



Teerthanker Mahaveer University-Moradabad (U.P)

**Teerthanker Mahaveer Medical College & Research Centre
(TMMCRC)**

Value Added Course

on

Advanced Airway Skills

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DEPARTMENT OF ANAESTHESIA

Airway Management

KEY CONCEPTS

- ❶ Improper face mask technique can result in continued deflation of the anesthesia reservoir bag despite the adjustable pressure-limiting valve being closed, usually indicating a substantial leak around the mask. In contrast, the generation of high breathing circuit pressures with minimal chest movement and breath sounds implies an obstructed airway or obstructed tubing.
- ❷ The laryngeal mask airway partially protects the larynx from pharyngeal secretions, but not gastric regurgitation.
- ❸ After insertion of an endotracheal tube (ETT), the cuff is inflated with the least amount of air necessary to create a seal during positive-pressure ventilation to minimize the pressure transmitted to the tracheal mucosa.
- ❹ Although the persistent detection of CO_2 by a capnograph is the best confirmation of tracheal placement of an ETT, it cannot exclude bronchial intubation. The earliest evidence of bronchial intubation often is an increase in peak inspiratory pressure.
- ❺ After intubation, the cuff of an ETT should not be felt above the level of the cricoid cartilage, because a prolonged intralaryngeal location may result in postoperative hoarseness and increases the risk of accidental extubation.
- ❻ Unrecognized esophageal intubation can produce catastrophic results. Prevention of this complication depends on direct visualization of the tip of the ETT passing through the vocal cords, careful auscultation for the presence of bilateral breath sounds and the absence of gastric gurgling while ventilating through the ETT, analysis of exhaled gas for the presence of CO_2 (the most reliable automated method), chest

radiography, airway ultrasonography, or use of fiberoptic bronchoscopy.

- 7 Clues to the diagnosis of bronchial intubation include unilateral breath sounds, unexpected hypoxia with pulse oximetry (unreliable with high inspired oxygen concentrations), inability to palpate the ETT cuff in the sternal notch during cuff inflation, and decreased breathing bag compliance (high peak inspiratory pressures).
- 8 The large negative intrathoracic pressures generated by a struggling patient in laryngospasm can result in the development of negative-pressure pulmonary edema, particularly in healthy patients.

Expert airway management is an essential skill in anesthetic practice. This chapter reviews the anatomy of the upper respiratory tract, describes necessary airway equipment, presents various management techniques, and discusses complications of laryngoscopy, intubation, and extubation. Patient safety depends on a thorough understanding of each of these topics.

ANATOMY

The upper airway consists of the pharynx, nose, mouth, larynx, trachea, and mainstem bronchi. The mouth and pharynx are also a part of the upper gastrointestinal tract. The laryngeal structures in part serve to prevent aspiration into the trachea.

There are two openings to the human airway: the nose, which leads to the nasopharynx, and the mouth, which leads to the oropharynx. These passages are separated anteriorly by the palate, but they join posteriorly in the pharynx (**Figure 19–1**). The pharynx is a U-shaped fibromuscular structure that extends from the base of the skull to the cricoid cartilage at the entrance to the esophagus. It opens anteriorly into the nasal cavity, the mouth, the larynx, and the nasopharynx, oropharynx, and laryngopharynx, respectively. The nasopharynx is separated from the oropharynx by an imaginary plane that extends posteriorly. At the base of the tongue, the epiglottis functionally separates the oropharynx from the laryngopharynx (or hypopharynx). The epiglottis prevents aspiration by covering the glottis—the opening of the larynx—during swallowing. The larynx is a cartilaginous skeleton held together by ligaments and muscle. The larynx is composed of nine cartilages (**Figure 19–2**): thyroid, cricoid, epiglottic, and (in pairs) arytenoid, corniculate, and cuneiform. The thyroid cartilage shields the conus elasticus, which forms the vocal cords.

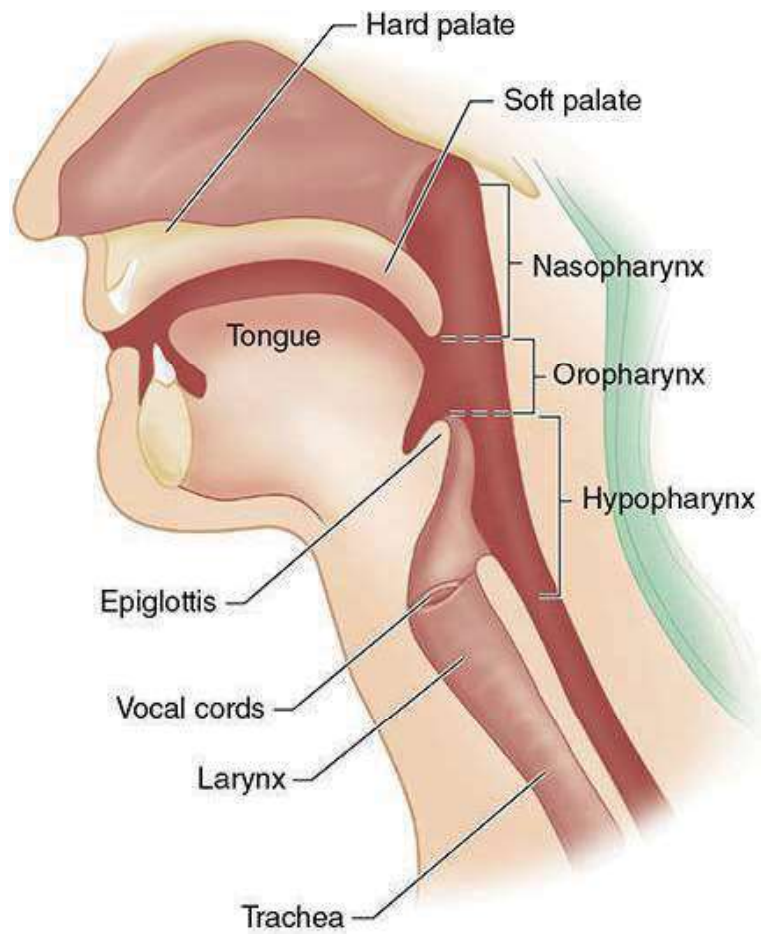


FIGURE 19–1 Anatomy of the airway.

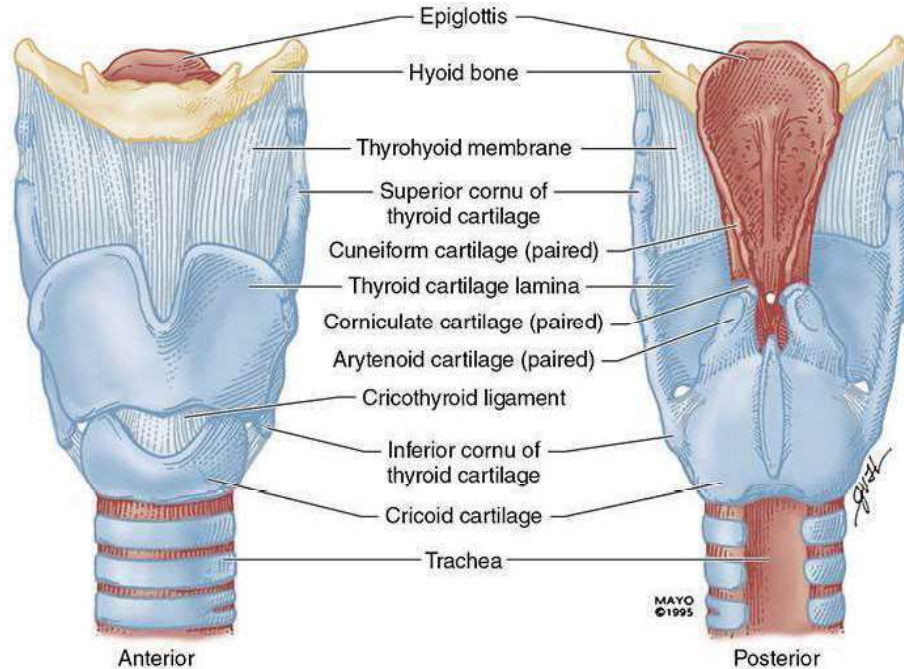


FIGURE 19–2 Cartilaginous structures comprising the larynx. (With permission from The Mayo Foundation.)

The sensory supply to the upper airway is derived from the cranial nerves (**Figure 19–3**). The mucous membranes of the nose are innervated by the ophthalmic division (V_1) of the trigeminal nerve anteriorly (anterior ethmoidal nerve) and by the maxillary division (V_2) posteriorly (sphenopalatine nerves). The palatine nerves provide sensory fibers from the trigeminal nerve (V_2) to the superior and inferior surfaces of the hard and soft palate. The **olfactory nerve** (cranial nerve I) innervates the nasal mucosa to provide the sense of smell. The lingual nerve (a branch of the mandibular division [V_3] of the trigeminal nerve) and the glossopharyngeal nerve (cranial nerve IX) provide general sensation to the anterior two-thirds and posterior one-third of the tongue, respectively. Branches of the facial nerve (VII) and glossopharyngeal nerve provide the sensation of taste to those areas, respectively. The **glossopharyngeal nerve** also innervates the roof of the pharynx, the tonsils, and the undersurface of the soft palate. The **vagus nerve** (cranial nerve X) provides sensation to the airway below the epiglottis. The superior laryngeal branch of the vagus divides into an external (motor) nerve and an internal (sensory) laryngeal nerve that provide sensory supply to the larynx between the epiglottis and the vocal cords. Another branch of the vagus, the **recurrent laryngeal nerve**, innervates the larynx below

the vocal cords and the trachea.

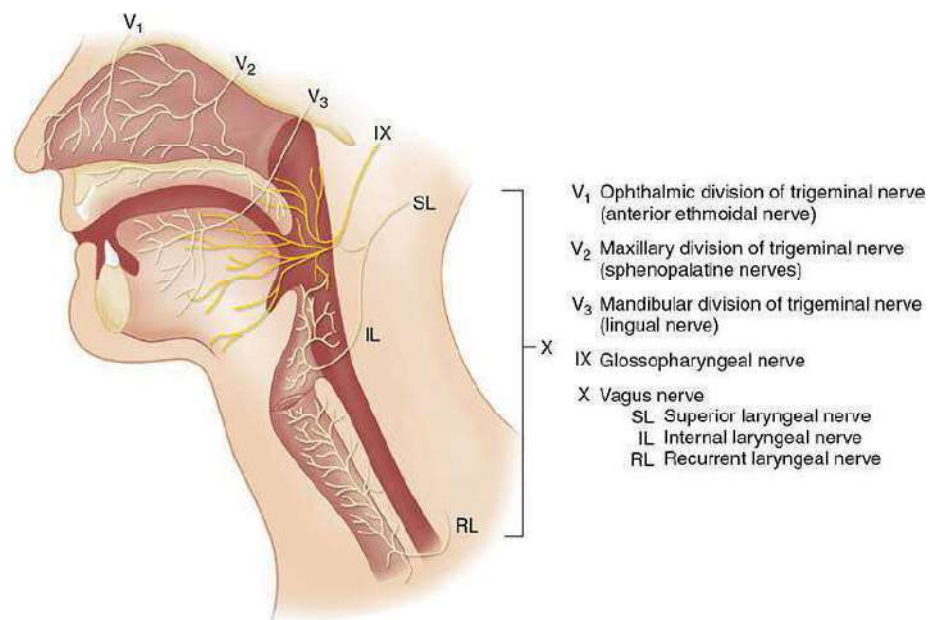


FIGURE 19–3 Sensory nerve supply of the airway.

The muscles of the larynx are innervated by the recurrent laryngeal nerve, with the exception of the cricothyroid muscle, which is innervated by the external (motor) laryngeal nerve, a branch of the superior laryngeal nerve. The posterior cricoarytenoid muscles abduct the vocal cords, whereas the lateral cricoarytenoid muscles are the principal adductors.

Phonation involves complex simultaneous actions by several laryngeal muscles. Damage to the motor nerves innervating the larynx leads to a spectrum of speech disorders ([Table 19–1](#)). Unilateral denervation of a cricothyroid muscle causes very subtle clinical findings. Bilateral palsy of the superior laryngeal nerve may result in hoarseness or easy tiring of the voice, but airway control is not jeopardized.

TABLE 19–1 The effects of laryngeal nerve injury on the voice.

Nerve	Effect of Nerve Injury
Superior laryngeal nerve	
Unilateral	Minimal effects
Bilateral	Hoarseness, tiring of voice
Recurrent laryngeal nerve	
Unilateral	Hoarseness
Bilateral	
Acute	Stridor, respiratory distress
Chronic	Aphonia
Vagus nerve	
Unilateral	Hoarseness
Bilateral	Aphonia

Unilateral injury to a recurrent laryngeal nerve results in paralysis of the ipsilateral vocal cord, causing deterioration in voice quality. Assuming intact superior laryngeal nerves, *acute* bilateral recurrent laryngeal nerve palsy can result in stridor and respiratory distress because of the remaining unopposed tension of the cricothyroid muscles. Airway problems are less frequent in *chronic* bilateral recurrent laryngeal nerve loss because of the development of various compensatory mechanisms (eg, atrophy of the laryngeal musculature).

Bilateral injury to the vagus nerve affects both the superior and the recurrent laryngeal nerves. Thus, bilateral vagal denervation produces flaccid, midpositioned vocal cords similar to those seen after administration of succinylcholine. Although phonation is severely impaired in these patients, airway control is rarely a problem.

The blood supply of the larynx is derived from branches of the thyroid arteries. The cricothyroid artery arises from the superior thyroid artery itself, the first branch given off from the external carotid artery, and crosses the upper cricothyroid membrane (CTM), which extends from the cricoid cartilage to the thyroid cartilage. The superior thyroid artery is found along the lateral edge of the CTM.

The trachea begins beneath the cricoid cartilage and extends to the carina, the point at which the right and left mainstem bronchi divide (**Figure 19–4**). Anteriorly, the trachea consists of cartilaginous rings; posteriorly, the trachea is membranous.

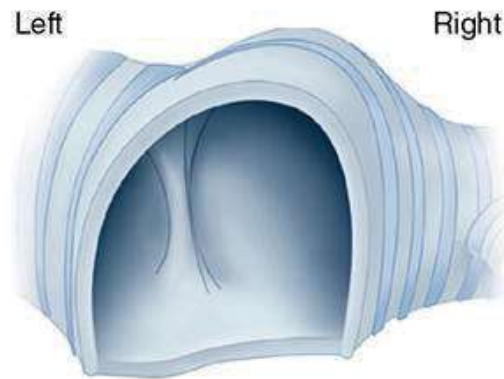


FIGURE 19–4 Carina.

ROUTINE AIRWAY MANAGEMENT

Routine airway management associated with general anesthesia consists of:

- Preanesthetic airway assessment
- Preparation and equipment check
- Patient positioning
- Preoxygenation (denitrogenation)
- Bag and mask ventilation
- Intubation or placement of a laryngeal mask airway (if indicated)
- Confirmation of proper tube or airway placement
- Extubation

AIRWAY ASSESSMENT

A preanesthetic airway assessment is mandatory before every anesthetic procedure. Several anatomical and functional maneuvers can be performed to estimate the difficulty of endotracheal intubation; successful ventilation (with or without intubation) must be achieved by the anesthetist if mortality and morbidity are to be avoided. Assessments include:

- Mouth opening: an incisor distance of 3 cm or greater is desirable in an adult.
- Mallampati classification: a frequently performed test that examines the size of the tongue in relation to the oral cavity. The more the tongue obstructs the view of the pharyngeal structures, the more difficult intubation may be ([Figure 19–5](#)).

- Class I: The entire palatal arch, including the bilateral faucial pillars, is visible down to the bases of the pillars.
- Class II: The upper part of the faucial pillars and most of the uvula are visible.
- Class III: Only the soft and hard palates are visible.
- Class IV: Only the hard palate is visible.
- Thyromental distance: This is the distance between the mentum (chin) and the superior thyroid notch. A distance greater than 3 fingerbreadths is desirable.
- Neck circumference: A neck circumference of greater than 17 inches is associated with difficulties in visualization of the glottic opening.

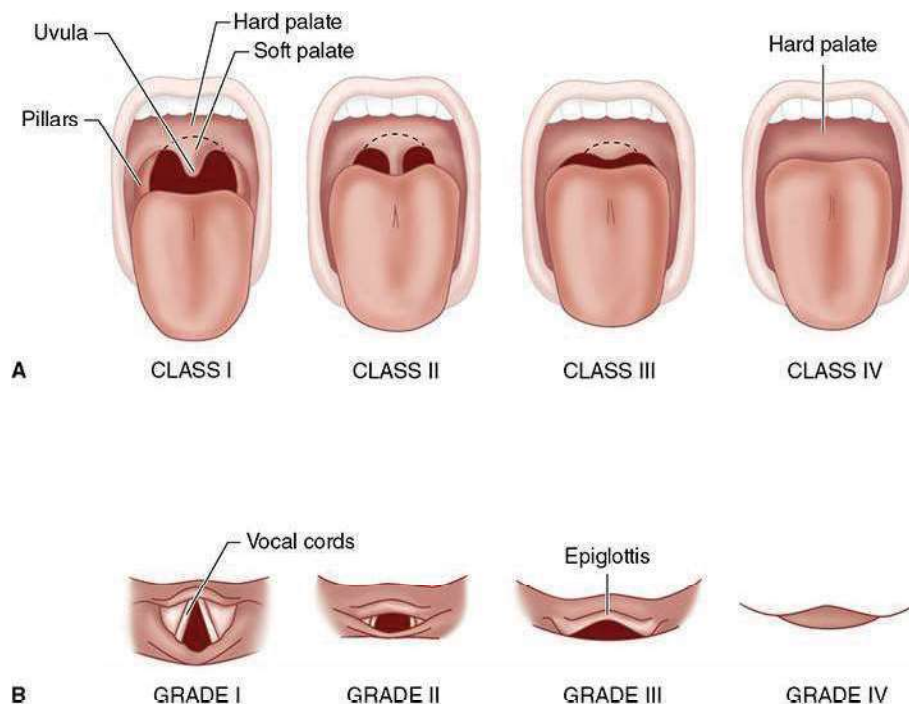


FIGURE 19-5 A: Mallampati classification of oral opening. **B:** Grading of the laryngeal view. A difficult orotracheal intubation (grade III or IV) may be predicted by the inability to visualize certain pharyngeal structures (class III or IV) during the preoperative examination of a seated patient. (Reproduced with permission from Mallampati SR, Gatt SP, Gugino LD, et al. A clinical sign to predict difficult tracheal intubation: A prospective study. *Can Anaesth Soc J*. 1985 Jul;32(4):429-434)

Although the presence of these examination findings may not be particularly

sensitive for detecting a difficult intubation, the absence of these findings is predictive for relative ease of intubation.

Increasingly, patients present with morbid obesity and body mass indices of 30 kg/m² or greater. Although some morbidly obese patients have relatively normal head and neck anatomy, others have much redundant pharyngeal tissue and increased neck circumference. Not only may these patients prove to be difficult to intubate, but routine ventilation with bag and mask also may be problematic.

Ultrasound examination of the airway has also been suggested to be of assistance in airway assessment and management (**Figures 19–6** through **19–8**). Ultrasound can be used as an adjunct to confirm ETT placement as well as to assist in identification of the cricothyroid membrane during emergent cricothyroidotomy.

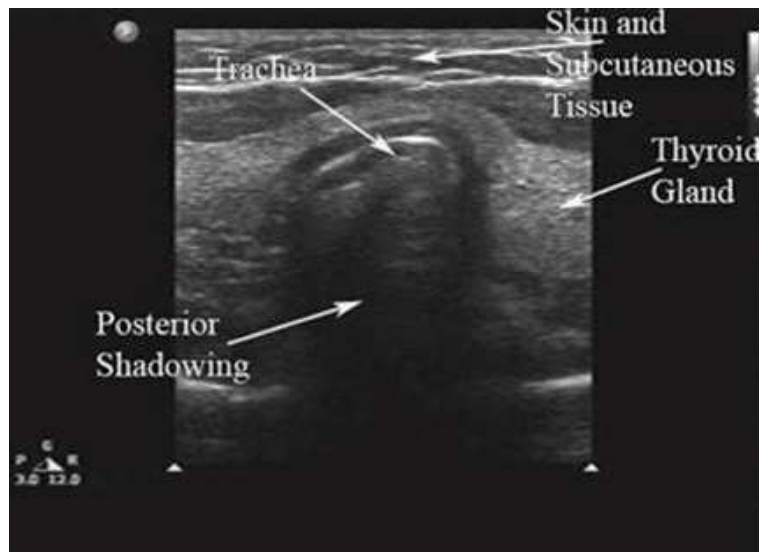


FIGURE 19–6 A transverse view of the trachea with landmarks. The anechoic area posterior to the trachea represents shadowing resulting from an attenuation of the ultrasound beam through the dense cartilage of the rings. (Reproduced with permission from Carmody KA, Moore CL, Feller-Kopman D. *Handbook of Critical Care and Emergency Ultrasound*. New York, NY: McGraw-Hill Education; 2011.)

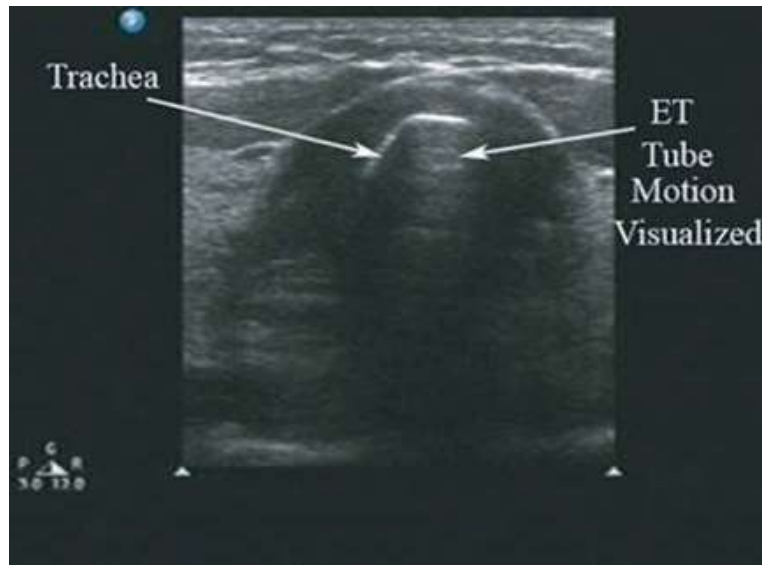


FIGURE 19–7 The trachea during intubation as the tube passes underneath the probe. The *arrow* points to a subtle area of increased echogenicity just distal to the tracheal cartilage. This area is where movement is most often visualized in real time during an intubation. (Reproduced with permission from Carmody KA, Moore CL, Feller-Kopman D. *Handbook of Critical Care and Emergency Ultrasound*. New York, NY: McGraw-Hill Education; 2011.)

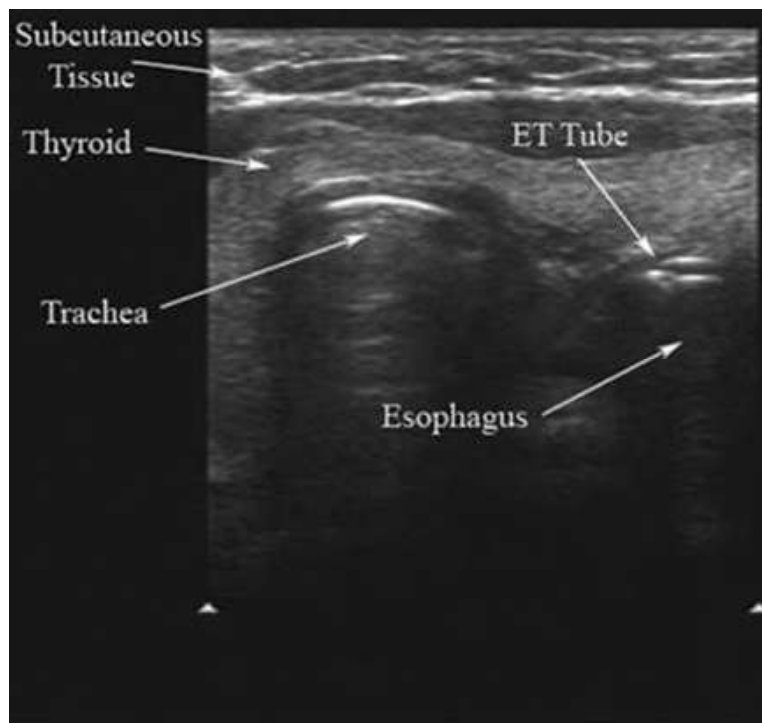


FIGURE 19–8 A transverse view of the trachea and esophagus during an esophageal intubation. In this image the esophagus is visualized posterior and lateral to the trachea. Two parallel echogenic lines are seen in the proximal esophagus, representing the inner and outer walls of the endotracheal (ET) tube as it passes through the lumen of the esophagus. (Reproduced with permission from Carmody KA, Moore CL, Feller-Kopman D. *Handbook of Critical Care and Emergency Ultrasound*. New York, NY: McGraw-Hill Education; 2011.)

EQUIPMENT

The following equipment should be routinely available for airway management:

- An oxygen source
- Capability to ventilate with bag and mask
- Laryngoscopes (direct and video)
- Several ETTs of different sizes with available stylets and bougies
- Other (not ETT) airway devices (eg, oral, nasal, supraglottic airways)
- Suction
- Pulse oximetry and CO₂ detection
- Stethoscope
- Tape
- Blood pressure and electrocardiography (ECG) monitors
- Intravenous access

A flexible fiberoptic bronchoscope should be immediately available when difficult intubation is anticipated but need not be present during all routine intubations.

Oral & Nasal Airways

Loss of upper airway muscle tone (eg, weakness of the genioglossus muscle) in anesthetized patients allows the tongue and epiglottis to fall back against the posterior wall of the pharynx. Repositioning the head or a jaw thrust is the preferred technique for opening the airway. To maintain the opening, an artificial airway can be inserted through the mouth or nose to maintain an air passage between the tongue and the posterior pharyngeal wall (**Figure 19–9**). Awake or lightly anesthetized patients with intact laryngeal reflexes may cough or even develop laryngospasm during airway insertion. Placement of an oral airway is

sometimes facilitated by suppressing airway reflexes, and, in addition, sometimes by depressing the tongue with a tongue blade. Adult oral airways typically come in small (80 mm [Guedel No. 3]), medium (90 mm [Guedel No. 4]), and large (100 mm [Guedel No. 5]) sizes.

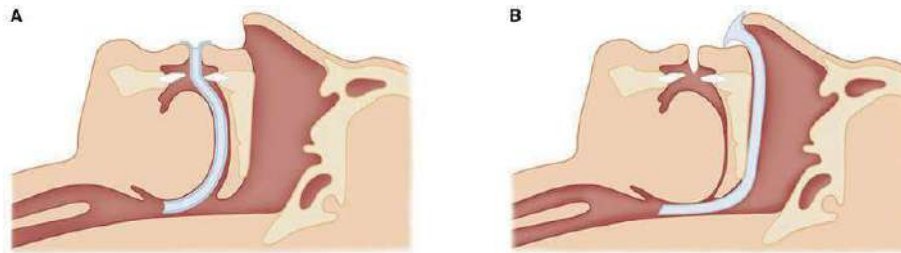


FIGURE 19-9 **A:** The oropharyngeal airway in place. The airway follows the curvature of the tongue, pulling it and the epiglottis away from the posterior pharyngeal wall and providing a channel for air passage. **B:** The nasopharyngeal airway in place. The airway passes through the nose and extends to just above the epiglottis. (Modified with permission from Dorsch JA, Dorsch SE. Face masks and airways. In: *Understanding Anesthesia Equipment*. 4th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 1999.)

The length of a nasal airway can be estimated as the distance from the nares to the meatus of the ear and should be approximately 2 to 4 cm longer than oral airways. Because of the risk of epistaxis, nasal airways are less desirable in anticoagulated or thrombocytopenic patients. Also, nasal airways (and nasogastric tubes) should be used with caution in patients with basilar skull fractures, as there has been a case report of a nasogastric tube entering the cranial vault. All tubes inserted through the nose (eg, nasal airways, nasogastric catheters, nasotracheal tubes) should be lubricated before being advanced along the floor of the nasal passage.

Face Mask Design & Technique

The use of a face mask can facilitate the delivery of oxygen or an anesthetic gas from a breathing system to a patient by creating an airtight seal with the patient's face (**Figure 19-10**). The rim of the mask is contoured and conforms to a variety of facial features. The mask's 22-mm orifice attaches to the breathing circuit of the anesthesia machine through a right-angle connector. Several mask designs are available. Transparent masks allow observation of exhaled humidified gas and immediate recognition of vomitus. Retaining hooks surrounding the orifice can be attached to a head strap so that the mask does not have to be continually

held in place. Some pediatric masks are specially designed to minimize apparatus dead space (**Figure 19–11**).

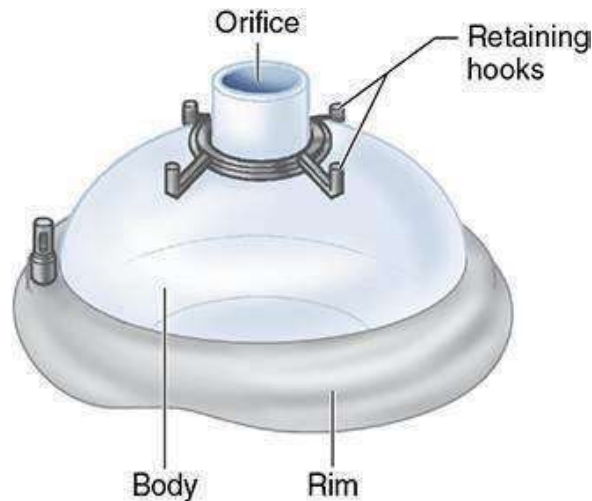


FIGURE 19–10 Clear adult face mask.

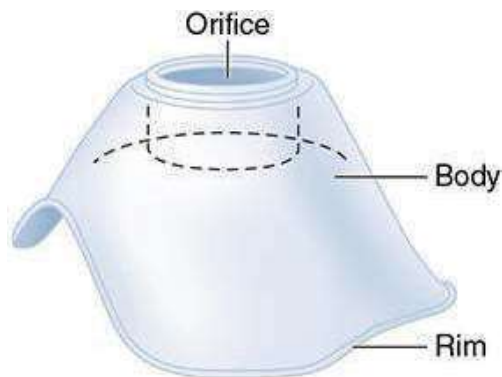


FIGURE 19–11 The Rendell–Baker–Soucek pediatric face mask has a shallow body and minimal dead space.

POSITIONING

When manipulating the airway, correct patient positioning is very helpful. Relative alignment of the oral and pharyngeal axes is achieved by having the patient in the “sniffing” position. When cervical spine pathology is suspected, the head must be kept in a neutral position during all airway manipulations. In-line stabilization of the neck must be maintained during airway management in these patients, unless appropriate cervical radiographs have been reviewed and

cleared by an appropriate specialist. Patients with morbid obesity should be positioned on a 30° upward ramp (see [Figure 41–2](#)), as the functional residual capacity (FRC) of obese patients deteriorates in the supine position, leading to more rapid deoxygenation should ventilation be impaired.

PREOXYGENATION

When possible, preoxygenation with face mask oxygen should precede all airway management interventions. Oxygen is delivered by mask for several minutes prior to anesthetic induction. In this way, the functional residual capacity, the patient's oxygen reserve, is purged of nitrogen. Up to 90% of the normal FRC of 2 L following preoxygenation is filled with oxygen. Considering the normal oxygen demand of 200 to 250 mL/min, the preoxygenated patient may have a 5 to 8 min oxygen reserve. Increasing the duration of apnea without desaturation improves safety, if ventilation following anesthetic induction is delayed. Conditions that increase oxygen demand (eg, sepsis, pregnancy) and decrease FRC (eg, morbid obesity, pregnancy, ascites) reduce the apneic period before desaturation ensues. Assuming a patent air passage is present, oxygen insufflated into the pharynx may increase the duration of apnea tolerated by the patient. Because oxygen enters the blood from the FRC at a rate faster than CO₂ leaves the blood, a negative pressure is generated in the alveolus, drawing oxygen into the lung (*apneic oxygenation*). With flow of 100% oxygen and a patent airway, arterial saturation can be maintained for a longer period despite no ventilation, permitting multiple airway interventions should a difficult airway be encountered.

BAG AND MASK VENTILATION

Bag and mask ventilation (BMV) is the first step in airway management in most situations, with the exception of patients undergoing rapid sequence intubation or elective awake intubation. Rapid sequence inductions avoid BMV to minimize stomach inflation and to reduce the potential for the aspiration of gastric contents in nonfasted patients and those with delayed gastric emptying. In emergency situations, BMV precedes attempts at intubation in an effort to oxygenate the patient, with the understanding that there is an implicit risk of aspiration.

Effective mask ventilation requires both a gas-tight  mask fit and a patent airway. Improper face mask technique can result in continued deflation of the anesthesia reservoir bag despite the adjustable pressure-limiting valve being

closed, usually indicating a substantial leak around the mask. In contrast, the generation of high breathing circuit pressures with minimal chest movement and breath sounds implies an obstructed airway or obstructed tubing.

If the mask is held with the left hand, the right hand can be used to generate positive-pressure ventilation by squeezing the breathing bag. The mask is held against the face by downward pressure on the mask exerted by the left thumb and index finger (**Figure 19–12**). The middle and ring finger grasp the mandible to facilitate extension of the atlantooccipital joint. This is a maneuver that is easier to teach with a mannequin or patient than to describe. Finger pressure should be placed on the bony mandible and not on the soft tissues. The little finger is placed under the angle of the jaw and used to thrust the jaw anteriorly, the most important maneuver to open the airway.



FIGURE 19–12 One-handed face mask technique.

In difficult situations, two hands may be needed to provide adequate jaw thrust and to create a mask seal. Therefore, an assistant may be needed to squeeze the bag, or the machine's ventilator can be used. In such cases, the thumbs hold the mask down, and the fingertips or knuckles displace the jaw forward (**Figure 19–13**). Obstruction during expiration may be due to excessive downward pressure from the mask or from a ball-valve effect of the jaw thrust. The former can be relieved by decreasing the pressure on the mask, and the latter

by releasing the jaw thrust during this phase of the respiratory cycle. Positive-pressure ventilation using a mask should normally be limited to 20 cm of H₂O to avoid stomach inflation.



FIGURE 19–13 A difficult airway can often be managed with a two-handed technique.

Most patients' airways can be maintained with a face mask and an oral or nasal airway. Mask ventilation for long periods may result in pressure injury to branches of the trigeminal or facial nerves. Because of the absence of positive airway pressures during spontaneous ventilation, only minimal downward force on the face mask is required to create an adequate seal. If the face mask and mask straps are used for extended periods, the position should be regularly changed to prevent injury. Care should be used to avoid mask or finger contact with the eye, and the eyes should be taped shut as soon as possible to minimize the risk of corneal abrasions.

If the airway is patent, squeezing the bag will result in the rise of the chest. If

ventilation is ineffective (no sign of chest rising, no end-tidal CO₂ detected, no condensation in the clear mask), oral or nasal airways can be placed to relieve airway obstruction secondary to lax upper airway muscle tone or redundant pharyngeal tissues. Difficult mask ventilation is often found in patients with morbid obesity, beards, and craniofacial deformities. It is sometimes difficult to form an adequate mask fit with the cheeks of edentulous patients.

In years past, anesthetics were routinely delivered solely by mask or ETT administration. In recent decades, a variety of supraglottic devices has permitted both airway rescue (when adequate BMV is not possible) and routine anesthetic airway management (when intubation is not necessary).

SUPRAGLOTTIC AIRWAY DEVICES

Supraglottic airway devices (SADs) are used with both spontaneously breathing and ventilated patients during anesthesia. They have also been employed as conduits to aid endotracheal intubation when both BMV and endotracheal intubation have failed. All SADs consist of a tube that is connected to a respiratory circuit or breathing bag, which is attached to a hypopharyngeal device that seals and directs airflow to the glottis, trachea, and lungs. Additionally, these airway devices occlude the esophagus with varying degrees of effectiveness, reducing gas distention of the stomach. Different sealing devices to prevent airflow from exiting through the mouth are also available. Some are equipped with a port to suction gastric contents. None offer the protection from aspiration pneumonitis offered by a properly sited, cuffed endotracheal tube.

Laryngeal Mask Airway

A laryngeal mask airway (LMA) consists of a wide-bore tube whose proximal end connects to a breathing circuit with a standard 15-mm connector, and whose distal end is attached to an elliptical cuff that can be inflated through a pilot tube. The deflated cuff is lubricated and inserted blindly into the hypopharynx so that, once inflated, the cuff forms a low-pressure seal around the entrance to the larynx. This requires anesthetic depth and muscle relaxation slightly greater than that required for the insertion of an oral airway. Although insertion is relatively simple ([Figure 19–14](#)), attention to detail will improve the success rate ([Table 19–2](#)). An ideally positioned cuff is bordered by the base of the tongue superiorly, the pyriform sinuses laterally, and the upper esophageal sphincter inferiorly. If the esophagus lies within the rim of the cuff, gastric distention and

regurgitation become possible. Anatomic variations prevent adequate functioning in some patients. However, if an LMA is not functioning properly after attempts to improve the “fit” of the LMA have failed, most practitioners will try another LMA one size larger or smaller. The shaft can be secured with ² tape to the skin of the face. The LMA partially protects the larynx from pharyngeal secretions (but *not* gastric regurgitation), and it should remain in place until the patient has regained airway reflexes. This is usually signaled by coughing and mouth opening on command. The LMA is available in many sizes ([Table 19–3](#)).

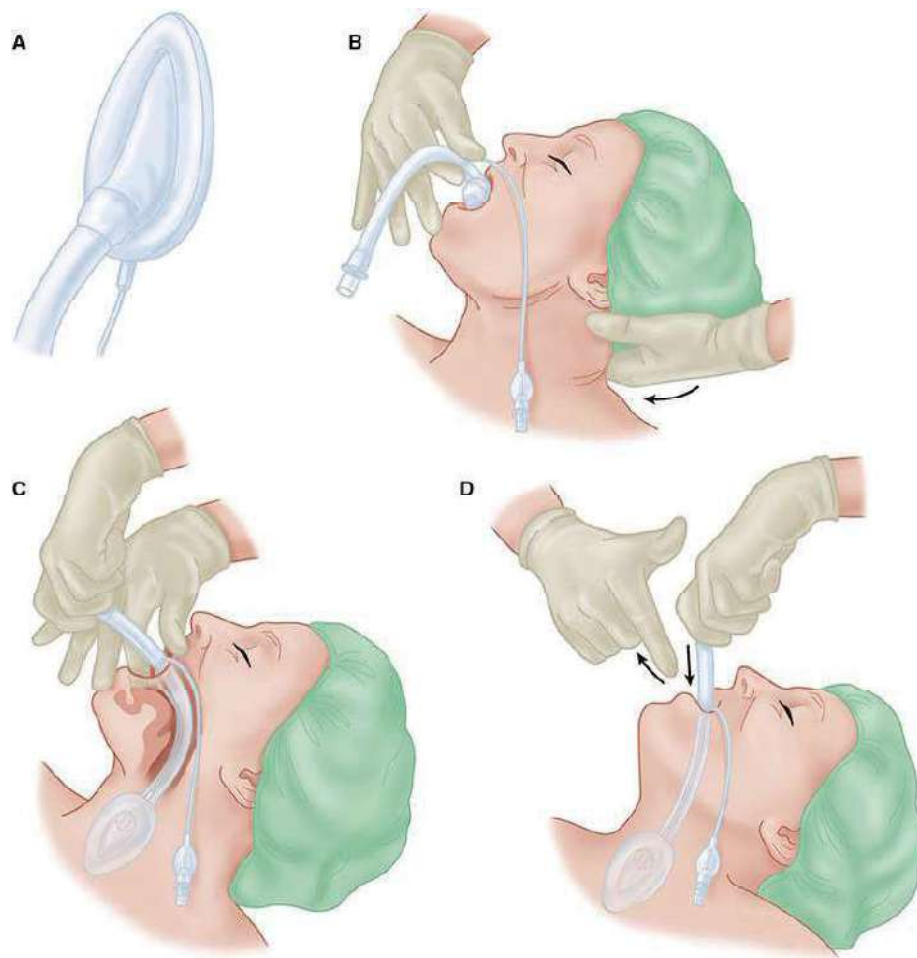


FIGURE 19–14 **A:** The laryngeal mask ready for insertion. The cuff should be deflated tightly with the rim facing away from the mask aperture. There should be no folds near the tip. **B:** Initial insertion of the laryngeal mask. Under direct vision, the mask tip is pressed upward against the hard palate. The middle finger

may be used to push the lower jaw downward. The mask is pressed forward as it is advanced into the pharynx to ensure that the tip remains flattened and avoids the tongue. The jaw should not be held open once the mask is inside the mouth. The nonintubating hand can be used to stabilize the occiput. **C:** By withdrawing the other fingers and with a slight pronation of the forearm, it is usually possible to push the mask fully into position in one fluid movement. Note that the neck is kept flexed and the head extended. **D:** The laryngeal mask is grasped with the other hand and the index finger withdrawn. The hand holding the tube presses gently downward until resistance is encountered. (Reproduced with permission from LMA North America.)

TABLE 19–2 Successful insertion of a laryngeal mask airway depends upon attention to several details.

1. Choose the appropriate size (Table 19–3) and check for leaks before insertion. 2. The leading edge of the deflated cuff should be wrinkle free and facing away from the aperture (Figure 19–14A). 3. Lubricate only the back side of the cuff. 4. Ensure adequate anesthesia before attempting insertion. 5. Place patient’s head in sniffing position (Figure 19–14B and Figure 19–26). 6. Use your index finger to guide the cuff along the hard palate and down into the hypopharynx until an increased resistance is felt (Figure 19–14C). The longitudinal black line should <i>always</i> be pointing directly cephalad (ie, facing the patient’s upper lip). 7. Inflate with the correct amount of air (Table 19–3). 8. Ensure adequate anesthetic depth during patient positioning. 9. Obstruction after insertion is usually due to a down-folded epiglottis or transient laryngospasm. 10. Avoid pharyngeal suction, cuff deflation, or laryngeal mask removal until the patient is awake (eg, opening mouth on command).

TABLE 19–3 A variety of laryngeal masks with different cuff volumes are available for different sized patients.

Mask Size	Patient Size	Weight (kg)	Cuff Volume (mL)
1	Infant	<6.5	2–4
2	Child	6.5–20	Up to 10
2½	Child	20–30	Up to 15
3	Small adult	>30	Up to 20
4	Normal adult	<70	Up to 30
5	Larger adult	>70	Up to 30

The LMA provides an alternative to ventilation through a face mask or an ETT (**Table 19–4**). Relative contraindications for the LMA include patients with pharyngeal pathology (eg, abscess), pharyngeal obstruction, aspiration risk (eg, pregnancy, hiatal hernia), or low pulmonary compliance (eg, restrictive airways disease) requiring peak inspiratory pressures greater than 30 cm H₂O. The LMA may be associated with less frequent bronchospasm than an ETT. Although it is clearly not a substitute for endotracheal intubation, the LMA has proven particularly helpful as a lifesaving, temporizing measure in patients with difficult airways (those who cannot be mask ventilated or intubated) because of its ease of insertion and relatively high success rate (95–99%). It has been used as a conduit for an intubating stylet (eg, gum-elastic bougie), ventilating jet stylet, flexible fiberoptic bronchoscope, or small-diameter (6.0 mm) ETT. Several LMAs are available that have been modified to facilitate placement of a larger ETT, with or without the use of a bronchoscope. Insertion can be performed under topical anesthesia and bilateral superior laryngeal nerve blocks, if the airway must be secured while the patient is awake. Some newer supraglottic devices incorporate a channel to facilitate gastric decompression.

TABLE 19–4 Advantages and disadvantages of the laryngeal mask airway compared with face mask ventilation or tracheal intubation.¹

	Advantages	Disadvantages
Compared with face mask	- Hands-free operation - Better seal in bearded patients - Less cumbersome in ENT surgery - Often easier to maintain airway - Protects against airway secretions - Less facial nerve and eye trauma - Less operating room pollution	- More invasive - More risk of airway trauma - Requires new skill - Deeper anesthesia required - Requires some TMJ mobility - N₂O diffusion into cuff - Multiple contraindications
Compared with tracheal intubation	- Less invasive - Very useful in difficult intubations - Less tooth and laryngeal trauma - Less laryngospasm and bronchospasm - Does not require muscle relaxation - Does not require neck mobility - No risk of esophageal or endobronchial intubation	- Increased risk of gastrointestinal aspiration - Less safe in prone or jackknife positions - Limits maximum PPV[†] - Less secure airway - Greater risk of gas leak and pollution - Can cause gastric distention

[†]ENT, ear, nose, and throat; TMJ, temporomandibular joint; PPV, positive-pressure ventilation.

Variations in LMA design include:

- The ProSeal LMA, which permits passage of a gastric tube to decompress the stomach
- The I-Gel, which uses a gel occluder rather than inflatable cuff
- The Fastrach intubation LMA, which is designed to facilitate endotracheal intubation through the LMA device
- The LMA CTrach, which incorporates a camera to facilitate passage of an endotracheal tube

Sore throat is a common side effect following SAD use. Injuries to the lingual, hypoglossal, and recurrent laryngeal nerves have been reported. Correct device sizing, avoidance of cuff hyperinflation, adequate lubrication, and gentle movement of the jaw during placement may reduce the likelihood of such injuries.

Esophageal–Tracheal Combitube

The esophageal–tracheal Combitube consists of two fused tubes, each with a 15-mm connector on its proximal end (**Figure 19–15**). The longer blue tube has an occluded distal tip that forces gas to exit through a series of side perforations. The shorter clear tube has an open tip and no side perforations. The Combitube is usually inserted blindly through the mouth and advanced until the two black rings on the shaft lie between the upper and lower teeth. The Combitube has two inflatable cuffs, a 100-mL proximal cuff and a 15-mL distal cuff, both of which should be fully inflated after placement. The distal lumen of the Combitube usually comes to lie in the esophagus approximately 95% of the time so that

ventilation through the longer blue tube will force gas out of the side perforations and into the larynx. The shorter, clear tube can be used for gastric decompression. Alternatively, if the Combitube enters the trachea, ventilation through the clear tube will direct gas into the trachea.

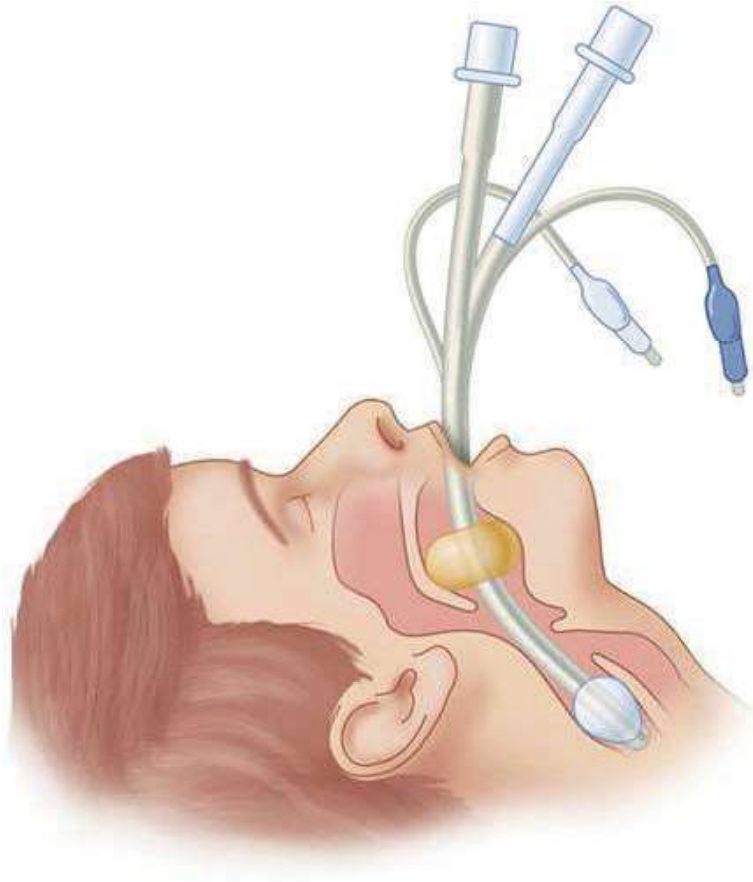


FIGURE 19–15 Combitube.

King Laryngeal Tube

The King laryngeal tube consists of a tube with a small esophageal balloon and a larger balloon for placement in the hypopharynx ([Figure 19–16](#)). Both balloons inflate through one inflation line. The lungs are inflated with gas that exits between the two balloons. A suction port distal to the esophageal balloon is present, permitting decompression of the stomach. If ventilation proves difficult after the King tube is inserted and the cuffs are inflated, the tube is likely inserted too deeply. Slowly withdraw the device until compliance improves.

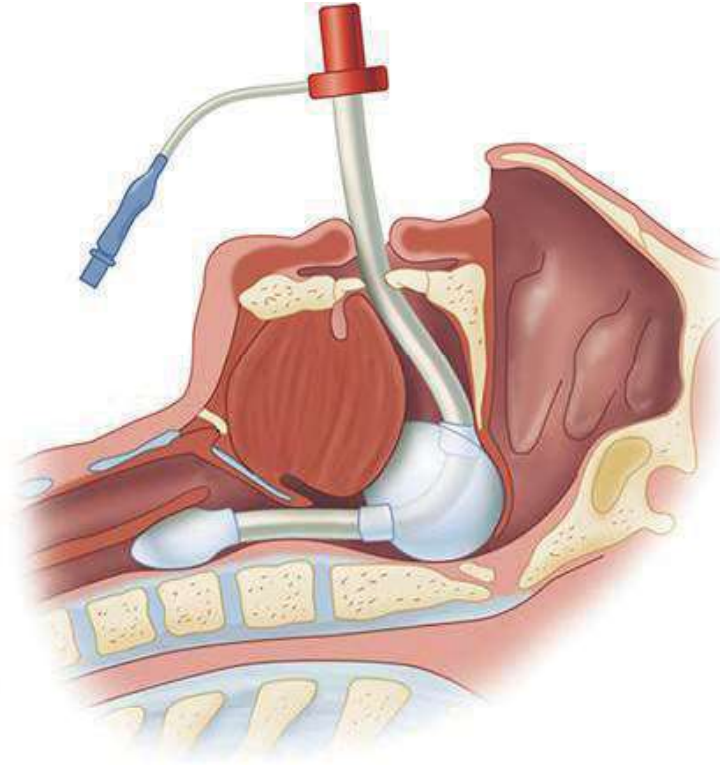


FIGURE 19–16 King laryngeal tube.

ENDOTRACHEAL INTUBATION

Endotracheal intubation is employed both for the conduct of general anesthesia and to facilitate the ventilator management of the critically ill.

Endotracheal Tubes (ETTs)

Standards govern ETT manufacturing (in the United States, American National Standard for Anesthetic Equipment; ANSI Z–79). ETTs are most commonly made from polyvinyl chloride. The shape and rigidity of ETTs can be altered by inserting a stylet. The patient end of the tube is beveled to aid visualization and insertion through the vocal cords. Murphy tubes have a hole (the Murphy eye) to decrease the risk of occlusion, should the distal tube opening abut the carina or trachea ([Figure 19–17](#)).



FIGURE 19–17 Murphy endotracheal tube.

Resistance to airflow depends primarily on tube diameter, but is also affected by tube length and curvature. ETT size is usually designated in millimeters of internal diameter, or, less commonly, in the French scale (external diameter in millimeters multiplied by 3). The choice of tube diameter is always a compromise between maximizing flow with a larger size and minimizing airway trauma with a smaller size ([Table 19–5](#)).

TABLE 19–5 Oral endotracheal tube size guidelines.

Age	Internal Diameter (mm)	Cut Length (cm)
Full-term infant	3.5	12
Child	$4 + \frac{\text{Age}}{4}$	$4 + \frac{\text{Age}}{2}$
Adult		
Female	7.0–7.5	24
Male	7.5–9.0	24

Most adult ETTs have a cuff inflation system consisting of a valve, pilot balloon, inflating tube, and cuff ([Figure 19–17](#)). The valve prevents air loss after cuff inflation. The pilot balloon provides a gross indication of cuff inflation. The inflating tube connects the valve to the cuff and is incorporated into the tube's wall. By creating a tracheal seal, ETT cuffs permit positive-pressure ventilation and reduce the likelihood of aspiration. Uncuffed tubes are often used in infants and young children; however, in recent years, cuffed pediatric tubes have been increasingly favored.

There are two major types of cuffs: high pressure (low volume) and low pressure (high volume). High-pressure cuffs are associated with more ischemic damage to the tracheal mucosa and are less suitable for intubations of long duration. Low-pressure cuffs may increase the likelihood of sore throat (larger mucosal contact area), aspiration, spontaneous extubation, and difficult insertion (because of the floppy cuff). Nonetheless, because of their lower incidence of mucosal damage, low-pressure cuffs are most frequently employed.

Cuff pressure depends on several factors: inflation volume, the diameter of the cuff in relation to the trachea, tracheal and cuff compliance, and intrathoracic pressure (cuff pressures increase with coughing). Cuff pressure may increase during general anesthesia from diffusion of nitrous oxide from the tracheal mucosa into the ETT cuff.

ETTs have been modified for a variety of specialized applications. Flexible, spiral-wound, wire-reinforced ETTs (armored tubes) resist kinking and may prove valuable in some head and neck surgical procedures or in the prone patient. If an armored tube becomes kinked from extreme pressure (eg, an awake patient biting it), however, the lumen will often remain permanently occluded, and the tube will need replacement. Other specialized tubes include microlaryngeal tubes, double-lumen endotracheal tubes (to facilitate lung isolation and one-lung ventilation), ETTs equipped with bronchial blockers (to facilitate lung isolation and one-lung ventilation), metal tubes designed for laser airway surgery to reduce fire hazards, and preformed curved tubes for nasal and oral intubation in head and neck surgery.

LARYNGOSCOPES

A laryngoscope is an instrument used to examine the larynx and to facilitate intubation of the trachea. The handle usually contains batteries to light a bulb on the blade tip ([Figure 19–18](#)), or, alternately, to power a fiberoptic bundle that terminates at the tip of the blade. Laryngoscopes with fiberoptic light bundles in their blades can be made magnetic resonance imaging compatible. The Macintosh and Miller blades are the most popular curved and straight designs, respectively, in the United States. The choice of blade depends on personal preference and patient anatomy. Because no blade is perfect for all situations, the clinician should become familiar and proficient with a variety of blade designs ([Figure 19–19](#)).



FIGURE 19-18 A rigid laryngoscope.

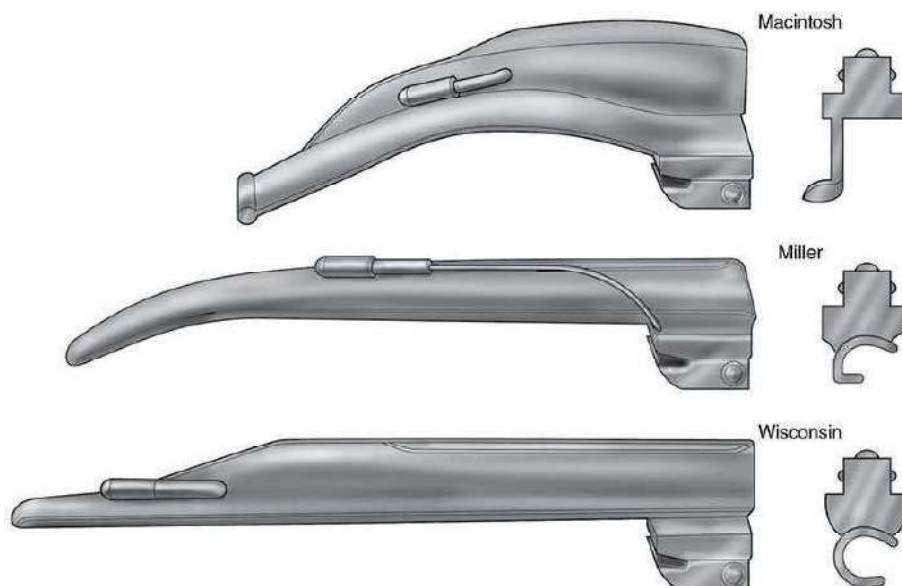


FIGURE 19-19 An assortment of laryngoscope blades.

VIDEO LARYNGOSCOPES

In recent years, myriad laryngoscopy devices that utilize video technology have revolutionized management of the airway. Direct laryngoscopy with a Macintosh or Miller blade mandates appropriate alignment of the oral, pharyngeal, and laryngeal structures to facilitate a direct view of the glottis. Various maneuvers, such as the “sniffing” position and external movement of the larynx with cricoid pressure during direct laryngoscopy, are used to improve the view. Video- or optically based laryngoscopes have either a video chip (DCI system, GlideScope, McGrath, Airway) or a lens/mirror (Airtraq) at the tip of the intubation blade to transmit a view of the glottis to the operator. These devices differ in the angulation of the blade, the presence of a channel to guide the tube to the glottis, and the single use or multiuse nature of the device.

Video or indirect laryngoscopy most likely offers minimal advantage to patients with uncomplicated airways. However, use in these patients is valuable as a training guide for learners, especially when the trainee is performing a direct laryngoscopy with the device while the instructor views the glottis on the video screen. Additionally, use in uncomplicated airway management patients improves familiarity with the device for times when direct laryngoscopy is not possible.

Indirect laryngoscopes generally improve visualization of laryngeal structures in difficult airways; however, visualization does not always lead to successful intubation. An ETT stylet is recommended when video laryngoscopy is to be performed. Some devices come with stylets designed to facilitate intubation with that particular device. Bending the stylet and ETT in a manner similar to the bend in the curve of the blade often facilitates passage of the ETT into the trachea. Even when the glottic opening is seen clearly, directing the ETT into the trachea can be difficult.

Indirect laryngoscopy may result in less displacement of the cervical spine than direct laryngoscopy; nevertheless, all precautions associated with airway manipulation in a patient with a possible cervical spine fracture should be maintained.

Varieties of indirect laryngoscopes include:

- Various Macintosh and Miller blades in pediatric and adult sizes have video capability in the Storz DCI system. The system can also incorporate an optical intubating stylet ([Figure 19–20](#)). The blades are similar to conventional intubation blades, permitting direct laryngoscopy and indirect video laryngoscopy. Assistants and instructors are able to see the view

obtained by the operator and adjust their maneuvers accordingly to facilitate intubation or to provide instruction, respectively.



FIGURE 19–20 Optical intubating stylet.

- The McGrath laryngoscope is a portable video laryngoscope with a blade length that can be adjusted to accommodate the airway of a child of age 5 years up to an adult ([Figure 19–21](#)). The blade can be disconnected from the handle to facilitate its insertion in morbidly obese patients in whom the space between the upper chest and head is reduced. The blade is inserted midline, with the laryngeal structures viewed at a distance to enhance intubation success.



FIGURE 19–21 McGrath laryngoscope.

- The GlideScope comes with disposable adult- and pediatric-sized blades (**Figure 19–22**). The blade is inserted midline and advanced until glottic structures are identified. The GlideScope has a 60° angle, preventing direct laryngoscopy and necessitating the use of stylet that is similar in shape to the blade.



FIGURE 19–22 Glidescope.

- Airtraq is a single-use optical laryngoscope available in pediatric and adult sizes ([Figure 19–23](#)). The device has a channel to guide the endotracheal tube to the glottis. This device is inserted midline. Success is more likely when the device is not positioned too close to the glottis.



FIGURE 19–23 Airtraq optical laryngoscope.

- Video intubating stylets have a video capability and light source. The stylet is introduced, and the glottis identified. Intubation with a video stylet may result in less cervical spine movement than with other techniques.

Flexible Fiberoptic Bronchoscopes

In some situations—for example, patients with unstable cervical spines, poor range of motion of the temporomandibular joint, or certain congenital or acquired upper airway anomalies—laryngoscopy with direct or indirect laryngoscopes may be undesirable or impossible. A flexible fiberoptic bronchoscope (FOB) allows indirect visualization of the larynx in such cases or in any situation in which awake intubation is planned ([Figure 19–24](#)). Bronchoscopes are constructed of coated glass fibers that transmit light and images by internal reflection (ie, a light beam becomes trapped within a fiber and exits unchanged at the opposite end). The insertion tube contains two bundles of fibers, each consisting of 10,000 to 15,000 fibers. One bundle transmits light from the light source (light source or incoherent bundle), which is either external to the device or contained within the handle ([Figure 19–24B](#)), whereas the other provides a high-resolution image (image or coherent bundle). Directional manipulation of the insertion tube is accomplished with angulation wires. Aspiration channels allow suctioning of secretions, insufflation of oxygen, or instillation of local anesthetic. Aspiration channels can be difficult to clean,

and, if not properly cleaned and sterilized after each use, may promote infection.

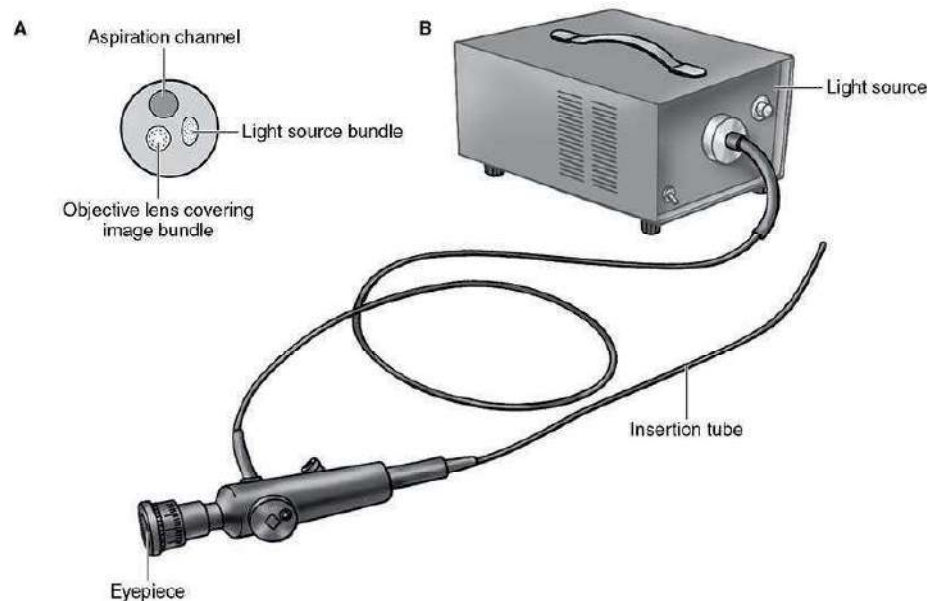


FIGURE 19–24 **A:** Cross section of a fiberoptic bronchoscope. **B:** A flexible fiberoptic bronchoscope with a fixed light source.

TECHNIQUES OF DIRECT & INDIRECT LARYNGOSCOPY & INTUBATION

Indications for Intubation

Inserting a tube into the trachea has become a routine part of delivering a general anesthetic. Intubation is not a risk-free procedure, and it is not a requirement for all patients receiving general anesthesia. An ETT is generally placed to protect the airway and for airway access. Intubation is indicated in patients who are at risk of aspiration and in those undergoing surgical procedures involving body cavities, the head and neck, and those who will be positioned so that the airway will be less accessible (eg, those undergoing surgery in the prone position, or whose head is rotated away from the anesthesia workstation). Mask ventilation or ventilation with an LMA is usually satisfactory for short minor procedures such as cystoscopy, examination under anesthesia, inguinal hernia repairs, extremity surgery, and so forth. Nevertheless, the indications for use of supraglottic airway devices during anesthesia continues to expand.

Preparation for Direct Laryngoscopy

Preparation for intubation includes checking equipment and properly positioning the patient. The ETT should be examined. The tube's cuff can be tested by inflating the cuff using a syringe. Maintenance of cuff pressure *after detaching the syringe* ensures proper cuff and valve function. Some anesthesiologists cut the ETT to a preset length to decrease the dead space, the risk of bronchial intubation, and the risk of occlusion from tube kinking (Table 19–5). The connector should be pushed firmly into the tube to decrease the likelihood of disconnection. If a stylet is used, it should be inserted into the ETT, which is then bent to resemble a hockey stick (Figure 19–25). This shape facilitates intubation of an anteriorly positioned larynx. The desired blade is locked onto the laryngoscope handle, and bulb function is tested. The light intensity should remain constant even if the bulb is jiggled. A blinking light signals a poor electrical contact, whereas fading indicates depleted batteries. An extra handle, blade, ETT (one size smaller than the anticipated optimal size), stylet, and intubating bougie should be immediately available. A functioning suction unit is needed to clear the airway in case of unexpected secretions, blood, or emesis.

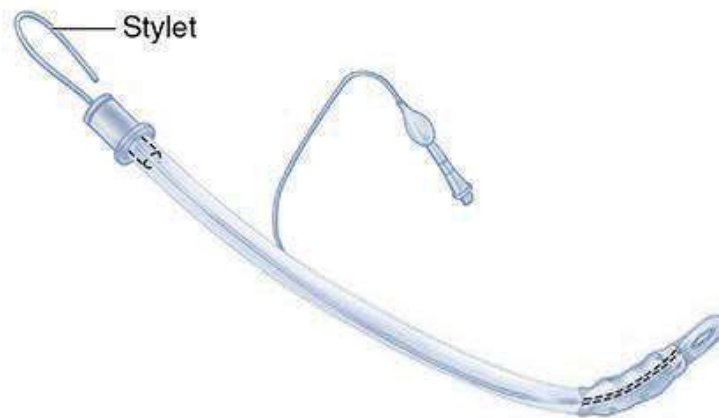


FIGURE 19–25 An endotracheal tube with a stylet bent to resemble a hockey stick.

Adequate glottis exposure during laryngoscopy often depends on correct patient positioning. The patient's head should be level with the anesthesiologist's waist or higher to prevent unnecessary back strain during laryngoscopy.

Direct laryngoscopy displaces pharyngeal soft tissues to create a direct line of vision from the mouth to the glottic opening. Moderate head elevation (5–10 cm above the surgical table) and extension of the atlantooccipital joint place the

patient in the desired sniffing position (**Figure 19–26**). The lower portion of the cervical spine is flexed by resting the head on a pillow or other soft support.

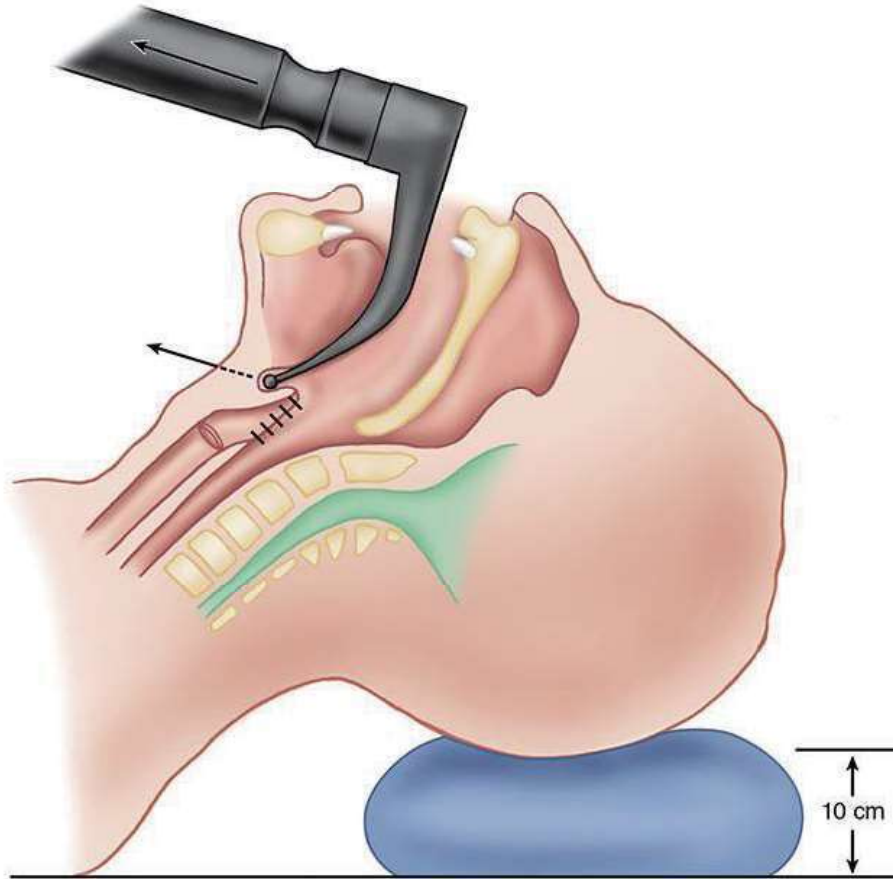


FIGURE 19–26 The sniffing position and intubation with a Macintosh blade.
(Modified with permission from Dorsch JA, Dorsch SE. *Understanding Anesthesia Equipment: Construction, Care, and Complications*. Philadelphia, PA: Lippincott Williams & Wilkins, 1991.)

As previously discussed, preparation for induction and intubation also involves routine preoxygenation. Preoxygenation can be omitted in patients who object to the face mask; however, failing to preoxygenate increases the risk of rapid desaturation following apnea.

Because general anesthesia abolishes the protective corneal reflex, care must be taken during this period not to injure the patient's eyes by unintentionally abrading the cornea. Thus, the eyes are routinely taped shut as soon as possible, often after applying an ophthalmic ointment before manipulation of the airway.

Orotracheal Intubation

The laryngoscope is held in the left hand. With the patient's mouth opened the blade is introduced into the right side of the oropharynx—with care to avoid the teeth. The tongue is swept to the left and up into the floor of the pharynx by the blade's flange. Successful sweeping of the tongue leftward clears the view for ETT placement. The tip of a curved blade is usually inserted into the vallecula, and the straight blade tip covers the epiglottis. With either blade, the handle is raised up and away from the patient in a plane perpendicular to the patient's mandible to expose the vocal cords (Figure 19–27). Trapping a lip between the teeth and the blade and leverage on the teeth are avoided. The ETT is taken with the right hand, and its tip is passed through the abducted vocal cords. The “backward, upward, rightward, pressure” (BURP) maneuver applied externally moves an anteriorly positioned glottis posterior to facilitate visualization of the glottis. The ETT cuff should lie in the upper trachea, but beyond the larynx. The laryngoscope is withdrawn, again with care to avoid tooth damage. The cuff is inflated with the least amount of air necessary to create a seal during positive-pressure ventilation to minimize the pressure transmitted to the tracheal mucosa. Overinflation may inhibit capillary blood flow, injuring the trachea. Compressing the pilot balloon with the fingers is *not* a reliable method of determining whether cuff pressure is either sufficient or excessive.

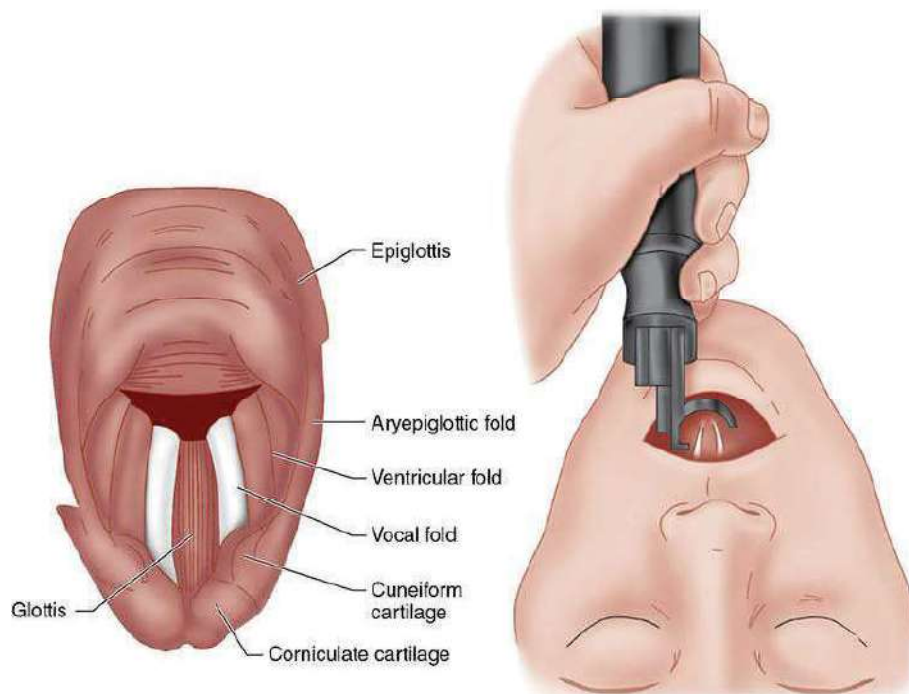


FIGURE 19–27 Typical view of the glottis during laryngoscopy with a curved blade. (Modified with permission from Barash PG. *Clinical Anesthesia*. 4th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2001.)

After intubation, the chest and epigastrium are immediately auscultated, and a capnographic tracing (the definitive test) is monitored to ensure intratracheal location (**Figure 19–28**). If there is doubt as to whether the tube is in the esophagus or trachea, repeat the laryngoscopy to confirm placement. End-tidal CO₂ will not be produced if there is no cardiac output. FOB through the tube and visualization of the tracheal rings and carina will likewise confirm correct placement. Otherwise, the tube is taped or  tied to secure its position. Although the persistent detection of CO₂ by a capnograph is the best confirmation of tracheal placement of an ETT, it cannot exclude bronchial intubation. The earliest evidence of bronchial intubation often is an increase in peak inspiratory pressure. Proper tube location can be reconfirmed by palpating the cuff in the sternal notch while compressing the pilot balloon with the  other hand. The cuff should not be felt above the level of the cricoid cartilage, because a prolonged intralaryngeal location may result in postoperative hoarseness and increases the risk of accidental extubation. Tube position can also be documented by chest radiography.

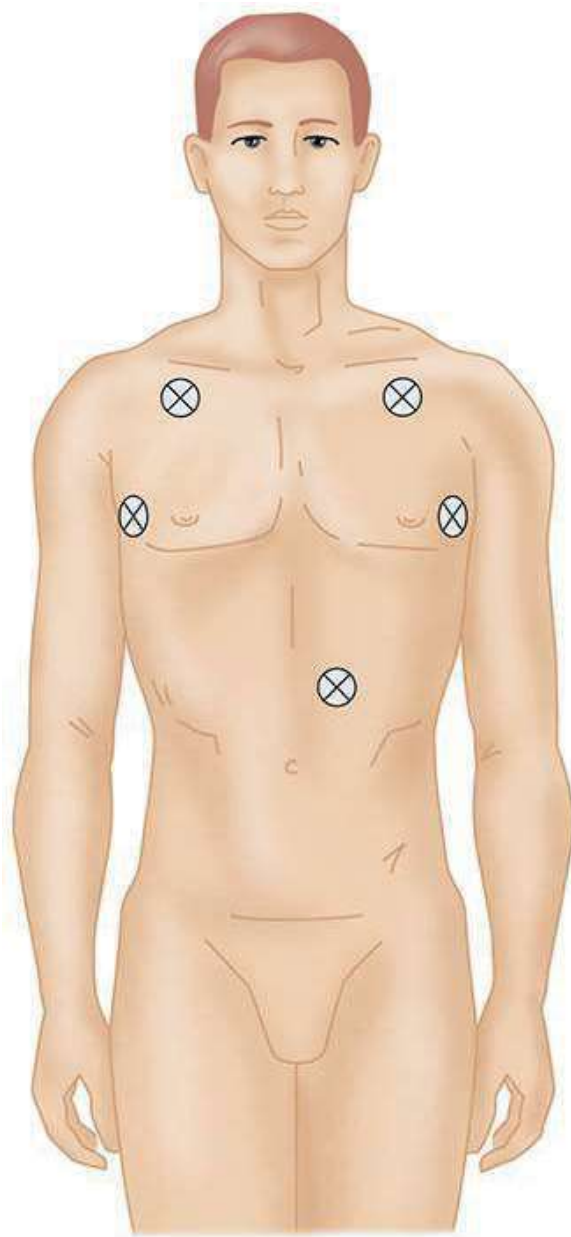


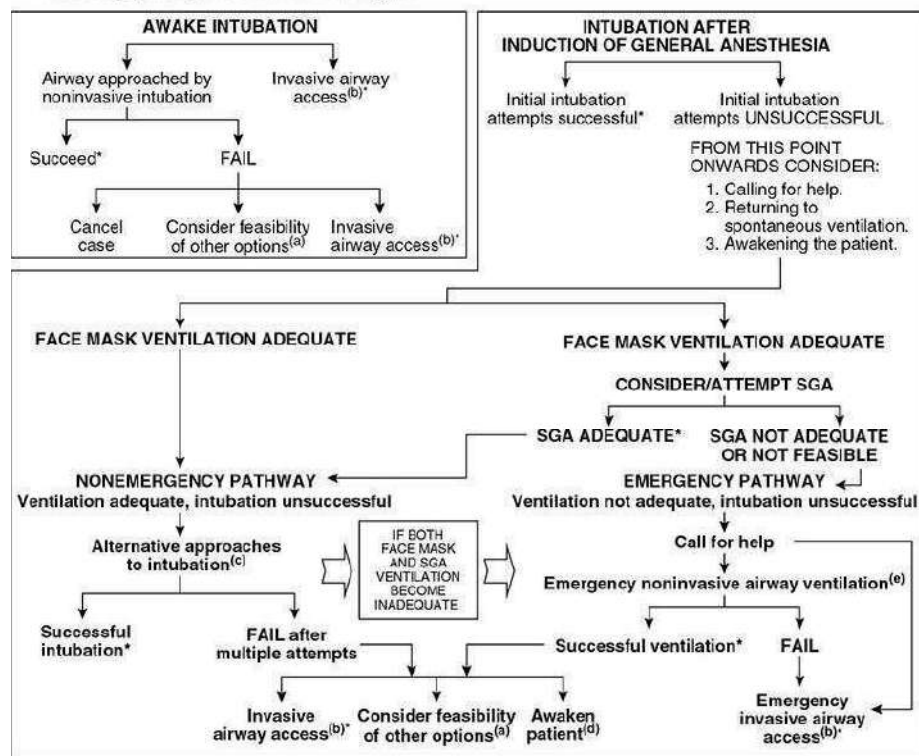
FIGURE 19–28 Sites for auscultation of breath sounds at the apices and over the stomach.

The description presented here assumes an unconscious patient. Oral intubation is usually poorly tolerated by awake, fit patients. Intravenous sedation, application of a local anesthetic spray in the oropharynx, regional nerve block, and constant reassurance will improve patient acceptance.

A failed intubation should not be followed by identical repeated attempts. Changes must be made to increase the likelihood of success, such as repositioning the patient, decreasing the tube size, adding a stylet, selecting a different blade, using an indirect laryngoscope, attempting a nasal route, or requesting the assistance of another anesthesia provider. If the patient is also difficult to ventilate with a mask, alternative forms of airway management (eg, second-generation supraglottic airway devices, jet ventilation via percutaneous tracheal catheter, cricothyrotomy, tracheostomy) must be immediately pursued. The guidelines developed by the American Society of Anesthesiologists for the management of a difficult airway include a treatment plan algorithm ([Figure 19–29](#)).

American Society of
Anesthesiologists®
DIFFICULT AIRWAY ALGORITHM

1. Assess the likelihood and clinical impact of basic management problems:
 - Difficulty with patient cooperation or consent
 - Difficult mask ventilation
 - Difficult supraglottic airway placement
 - Difficult laryngoscopy
 - Difficult intubation
 - Difficult surgical airway access
2. Actively pursue opportunities to deliver supplemental oxygen throughout the process of difficult airway management.
3. Consider the relative merits and feasibility of basic management choices:
 - Awake intubation vs. intubation after induction of general anesthesia
 - Non-invasive technique vs. invasive techniques for the initial approach to intubation
 - Video-assisted laryngoscopy as an initial approach to intubation
 - Preservation vs. ablation of spontaneous ventilation
4. Develop primary and alternative strategies:



*Confirm ventilation, tracheal intubation, or SGA placement with exhaled CO₂.

FIGURE 19–29 Difficult airway algorithm. Notes: (a) Other options include (but are not limited to): surgery utilizing face mask or supraglottic airway (SGA) anesthesia (eg, laryngeal mask airway [LMA], intubating LMA [ILMA], laryngeal tube), local anesthesia infiltration, or regional nerve blockade. Pursuit of these options usually implies that mask ventilation will not be problematic. Therefore, these options may be of limited value if this step in the algorithm has been reached via the emergency pathway. (b) Invasive airway access includes surgical or percutaneous airway, jet ventilation, and retrograde intubation. (c)

Alternative difficult intubation approaches include (but are not limited to) video-assisted laryngoscopy, alternative laryngoscope blades, SGA (eg, LMA or ILMA) as an intubation conduit (with or without fiberoptic guidance), fiberoptic intubation, intubating stylet or tube changer, light wand, and blind oral or nasal intubation. (d) Consider re-preparation of the patient for awake intubation or canceling surgery. (e) Emergency noninvasive airway ventilation consists of an SGA. (Reproduced with permission from American Society of Anesthesiologists Task Force on the Management of the Difficult Airway. Practice guidelines for management of the difficult airway: An updated report by the American Society of Anesthesiologists Task Force on the Management of the Difficult Airway. *Anesthesiology*. 2003 May;98(5):1269-1277.)

The Difficult Airway Society (DAS) also provides a useful approach for the management of the unanticipated difficult airway (**Figure 19–30**).

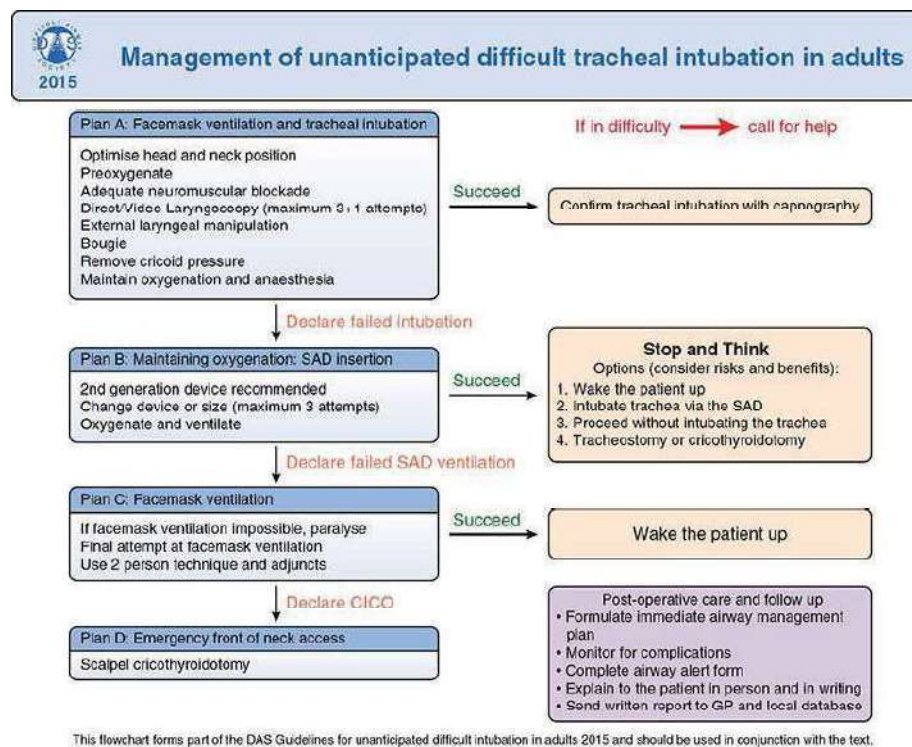


FIGURE 19–30 Difficult Airway Society difficult intubation guidelines: overview. CICO, can't intubate can't oxygenate; SAD, supraglottic airway device. (Reproduced with permission from Frerk C, Mitchell V, McNarry A, et al. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. *Br J Anaesth*. 2015 Dec;115(6):827-848.)

The combined use of a video laryngoscope and an intubation bougie often can

facilitate intubation, when the endotracheal tube cannot be directed into the glottis despite good visualization of the laryngeal opening (**Figure 19–31**). Progression through the DAS plans A to D prevents the anesthetist from unnecessarily repeating the same failed approaches to airway management and maximizes the possibility of preserving patient oxygenation as the airway is secured.



FIGURE 19–31 Bougie.

Nasotracheal Intubation

Nasal intubation is similar to oral intubation except that the ETT is advanced through the nose and nasopharynx into the oropharynx before laryngoscopy. The nostril through which the patient breathes most easily is selected in advance and prepared. Phenylephrine (0.5% or 0.25%) or tolazoline nose drops constrict blood vessels and shrink mucous membranes. If the patient is awake, local anesthetic ointment (for the nostril, delivered via an ointment-coated nasopharyngeal airway), spray (for the oropharynx), and nerve blocks can also be utilized.

An ETT lubricated with water-soluble jelly is introduced along the floor of the nose, below the inferior turbinate, *at an angle perpendicular to the face*. The tube's bevel should be directed laterally away from the turbinates. To ensure that the tube passes along the floor of the nasal cavity, the proximal end of the ETT should be pulled cephalad. The tube is gradually advanced, until its tip can be visualized in the oropharynx. Laryngoscopy, as discussed, reveals the abducted vocal cords. Often the distal end of the ETT can be pushed into the trachea without difficulty. If difficulty is encountered, the tip of the tube may be directed through the vocal cords with Magill forceps, being careful not to damage the cuff. Nasal passage of ETTs, airways, or nasogastric catheters carries greater risk in patients with severe midfacial trauma because of the risk of intracranial placement (**Figure 19–32**).



FIGURE 19–32 Radiograph demonstrating a 7.0-mm endotracheal tube placed through the cribriform plate into the cranial vault in a patient with a basilar skull fracture.

Although less used today, blind nasal intubation of spontaneously breathing patients can be employed. In this technique, after applying topical anesthetic to the nostril and pharynx, a breathing tube is passed through the nasopharynx. Using breath sounds as a guide, it is directed toward the glottis. When breath sounds are maximal, the anesthetist advances the tube during inspiration in an effort to blindly pass the tube into the trachea.

Flexible Fiberoptic Intubation

Fiberoptic intubation (FOI) is routinely performed in awake or sedated patients with problematic airways. FOI is ideal for:

- A small mouth opening

- Minimizing cervical spine movement in trauma or rheumatoid arthritis
- Upper airway obstruction, such as angioedema or tumor mass
- Facial deformities, facial trauma

FOI can be performed awake or asleep via oral or nasal routes in the following scenarios:

- **Awake FOI**—Predicted inability to ventilate by mask, upper airway obstruction
- **Asleep FOI**—Failed intubation, desire for minimal cervical spine movement in patients who refuse awake intubation, anticipated difficult intubation when ventilation by mask appears easy
- **Oral FOI**—Facial, skull injuries
- **Nasal FOI**—A poor mouth opening

When FOI is considered, careful planning is necessary, as it will otherwise add to the anesthesia time prior to surgery. Patients should be informed of the need for awake intubation as a part of the informed consent process.

The airway is anesthetized with a local anesthetic spray, and patient sedation is provided, as tolerated. Dexmedetomidine has the advantage of preserving respiration while providing sedation. Airway anesthesia is discussed in the Case Discussion at the end of this chapter.

If nasal FOI is planned, both nostrils are prepared with vasoconstrictive spray. The nostril through which the patient breathes more easily is identified. Oxygen can be insufflated through the suction port and down the aspiration channel of the FOB to improve oxygenation and blow secretions away from the tip.

Alternatively, a large nasal airway (eg, 36FR) can be inserted in the contralateral nostril. The breathing circuit can be directly connected to the end of this nasal airway to administer 100% oxygen during laryngoscopy. If the patient is unconscious and not breathing spontaneously, the mouth can be closed and ventilation attempted through the single nasal airway. When this technique is used, adequacy of ventilation and oxygenation should be confirmed by capnography and pulse oximetry. The lubricated shaft of the FOB is introduced into the ETT lumen. It is important to keep the shaft of the bronchoscope relatively straight (**Figure 19–33**) so that if the head of the bronchoscope is rotated in one direction, the distal end will move to a similar degree and in the same direction. As the tip of the FOB passes through the distal end of the ETT, the epiglottis or glottis should be visible. The tip of the bronchoscope is

manipulated, as needed, to pass the abducted cords.



FIGURE 19–33 Correct technique for manipulating a fiberoptic bronchoscope through an endotracheal tube is shown in the top panel; avoid curvature in the bronchoscope, which makes manipulation difficult.

Having an assistant thrust the jaw forward or apply cricoid pressure may improve visualization in difficult cases. Grasping the tongue with gauze and pulling it forward may also facilitate intubation.

Once in the trachea, the FOB is advanced to within sight of the carina. The presence of tracheal rings and the carina is proof of proper positioning. The ETT is pushed off the FOB. The acute angle around the arytenoid cartilage and epiglottis may prevent easy advancement of the tube. Use of an armored tube usually decreases this problem due to its greater lateral flexibility and more

obtusely angled distal end. Proper ETT position is confirmed by viewing the tip of the tube an appropriate distance (3 cm in adults) above the carina before the FOB is withdrawn.

Oral FOI proceeds similarly, with the aid of various oral airway devices to direct the FOB toward the glottis and to reduce obstruction of the view by the tongue.

SURGICAL AIRWAY TECHNIQUES

“Invasive” airways are required when the “can’t intubate, can’t ventilate” scenario presents and may be performed in anticipation of such circumstances in selected patients. The options include surgical cricothyrotomy, catheter or needle cricothyrotomy, transtracheal catheter with jet ventilation, and retrograde intubation.

Surgical cricothyrotomy refers to surgical incision of the cricothyroid membrane (CTM) and placement of a breathing tube. More recently, several needle/dilator cricothyrotomy kits have become available. Unlike surgical cricothyrotomy, where a horizontal incision is made across the CTM, these kits utilize the Seldinger catheter/wire/dilator technique. A catheter attached to a syringe is inserted across the CTM (**Figure 19–34**). When air is aspirated, a guidewire is passed through the catheter into the trachea (**Figure 19–35**). A dilator is then passed over the guidewire, and a breathing tube placed (**Figure 19–36**).



FIGURE 19–34 Cricothyrotomy. Slide catheter into trachea. (Used with permission from Lawrence B. Stack, MD.)

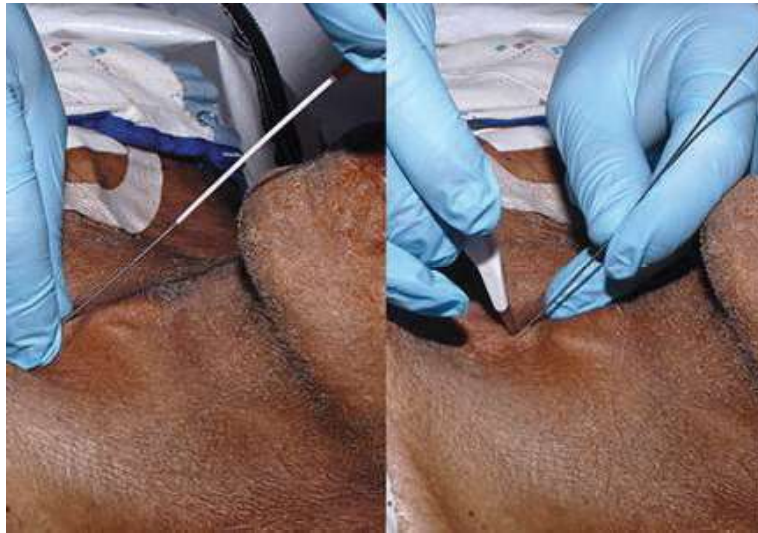


FIGURE 19–35 Cricothyrotomy. Incision at wire entry site. Remove catheter and make incision at the wire entry site. (Used with permission from Lawrence B. Stack, MD.)



FIGURE 19–36 Cricothyrotomy. Insert tracheostomy tube/introducer. Insert both devices over the wire and into the trachea. (Used with permission from Lawrence B. Stack, MD.)

Catheter-based salvage procedures can also be performed. A 16- or 14-gauge

intravenous cannula is attached to a syringe and passed through the CTM toward the carina. Air is aspirated. If a jet ventilation system is available, it can be attached. The catheter *must* be secured, otherwise the jet pressure will push the catheter out of the airway, leading to potentially disastrous subcutaneous emphysema. Short (1-s) bursts of oxygen ventilate the patient. Sufficient outflow of expired air must be assured to avoid barotrauma. Patients ventilated in this manner may develop subcutaneous or mediastinal emphysema and may become hypercapneic despite adequate oxygenation. Transtracheal jet ventilation will usually require conversion to a surgical airway or tracheal intubation.

Should a jet ventilation system not be available, a 3-mL syringe can be attached to the catheter and the syringe plunger removed. A 7.0-mm internal diameter ETT connector can be inserted into the syringe and attached to a breathing circuit or an AMBU bag. As with the jet ventilation system, adequate exhalation must occur to avoid barotraumas.

Retrograde intubation is another approach to secure an airway. A wire is passed via a catheter placed in the CTM. The wire is angulated cephalad and emerges either through the mouth or nose. The distal end of the wire is secured with a clamp to prevent it from passing through the CTM. The wire can then be threaded into an FOB with a loaded endotracheal tube to facilitate and confirm placement. Conversely, a small endotracheal tube can be guided by the wire into the trachea. Once placed, the wire is removed.

PROBLEMS FOLLOWING INTUBATION

Following apparently successful intubation, several scenarios may develop that require immediate attention. Anesthesia staff *must* confirm that the tube is correctly placed with auscultation of bilateral breath sounds immediately following placement. Detection of end-tidal CO₂ remains the gold standard in this regard, with the caveat that cardiac output must be present for end-tidal CO₂ production.

Decreases in oxygen saturation can occur following tube placement. This is often secondary to endobronchial intubation, especially in small children and infants. Decreased oxygen saturation perioperatively may be due to inadequate oxygen delivery (oxygen not turned on, patient not ventilated) or to ventilation/perfusion mismatch (almost any form of lung disease). When saturation declines, the patient's chest is auscultated to confirm bilateral tube placement and to listen for wheezes, rhonchi, and rales consistent with lung pathology. The breathing circuit is checked. An intraoperative chest radiograph

may be needed to identify the cause of desaturation. Intraoperative fiberoptic bronchoscopy can also be performed and used to confirm proper tube placement and to clear mucous plugs. Bronchodilators and deeper planes of inhalation anesthetics are administered to treat bronchospasm. Obese patients may desaturate secondary to a reduced FRC and atelectasis. Application of positive end-expiratory pressure may improve oxygenation.

Should the end-tidal CO₂ decline suddenly, pulmonary (thrombus) or venous air embolism should be considered. Likewise, other causes of a sudden decline in cardiac output or a leak in the circuit should be considered.

A rising end-tidal CO₂ may be secondary to hypoventilation or increased CO₂ production, as occurs with malignant hyperthermia, sepsis, a depleted CO₂ absorber, or breathing circuit malfunction.

Increases in airway pressure may indicate an obstructed or kinked endotracheal tube or reduced pulmonary compliance. The endotracheal tube should be suctioned to confirm that it is patent and the lungs auscultated to detect signs of bronchospasm, pulmonary edema, endobronchial intubation, or pneumothorax.

Decreases in airway pressure can occur secondary to leaks in the breathing circuit or inadvertent extubation.

TECHNIQUES OF EXTUBATION

Most often, extubation should be performed when a patient is either deeply anesthetized or awake. In either case, adequate recovery from neuromuscular blocking agents should be established prior to extubation.

Extubation during a light plane of anesthesia (ie, a state between deep and awake) is avoided because of an increased risk of laryngospasm. The distinction between deep and light anesthesia is usually apparent during pharyngeal suctioning: any reaction to suctioning (eg, breath holding, coughing) signals a light plane of anesthesia, whereas no reaction is characteristic of a deep plane. Similarly, eye opening or purposeful movements imply that the patient is sufficiently awake for extubation.

Extubating an awake patient is usually associated with coughing (bucking) on the ETT. This reaction increases the heart rate, central venous pressure, arterial blood pressure, intracranial pressure, intraabdominal pressure, and intraocular pressure. It may also cause wound dehiscence and increased bleeding. The presence of a ETT in an awake asthmatic patient may trigger bronchospasm. Some practitioners attempt to decrease the likelihood of these effects by

administering 1.5 mg/kg of intravenous lidocaine 1–2 min before suctioning and extubation; however, extubation during deep anesthesia may be preferable in patients who cannot tolerate these effects (provided such patients are not at risk of aspiration and/or do not have airways that may be difficult to maintain after removal of the ETT).

Regardless of whether the tube is removed when the patient is deeply anesthetized or awake, the patient's pharynx should be thoroughly suctioned before extubation to decrease the potential for aspiration of blood and secretions. In addition, patients should be ventilated with 100% oxygen in case it becomes difficult to establish an airway after the ETT is removed. Just prior to extubation, the ETT is untaped or untied and its cuff is deflated. The tube is withdrawn in a single smooth motion, and a face mask is applied to deliver oxygen. Oxygen delivery by face mask is maintained during the period of transportation to the postanesthesia care area.

COMPLICATIONS OF LARYNGOSCOPY & INTUBATION

The complications of laryngoscopy and intubation include hypoxia, hypercarbia, dental and airway trauma, tube malpositioning, physiological responses to airway instrumentation, and tube malfunction. These complications can occur during laryngoscopy and intubation, while the tube is in place, or following extubation ([Table 19–6](#)).

TABLE 19–6 Complications of intubation.

During laryngoscopy and intubation

Malpositioning

- Esophageal intubation

- Bronchial intubation

- Laryngeal cuff position

Airway trauma

- Dental damage

- Lip, tongue, or mucosal laceration

- Sore throat

- Dislocated mandible

- Retropharyngeal dissection

Physiological reflexes

- Hypoxia, hypercarbia

- Hypertension, tachycardia

- Intracranial hypertension

- Intraocular hypertension

- Laryngospasm

Tube malfunction

- Cuff perforation

While the tube is in place

Malpositioning

- Unintentional extubation

- Bronchial intubation

- Laryngeal cuff position

Airway trauma

- Mucosal inflammation and ulceration

- Excoriation of nose

Tube malfunction

- Fire/explosion

- Obstruction

Following extubation

Airway trauma

- Edema and stenosis (glottic, subglottic, or tracheal)

- Hoarseness (vocal cord granuloma or paralysis)

- Laryngeal malfunction and aspiration

Laryngospasm

- Negative-pressure pulmonary edema

Airway Trauma

Instrumentation with a metal laryngoscope blade and insertion of a stiff ETT often traumatizes delicate airway tissues. Tooth damage is a common cause of

(relatively small) malpractice claims against anesthesiologists. Laryngoscopy and intubation can lead to a range of complications from sore throat to tracheal stenosis. Most of these are due to prolonged external pressure on sensitive airway structures. When these pressures exceed the capillary–arteriolar blood pressure (approximately 30 mm Hg), tissue ischemia can lead to a sequence of inflammation, ulceration, granulation, and stenosis. Inflation of an ETT cuff to the minimum pressure that creates a seal during routine positive-pressure ventilation (usually at least 20 mm Hg) reduces tracheal blood flow by 75% at the cuff site. Further cuff inflation or induced hypotension can totally eliminate mucosal blood flow.

Postintubation croup caused by glottic, laryngeal, or tracheal edema is particularly serious in children. The efficacy of corticosteroids (eg, dexamethasone—0.2 mg/kg, up to a maximum of 12 mg) in preventing postextubation airway edema remains controversial, but this approach is often used. Vocal cord paralysis from cuff compression or other trauma to the recurrent laryngeal nerve results in hoarseness and increases the risk of aspiration. The incidence of postoperative hoarseness seems to increase with obesity, difficult intubations, and anesthetics of long duration. Curiously, applying a water-soluble lubricant or a local anesthetic-containing gel to the tip or cuff of the ETT does not decrease the incidence of postoperative sore throat or hoarseness, and, in some studies, actually increased the incidence of these complications. Smaller tubes (size 6.5 in women and size 7.0 in men) are associated with fewer complaints of postoperative sore throat. Repeated attempts at laryngoscopy during a difficult intubation may lead to periglottic edema and the inability to ventilate with a face mask, thus turning a bad situation into a life-threatening one.

Errors of Endotracheal Tube Positioning

❷ Unrecognized esophageal intubation can produce catastrophic results. Prevention of this complication depends on direct visualization of the tip of the ETT passing through the vocal cords, careful auscultation for the presence of bilateral breath sounds and the absence of gastric gurgling while ventilating through the ETT, detection of CO₂ in exhaled gas (the most reliable automated method), chest radiography, airway ultrasonography, or the use of an FOB.

Even though it is confirmed that the tube is in the trachea, it may not be correctly positioned. Overly “deep” insertion usually results in intubation of the right mainstem bronchus because the right bronchus forms a less acute angle

with the trachea than the left  bronchus. Clues to the diagnosis of bronchial intubation include unilateral breath sounds, unexpected hypoxia with pulse oximetry (unreliable with high inspired oxygen concentrations), inability to palpate the ETT cuff in the sternal notch during cuff inflation, and decreased breathing-bag compliance (high peak inspiratory pressures).

In contrast, inadequate insertion depth will position the cuff in the larynx, predisposing the patient to laryngeal trauma. Inadequate depth of insertion can be detected by palpating the cuff over the thyroid cartilage. Because no one technique protects against all possibilities for misplacing an ETT, minimal testing should include chest auscultation, routine capnography, and occasionally cuff palpation.

If the patient is repositioned, tube placement must be reconfirmed. Neck extension or lateral rotation most often moves an ETT away from the carina, whereas neck flexion most often moves the tube toward the carina.

At no time should excessive force be employed during intubation. Esophageal intubations can result in esophageal rupture and mediastinitis. Mediastinitis presents as severe sore throat, fever, sepsis, and subcutaneous air often manifesting as crepitus. Early intervention is necessary to avoid mortality. If esophageal perforation is suspected, consultation with an otolaryngologist or thoracic surgeon is recommended. Vocal cord injury can likewise result from repeated, forceful attempts at endotracheal intubation.

Physiological Responses to Airway Instrumentation

Laryngoscopy and tracheal intubation violate the patient's protective airway reflexes and predictably lead to hypertension and tachycardia when performed under "light" planes of general anesthesia. The insertion of an LMA is typically associated with less hemodynamic change. Hemodynamic changes can be attenuated by intravenous administration of lidocaine, opioids, or β -blockers, or deeper planes of inhalation anesthesia in the minutes before laryngoscopy. Hypotensive agents, including sodium nitroprusside, nitroglycerin, esmolol, nicardipine, and clevidipine, can attenuate the transient hypertensive response associated with laryngoscopy and intubation. Cardiac arrhythmias—particularly ventricular premature beats—sometimes occur during intubation and may indicate light anesthesia.

Laryngospasm is a forceful involuntary spasm of the laryngeal musculature caused by sensory stimulation of the superior laryngeal nerve. Triggering stimuli include pharyngeal secretions or passing an ETT through the larynx during

extubation. Laryngospasm is usually prevented by extubating patients either deeply asleep or fully awake, but it can occur—albeit rarely—in an awake patient. Treatment of laryngospasm includes providing gentle positive-pressure ventilation with an anesthesia bag and mask using 100% oxygen or administering intravenous lidocaine (1–1.5 mg/kg). If laryngospasm persists and hypoxia develops, small doses of succinylcholine (0.25–0.5 mg/kg) may be required (perhaps in combination with small doses of propofol or another anesthetic) to relax the laryngeal muscles and to allow controlled ventilation. The large negative intrathoracic pressures generated by a struggling patient during laryngospasm can result in the development of negative-pressure pulmonary edema, particularly in healthy patients.

Whereas laryngospasm may result from an abnormally sensitive reflex, aspiration can result from depression of laryngeal reflexes following prolonged intubation and general anesthesia.

Bronchospasm is another reflex response to intubation and is most common in asthmatic patients. Bronchospasm can sometimes be a clue to bronchial intubation. Other pathophysiological effects of intubation include increased intracranial and intraocular pressures.

Endotracheal Tube Malfunction

ETTs do not always function as intended. Polyvinyl chloride tubes may be ignited by cautery or laser in an oxygen/nitrous oxide–enriched environment. Valve or cuff damage is not unusual and should be excluded by careful inspection of the ETT prior to insertion. Obstruction of the ETT can result from kinking, from foreign body aspiration, or from thick or inspissated secretions in the lumen.

CASE DISCUSSION

Evaluation & Management of a Difficult Airway

A 47-year-old man with a long history of tobacco and alcohol abuse presents for emergency drainage of a right-sided submandibular abscess.

What are some important anesthetic considerations during the

preoperative evaluation of a patient with an abnormal airway?

Induction of general anesthesia followed by direct laryngoscopy and oral intubation is dangerous, if not impossible, in several situations. (Table 19–7). To determine the optimal intubation technique, the anesthesiologist must elicit an airway history and carefully examine the patient’s head and neck. Any available prior anesthesia records should be reviewed for previous problems in airway management. If a facial deformity is severe enough to preclude a good mask seal, positive-pressure ventilation may be impossible. Furthermore, patients with hypopharyngeal disease are more dependent on awake muscle tone to maintain airway patency. These two groups of patients should generally not be allowed to become apneic—including induction of anesthesia, sedation, or muscle paralysis—until their airway is secured.

TABLE 19–7 Conditions associated with difficult intubations.

Tumors

- Cystic hygroma
- Hemangioma
- Hematoma¹

Infections

- Submandibular abscess
- Peritonsillar abscess
- Epiglottitis

Congenital anomalies

- Pierre Robin syndrome
- Treacher Collins syndrome
- Laryngeal atresia
- Goldenhar syndrome
- Craniofacial dysostosis

Foreign body

Trauma

- Laryngeal fracture
- Mandibular or maxillary fracture
- Inhalation burn
- Cervical spine injury

Obesity

Inadequate neck extension

- Rheumatoid arthritis²
- Ankylosing spondylitis
- Halo traction

Anatomic variations

- Micrognathia
- Prognathism
- Large tongue
- Arched palate
- Short neck
- Prominent upper incisors

¹Can occur postoperatively in patients who have had any neck surgery.

²Also affects arytenoids making them immobile.

If there is an abnormal limitation of the temporomandibular joint that may not improve with muscle paralysis, a nasal approach with an FOB should be considered. Infection confined to the floor of the mouth usually does not preclude nasal intubation. If the hypopharynx is involved to the level of the hyoid bone, however, any translaryngeal attempt will be difficult. Other clues to a potentially difficult laryngoscopy include limited neck extension ($<35^\circ$), a distance between the tip of the patient's mandible

and hyoid bone of less than 7 cm, a sternomental distance of less than 12.5 cm with the head fully extended and the mouth closed, and a poorly visualized uvula during voluntary tongue protrusion. It must be stressed that because no examination technique is foolproof and the signs of a difficult airway may be subtle, the anesthesiologist must always be prepared for unanticipated difficulties.

The anesthesiologist should also evaluate the patient for signs of airway obstruction (eg, chest retraction, stridor) and hypoxia (agitation, restlessness, anxiety, lethargy). Aspiration pneumonia is more likely if the patient has recently eaten or if pus is draining from an abscess into the mouth. In either case, techniques that ablate laryngeal reflexes (eg, topical anesthesia) should be avoided.

Cervical trauma or disease is a factor that should be evaluated prior to direct laryngoscopy. Cervical arthritis or previous cervical fusion may make it difficult for the head to be put in the sniffing position; these patients are candidates for bronchoscopy to secure the airway, as discussed previously. Trauma patients with unstable necks or whose neck has not yet been “cleared” are also candidates for bronchoscopy for tracheal intubation. Alternatively, laryngoscopy with in-line stabilization can be performed (**Figure 19–37**).



FIGURE 19–37 Technique for airway management of a patient with suspected spinal cord injury. One individual holds the head firmly with the patient on a backboard, the cervical collar left alone if in place, ensuring

that neither the head nor neck moves with direct laryngoscopy. A second person applies cricoid pressure and the third performs laryngoscopy and intubation.

In the case under discussion, physical examination reveals swelling below the mandible and trismus that limits the patient's ability to open his mouth. Mask fit does not seem to be impaired. CT of the head and neck suggests that the infection has spread along tissue planes and is displacing the airway to the left.

Which intubation technique is indicated?

Oral and nasal intubations can be performed in awake patients. Whether the patient is awake or asleep or whether intubation is to be oral or nasal, it can be performed with direct laryngoscopy, fiberoptic visualization, or video laryngoscopy techniques.

Intubation may be difficult in this patient, however, because of limited mouth opening and distortion/displacement of the glottis. Induction of anesthesia should, therefore, be delayed until after the airway has been secured. Useful alternatives include awake fiberoptic intubation, awake video laryngoscopy, or awake use of optical stylets. The final decision depends on the availability of equipment and the experiences and preferences of the anesthesia caregivers.

Regardless of which alternative is chosen, an emergency surgical airway may be necessary. An experienced team, including a surgeon, should be in the operating room and all necessary equipment should be available and unwrapped. The neck can be prepped and draped.

What premedication would be appropriate for this patient?

Any loss of consciousness or interference with airway reflexes could result in airway obstruction or aspiration. Glycopyrrolate would be a good choice of premedication because it minimizes upper airway secretions without crossing the blood–brain barrier. Parenteral sedatives should be very carefully titrated. Dexmedetomidine and ketamine preserve respiratory effort and could be used as sedatives. Psychological preparation of the patient, including explaining each step planned in securing the airway, may improve patient cooperation.

What nerve blocks could be helpful during an awake

intubation?

The lingual and some pharyngeal branches of the glossopharyngeal nerve that provide sensation to the posterior third of the tongue and oropharynx are easily blocked by bilateral injection of 2 mL of local anesthetic into the base of the palatoglossal arch (also known as the anterior tonsillar pillar) with a 25-gauge spinal needle (**Figure 19–38**).



FIGURE 19–38 Nerve block. While the tongue is laterally retracted with a tongue blade, the base of the palatoglossal arch is infiltrated with local anesthetic to block the lingual and pharyngeal branches of the glossopharyngeal nerve. Note that the lingual branches of the glossopharyngeal nerve are not the same as the lingual nerve, which is a branch of the trigeminal nerve.

Bilateral **superior laryngeal nerve blocks** and a transtracheal block would anesthetize the airway below the epiglottis (**Figure 19–39**). The hyoid bone is located, and 3 mL of 2% lidocaine is infiltrated 1 cm below each greater cornu, where the internal branch of the superior laryngeal nerves penetrates the thyrohyoid membrane.

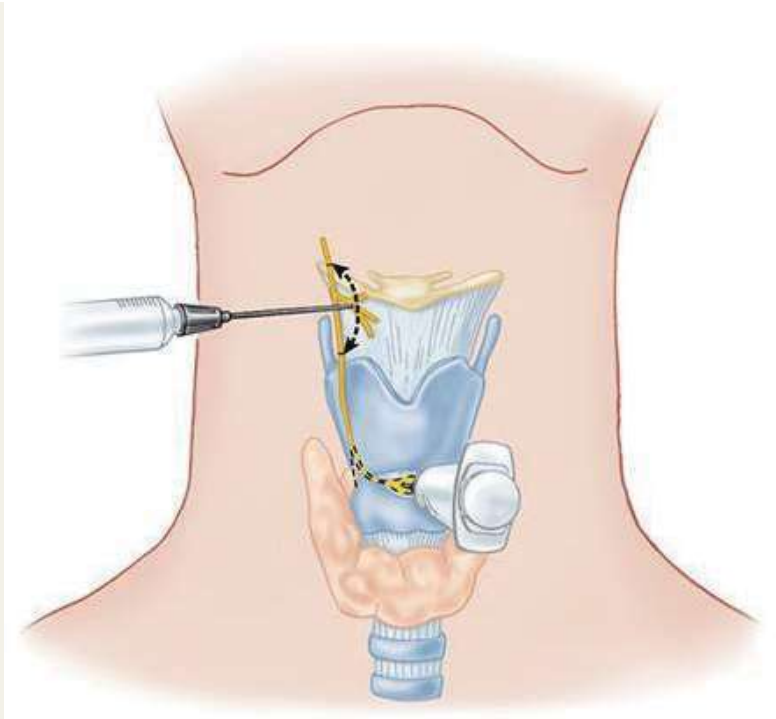


FIGURE 19–39 Superior laryngeal nerve block and transtracheal block.

A transtracheal block is performed by identifying and penetrating the CTM while the neck is extended. After confirmation of an intratracheal position by aspiration of air, 4 mL of 4% lidocaine is injected into the trachea at end expiration. A deep inhalation and cough immediately following injection distribute the anesthetic throughout the trachea. Although these blocks may allow the awake patient to tolerate intubation better, they also obtund protective cough reflexes, depress the swallowing reflex, and may lead to aspiration. Topical anesthesia of the pharynx may induce a transient obstruction from the loss of reflex regulation of airway caliber at the level of the glottis.

A relatively simple alternative to all of these is to allow the patient to breathe atomized lidocaine for several minutes prior to instrumentation as is typically done for outpatient bronchoscopy.

Because of this patient's increased risk for aspiration, local anesthesia might best be limited to the nasal passages. Four percent cocaine has no advantages compared with a mixture of 4% lidocaine and 0.25% phenylephrine and can cause cardiovascular side effects. The maximum safe dose of local anesthetic should be calculated—and not exceeded. Local

anesthetic is applied to the nasal mucosa with cotton-tipped applicators until a nasal airway that has been lubricated with lidocaine jelly can be placed into the naris with minimal discomfort. Benzocaine spray is frequently used to topicalize the airway, but can produce methemoglobinemia, and for this reason we prefer lidocaine.

Why is it necessary to be prepared for a surgical airway?

Laryngospasm is always a possible complication of intubation in the nonparalyzed patient, even if the patient remains awake. Laryngospasm may make positive-pressure ventilation with a mask impossible. If succinylcholine is administered to break the spasm, the consequent relaxation of pharyngeal muscles may lead to upper airway obstruction and continued inability to ventilate. In this situation, an emergency cricothyrotomy may be lifesaving.

What are some alternative techniques that might be successful?

Other possible strategies include the retrograde passage of a long guidewire or epidural catheter through a needle inserted across the CTM. The catheter is guided cephalad into the pharynx and out through the nose or mouth. An ETT is passed over the catheter, which is withdrawn after the tube has entered the larynx. Variations of this technique include passing the retrograde wire through the suction port of a flexible FOB or the lumen of a reintubation stylet that has been preloaded with an ETT. These thicker shafts help the ETT negotiate the bend into the larynx more easily. Obviously, a vast array of specialized airway equipment exists and must be readily available for management of difficult airways (**Table 19–8**). Either of these techniques would have been difficult in the patient described in this case because of the swelling and anatomic distortion of the neck that can accompany a submandibular abscess.

TABLE 19–8 Suggested contents of the portable storage unit for difficult airway management.^{1,2}

- Rigid laryngoscope blades of alternate design and size from those routinely used.
- Endotracheal tubes (ETTs) of assorted size.
- ETT guides. Examples include (but are not limited to) semirigid stylets with or without a hollow core for jet ventilation, light wands, and forceps designed to manipulate the distal portion of the ETT.
- Laryngeal mask airways of assorted sizes.
- Fiberoptic intubation equipment and assorted video and indirect laryngoscopes.
- Retrograde intubation equipment.
- At least one device suitable for emergency nonsurgical airway ventilation. Examples include (but are not limited to) transtracheal jet ventilator, hollow jet ventilation stylet, and Combitube.
- Equipment suitable for emergency surgical airway access (eg, cricothyrotomy).
- An exhaled CO₂ detector.

¹Modified with permission from the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Practice guidelines for management of the difficult airway: A report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. *Anesthesiology*. 2003 May;98(5):1209-1277.

²The items listed in this table are suggestions. The contents of the portable storage unit should be customized to meet the specific needs, preferences, and skills of the practitioner and healthcare facility.

What are some approaches when the airway is unexpectedly difficult?

The unexpected difficult airway can present both in elective surgical patients and also in emergency intubations in intensive care units, the emergency department, or general hospital wards. Should video laryngoscopy fail even after attempts with an intubating bougie, an intubating LMA should be attempted (**Figure 19–40**). If ventilation is adequate, an FOB can be loaded with an ETT and passed through the LMA into the trachea. Correct tube position is confirmed by visualization of the carina.



FIGURE 19–40 Intubating laryngeal mask airway.

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Preface

“When you can’t breathe nothing else matters.

So always treat me with respect. I’m your **AIRWAY**”

Basic airway management is a fundamental skill that all EMS professionals should master. It has evolved significantly in recent years. Techniques and devices are being developed and changing constantly.

I am a strong believer of the fact that our patients deserve nothing less than an excellent airway management and that is their fundamental right. We, the anaesthesiologists are the prime providers of the airway management skills. Learning the up to-date techniques in the field and propagating the learnt techniques remains the backbone of this manual.

This manual emphasizes on the ‘must knows’ of the advanced airway skills. It comprises of four handouts being written by eminent airway caregivers in their respective fields. We tried to simplify the techniques in a concise manner so that it will be easy to remember. This manual should be of great help to practicing as well as budding anaesthesiologists and intensivists.

This manual would not be possible without a strong support group. The team members have translated their rich clinical experience in the field of airway into words. I thank all of them for their tireless efforts and dedication without which this manual would not be possible.

I wish you all a leisure reading!

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SUPRAGLOTTIC AIRWAY DEVICES:

WHERE WE HAVE REACHED

Supraglottic airway devices (SADs) are also known as extraglottic airway devices. These devices can be inserted into the pharynx with their distal ends lying in the hypopharynx or esophagus to allow ventilation, oxygenation, and administration of anesthetic gases, without the need for endotracheal intubation.

Classification based on Evolution of Supraglottic Airway Device

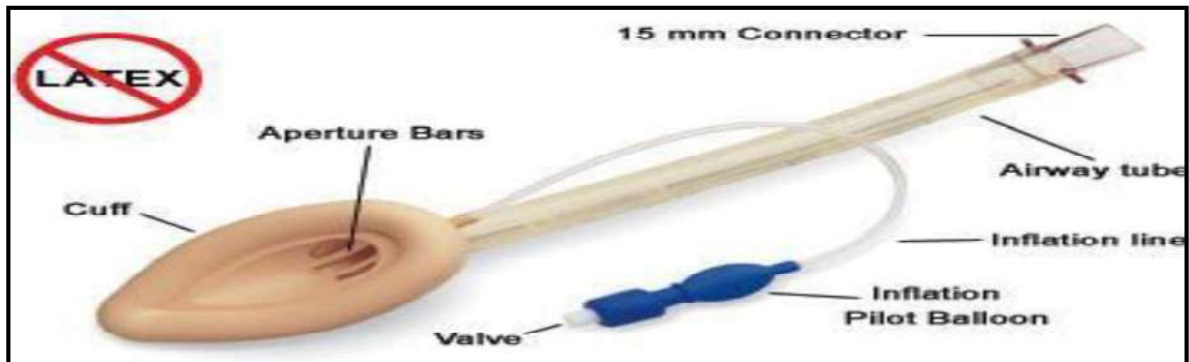
<i>First Generation Devices: Simple airway tubes</i>	<i>Second Generation Devices: Airway tubes with addition of drainage tube to reduce risk of aspiration</i>	<i>Third generation SAD</i>
LMA Classic LMA Flexible Intubating LMA	ProSeal LMA LMA Supreme i-gel Ambu AuraGain Combitube	Baska 3gLM

Uses of SADs:

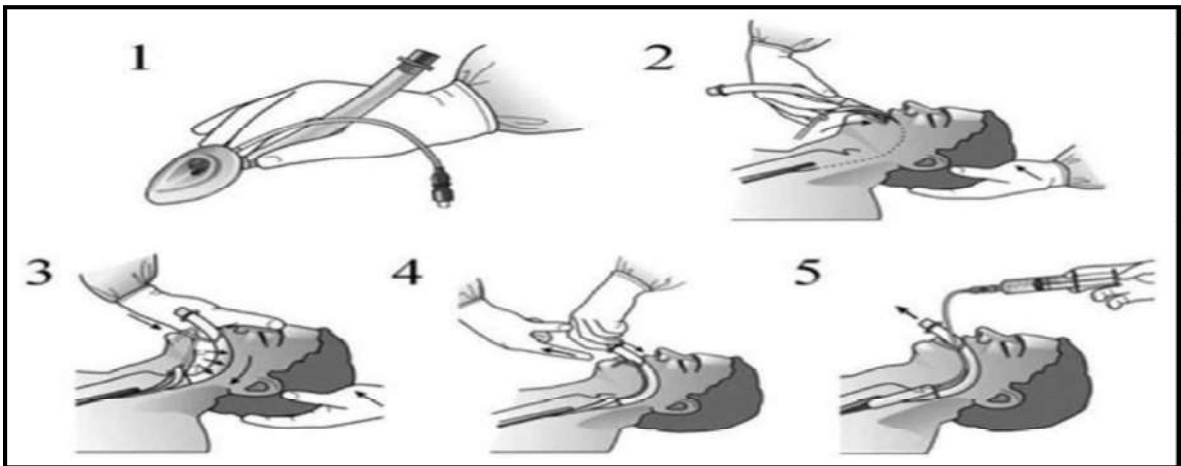
- Routine & Emergency anesthesia: In the operating room & remote areas
- Difficult airway & role of the LMA in ASA Difficult Airway Algorithm
- Weaning in ICU
- Cardiopulmonary resuscitation (CPR)
- Fiberoptic intubation
- Avoiding the complications of intubation

Laryngeal Mask Airway (Classic)

- First introduced by Dr Archie Brain in 1988
- LMA classic is not an ideal airway device because the low-pressure seal may be inadequate for positive pressure ventilation, and it does not protect the lungs from aspiration



Techniques of insertion of LMA



Fastrach – Intubating Laryngeal Mask Airway

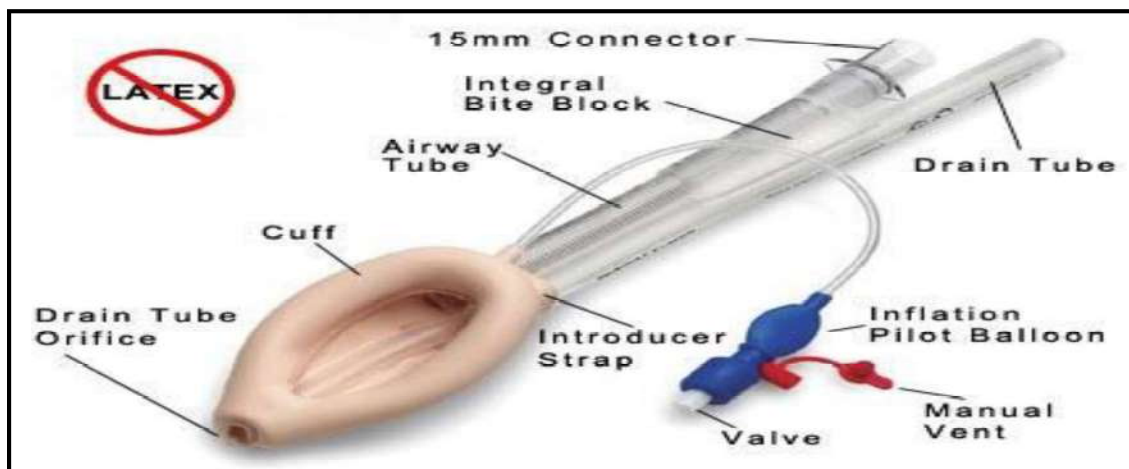
- Fastrach a modification of the LMA is in use from 1997
- designed as a conduit for tracheal intubation in neutral position
- ILMA has a success rate for endotracheal intubation of approximately 93%.
- The LMA-Fastrach tracheal tube should not remain in place for long periods of time because it has a high pressure cuff
- The LMA-Fastrach is unsuitable for use in the MRI unit



The ProSeal Laryngeal Mask Airway (PLMA):

Additional features from LMA -Classic are:

- Improve the laryngeal seal without increasing mucosal pressures
- Separate the respiratory and alimentary tracts
- Provide higher airway seal pressures for use with positive pressure ventilation (PPV)
- Includes a built-in bite block that protects against occlusion
- Drain tube provides direct access to stomach contents
- Insertion without the need to place fingers in the patients mouth



Techniques of insertion:

1. Introducer insertion technique
2. Index finger insertion technique

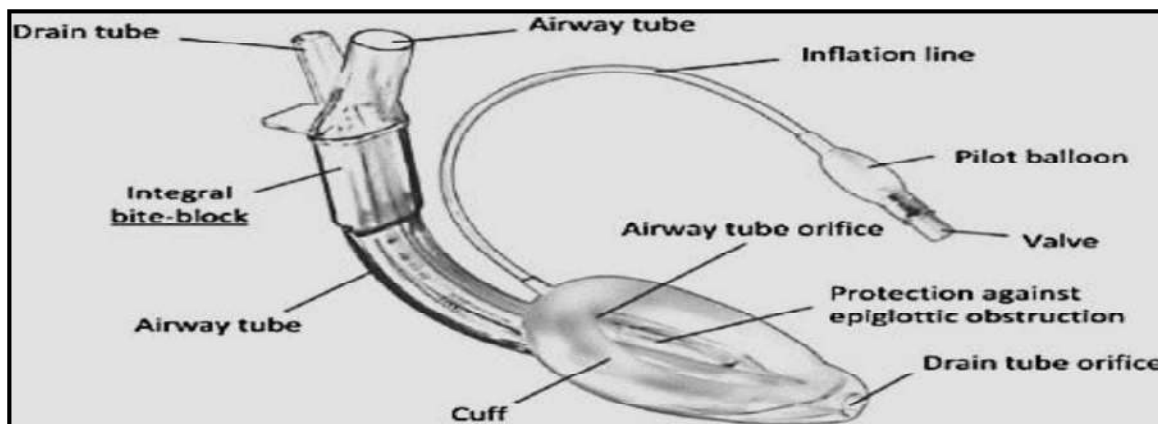
Gum elastic bougie guided insertion

Confirmation of cuff placement

- After inflation of cuff it will pop out, smooth oval swelling in neck, no visible cuff in oral cavity
- Bite block-depth of insertion (should be at the level of the teeth)
- Ventilation
 - *Chest movement, feel of bag
 - *Capnography
 - *Ease of ventilation
- Suprasternal notch test (Brimacombe bounce) should be present
- Able to pass oro-gastric tube

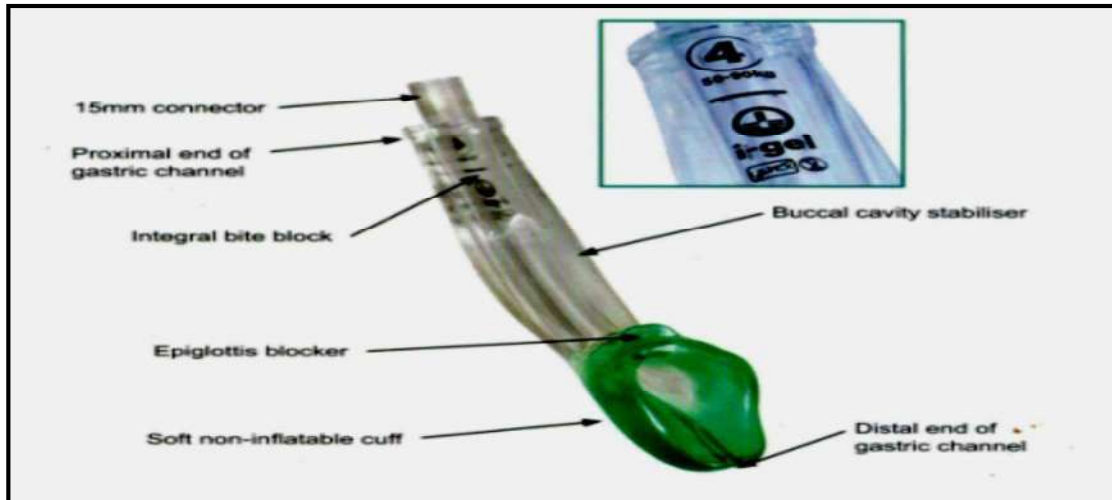
LMA Supreme

- Introduced in 2007
- LMA Supreme is a single use
- Compared with the PLMA, the insertion success rate is higher but the PLMA is associated with significantly higher leak pressures



I-GEL

- Invented by Dr. Muhammed Aslam Nasir in 2007
- Single use & truly anatomical device
- Cuff less: Made of thermoplastic elastomer (SEBS)
- Narrow-bore esophageal device tube
- Short wide bore airway tube and an integral bite block



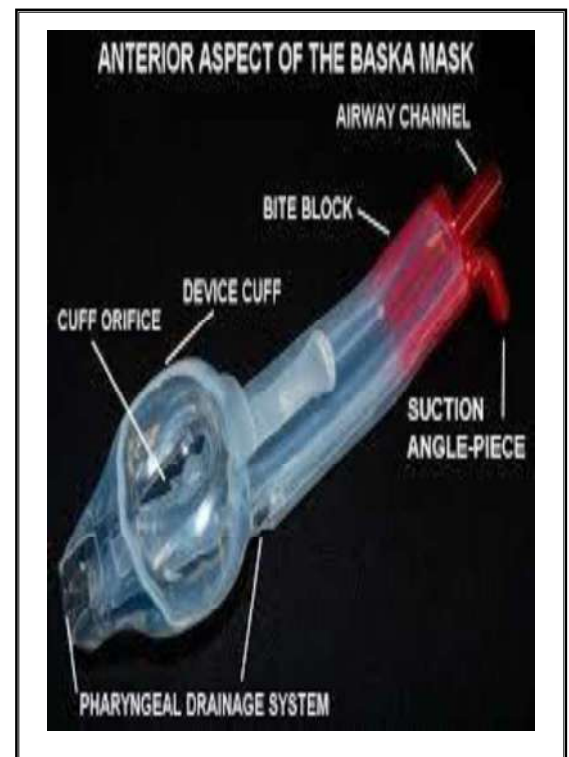
What's New????

Baska Mask

- It is a newer supraglottic airway device made of medical grade silicone introduced in 2012
- It is available in four sizes (3, 4, 5 and 6) for patients ranging between 30 kg to > 100 kg

Components

1. Cuffless membranous bowl: It inflates and deflates with each positive pressure breath during inspiration and expiration respectively.
2. Tab: It helps to increase device angulation for easy negotiation of the oro-pharyngeal curve during placement of the device.
3. Dual drainage system i.e. an esophagus drainage inlet and side channel to drain pharyngeal contents.
4. Bite block



Techniques of insertion:

- Lubricate the device with water soluble jelly
- Place patient head and neck in neutral position
- Open the mouth of the patient
- Compress the proximal firmer parts of the mask between thumb and two fingers
- Push the mask past the front teeth towards the hard palate
- If needed, pull the tube to negotiate the palatopharyngeal curve. Once the tip of the mask crosses the curve release the tube
- The mask is advanced until resistance is encountered
- Fix the device and connect to anaesthesia circuit

3gLM

- Similar to Baska mask & seals the laryngeal orifice
- It consists of a non-inflatable cuff which adapts to the laryngeal anatomy during PPV
- It has two gastric tube channels for drainage of gastric contents



VIDEOLARYNGOSCOPES: NEED OF THE HOUR !!!

Introduction:

Videolaryngoscopy (VL) utilizes video camera technology to visualize airway structures and facilitate endotracheal intubation (ETI). Despite a lack of clear evidence suggesting VL improves overall ETI success, videolaryngoscope has quickly become a well-established tool in the armamentarium of the anesthesiologist as well as other healthcare providers (e.g., emergency department, intensive care unit, and prehospital settings) involved in airway management.

Direct laryngoscopy (DL) remains the gold standard technique as an effective means to securing the airway. It is a complicated technical skill with a variable learning curve requiring training, experience, and regular practice to acquire and maintain. DL requires a direct line of sight to align airway axes (oral-pharyngeal-laryngeal) for optimal glottic visualization. Oftentimes, manipulations to align these axes include head extension, neck flexion, laryngeal manipulation, and other stressful movements. Macintosh DL lifting forces can require 35-50 N to expose the glottis. These manipulations of the airway have adverse implications from significant hemodynamic disturbance, cervical instability, injury to oral and pharyngeal tissues, and dental damage.

In contrast to DL, videolaryngoscope utilizes indirect laryngoscopy via its camera; thereby eliminating the need for a direct line of sight to visualize airway structures. In fact, this helps improve glottic visualization. VL requires the application of less force (5-14 N) to the base of the tongue, therefore is less likely to stimulate stress response and induce local tissue injury. Certain videolaryngoscopes have been shown to produce less cervical movement when compared to DL. Furthermore, there is a faster learning curve relative to DL independent of status as a novice or experienced laryngoscopist.

Classification:

The most commonly used classification is:

- 1) Macintosh-modification: like C-MAC, McGrath
- 2) Angulated blade: like King vision
- 3) Tube/guide channel: like Airtraq

□ **C-MAC:**



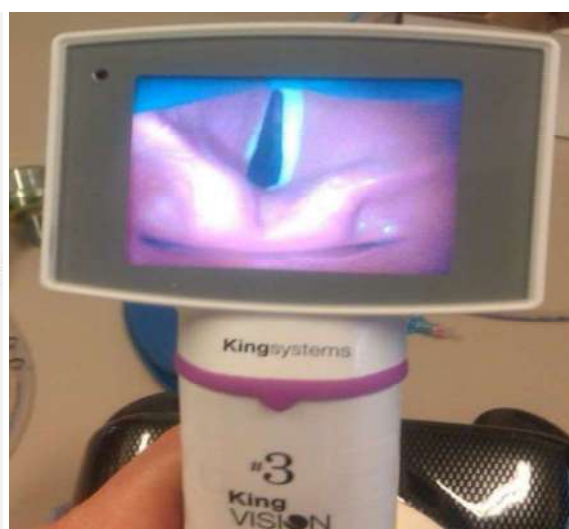
- Macintosh-modification
- 7" LCD display
- Reusable and disposable blades
- Macintosh, Miller and D blades
- Adult and paediatric sizes
- Advantage is the ability to perform both indirect and direct laryngoscopy
- Do not always require a stylet

□ **McGrath:**

- Macintosh-like curvature & non-channeled; 11.9 mm disposable blades in 4 sizes
- Light weight and portable thus better ergonomics
- Single device can be used to intubate all age groups
- The anterior camera angle enables better anatomical positioning
- 2.5" LCD portrait screen reduces the risk of soft palate injury caused by 'blind-spot'
- Replaceable 3.6V lithium power cells which lasts for 250 minutes
- Can perform direct and indirect laryngoscopy
- May not always require stylet
- The McGRATH® X blade is solution for difficult airway scenarios

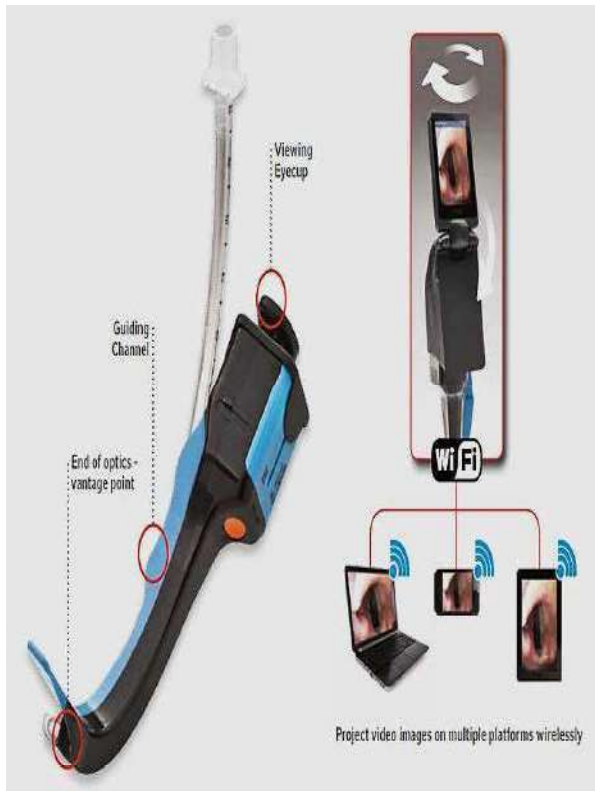


□ King vision:



- Angulated blade
- Requires stylet if non-channelled blade
- Light weight and portable
- Adult and paediatric sizes
- Disposable blade

□ **Airtraq:**



- Tube guide channel
- Prism based optics
- Disposable blades of adult and paediatric sizes
- Light weight and portable
- Blade for nasal intubation and double lumen tube available

Advantages:

1. Unnecessary to align airway axis
2. Improved glottis visualization
3. Higher ETI success rate with non-expert, and possibly expert
4. It allows others to view the screen and/or help facilitate ETI (e.g. Redirect cricoid pressure, acquire other airway devices)
5. Effective tool for those who infrequently intubate as well as for students
6. Less cervical manipulation
7. Possible awake assessment/intubation
8. Recording can be done for documentation & teaching purpose

Disadvantages:

1. Difficulty in passing ETT despite improved glottis visualization (esp. with angulated blades)
2. Possible increased intubation time
3. Variable learning curve
4. Potential weakening development/maintenance of DL skill set, especially in non-experts of airway management
5. Potential for false sense of security and lack of preparation for difficult airway
6. 2-D view with loss of depth perception
7. Obscured view by fogging and secretions on camera lens
8. More complicated
9. expensive

Uses:

Anticipated and unanticipated difficult

2. Routine intubation
3. Emergency situations with high risk patients (ASA III & IV)
4. Intubation in cervical spine patients
5. VL can serve as a teaching and supervising tool for tracheal intubation
6. Awake intubation using VL
7. Using VL to visualize and facilitate, a more confident ETT exchange has been described
8. Foreign body removal from the hypo-pharynx
9. Placement of a double-lumen tube
10. Facilitating percutaneous tracheostomy

Parts:

All videolaryngoscopes primarily have four parts namely:

1. Blade
2. Battery
3. Screen/display
4. Camera with light source

Technique of insertion:

- Check the proper functioning of the equipment.
- Choose the right size blade according to the age, weight, sex of the patient
- In channelled blade ensure that the tube is properly lubricated and the tip should not project beyond the blade (to avoid obscuring the view).
- If using a stylet, ensure its proper lubrication and angulate the tube in concordance to the angle of the blade.
- Position patient's head (neutral position)
- *In case of **C-MAC**:*
 - ✓ Introduce the blade from right and sweep to the left side of the oral cavity
 - ✓ After bypassing the base of tongue, focus eyes on camera to locate the epiglottis and enter the tip of the blade into the vallecula and lift the larynx
 - ✓ Introduce the ETT (with or without stylet) into oral cavity (under vision) and after negotiating the base of tongue guide it further looking at the camera and intubate the trachea.
- *For other videolaryngoscopes:*
 - ✓ Introduce the blade in the midline looking into the oral cavity
 - ✓ Slowly guide the scope beyond the base of tongue while looking at the camera
 - ✓ Visualise epiglottis and place the tip of the blade in the vallecula
 - ✓ If channelled blade then pass the ETT looking at the camera
 - ✓ In case of non-channelled, insert the ETT in oral cavity and guide it across vocal cord looking at the camera

Limitations and difficulties:

Difficulty may be encountered with inserting certain VL devices into the oral cavity. The angulated blade requires a greater tilt of the handle to enter the oropharynx. Various patient factors (e.g., obesity, large chests/breasts, short neck, etc.) can make achieving this tilt a challenge. Also, injuries can occur by blind advancement of the stylet ETT before being in the video camera's field of view. Another possibility is the operator placing all their attention on the monitor and blindly attempting instrument insertion into the oropharynx.

More studies are still needed to determine whether VL actually improves ETI success rates and thereby a potential replacement to traditional direct laryngoscopy. Advances in technology have heralded a wide array of different models of videolaryngoscopes each with their own strengths, weaknesses and other optimal applications. The role of videolaryngoscopes continues to evolve each day which needs to be embraced

FLEXIBLE FIBRE-OPTIC BRONCHOSCOPY

Flexible fibre-optic bronchoscopy (FOB) is a diagnostic and therapeutic procedure of great value in the clinical practice of anesthesia.

FOB is universally recognized as the **gold standard** in the awake, sedated or anesthetized “difficult to intubate” patients.

Fibre-optic technology- It uses fibre-optic bundles to transmit images from the distal lens. These glass bundles run the length of the scope containing thousands of glass fibers, approx. 8 – 10 microns in diameter. The image transmission bundle allows light to travel along the length of the fiber, being internally reflected along its length to the eyepiece whilst still retaining a sharp image of the object. A typical fibre-optic bundle contains 10,000 glass fibers.

Indications –

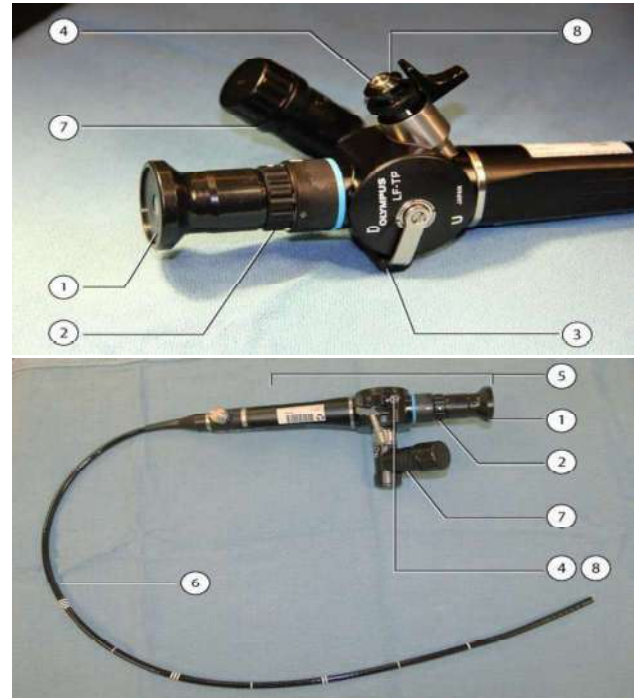
- Difficult intubation(DI) or history of prior DI
- Prevention of cervical spine motion in at-risk patients
- Diagnostic purposes-trouble-shooting hypoxemia, high airway pressures, observation for vocal cord paralysis, tracheomalacia
- Therapeutic uses- ETT exchange, positioning of DLT, intra-tracheal observation of tracheostomy instrument entry

Advantages-

- Allows complete visual examination of the airway before intubation
- Provides conformation of tube placement
- Eliminates the need for three-axis alignment
- Less potential for airway & dental trauma
- Can be performed in multiple patient position

Components of FOB:

1. **Eyepiece** –can attach camera to display on screen
2. **Diopter focusing ring**- adjustable to sharpen the image
3. **Angulation control lever**- up & down movement of the tip in vertical plane (240-350 degrees)
4. **Working channel port**- 1.2-2.8mm in diameter, runs the length of FOB
5. **Body/handle/control section**
6. **Insertion cord**- 50-65cm in length, contains fibre-optic bundles
7. **Light source**
8. **Suction valve/port**



Models available:

Sizes from infant to adults with varying features

- Karl Storz- 2.8-5.0 mm(external diameter), 50-65 cm(working length), 1.2-2.3mm (working channel)
- Ambu Ascope™ (3 family) - disposable with suction, battery operated, large, regular & slim versions having 5.8, 5.0, 3.8 mm (External diameter), 63 cm (working length), 2.8, 2.2, 1.2 mm (working channel) respectively.
- Pentax
- Olympus

Techniques of FOB: Nasal & Oral routes

Awake & Anesthetized

Care of FOB:

- Avoid twisting insertion cord as it may break fibre-optic fibres.
- Rotation should be from body of FOB
- Use bite block in awake pts to prevent inadvertent biting
- Store with insertion cord straight, suspend from the handle in dedicated cart

Steps of usage:

1. Place the FOB cart on the left side of patient and check the scope.
2. Position the patient and attach ASA monitors.
3. Adjust eyepiece to bring black marker at 12-o'clock position.
4. Focus some written material using diopter adjustable ring.
5. Check suction port and working port.
6. Railroad the desired ETT onto the FOB and secure at the top.
7. Hold the handle in dominant hand with thumb on the angulation lever and index finger on suction button.
8. Non-dominant hand to hold the insertion cord 15cm from the tip.
9. Insert and follow the black hole using flexible tip and rotational movement of the handle.

What's new with flexible FOB???

Ambu Ascopes™ –

- New Disposable flexible bronchoscope
- Fibre-less
- Built-in camera with light emitting diode (LED)
- Lightweight
- Battery- operated with
- Suction port.



CRICOTHYROIDOTOMY AND PERCUTANEOUS DILATATIONAL TRACHEOSTOMY

“We are the real Masters”

Cricothyroidotomy is the endpoint for almost all *can't intubate & can't ventilate* situations

Indications of cricothyroidotomy:

- Oedema of glottis
- Severe maxilla-facial fractures
- Laryngeal injury
- Severe oro-pharyngeal haemorrhage
- CICV situation
- Pulmonary toileting & Bronchoscopy

Contraindications of cricothyroidotomy:

- Obliterated anatomical landmarks
- Obesity
- Cervical and laryngeal trauma
- Airway obstruction distal to sub-glottis
- Laryngeal cancer extending to sub-glottis
- Coagulopathy
- Age < 12 years

Types of Cricothyroidotomy:

- Needle
- Open or surgical
- Rapid four step method
- Percutaneous (**Melker**)
- Kit based (**PCK, Quicktrach**)

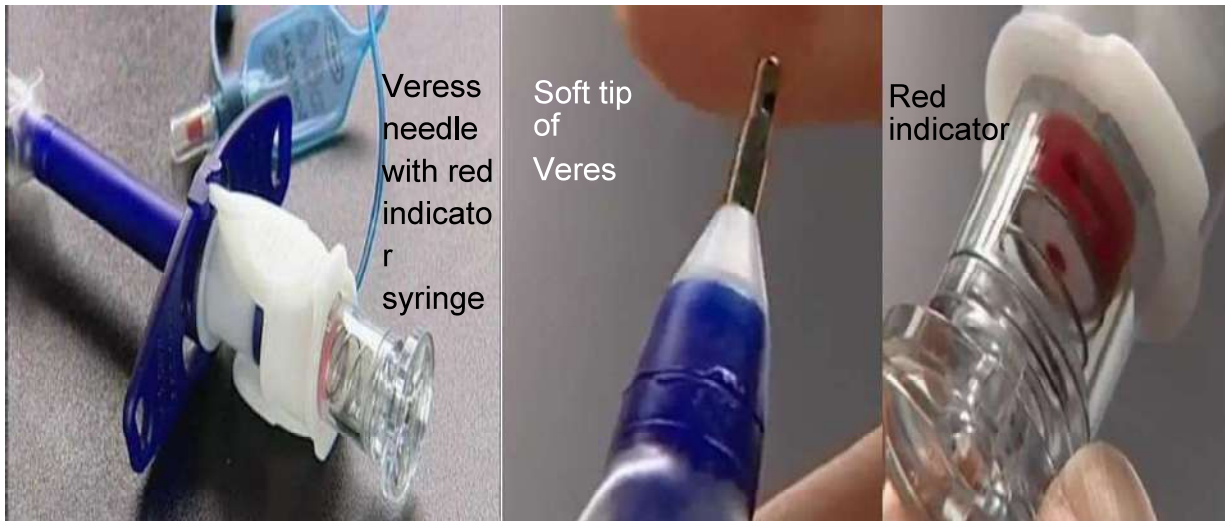
Kit based cricothyrotomy:

- Composite kits used
- Very rapid technique (<1 minute)

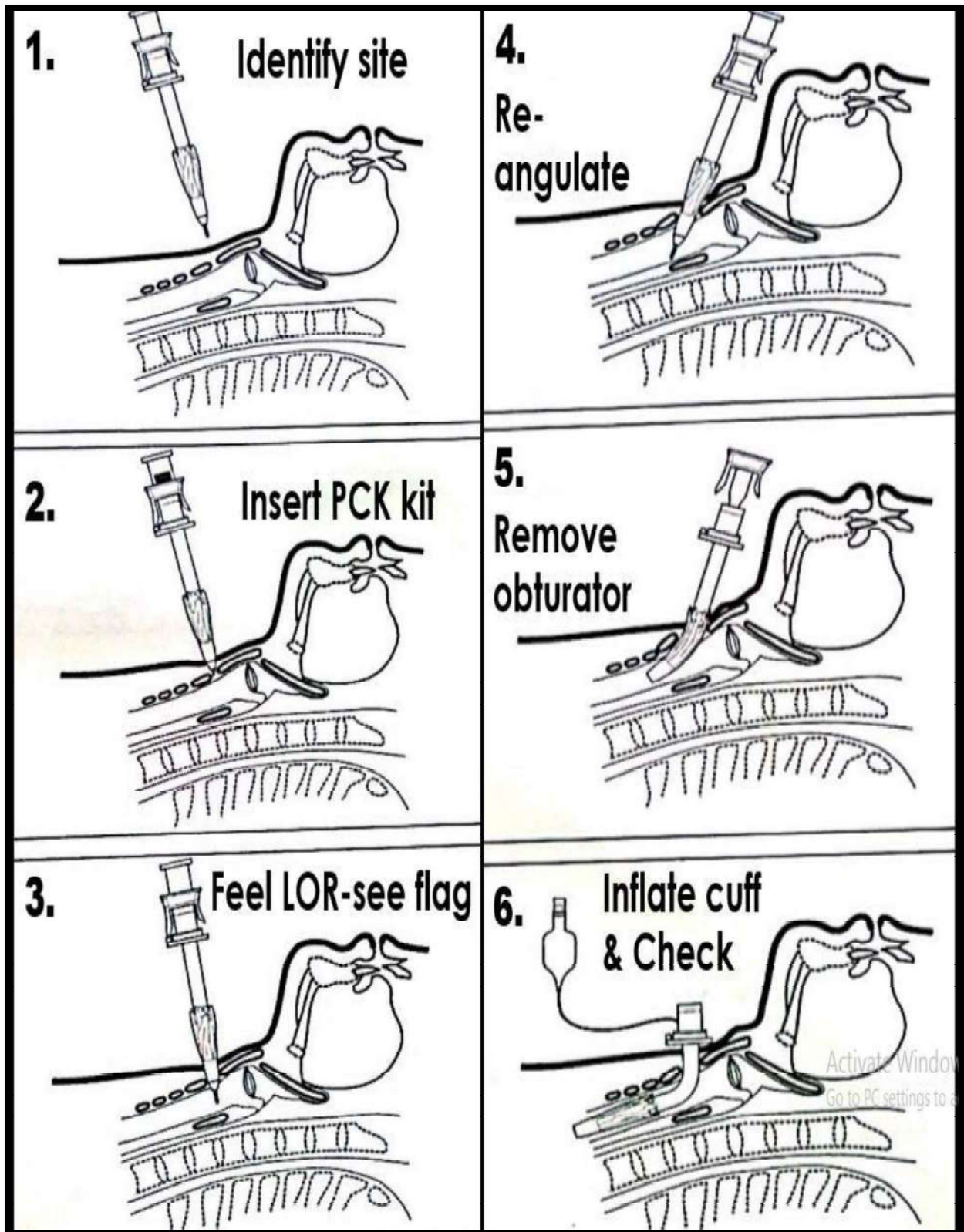


Portex PCK (Smith's)

Quick-trach (DS Mediac)



Steps for Cricothyrotomy:



Percutaneous dilatational tracheostomy (PCDT):

It is anaesthesiologist's forté towards complete airway solutions.

Indications of PCDT:

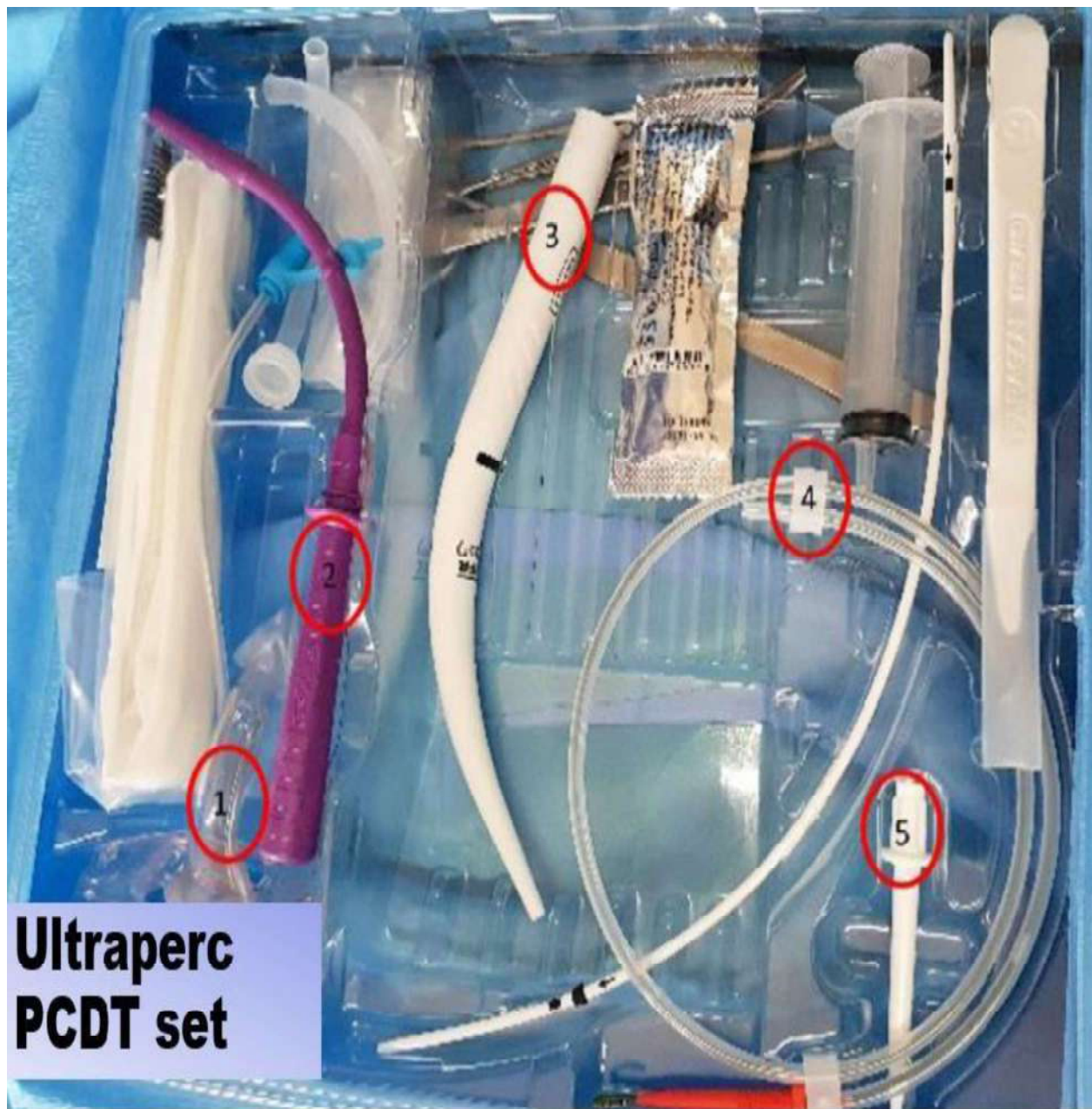
- Intubation > 7 days
- Patients >18 years of age
- Expected >10 days mechanical ventilation

Contraindications of PCDT:

- Emergency tracheostomy.
- Cervical spine injury.
- Infection at the site
- Distorted neck anatomy
- BMI > 35
- Platelet count <50000/cu. mm & INR >1.5

Techniques for PCDT:

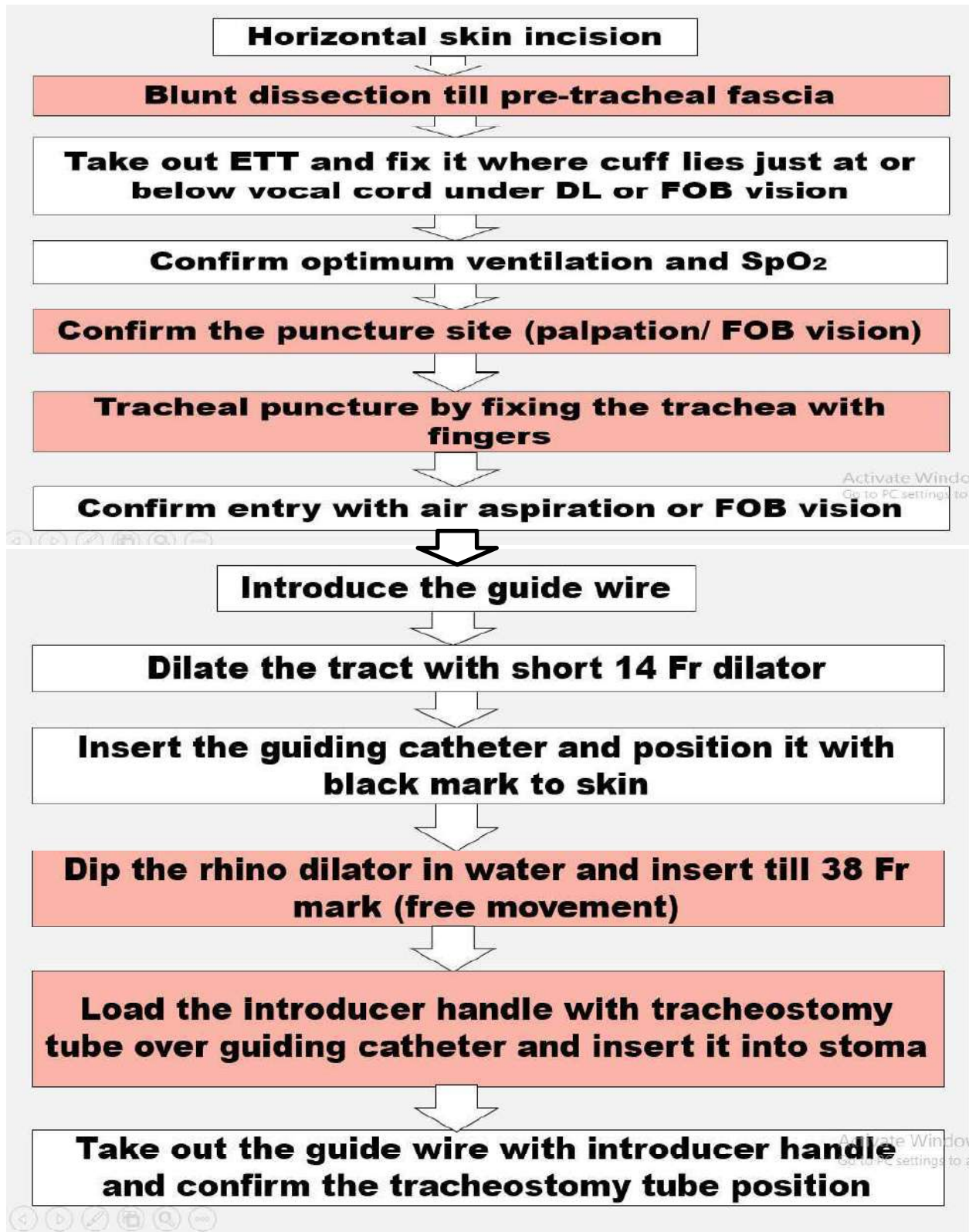
- Ciaglia's multiple dilation
- Griggs' forceps dilatation
- Fantoni's translaryngeal method
- Single tapered dilation (blue rhino & white rhino)
- Frova's Percutwist
- Ambesh's T-dragger
- Balloon dilatational (Blue dolphin)
- Safe-Trach



Major components of Portex Ultraperc™ PCDT set.

- | | |
|--|--------------------------------------|
| 1. Ultrasuctionoid blue line tracheostomy tube | 4. Soft J tipped metallic guide wire |
| 2. Tracheostomy tube introducer handle | 5. Short dilator. (14 French) |
| 3. Single tapered White rhino dilator. | |

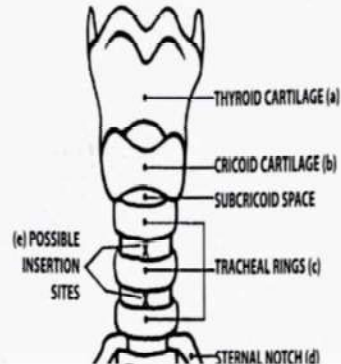
Steps of PCDT with Ultraperc™ set:



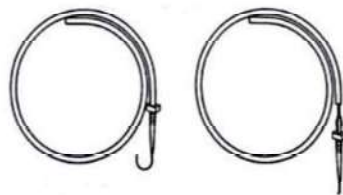
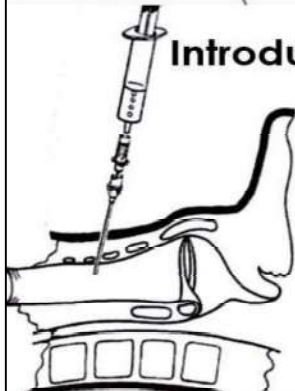
Neck extension



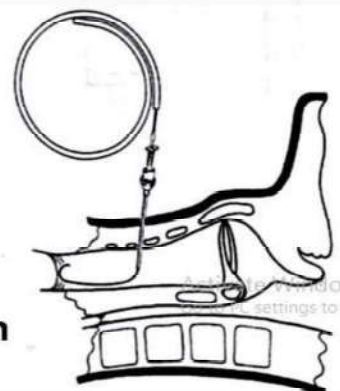
Horizontal skin incision



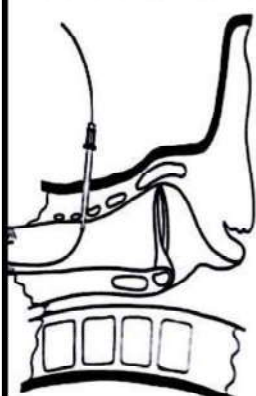
Introducer needle entry



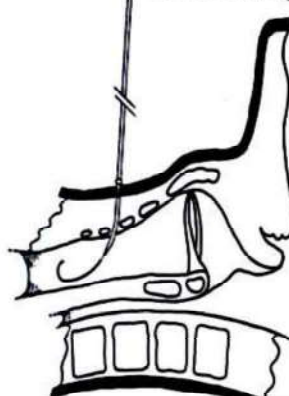
Guide wire insertion



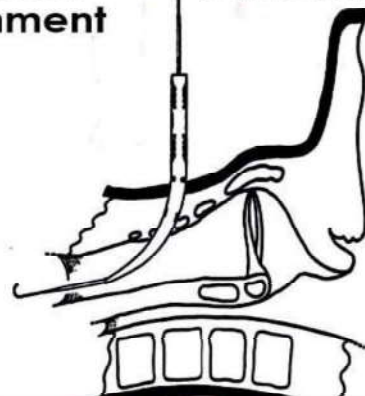
Short dilator entry



Guiding catheter alignment



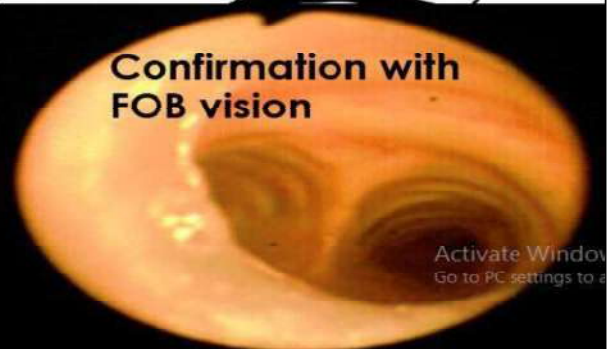
White rhino



Tracheostomy tube insertion



Confirmation with FOB vision



Confirmation of tracheostomy tube placement:

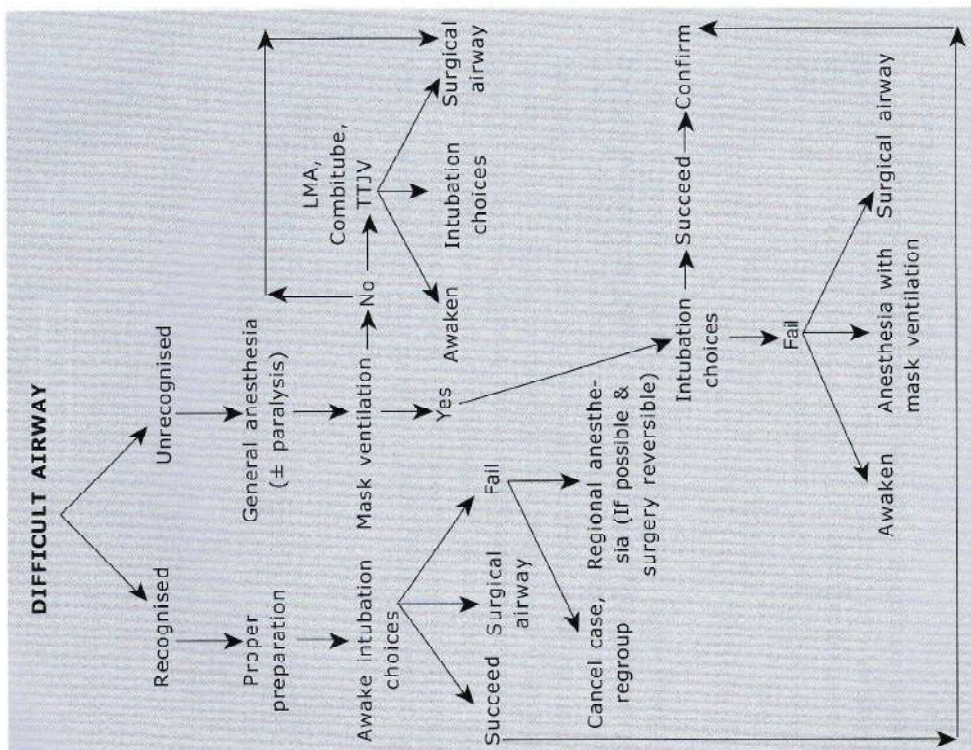
- Bilateral chest auscultation
- EtCO₂ tracing on the monitor
- Ventilation indices
- FOB vision by visualization of carina

Post Cricothyrotomy and PCDT care:

- Cuff pressure : 25-30 cm-H₂O (8-12 hourly measure)
- Alcohol gel & Hand washing
- Closed system suction
- Assess stoma site every 24 hours
- Sub-glottic suction 4 hourly
- Saline nebulization 6 hourly
- Replace HME filter after every 24 hours
- **Suctioning:**
 - ☐ Appropriate size (<2/3rd of tracheostomy tube)
 - ☐ 100% oxygen for >30 seconds
 - ☐ Do not touch the carina
 - ☐ Suction pressures: 80-150 mm-hg
 - ☐ Complete within 10-15 sec
- **Tube change:**
 - ☐ Cricothyrotomy: Convert to tracheostomy < 24 hours
 - ☐ PCDT: After 7-10 days and every 7-10 days

..Thank you..

DIFFICULT
AIRWAY
ALGORITHM



The ASA Algorithm outlined above has three limbs for three different difficult airway scenarios. The ASA Algorithm to be useful to the clinicians needs greater clarity as to which limb of the algorithm is to be followed in which situation. To fulfill this vital need, the ASA Algorithm has been subdivided into three algorithms to provide a greater clarity and detail for better implementation.

1: ASA DIFFICULT AIRWAY ALGORITHM

PART-I

RECOGNIZED DIFFICULT LARYNGOSCOPY & INTUBATION

AWAKE INTUBATION, AFTER CONSENT
(Psychological preparation, Antisialagogue, Sedation, LA-Topical & Nerve Block)

TECHNIQUES

(Direct Laryngoscopy & Intubation, Blind Nasal/Oral Intubation, Fiberoptic Intubation, ILMA-assisted intubation, Trachlight Intubation, Retrograde Intubation, Percutaneous Dilational Tracheostomy)

FAILED

Re-preparation
GA (uncooperative patient)
Surgical Airway
Cancel
Reg. Analg

1B: ASA DIFFICULT AIRWAY ALGORITHM**PART-II**

UNRECOGNIZED DIFFICULT LARYNGOSCOPY & INTUBATION
(Can Ventilate) (*Patient usually paralyzed*)

ONE OR TWO-PERSON MASK VENTILATION.
EFFORT CONTINUES

OPTIMAL/BEST DIRECT LARYNGOSCOPY & INTUBATION ATTEMPT

(Experienced anesthetist, Sniffing position, Insignificant muscle tone,
Optimal external laryngeal manipulation,
Different blade size & shape)

FAILED - Other Methods of Intubation

(FOI, ILMA-1, TL-1, Blind nasal/oral I, Retrograde I, PCT)

Repeated Attempt Failed
(But Can Ventilate)

1. Awaken patient.
2. Surgery under mask anesthesia.
3. Surgical airway.

Repeated Attempt Failed
(Inability to Ventilate - CVCI)
Follow CVCI Algorithm. (PART-III)

1C: ASA DIFFICULT AIRWAY ALGORITHM**PART-III**

UNRECOGNISED DIFFICULT DIRECT LARYNGOSCOPY & INTUBATION

(CANNOT VENTILATE CANNOT INTUBATE (CVCI): 0.01-2.0/10,000)

LMA

COMBITUBE

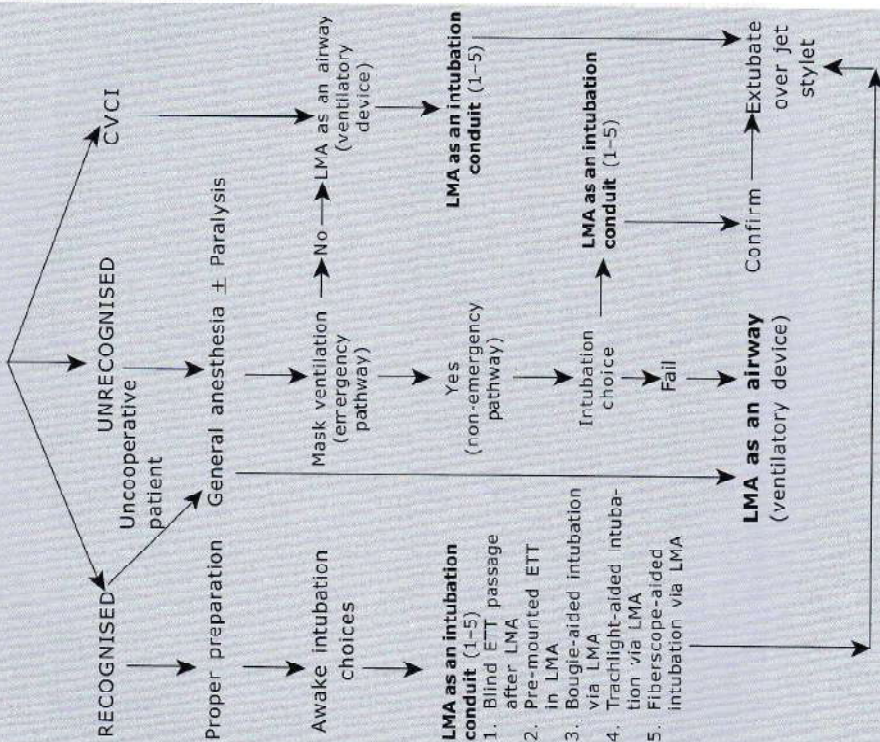
(LT, LTS, PA Xpress have been used but are not yet
in the ASA Algorithm)

TRANSTRACHEAL JET VENTILATION & Consider awakening the patient

(Experienced hands may now use a variety of intubation choices if
not previously used - ILMA-1, TL-1, FOI etc)

1D: LMA AS AN INTUBATION CONDUIT IN THE AWAKE INTUBATION LIMB, ANESTHETIZED NON-EMERGENCY AND EMERGENCY PATHWAY OF THE ASA'S DIFFICULT AIRWAY ALGORITHM

ASA'S DIFFICULT AIRWAY ALGORITHM & ROLE OF LMA



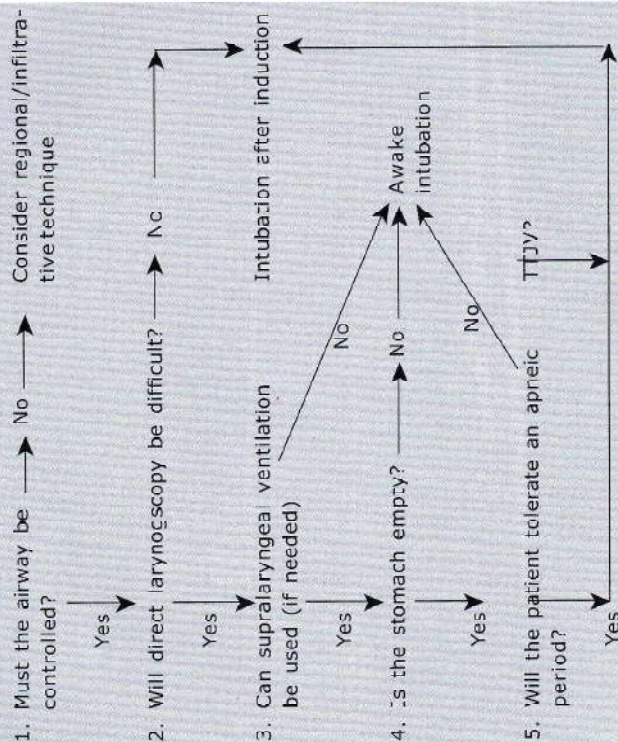
Note: The details of all these methods of LMA-assisted intubation are given in Chapter 10.

1E: HOW TO AVOID DIFFICULT AIRWAY SITUATION

(Rosenblatt W—ASA's Refresher Course Lecture 2007)

Ask 5 questions and plan accordingly

(Before asking the 5 questions: Perform detailed airway assessment)



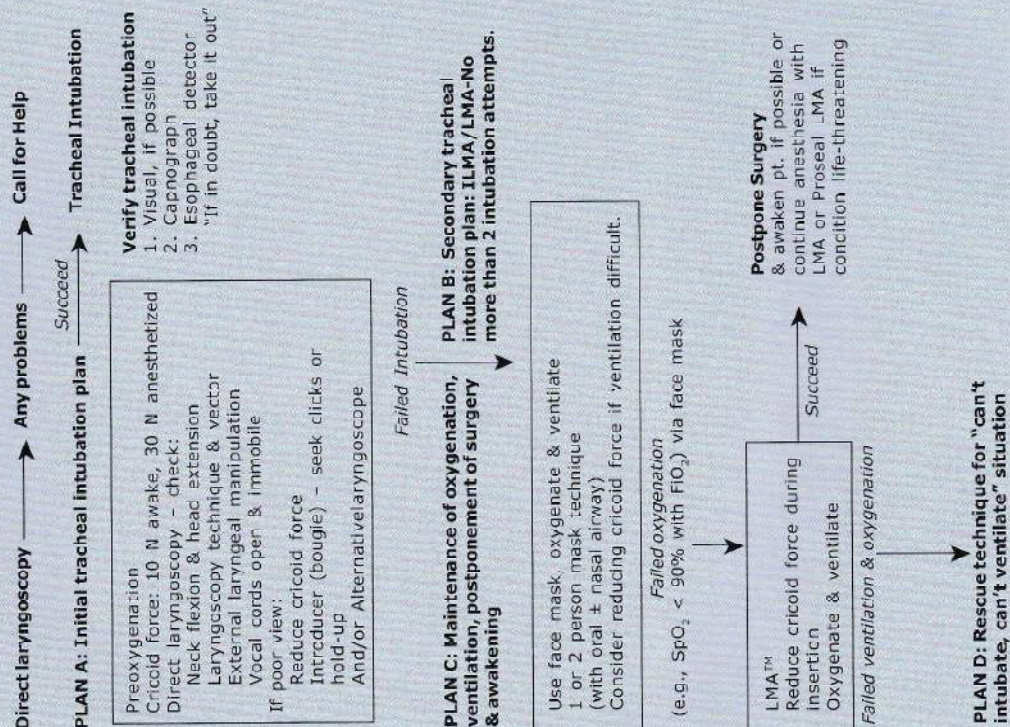
1F: ASA DIFFICULT AIRWAY ALGORITHM: TAKE HOME MESSAGES

- If suspicious → Secure the airway awake
- If can Ventilate but cannot intubate → Awaken patient
- If CVCi → Immediately employ CVCi option
- Always have an alternative plan → Think Ahead
- (CVCi=cannot ventilate, cannot intubate)

2A: DIFFICULT AIRWAY SOCIETY AIRWAY

GUIDELINES (UK): 2004

Unanticipated difficult tracheal intubation – during rapid sequence induction of anesthesia in non-obstetric adult patient.

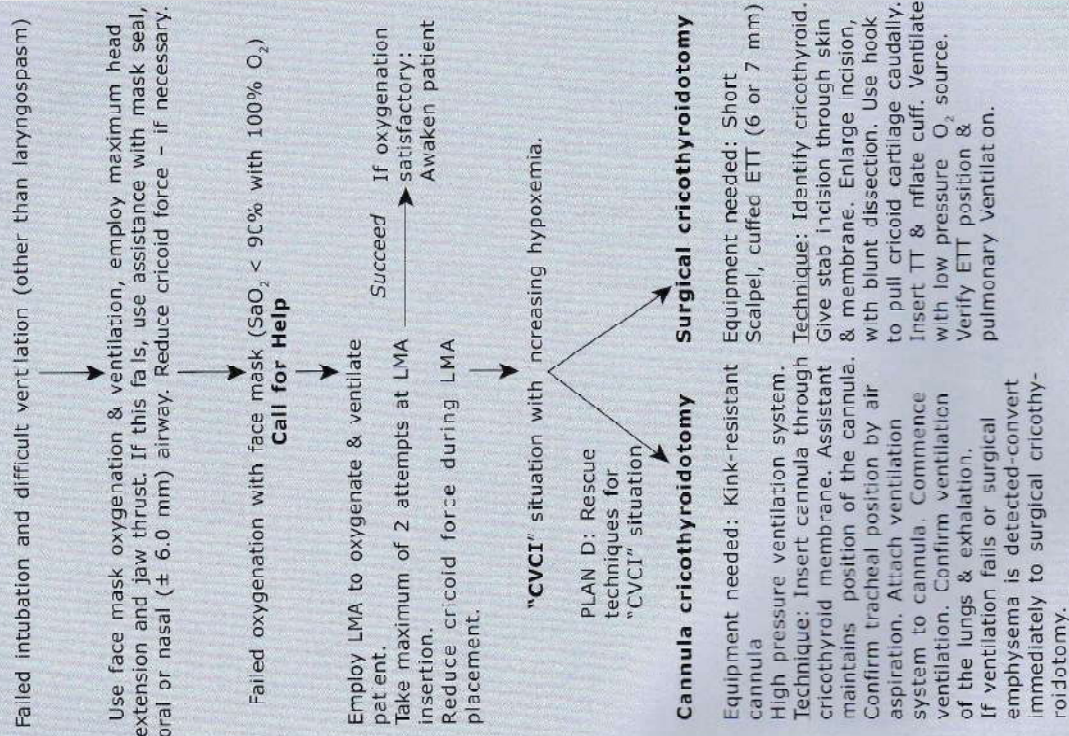


ALGORITHMS FOR ALL OCCASIONS

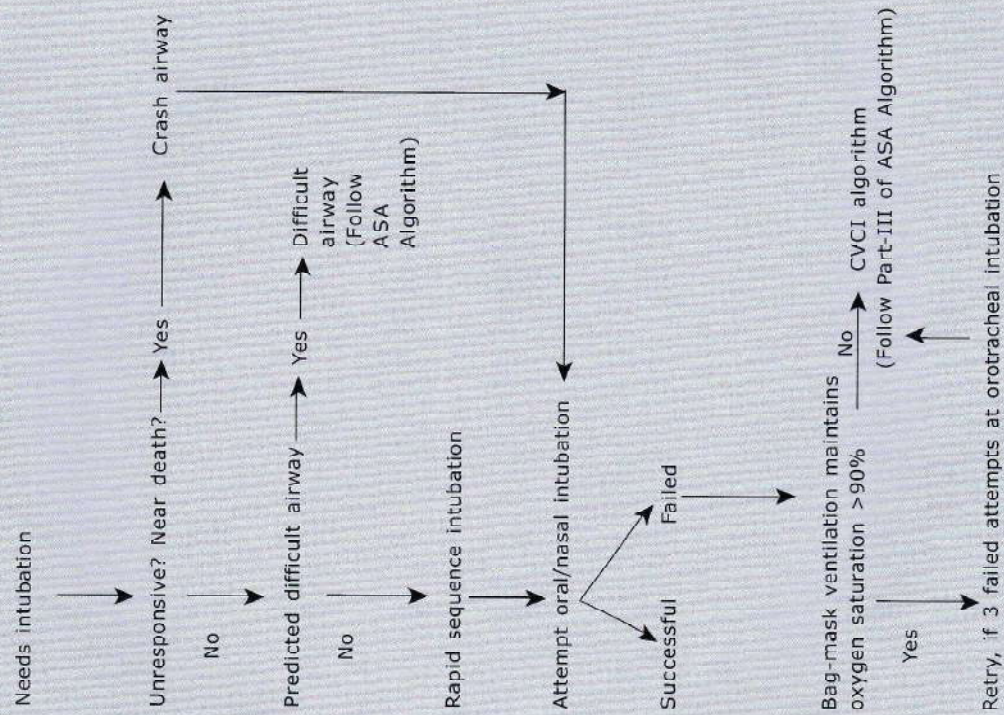
2B: DIFFICULT AIRWAY SOCIETY AIRWAY

GUIDELINES (UK): 2004

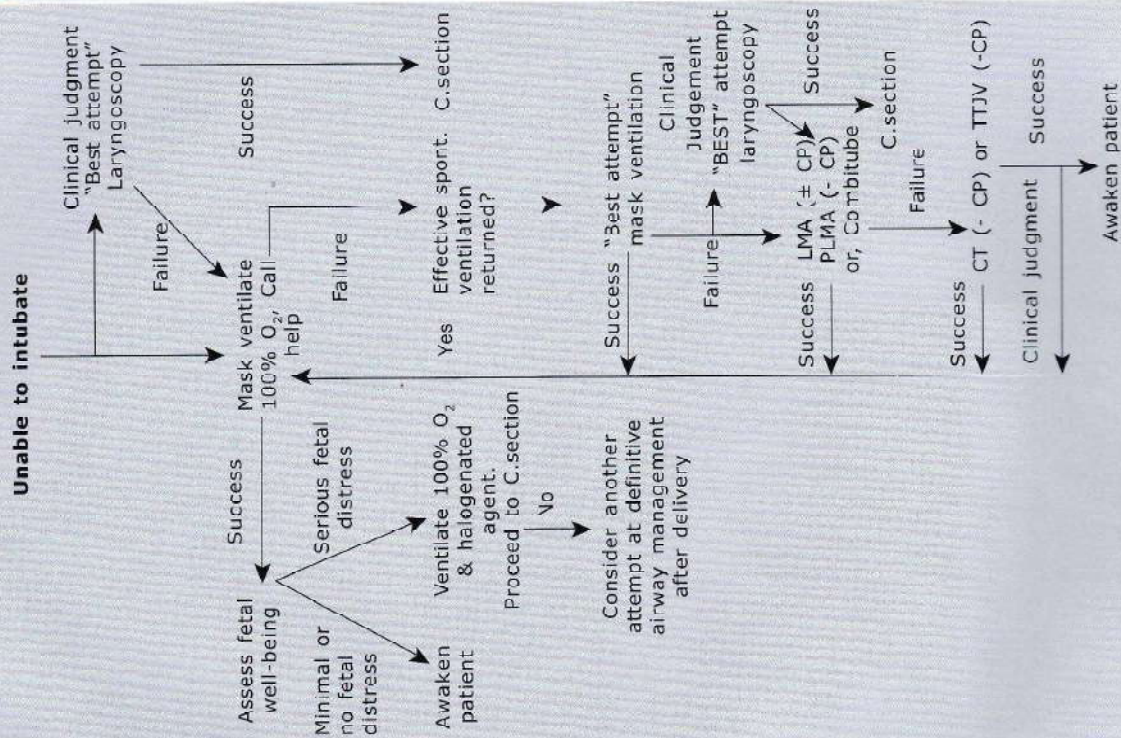
Failed intubation, increasing hypoxemia and difficult ventilation in the paralyzed anesthetized patient: Rescue techniques for the "CVCII" situation



3. EMERGENCY AIRWAY MANAGEMENT ALGORITHM

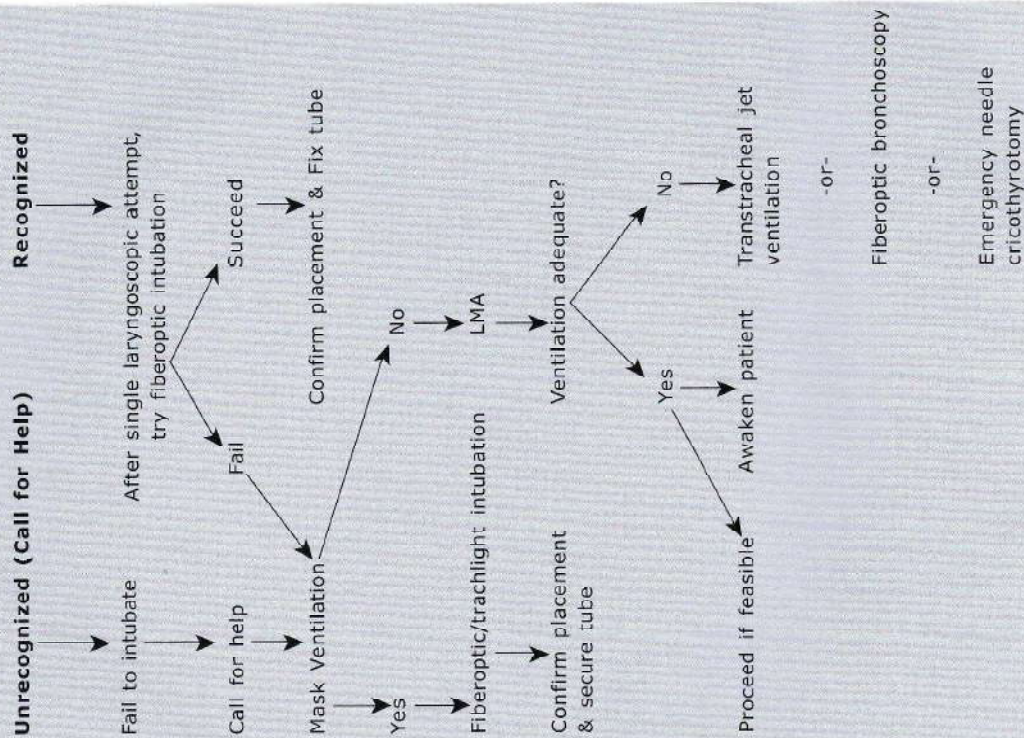


4. DIFFICULT AIRWAY MANAGEMENT ALGORITHM FOR OBSTETRICAL PATIENT

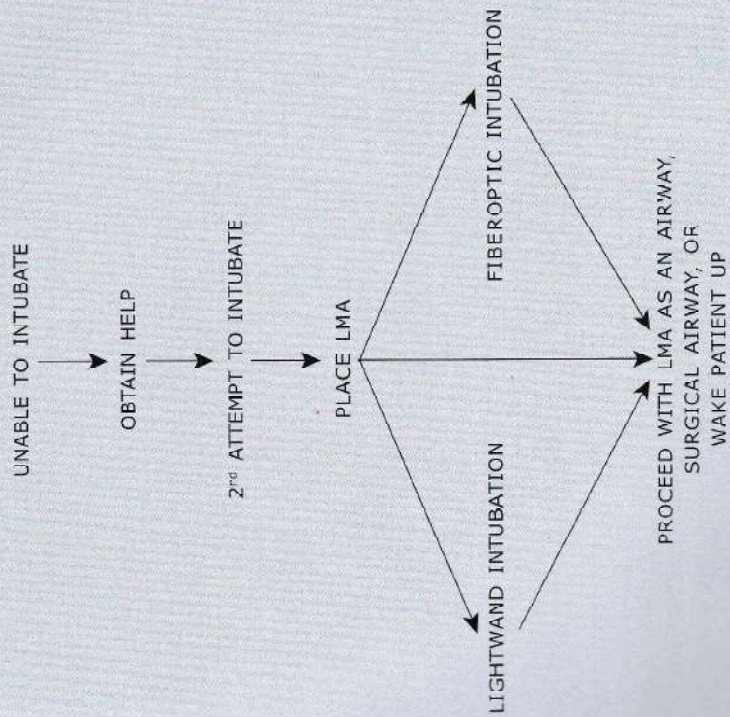


(LMA=Laryngeal mask airway, PLMA=Proseal LMA, CT=Cricothyrotomy, TTJV=Transtacheal jet ventilation, CP=Cricoid pressure)

5. DIFFICULT AIRWAY ALGORITHM FOR PEDIATRIC PATIENT

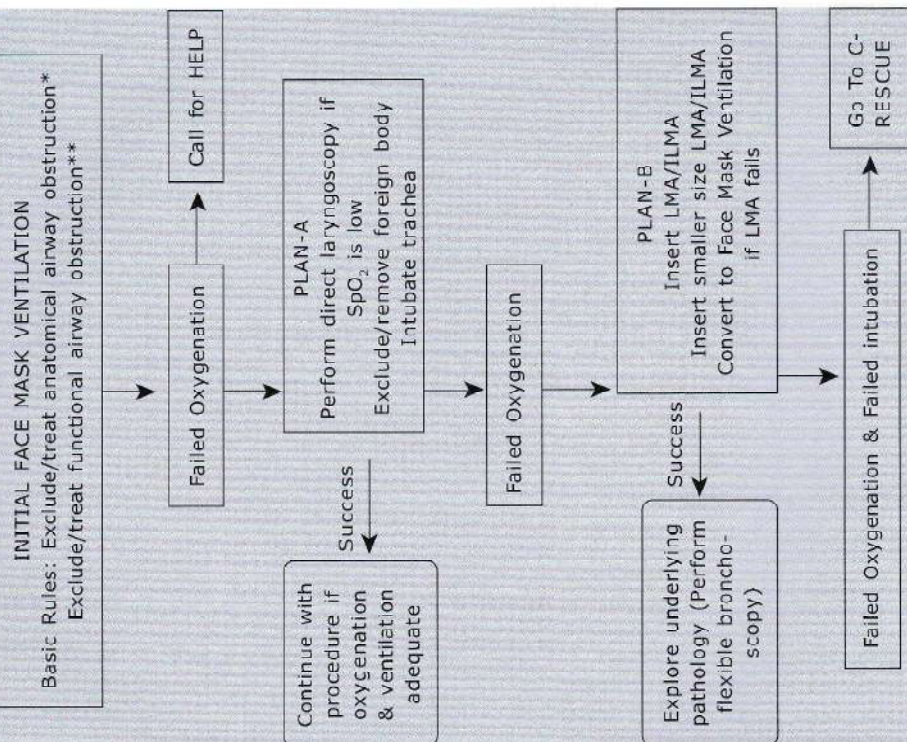


6. SIMPLIFIED DIFFICULT AIRWAY ALGORITHM FOR PEDIATRIC PATIENT



7. UNANTICIPATED DIFFICULT PEDIATRIC AIRWAY ALGORITHM

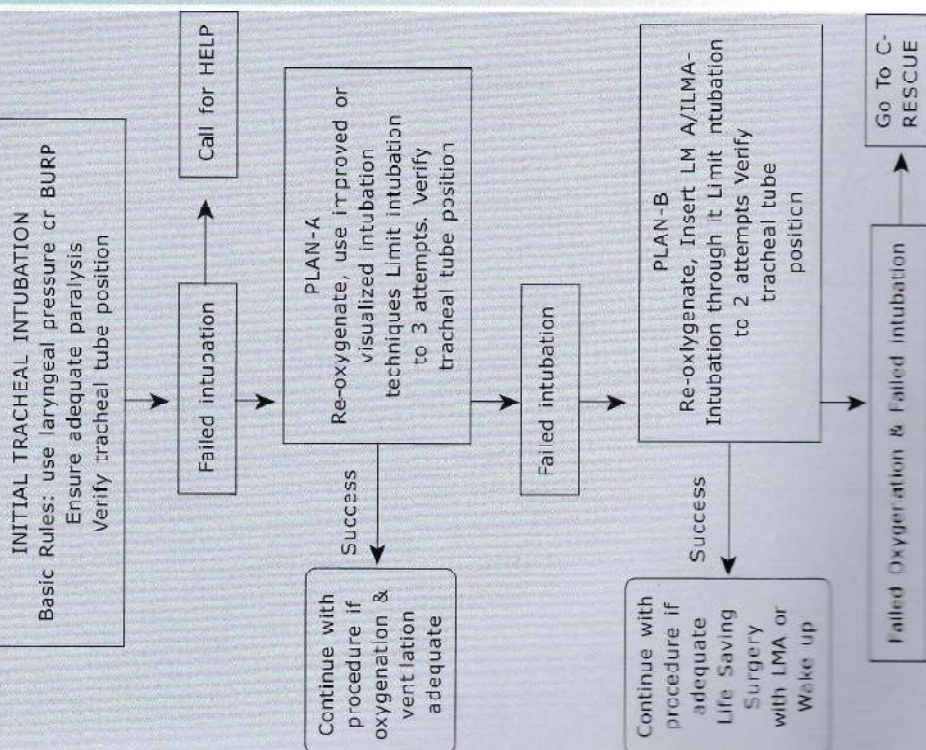
A. DIFFICULT FACE MASK VENTILATION & OXYGENATION

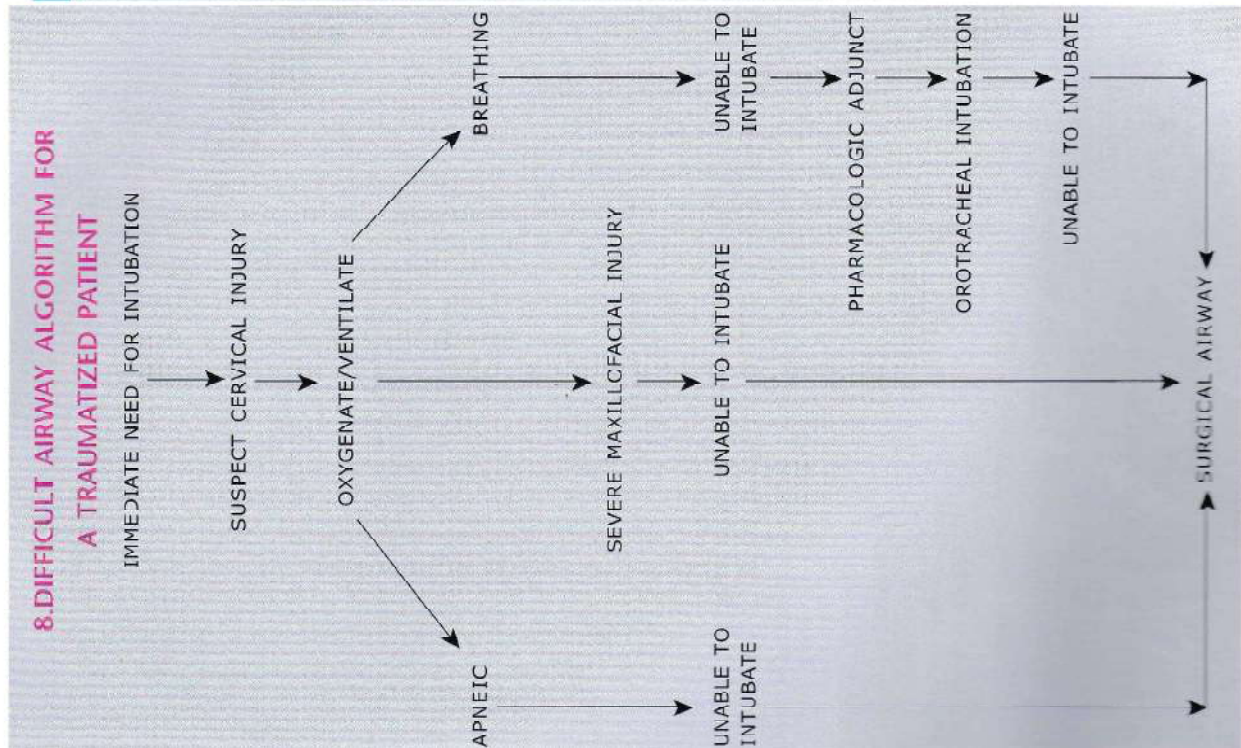
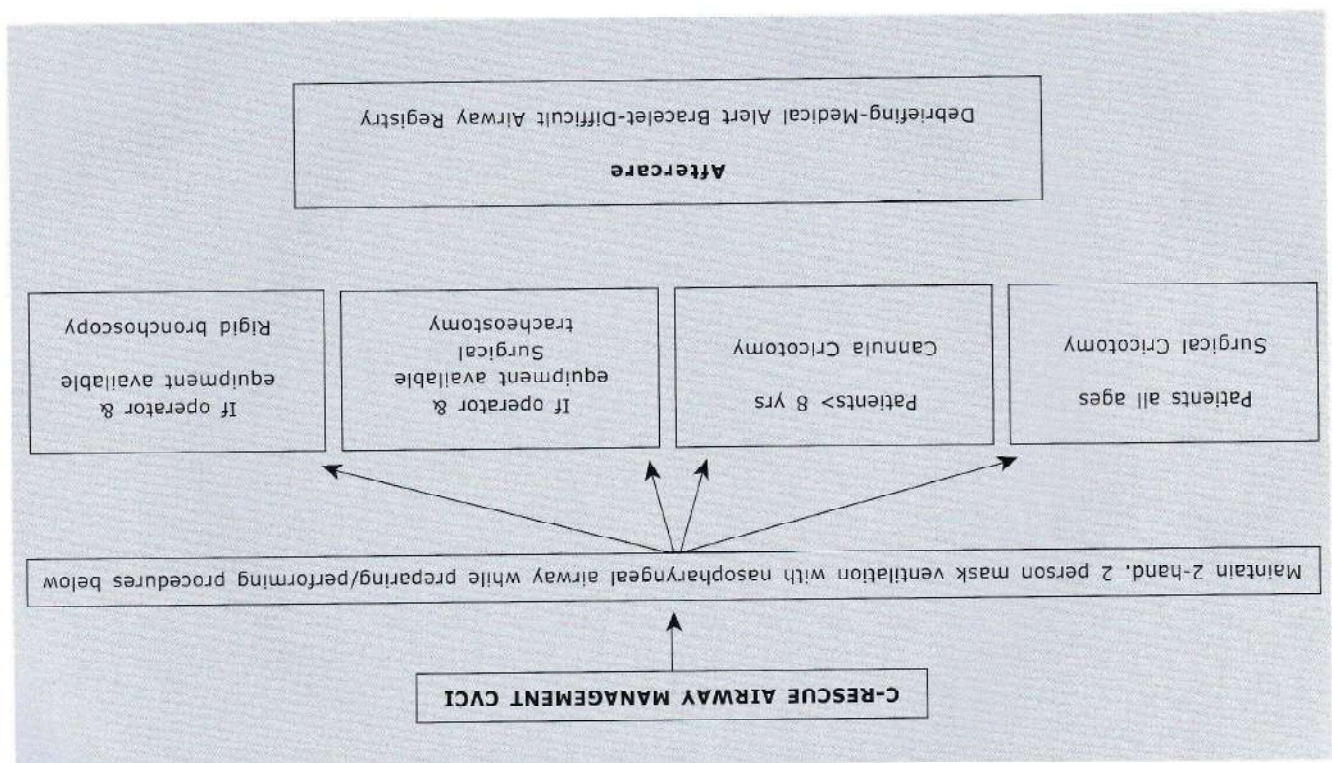


* Anatomical or iatrogenic airway obstruction as that due to large adenoids/tonsils; glottic foreign body (chewing gum, forgotten gauze pack, regurgitation).

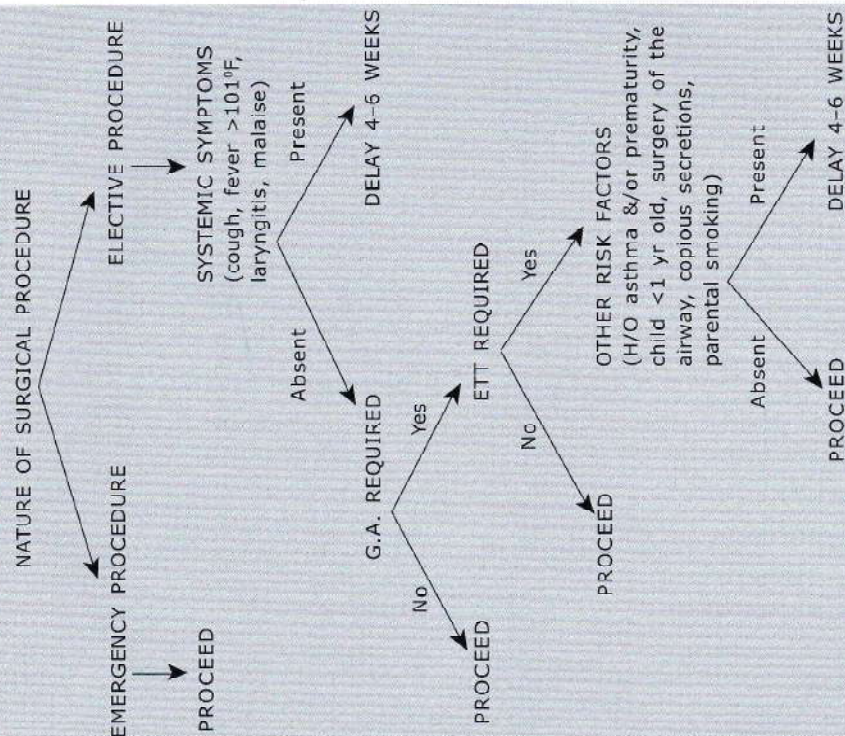
** Functional airway obstruction as a result of insufficient depths of anesthesia or muscle paralysis, and/or laryngospasm & bronchospasm.

B. DIFFICULT TRACHEAL INTUBATION





9. MARTIN'S ALGORITHM FOR PEDIATRIC PATIENT WITH UPPER RESPIRATORY INFECTION



(Martin L. *Pediatric Clinics of North America* 1994;41:121)

10. BELL'S ALGORITHM FOR DIFFICULTY WITH VENTILATION

PRE-EMPT ADVERSE OUTCOME

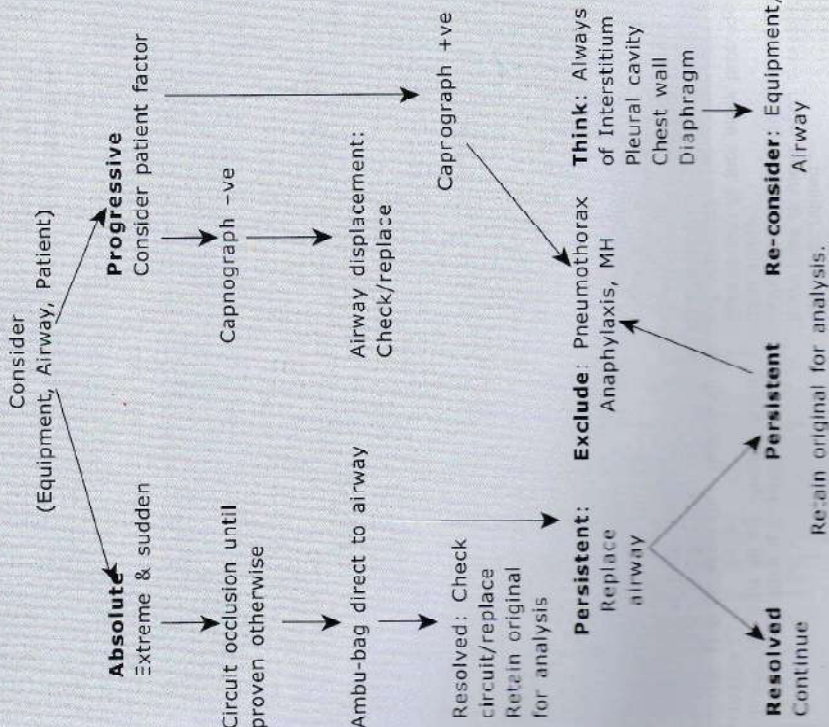
Prevent circuit & airway occlusion: look for patency, leaks & foreign bodies.

Detect early: All monitoring functional & applied (capnography, oximetry etc)

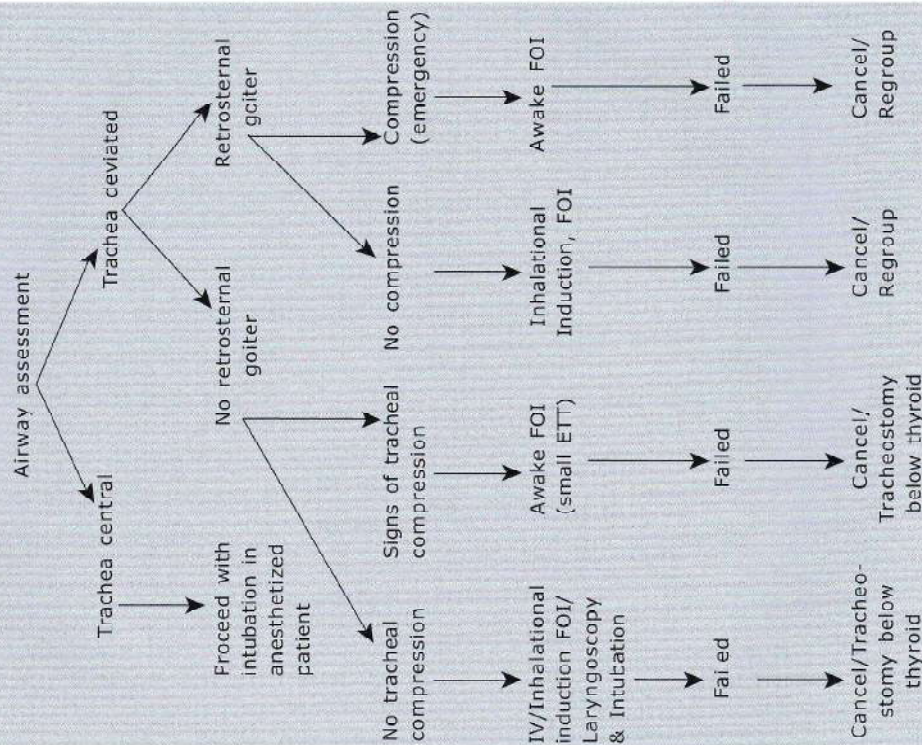
Diagnose & manage: Ambu-bag present & functional.

INCREASED RESISTANCE TO VENTILATION

(Not obviously attributable to failure of neuromuscular Block, endobronchial intubation e.c)



11. ALGORITHM FOR DECIDING AWAKE VS ASLEEP INTUBATION IN PATIENTS WITH GOITRE



12. BRIMACOMBE'S ALGORITHM FOR AIRWAY OBSTRUCTION WITH PROSEAL LM IN PLACE

