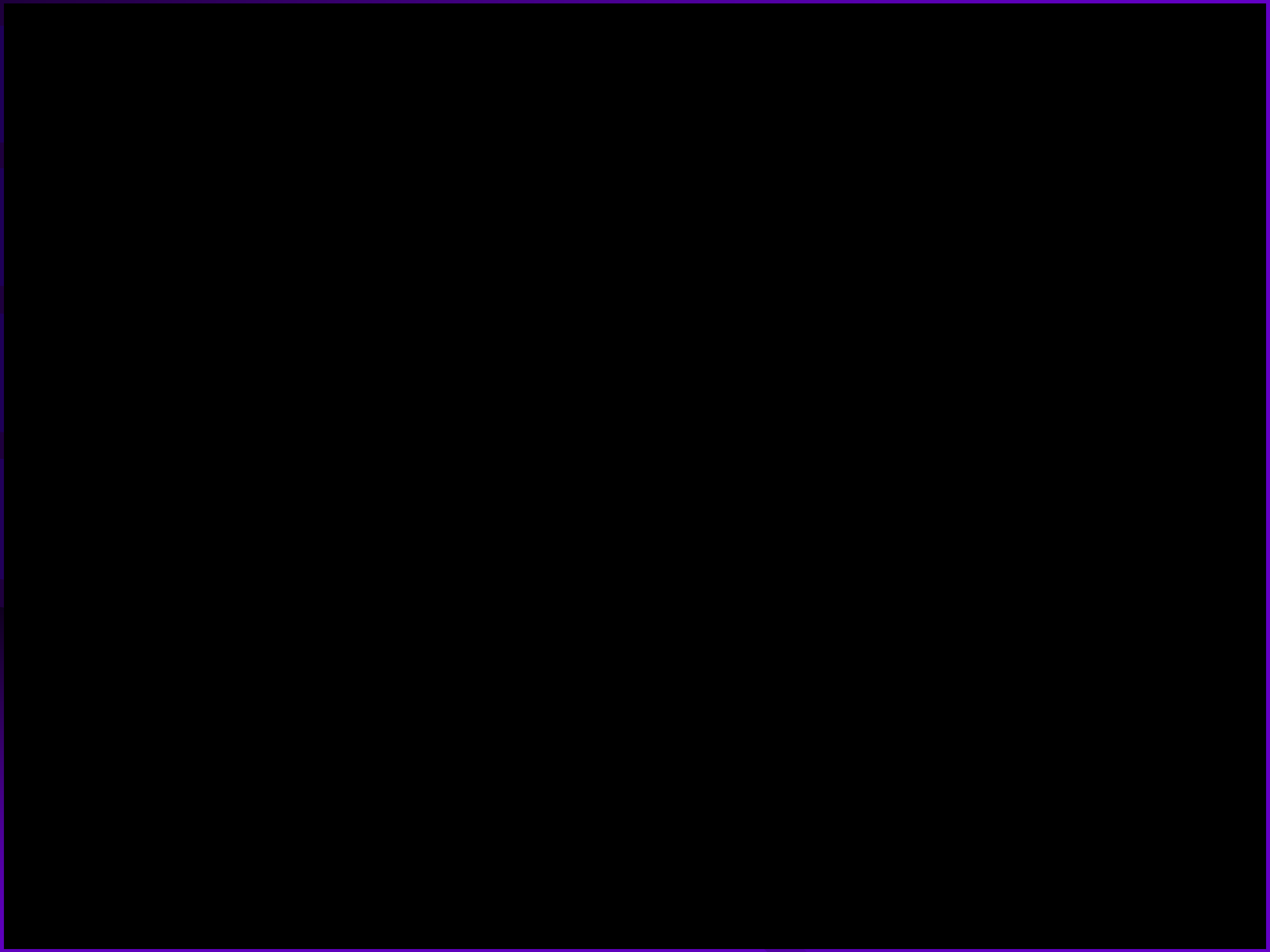
Respiratory Compromise

- Respiratory Distress
- Respiratory Failure
- Respiratory Arrest

Respiratory Compromise

- Respiratory Distress
  - Child is alert or agitated, normal tone
  - Pink or pallid skin color
  - Increased work of breathing
  - Chest rise is normal or shallow
  - Tachypnea is present
  - Breath sounds may include wheezing

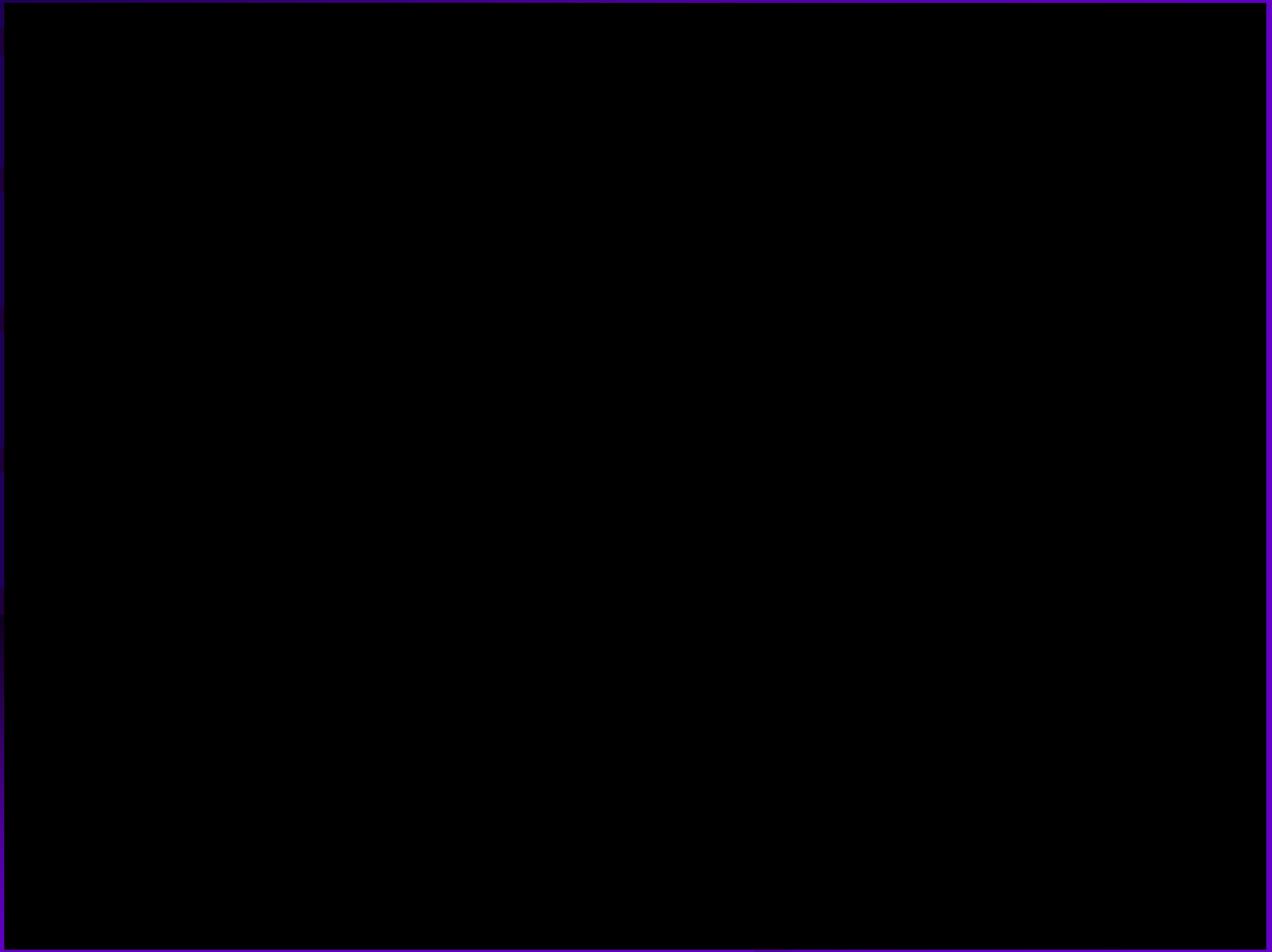
Respiratory Distress



Respiratory Compromise

- Respiratory Failure
  - Child will appear ill
  - Agitation or somnolence with hypotonia
  - Greatly increased work of breathing
  - Tachypnea (+/- periods of bradypnea)
  - Skin is pallid, mottled or cyanotic

Respiratory Failure



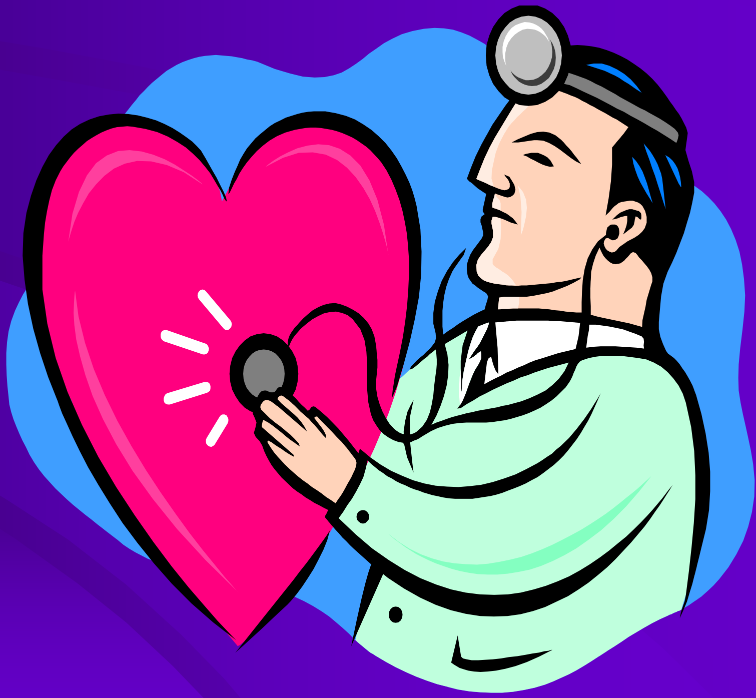
Respiratory Failure

- Inability of the respiratory system to meet demands for oxygenation and CO_2 elimination or both.
- May occur with or without respiratory distress.
- Objectively defined by the ABG.

Respiratory Compromise

- Respiratory Arrest
  - Unresponsive, no muscle tone
  - No visible chest rise
  - Absent work of breathing
  - Cyanosis

What Can We Do?

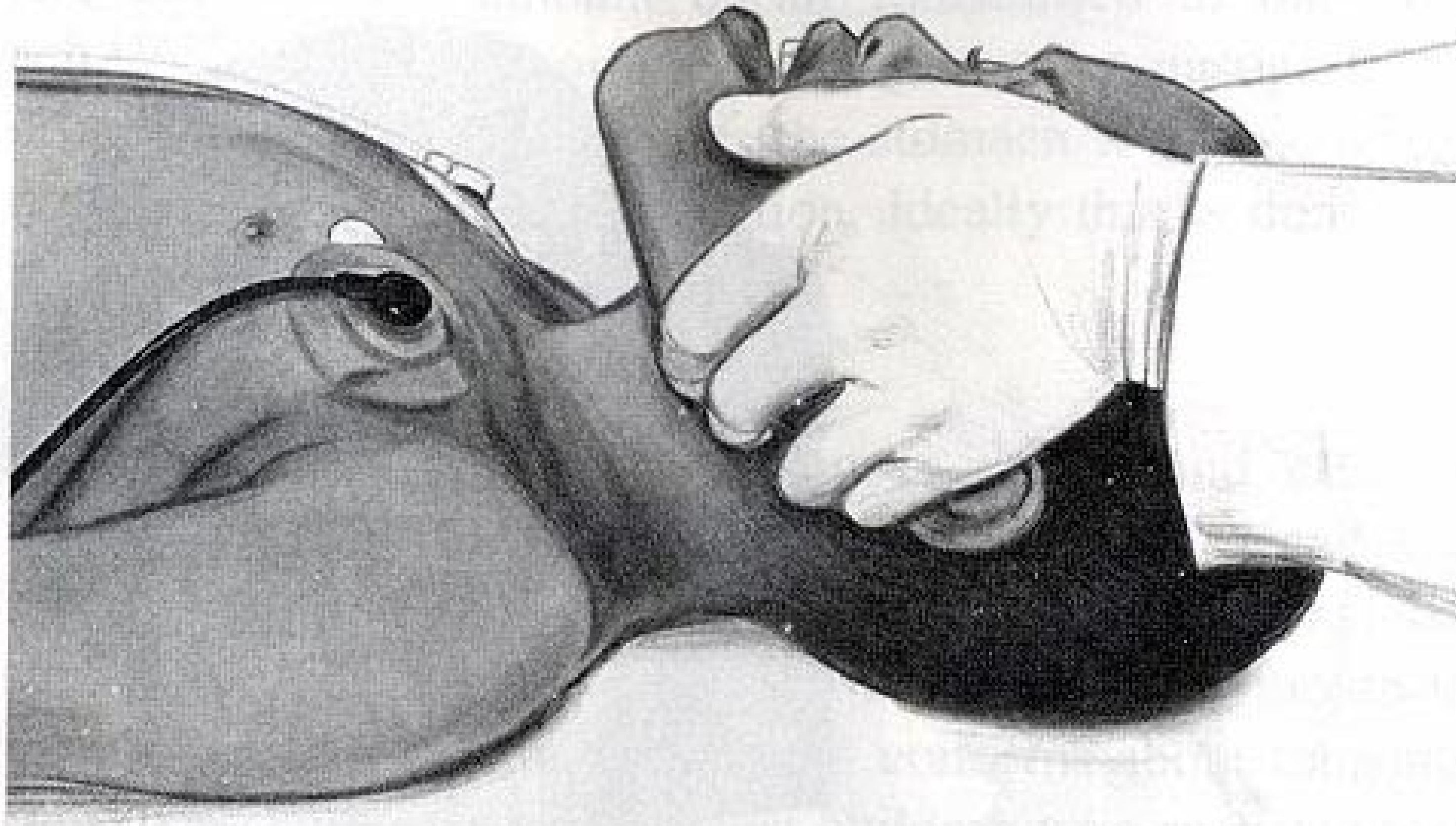


Goals of Airway Therapy

- Recognize respiratory distress and failure before they progress to arrest.
- Anticipate respiratory problems.
- Support those functions that are lost or compromised.
- Start with least invasive methods.

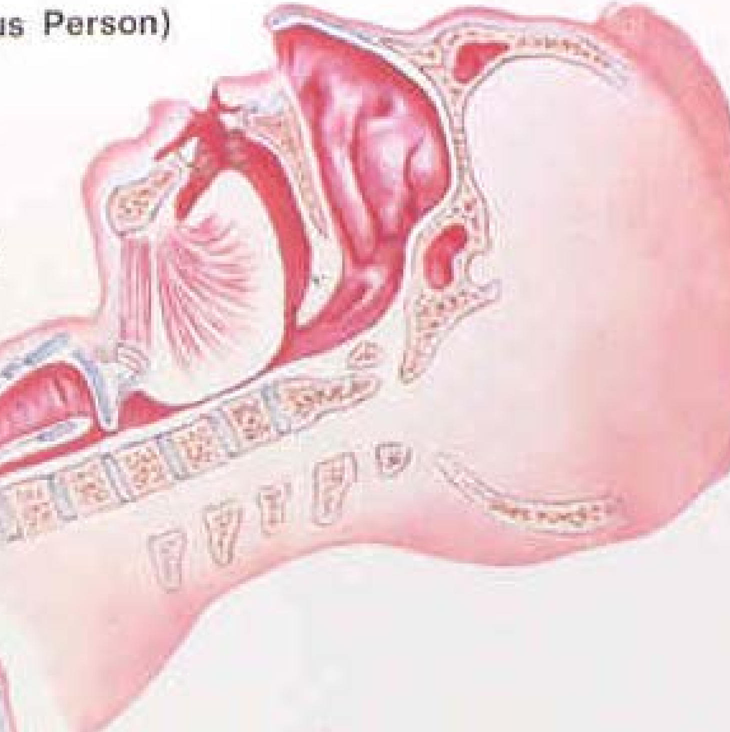
Interventions

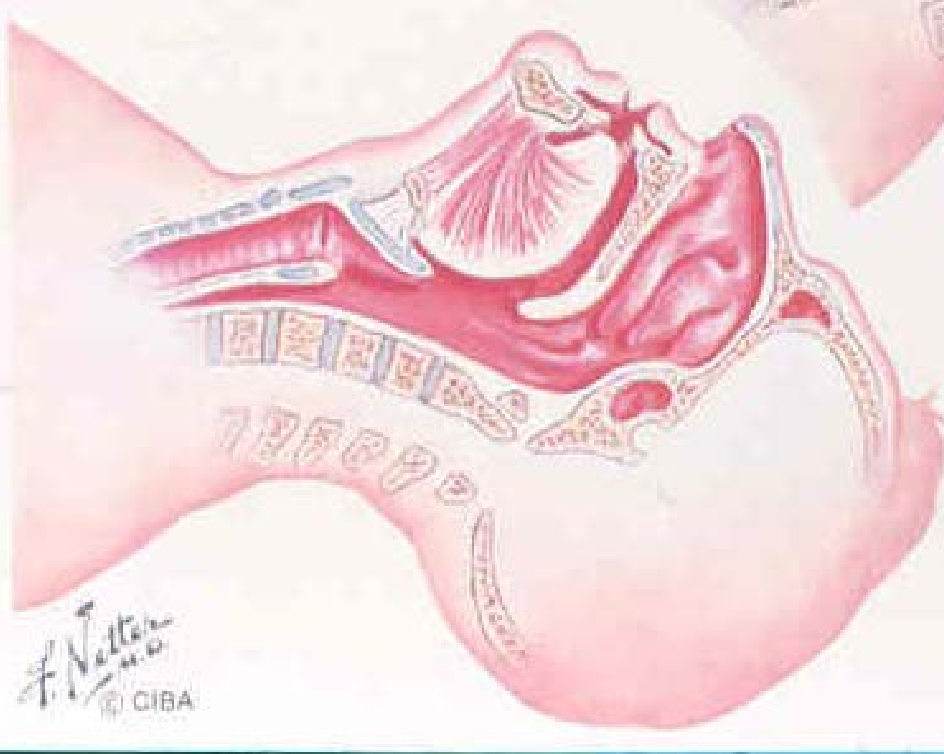
- Open and Position the Airway
- Oxygen
- Nasopharyngeal Airway
- Oropharyngeal Airway
- Bag-Valve-Mask Ventilation
- Endotracheal Intubation
- Alternatives



Airway Obstruction and Patency (Unconscious Person)

Obstruction. With head flexed, flaccid tongue drops back against posterior pharyngeal wall because mandible (to which tongue is attached) recedes. Epiglottis also falls back because hyoid bone recedes. Pharynx is narrowed by flexion of cervical vertebrae





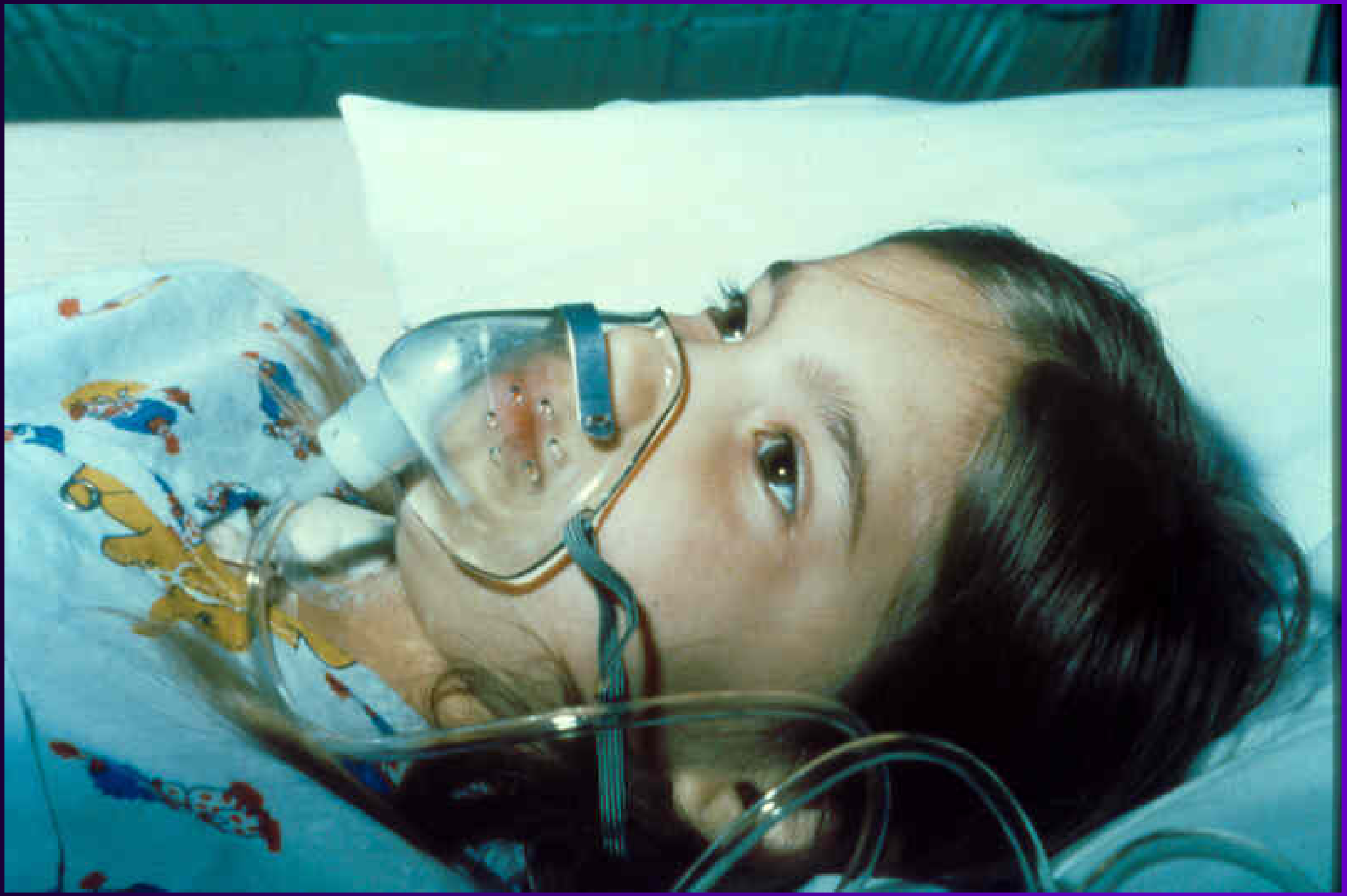
Patency. With head extended (head-tilt maneuver), mandible usually moves forward (or is actively pushed forward with jaw-thrust maneuver); tongue is thus drawn forward. Epiglottis is also pulled anteriorly by movement of hyoid bone. Pharynx is widened by extension of cervical vertebrae

Interventions

- Administer Oxygen
  - Nasal cannula
  - Simple face mask
  - Non-rebreather mask

Nasal Cannula

Simple Face Mask



Non-Rebreather Mask

Nasopharyngeal Airway

- Soft rubber or plastic tube in many sizes
- Used to bypass upper airway obstruction
- Well tolerated in semiconscious or conscious patients
- Easily obstructed with secretions in small children

- Flange at tip of nose
- End at tragus of ear

Oropharyngeal Airway

- Holds tongue away from the posterior pharyngeal wall.
- Use only in unconscious patients.
- Measure from the corner of the mouth to the angle of the jaw.

- Flange at level of teeth
- Curved portion at angle of jaw

Anyone who provides critical care to children needs to be expert in managing the unprotected airway with a bag-valve-mask.

"When bag-valve-mask is done appropriately, it can be every bit as effective as endotracheal intubation."

Jim Seidel, MD

Airway Management Maxim

Airway Management DOES NOT Mean Intubation!

Airway management means just that!

Patients will not die because you do not or cannot intubate them. They will die if you do not ventilate and/or oxygenate them.

Bag-valve-mask technique

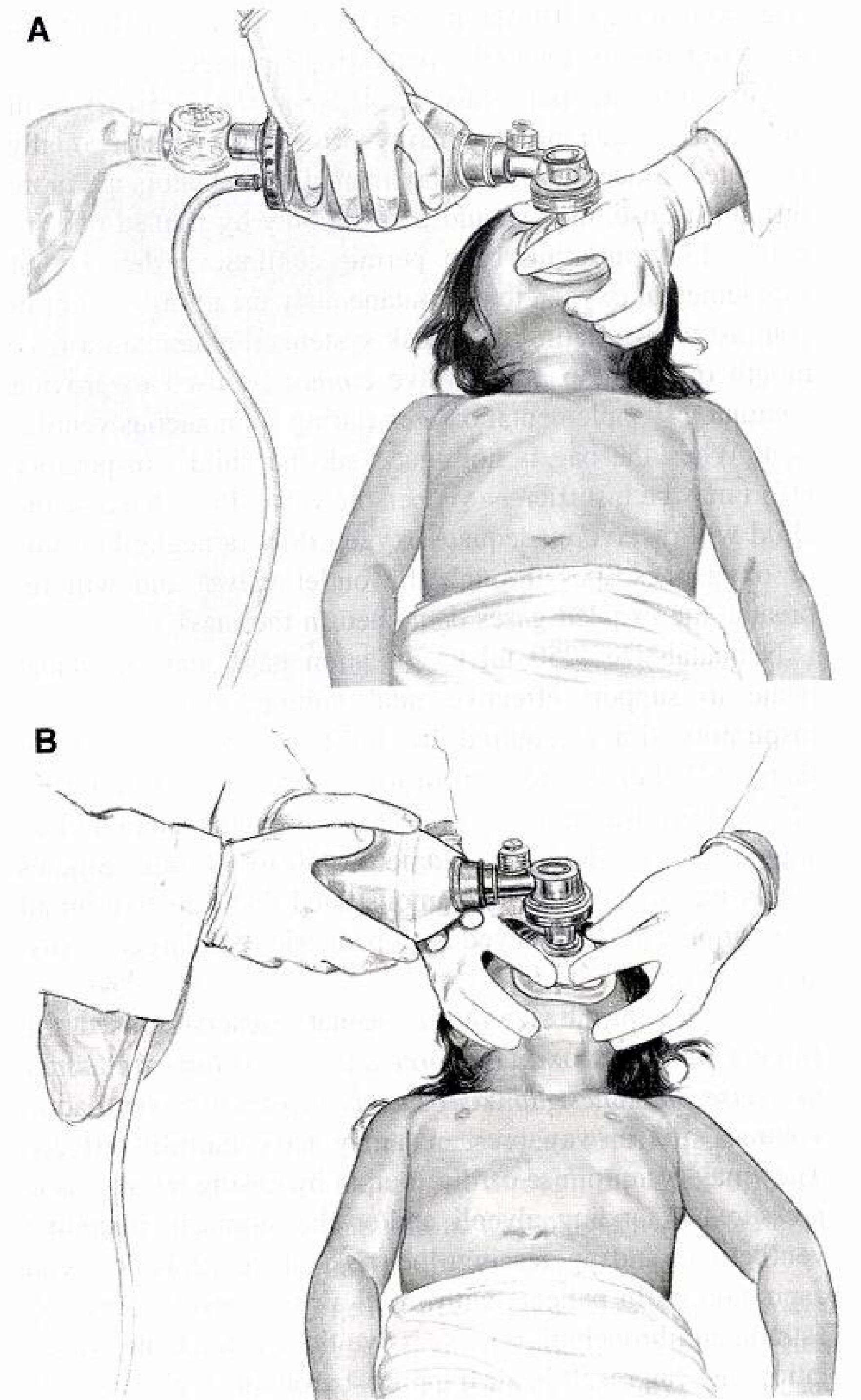
Identify patient in need of assisted ventilation

Select appropriately sized mask and bag

Squeeze the bag just until visible chest rise is initiated and say “Squeeze”

Release pressure on the bag to allow for exhalation and say “Release, release”

Ventilate at 12 to 20/min

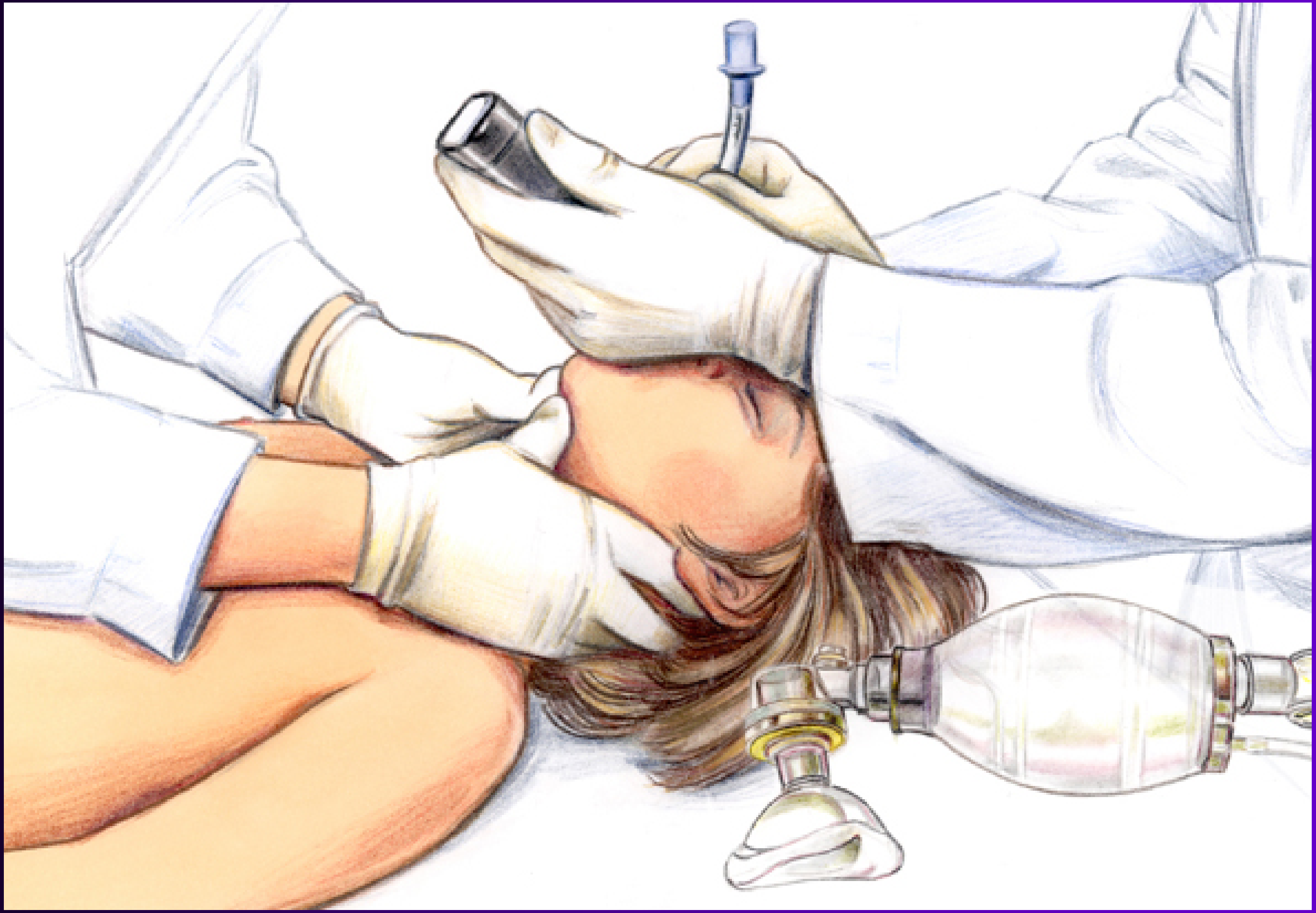

A
B

Bag-valve-mask ventilation

- Potential Complications:
  - Gastric distention, may lead to hypoventilation because of poor diaphragmatic movement.
  - Regurgitation and aspiration.

  - Use of properly sized equipment, good technique, cricoid pressure and placement of a nasogastric tube will minimize these complications.

Endotracheal Intubation



Endotracheal Intubation

- Advantages:
  - Ability to deliver higher ventilatory pressures, Fi02 and PEEP
  - Pulmonary toilet
  - Isolates and protects the airway
  - Route for delivery of medications
  - Prevents loss of airway due to personnel fatigue or error

Endotracheal Intubation

- Indications:
  - Respiratory or cardiopulmonary arrest
  - Respiratory failure
  - Severe respiratory distress
  - Loss of protective airway reflexes (CNS)
  - Functional or anatomic airway obstruction
  - Need for high Fi02 or PEEP to maintain gas exchange

Endotracheal Intubation

- Disadvantages/Complications:
  - Esophageal intubation
  - Right main stem bronchus intubation
  - Hypoxia/bradycardia during intubation
  - Risk of vomiting and aspiration
  - Oral/dental/airway trauma
  - Pneumothorax
  - Increased intracranial pressure

Most Important Decisions about RSI must be made before any drug is pushed!

- What if…
  - I am unable to intubate this patient?
  - I am unable to ventilate this patient?
- What is “Plan B”, other techniques, equipment, personnel?
- Do I really need to intubate/paralyze this patient?
- Does this patient have any contra-indications to any drugs I will be using?

Other equipment considerations

- 2005 AHA Guidelines approved use of cuffed ET tubes in a hospital setting.
  - Many pediatric airway problems require increased ventilatory pressures.
  - Do NOT inflate cuff routinely. Do NOT over-inflate.
  - Monitor airway pressure.

Endotracheal Intubation

- Laryngoscopy can cause:
  - Stimulation of cough/gag reflex.
  - Increased HR, BP, ICP, intraocular pressure.

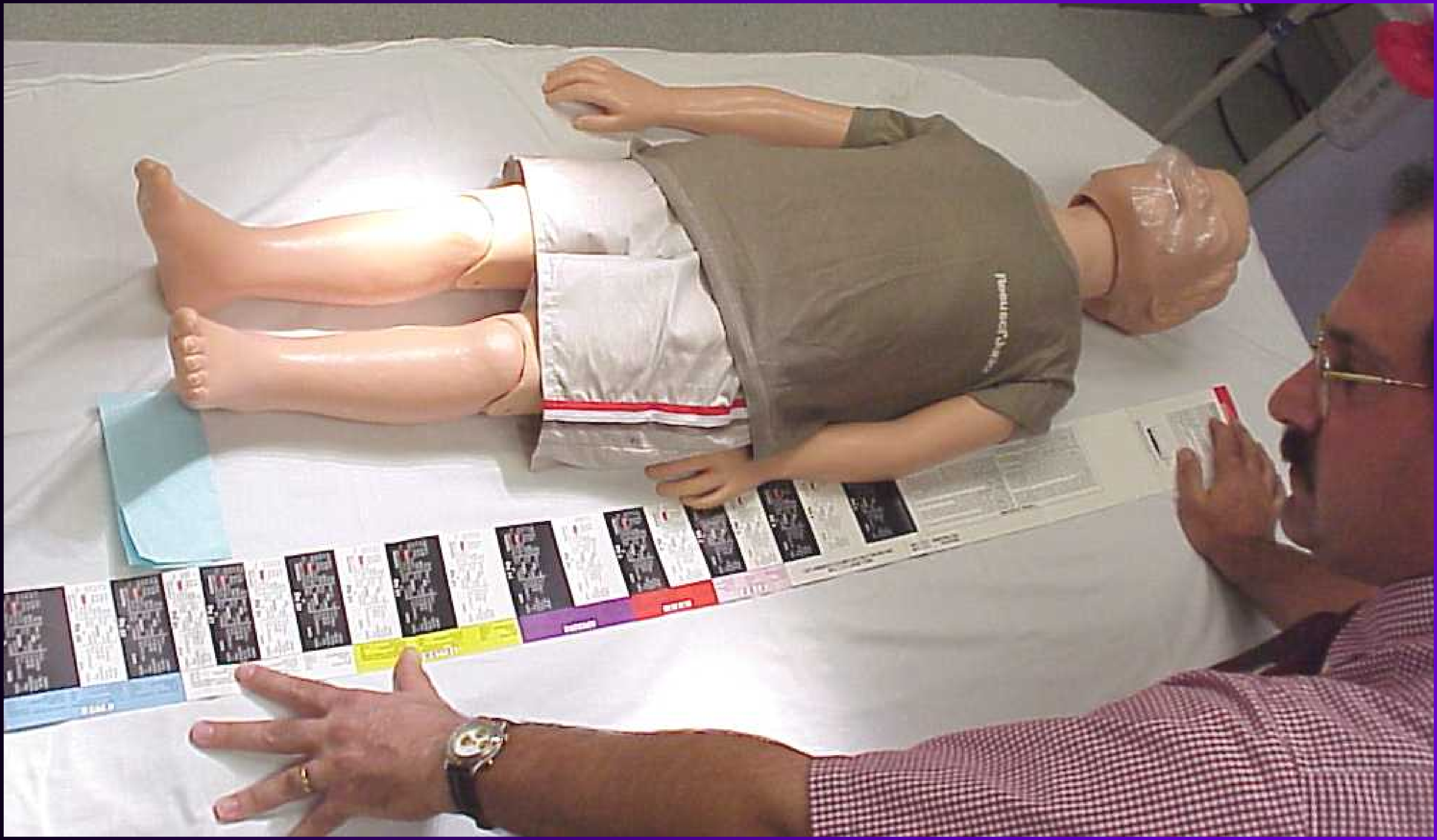
  - Infants and young children have a more pronounced vagal response to ETI, i.e. the need for premedication with Atropine.

Endotracheal Intubation

- The Endotracheal Tube
- The Laryngoscope Blade
- Key Points on Intubation Procedure
- Verifying Placement
- Potential Problems

Important Formula to Estimate Size of Equipment

- ET tube - (age in years/4) +4
  - ½ size smaller if using cuffed tube
- Depth of insertion
  - Internal diameter (in mm) x 3
  - (Age in years/2) + 12

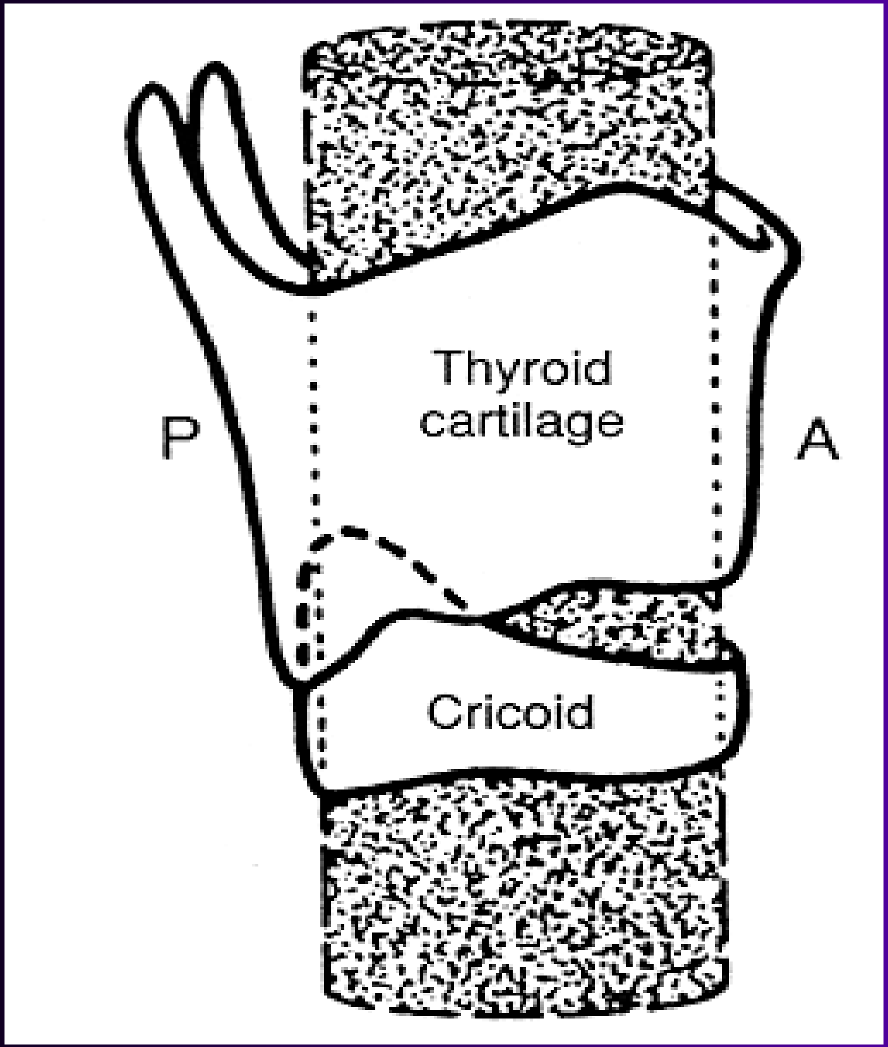


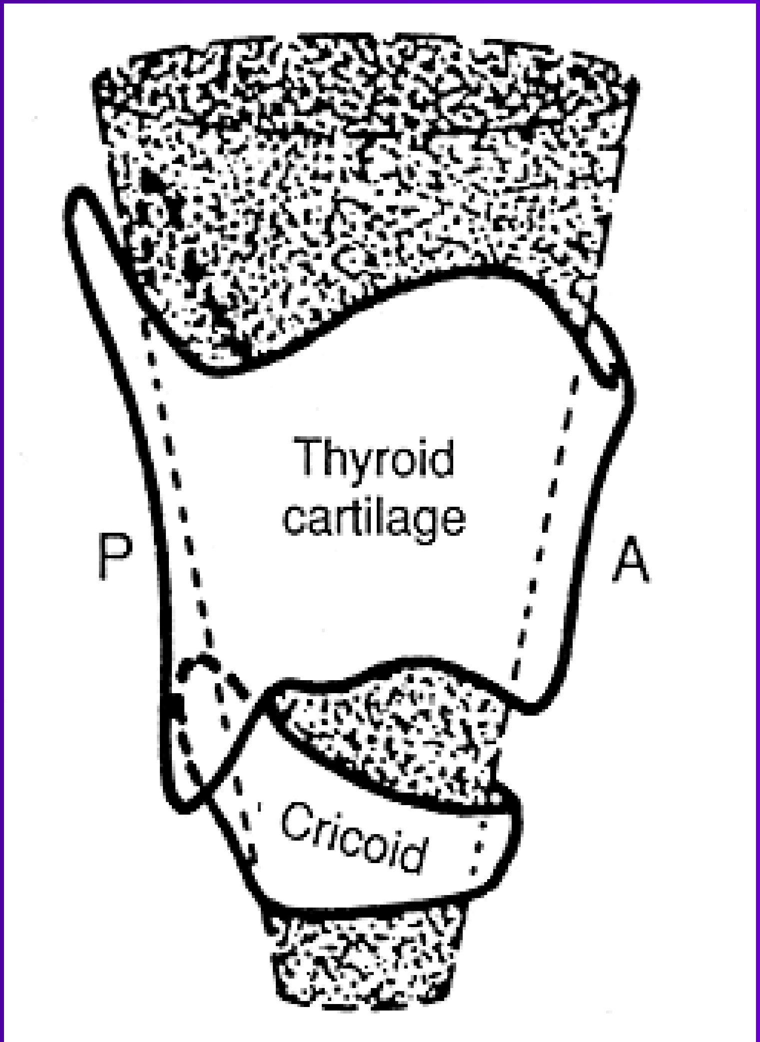
Equipment for intubating

- When do we use cuffed tubes?

- Why?

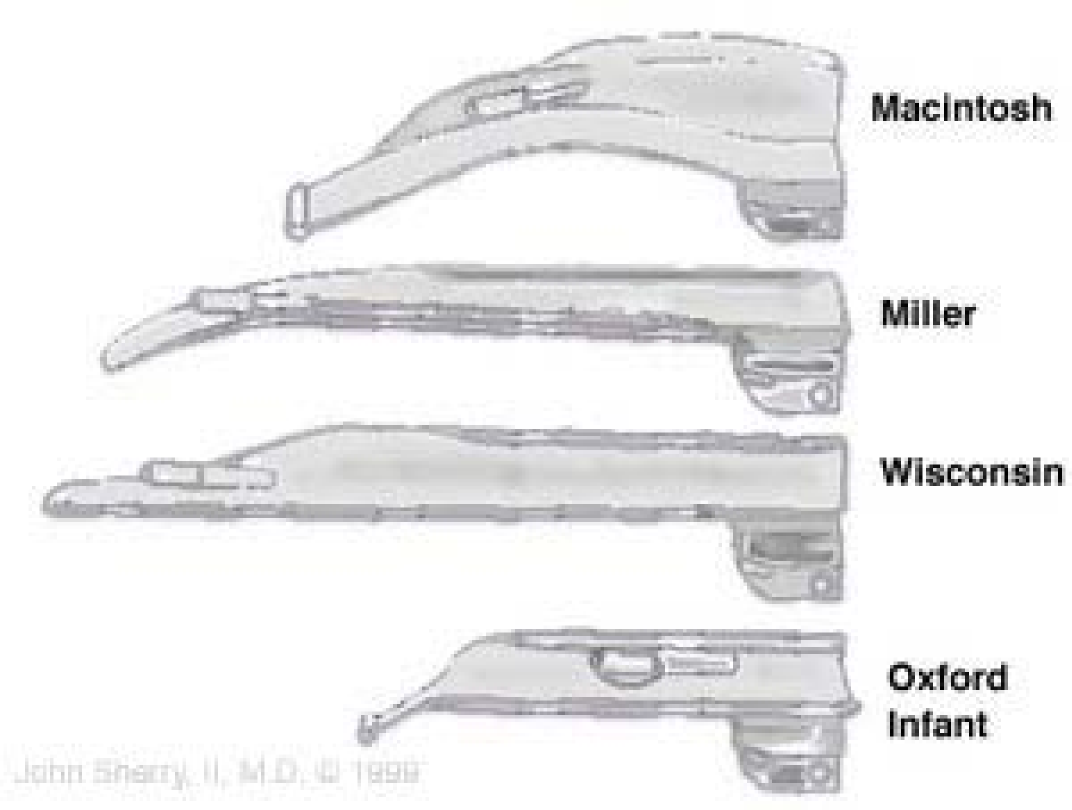
Larynx anatomy





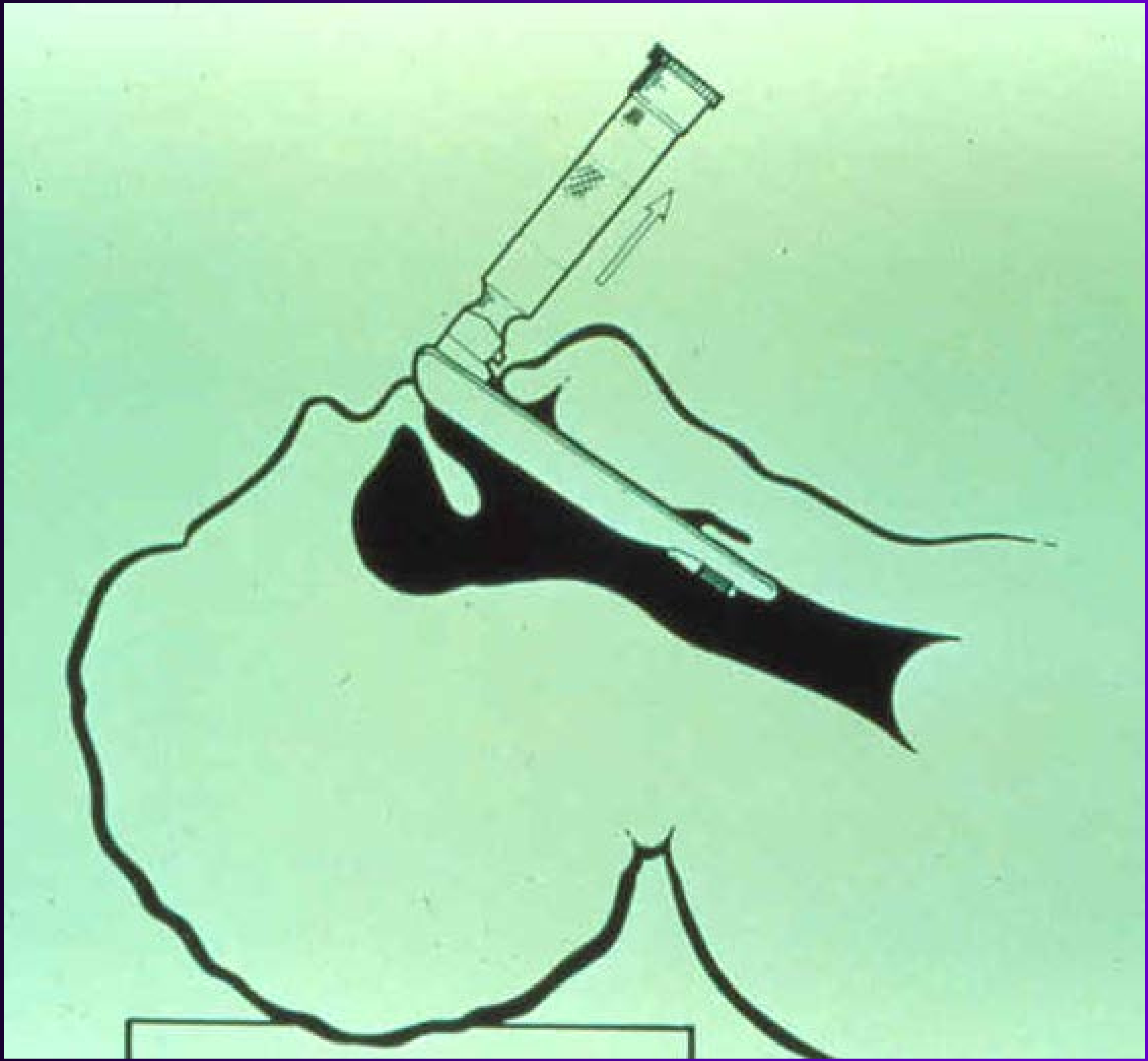
Equipment for intubating

- When do we use Miller (straight) vs. Macintosh (curved) blades?



Blade Types

- Miller = straight blade
  - Used in infants and young children
  - Can be used in older kids
  - Slips under epiglottis
- MacIntosh = curved blade
  - Slips into vallecula
- For older kids and adults, use the type with which you are comfortable



Endotracheal Intubation

- Procedure
  - Prepare personnel, meds, equipment
  - Pre-oxygenate with 100% 02 using BVM
  - Continuously monitor heart rate and oxygen saturation
  - Position head so as to line up airway axes

Endotracheal Intubation

- Open mouth, place laryngoscope in right side of mouth, sweep tongue to midline and lift to visualize the airway.
- Advance the ETT through the vocal cords under direct visualization, advancing until the marker is just below the level of the cords.

Endotracheal Intubation

- Remove stylet, place C02 detection device, and begin ventilating
- Observe for symmetrical chest rise
- Listen in both axilla and over stomach
- Once placement is confirmed, secure and tape tube

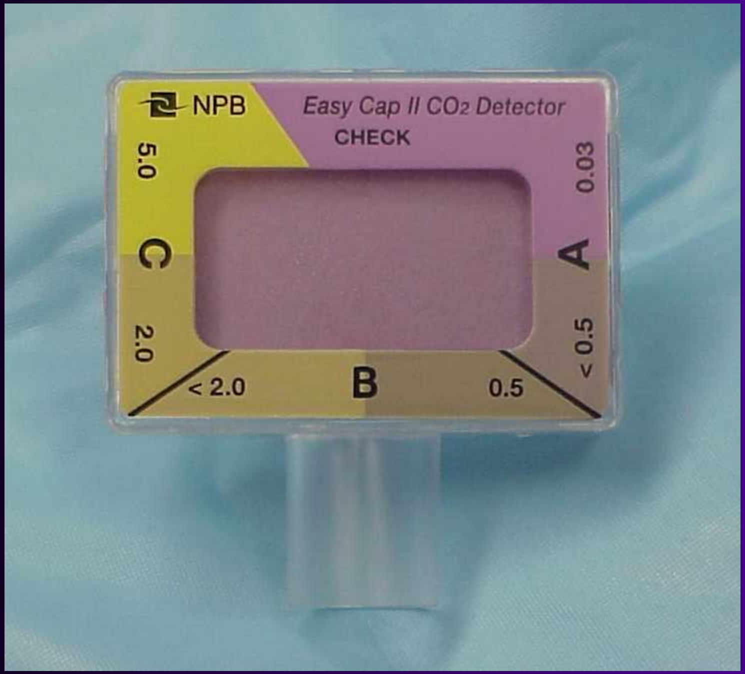
Determining ETT position

- Clinical determinants unreliable, especially for infants and children
  - Breath sounds radiate widely
  - ETT condensation unreliable
- ET-CO_2 detectors
    - Use Pedi-Cap for children less than 20kg

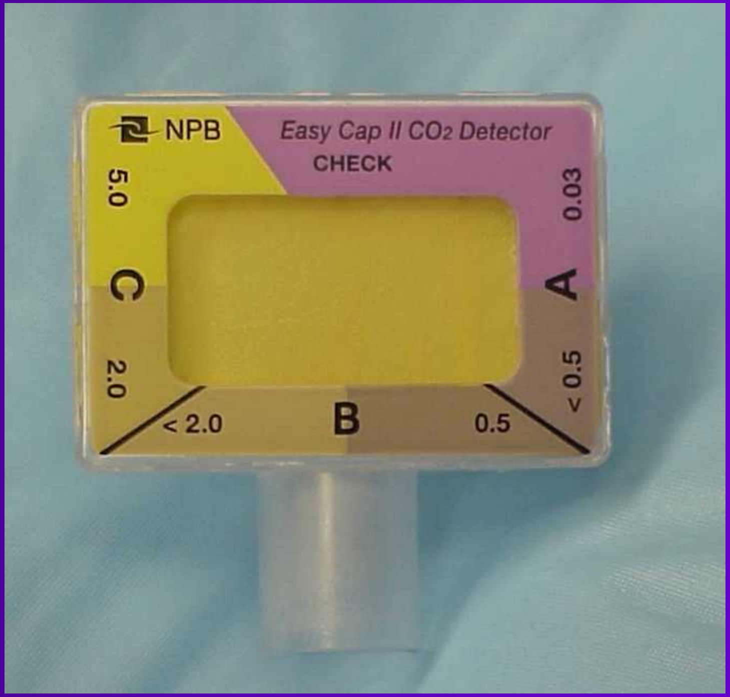
Capnometry

- pH sensitive filter paper
- Detects exhaled CO_2 >0.5%
- Specific for correct tube placement when color changes
- Increases airway resistance

Purple - **P**roblem: No CO2



Yellow - **Y**es!
Exhaled C02



Expired CO_2

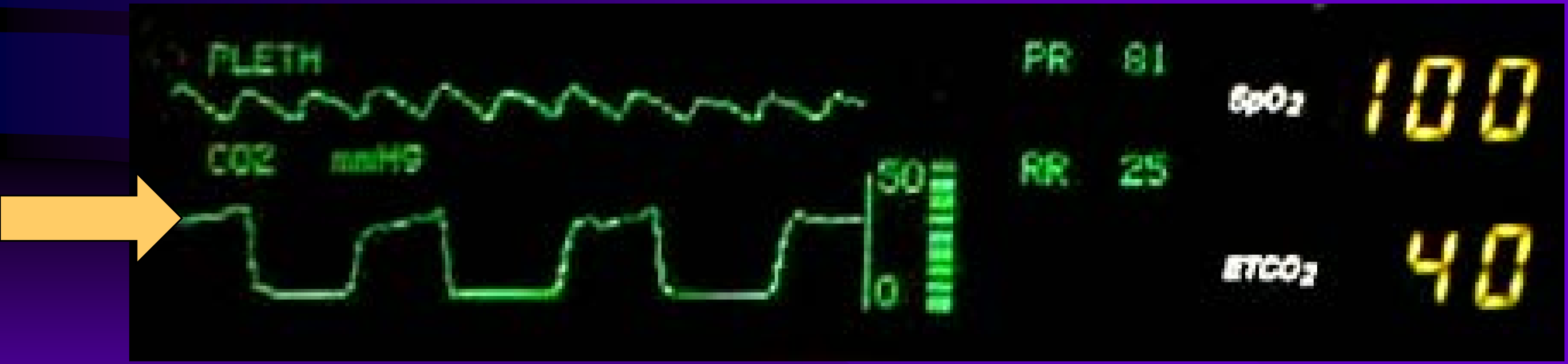
- False negative: inadequate pulmonary blood flow or severe airway obstruction
- Expired CO_2 correlates with effectiveness of compression-induced cardiac output
  - Absent color change correlates with death in cardiac arrest
- Massive pulmonary embolus
- Pulmonary edema (ARDS)

$ETCO_2$ Monitor

- Square wave pattern = TT in trachea.
- Otherwise, two possibilities:
  - TT not in trachea: Extubate, BMV.
  - Lungs not exhaling CO_2.
    - Severe air trapping (status asthmaticus).
    - Poor pulmonary perfusion (CPR).
- Consider an alternative means of confirming tracheal intubation, or extubate and initiate BMV if tracheal intubation cannot be confirmed.

$ETCO_2$ Monitor

- $ETCO_2$ monitor shows a **<u>square</u>** wave form. Peak PCO_2 occurs during end of exhalation cycle ("end tidal").



- Normal (square) wave form confirms tracheal intubation.

$ETCO_2$ Monitor

- Top tracing shows abnormal $ETCO_2$ wave form (red arrow). Compare this to normal $ETCO_2$ wave form below (yellow arrow), which confirms tracheal intubation.

Aftercare

- It is imperative to continue to monitor an intubated pediatric patient, especially during transport/transfer.
- Short trachea makes it easy for the tube to become dislodged.
- Continuously monitor the pulse oximeter, heart rate, chest rise, breath sounds and color.

Oops! What now?

- Patient is successfully intubated.
- Difficult to bag.
- Becomes more tachycardic (130 → 160).
- Becomes hypotensive (80/40).
- O2 Sats start to fall (95% to 89%).

What’s Wrong??

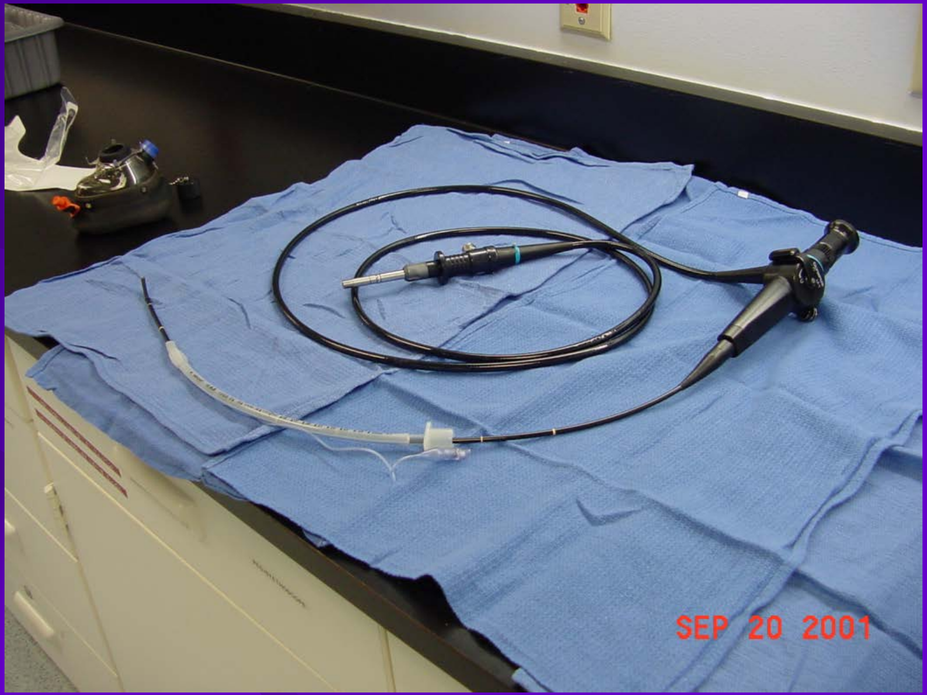
- Sudden deterioration: DOPE
- D- Dislodged – into the esophagus or right main stem bronchus
- O- Obstruction – vomit, secretions, blood or kinks
- P- Pneumothorax- may have tracheal deviation, absent breath sounds on one side, shock. – immediate decompression
- E- Equipment failure

What If You Can’t Intubate???

Other Airway Alternatives

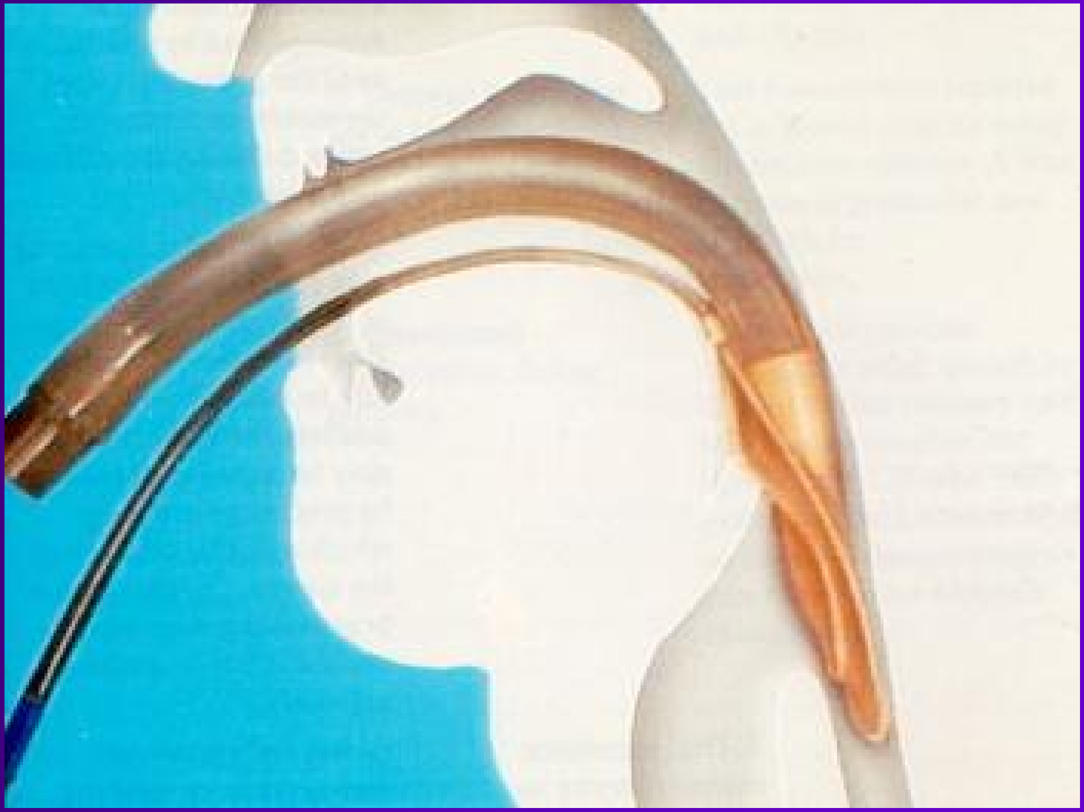
Develop a Critical Airway Algorithm

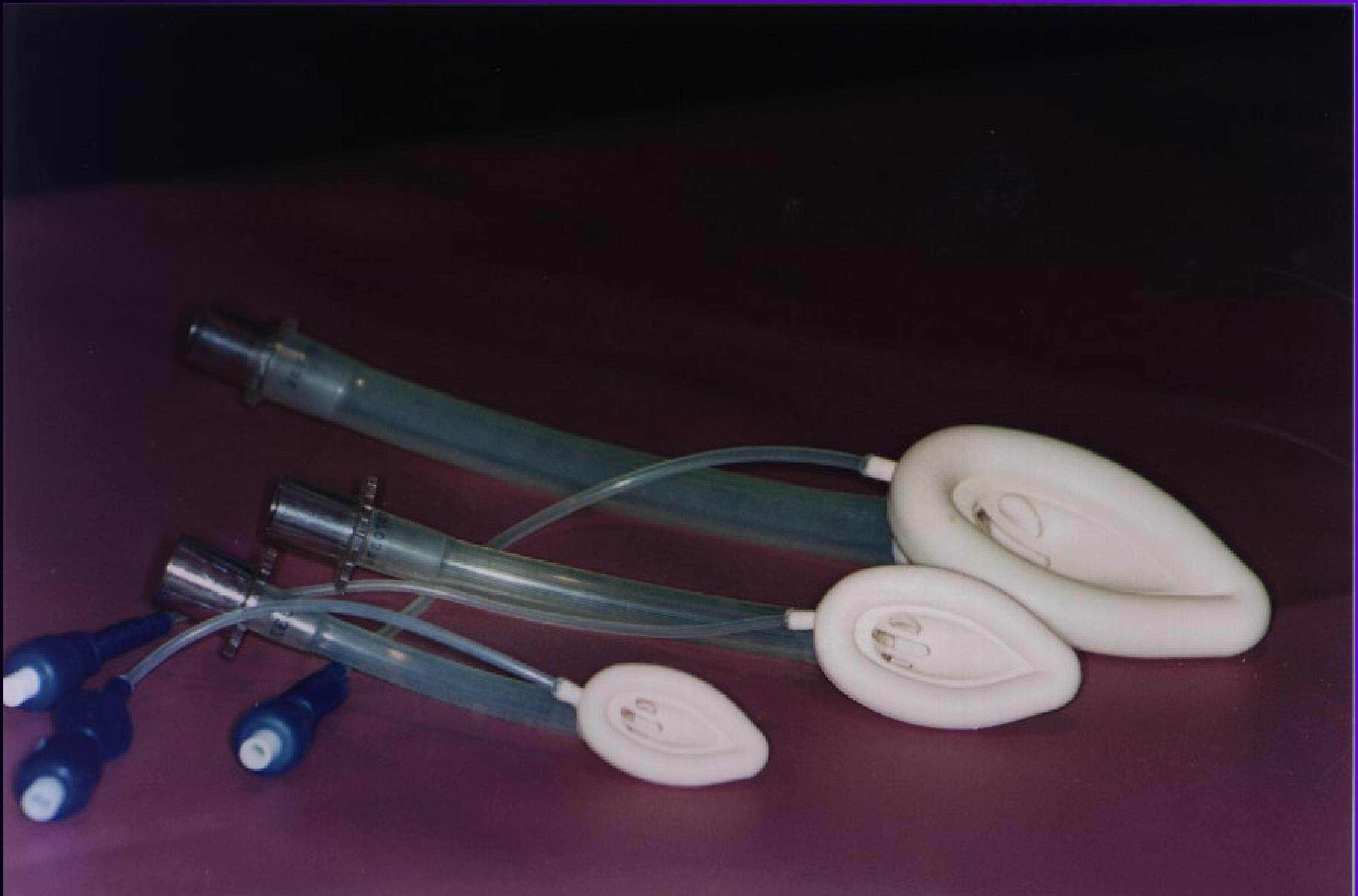
Have a backup plan for everything!



Alternatives

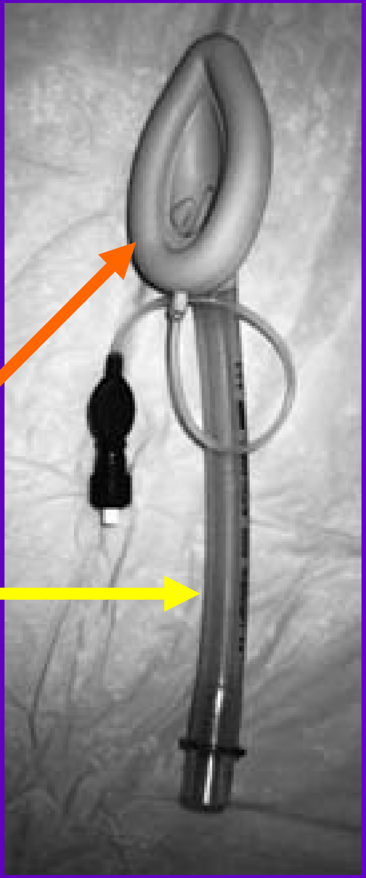
- Laryngeal Mask Airway





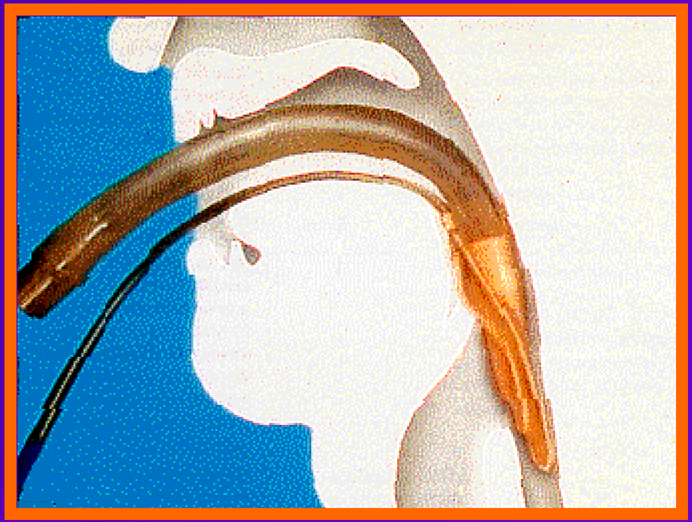
Laryngeal Mask Airway

- The LMA was invented by Dr. Archie Brain at the London Hospital, Whitechapel in 1981
- The LMA consists of two parts:
  - The mask
  - The tube
- The LMA has proven to be very effective in the management of airway crisis



Laryngeal Mask Airway

- The LMA design:
  - Provides an “oval seal around the laryngeal inlet” once the LMA is inserted and the cuff inflated.
  - Once inserted, it lies at the crossroads of the digestive and respiratory tracts.



Indications for use of the LMA

- Situations involving a difficult mask (BVM) fit.
- May be used as a back-up device where endotracheal intubation is not successful.
- May be used as a “second-last-ditch” airway where a surgical airway is the only remaining option.

LMA Use in Pediatrics

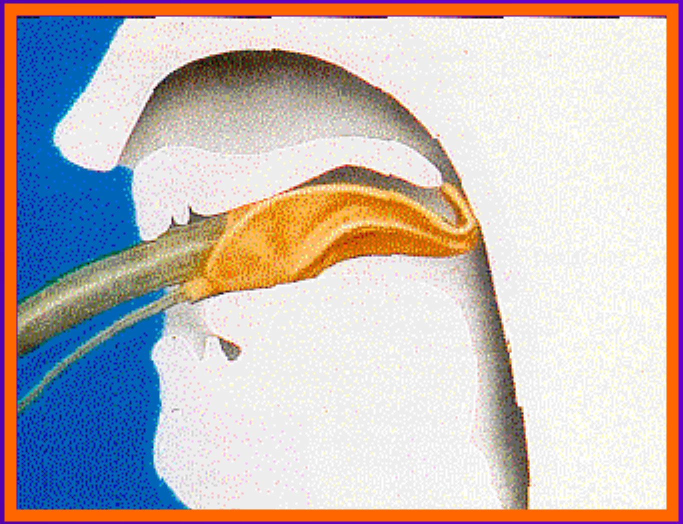
- Used by anesthesiologists in the OR.
- Back-up plan in many Peds ED’s.
- Gaining support in pre-hospital arena.

Choose the Proper Size !!

- Verify that the size of the LMA is correct for the patient
- Recommended Size guidelines:
  – Size 1: under 5 kg
  – Size 1.5: 5 to 10 kg
  – Size 2: 10 to 20 kg
  – Size 2.5: 20 to 30 kg
  – Size 3: 30 kg to small adult
  – Size 4: adult
  – Size 5: Large adult/poor seal with size 4

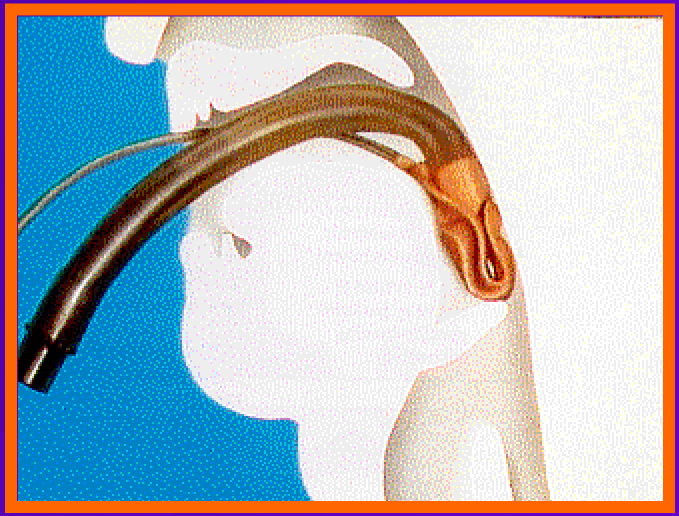
Problems with LMA Insertion

- Failure to press the deflated mask up against the hard palate or inadequate lubrication or deflation can cause the mask tip to fold back on itself.



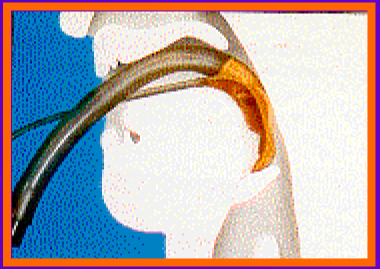
Problems with LMA Insertion

- Once the mask tip has started to fold over, this may progress, pushing the epiglottis into its down-folded position causing mechanical obstruction

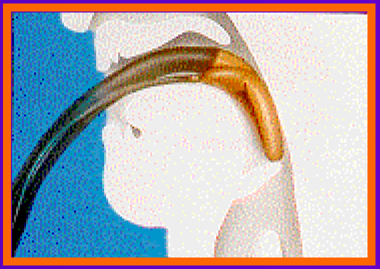


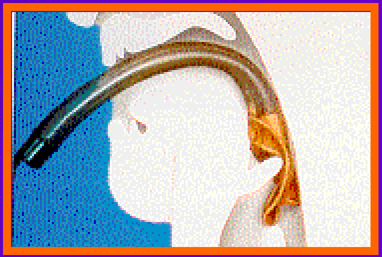
Problems with LMA Insertion

- If the mask tip is deflated forward it can push down the epiglottis causing obstruction.



- If the mask is inadequately deflated it may either.
  - push down the epiglottis.
  - penetrate the glottis.





Intubating LMA

KING Supraglottic Airways

- **Benefits:**
- Seals in the esophagus and oropharynx to provide positive pressure ventilation
- Single inflation port
- Color-coded full range of sizes
- Suction port

KING Supraglottic Airways

- Studies thus far only in simulation lab.
- Time to securing the airway less than with standard endotracheal intubation and higher success rate using King.
- EMS providers perceived the pediatric King LT-D to be easier to use than pediatric endotracheal intubation

Future Research

- Ideal study: randomized, controlled trial in real patients in the prehospital setting.
- Compare success rates with ET intubation vs. LMA vs. King Airway
- Problems:
  - Low numbers of pediatric cases
  - Consent issues

Emerging Technology

- Video laryngoscopy in the field
- Promising: but…..?Cost ?Proven benefit

- Always have a “Plan B”, cause Plan A does not always work.

Challenging Pediatric Airways

- Congenital
- Infectious
- Orifice issues

Challenging Airways

- Congenital
  - Down’s Syndrome
  - Beckwith- Wiedemann
  - Pierre-Robin
  - Treacher Collins
  - Crouzon’s Syndrome
  - Tracheal abnormalities

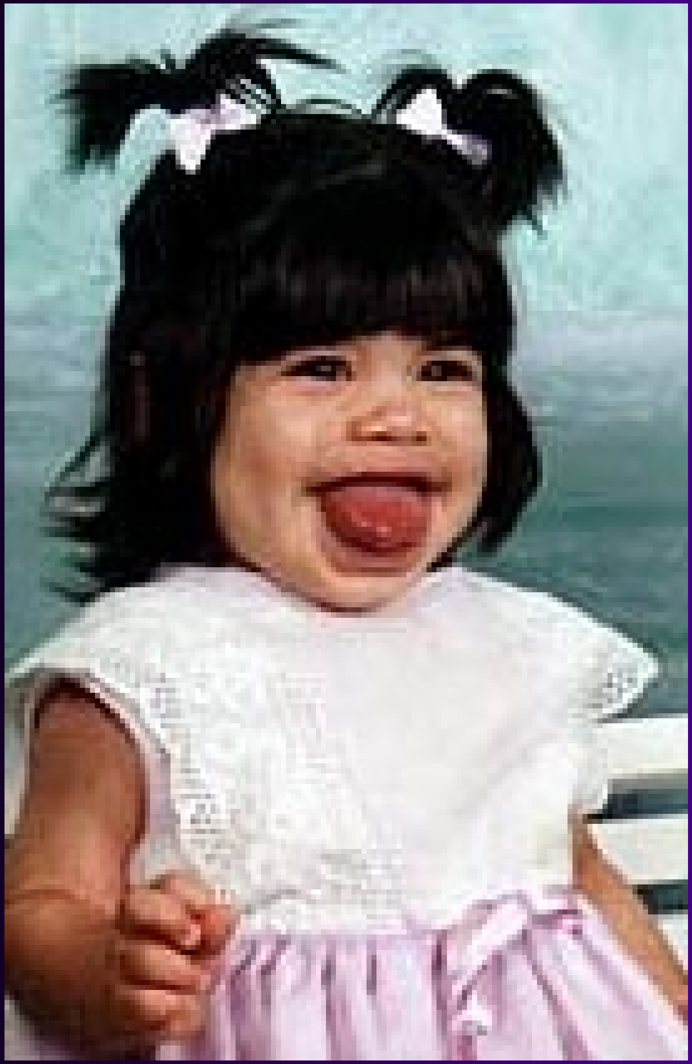
Down's Syndrome

- Small trachea
- Short, broad neck
- Micrognathia
- Relative macroglossia

Down' Syndrome

- Atlanto-axial dislocation

Macroglossia



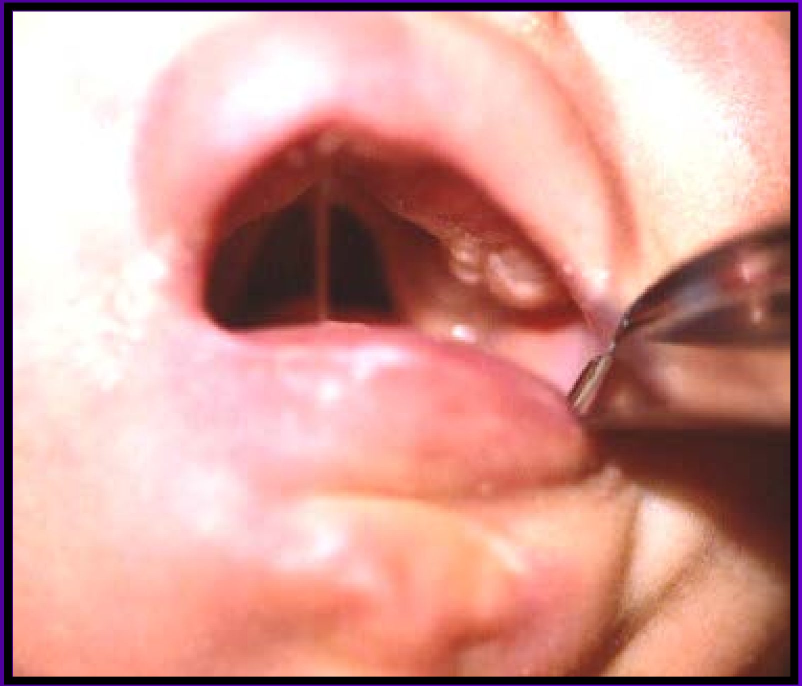
Beckwith- Wiedemann Syndrome

Micrognathia

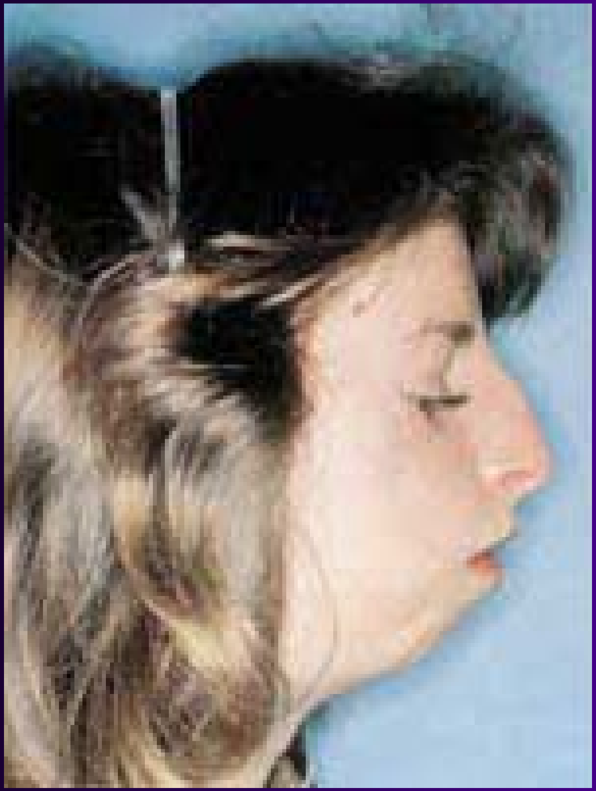
Pierre Robin
Sequence

Micrognathia

Pierre Robin Sequence-
High-arched palate



Mid-facial Hypoplasia

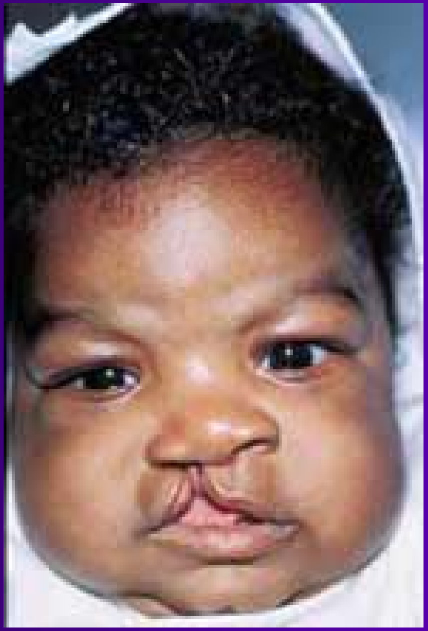


Treacher Collins Syndrome

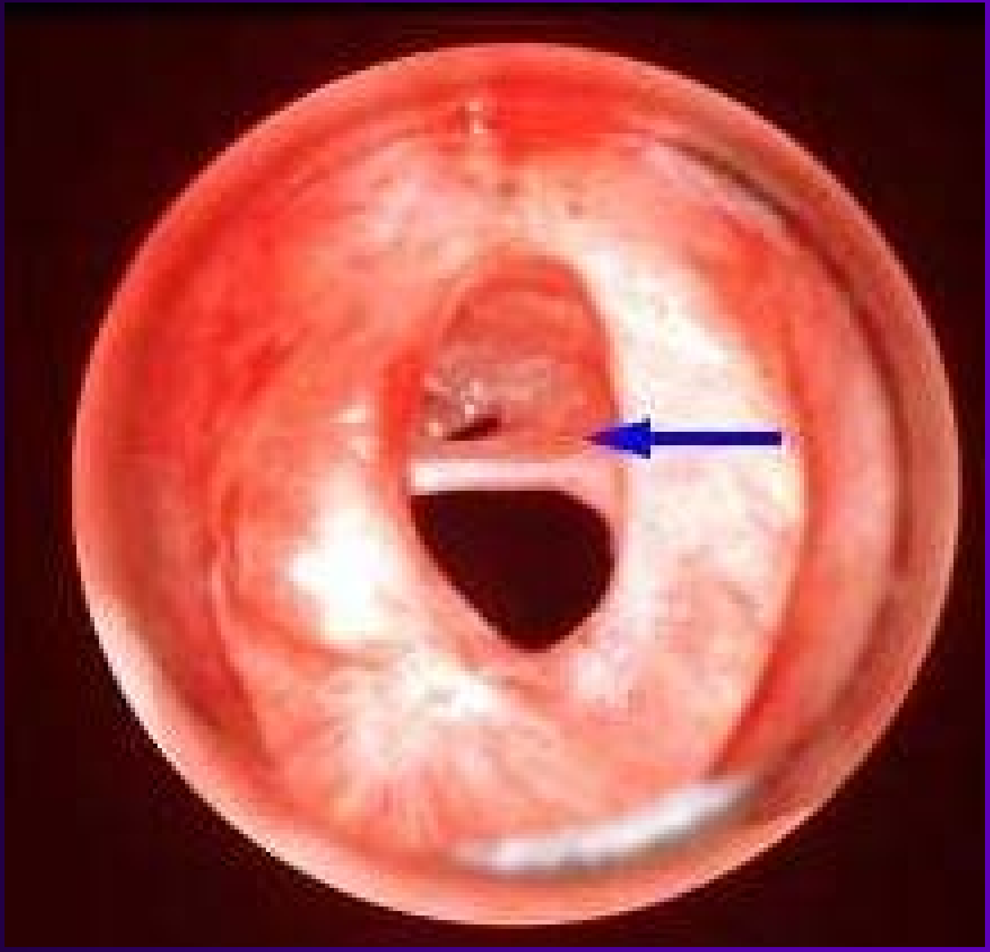
Mid-facial Hypoplasia

Crouzon's
Syndrome

Cleft lip and/or palate



Tracheal Web

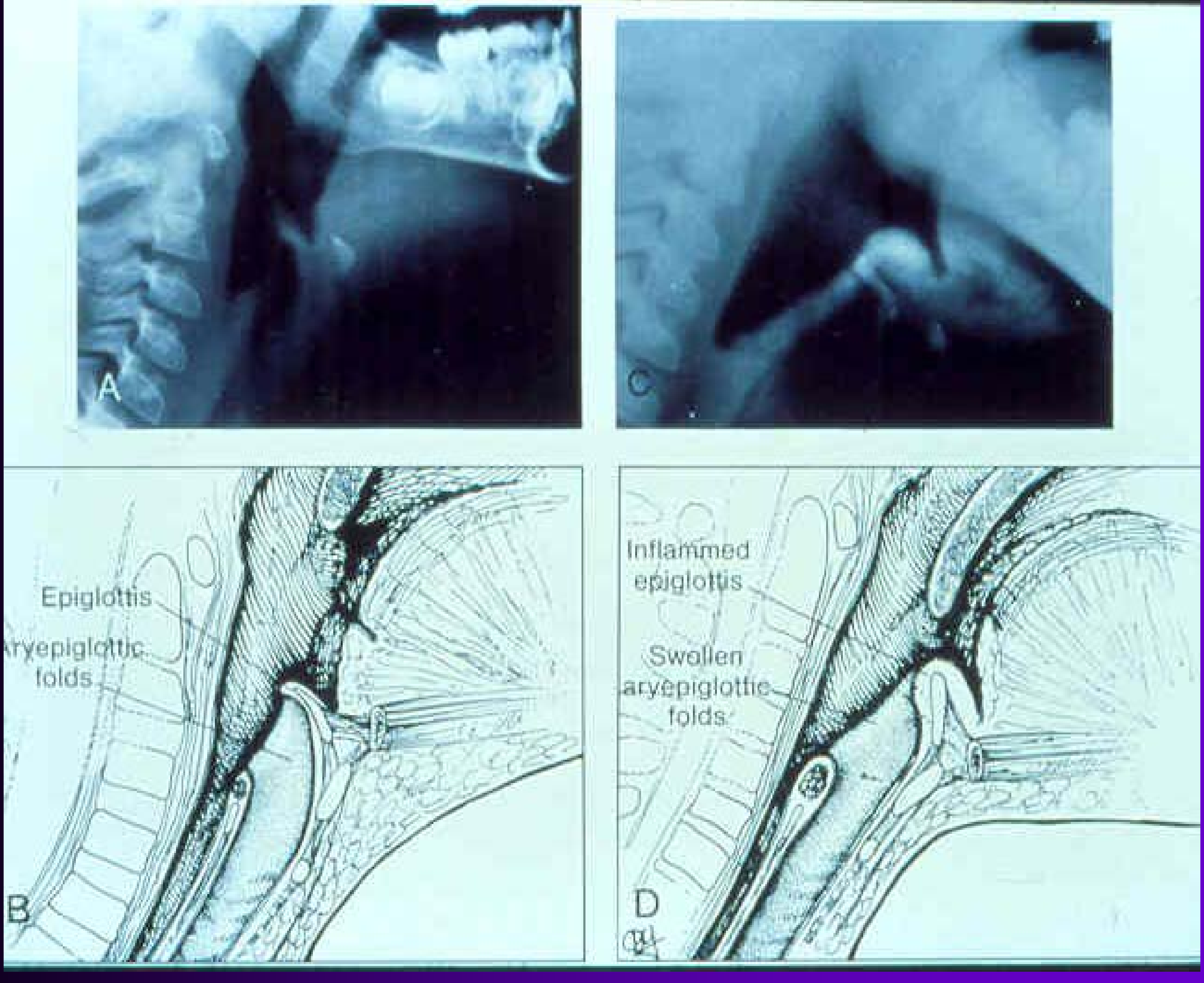


Challenging Airways

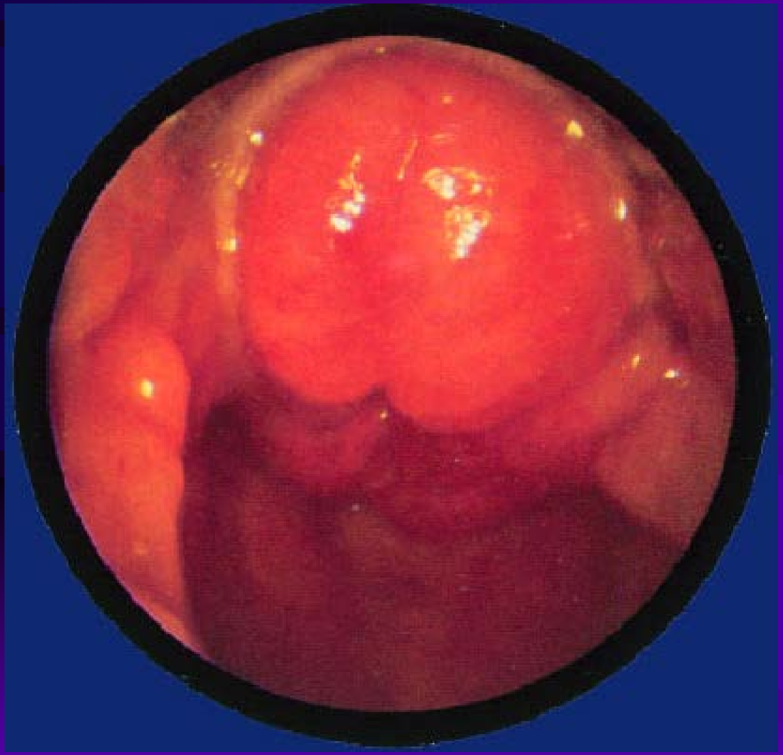
- Infectious
  - Laryngeal papillomatosis
  - Epiglottitis
  - Airway abscesses
  - Tonsillar obstruction/EBV

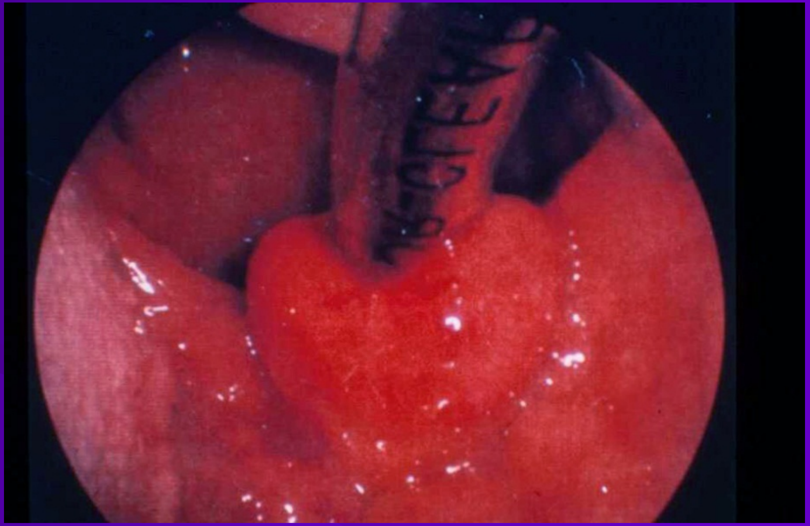
Other Causes of Upper Airway Obstruction

Laryngeal Papillomatosis


A
C
Epiglottis
Aryepiglottic
folds
B
Inflammed
epiglottis
Swollen
aryepiglottic
folds
D

Epiglottitis

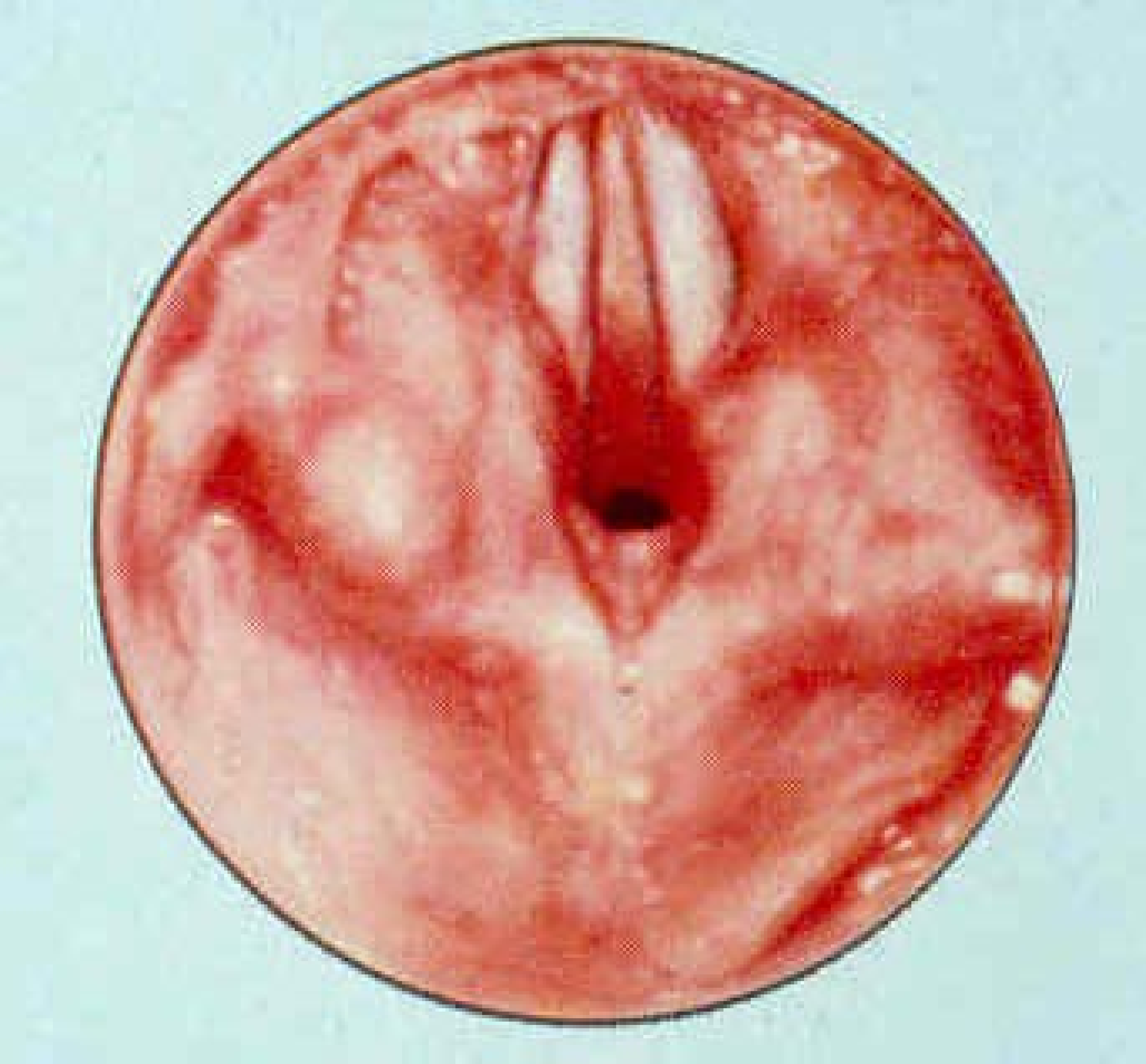




Challenging Airways

- Orifice issues
  - acquired abnormalities
  - foreign body

Subglottic Stenosis



Foreign Body Aspiration

- Food items are the most commonly aspirated FB.
- Balloons are the most common FB to result in death.

Your First Clue:
Foreign Body Aspiration

- A history of choking is the most reliable predictor of FB aspiration.
- Other signs and symptoms include:
  - Upper airway: Stridor, respiratory or cardiopulmonary arrest.
  - Lower airway: Coughing, wheezing, retractions, decreased breath sounds, cyanosis.

EMS Management

- Upper airway FB:
  - If patient is able to cough or speak:
    - **Leave in a position of comfort.**
    - **Provide supplemental oxygen.**
    - **Priority transport to ED for removal.**
- Lower airway/esophageal FB:
  - Position of comfort, transport

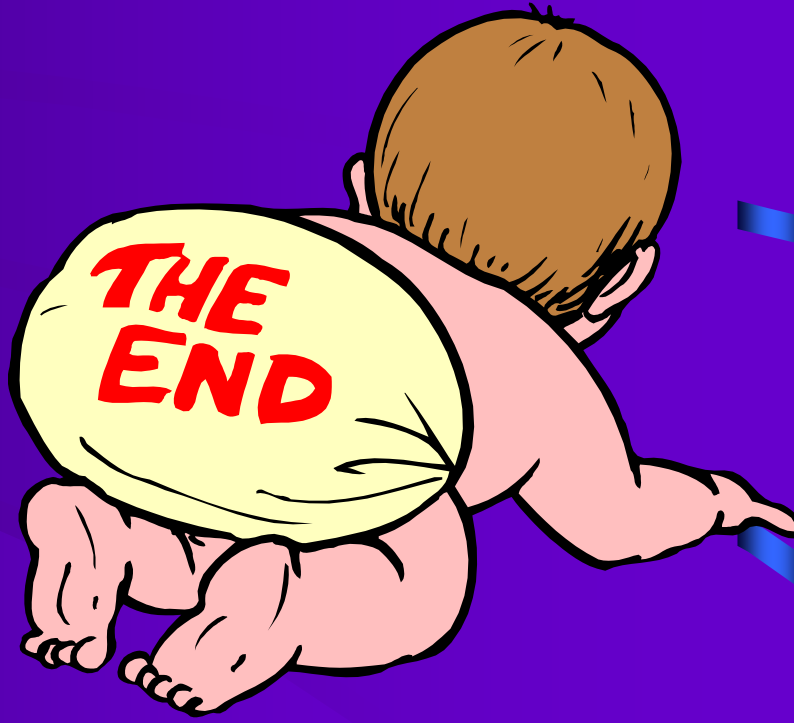
Definitive Management

- Laryngoscopy and removal with pediatric Magill forceps
- If unable to grasp FB at or near the vocal cords, OK to push it in to secure the airway!

Closing Comments

- Pediatric airway problems must be addressed calmly yet swiftly
  - Less frequently encountered/ less experience
  - More time-critical
  - Be cognizant of anatomic/ physiologic differences
- Proper equipment is a key to success
  - Proper sizes
  - Broselow tape
  - Pediatric drug doses
  - Correct end-tidal CO2 detectors
- Always think about “what next?” both for success and failure of technique, before undertaking an intervention.
- Practice! Practice! Practice!

Questions?



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