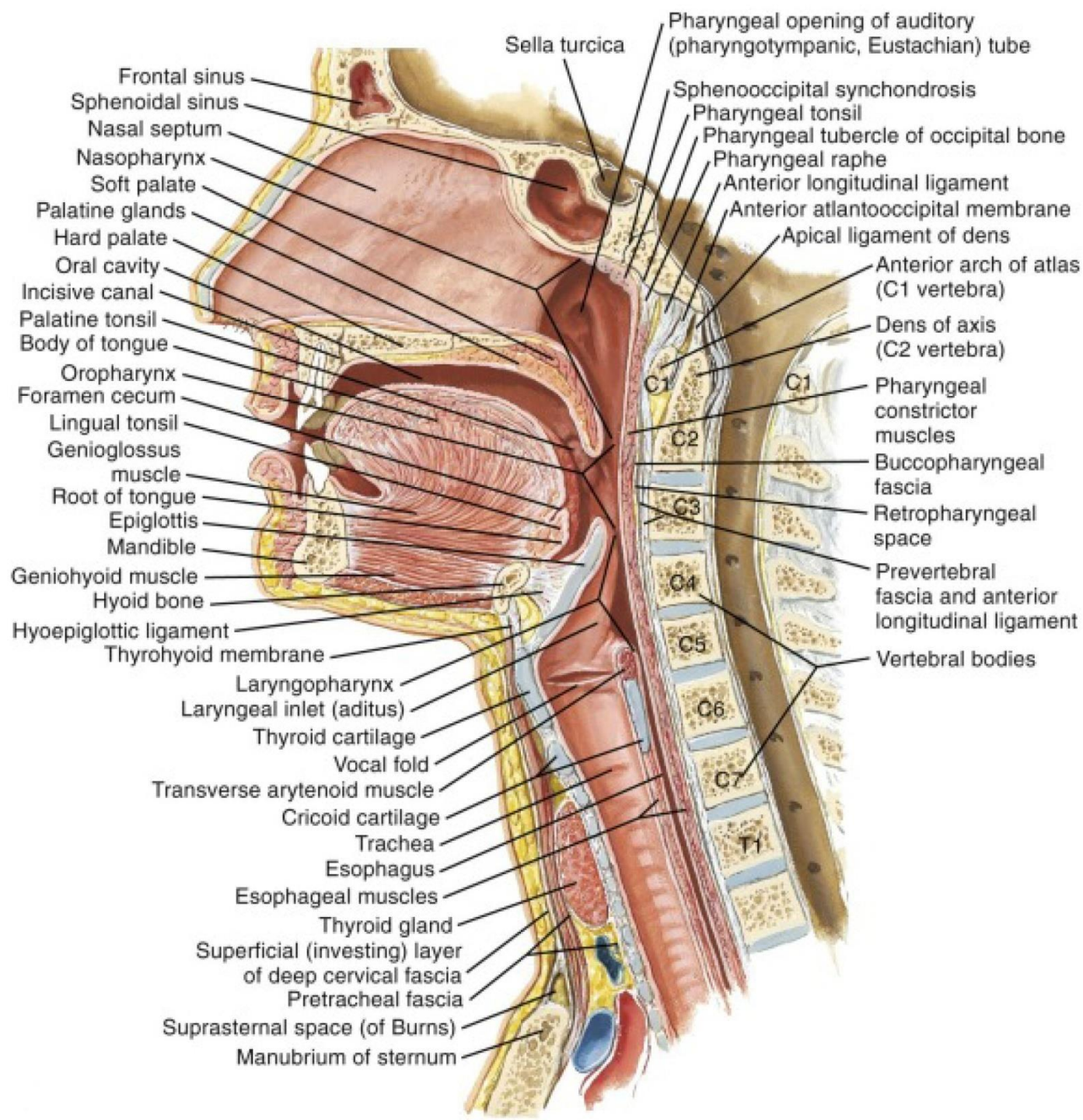
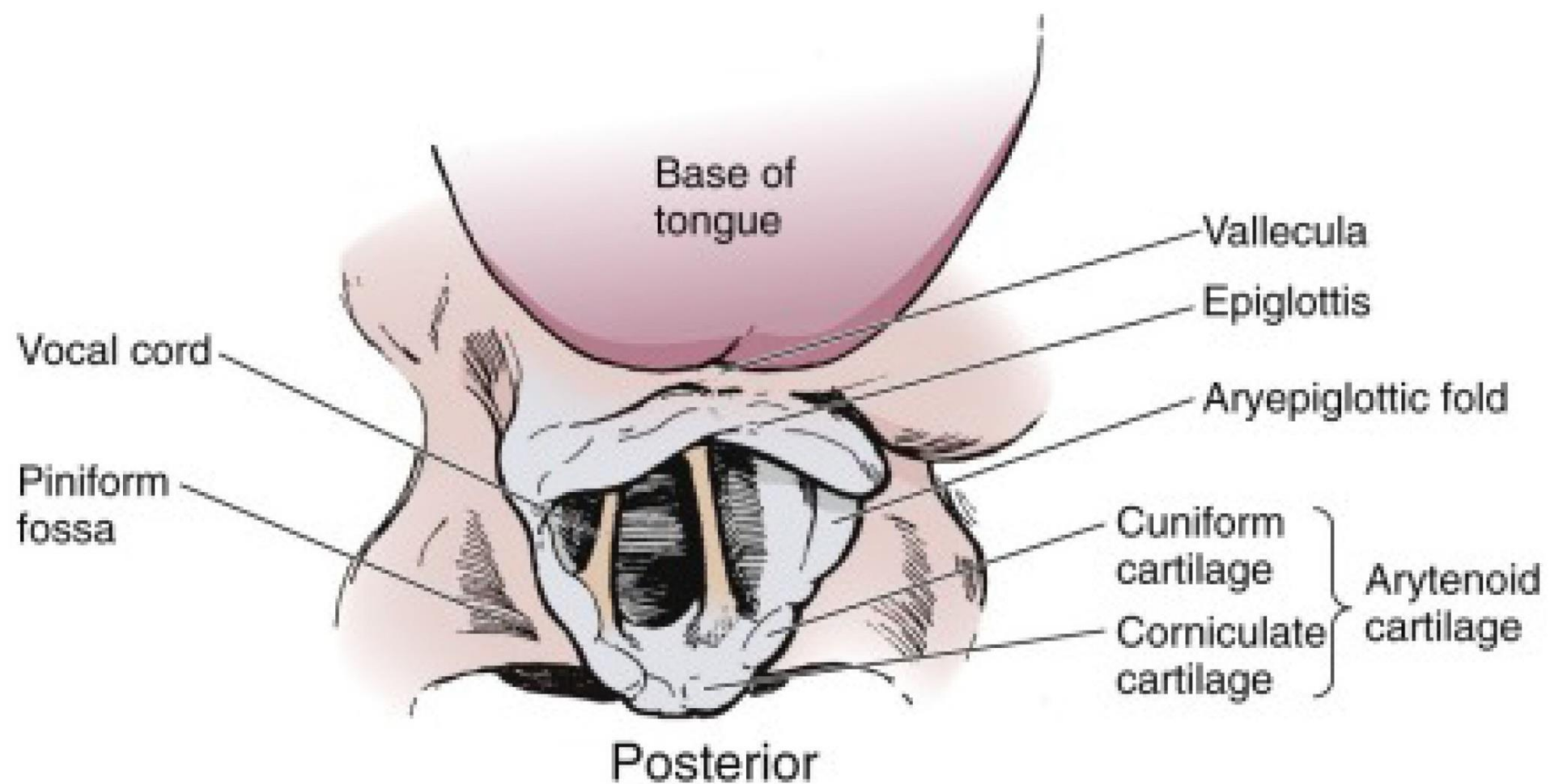


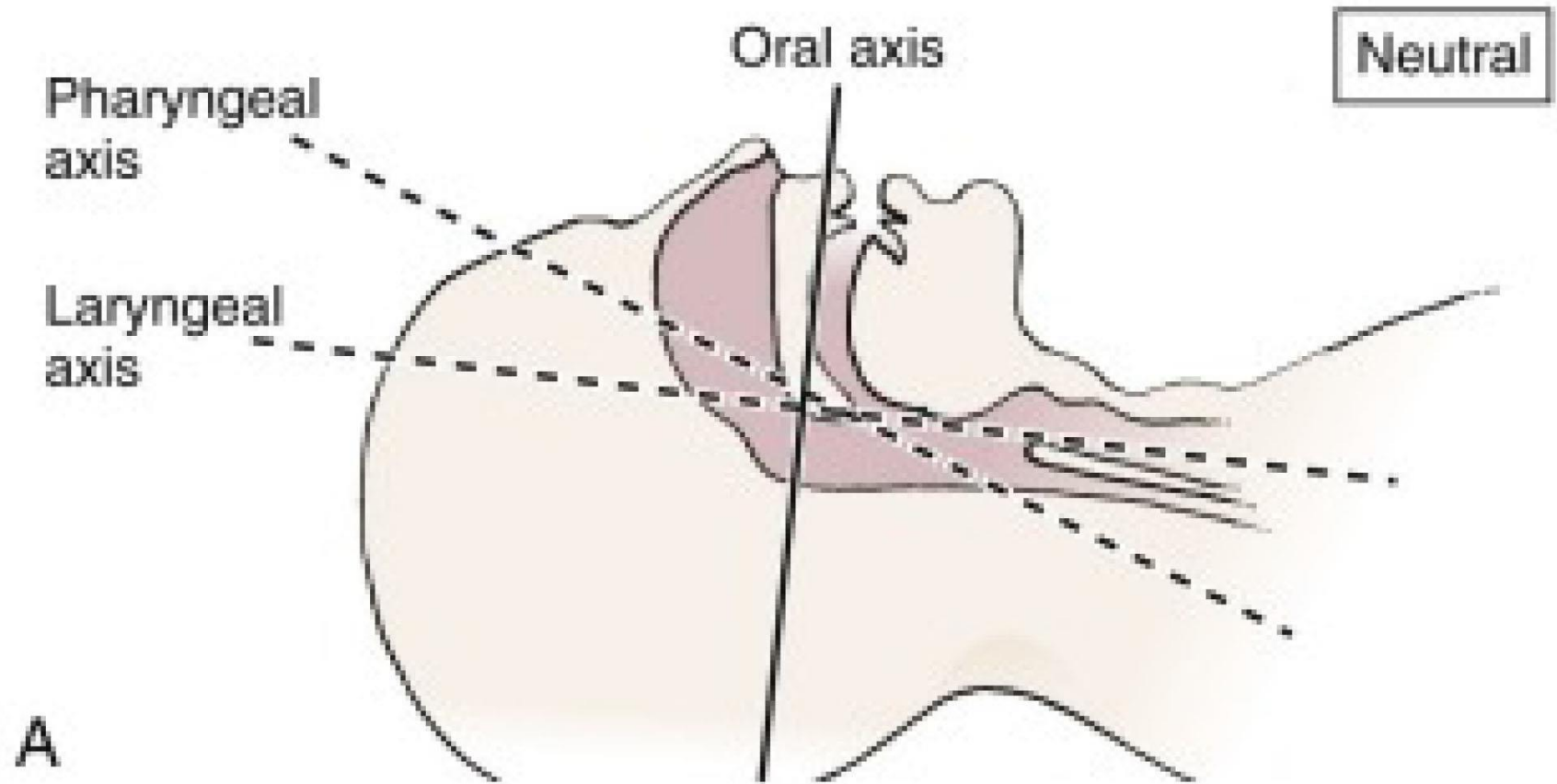
مدیریت راه هوایی اطفال

دکتر سید مہدی ضیا ضیابری

متخصص طب اورژانس









Oral axis

Head elevated

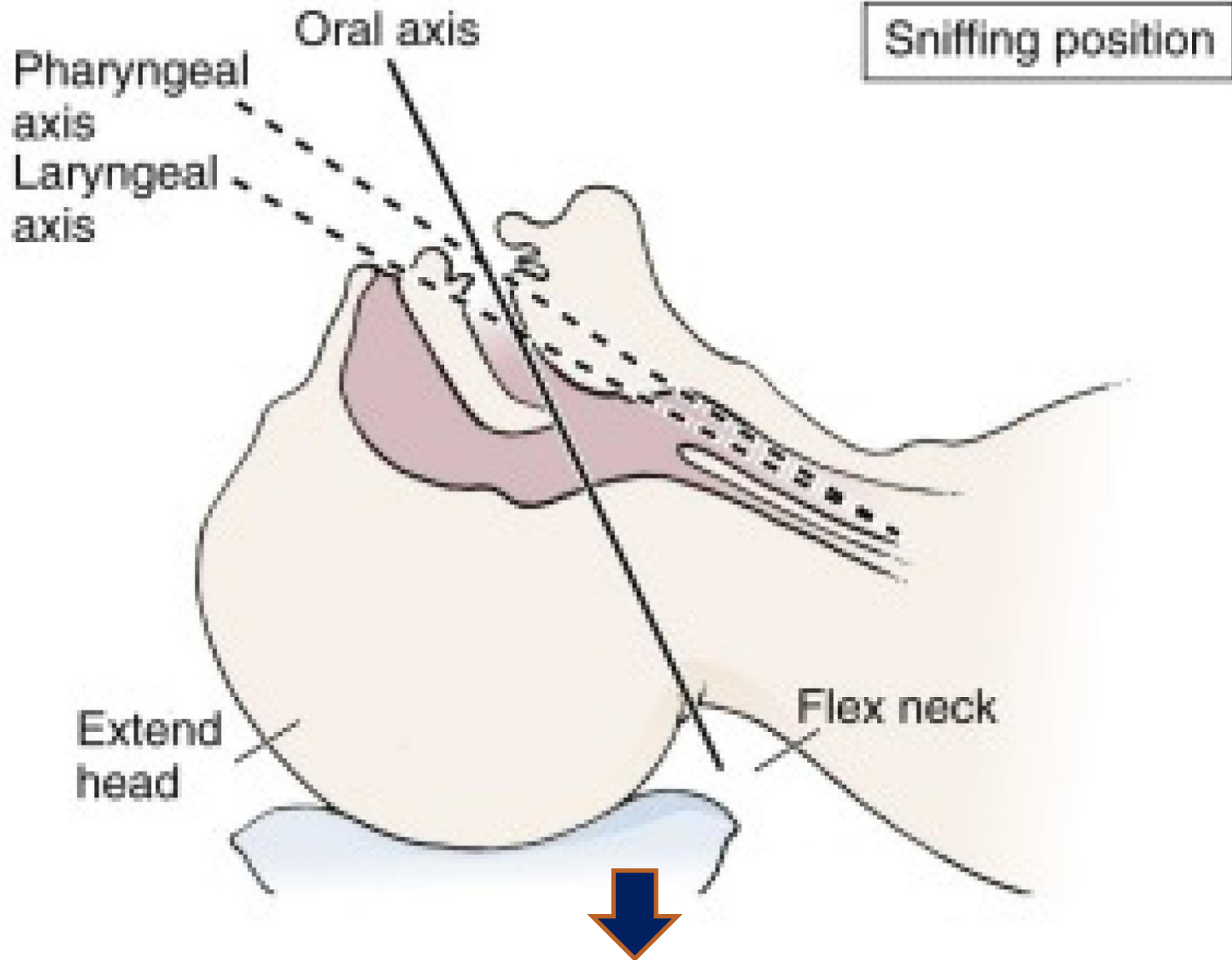
Pharyngeal axis

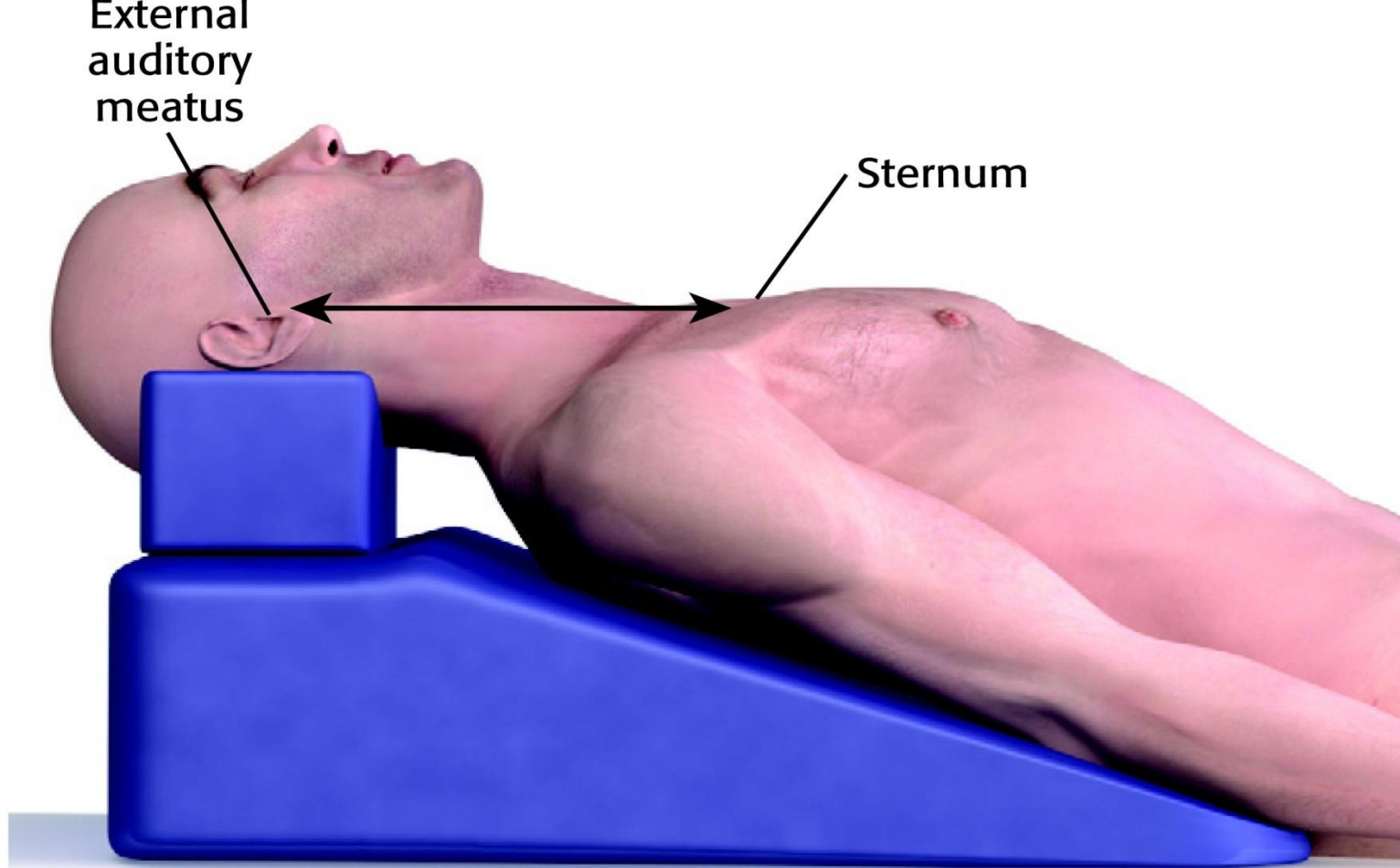
Laryngeal axis

Elevate occiput 10 cm

B





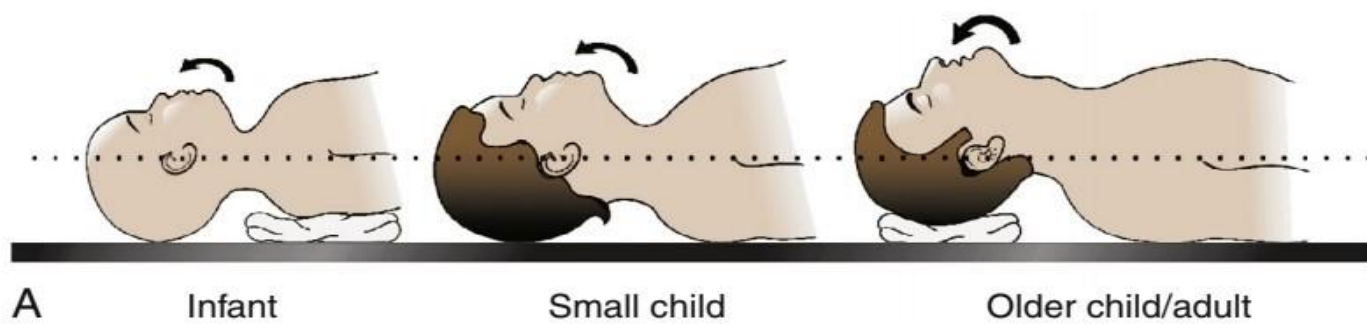


**Figure 3-2** The best position for opening the upper airway in morbidly obese patients is elevation of the head, neck, and shoulders so that the external auditory meatus is aligned with the sternum. The Troop Elevation Pillow (Mercury Medical, Clearwater, FL) is shown here; however, similar results may be achieved with other devices or a ramp of towels and pillows. *Note:* The device is demonstrated here on a nonobese patient.

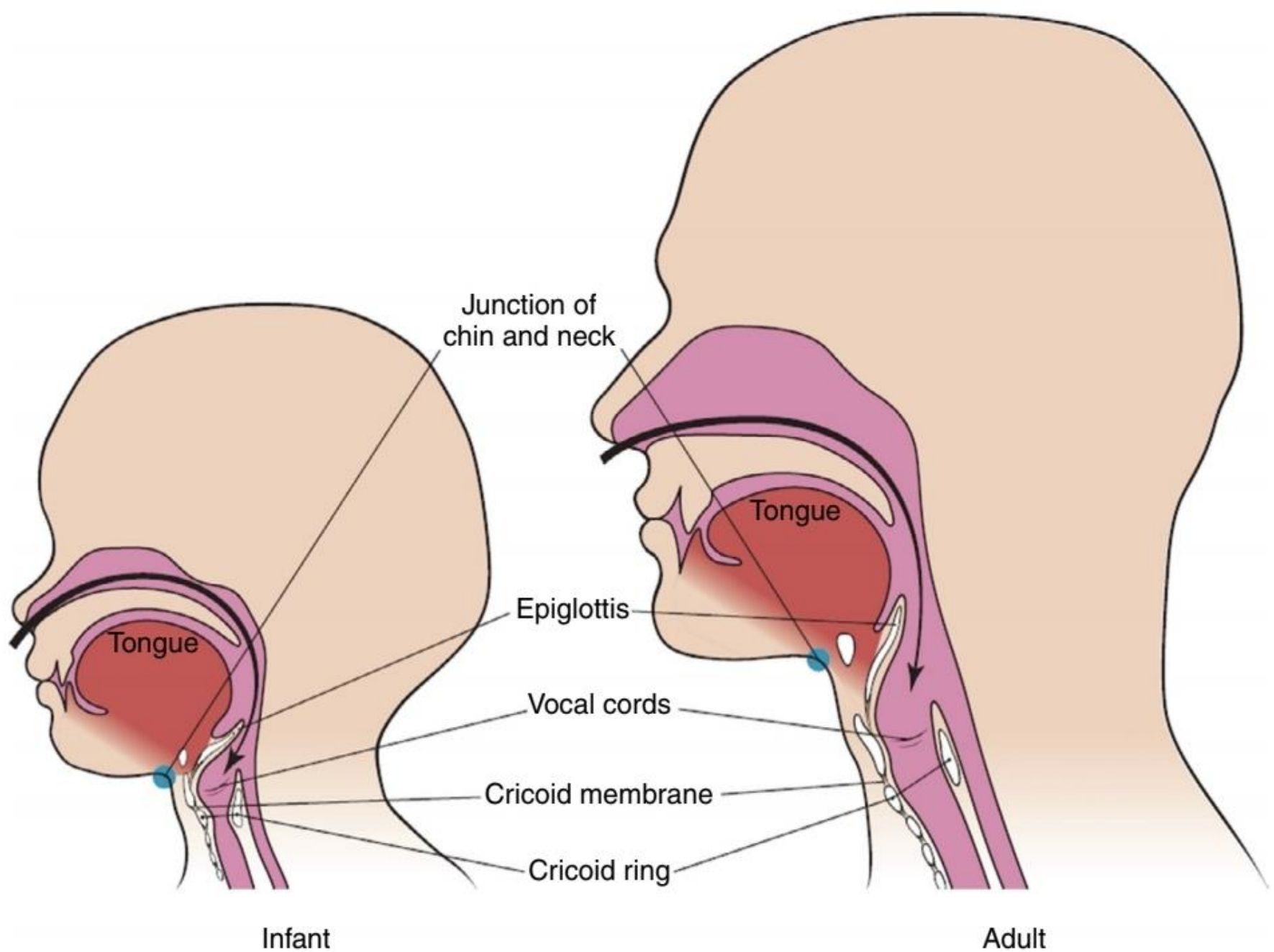


**TABLE 156.1    Anatomic Differences in Pediatric Airway Management**

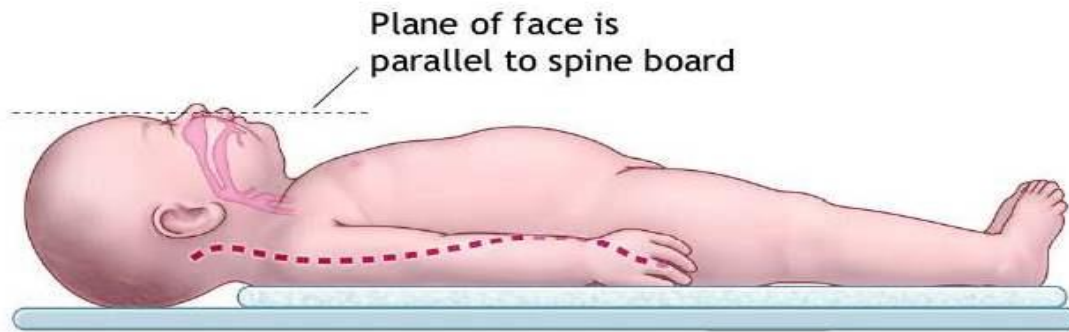
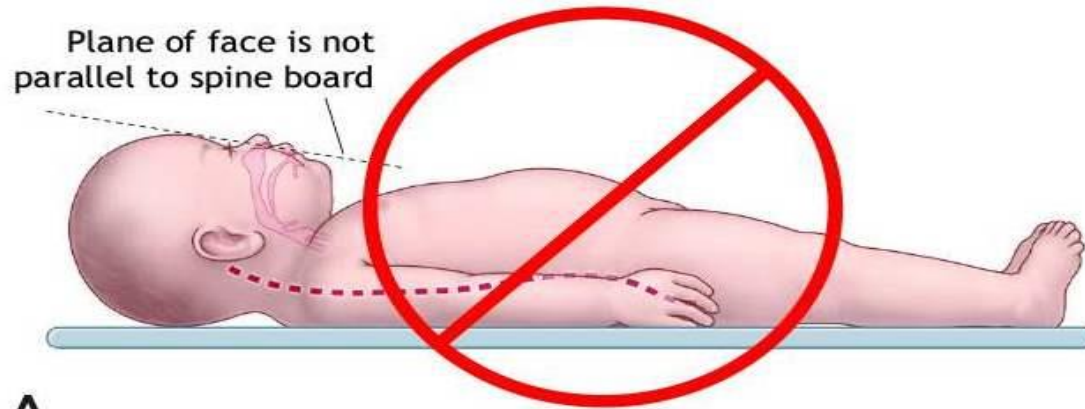
<b>Anatomic Difference</b>	<b>Implications for Airway Management</b>	<b>Solution</b>
Large occiput and head	Neck position flexed when lying supine and flat on stretcher	Shoulder roll required for optimal positioning of young infant
Large tongue	May occlude airway in the unconscious or obtunded patient	Jaw thrust and oral or nasopharyngeal airway useful adjuncts during airway management
High, anterior airway	Visualization of the vocal cords may be difficult	Correct positioning prior to laryngoscopy critical
Upper airway anatomy and narrow subglottic region	Upper airway prone to dynamic collapse and inflammation (e.g., croup)	Cuffed tubes safe, and sometimes preferred, as long as cuff pressure monitored
Large tonsils and adenoids	Prone to bleeding with manipulation	Blind nasotracheal intubation relatively contraindicated younger than 10 years old
Small cricothyroid membrane	Surgical cricothyrotomy difficult	Needle cricothyrotomy recommended in infants and young children
Large stomach, dependence on diaphragmatic excursion for ventilation	Insufflation of the stomach during BMV can compromise ventilation	Use orogastric or nasogastric tube for decompression



**Fig. 156.1** Correct positioning of a pediatric patient to ensure optimal airway alignment utilizing a line passing through the external auditory canal and the anterior shoulder. (A) The small infant requires a shoulder roll to achieve optimal positioning, the small child typically requires neither a shoulder roll nor head support, and the older child/adolescent may require head support. (B) In this small child, a line drawn through the external auditory canal and the anterior shoulder reveals the child to be in good position without support. Slight extension of the head results in the achievement of the sniffing position.

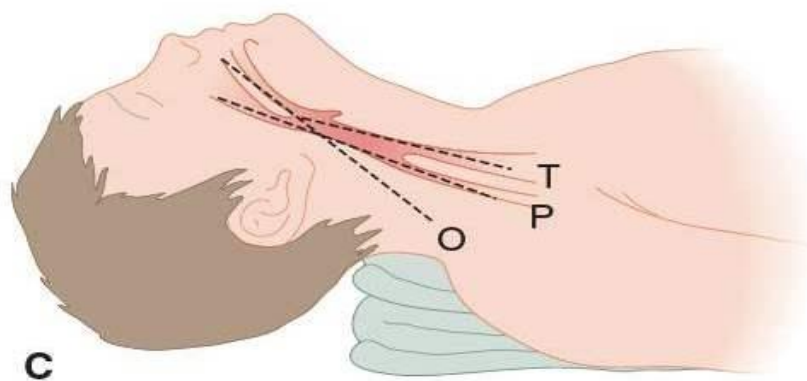
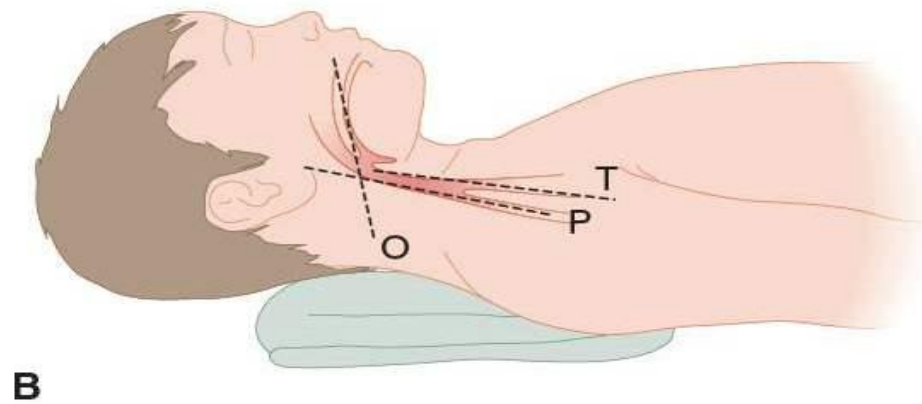
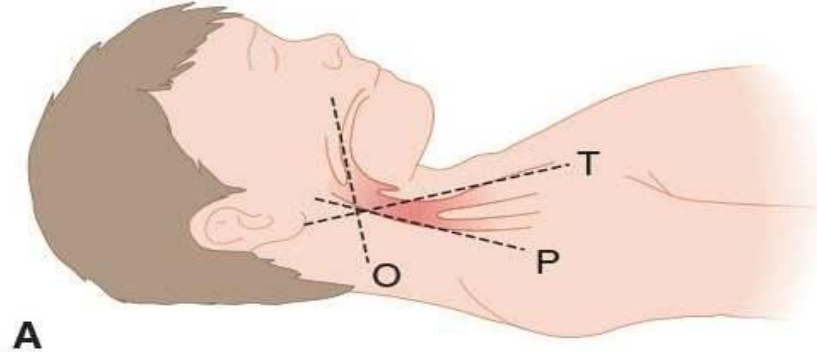


**Fig. 156.2** High, anterior airway of the small child. Anatomic difference in the relation of the glottis in the small child compared with the adult.



**FIGURE 10-2 Positioning for Airway Maintenance.** **A.** Improper positioning of a child to maintain a patent airway. The disproportion between the size of the child's cranium and midface leads to a propensity for the posterior pharynx to buckle anteriorly. The large occiput causes passive flexion of the cervical spine. **B.** Proper positioning of a child to maintain a patent airway. Avoid passive flexion of the cervical spine by keeping the plane of the midface parallel to the spine board in a neutral position, rather than in the "sniffing position." Placement of a 1-inch layer of padding beneath the infant's or toddler's entire torso will preserve neutral alignment of the spinal column.





**FIGURE 111-1.** Alignment of axes. A. Large occiput and anterior airway make alignment of airway axes difficult. B. Shoulder roll aligns tracheal and pharyngeal axes, but (C) neck extension may be needed to align all three airway axes. O = oral; P = pharyngeal; T = tracheal.



# Bag-Mask Ventilation

## Indications

Initial ventilation technique in apneic patients  
Rescue ventilation after failed intubation

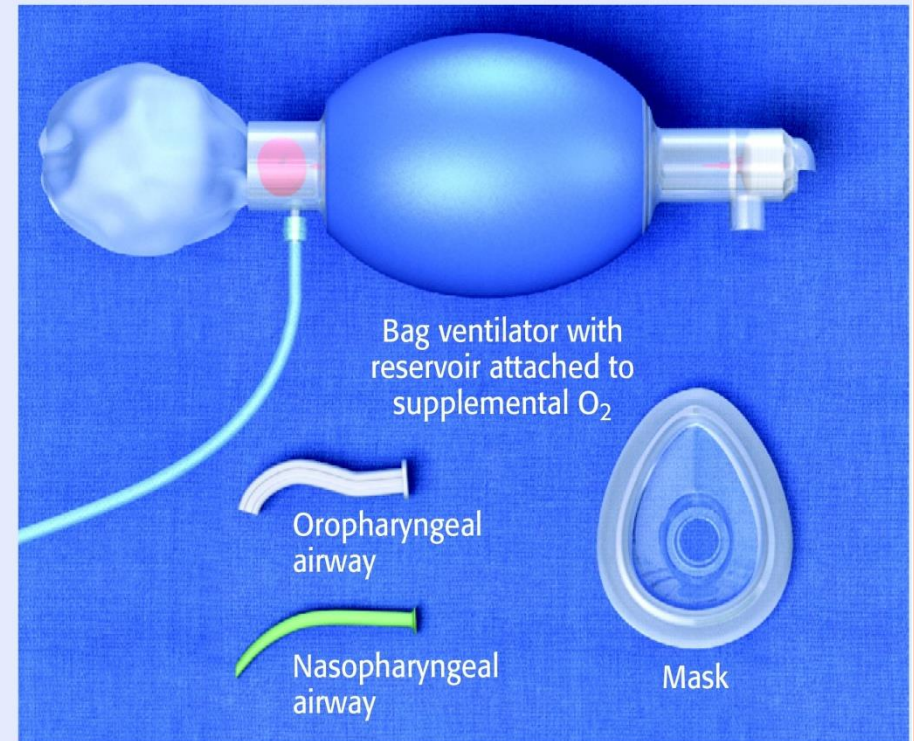
## Contraindications

Situations when application of a face mask is impossible  
(e.g., deforming facial trauma, thick beards)

## Complications

Inability to ventilate  
Gastric inflation

## Equipment



**Review Box 3-2** Bag-mask ventilation: indications, contraindications, complications, and equipment.

# BAG-MASK VENTILATION

## ONE-HANDED TECHNIQUE



The "C-E" clamp technique provides the most effective seal.

Use your thumb and index finger to form a letter "C" and provide anterior pressure on the mask.



Use your third, fourth, and fifth fingers to lift the mandible up into the mask. It may be possible to place the fifth finger behind the mandible and perform a jaw thrust.

## TWO-HANDED TECHNIQUE



The traditional technique is the "double C-E" method.

Use the thumb and index fingers of both hands to encircle the top of the mask.



Use the third, fourth, and fifth fingers of each hand to lift both sides of the mandible to meet the mask. It is difficult to do a good jaw lift with this method.



A better two-handed method is to hold the mask in place with the thenar eminences of both hands.




Use the long fingers under the mandible to do a jaw lift while also pressing the mask firmly against the face. This allows the operator to do a good jaw lift and create a good seal with the strongest muscles of the hands.





Proper facemask size.

GENERIC PEDIATRIC RSI

zero – 10+ min. <b>Preparation</b>		
	<b>Preoxygenation</b>	100% O <sub>2</sub>
	Apneic preoxygenation (1-2 lpm per year of age to a max of 15 lpm)	
	<b>Pre-Intubation Optimization</b>	Atropine*
zero	<b>Paralysis with Induction</b>	Etomidate, SCh or Rocuronium
zero + 15 sec.	<b>Positioning</b>	Consider shoulder roll for infants < 6 months
zero + 45 sec.	<b>Placement with Proof</b>	Intubate
	Confirm placement clinically and with ET/CO <sub>2</sub> detection	
zero + 1 min.	<b>Post-Intubation Management</b>	Sedation and analgesia
	Paralysis only if necessary	

\* optional, used principally for infants less than one year of age

The Broselow Luten zones for  
PEDIATRIC DRUGS AND EQUIPMENT

the.difficult  
airwaycourse™

theairwaysite.com

INTUBATION CONSIDERATIONS IN CHILDREN

**Insertion Depth** — see color chart

**Ventilator Settings**

**FiO<sub>2</sub>:** 100%

**PEEP:** 5 cm H<sub>2</sub>O initial

**PIP:** 20–30 cm H<sub>2</sub>O

**Inspiratory Time:** see color chart

**Tidal Volume\* and RR:** see color chart

**Post Intubation** — Secure tube at lip and stabilize neck

\*Tidal volume of 6–10 mL/kg frequently used, but assess patient to determine there is chest rise and distal air entry on exam. Adequate tidal volume typically requires PIP of at least 15 cm H<sub>2</sub>O if lung compliance is normal.

ZONE	3kg	4kg	5kg	PINK	RED	PURPLE	YELLOW	WHITE	BLUE	ORANGE	GREEN
Length (cm)	46–52	52–57	57–61	61–67	67–75	75–85	85–97	97–109	109–121	121–133	133–146
Weight (kg)	3	4	5	6–7	8–9	10–11	12–14	15–18	19–23	24–29	30–36
<b>PRETREATMENT</b>											
Atropine	0.06 mg	0.08 mg	0.1 mg	0.13 mg	0.17 mg	0.2 mg	N/A	N/A	N/A	N/A	N/A
<b>INDUCTION</b>											
Etomidate	0.9 mg	1.2 mg	1.5 mg	2 mg	2.5 mg	3.2 mg	4 mg	5 mg	6.3 mg	8 mg	10 mg
Ketamine	6 mg	8 mg	10 mg	13 mg	17 mg	20 mg	26 mg	33 mg	42 mg	53 mg	66 mg
Propofol	9 mg	12 mg	15 mg	20 mg	25 mg	32 mg	40 mg	50 mg	63 mg	80 mg	100 mg
<b>PARALYSIS</b>											
Succinylcholine	6 mg	8 mg	10 mg	13 mg	17 mg	20 mg	26 mg	33 mg	40 mg	53 mg	66 mg
Rocuronium	3 mg	4 mg	5 mg	7 mg	9 mg	10 mg	13 mg	17 mg	21 mg	27 mg	33 mg
<b>MAINTENANCE*</b>											
Vecuronium	0.3 mg	0.4 mg	0.5 mg	0.7 mg	0.9 mg	1 mg	1.3 mg	1.7 mg	2.1 mg	2.7 mg	3.3 mg
Lorazepam	0.15 mg	0.2 mg	0.25 mg	0.3 mg	0.4 mg	0.5 mg	0.6 mg	0.8 mg	1 mg	1.3 mg	1.6 mg
<b>EQUIPMENT</b>											
ET Tube (mm)	3.5 unc/3.0 cuff	3.5 unc/3.0 cuff	3.5 unc/3.0 cuff	3.5 unc/3.0 cuff	3.5 unc/3.0 cuff	4.0 unc/3.5 cuff	4.5 unc/4.0 cuff	5.0 unc/4.5 cuff	5.5 unc/5.0 cuff	5.5 cuff	6.0 cuff
Lip-Tip (cm)	9–9.5	9.5–10	10–10.5	10–10.5	10.5–11	11–12	12.5–13.5	14–15	15.5–16.5	17–18	18.5–19.5
Suction	8 F	8 F	8 F	8 F	8 F	8–10 F	10 F	10 F	10 F	10 F	12 F
L-Scope blade	1 St.	1 St.	1 St.	1 St.	1 St.	1 St.	2 St./Cvd.	2 St./Cvd.	2 St./Cvd.	2–3 St./Cvd.	2–3 St./Cvd.
Stylet	6 F	6 F	6 F	6 F	6 F	6 F	10 F	10 F	10 F	14 F	14 F
Oral Airway	50 mm	50 mm	50 mm	50 mm	50 mm	60 mm	60 mm	60 mm	70 mm	80 mm	80 mm
NP Airway	14 F	14 F	14 F	14 F	14 F	18 F	20 F	22 F	24 F	26 F	26 F
ETCO <sub>2</sub> Detector	PED	PED	PED	PED	PED	PED	PED	ADULT	ADULT	ADULT	ADULT
BVM (min vol mLs)	450	450	450	450	450	450	450	450–750	750–1000	750–1000	1000
LMA	1	1	1	1.5	1.5	2	2	2	2–2.5	2.5	3
<b>VENTILATION</b>											
Tidal Volume mL	20–30	24–40	30–50	40–65	50–85	65–105	80–130	100–165	125–210	160–265	200–330
Frequency (BPM)	20–25	20–25	20–25	20–25	20–25	15–25	15–25	15–25	12–20	12–20	12–20
Insp. time (sec)	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8



**A**

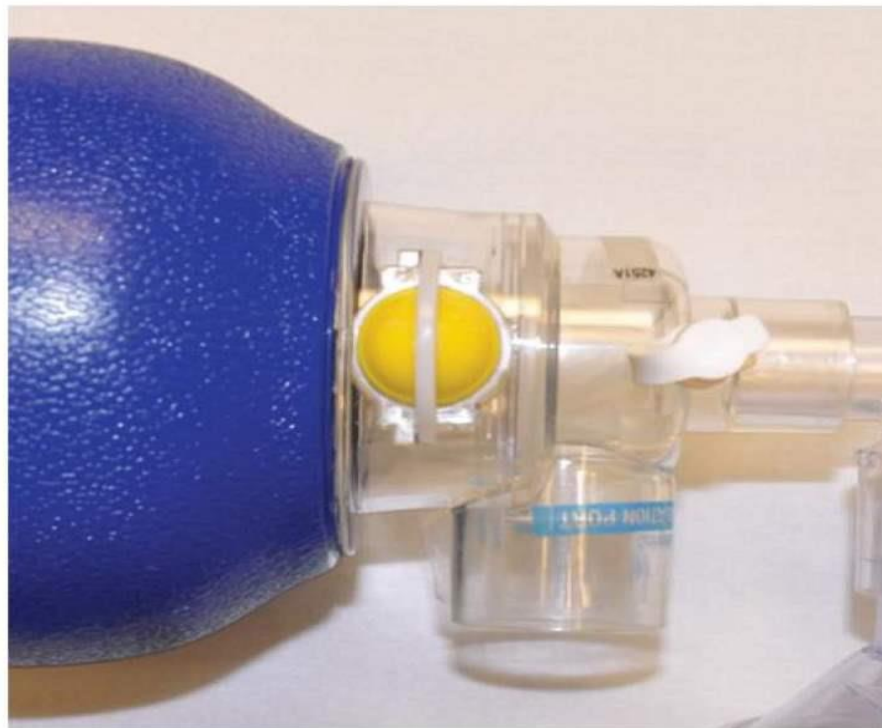


**B**

**FIGURE 111-4.** Bag-mask ventilation using (A) the “C-grip” or “E-C clamp” technique for small children, pulling the face into the mask, and (B) the two-person, two-handed technique.



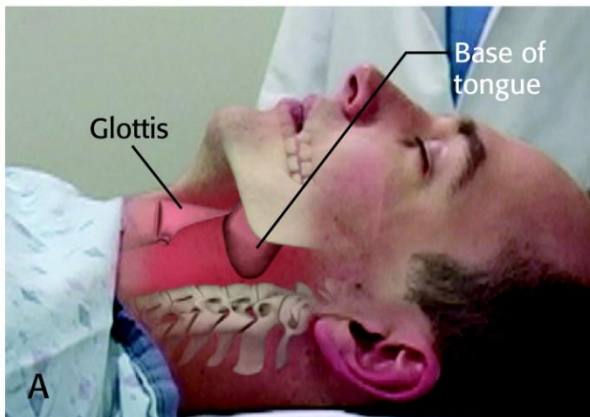
- Most **pediatric bags** incorporate a **pop-off**, or **pressure-relief, valve**. Designed to **avoid barotrauma**, the **valve will open** at a **preset peak pressure** (usually **35 to 40 cm H<sub>2</sub>O of pressure**).
- However, in **some diseases** associated with **high airway pressures**, such as **asthma** or airway obstruction, **higher peak pressures may be needed** to achieve adequate ventilation. In these circumstances, **disable** or **occlude the pop-off valve manually**

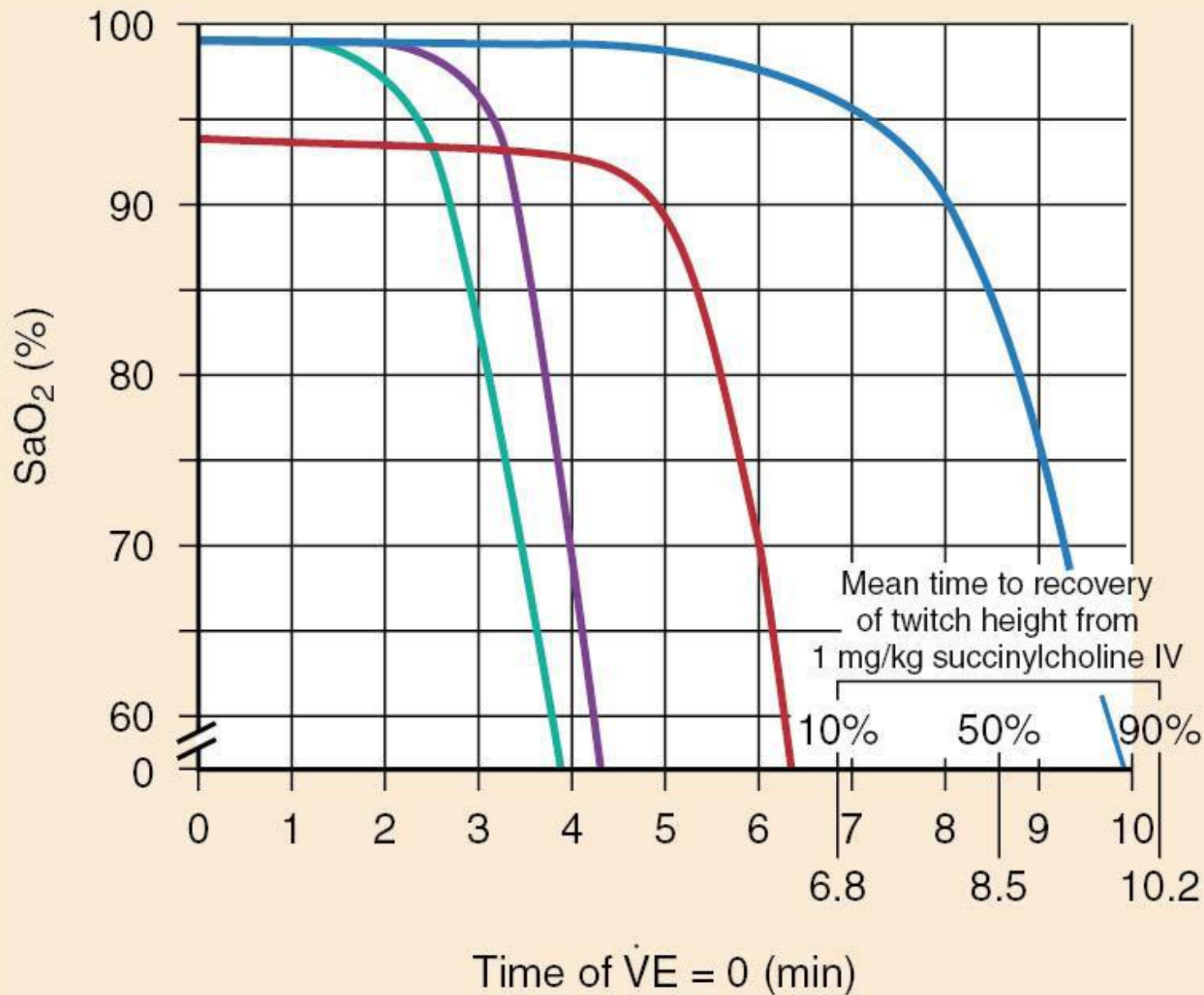


**FIGURE 111-5.** The pop-off valve on a pediatric bag-valve mask, designed to prevent barotraumas, may need to be occluded when higher pressures are required, such as in patients with asthma.



## MANUAL AIRWAY MANEUVERS





- Obese 127-kg adult
- Normal 10-kg child
- Normal 70-kg adult
- Moderately ill 70-kg adult

**Children are prone to desaturation due to their high metabolic rate and their lungs' small functional residual capacity, making preoxygenation and maintenance of oxygenation during intubation attempts crucial.**



# Direct Laryngoscopy

## Indications

Routine emergency intubation  
Difficult airways

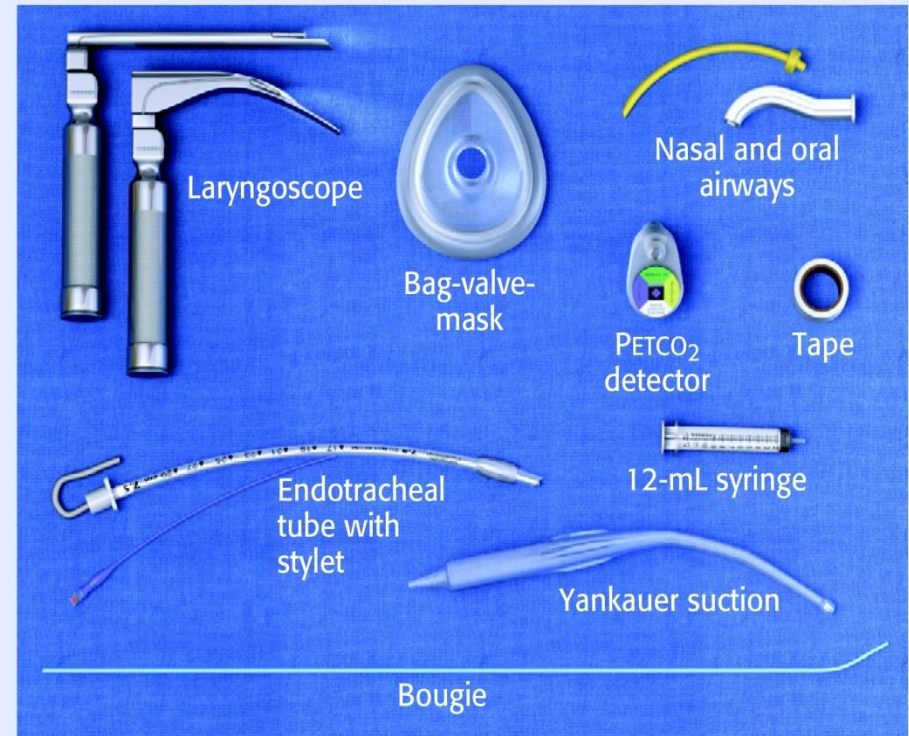
## Contraindications

Hypoxia (perform bag-mask ventilation instead)  
Limited mouth opening  
Upper airway distortion or swelling  
Kyphosis (extreme curvature of the upper back)  
Copious blood or secretions

## Complications

Hypoxic brain injury  
Cardiac arrest  
Aspiration  
Upper airway trauma  
Dental trauma

## Equipment

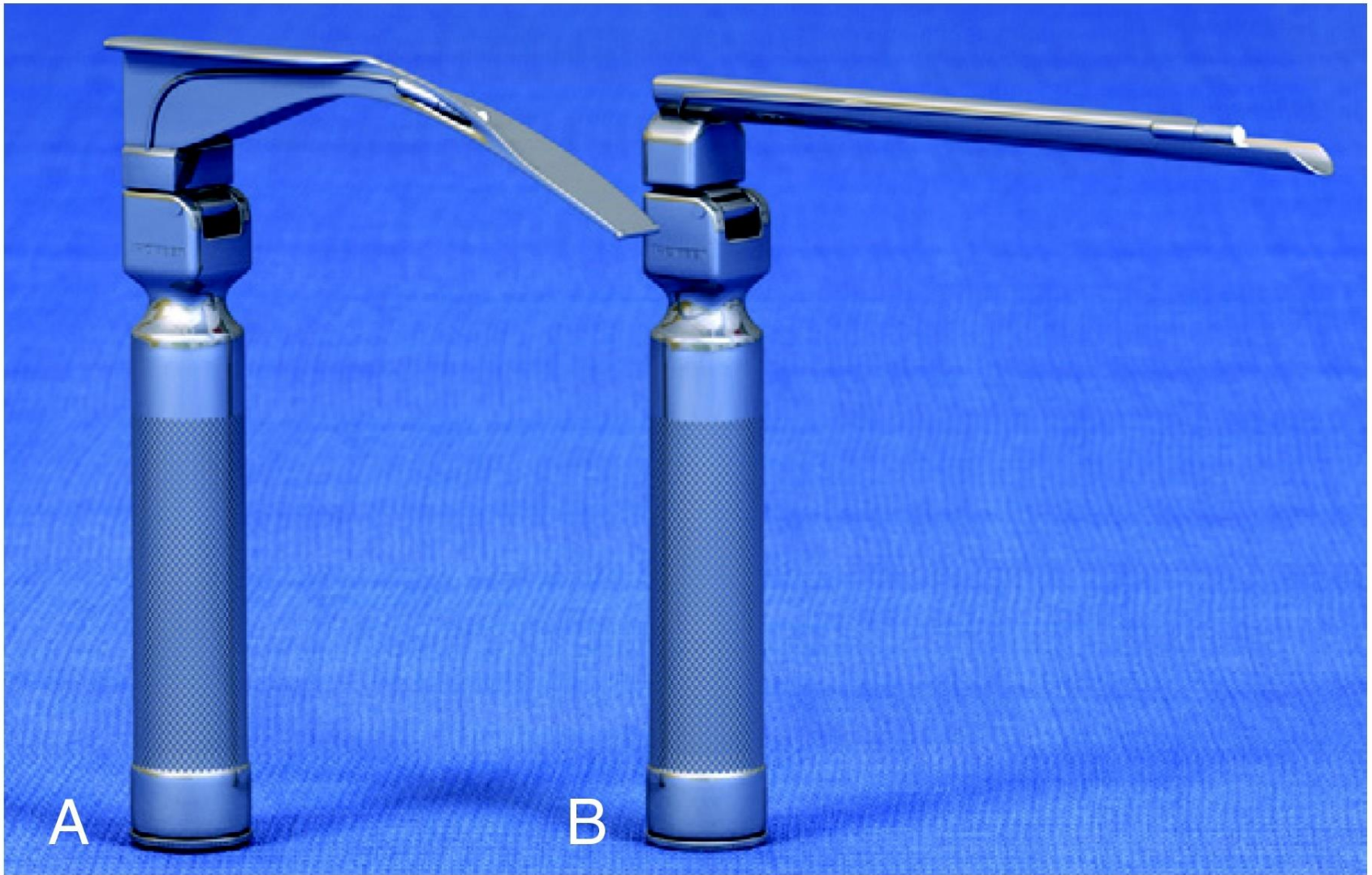


**Review Box 4-1** Direct laryngoscopy: indications, contraindications, complications, and equipment.

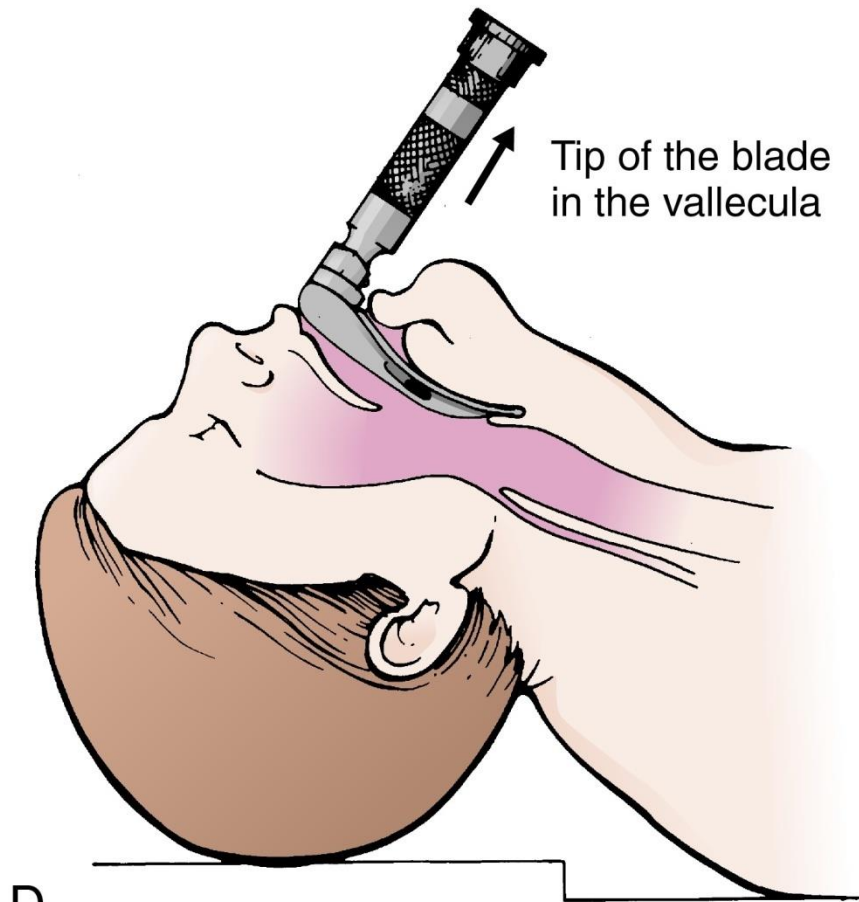
## ○ Indications for pediatric intubation can be placed into four categories:

- ❖ (1) inability to oxygenate and ventilate;
- ❖ (2) inability to maintain or protect the airway;
- ❖ (3) potential for clinical deterioration;
- ❖ (4) facilitation of necessary diagnostic studies, procedures, or for safe patient transport (e.g., high risk of decompensation on route).

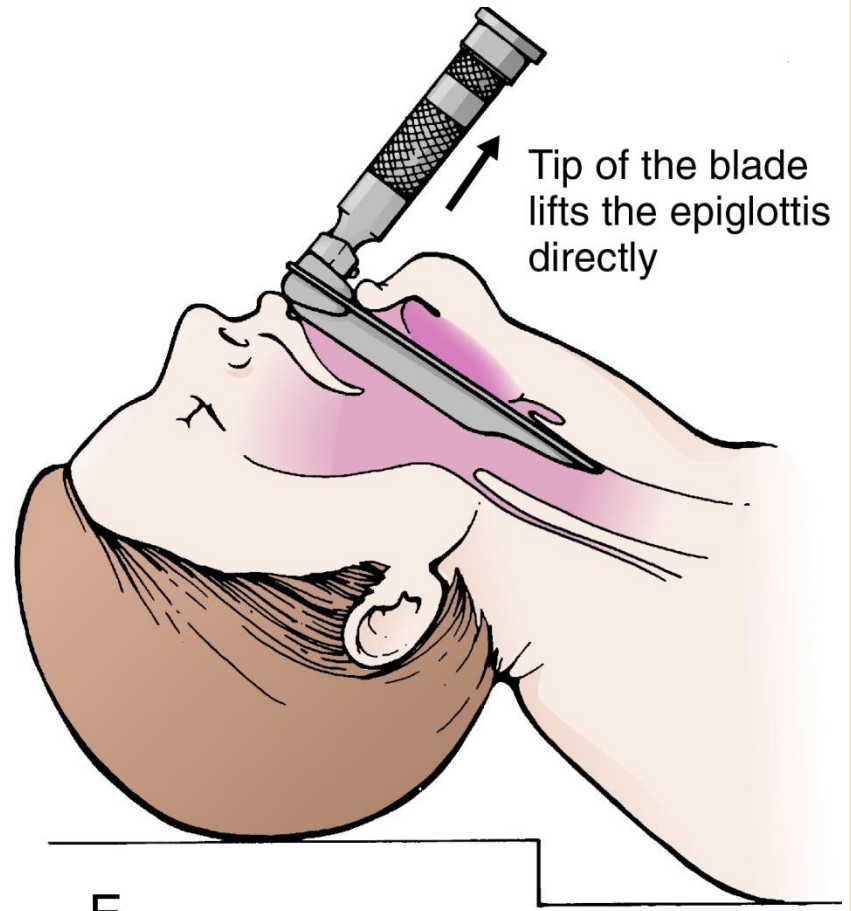




**Figure 4-5** Macintosh (**A**) and Miller (**B**) laryngoscope blades.



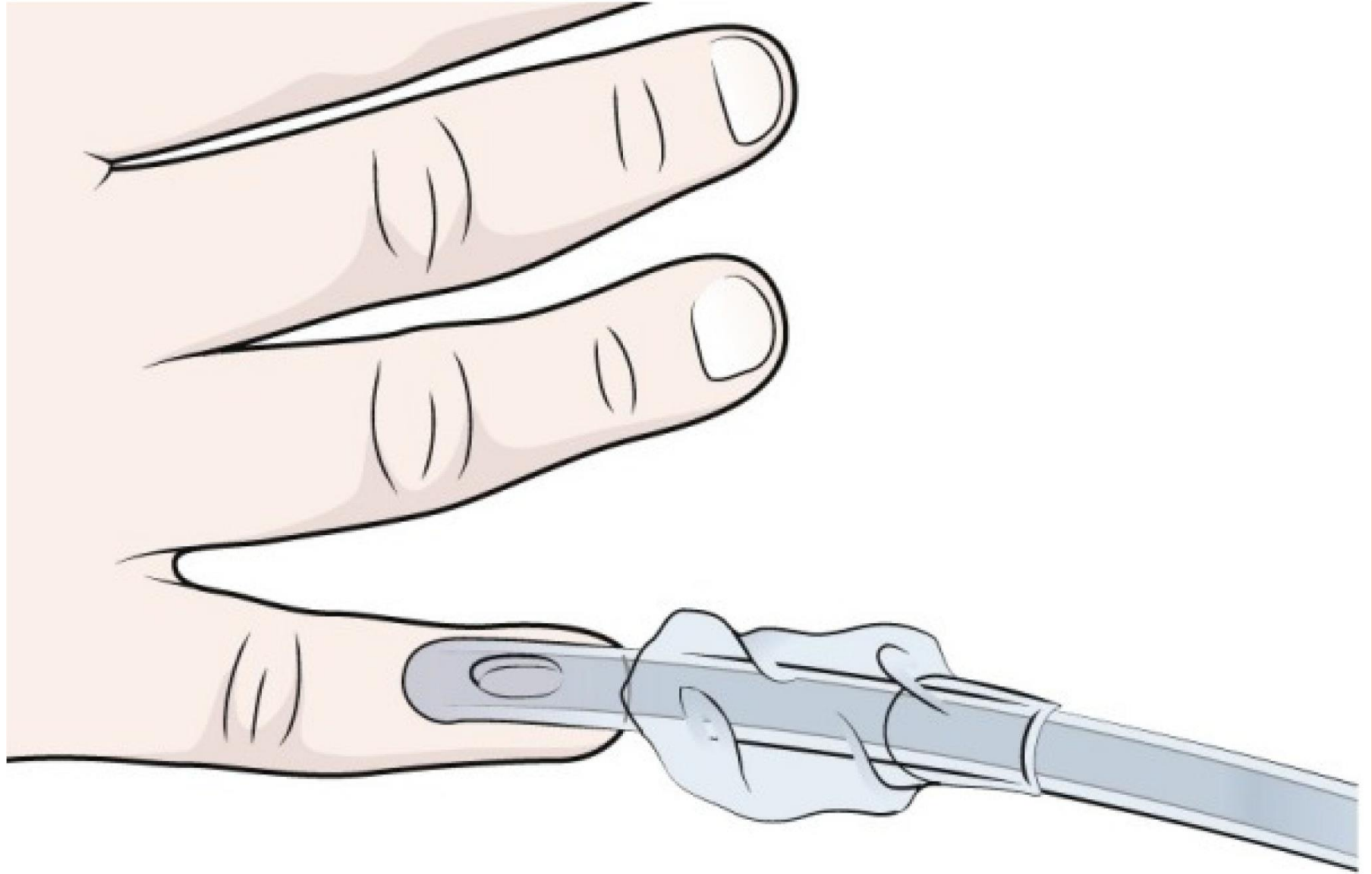
D



E

Anatomy





**Figure 4–5** Pediatric endotracheal tube size estimation using the fingernail width of the little finger.

# ETT SIZE

❖ **ETT Size: (Age [yr] + 16) / 4**

**OR**

❖ **ETT Size: (Age[yr] / 4) + 4**

Uncuffed tube size (mm) =  $4 + (\text{Age (yr)} / 4)$

Cuffed tube size (mm) =  $3 + (\text{Age (yr)} / 4)$

# TRACHEAL TUBE DEPTH

## ○Children:

**Tracheal tube depth (cm) = age (yr)/2 + 12**  
**3( Internal diameter of the ETT )**

Depth can be estimated using the formula below:

Tube internal diameter  $\times$  3 = tube depth at lips



## ○Adults:


**Tracheal tube depth (cm) = 21 cm (women)**

**Tracheal tube depth (cm) = 23 cm (men)**

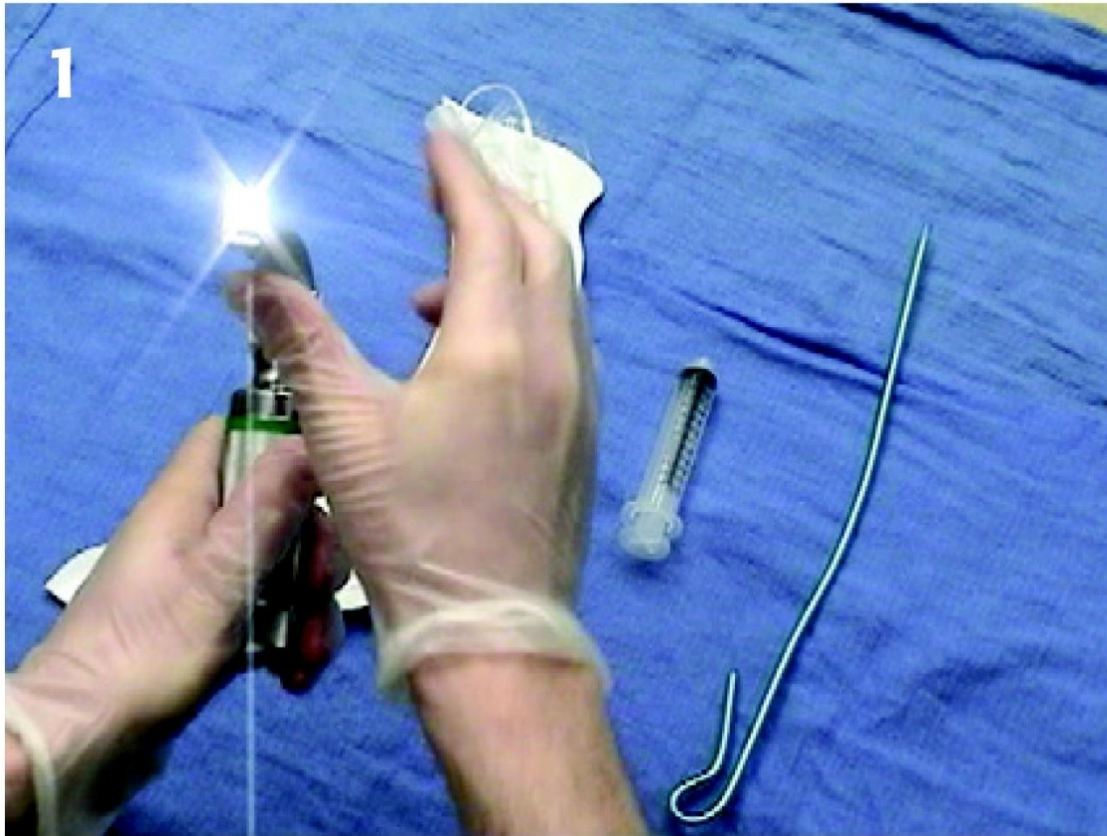
# **PEDIATRIC BASIC AND ADVANCED LIFE SUPPORT**

**Cuffed ETTs are suggested to reduce air leak  
and the need for tube exchanges for  
patients of any age who require intubation**



- **Current cuff technology can accurately measure cuff inflation pressures, and we recommend using cuffed tubes for intubation of children, particularly in instances of high airway pressures or poor compliance (e.g., asthma, pneumonia, and acute respiratory distress syndrome [ARDS]).**
  - **Utilizing a cuffed ETT may obviate the need to replace and upsize a tube when there is significant air leak that impacts ventilation, avoiding the risk of losing an already secured airway.**
- 

1



Check all equipment, including the light on the laryngoscope and the cuff on the endotracheal tube.

Ensure that suction and difficult airway devices are within reach.



2



Place patient in the sniffing position, elevate the bed so that the patient's head is at the level of the lower part of your sternum, and preoxygenate.



- Careful attention to preoxygenation is crucial. Additionally, use of nasal cannula (1–2 L/min/year of age to a maximum of 15 L/min) during the apneic period may help support oxygenation until intubation can be achieved.
- BMV should be provided between intubation attempts when oxygen saturation levels start to decline below 95%.





Hold laryngoscope with your left hand. Open patient's mouth with your right hand and introduce the laryngoscope into the right side of the patient's mouth.

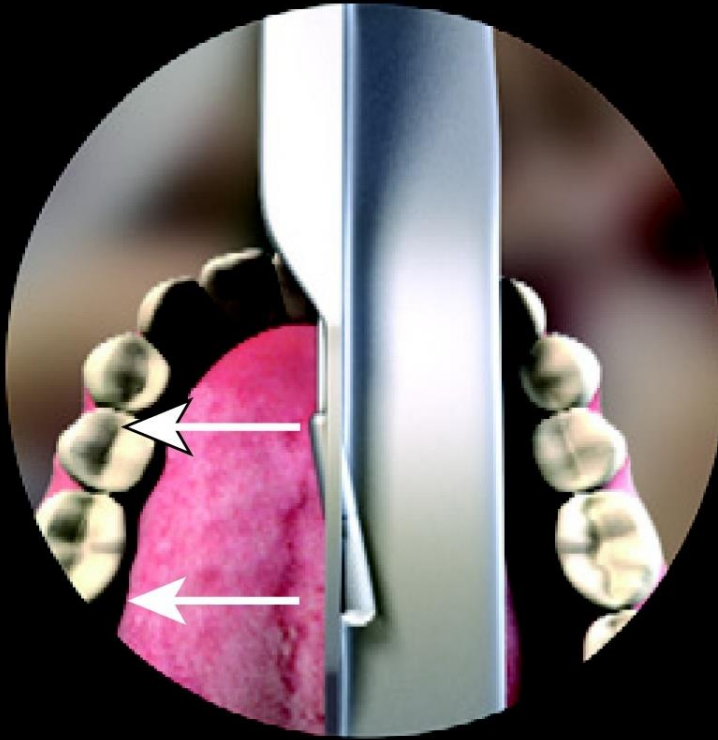


- Emergency clinicians should start the intubation procedure by placing the laryngoscope blade just to the base of the tongue and lift up to view the airway anatomy.

- Identify structures progressively, first directly identifying the base of the tongue and the epiglottis prior to insertion of the straight blade underneath the epiglottis or the curved blade into the vallecula to visualize the vocal cords.

- If no laryngeal structures are identified due to inadvertent deep insertion, the blade should be slowly withdrawn under visualization, and the cords or the epiglottis will often fall into view.

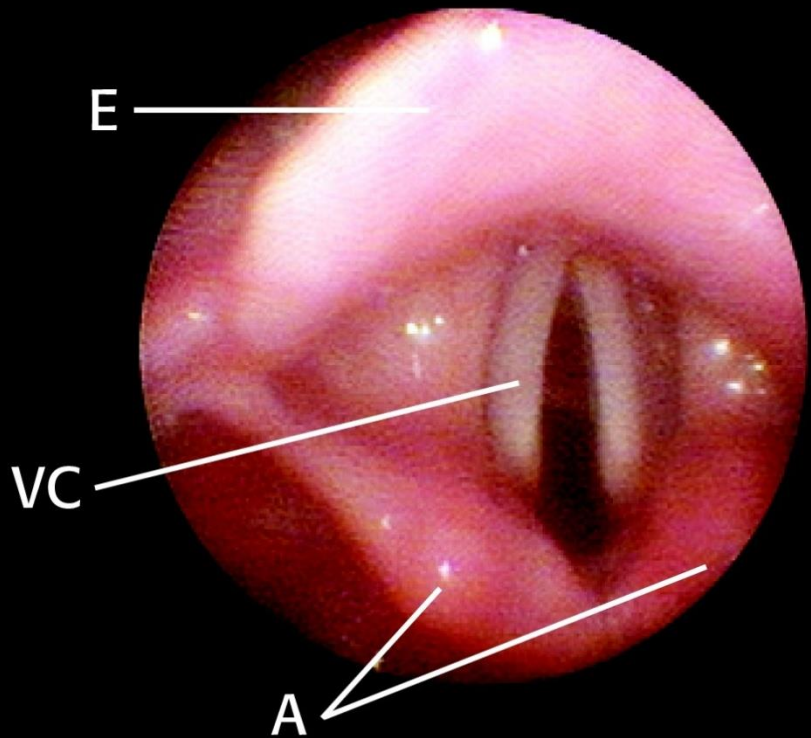
4



Push the tongue to the left side of the mouth, slowly advance the blade, and progressively identify the base of the tongue, the epiglottis, and the posterior cartilages.



5



Place the Macintosh blade in the vallecula, or the Miller blade under the epiglottis (E), and visualize the vocal cords (VC) and arytenoid cartilages (A).

*Do not take your eyes off of the cords once they are identified!*

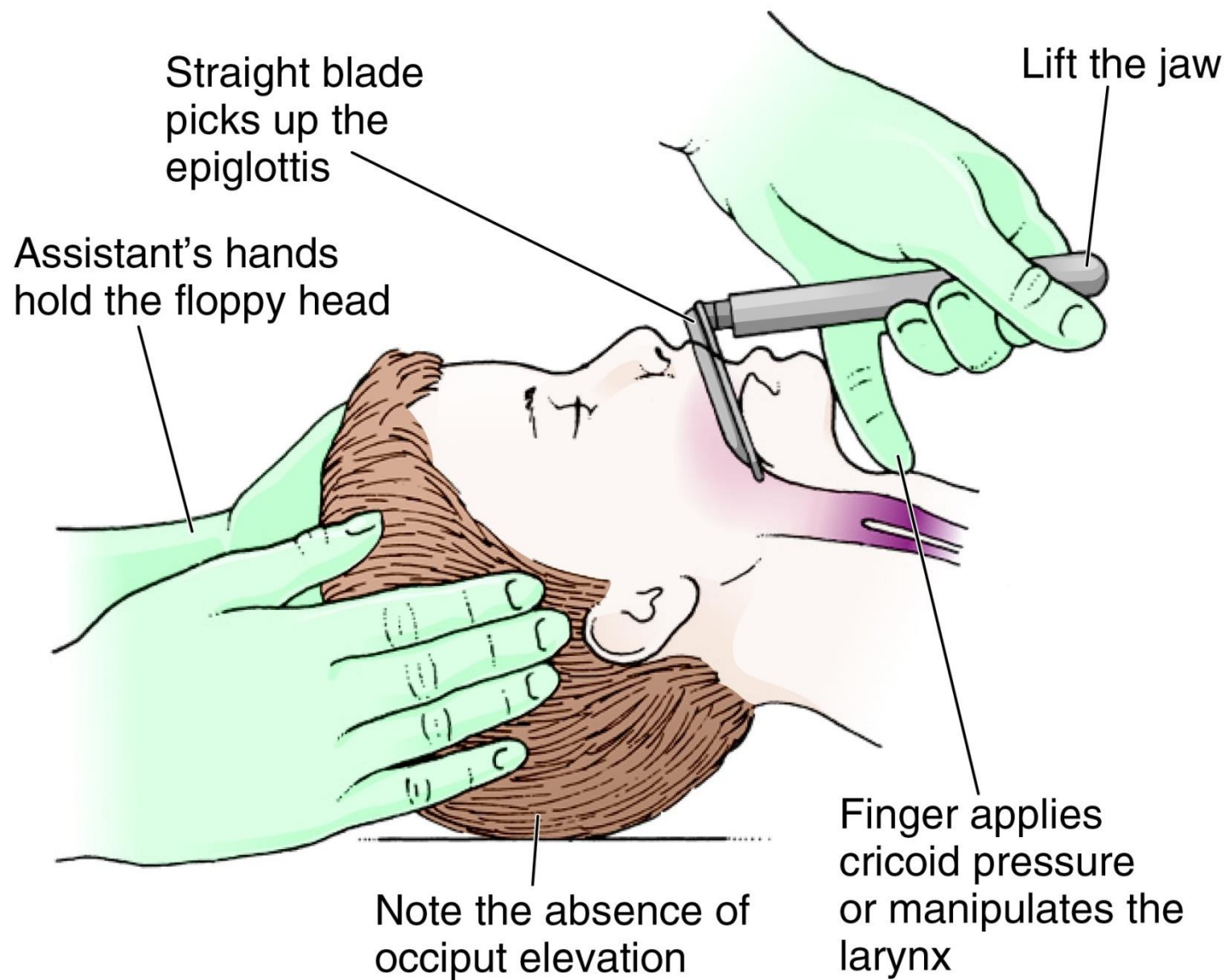




Lift in the direction of the laryngoscope handle.

Manipulate the thyroid cartilage to achieve optimal laryngeal exposure. Have an assistant maintain that position during intubation.





**Figure 4-13** Oral intubation in a child with a straight blade. The proportionately large floppy head of a child may present some difficulty, and an assistant may be required to hold the child's head straight.



**The narrowest point of the child's trachea is at the cricoid ring, which is also the site of mucosal swelling associated with croup.**

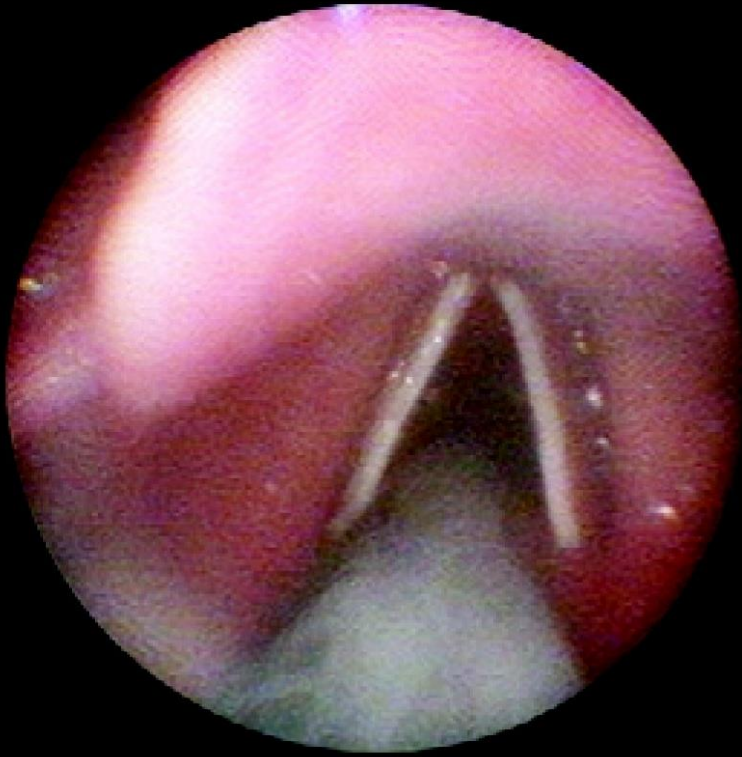




Instruct an assistant to retract the right cheek for better visualization. Pass the tube on the right side of the patient's mouth. *Do not allow the tube to obstruct your view of the vocal cords during advancement!*



8



Under direct visualization, pass the tube 3–4 cm beyond the vocal cords.



9



Remove the stylet and inflate the pilot balloon.

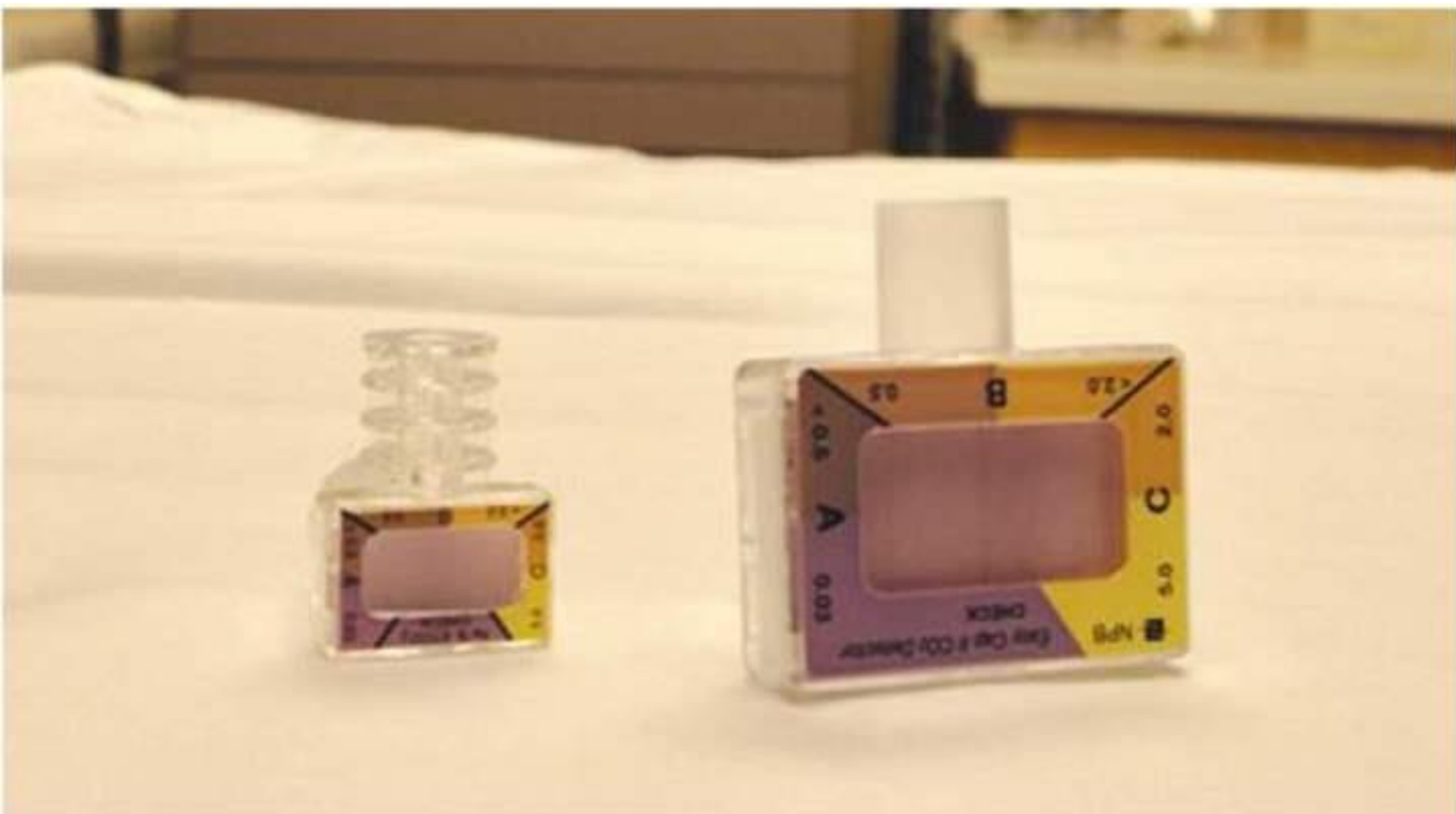


10



Confirm proper placement with end-tidal CO<sub>2</sub> detection, auscultation, and a chest radiograph.





**FIGURE 111-6.** Examples of a pediatric colorimetric end-tidal carbon dioxide detector for children <15 kg and a standard one for larger children.

**Even small movements of the child's head can result in accidental displacement of the tube:** flexion of the neck can advance the tube into a mainstem bronchus, whereas neck extension can lead to unintended extubation



**TABLE 1.1 Sample Rapid Sequence Intubation Using Etomidate and Succinylcholine.**

<b>Time</b>	<b>Step</b>
Zero minus 10 min	Preparation
Zero minus 5 min	Preoxygenation—100% oxygen for 3 min or 8 vital capacity breaths
Zero minus 3 min	Preintubation optimization—as indicated
Zero	Paralysis with induction <ul style="list-style-type: none"><li>• Etomidate, 0.3 mg/kg</li><li>• Succinylcholine, 1.5 mg/kg</li></ul>
Zero plus 30 s	Positioning—Sellick maneuver optional
Zero plus 45 s	Placement <ul style="list-style-type: none"><li>• Laryngoscopy and intubation</li><li>• End-tidal carbon dioxide confirmation</li></ul>
Zero plus 2 min	Postintubation management <ul style="list-style-type: none"><li>• Sedation and analgesia as indicated</li><li>• Initiate mechanical ventilation</li><li>• NMBA only if needed after adequate sedation, analgesia</li></ul>





**Figure 2-12** CO<sub>2</sub> monitors. **A**, Quantitative monitor. A capnography waveform (*arrow*) is displayed, as is a capnometry numerical reading (37). **B**, Qualitative device. This simple colorimetric detector is used to verify endotracheal tube position and changes color when exposed to CO<sub>2</sub>.

Some procedures *are not indicated* in children because of anatomic differences. *Blind nasotracheal intubation is relatively contraindicated in children <10 years old*, because the prominent adenoidal and tonsillar lymphoid tissue is likely to bleed and the acute airway angles described earlier make success less likely



# Laryngeal Mask Airway Insertion

## Indications

- Failed rapid-sequence intubation
- Difficult bag-mask ventilation
- Difficult intubation
- Facial trauma
- Obesity
- Primary airway in cardiac arrest or use by emergency medical services

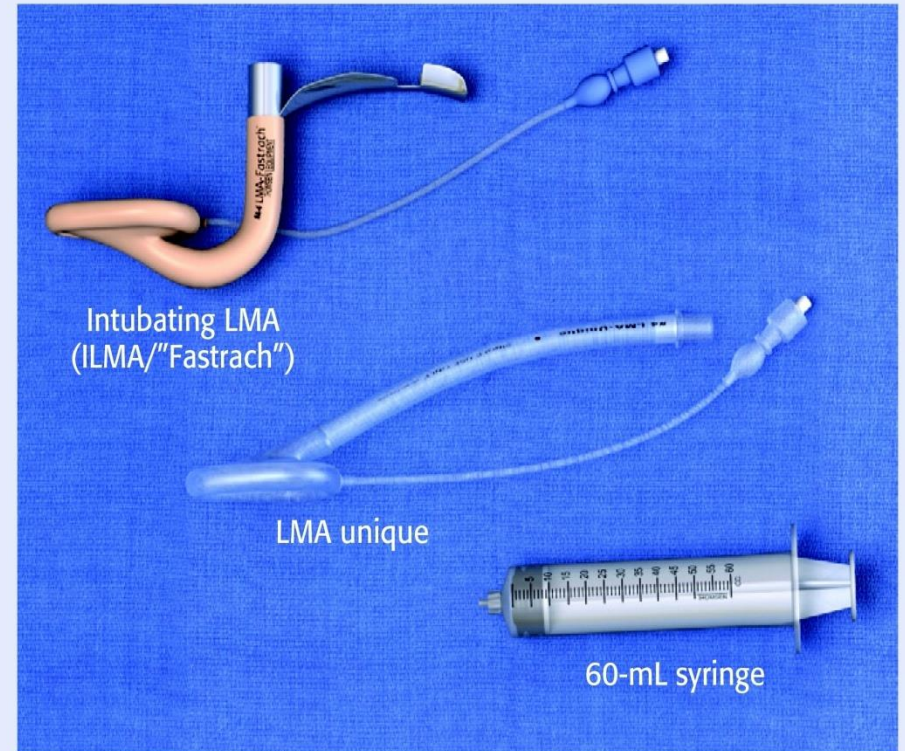
## Contraindications

- Limited mouth opening ( $<2$  cm)
- High airway pressure
- Inadequate paralysis or sedation

## Complications

- Inability to ventilate (rare)
- Inability to intubate
- Aspiration (rare)

## Equipment



**Review Box 3-3** Laryngeal mask airways: indications, contraindications, complications, and equipment.



**Fig. 1.17** The i-gel mask airway (Intersurgical, Berkshire, England) does not have an inflatable cuff and is available in sizes from infant to adult.

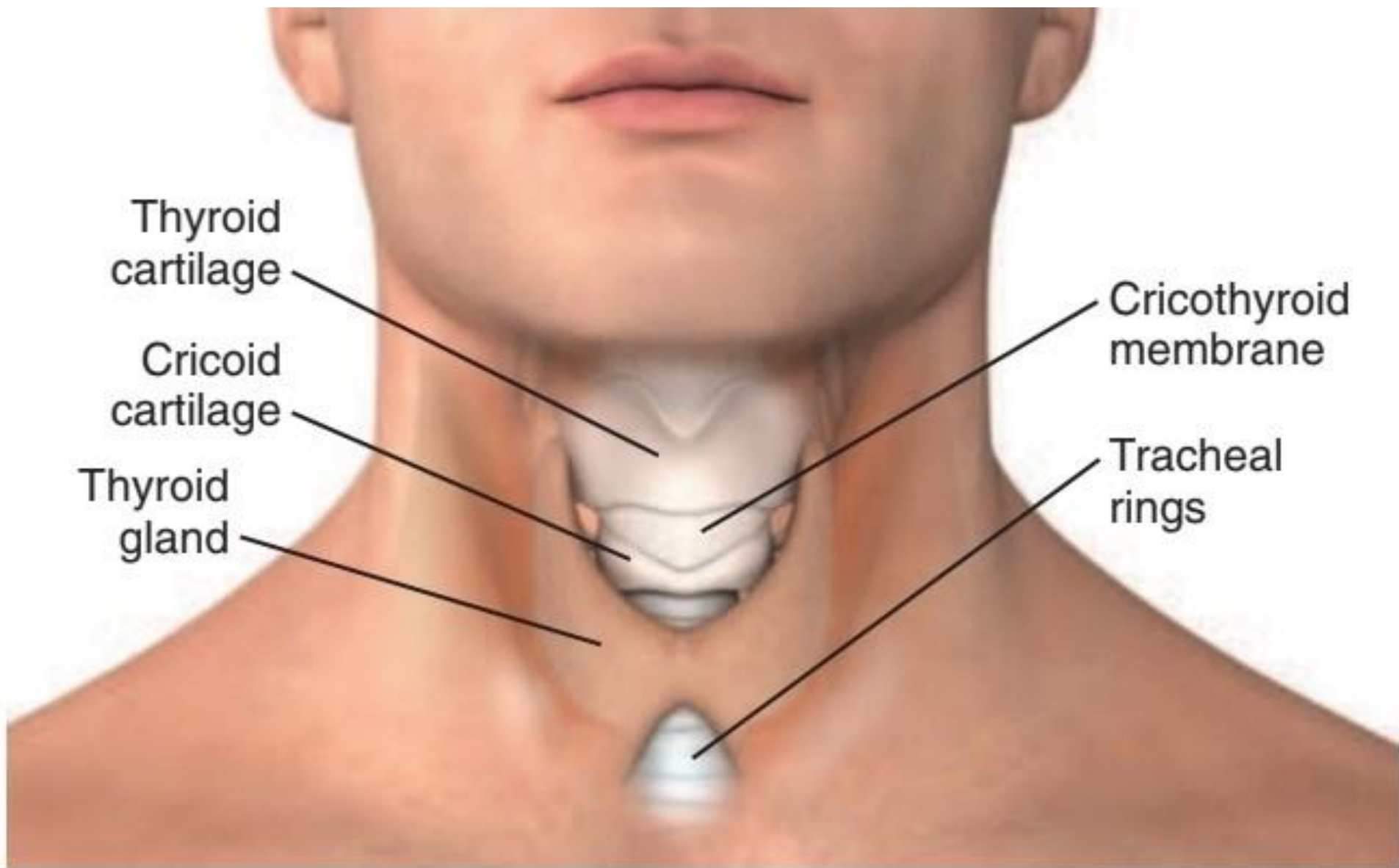


**Fig. 1.19** King laryngeal tube incorporates two cuffs but inflates with a single bolus of air. There is a channel in the back for passage of an orogastric tube. It is available in a variety of adult and pediatric sizes.



**Fig. 1.12** GlideScope titanium handles incorporate similar video elements in a lightweight titanium blade with a narrower side profile. Connection to the video display is made by a USB-style cord.





**Figure 6.1** Normal adult larynx. Note position and configuration of the cricothyroid membrane.

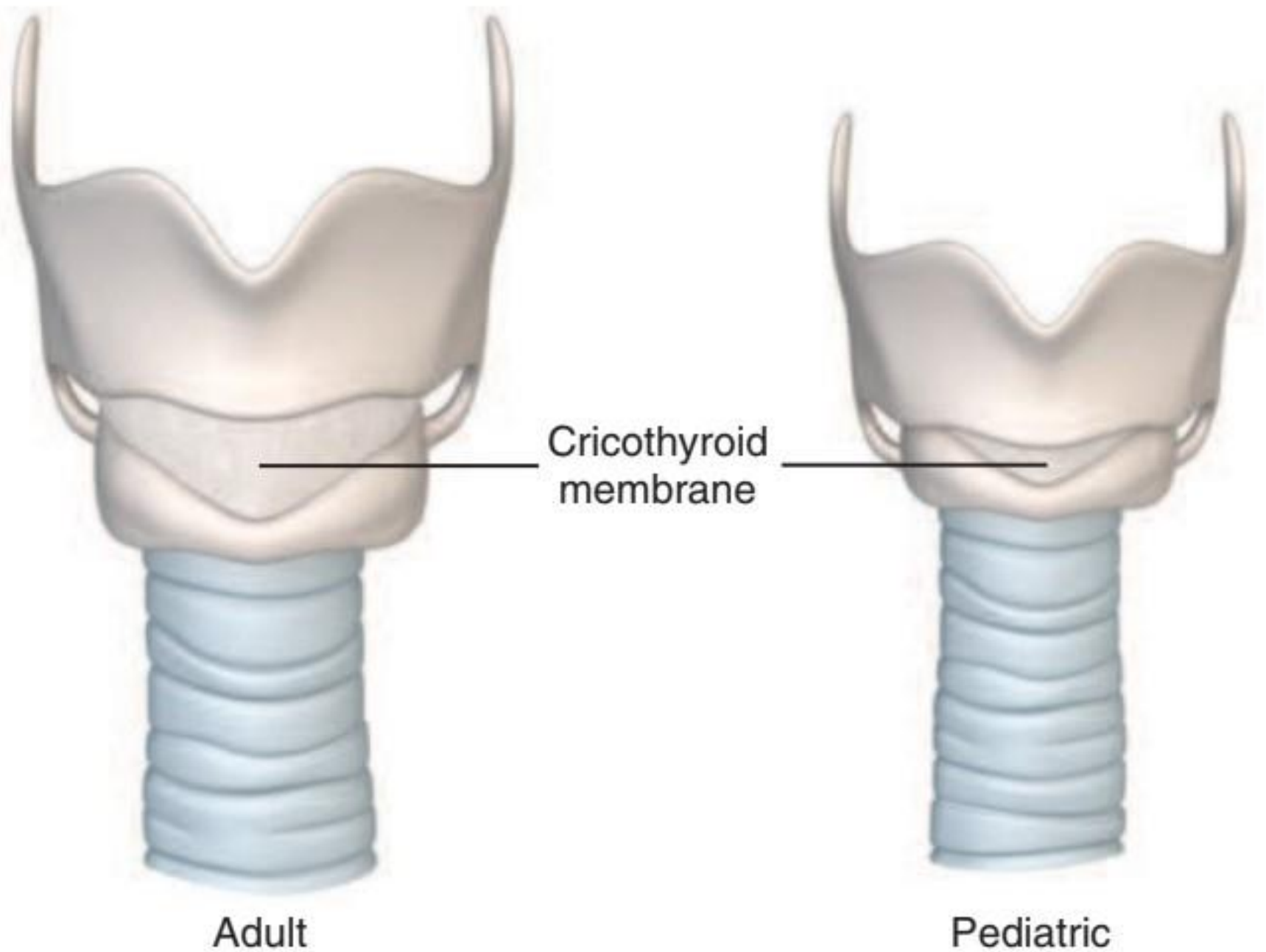
Cricothyrotomy is indicated when oral or nasal intubation is impossible or fails and when BMV or EGD cannot maintain adequate oxygen saturation (the **can't intubate, can't ventilate situation**).



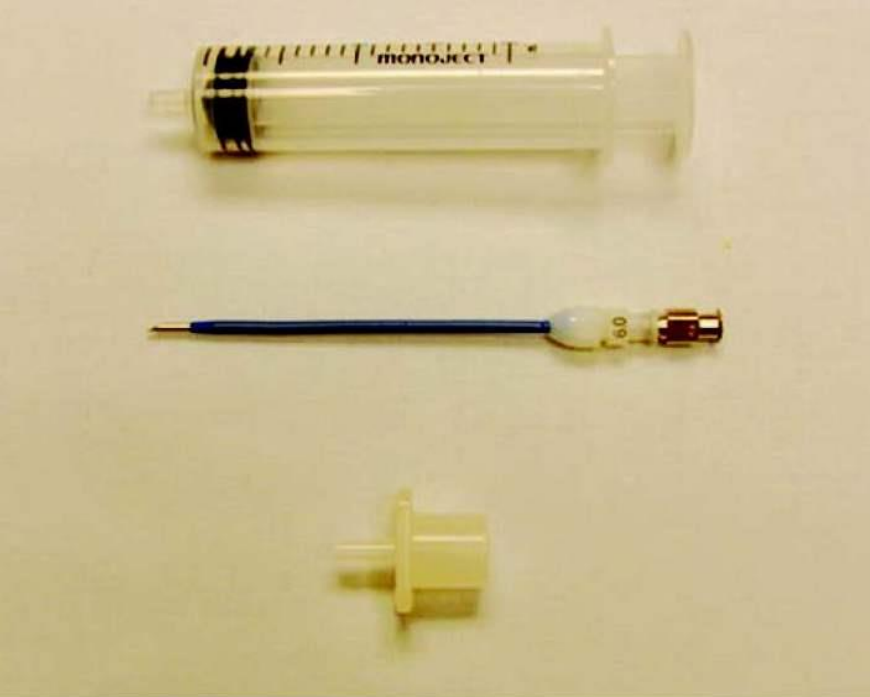
**Surgical cricothyrotomy is contraindicated in children <10 years old because the cricothyroid membrane is too small.**

**Therefore, in children <10 years of age, needle cricothyrotomy is the subglottic, invasive airway of choice.**

**The literature does not support a specific age cutoff for needle cricothyrotomy versus surgical cricothyrotomy, but needle cricothyrotomy should be performed when indicated in infants and small children (<6 years of age or older depending on anatomic landmarks).**



Adult larynx compared with a pediatric larynx.



# Percutaneous Translaryngeal Ventilation

## Indications

Similar to surgical cricothyrotomy  
Failed attempts at endotracheal intubation with an inability to  
bag-mask ventilate to an oxygen saturation  $>90\%$   
Airway obstruction above the level of the cricothyroid membrane  
Preferred method of securing a crash airway in infants  
and children

## Contraindications

Ability to secure the airway through less invasive means  
Laryngeal transection or fracture

## Complications

*Associated with needle placement*

- Subcutaneous emphysema
- Kinking of the catheter
- Bleeding
- Malposition of the catheter
- Posterior tracheal wall perforation
- Pneumothorax

*Associated with ventilation*

- Barotrauma, pneumothorax, pneumomediastinum
- Hypercapnia, respiratory acidosis

## Equipment

For cricothyroid  
membrane puncture:



14-gauge angiocatheter

Saline-filled 5-mL syringe

For attachment to  
bag-valve device:



3-mL syringe and  
7.0 ETT adapter

- or -



Cut IV tubing and  
2.5 ETT adapter

For attachment to wall oxygen source:



Transtacheal  
jet ventilation kit

**Needle-based rescue procedures should be considered an “oxygenation” strategy rather than a “ventilation” strategy, because progressive hypercarbia will inevitably ensue, limiting the utility of this technique for long-term use.**



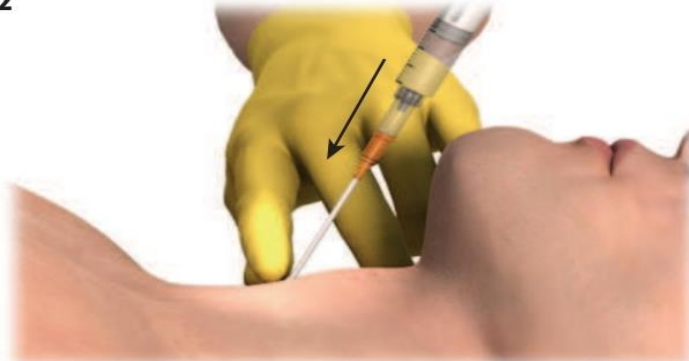
## PERCUTANEOUS TRANSLARYNGEAL VENTILATION

1



Hyperextend the patient's neck if possible. Locate the cricothyroid membrane with your nondominant hand.

2



Attach a 14-gauge angiocatheter to a saline-filled syringe. Insert the needle through the skin, subcutaneous tissue, and membrane directed at a 30° to 45° angle caudally.

3



Aspirate the syringe as you advance the needle; air bubbles will be seen in the syringe when the trachea is entered.

4



Once the trachea is entered, advance the catheter over the needle until the hub is flush with the skin.

5



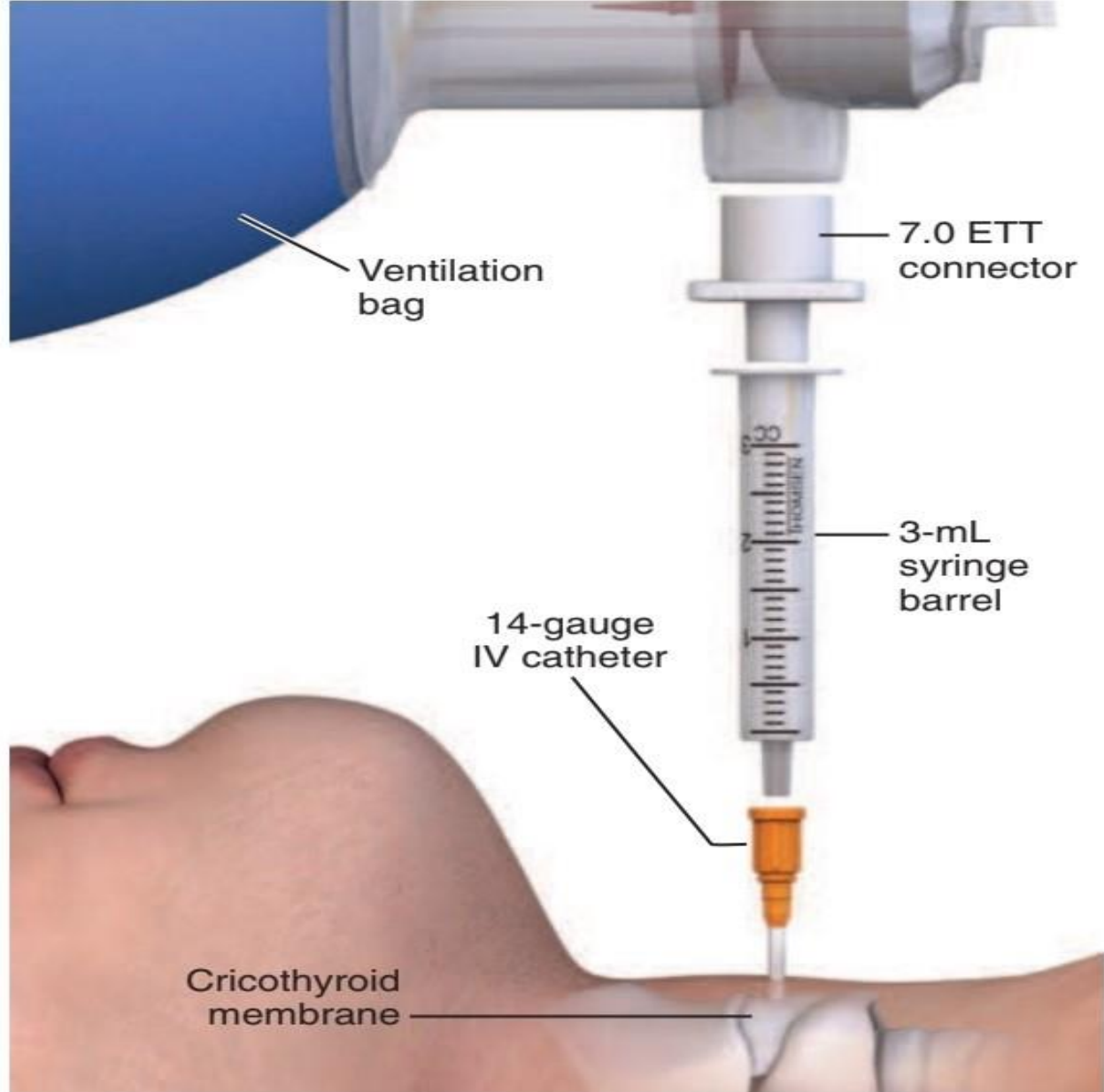
Remove the needle.

6



Attach the oxygen supply and begin to ventilate the patient.





**Figure 6.13** Homemade ventilation setup for transtracheal catheter ventilation using a ventilation bag, a standard endotracheal tube adapter, a 3-mL syringe, and a 14-gauge angiocatheter. *ETT*, Endotracheal tube; *IV*, intravenous.

