Supraglottic Airway Devices As A New Method Of Difficult Airway Management

An essay
Submitted for fulfillment of master degree In Anesthesiology and Intensive Care

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*I always feel indebted to God for his most gracious help”*

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List of abbreviations

ASA: American society of anaesthesia

AO: atlanto-occipital joint.

DAS: difficult airway society

ETT: endotracheal tube

ILMA: intubating laryngeal mask airway.

LMA-PROSEAL: laryngeal mask airway –proseal.

LMA_Ctrach: laryngeal mask airway C-trach

LMA-Fastrach: laryngeal mask airway fastrach

LMA-Classic: laryngeal mask airway-classic

SIPLA: The Streamlined Pharynx Airway Liner

TM: thyromental distance.
Introduction

The maintenance of a patent airway is one of the fundamental responsibilities of every anesthesiologist. Difficult intubation is responsible for a large proportion of anesthesia-related complications that may result in permanent disability or even death. When an airway problem is encountered, anesthesiologist should use the technique that he is most familiar or experienced with to gain control of the situation. (*Henderson JJ, et al; 2004*)

During routine anaesthesia the incidence of difficult tracheal intubation has been estimated to be 3-18%. Generally, failed tracheal intubation occurs once in every 2230 attempts. For the average anesthesiologist in the United States, that represents one failed intubation every other year. The incidence is small, but the potential consequences of difficult airway management are of major importance, Sometimes there is difficult situation that can face the anesthologist which is cannot intubate cannot ventilate which is very dangerous and can lead to death, The introduction of the Supraglottic airway devices is considered a solution to this problem which helps not only to maintain ventilation but also can be a tunnel that facilitates the tracheal intubation. (*Megha U et al; 2013*)

Supraglottic Airway Devices are devices that ventilate patients by delivering anesthetic gases/oxygen above the level of the vocal cords and are designed to overcome the disadvantages of endotracheal intubation as: soft tissue, tooth, vocal cords, laryngeal and tracheal damage,
exaggerated hemodynamic response, barotrauma, etc. The advantages of the Supraglottic airway devices include: avoidance of laryngoscopy, less invasive for the respiratory tract, better tolerated by patients, increased ease of placement, improved hemodynamic stability in emergence, less coughing, less sore throat, hands free airway and easier placement by inexperienced personal. The American Society of Anesthesiologists’ Task Force on Management of the Difficult Airway suggests considering the use of the Supraglottic airway devices when intubation problems occur in patients with a previously unrecognized difficult airway, especially in a “cannot ventilate, cannot intubate” situation. (Rani A sunder, et al; 2012)
Chapter 1

Airway anatomy

Other than rendering a patient insensible to pain, no characteristic better defines an anesthiologist than the ability to manage an airway and patient’s breathing and this requires a detailed knowledge of airway anatomy.

-**The mouth:**

*Description*

The mouth extends from the lips (anterior) to the isthmus of the faucæ (posterior). There are two sections connected together through the mouth aperature:

- Vestibule – slit-like cavity between the cheeks/lips and gingivae/teeth
- Oral cavity – from the alveolar arch of the maxilla and the mandible and teeth to the oropharyngeal isthmus (*Erdmann, 2001*).

![Figure 1: The mouth (Ovassapian, 1996).](image-url)
**Relations**

Roof – hard and soft palate

Floor – two thirds of the tongue and reflection its mucous membrane on the mandible The floor of the mouth is mainly supported by the paired *mylohyoid* muscles arising from the mandible and inserting into the hyoid bone. The mylohyoid muscle subdivides the area beneath the jaw and tongue into two potential spaces; the *submandibular space* (below the muscle) and the *sublingual space* (above the muscle)

Posterior – isthmus separates the oral cavity from the oropharynx *(Erdmann, 2001)*.

**Important features**

- The **hard palate** is made up of the palatine processes of the maxillae and the horizontal plates of the palatine bones.

- The **soft palate** hangs like a curtain suspended from the posterior edge of the hard palate.

- Its free border bears the *uvula* centrally and blends on either side with the pharyngeal wall.

- The ‘skeleton’ of the soft palate is a tough fibrous sheet termed the *palatine aponeurosis*, which is attached to the posterior edge of the hard palate and is continuous on each side with the tendon of tensor palati *(Ellis et al., 2003)*.

- The **muscles of the soft palate** are five(table 1):

They help to close off the nasopharynx in deglutition and phonation.

Table 1 muscles of the soft palate *(Ellis et al., 2003)*.

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<th>Muscle</th>
<th>Action</th>
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<td>1. The <em>tensor palate</em></td>
<td>tighten and flatten the soft palate.</td>
</tr>
<tr>
<td>2. The <em>levatorpalati</em></td>
<td>It elevates the soft palate</td>
</tr>
<tr>
<td>3. The <em>palatoglossus</em></td>
<td>approximates the palatoglossal folds</td>
</tr>
<tr>
<td>4. The <em>palatopharyngeus</em></td>
<td>approximates the palatopharyngeal folds</td>
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<tr>
<td>5. The <em>musculus uvulae</em></td>
<td>Maintains the uvula in position</td>
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Airway anatomy

Figure 2: Muscles of the palate from a posterior view with resection line outline (Ellis et al., 2003).

-**The tongue:**

The **tongue** is a muscular hydrostat on the floors of the mouths for taste, manipulating food for mastication, phonetic articulation and cleaning one's teeth.

- The average length :10 cm
- The eight muscles of the human tongue are classified as either *intrinsic* or *extrinsic* (table2). The four intrinsic muscles act to change the shape of the tongue and are not attached to any bone. The four extrinsic muscles act to change the position of the tongue and are anchored to bone(fig.3)(Ellis et al., 2003).

-**Extrinsic muscles:**

Figure 3: Extrinsic muscles of the tongue (Ovassapian, 1996).
### Table 2 Extrinsic muscles of the tongue *(Ronald, 2000)*.

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<thead>
<tr>
<th>Muscle</th>
<th>Action</th>
<th>Notes</th>
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<td>1. Genioglossus (fan-shaped forming the majority of the body of the tongue)</td>
<td>depresses and protrudes the tongue (Contraction of the genioglossus stabilizes and enlarges the portion of the upper airway vulnerable to collapse)</td>
<td>- A relaxation of the genioglossus and geniohyoideus muscles, esp. during REM sleep, is implicated in Obstructive Sleep Apnea (OSA.)</td>
</tr>
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<td>2. Hyoglossus (thin and quadrilateral)</td>
<td>depresses and retracts the tongue makes the dorsum more convex</td>
<td></td>
</tr>
<tr>
<td>3. Styloglossus The smallest</td>
<td>-draws up the sides of the tongue to create a trough for swallowing -As a pair they also aid in retracting the tongue</td>
<td>the shortest and smallest of the three styloid muscles</td>
</tr>
<tr>
<td>4. Palatoglossus, glossopalatinus, or palatoglossal muscle</td>
<td>Elevates posterior tongue, closes the oropharyngeal isthmus, and aids initiation of swallowing.</td>
<td>small fleshy fasciculus, narrower in the middle than at either end, forming, the glossopalatine arch</td>
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**-Intrinsic muscles:** Their main function is to provide the tongue shape:

1. The **Longitudinalislinguæ superior**
2. The **Longitudinalislinguæ**
3. The **Verticalislinguæ**
4. The **Transversuslinguæ**

**Vascular Supply**

2. Teeth – maxillary artery (via superior and inferior alveolar branches).
3. Tongue – lingual artery (venous via lingual vein into internal jugular)

A lingual artery hematoma from oral trauma or tongue laceration can cause bleeding into the sublingual and submaxillary spaces, resulting in elevation of the tongue and the floor of the mouth with subsequent upper airway obstruction *(Kattan and Snyder, 1991)*.

**Nerve Supply**

- **Vestibule:**
  - Sensory from the branches of the trigeminal nerve (V2 and V3).
  - Motor from the facial nerve (VII).
- **Tongue:**
  - Taste – anterior two-thirds via the facial nerve (VII via chorda tympani), posterior one-third via the glossopharyngeal nerve (IX).
  - Motor from the hypoglossal nerve (XII). So damage to the hypoglossal nerve can result in deviation of the tongue to the damaged side.

  The palatoglossus is the only muscle of the tongue that is not innervated by the hypoglossal nerve (CN XII). It is innervated by the Vagus nerve (CN X) and fibres from the cranial part of the accessory nerve (CN XI) via the pharyngeal plexus.

- **Palate:**
  - Sensory and motor from the trigeminal nerve (V2).
  - Taste from the facial nerve (Erdmann, 2001).

- **The Nose:**

  **Description**

  A pyramidal structure of bone, cartilage and the nasal cavities. A midline nasal septum divides the nasal cavity into two separate areas, which open anteriorly via the nares and posteriorly via the choanae (Ellis et al., 2003).

  The nose is divided anatomically into

  - The external nose

  The anterior and lower portions of the nose are mainly supported by cartilage, forming a vault or vestibule bounded by the medial and
lateral crura. This U-shaped dome of the nasal vestibule keeps the nostril patent. The bony framework comprises two nasal bones (in the upper portion), the vomer (located inferiorly) and the perpendicular plate of the ethmoid (located superiorly). The cartilage of the nasal septum comprises the central support. External deformity of the nose may indicate internal nasal obstruction of one or both sides, which may influence which side a nasal intubation should be performed on. The external openings to the nose are called the nares and are formed by the alae laterally, the columella centrally, and the nasal tip superiorly (Morris, 1988).

-The cavity of the nose is subdivided by the nasal septum into two quite separate compartments that open to the exterior by the nares and into the nasopharynx by the posterior nasal apertures or choanae. Immediately within the nares is a small dilatation, the vestibule (Morris, 1988).

Relations and parts

Each side of the nose presents a roof, a floor, a medial and lateral wall.

The roof first slopes upwards and backwards to form the bridge of the nose (the nasal and frontal bones), then has a horizontal part (the cribriform plate of the ethmoid) and finally a downward-sloping segment (the body of the sphenoid) (Ellis et al., 2003).

The floor is concave from side to side and slightly so from before backwards parallel to the hard palate. It is formed by the palatine process of the maxilla and the horizontal plate of the palatine bone.

The medial wall is the nasal septum, formed by the septal cartilage, the perpendicular plate of the ethmoid and the vomer (fig 4).
Figure 4: The septum of the nose (Ellis and Feldman, 1993).

The lateral wall (fig.5) has a bony framework made up of the ethmoidal labyrinth above, the maxilla below, in front and the perpendicular plate of the palatine bone behind. This is supplemented by the three scroll-like conchae (or turbinate bones), each arching over a meatus.

The upper and middle conchae are derived from the medial aspect of the ethmoid labyrinth the inferior concha is a separate bone. These serve to increase the surface area of the nasal cavity.

Onto the lateral wall open the orifices of the paranasal sinuses and the nasolacrimal duct the middle meatus is the most important functional area as all the sinuses open into this meatus with the exception of the sphenoidal and the posterior ethmoidal cells. The openings of the sinus ostia into the middle meatus are close together and form the ostio-meatal complex. Prolonged obstruction of these ostia during prolonged nasotracheal intubation can lead on to chronic sinusitis (Ellis et al., 2003).
**Blood supply**
- The upper part of the cavity..... anterior and posterior ethmoidal branches of the opthalmic artery( internal carotid artery).
- the lower part of the cavity .......The sphenopalatine branch ( maxillary artery ).
- antero-inferior part of the septum..... the septal branch of the superior labial branch of the facial artery anastomosing with The sphenopalatine branch.

It is from this zone, just within the vestibule of the nose, that epistaxis occurs in some 90% of cases (Little’s area) (Kiesselbach’s plexus) is an area where several vessels anastomose on the anterior septum (Erdmann, 2001).

**Nerve supply**

The olfactory nerve (I) supplies the specialized olfactory zone of the nose, which occupies an area of some 2 cm2 in the uppermost parts of the septum and lateral walls of the nasal cavity.
Common sensation to the nasal cavity arises from the nasociliary branch of the ophthalmic division and the maxillary division of the trigeminal nerve (Morris, 1988).

Given the complexity of nerve supply to this area, nasal anaesthesia can be accomplished only with multiple blocks and infiltration as well as topical anaesthetic applied to the nasal mucosa (cocaine 4%, lidocaine 4%, and phenylephrine 1% in combination) (Ronald, 2000).

Nasal intubation

The major nasal air passage lies beneath the inferior concha and a nasotracheal tube should be encouraged to use this passage by passing it directly backwards along the floor of the nose preferably on the right side to avoid trauma from the beveled tip of the tube. Occasionally, the posterior end of the inferior turbinate may be hypertrophied and may offer resistance to the easy passage of the tube.

The nasotracheal tube must curve anteriorly as it passes through the nasopharynx. A well-curved and rigid tube may increase the chances of success of attempts at blind nasal intubation, but may also increase the chances of trauma to the anterior tracheal wall (Ronald, 2000).
-The Pharynx:

Description
The pharynx is a wide muscular tube that forms the common upper pathway of the respiratory and alimentary tracts.

Relations
Anterior – nose and mouth.
Posterior – retropharyngeal space, prevertebral fascia and upper six cervical vertebrae.
Superior – sphenoid (body) and occipital (basilar region) bones.
Inferior – becomes continuous with the Oesophagus at the level of the 6th cervical vertebra (C6) (Erdmann, 2001).

Parts
The nasopharynx
The nasopharynx lies behind the nasal cavity and above the soft palate from the skull base to the soft palate at the bottom of the atlas (C1). Communicating with the nasopharynx are five passages: two nasal choanae, two eustachian tubes, and the inferior continuation with the oropharynx (the pharyngeal isthmus) which becomes closed off during the act of swallowing.
In this area are found the lymphoid or adenoid tonsil tissues along the roof and posterior walls. Enlargement of these tissues may result in chronic nasal obstruction and difficulty in establishing a nasotracheal airway; it is certainly a factor contributing to sleep apnea (Ronald, 2000).

The sensory nerve supply to the nasopharynx is via the three divisions of the trigeminal nerve. Because of this broad distribution of affrents, topical application of local anaesthetic is the only means to achieve effective analgesia.

**Figure 7:** Diagram of sagittal section of the pharynx to illustrate the three subdivisions of the pharynx (Ellis and Feldman, 1993).

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**Applied Anatomy to the Nasopharynx:**

In patients whose large tongues fill their oral cavities, face mask ventilation permits entry of gas through the nasopharynx into the lungs, but the soft palate, posterior pharyngeal wall, and tongue often form a unidirectional valve that blocks exhalation. Gas trapping is avoided by periodic release of the mandible or by insertion of an artificial airway (Ovassapian and Meyer, 1998).
The oropharynx

The mouth cavity leads into the oropharynx through the oropharyngeal isthmus, which is bounded by the palatoglossal arches, the soft palate and the dorsum of the tongue. Extending in height from the soft palate to the tip of the epiglottis (the bottom of C3) (Ellis et al., 2003).

Because sensory innervation of the mouth and oropharynx comes from a variety of sources (maxillary nerve “VII” via the palatine and nasopharyngeal branches; lingual branch from mandibular division “VIII” of the trigeminal nerve; glossopharyngeal nerve; and pharyngeal plexus), this area is amenable only to topically administered local anaesthetic agents in preparation for awake intubation. However, it may be useful at times to anaesthetize the posterior third of the tongue and anterior epiglottis by local anaesthetics injected near the glossopharyngeal nerve medial to the base of the anterior tonsillar pillar. This technique is used to attenuate the gag reflex and the patient’s response to awake laryngoscopy (Ronald, 2000).

The laryngopharynx

The third part of the pharynx extends from the tip of the epiglottis to the lower border of the cricoid at the level of C6 (Ellis et al., 2003). Anteriorly, is the laryngeal inlet, bounded by the aryepiglottic folds then, below this the larynx bulges back into the centre of the laryngopharynx leaving a recess on either side termed the piriform fossa which are bounded by aryepiglottic fold medially and the thyroid cartilage and thyrohyoid membrane laterally (Ronald, 2000).
As in the oropharynx, the mucosa of the posterior pharynx is innervated by the pharyngeal plexus (nerves X, XI, and IX) which supplies sensory innervation to the hypopharynx (Ronald, 2000).

Branches of the superior laryngeal nerve lie in the medial and lateral walls of the piriform sinuses and carry sensory innervation to the structures in the areas above the vocal cords. These sensory nerves can be blocked by diffusion of local anaesthetic either by direct application or from soaked pledgets. The internal branch of the superior laryngeal nerve can be blocked from an external approach before the nerve penetrates the thyrohyoid membrane inferior to the greater cornu of the hyoid bone.

-The properly positioned laryngeal mask airway (LMA) seals against the cricoid cartilage and cricopharyngeus muscle inferiorly, the base of the tongue superiorly and the piriform recess laterally (Brain, 1983).

-During blind nasal or lightwand intubation, tubes caught in the piriform recesses should be withdrawn a few centimeters and rotated internally to enter the larynx (Ovassapian and Meyer, 1998).

![Image of the pharynx](Erdmann, 2001)

Figure 9: The pharynx (Erdmann, 2001).
Airway anatomy

**The muscles of the pharynx (table 3)**

Muscles of the pharynx are the superior, middle and inferior constrictors, the stylopharyngeus, salpingopharyngeus and palatopharyngeus (fig. 9).

**The constrictor muscles** have an extensive origin from the skull, mandible, hyoid and larynx on either side; they sweep around the pharynx to become inserted into the median raphe, which runs the length of the posterior aspect of the pharynx, being attached above to the pharyngeal tubercle on the basilar part of the occipital bone and blending below with the oesophageal wall (*Ellis et al., 2003*).

In anaesthetized patients, the function of the inferior constrictor is mimicked by pressing the cricoid ring against C6 (Sellick’s maneuver) and from the oblique line on the lamina of the thyroid cartilage (*Sellick, 1961*).

**Table 3** muscles of the pharynx (*Ellis et al., 2003*).

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>stylopharyngeus</td>
<td>elevates the larynx</td>
</tr>
<tr>
<td></td>
<td>,elevates the pharynx</td>
</tr>
<tr>
<td></td>
<td>,dilates the pharynx to permit the passage of a large food bolus, thereby facilitating swallowing</td>
</tr>
<tr>
<td>salpingopharyngeus</td>
<td>raise the pharynx and larynx during deglutition (swallowing) and laterally draws the pharyngeal walls up also opens the pharyngeal orifice of the pharyngotympanic tube during swallowing</td>
</tr>
<tr>
<td>palatopharyngeus</td>
<td>pulls pharynx and larynx</td>
</tr>
</tbody>
</table>
Nerve supply

the pharyngeal nerve plexus, which transmits the fibres of the accessory nerve in the pharyngeal branch of the vagus. In addition, the inferior constrictor receives filaments from the external branch of the superior laryngeal and the recurrent laryngeal branch of the vagus. Stylopharyngeus is the only muscle in the pharynx innervated by the glossopharyngeal nerve (CN IX).

The airway during anaesthesia

Functionally, the pharynx is comparable to a collapsible tube. The pharyngeal airway, unlike the nasal or laryngeal airway, is not supported by a rigid bony or cartilaginous structure. The pharyngeal airway is easily collapsed by the posterior displacement of the mandible during sleep in the supine position, flexion of the neck or external compression over the hyoid bone. More important, it is also easily collapsed by negative pressure within the pharyngeal lumen created by inspiration effort, especially when airway maintaining muscles (genioglossus, geniohyoid, sternohyoid, sternothyroid, and thyrohyoid muscles) are depressed or paralyzed.

- Suction force by the inspiratory activity of the diaphragm and intercostal muscles must be well balanced by the tone of the muscles supporting the upper airway and dilating it and it's exaggerated by increased nasal and pharyngeal airway resistance. In addition once pharyngeal closure occurs mucosal adhesion of the collapsed pharyngeal wall becomes an added force against the opening of pharyngeal air passage (Cistulli and Sullivan, 1994).

- The following reflex mechanisms help to maintain the balance between the dilatory and collapsing force in the pharynx:
1. Chemoreceptor stimuli such as hypercapnia and hypoxia stimulate the airway dilator muscles preferentially over the stimulation of the diaphragm so as to maintain airway patency.

2. Negative pressure in the nose, pharynx or larynx activates the pharyngeal dilator muscles and decrease diaphragmatic activity.

-Upper airway mechanoreceptors are located superficially in the airway mucosa and are easily blocked by topical anaesthesia.

Sleep, sedation, and anaesthesia depress upper airway muscles more than they do the diaphragm. Arousal from sleep shifts the balance towards pharyngeal dilatation.

-It is commonly perceived that when a patient is anaesthetized in the supine position the airway readily becomes obstructed as a result of the muscles of the jaw becoming relaxed and the tongue falling back to obstruct the oropharynx.

The sequence of events appears to be as follows:

1 the tongue obstructs the oral airway by impinging on the palate (hence snoring).

2 the nasal airway is blocked by the falling back of the soft palate.

Relief of either of these obstructions will produce a clear airway.

---The Larynx:

*Description*

The larynx forms a functional protective sphincter of the respiratory tract as well as containing the vocal apparatus. It consists of a complex arrangement of muscles, cartilage, membranes and ligaments. It extends from C3 to C6 in the midline (adult)(*Ronald, 2000*).

*Relations*

Anterior – superficial structure, is covered by the fascia (deep and superficial), platysma and skin.

Posterior – pharynx, prevertebral muscles and cervical vertebrae.
Superior – pharynx.
Inferior – becomes continuous with the Trachea (Erdmann, 2001).

-The laryngeal cartilages

The larynx is composed of nine cartilage structures, three single and three paired; the thyroid (the largest and most notable, also called the Adam’s apple), cricoid, arytenoid (two), corniculate (two), and cuneiform (two) cartilages and the epiglottis (Fig.9-10) (Ronald, 2000).

-The thyroid cartilage (paired) is shield-like and consists of two laminae meeting in the midline inferiorly, leaving the thyroid notch between them above. The laminae carry superior (at c4) and inferior (at c5) horns, or cornua, at the upper and lower extremities of their posterior borders; the inferior horn bears a circular facet on its inner surface for the cricoid cartilage while The two superior horns aid in the suspension from the hyoid bone (Sykes and Isaacs, 1996).

-The cricoid cartilage (single) is in the shape of a signet ring and situated at the C6 level; the ‘signet’ shorter in the anterior (5 to 7 mm) than in the taller posterior (2 to 3 mm) portion. It articulates on its lateral border with the thyroid cornua and on its upper border with the arytenoid cartilages (Sykes and Isaacs, 1996).

-The arytenoid cartilages (paired) are three-sided pyramids that sit one on either side of the supero-lateral aspect of the lamina of the cricoid. Each has a lateral muscular process, into which are inserted the posterior and lateral cricoarytenoid muscles, and an anterior vocal process, which is the posterior attachment of the vocal ligament (Ronald, 2000).

-The epiglottis is likened to a leaf it is attached at its lower tapering end to the back of the thyroid cartilage by means of the thyro-epiglottic ligament. Its superior extremity projects upwards and backwards behind the hyoid and the base of the tongue and overhangs the inlet of the larynx.
The posterior aspect of the epiglottis is free and bears a bulge termed the *tubercle* in its lower part.

The upper part of the anterior aspect of the epiglottis is also free; its covering mucous membrane sweeps forward centrally onto the tongue, on either side and onto the side walls of the oropharynx to form respectively the median glosso-epiglottis and the lateral glosso-epiglottic folds. The valleys on either side of the median glosso-epiglottic fold are termed the *valleculae*; The lower part of the anterior surface of the epiglottis is attached to the back of the hyoid bone by the hyo-epiglottic ligament (*Ellis et al., 2003*).

![Diagramatic illustration of the anterior view of the larynx.](image)

**Figure10**: Diagramatic illustration of the anterior view of the larynx.

The larynx is suspended from the hyoid bone by the thyrohyoid ligament. The cricothyroid ligament provides easy and fast access to the larynx. Translaryngeal injection of local anaesthetics is performed through this ligament. Transtracheal injection is achieved through the cricotracheal ligament (*Ellis and Feldman, 1993*).

The **corniculate cartilage**(paired) is a small nodule lying at the apex of the arytenoid.

The **cuneiform cartilage**(paired) is a flake of cartilage.

These provide attachments for some intrinsic laryngeal muscles and are both found within the aryepiglottic and reinforce the walls of the
aryepiglottic folds against the boluses of food deflected by the epiglottis during swallowing into piriform recesses (Ronald, 2000).

![Figure 11: laryngeal structure](Ronald, 2000).

**The Interior of the Larynx**

The epiglottis, aryepiglottic folds, and corniculate cartilages define the glottic opening, or the “"aditus"" Immediately within the aditus (Fig. 11) (Fung and Devitt, 1995). The epiglottis is found projecting posteriorly into the glottis, inferior to this appears the first set of lateral folds, the vestibular folds or false vocal cords. Inferior and parallel to the false cords lie the true vocal cord. The vocal cords extend from the arytenoid cartilages posteriorly to the thyroid cartilage anteriorly. The laryngeal recess between the false and true vocal cords is termed the ventricle, which at times can inadvertently catch the advancing ET while the tube approaches the rimaglottidis, the opening between the true vocal cords (Morris, 1988).

Whereas the false cords point downward, the true cords are directed upward. This design facilitates the expiration of air but can passively resist up to 140 mmgh of an incoming column of air and contributes to the ineffectiveness of positive pressure ventilation through a closed glottis as occurs during laryngospasm (Fung and Devitt, 1995).
The cartilages and ligaments of the larynx seen laterally (Ellis and Feldman, 1993).

**The muscles of the larynx**

The muscles of the larynx can be divided into the extrinsic group, which attach the larynx to its neighbours and the intrinsic group, which are responsible for moving the cartilages of the larynx one against the other.

The **extrinsic muscles** of the larynx are the sternothyroid, thyrohyoid and the inferior constrictor of the pharynx. In addition, a few fibres of stylopharyngeus and palatopharyngeus reach forward to the posterior border of the thyroid cartilage.

- Other muscles play an important part in movements of the larynx indirectly, via its close attachment, by ligaments and muscle, with the hyoid bone. These muscles help to elevate and depress the larynx; the
indirect elevators are the mylohyoid, stylohyoid and geniohyoid, and the indirect depressors are the sternohyoid and omohyoid.

- The intrinsic muscles (fig.13) of the larynx have a threefold function: they open the cords in inspiration, they close the cords and the laryngeal inlet during deglutition and they alter the tension of the cords during speech (table 4).

Table 4 muscles of the larynx (*Ellis et al., 2003*).

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>The posterior cricoarytenoid</td>
<td>the posterior surface of the lamina of the cricoid</td>
<td>posterior aspect of the muscular process of the arytenoid</td>
<td>abducts the cord</td>
<td>the only muscle to do so.</td>
</tr>
<tr>
<td>The lateral cricoarytenoid</td>
<td>superior border of the arch of the cricoid</td>
<td>the lateral aspect of the arytenoid cartilage</td>
<td>adducts the cord</td>
<td></td>
</tr>
<tr>
<td>The interarytenoid</td>
<td>made up of transverse and oblique fibres; the latter groupwards and outwards as the aryepiglottic muscle, in the aryepiglottic fold</td>
<td>close the glottis, particularly its posterior part</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thyroarytenoid</td>
<td>posterior aspect of the junction of the laminae of the thyroid cartilage</td>
<td>the arytenoids cartilage</td>
<td>shorten, and thus relax, the vocal cord</td>
<td>Some fibres form the thyroepiglottic muscle</td>
</tr>
<tr>
<td>Vocalis</td>
<td>some fibres of the deep aspect of the thyroarytenoid</td>
<td>the vocal fold</td>
<td>tension of the cord.</td>
<td></td>
</tr>
<tr>
<td>Cricothyroid</td>
<td>part of the outer aspect of the arch of the cricoid cartilage</td>
<td>inferior border of the lamina of the thyroid cartilage</td>
<td>puts the vocal cords on stretch; as it is the only tensor of the cord.</td>
<td>only intrinsic laryngeal muscle which lies outside the cartilaginous framework</td>
</tr>
</tbody>
</table>
**Blood supply**

1. **Arterial:**
   - Superior laryngeal (from superior thyroid artery) – accompanies the internal branch of the superior laryngeal nerve.
   - Inferior laryngeal (from inferior thyroid artery) – accompanies the recurrent laryngeal nerve.

2. **Venous:**
   into the corresponding superior and inferior thyroid veins
   (Erdmann, 2001).

**Nerve supply**

- Branches of vagus (X) nerve:
- Superior laryngeal nerve – passes deep to the internal and external carotid arteries and then divides into:
  - External branch (small) – motor to cricothyroid.
  - Internal branch (larger) – sensory above the vocal cords and the inferior surface of the epiglottis(superior surface of the epiglottis is supplied by the glossopharyngeal nerve).
- Recurrent (inferior) laryngeal nerve
Airway anatomy

– on the right side it leaves the vagus as it crosses the subclavian artery, loops under it and ascends in the tracheo-oesophageal groove.

On the left side it leaves the vagus as it crosses the aortic arch, loops under it and ascends in the tracheo-oesophageal groove. It supplies:

Motor to all intrinsic muscles of the larynx (except cricothyroid) *(Erdmann, 2001).*

Sensation below the vocal cords.

**Laryngoscopic anatomy**

To view the larynx at direct laryngoscopy and then to pass a tracheal tube depends on getting the mouth, the oropharynx and the larynx into one plane. Flexion of the neck brings the axes of the oropharynx and the larynx in line but the axis of the mouth still remains at right angles to the others; their alignment is achieved by full extension of the head at the atlanto-occipital joint. This is the position, with the nose craning forwards and upwards, that the anaesthetist assumes in sniffing the fresh air after a long day in the operating theatre, or in moving the head forward to take the first sip from a pint of beer that is full to the brim.

At laryngoscopy, the anaesthetist first views the base of the tongue, the valleculae and the anterior surface of the epiglottis. The laryngeal aditus then comes into view (Fig. 30), bounded in front by the posterior aspect of the epiglottis, with its prominent epiglottic tubercle. The aryepiglottic folds are seen on either side running postero-medially from the lateral aspects of the epiglottis; they are thin in front but become thicker as they pass backwards where they contain the cuneiform and corniculate cartilages. The vocal cords appear as pale, glistening ribbons that extend
Figure 14: View of the larynx at laryngoscopy.

From the angle of the thyroid cartilage backwards to the vocal processes of the arytenoids. Between the cords is the triangular (apex forward) opening of the rima glottidis, through which can be seen the upper two three rings of the trachea.

-The Trachea:

Description

-The trachea extends from its attachment to the lower end of the cricoid cartilage at the level of the 6th cervical vertebra to its termination at the bronchial bifurcation the lower end of the trachea extend to the level of the 5th or in full inspiration the 6th thoracic vertebra (Ellis and Feldman, 1993).

- In the adult, the trachea is some 15 cm long, of which 5 cm lie above the suprasternal notch; this portion is somewhat greater (nearly 8 cm) when the neck is fully extended (Wethorpe, 1987).

- The diameter of the trachea is correlated with the size of the subject a good working rule is that it has the same diameter as the patient’s index finger (Ellis and Feldman, 1993).
- The patency of the trachea is due to a series of 16–20 C-shaped cartilages joined vertically by fibro-elastic tissue and closed posteriorly by the non-striated trachealis muscle. The cartilage at the tracheal bifurcation is the keel-shaped carina (Ellis and Feldman, 1993).

**Relations** (Table 5)

Table 5 relations of the trachea (Wethorpe, 1987).

<table>
<thead>
<tr>
<th>Part</th>
<th>Neck</th>
<th>Chest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anterior</strong></td>
<td>skin, superficial and deep fascia, thyroid isthmus, branches of the superior thyroid artery, sternohyoid and sternothyroid muscles, inferior thyroid veins, thyroidea ima artery</td>
<td>inferior thyroid veins, sternothyroid muscles, the remains of the thymus, the brachiocephalic artery and the left common carotid artery, arch of the aorta</td>
</tr>
<tr>
<td><strong>Posterior</strong></td>
<td>oesophagus, with the recurrent laryngeal nerves</td>
<td>oesophagus, with the recurrent laryngeal nerves</td>
</tr>
<tr>
<td><strong>Right</strong></td>
<td>carotid sheath and its contents (the common carotid artery, the internal jugular vein and the vagus nerve), right thyroid lobe</td>
<td>pleura, except where it is separated by the azygos vein and the right vagus nerve, large tracheobronchial lymph nodes</td>
</tr>
<tr>
<td><strong>Left</strong></td>
<td>carotid sheath and its contents (the common carotid artery, the internal jugular vein and the vagus nerve), left thyroid lobe</td>
<td>left common carotid and left subclavian arteries, the aortic arch and the left vagus, large tracheobronchial lymph nodes</td>
</tr>
</tbody>
</table>
**Vascular, lymphatic and nerve supply**

The arterial .... inferior thyroid arteries ,the venous drainage .... inferior thyroid veins,Lymphatics ..... deep cervical, pretracheal and paratracheal nodes ,nerve supply .....recurrent laryngeal while sympathetic supply … middle cervical ganglion (Ellis and Feldman, 1993).

**The bronchi and bronchial tree:**

**DESCRIPTION**

The trachea bifurcates at the T4 level into the right and left main bronchi. The last tracheal ring is wider and larger, and forms a ridge called the carina.

The right main bronchus is shorter,wider and more vertical than the left (25°). After 2.5 cm, it gives off the right upper bronchus. The left main bronchus is more angled (45°) and is 5 cm long (Ellis and Feldman, 1993).

**STRUCTURE**

1. Right main bronchus terminates in three lobar bronchi – upper, middle and lower – that supply the respective lung lobes. Each lobar bronchus then terminates in segmental bronchi as follows:
   - Upper – apical, anterior and posterior
   - Middle – lateral and medial
   - Lower – superior, medial basal, anterior basal, lateral basal and posterior basal

2. Left main bronchus terminates in two lobar bronchi – upper and lower – also supplying the respective lung lobes. The corresponding segmental bronchi are:
   - Upper – apical, anterior, posterior, superior lingual and inferior lingual
   - Lower – superior, medial basal (small and variable), anterior basal, lateral basal and posterior basal (Erdmann, 2001).
Because the right upper lobe bronchus arises only a short distance below the carina, it is not possible to place a tube in that bronchus without the risk of obstruction of the upper lobe. To overcome this difficulty, right sided endotracheal tubes and the right Robert Shaw and Carlens double lumen tube have an orifice in the lateral surface of the tube which coincides with the opening of the right upper lobe, not for left bronchus, as the 5 cm distance between the carina and left upper lobe bronchus leaves ample room for theuffed end of an endotracheal tube (Ellis and Feldman, 1993).
Chapter 2

Pathophysiology of the upper airway

The anatomical balance of soft tissue and bony framework of the upper airway is affected by conditions that increase tongue size, reduce pharyngeal size or both. The tongue is attached to the mandible and the hyoid bone through various muscles thereby limiting the space available for it to be compressed during laryngoscopy. Variations in tongue size are well described in the literature especially in the presence of coexisting genetic disorders, developmental diseases, obesity and obstructive sleep apnea (OSA). Other congenital and acquired conditions that may result in glossopharyngeal disproportion include macroglossia resulting from hypothyroidism, pickwickian Syndrome, acromegaly, amyloidosis, angioedema, anaphylaxis, prolonged trendelenburg positioning and trauma. The contribution of reduced pharyngeal volume is unclear in the general population but immediately obvious in patients with upper airway edema, infection and excessive adipose tissue. The impact of this imbalance on likelihood of airway closure has been explored in cephalometric studies of the upper airway (Tsuiki et al., 2008). Patients with OSA were shown to have significantly larger tongues than patients without the disease the same study also confirmed a more caudal location of the larger tongue in OSA (Fig.15 )
The contribution of physical forces driven by the Bernoulli Effect (O'Grady et al., 1997) on the progression of upper airway narrowing has also been established. Patients with OSA have redundant tissue in the upper airway secondary to the negative pressure caused by orifice flow during obstructive epochs in sleep. The net effect of increased upper airway soft tissue is that the forces that work to maintain airway patency during sleep and anesthesia resulting in total airway collapse.

Factors Affecting Access to the Upper Airway

One of the important causes of a difficult airway relates to the physical inability to introduce laryngoscope into the upper airway with sufficient clearance to allow oral or nasal manipulation of an endotracheal tube. When performing direct laryngoscopy there must be room for the laryngoscope blade, the endotracheal tube as well as a direct line of sight. Thus, conditions that affect mouth opening all contribute to the difficult airway problem. In addition to fixed limitation of mouth opening, certain conditions such as mandibular trauma and upper airway infection can cause dynamic limitation of mouth opening primarily related to pain.

Factors Affecting Laryngoscopic Visualization Vector

Although the concept of aligning the oropharyngeal axis with the direct laryngoscopy visualization axis is commonly promulgated during
didactic airway sessions this classical concept has not been supported by recent real-time magnetic resonance imaging of the airway. Nevertheless although the exact alignment of the axis is rarely achieved optimizing the relationship between these axes remains a major goal of direct laryngoscopy. As a result a focused analysis of the factors limiting this optimization is necessary during discussion of the expected difficult airway (Barash et al., 2006).

**The Expected Difficult Airway**

**Neck Mobility**

Optimal laryngoscopic visualization of the larynx is critically dependent on the ability to align the oral and pharyngeal long axes (Fig. 16).

![Figure 16](image.png)

**Figure 16:** For the laryngoscopic visualization axis (LVA) to permit laryngeal visualization, appropriate positioning of the head and neck is essential. Inability to extend the neck will result in the divergence of line of sight from the laryngeal visualization vector and persistently poor views. Failure to detect limited head extension is commonly associated with difficult intubations.

A direct vector of sight would not be able to reach the larynx if neck mobility is restricted. Although classic teaching suggests that the sniffing position is required for optimal laryngoscopic visualization (Biebuyck and Benumof, 1991) recent literature shows that head extension is the more significant factor in the majority of patients (Adnet et al., 2001) except in the presence of obesity where the sniffing position
is advantageous. The caveats to this rule include presence of normal teeth, adequate submental space for tongue compression, normal glottic structure and position of the larynx (Benumof, 2002).

Excessive laryngoscopic force in patients with reduced head extension causes the cervical spine to bow forward, directly pushing the glottis to a more anterior position which is out of reach of the laryngoscopic visualization vector (Benumof, 2002).

**Dental Factors**

Size of the upper incisors has an increasing impact on the visualization vector with progressive limitation of neck mobility. Accordingly absence of upper incisors permits better laryngoscopic vector alignment and presence of long upper incisors adversely impacts ease of laryngoscopy and tracheal intubation. It is also important to note that partial loss of upper teeth could cause the laryngoscope blade to get “stuck” between teeth and impede vector alignment (Rocke et al., 1992). The impact of dental structure on mask ventilation is less clear previous studies have indicated that edentulous patients are associated with difficult mask ventilation but edentulous state was not an independent predictor of difficult or impossible mask ventilation in the largest studies to date (Kheterpal et al., 2009). Dentures may help maintain upper airway structure and permit a tighter mask fit but expert opinion on retaining dentures during airway management is unclear (Kheterpal et al., 2009).

**Submental Factors**

The bony cage that makes up the framework of the upper airway is formed by the maxilla, mandible, hard palate forming the “roof” and the cervical vertebral column at the back. Conditions that reduce the anteroposterior distance of the mid-face, mandibular length and position
of the hyoid bone all adversely impact the ease of mask ventilation and tracheal intubation. The floor of the upper airway is formed by soft tissue that is bounded anteriorly and laterally by the mandibular edges and the hyoid bone posteriorly (Brown et al., 1991).

This virtual space often referred to as the submentum or the submental space is of crucial importance to the success or failure of laryngoscopy. The tongue is attached to the mandible and the hyoid bone through upper airway muscles primarily the genioglossus, the hyoglossus and the mylohyoid. The mylohyoid extends like a diaphragm across the floor of the submental space (Brown et al., 1991).

This places a definite limitation to the volume of tongue that can be displaced during laryngoscopy. Tongue volumes in excess of the critical capacity of the submental space influence the laryngoscopic view. Similarly, disease states that reduce the compliance of the submental tissues namely scarring from surgery, burns or radiation therapy will also impact laryngoscopic view (Brown et al., 1991). Correct positioning of the laryngoscopic blade tip in the fold between the tongue and the epiglottis causes the epiglottis to fold upward bringing the larynx into view. Factors that may interfere with correct placement of the laryngoscope blade include vallecular cysts and lingual tonsillar hypertrophy. The forces that are exerted by the tip of the laryngoscope in this position pull the glosso-epiglottic ligament (Brown et al., 1991) and cause the hyoid bone to tilt forward. The hyoid bone has ligamentous attachment to the epiglottis and this forward tilting movement causes the epiglottis to tilt up opening up the glottic inlet. The mechanics of the hyoid bone are uniquely different in patients with difficult airways. This was demonstrated in a study where lateral radiography was performed during laryngoscopy in patients with a history of failed tracheal intubation (Fahy et al., 1990).
In these patients the blade tip failed to make contact with the hyoid and instead the tongue was compressed into a pear shape. This pear-shaped deformity of the tongue pressed down the epiglottis and forced the hyoid to tilt in the opposite direction with resultant downward folding of the epiglottis onto the posterior pharyngeal wall. This mechanism was confirmed in a subsequent mathematical modeling of osseous factors in difficult intubation (Charters, 1994).

The net effect of this scenario is a persistent epiglottic view on laryngoscopy because the effective submental volume is critically smaller than the minimum volume displacement of tongue needed to optimally position the laryngoscope tip. Straight laryngoscope blades with smaller displacement volumes than the curved blade offer better laryngeal views based on this mechanistic explanation. The same factors come into play with significant upper incisor overbite where the effect of a relatively anterior maxilla mimics the effect of a recessed mandible (Charters, 1994).

**Mandibular Subluxation**

The process of jaw-thrust causes the mandible to slide forward out of the mandibular socket resulting in the forward displacement of the tongue and attached submental tissues (Figure 17). Disease states associated with a reduction in this mobility have been shown to be associated with difficult mask ventilation and tracheal intubation (Figure 18). This component of the laryngoscopic visualization vector has been historically underappreciated and understudied (Charters, 1994).
Figure 17: Temporo-mandibular joint in closed (a) and open (b) positions. Note the forward sliding and rotation of the mandibular condyle.

Figure 18: Impact of diseased temporomandibular joint on mouth opening. Here left sided TMJ ankylosis seen on the coronal CT causes severe trismus and impossible laryngoscopy.
Factors Affecting Laryngeal Structures

Successful tracheal intubation is also dependent on the size of the glottic opening and subglottic structures. Fixed or dynamic abnormalities of the laryngeal structures prevent successful tracheal intubation even in the presence of optimal laryngoscope vector visualization. Several acute and chronic conditions affect laryngeal, subglottic and tracheal caliber; these conditions typically are associated with clinical signs such as stridor and increasing levels of distress with increasing degrees of airway narrowing.

Anatomy and Physiology of the Compromised and Critical Airway

One way to describe airway narrowing is as follows: occult airway narrowing, stable critically narrowed airway and compromised airway.

Figure 19: Laryngeal web almost completely occluding the airway. As a rule, presence of hoarseness, stridor, or respiratory distress should alert anesthesiologists to the need for rapid airway management. Such airway pathology requires a great deal of skill as repeated manipulation of the airway could convert a stable airway narrowing to a compromised airway situation.
Both the latter conditions are associated with a significant risk of difficult mask ventilation, failed tracheal intubation and the eventual need for surgical airway. Subclinical airway narrowing refers to occult diseases affecting airway caliber with no accompanying signs or symptoms. There is no way to identify these patients prior to laryngoscopy using standard airway physical exam elements. A high index of suspicion should be used in certain syndromes and disease conditions that predispose to airway narrowing such as thyroid or anterior mediastinal masses. The stable critically narrowed airway refers to the presence of stridor in the absence of respiratory failure or hypoxia. The implication here is that there is sufficient time to assess the airway thoroughly and plan for successful tracheal intubation with contingency plans in the event the primary technique fails. However, the margin for error in this class is significantly lower than the subclinical airway narrowing group. The compromised airway refers to stridor in the presence of accompanying respiratory distress or hypoxia. The presence of stridor in an acute setting should alert the practitioner to the presence of a difficult airway with high likelihood of rapid progression to acute respiratory compromise. The upper airway caliber has a great impact on work of breathing as defined by the gas flow equation (for laminar flow) (O’Grady et al., 1997).

\[
\text{Flow} = \frac{\text{Radius}^4 \times \text{Pressure differential across obstruction}}{\text{Viscosity of inspired air} \times \text{length of upper airway}}
\]

Two important clinical implications exist for this equation. Flow is proportional to the fourth power of the radius measured at the narrowest point of the airway. As a result of this fourth power when the airway caliber is doubled the flow increases by 16 times and more importantly when the airway caliber is halved the flow decreases by 16 times. Thus the pressure differential needed to maintain adequate air flow in the
presence of airway narrowing is significantly greater causing a huge burden on the respiratory muscles. Often in the presence of chronic airway narrowing compensatory - reduced time to secure the airway introducing an additional time constraint to the difficult airway management and increasing the need for expert airway management (O’Grady et al., 1997).

**Clinical assessment of the airway**

Clinical prediction of the difficult airway follows detailed review of patient history, general, physical examination and specific airway-related assessment. The clinical conditions associated with difficult airway can be classified loosely into congenital diseases, traumatic conditions, systemic diseases, airway tumors and upper airway infections.

**Systemic Conditions**

**Pregnancy**

Pregnancy is associated with increased risk of difficult mask ventilation, difficult intubation and rapid progression of hypoxemia. (Barash et al., 2006). Recent research shows that labor is associated with dynamic increases in Mallampati class secondary to upper airway edema that settles over time after labor (Kodali et al., 2008). Rocke and colleagues (Rocke et al., 1992) identified difficult intubation in 7.9 % of pregnant patients. Associated features for difficult intubation in pregnancy are pre/eclampsia, short neck, obesity, absent or excessively large maxillary incisors and receding mandible.

**Diabetes Mellitus**

The association between diabetes and difficult airway relates to the glycosylation of joints and development of stiff joint syndrome (Salzarulo and Taylor, 1986). The primary joints affected in patients with difficult laryngoscopy are the TMJ and the cervical spine presenting
limitation of mouth opening, mandibular subluxation and head extension. The two tests described to identify stiff joint syndrome are the palm print test and the prayer sign (*Nadal et al., 1998*). The former tests the ability to make full contact with a flat surface and increasing risk of difficult airway is seen with decreasing surface contact. The prayer sign refers to the ability to place the palms together “in prayer” with diabetic stiff joint patients having progressive difficulty to achieve this (Fig.19). It is estimated that about a third of long-term early onset diabetics develop stiff joint syndrome (*Buckingham et al., 1986*) and its presence is an extremely accurate predictor of difficult airway.
Figure 20: Prayer sign—inaability to oppose palms due to progressive stiffening of the joints caused by diabetes mellitus. It is estimated that about a third of long-term early onset diabetics develop stiff joint syndrome and its presence is an extremely accurate predictor of difficult airway.

Rheumatoid Arthritis

This is one of the more common autoimmune conditions with unique implications for airway management. Severe joint involvement of the TMJ, cervical spine, and extremities dirimpacts access to the airway, visualization vector and mandibular subluxation. The more important implication is cervical spine instability. Symptoms suggestive of nerve root or spinal cord compression and limitation of neck movement should alert the practitioner to the risk of permanent neurological injury with direct laryngoscopy and intubation, although this is an extremely rarely reported outcome. Hoarseness, dysphonia or stridor could suggest significant laryngeal distortion from joint involvement and awake flexible
bronchoscopic techniques or a surgical airway may be preferable in these cases.

**Trauma**

Trauma to the head and neck impacts the airway *(Langeron et al., 2009)* typically due to direct injury with attendant airway distortion, bleeding, trismus and airway edema. Stridor, inability to speak, laryngeal cartilage fracture or neck emphysema suggests airway disruption and signals the emergent need for airway management by practitioners experienced in bronchoscopy and tracheostomy. Blind endotracheal intubation is likely to produce a catastrophic loss of airway with high risk of patient death in this clinical scenario. Injury precautions for the cervical spine are a mechanical impediment to achieving a satisfactory laryngoscopic visualization vector and may impair mouth opening. In the presence of known cervical spine injury the force of laryngoscopy can worsen compression of the spinal cord and affect neurological outcome by causing anterior bowing and displacement of the mid-lower cervical vertebrae.

**Burns**

Acute head and neck burns, exposure to explosions or fires in enclosed spaces and airway burns are associated with difficult airway *(de Campo and Aldrete, 1981)*. The mechanisms include airway edema secondary to thermal injury and tracheobronchial disruption from shock waves related to explosions. Difficult intubation is seen in patients with significant tongue edema and submental edema. Presence of hoarse voice, oral burns, singed nasal hairs, non compliant submental tissues and facial swelling should alert the practitioner to potentially difficult intubation and emergent flexible bronchoscopic intubation should be performed where feasible *(Norton and Kyff, 1991)*. Chronic anterior head and neck
scarring from thermal and chemical burns produces extreme difficulty with the airway through limitation in neck mobility and mouth opening. Chemical ingestion causes significant distortion of the upper airway, making identification of the glottic inlet impossible using conventional laryngoscopy in many patients with false passages and grossly narrowed airway caliber (Norton and Kyff, 1991).

**Airway Tumors**

Tumors developing from and close to the upper and lower airway present independent challenges to airway management. Tumors within the airway lumen include oral cancers, laryngeal tumors and bronchogenic carcinoma. Oral cancers can increase tongue volume or reduce pharyngeal and submental compliance or affect mouth opening (Ferlito et al., 1999) (Figure 21).
Squamous cell carcinoma of the tongue causes swelling and induration, thereby reducing tongue and submental tissue compliance. Inability to compress the tongue into the submental space results in difficult laryngoscopy.

Laryngeal tumors predispose to sudden loss of airway and often present physical impediments to passage of endotracheal tubes (Ferlito et al., 1999). Bronchogenic carcinoma produces significant airway narrowing and distortion. All these conditions are easily traumatized causing bleeding into the airway. Extrathoracic tumors that lie outside the lumen of the airway influence airway management in one of several ways (Souza et al., 1999). Large goiters produce significant physical impediment to laryngoscopy and are associated with airway compression.
secondary to erosion of tracheal rings (Shaha, 2008). Anaplastic thyroid carcinoma has been known to erode the tracheal wall and cause airway collapse, distortion or bleeding though this is very uncommon (Licker et al., 1997). Thyroid masses are a physical impediment to successful surgical airway access. Life threatening hemorrhage has followed thyroid injury during attempted tracheostomy. Intrathoracic tumors related to the airway present several problems patients with these tumors can exhibit positional or dynamic airway obstruction. Superior vena cava syndrome can significantly impact the airway management (Hammer, 2004). Superior vena cava syndrome is associated with head and neck plethora, increased airway edema and a risk of airway collapse. The loss of airway tone related to loss of consciousness in these patients is due to intrathoracic airway compression tracheal intubation may not be adequate to ventilate the patient due to the loss of airway patency distal to the endotracheal tube (Hammer, 2004).

**Upper Airway Infections**

Infections related to the tonsils, teeth, epiglottis and retropharyngeal tissues cause distortion of airway, reduced submental compliance and increase risk of airway soiling due to accidental abscess rupture with instrumentation. Quinsy or tonsillar abscesses are rare but significant causes of airway loss under sedation or anesthesia (Beriault et al., 2006) (Figure 22).
Figure 22: Chronic tonsillitis predisposes to tonsillar abscess formation. Such upper airway infections have the potential to result in rapid loss of airway under anesthesia.

Ludwig’s angina refers to the multiplane infection of the submental tissues usually caused by molar root infection resulting in brawny induration (Figure 23).

Figure 23: Deep neck space infection, commonly related to dental sepsis. The loss of submental tissue compliance coupled with increase in peri-airway soft tissue results in difficult airway. It is essential that a clear airway management plan and back-up plans are made in conjunction with ENT surgeons.
Retropharyngeal abscess causes difficulty swallowing and typically presents with drooling, odynophagia and significant airway narrowing secondary to posterior pharyngeal wall edema and abscess. All these conditions have significant risks of failed mask ventilation and difficult or impossible intubation. Cautious flexible bronchoscopic or surgical airway access should be performed by experienced practitioners. While recognition of these conditions should prompt a high-index of suspicion that airway difficulties are highly probable, lingual tonsillar hyperplasia may be entirely occult and associated with difficult mask ventilation and laryngoscopic intubation (Ovassapian et al., 2002).
Chapter 3

Prediction and Assessment of difficult airway

(A) Difficult Intubation:

Defined by ASA as a clinical situation in which a trained anesthesiologist experiences difficulty with mask ventilation, difficulty with intubation, or both. *(Janssens and Hartstein, 2001).*

There have been various attempts at defining what is meant by a difficult intubation but the most widely used classification is by Cormack and Lehane which describes the best view of the larynx seen at laryngoscopy *(Cormack and Lehane, 1984).*

*Cormack And Lehane Grading:*

• **grade I** - visualization of entire laryngeal aperture. (95%).
• **grade II** - visualization of posterior part of the laryngeal aperture. (4%).
• **grade III** - visualization of epiglottis only. (1%).
• **grade IV** - the epiglottis is not even visible. (0.05%).

![Figure 24: Laryngoscopic View Grades (Cormack and Lehane, 1984).](image)

(B) Difficult Mask ventilation:

Is said to occur when “it is not possible for the unassisted anesthesiologist to maintain the oxygen saturation above 90% using
100% oxygen and positive pressure mask ventilation in a patient whose oxygen saturation was above 90% before anesthetic intervention” or when “it is not possible for the unassisted anesthesiologist to prevent or reverse signs of inadequate ventilation during positive pressure mask ventilation” (ASA definitions) (Gabbott and Beringer, 2007).

**Airway Assessment & Predictors Of Difficult Airway**

**I. History:**

They are clues from the history that suggest difficult airway management these are shown in table (6) (Cattano et al., 1956).

**Table (6)**

<table>
<thead>
<tr>
<th>Finding</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry cough</td>
<td>Possible tracheobronchial compression.</td>
</tr>
<tr>
<td>Easy bleeding</td>
<td>epistaxis risk.</td>
</tr>
<tr>
<td>Long standing diabetes mellitus</td>
<td>Limited cervical mobility.</td>
</tr>
<tr>
<td>Loud snoring</td>
<td>Prone to soft tissue obstruction.</td>
</tr>
<tr>
<td>Major trauma</td>
<td>Unstable neck limited safe mobility.</td>
</tr>
<tr>
<td>Radiation to neck</td>
<td>Fibrosis and immobility.</td>
</tr>
<tr>
<td>Recent temporal craniotomy</td>
<td>Limited mandibular mobility.</td>
</tr>
<tr>
<td>Smoking</td>
<td>Salivation, cough ,laryngeal spasm.</td>
</tr>
<tr>
<td>Undigested food returning to the mouth</td>
<td>Aspiration risk.</td>
</tr>
<tr>
<td>Gastroesophageal reflux</td>
<td>Aspiration risk.</td>
</tr>
</tbody>
</table>
II. General, physical and regional examination:

1. Obesity:

![Figure 25: positioning of obese patient (Brodsy et al., 2002).](image)

Patients with morbid obesity possess one or more anatomical features associated with difficult mask ventilation and rapidly develop hypoxemia when this is inadequate or impossible. A higher incidence of difficult intubation has also been suggested in patients with morbid obesity and so some clinicians choose awake intubation as their primary strategy for airway management. The awake fiberoptic play a major role in such these patients (Brodsy et al., 2002).

2. Patency of nares:

   look for masses inside nasal cavity (e.g. polyps), deviated nasal septum, etc. (Casati et al., 2005).

3. Mouth opening:

   Of at least 2 large finger breadths between upper and lower incisors in adults is desirable (Casati et al., 2005).
4. Teeth:

Prominent upper incisors or canines with or without overbite can impose a limitation on alignment of oral or pharyngeal axes during laryngoscopy and especially in association with a large base of tongue. They can compound the difficulty during the direct laryngoscopy or bag-mask ventilation. An edentulous state, on the other hand can render axis alignment easier but hypopharyngeal obstruction by the tongue can occur (Casati et al., 2005).

Figure 26: limited mouth opening (Casati et al., 2005).

Figure 27: protruded teeth (Casati et al., 2005).
**Specific tests for assessment:**

**A. Anatomical criteria**

1. **Relation between tongue/pharyngeal size:**

   Mallampati test: The Mallampati classification correlates tongue size to pharyngeal size. This test is performed with the patient in the sitting position, head in a neutral position, the mouth wide open and the tongue protruding to its maximum. Patient should not be actively encouraged to phonate as it can result in contraction and elevation of the soft palate leading to a spurious picture (*Crockard, 2003*).

   Classification is assigned according to the extent the base of tongue is able to mask the visibility of pharyngeal structures into three classes:

   **Class I:** Visualization of the soft palate, fauces; uvula, anterior and the posterior pillars.

   **Class II:** Visualization of the soft palate, fauces and uvula.

   **Class III:** Visualization of soft palate and base of uvula.

   In Samsoon and Young’s modification (1987) of the Mallampati classification, a IV class was added.

   **Class IV:** Only hard palate is visible. Soft palate is not visible at all.

   To avoid false positive or false negative this test should be repeated twice. Since it is not possible to measure the size of the posterior part of the tongue relative to the capacity of the oropharynx this method of assessment gives an indirect means of evaluating their relative proportionality (*Crockard, 2003*).
2. Atlanto-occipital joint (AO) extension:

It assesses feasibility to make sniffing or Magill position for intubation i.e. alignment of oral, pharyngeal and laryngeal axes into an arbitrary straight line. The patient is asked to hold head erect, facing directly to the front, then he is asked to extend the head maximally and the examiner estimates the angle traversed by the occlusal surface of upper teeth. Measurement can be by simple visual estimate or more accurately with a goniometer. Any reduction in extension is expressed in grades:

Grade I: >35°
Grade II: 22°-34°
Grade III: 12°-21°
Grade IV: < 12°

Normal angle of extension is 35° or more (Crockard, 2003).
3. Mandibular space:
   
   i. Thyromental (T-M) distance (Patil’s test):

   It is defined as the distance from the mentum to the thyroid notch while the patient’s neck is fully extended. This measurement helps in determining how readily the laryngeal axis will fall in line with the pharyngeal axis when the atlanto-occipital joint is extended. Alignment of these two axes is difficult if the T-M distance is < 3 finger breadths or < 6 cm in adults; 6-6.5 cm is less difficult, while > 6.5 cm is normal (Crockard, 2003).

   ![Figure 29](image)

   **Figure 29:** Thyromental distance (from the mentum of the mandible to the superior margin of the thyroid cartilage) should exceed 6 cm or 3 fingerbreadths (Crockard, 2003).

   ii. Sterno-mental distance:

   Sava estimated distance from the suprasternal notch to the mentum and investigated its possible correlation with the Mallampati class, jaw protrusion, interincisor gap and thyromental distance. It was measured with the head fully extended on the neck with the mouth closed. A value of less than 12 cm is found to predict a difficult intubation (Sava and Leman, 2001).
iii. Mandibulo-hyoid distance:

Measurement of mandibular length from chin (mental) to hyoid should be at least 4 cm or three finger breadths. It was found that laryngoscopy became more difficult as the vertical distance between the mandible and hyoid bone increased (Sava and Leman, 2001).

![Diagram of mandibulo-hyoid distance](image)

**Figure 30:** Mandiulo-hyoid distance (Crockard, 2003).

iv. Inter-incisor distance:

It is the distance between the upper and lower incisors. Normal is 4.6 cm or more; while > 3.8 cm predicts difficult airway (Crockard, 2003)

**Risk Index of El-Ganzouri for Difficult Tracheal Intubation:**

Multivariate analysis of the variables affecting difficult tracheal intubation allows development of a risk index which can be used to assess patients prior to intubation. The 7 variables identified are independent predictors of difficulty with tracheal visualization (McCarthy et al., 1996).
<table>
<thead>
<tr>
<th>Variable</th>
<th>Finding</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>mouth opening</td>
<td>≥ 4 cm</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>&lt; 4 cm</td>
<td>1</td>
</tr>
<tr>
<td>thyromental distance</td>
<td>&gt; 6.5 cm</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>6.0–6.5 cm</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>&lt; 6.0 cm</td>
<td>2</td>
</tr>
<tr>
<td>Mallampati score</td>
<td>I</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>2</td>
</tr>
<tr>
<td>neck movement</td>
<td>&gt; 90°</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>80–90°</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>&lt; 80°</td>
<td>2</td>
</tr>
<tr>
<td>ability to prognath</td>
<td>yes</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>no</td>
<td>1</td>
</tr>
<tr>
<td>body weight</td>
<td>&lt; 90 kilograms</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>90–110 kilograms</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>&gt; 110 kilograms</td>
<td>2</td>
</tr>
<tr>
<td>history of difficult intubation</td>
<td>none</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>questionable</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>definite</td>
<td>2</td>
</tr>
</tbody>
</table>
Interpretation

- minimum score: 0
- maximum score: 12

<table>
<thead>
<tr>
<th>Index Score</th>
<th>Tracheal Intubation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4</td>
<td>unlikely to be difficult</td>
</tr>
<tr>
<td>≥ 4</td>
<td>likely will be difficult</td>
</tr>
</tbody>
</table>

(McCarthy et al., 1996).

Algorithms for difficult airway management

Problems with tracheal intubation are infrequent but are the most common cause of anesthetic death or brain damage the clinical situation is not always managed well. The Difficult Airway Society (DAS) has developed guidelines for management of the unanticipated difficult tracheal intubation in the non-obstetric adult patient without upper airway obstruction. These guidelines have been developed by consensus and are based on evidence and experience (Gabbott and Beringer, 2007).

The Difficult Airway Society guidelines

Effective airway management requires careful planning so that back up plans (plan B, C, D) can be executed when the primary technique (plan A) fails. This philosophy forms the basis of the DAS guidelines. Two other principles are particularly important. Maintenance of oxygenation takes priority over everything else during the execution of each plan. Anesthetists should seek the best assistance available as soon as difficulty with laryngoscopy is experienced. The basic structure of the DAS flow-charts contains the plans, core techniques and shows the possible outcomes. The plans are labeled A–D:

- **Plan A**: Initial tracheal intubation plan.
- **Plan B**: Secondary tracheal intubation plan, when Plan A has failed.
- **Plan C:** Maintenance of oxygenation and ventilation, postponement of surgery, and awakening the patient, when earlier plans fail.

- **Plan D:** Rescue techniques for ‘can’t intubate, can’t ventilate’ (CICV) Situation *(Gabbott and Beringer, 2007)*.

**Suggested equipment for a difficult airway cart (American Society of Anesthesiologists).**

- Rigid laryngoscope blades of alternate design and size (may include video laryngoscopy)
- Tracheal tubes of assorted sizes.
- Tracheal tube guides.
- Supraglottic airway devices.
- Flexible bronchoscopic intubation equipment.
- Retrograde intubation equipment.
- At least one device suitable for emergency noninvasive airway ventilation (Combitube®, jetventilation stylet, transtracheal jet ventilator).
- Equipment suitable for emergency invasive airway access.
- Exhaled CO₂ detector.
Figure 30: Basic structure of DAS Guidelines flow-chart

*(Gabbott and Beringer, 2007)*.
The Difficult Airway Algorithm of the American Society of Anesthesiologists (ASA) was developed to guide clinicians in the management of the patient who is either predicted to have a difficult airway or whose airway cannot be adequately managed after induction of anesthesia.

Figure 31: ASA algorithm for difficult airway management

(Gabbott and Beringer, 2007).
Chapter 4

Supraglottic Airway Devices

Supraglottic airway devices have become a standard fixture in airway management filling a niche between the face mask and tracheal tube in terms of both anatomical position and degree of invasiveness. These devices sit outside the trachea but provide a hands free means of achieving a gas-tight airway (Cormack and Lehane, 1984). The first successful supraglottic airway device the Laryngeal Mask Airway (LMA)-Classic, became available in 1989. As time went on additional devices were added to the LMA family to satisfy specific needs and a number of other devices were developed (Cormack and Lehane, 1984).

Laryngeal Mask Airway:

Types:

1-LMA-Classic

History:
The LMA was introduced by Dr Archie Brain in 1981 (Cormack and Lehane, 1984).

Figure 33: The LMA-Classic (standard LMA, Classic LMA, LMA-C, cLMA) (Woods, 1994)
Description:

Consists of a curved tube (shaft) connected to an elliptical spoon-shaped mask (cup) at a 30° angle. There are two flexible vertical bars where the tube enters the mask to prevent the tube from being obstructed by the epiglottis. An inflatable cuff surrounds the inner rim of the mask. An inflation tube and self-sealing pilot balloon are attached to the proximal wider end of the mask. A black line runs longitudinally along the posterior aspect of the tube. At the machine end of the tube is a 15-mm connector. The LMA is made from silicone and contains no latex. A method to choose the correct size laryngeal mask for children is to match the widest part of the mask to the width of the second to fourth fingers (Ellis and Feldman, 2000).

Insertion:

a) Standard Technique:

The standard insertion technique uses a midline or slightly diagonal approach with the cuff fully deflated.

The head should be extended and the neck flexed (sniffing position).

This position is best maintained during insertion by using the non-inserting hand to stabilize the occiput. The LMA can be inserted without placing the head in this position (Ellis and Feldman, 2000).

The tube portion is grasped as if it were a pen, with the index finger pressing on the point where the tube joins the mask. With the aperture facing forward (and the black line facing the patient's upper lip), the tip of the cuff is placed against the inner surface of the upper incisors or gums. At this point, the tube should be parallel to the floor. If the mouth is being held open, the jaw should be released during further
insertion. In the patient with a restricted mouth opening an alternative method is to pass the LMA behind the molar teeth into the pharynx. The tubular part is then maneuvered toward the midline (Ellis and Feldman, 2000).

**Figure 34:** Initial insertion of the laryngeal mask. Under direct vision, the mask tip is pressed upward against the hard palate (Ellis and Feldman, 2000).

The middle finger may be used to push the lower jaw downward. The mask is pressed upward 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 (Ellis and Feldman, 2000).

**Figure 35:** Stabilization of the laryngeal mask. 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. (Ellis and Feldman, 2000).
If resistance is felt, the tip may have folded on itself or impacted on an irregularity or the posterior pharynx. In this case, a diagonal shift in direction is often helpful, or a gloved finger may be inserted behind the mask to lift it over the obstruction (Ellis and Feldman, 2000).

b) 180-degree Technique:

Another technique is to insert the LMA with the laryngeal aperture pointing cephalad and rotate it 180 degrees as it enters the hypopharynx. (A distinct pop may be felt by the introducing hand. This method may be as satisfactory as the standard technique, especially in pediatric patients. It has been postulated that rotation of the bulky LMA cuff in the close proximity of the hypopharynx could dislocate the arytenoid cartilages (Brimacombe and Berry, 1994).

c) Partial Inflation Technique:

Yet another technique is to partially or fully inflate the cuff before insertion. Although this technique may offer some advantages for an inexperienced user, the device may frequently be malpositioned. The incidence of sore throat may be reduced with the partial inflation method (Brimacombe and Berry, 1994).

Uses:

The LMA can serve as a conduit through which a tracheal tube, stylet, or fiberscope is passed. It acts to position the device over the laryngeal aperture. The 30° angle between the tube and cuff was chosen because it was found to be optimal for intubation through the LMA (Carey et al., 1991).

Tracheal tube or fiberscope passage may be aided by removing the bars at the junction of the tube and mask. This is not recommended by the manufacturer. A tracheal tube with the bevel point in the midline may facilitate the passage between the bars (Carey et al., 1991).
The LMA-Classic can be used to aid **fiberoptic-guided intubation**. The LMA is inserted in the usual manner. The fiberscope, with a well-lubricated tracheal tube and a fully deflated cuff threaded over its shaft, is advanced through the LMA. The fiberscope is advanced into the trachea, and the tracheal tube is advanced over the fiberscope into the trachea (*Carey et al.*, 1991).

**Problems:**

Some standard tracheal tubes may not be long enough to insert through the LMA-Classic. Deeper placement can be achieved by using a longer tracheal tube, shortening the LMA tube, removing the connector from the LMA, deflating the LMA cuff using a split LMA or using a device such as a stylet to advance the tracheal tube farther. As the tracheal tube is passed through the LMA-Classic, the pilot tube may become kinked (*Moeller-Bertram et al.*, 2004).

**2 - LMA Classic Excel (LMA North America, Inc)**

The LMA Classic Excel (Fig. 3) improves on the LMA Classic with the addition of an epiglottic elevating bar and removable connector to facilitate introduction of an ET through the LMA after placement. The LMA Classic Excel is available in sizes 3 to 5 and accommodates ETs up to size 7.5; it is reusable up to 60 times (*Jolliffe and Jackson*, 2008).
**Figure 36:** Laryngeal mask airway LMA Classic Excel (Jolliffe and Jackson, 2008).

**Figure 37:** LMA-Flexible (Welsh, 1990).

3-LMA-Flexible

**Description:**

The LMA-Flexible (wire-reinforced, reinforced LMA, RLMA, FLMA, flexible LMA), differs from the LMA-Classic in that it has a flexible, wire-reinforced tube. This tube is longer and narrower than the tube on the LMA-Classic. The cuff sizes are the same as for the LMA-
Classic. A single-use version is also available. The sizes for the single-use version are the same as for the multiuse one (Welsh, 1990).

**Insertion:**

A stylet, small tracheal tube or other device may be inserted into the tube to stiffen it. The manufacturer recommends that it be held between the thumb and index finger at the junction of the tube and cuff and positioned by inserting the index finger to its fullest extent into the oral cavity until resistance is encountered (Welsh, 1990).

Other methods for insertion have been described. Some techniques such as the 180-degree technique may not work with this LMA. After insertion, the tube may be brought through the nose (Welsh, 1990).

**Uses:**

The LMA-Flexible is designed for use with surgery on the head, neck and upper torso where the LMA-Classic would be in the way. A throat pack should be used if there is a risk of dental fragments becoming wedged behind the cuff. If malocclusion testing is needed, the tubing can be coiled inside the mouth (Welsh, 1990).

**Problems:**

The spiral reinforcing wire in the LMA-Flexible may become disrupted. Sometimes, the disruption is internal and can only be discovered by looking carefully down the shaft, Hidden defect in flexible laryngeal mask airway. Defects in the wire may cause obstruction if the tube is bent or pieces of wire could break off and migrate into the tracheobronchial tree (Molloy and Orr, 1999).

The small diameter of the tube limits the size endoscope or tracheal tube that can be passed through the LMA-Flexible. It has been recommended that prolonged spontaneous ventilation be avoided because the smaller tube causes increased resistance (Welsh, 1990).
The LMA-Flexible is unsuitable for magnetic resonance imaging (MRI) scanning if image quality in the region of the LMA is important. The metallic rings will cause image distortion. Malposition is less easily diagnosed with the LMA-Flexible than with the LMA-Classic because the tube gives no clear indication of cuff orientation (Molloy and Orr, 1999).

![Figure 38: LMA-Fastrach with tracheal tube](image)

4-LMA-Fastrach

The tube on the LMA is shorter and wider than on the LMA-Classic and has a metal handle. Note that the tracheal tube connector has been removed (Molloy and Orr, 1999).

The LMA-Fastrach (intubating LMA, ILMA, ILM, intubating laryngeal mask airway) was designed to overcome some of the limitations of the LMA-Classic during tracheal intubation. The LMA-Classic was too floppy to optimize alignment with the glottis and the long narrow tube could not accommodate a standard tracheal tube. Another objective was to eliminate the need to distort the anterior pharyngeal anatomy in order
to visualize the laryngeal inlet, making the device applicable to patients with a history of difficult intubation and a “high” or “anterior” larynx (Molloy and Orr, 1999).

**Description:**

The LMA-Fastrach has a short, curved stainless steel shaft with a standard 15-mm connector. The tube is of sufficient diameter that a cuffed 9-mm tracheal tube can be inserted and short enough to allow a standard tracheal tube cuff to pass beyond the vocal cords. The metal handle is securely bonded to the shaft near the connector end to facilitate one-handed insertion, position adjustment and maintain the device in a steady position during tracheal tube insertion and removal. There is a single, movable epiglottic elevator bar in place of the two vertical bars.

A V-shaped guiding ramp is built into the floor of the mask aperture to direct the tracheal tube toward the glottis. The tip is slightly curved to permit atraumatic insertion (Ferson et al., 2001).

**Insertion:**

The LMA-Fastrach was designed for use with the patient in the neutral position. This includes using a head support such as a pillow but no head extension. The insertion technique consists of one-hand movements in the sagittal plane. It does not require placing fingers into the patient's mouth, thus minimizing the risk of injury or infection transmission as well as allowing insertion from almost any position. (Ferson et al., 2001).

The LMA-Fastrach should be deflated and lubricated in a manner similar to the LMA-Classic. It is held by the handle which should be approximately parallel to the patient's chest. The mask tip is positioned flat against the hard palate immediately posterior to the upper incisors then slid back and forth over the palate to distribute the lubricant. After
the mask is flattened against the hard palate it is inserted with a rotational movement along the hard palate and the posterior pharyngeal wall. The mouth opening may need to be increased momentarily to permit the widest part of the mask to enter the oral cavity (Ferson et al., 2001).

The handle should not be used as a lever to force the mouth open. As the mask moves toward the pharynx it should be firmly pressed to the soft palate and posterior pharyngeal wall to keep the tip from folding. The curved part of the metal tube should be advanced without rotation until it contacts the patient's chin, then kept in contact with the chin as the device is rotated inward. The handle should not be used to lever upward during insertion because this will cause the mask to press into the tongue (Ferson et al., 2001).

When properly inserted the tube should emerge from the mouth directed somewhat caudally. Aligning the internal LMA-Fastrach aperture and the glottic opening by finding the position that produces optimal ventilation and then applying a slight anterior lift with the LMA-Fastrach handle facilitates correct positioning and blind intubation (Ferson et al., 2001).

**Uses:**

Although the LMA-Fastrach has been designed to facilitate tracheal intubation, it can also be used as a primary airway device. It is especially useful for the anticipated or unexpected difficult airway (Ferson et al., 2001).

The LMA-Fastrach can be inserted with the same or better success than the LMA-Classic. It is easier to place than the LMA-Classic when manual in-line stabilization is used. However, in patients with limited neck movement intubation may be less likely to be successful and take longer than if a lighted intubation stylet is used (Moeller-Bertram et al., 2004).
Muscle relaxants are not necessary for intubation through the LMA-Fastrach but may increase the success rate. Cricoid pressure will decrease the likelihood of success and may need to be released to allow intubation (Harry and Nolan, 1999).

The tracheal tube recommended by the manufacturer for use with the LMA-Fastrach is a silicone, wire-reinforced, cuffed tube with a tapered patient end and a blunt tip (Moeller-Bertram et al., 2004).

This tube is flexible which allows negotiation around the anatomical curves of the airway (Bahk and Choi, 1999).

It has a high-pressure, low-volume cuff that reduces resistance during intubation and makes cuff perforation as the tube passes through the LMA less likely. There is a stabilizer that allows the LMA to be removed without extubating the patient. Whatever tracheal tube is used it is essential that it is possible to remove the connector. It is important to lubricate the tracheal tube well and pass it through the LMA several times before use (Bahk and Choi, 1999).

**Problems:**

Currently, the smallest size available of the LMA-Fastrach is the number 3. This has been found to work well for intubation of patients over 30 kg but for patients under this weight successful intubation through this device is less certain (Harry and Nolan, 1999).

The LMA-Fastrach tracheal tube is expensive and should not remain in place for long periods of time because it has a high-pressure cuff. The LMA-Fastrach requires more time for intubation and results in more esophageal intubations and mucosal trauma than rigid laryngoscopy. Blind intubation through the LMA-Fastrach generates cardiovascular responses similar to tracheal intubation using direct laryngoscopy. When the LMA-Fastrach is removed the tracheal tube may be displaced downward or dislodged (Weiss et al., 2001).
The large diameter of the LMA-Fastrach airway tube can cause difficulty during insertion in the patient with a limited mouth opening and may put dentition at risk. Compared with the LMA-Classic the LMA-Fastrach causes an increased incidence of sore throat, sore mouth and difficulty swallowing (Brimacombe et al., 2004).

While LMA-Fastrach is easier to place than the LMA-Classic and placement is more likely to be successful in patients with immobilized cervical spines, the LMA-Fastrach may exert pressure on the cervical spine. Intubation through the LMA-Fastrach may cause significant motion of the cervical spine. It may be difficult to insert in the patient with a cervical collar, especially if cricoid pressure is used. Anesthesia providers who have limited use of the left arm will find the LMA-Fastrach difficult to use (Brimacombe et al., 2004).
Figure 39: The LMA-CTrach. It has two built-in fiberoptic channels, one to convey light from and the other to convey the image to the viewer. The monitor (viewer) is attached to the LMA-CTrach via a magnetic latch connector.

*Timmerrmann et al., 2004.*

**5-LMA-CTrach**

**Description:**

The LMA-CTrach is similar in construction to the LMA-Fastrach. It has two built-in fiberoptic channels, one to convey light from and the other to convey the image to the viewer (*Timmerrmann et al., 2004*). These emerge at the distal end of the airway tube under the epiglottic elevating bar which lifts the epiglottis as the tracheal tube passes through the LMA-CTrach into the larynx. The fiberoptic system is sealed and robust, so the LMA-CTrach can be autoclaved (*Timmerrmann et al., 2004*).

The monitor (viewer) is attached to the LMA-CTrach via a magnetic latch connector. It has controls for focusing and image...
adjustment. The viewer is battery operated. The battery provides up to 30 minutes of continuous use and can be recharged. The LMA -CTrach is available in sizes 3, 4 and 5 and is reusable up to 20 times (Timmerrmann et al., 2004).

*Uses:*

The LMA-CTrach is lubricated and inserted similar to the LMA-Fastrach without the viewer attached. An antifogging solution should be applied to the optical lens. After the LMA has been inserted, the airway secured and the patient ventilated the viewer is switched ON and attached. A real-time image of the larynx is then displayed. If positioning is not satisfactory various maneuvers can be performed to improve the view . After a satisfactory glottic aperture image is achieved, the tracheal tube is advanced and viewed as it enters the trachea. Once the patient is intubated, the viewer is detached and the laryngeal mask removed leaving the tracheal tube in place (Bilgin and Yylmaz, 2006).

![Figure 40: LMA-ProSeal. Note the integral bite block.](image)
6-LMA-ProSeal

**Description:**

The LMA-ProSeal (LMA-PROSEAL, PLM) has four main parts:  
The **cuff, inflation line with pilot balloon, airway tube and drain (gastric access) tube.**

The airway (breathing, ventilation) tube of the LMA-ProSeal is shorter and smaller in diameter than that of the LMA-Classic and is wire reinforced which makes it more flexible. There is a locating strap on the anterior distal tube to prevent the finger slipping off the tube and to provide an insertion slot for the introducer tool. An accessory vent under the drainage tube in the bowl prevents secretions from pooling and acts as an accessory ventilation port. The LMA-ProSeal has a deeper bowl than the LMA-Classic and does not have aperture bars. There is a bite block between the tubings at the level where the teeth would contact the device (*Asai and Brimacombe, 2000*).

The drain (drainage, esophageal drain) tube is parallel and lateral to the airway tube until it enters the cuff bowl where it continues to an opening in the tip that is sloped anteriorly. When the LMA-ProSeal is correctly positioned the cuff tip lies behind the cricoid cartilage at the origin of the esophagus. It allows liquids and gases to escape from the stomach, reduces the risks of gastric insufflation and pulmonary aspiration allows devices to pass into the esophagus and provides information about the LMA-ProSeal position. The drain tube is designed to prevent the epiglottis from occluding the airway tube and eliminating the need for airway bars. A gastric tube, Doppler probe, thermometer, stethoscope or medication can A plastic supporting ring around the distal drain tube prevents the tube from collapsing when the cuff is inflated (*Asai and Brimacombe, 2000*).
The LMA-ProSeal has a second dorsal cuff (Fig 28). This pushes the mask anteriorly to provide a better seal around the glottic aperture and helps to anchor the device in place (Asai and Brimacombe, 2000). The dorsal cuff is not present on sizes 1 1/2 to 2 1/2. The cuff is softer than that on an LMA-Classic. The ventral cuff is larger proximally to improve the seal (Asai and Brimacombe, 2000).

A silicone-coated malleable metal introducer to facilitate placement of the LMA-ProSeal is available. It has a curved, malleable silicone-coated blade with a guiding handle. The distal end fits into the locating strap and the proximal end fits into the airway tube (Asai and Brimacombe, 2000).
Figure 42: Metal introducer used to facilitate placement of the LMA-ProSeal

(Asai and Brimacombe, 2000).

Figure 43: Posterior of the LMA-ProSeal showing the dorsal cuff

(Asai and Brimacombe, 2000).
Figure 44: Correct placement of the LMA ProSeal. Gastric tube placed in the esophageal lumen enables gastric emptying and assessment of the position of the distal end of the LMA Pro-Seal at the upper esophageal sphincter.

**Insertion:**

It is recommended that the LMA-ProSeal cuff be deflated into a wedge shape as with the LMA-Classic. The patient should be in the “sniffing” position (lower neck flexion and head extension) (Cook et al., 2005).

**Introducer Technique**

The tip of the metal introducer is inserted into the strap at the top of the cuff. The airway and drainage tubes are folded around the introducer blade and into matching slots on either side of the introducer. Lubricant should be placed on the posterior tip. The tip is then pressed against the hard palate and maneuvered to spread the lubricant along the hard palate. If the palate is high a slightly lateral approach may briefly release cricoid pressure to allow the LMA-ProSeal to pass be needed. The cuff is then slid inward, keeping pressure against the palate (Stix et al., 2002).

As the LMA-ProSeal is inserted the introducer is kept close to the chin. The cuff should be observed to make certain that it has not folded over. The introducer is swung inward in a smooth circular movement.
The jaw can be pulled downward by an assistant or pushed downward with the middle finger until the cuff has passed the teeth but the jaw should not be held widely open because this may cause the tongue and epiglottis to drop downward blocking the mask's passage. The LMA-ProSeal is advanced until resistance is felt. The nondominant hand should be used to stabilize the airway tube as the introducer is removed by following the curvature backward out of the mouth, taking care to avoid damage to the teeth. The bite block should be at the teeth (Stix et al., 2002).

**Cuff Inflation**

After the LMA-ProSeal has been inserted the cuff should be inflated with enough air to achieve an intracuff pressure of up to 60 cm H₂O. During insertion and cuff inflation the front of the neck should be observed to see if the cricoid cartilage moves forward indicating that the mask has correctly passed behind it. The cuff volume required for the LMA-ProSeal to form an effective seal with the respiratory tract is lower than for the LMA-Classic (Genzwuerker et al., 2002).

**Uses:**

The LMA-ProSeal can be used for both spontaneous and controlled ventilation but is more suited to controlled ventilation. The sealing pressure is higher than with the LMA-Classic in adult and pediatric patients making it a better choice for situations where higher airway pressures are required where better airway protection is desirable and for surgical procedures in which intraoperative gastric drainage or decompression is needed (Stix et al., 2002).
**Problems:**
The LMA-ProSeal is less suitable as an intubation device than the LMA-Class. LMA-ProSeal may be somewhat more difficult and take slightly longer to insert than the LMA-Class in adults although overall success is equivalent (*Bordes et al., 2002*).

**7-LMA Supreme (LMA North America, Inc)**
Like the LMA ProSeal, the LMA Supreme (Fig. 7) has a modified cuff that achieves a 50% higher airway seal pressure than the Classic or the Unique and a gastric drain to suction the stomach, vent regurgitated stomach contents and confirm placement of the tip of the mask at the upper esophageal sphincter. A reinforced tip and molded distal cuff prevent folding. The curve and shape of the airway tube make insertion easier and placement more stable. The LMA Supreme is a single-use device, available in adult sizes 3 to 5; its clinical utility is similar to that of the LMA ProSeal.

![Figure 45: Laryngeal mask airway LMA Supreme.](image)
8-Intubating Laryngeal Airway, AIR-Q:

Description:

The Intubating Laryngeal Airway (ILA) is a reusable device made from silicone with a clear, curved tube, a dark blue and oval bowl. The bowl has a downward tilt at the tip to facilitate it slipping below the epiglottis. The opening into the bowl has ridges on the top and sides to prevent the epiglottis from being trapped resulting in a keyhole-shaped outlet. There are ridges in the bowl below the outlet. These are designed to improve the seal and to help isolate the esophagus (Cook et al., 2005).

The ILA is available in three sizes and allows use of standard tracheal tubes of ID 5.0 to 8.5. It can be autoclaved up to 40 times (Cook et al., 2005).

A reusable removal stylet for stabilizing the tracheal tube while the ILA is being removed following intubation is available from the manufacturer (Cook et al., 2005).

Figure 46: Intubating Laryngeal Airway

(Cook et al., 2005).
**Figure 47:** Bowl of the Intubating Laryngeal Airway  
*(Cook et al., 2005).*

**Insertion:**
A jaw lift is recommended when the device is inserted. Fiberoptic guidance for tracheal intubation produces the best results *(Cook et al., 2005).*

➢ **Indications that the LMA is properly positioned include:**
Normal breath sounds, chest movements, pressure-volume loops and volume monitoring not showing a leak and carbon dioxide waveforms with positive-pressure ventilation. If the patient is breathing spontaneously normal reservoir bag excursions and absence of signs of obstruction are indications of proper placement *(Asai and Latto, 1995).*

➢ **Intraoperative Management:**
During surgery airway patency and correct LMA orientation should be verified at regular intervals. The patient's upper abdomen should be periodically observed for signs of distention and epigastric auscultation performed. A lighter level of anesthesia than would be required if a tracheal tube were used is usually possible. If laryngospasm, wheezing,
swallowing, coughing, straining or breath holding occurs anesthesia should be deepened or muscle relaxants administered. An aerosol can be administered by using an LMA (Asai and Latto, 1995).

Nitrous oxide and carbon dioxide can diffuse into the cuff increasing intracuff pressure and volume. Cuff volume increases less with the LMA-Unique than with the LMA-Classic. The increase in volume may cause airway obstruction. Inflating the cuff with nitrous oxide will avoid this increase (Evans et al., 2002).

The LMA can be used with controlled (including mechanical) or spontaneous ventilation. Patient outcome has been found to be similar in nonparalyzed patients with positive-pressure ventilation or spontaneous breathing (Natalini et al., 2003).

If controlled ventilation is used the peak inspiratory pressure should be kept below 20 cm H₂O (30 cm H₂O with the ProSeal). Higher pressures may result in a leak around the mask, gastric distention and operating room pollution (Natalini et al., 2003).

Pressure control ventilation with or without PEEP which is available on newer anesthesia ventilators may be the mode of choice for controlled ventilation with the laryngeal mask because it allows a lower peak pressure for the same tidal volume with less leak around the LMA (Natalini et al., 2003).

For patients breathing spontaneously pressure-support ventilation improves gas exchange and reduces the work of breathing. The work of breathing can also be reduced by using CPAP (Natalini et al., 2003).

A sudden increase in leakage, snoring or other sounds often signals the need for more muscle relaxation although other causes such as LMA displacement, light anesthesia causing glottic closure, airway obstruction, a leaking cuff and a decrease in lung compliance related to the surgical
procedure are other possible causes. Adding air to the cuff will not always correct a leak and may make it worse by increasing tension in the cuff and pushing it away from the larynx (Welsh, 1990).

- **Head and Neck Procedures**

  The LMA has been used for **thyroid surgery**. The cuff displaces the gland anteriorly facilitating surgical access. Because damage to the recurrent laryngeal nerve is a complication of thyroid surgery it may be desirable to stimulate that nerve during and after surgery and observe the motion of the vocal cords by using a fiberscope through the LMA. An LMA can also be used to control the tension and position of the pharyngeal wall to facilitate surgical conditions. Tracheal deviation and narrowing should be considered relative contraindications to using the LMA in thyroid surgery. Ear procedures are well suited to the LMA (HolNicls and Patel, 2001).

- **Laparoscopy**

  Use of the LMA for laparoscopic procedures is controversial because it does not offer definitive protection from pulmonary aspiration of gastric contents. Studies suggest that the LMA is safe for gynecologic laparoscopy. It has also been used successfully for laparoscopic cholecystectomy but a case of aspiration has been reported. The LMA-ProSeal is recommended for these procedures (Janssens and Hartstein, 2001).

- **Cervical spine disease**

  **Unstable Cervical Spine**

  The optimal airway management for the patient with an unstable cervical spine is controversial. While the LMA requires less cervical manipulation during intubation than direct laryngoscopy it produces flexion and posterior cervical spine displacement despite manual
stabilization. This motion is in the opposite direction of laryngoscopy. Some investigators feel that the LMA should not be used for the patient with an unstable cervical spine unless intubation by standard techniques is unsuccessful (Ball and Jefferson, 2002).

➤ **Emergence from Anesthesia:**

It is important that the bite block or roll of gauze be left in place until the LMA is removed to maintain patency and prevent damage to the LMA. Cuff deflation should be performed only when the LMA is removed. If the cuff remains inflated as the LMA is removed a greater mass of secretions will also be removed but this technique increases the incidence of blood staining (but not sore throat) (Welsh, 1990).

While the patient is under deep anesthesia will decrease the incidence of coughing, breath holding and bronchospasm. It may be highly desirable in some situations such as after intraocular surgery. It should not be performed in a patient known to be difficult to intubate. Deep extubation has been associated with airway obstruction, regurgitation and laryngospasm (Ng and Smith, 2001).

➤ **Complications:**

**Aspiration of Gastric Contents**

The LMA does not form a watertight seal around the larynx and cannot be relied on to protect the tracheobronchial tree from the contents of the gastrointestinal tract as reliably as can a tracheal tube. The overall incidence of gastric content aspiration is low and has been reported as 2.3 per 10,000 to 10.2 per 10,000 in adults (Ng and Smith, 2001).
Gastric Distention

Gastric distention which has been implicated as a factor in aspiration can occur with positive-pressure ventilation. The incidence of gastric distention increases with increasing airway pressure and tidal volume but is unlikely to occur at airway pressures of less than 20 cm H$_2$O (30 cm H$_2$O for the LMA-ProSeal) if the LMA is properly positioned. The use of pressure-limited rather than volume-limited ventilation may help to avoid gastric dilatation (Siker and Grimaldos, 2000).

Damage to the Device

The LMA may break apart. This is usually occurs when the LMA is beyond its useful life span. The tube can be transected by the patient biting it. The cuff or pilot tube may be torn on a tooth or denture, damaged by surgery or by insertion of an intravenous catheter or nerve block needle. The device may be damaged during removal (Brimacombe and Berry, 1994).

Figure 48: This LMA came apart during autoclaving. It had been used more than the recommended number of times (Brimacombe and Berry, 1994).

To prevent the problem of pilot balloon tubing being caught in the snare used for tonsillectomy the tubing should be carefully taped. The wiring in a flexible LMA may become defective. This may result in
airway obstruction or the wires could break off and migrate into the tracheobronchial tree. The 15-mm connector may loosen after a few autoclave cycles. A case has been reported where the connector was removed and reversed (Brimacombe and Berry, 1994).

**Nerve Injury**

Palsies of the hypoglossal nerves have been reported after using an LMA. Local anesthesia applied to the LMA can mimic nerve injury and cause vocal cord paralysis (Miller, 2004).

- **Advantages:**
  
  **Ease of Insertion**

  An outstanding feature of the LMA is that it rapidly provides a clear airway in the vast majority of patients and is faster and easier to insert than a tracheal tube. The work load associated with LMA insertion is lower than for other methods of airway management (Weinger et al., 2000).

  **Low Operating Room Pollution**

  There is less operating room pollution with an LMA than with a face mask. During spontaneous ventilation trace gas concentrations are comparable to those with a tracheal tube (Weinger et al., 2000).

- **Relative contraindications:**

  To use of the LMA include situations associated with an increased risk of aspiration (full stomach, previous gastric surgery, gastroesophageal reflux, diabetic gastroparesis, over 14 weeks pregnant, dementia, trauma, opiate medications, increased intestinal pressure) unless other techniques for securing the airway have failed. Hiatal hernia is a relative contraindication to LMA use unless effective measures to empty the stomach have been taken. Patients with obesity may be candidates for the LMA (Weinger et al., 2000).
There is disagreement about the safety of the laryngeal mask for procedures such as laparoscopic surgery where intra-abdominal pressure is high. Successful use of the LMA in this situation has been reported. The patient with glottic or subglottic airway obstruction such as tracheomalacia or external tracheal compression should not be managed with a laryngeal mask because it cannot prevent tracheal collapse (Weinger et al., 2000).

Supraglottic pathology such as a cyst, abscess, hematoma or tissue disruption can make proper positioning difficult or impossible although the LMA has proven useful in upper airway obstruction caused by supraglottic edema, a thyroglossal tumor and tonsillar hypertrophy. A vallecular cyst has been reported to cause obstruction after the laryngeal mask was inserted. If the mask is pushed behind the epiglottis ventilation may be possible. It may be more appropriate to use alternative insertion techniques depending on the nature of the pathology (Weinger et al., 2000).

▶ Other Supraglottic Airway Devices

- **Combitube (Covidien)**

**Description:**

The Combitube (Fig. 11) is a disposable, double-lumen tube that combines the features of a conventional ET with those of an esophageal obturator airway. The Combitube has a large proximal oropharyngeal balloon and a distal esophageal (or tracheal), low-pressure small cuff with eight ventilatory holes between the cuffs and a single ventilatory port at the distal tip (Fig. 12). There is ventilation with the Combitube regardless of whether the distal tip is in the esophagus (common) (Fig. 13) or in the trachea (rare). In the latter case the device functions like a conventional ET when the distal cuff is inflated. When the distal tip is in the esophagus,
the distal cuff seals the esophagus against regurgitation of gastric contents and a gastric tube can be placed through the esophageal lumen (Agro et al., 2002).

The Combitube has been used worldwide for more than 20 years as an emergency airway chiefly in the prehospital setting. The Combitube is an easy-to-use device in a “cannot-ventilate-cannot-intubate” scenario.

**Figure 49:** Combitube esophageal/tracheal double-lumen airway: 2 different sizes

**Figure 49:** Combitube esophageal/tracheal double-lumen airway.
Supraglottic Airway Devices

**Figure 50:** Combitube placement in esophagus.

**Insertion:**
The tube is advanced until the 2 black depthmarks are at the level of the teeth. The distal esophageal cuff is inflated with 10 mL of air to seal the esophagus. The proximal pharyngeal cuff is inflated with 80 mL of air, securing the tube in place and sealing off the oral and nasal cavity. The patient’s lungs are ventilated through lumen 1 (pharyngeal lumen).

**Problems:**
One study compared the Combitube, the LMA ProSeal and the Laryngeal Tube S (LTS) in 90 patients who underwent general anesthesia for minor gynecologic procedures.
All patients were ASA physical status class I, II, or III and had a BMI less than 35 kg/m2. The Combitube was inferior for the technical aspects of ventilation, produced the highest cuff pressures and resulted in the highest incidence of airway morbidity.

Increased airway morbidity with the Combitube compared with the LMA during routine surgery has also been demonstrated by another study and airway management with the Combitube during routine general anesthesia is not recommended.

**Figure 51:** Laryngeal Tube Airway. The distal cuff blocks the esophagus. *(Genzwuerke and Vollmer, 2003).*
\textbf{Laryngeal Tube Airway}

\textit{Description:}

The Laryngeal Tube Airway (laryngeal tube, LT)) is a reusable silicone device that has a single lumen that is closed at the tip Single-use versions (LT-D) made of polyvinylchloride are available. The Laryngeal Tube Suction (LTS, Sonda laryngeal tube, SLT) has an additional (esophageal) lumen posterior to the respiratory lumen that ends just distal to the esophageal cuff for suctioning and gastric tube placement \textit{(Genzwuerke and Vollmer, 2003)}.

The LT has a small (esophageal, distal) cuff near the blind distal tip and a larger (oropharyngeal, pharyngeal) cuff near the middle of the tube with one inflation tube to inflate both light blue cuffs. Gas exchange is through two anterior-facing, oval-shaped openings (ventilation holes) between the two cuffs. These allow suctioning or fiberscope passage. In addition, there are side holes lateral to the top of the distal opening. A ramp leads from the posterior wall toward the main ventilatory outlet \textit{(Genzwuerke and Vollmer, 2003)}.

The airway tube is relatively wide and curved. There are three marks on the tube just below the connector to the breathing system. These indicate the range for proper depth placement. The tube size is color coded on the connector with each size having a different color \textit{(Genzwuerke and Vollmer, 2003)}.

\textit{Insertion:}

For insertion the patient's head is placed in the neutral or sniffing position. A jaw thrust may be helpful \textit{(Genzwuerke and Vollmer, 2003)}.

Both cuffs should be deflated and a water-based lubricant applied. After the tube is introduced into the mouth, the flat edge of the tip is placed against the hard palate, keeping the tube centered. The tube is then
slid along the palate and into the hypopharynx until resistance is felt. A malpositioned LT will often bounce back from the intended position. After insertion the marks on the shaft should be aligned with the teeth. If difficulty is encountered a lateral insertion or a laryngoscope may be helpful. The cuffs should be inflated to a pressure 60 cm H$_2$O. The proximal cuff will fill first. The volume required will depend on the patient (Asai and Shingu, 2005).

For nasotracheal intubation the laryngeal tube is inserted and a fiberscope with a tracheal tube advanced through the nose. The distal cuff of the laryngeal tube helps to identify the glottis which should be just in front of it. After the tracheal tube has entered the trachea the laryngeal tube is removed. The LT has been used to smooth emergence in a patient with a nasal intubation by substituting the LT for the tracheal tube (Asai and Shingu, 2004).

- **Perilaryngeal Airway**

**Description:**

The Perilaryngeal Airway (CobraPLA™, CPLA™, Cobra PLA™) is a single-use plastic device with a wide, tapered patient end that has a series of slots. It has a high-volume, low-pressure, oval cuff that is shaped to fit in the hypopharynx at the base of the tongue. It is available in eight sizes (Agro and Giampalmo, 1998).
Figure 52: Perilaryngeal Airway *(Agro and Giampalmo, 1998).*

**Insertion:**

Before use the tube should be checked for defects and the cuff for leaks. Lubricant should be applied to the entire cuff and the back and side of the patient end. The cuff should be deflated and folded back against the tube *(Agro and Giampalmo, 1998).*

**Evaluation**

The Cobra is easy to insert and is associated with a highly successful first insertion rate with a low incidence of sore throat in adults and pediatric patients *(Agro and Giampalmo, 1998).*
Figure 53: Side view of the Perilaryngeal Airway.

The large lumen makes it useful for passing a relatively large tracheal tube or fiberscope making it useful for assessing the airway. The short breathing tube allows a standard length tracheal tube with its cuff to pass well past the vocal cords. The Cobra does not need to be removed after intubation. The airway sealing pressure has been found to be higher and the laryngoscopic view superior with the Cobra compared with the LMA-Classic (Agro and Giampalmo, 1998).

Figure 54: Patient end of the Perilaryngeal Airway (Agro and Giampalmo, 1998).
Figure 55: Streamlined Pharynx Airway Liner. T, toe; B, bridge; H, heel.
(hein et al., 2005).
**The Streamlined Pharynx Airway Liner (SLIPA™)**

**Description:**

Is a plastic, disposable, uncuffed device that is anatomically preshaped to line the pharynx. It forms a seal with the pharynx at the base of the tongue and the entrance to the esophagus by virtue of the resilience of its walls. The distal part of the SLIPA is shaped like a hollow boot with a toe, bridge and heel. There is an anterior opening for ventilation. The end of the toe rests in the esophageal entrance (hein *et al.*, 2005).

The bridge fits into the pyriform fossae at the base of the tongue which it displaces from the posterior pharyngeal wall. The heel connects to the airway tube which is rectangular in shape and has a color-coded connector. The heel serves to anchor the SLIPA in a stable position (hein *et al.*, 2005).

The SLIPA is available in six adult sizes that relate to the dimension across the bridge: 47, 49, 51, 52, 55, and 57 mm. To choose the correct size this dimension should be matched to the width of the patient's thyroid cartilage (hein *et al.*, 2005).
**Insertion:**

The SLIPA should be examined for defects and water-soluble lubricant applied. It should be collapsed in the anterior-posterior plane before insertion. After insertion it spontaneously returns to its preinsertion shape. The head is extended and the device inserted toward the back of the mouth until the heel locates itself in the pharynx. It is helpful if the jaw is lifted forward during insertion. A laryngoscope or gloved fingers can be used to create a space in the pharynx. Airway seal pressure should be checked after insertion. If it is too low a larger size SLIPA should be tried. If positive-pressure ventilation is used the epigastrium should be auscultated to make certain that gastric inflation is not occurring *(hein et al., 2005).*

If obstruction is encountered immediately after insertion a downfolded epiglottis may be the cause. The head should be extended and the jaw pulled forward. If this does not correct the problem the SLIPA should be removed and reinserted with an accentuated jaw lift *(hein et al., 2005).*

**Evaluation**

The SLIPA is easy to insert and is associated with a high first insertion success rate even in inexperienced hands despite its irregular shape it imposes no more resistance than similar supraglottic devices. It can be used with both spontaneous breathing and controlled ventilation *(hein et al., 2005).*
**I-Gel**

The i-gel is a truly unique airway device and represents the culmination of years of extensive research and development. Everything about the i-gel has been designed to work in perfect unison with the anatomy the i-gel design was inspired by the physiology of the perilaryngeal framework itself - airway management as nature might have intended (**Gatward et al., 2008**).

*I-gel mirrors the anatomy*

The shape, softness and contours accurately mirror the perilaryngeal anatomy to create the perfect fit. This innovative concept means that no cuff inflation is required. The i-gel works in harmony with the patient’s anatomy so that compression and displacement trauma are significantly reduced or eliminated (**Gatward et al., 2008**).
The non-inflatable cuff

I-gel gets its name from the soft gel-like material from which it is made. It is the innovative application of this material that has enabled the development of a unique non-inflatable cuff. This key feature means insertion of i-gel is easy, rapid and consistently reliable (Gatward et al., 2008).

The simple, safe and rapid solution

I-gel is incredibly easy to use. A proficient user can achieve insertion of the i-gel in less than 5 seconds. With no inflatable cuff i-gel provides a safe and rapid airway management solution (Gatward et al., 2008).

Current indications for use of i-gel

Securing and maintaining a patent airway in routine and emergency anaesthetics for operations of fasted patients during spontaneous or Intermittent Positive Pressure Ventilation (IPPV) (Gatward et al., 2008).

Accurate and natural positioning

The i-gel accurately and naturally positions itself over the laryngeal framework providing a reliable perilaryngeal seal without the need for an inflatable cuff (Gatward et al., 2008).

Using the i-gel in resuscitation

I-gel may also be beneficial in establishing a patent airway during resuscitation of the unconscious adult patient in the pre-hospital or intra-hospital setting by personnel who are suitably trained and experienced in the use of airway management devices and advanced life support techniques. i-gel is not indicated for use in resuscitation in children (Gatward et al., 2008).
**Features and benefits**

I-gel has a host of features that provide significant benefits to the patient and the clinician. The tensile properties of the I-gel bowl, along with its shape and the ridge at its proximal end contribute to the stability of the device upon insertion. Upon sliding beneath the pharyngo-epiglottic folds it becomes narrower and longer creating an outward force against the tissues. The ridge at the proximal bowl catches the base of the tongue, also keeping the device from moving upwards out of position (and the tip from moving out of the upper esophagus) (Gatward et al., 2008).

I-gel does not have any epiglottic/aperture bars like some other supraglottic devices. I-gel has an artificial epiglottis called the ‘epiglottis blocker’ which prevents epiglottis from down-folding. But in case epiglottis does down-fold, the airway channel exits so deeply into the bowl of the cuff that there is no danger of the epiglottis interfering with the fresh gas flow (Gatward et al., 2008).
Sometimes there is a difficult situation that can face the anesthologist which is cannot intubate cannot ventilate which is very dangerous and can lead to death.

The introduction of the supraglottic airway devices is considered a solution to this problem which help not only to maintain ventilation but also can be a tunnel that facilitate the tracheal intubation (Megha U et al; 2013).

Supraglottic Airway Devices are devices that ventilate patients by delivering anesthetic gases/oxygen above the level of the vocal cords and are designed to overcome the disadvantages of endotracheal intubation as: soft tissue, tooth, vocal cords, laryngeal and tracheal damage, exaggerated hemodynamic response, barotrauma, etc. The advantages of the Supraglottic airway devices include: avoidance of laryngoscopy, less invasive for the respiratory tract, better tolerated by patients, increased ease of placement, improved hemodynamic stability in emergence, less coughing, less sore throat, hands free airway and easier placement by inexperienced personal. The American Society of Anesthesiologists’ Task Force on Management of the Difficult Airway suggests considering the use of the Supraglottic airway devices when intubation problems occur in patients with a previously unrecognized difficult airway, especially in a “cannot ventilate, cannot intubate” situation (Rani A sunder, et al; 2012).
References


References


Molloy ME and Orr I (1999): Defect in the wiring of reinforced laryngeal mask leading to airway obstruction. Anaesthesia;54:712–713


References

الملخص باللغة العربية

المحافظة على مجرى الهواء للمريض واحدة من أهم مسؤوليات طبيب التخدير لأن صعوبة تركيب الأنبوبي الحنجري مسؤولية عن نسبة كبيرة من مخاطر التخدير التي قد تؤدي إلى الوفاة وعلى طبيب التخدير توقيع معرفة صعوبة تركيب الأنبوبي الحنجري في مجرى الهواء واستخدام الوسيلة المناسبة والمعهودة لديه التي يجدها مناسبة لكي يتمكن من السيطرة على الموقف.

وجد أنه من أخطر المواقف التي تواجه طبيب التخديرانة في بعض الأحيان لا يواجه صعوبة في تركيب الأنبوبي الحنجري فحسب ولكن تصاحبها أيضا صعوبة في تهوية الرئتين مما قد يؤدي إلى وفاة المريض.

ومن هنا فأن اختراع الأجهزة الهوائية فوق المزمار تعد من أهم الحلول ليس فقط في تهوية الرئتين في حالة عدم القدرة على تركيب الأنبوبي الحنجري ولكن أيضا هناك أنواع منها تستخدم في تركيب الأنبوبي الحنجري.
الأجهزة الهوائية فوق المزمار كطريقة حديثة للتحكم
فى الممرات الهوائية الصعبة

رسالة
توظنة للحصول على درجة الماجستير في
tخدير والرعاية المركزية

مقدمة من

غادة (ألفالم/97) آين (1/9) مك
بكالوريوس الطب والجراحة-جامعة بنها

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