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TEAM

# ANESTHESIA



435

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## Airway management and equipment

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{Color index: **Important**★ | [Notes](#) | [Book](#) | [433 Notes](#) | [Extra](#) | [Editing File](#)}

### Objectives:

- Learn about basic airway anatomy.
- Conduct a preoperative airway assessment.
- Identify a potentially difficult airway.
- Understand the issues around aspiration and its prevention.
- Learn about the management of airway obstruction.
- Become familiar with airway equipment.
- Practice airway management skills including bag and mask ventilation, laryngeal mask insertion, endotracheal intubation.
- Learn about controlled ventilation and become familiar with ventilatory parameters.
- Appreciate the different ways of monitoring oxygenation and ventilation

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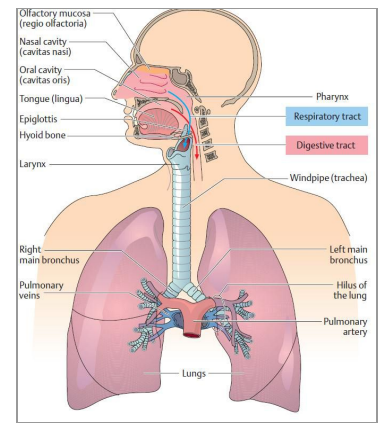
☆ All pictures and diagrams (except formulas and guidelines) used in this document are NOT in the doctor's slides but only for your own understanding.

# Review of the Anatomy

- The upper respiratory tract consists of the nasal cavity, pharynx and larynx.
- The lower respiratory tract consists of the trachea, bronchi and lung alveoli.

The right main bronchus is a direct continuation of the trachea so in case of foreign body inhalation, objects that descend beyond the trachea are more often found in the right endobronchial tree than in the left.

During GA, if we place the endotracheal tube very deep it will enter the right main bronchus → right endobronchial intubation which can cause serious complications such as hypoxia, left lung atelectasis and pneumothorax.<sup>1</sup>



## ★ The larynx

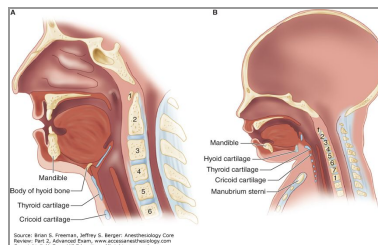
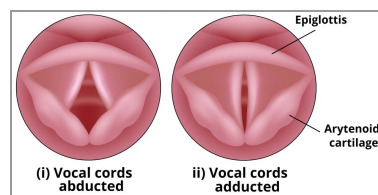
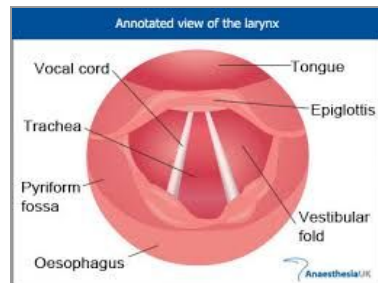
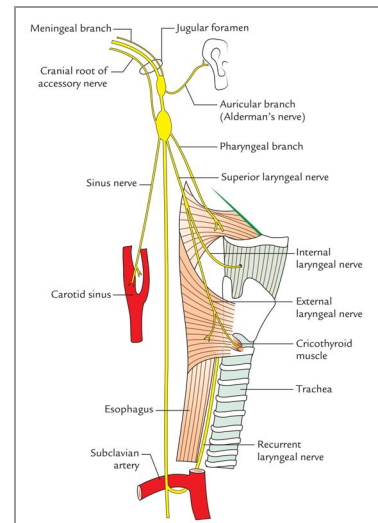
→ **Nerve supply:** all are branches of the vagus nerve<sup>2</sup>

1. **Motor:** all muscles which move the vocal cords (abductors, adductors and tensors) are supplied by the **recurrent laryngeal nerve** except the **cricothyroid muscle**, which is supplied by the **superior laryngeal nerve**. (recurrent laryngeal nerve can be injured during thyroidectomy. Which muscle is spared? Cricothyroid muscle.)
2. **Sensory:** **internal laryngeal nerve** (a branch of superior laryngeal n.) supplies what is above the vocal cords, **recurrent laryngeal nerve** supplies the larynx below the vocal cords.

Note that the right recurrent laryngeal wraps around the subclavian artery while the left branch wraps around the aortic arch.

→ **Important notes in anesthesia:**

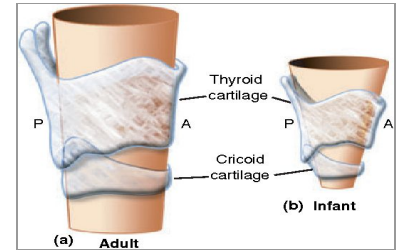
- The adult larynx is located at the level of C3-C6. Usually C5
- The vocal cords (formed by the thyroarytenoid ligaments) are the narrowest portion of the adult airway.
- Knowing the difference between adult and infant larynges.
  - **Adult larynx Vs. Infant larynx (the 7 Ss) IMPORTANT★**
- **Size:** smaller in infants
- **Shape:** funnel shaped in infants, cylindrical in adults. its wide superiorly and narrow inferiorly, (complications includes: stridor, easy trauma, easy stenosis) ; that's why it's difficult to intubate infants.
- **Softness:** laryngeal cartilages are softer and more susceptible to collapse in infants. We should do a very rapid and meticulous intubation in infant because of soft cartilage and mucosa. This softness can lead to oedema, inflammation, stridor and glottises with repeat attempt of intubations.
- **Superiorly** placed in infants, vocal cords lie at C3-C4 level and during swallowing they move up to C1-C2 whereas in adults it lies at C5
- **Straighter** and less oblique in infants
- **Sensitivity:** the infant larynx is more prone to spasms



<sup>1</sup> High risk of endobronchial intubation if we pass the tube deep, which? Right, Why? Less angulated, Shorter and wider. So what? No air in the left lung > Atelectasis and hypoxia

<sup>2</sup> Stimulation of the vagus nerve will cause parasympathetic effect > severe bradycardia > severe vasovagal attack > cardiac arrest.

- **Subglottis** is very narrow in infants, minimal swelling can lead to airway obstruction. **Subglottis is smaller than glottis, which can lead to impaction of ETT leading to trauma and fracture of arytenoid cartilage which can result in hoarseness, stridor (vocal cords paralysis.)**
- In addition, cartilages<sup>3</sup> take different shapes in infants:  
Epiglottis<sup>4</sup> is omega shaped, Arytenoid cartilage is large and cover significant posterior part of glottis, Thyroid is flat, And the diameter of cricoid is smaller than the glottis



## Airway Management:

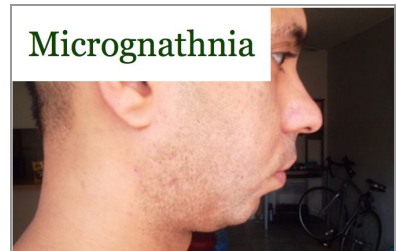
For proper airway management, two steps should be followed:

1. **Taking a thorough history**
  - History of prior difficulty **is the best predictor** (patient should provide a difficult airway card) **Was it difficult in intubation or ventilation? Ask for number of trials, complications like vocal cord injury and methods used.**
  - **Snoring and sleep apnea “Predictor of Difficult Mask Ventilation DMV” especially in obese patients.**
2. **Following the LEMON★ criteria:**
  - **Look**
  - **Evaluate | Examine**
  - **Mallampati**
  - **Obstruction**
  - **Neck mobility**

Now let's go one by one,

### → Look

- **Mandible size** micrognathia in genetic conditions such as trisomy 13 and fetal alcohol syndrome.
- **Tongue size** possible enlargement in hypothyroidism, acromegaly and obesity
- **Head size.** Head can be enlarged in children (hydrocephalus & rickets) and adult (acromegaly).
- **Neck anatomy** webbed? Increased neck circumference = difficult airway management.
- **Is the patient obese?** **Obesity is associated with an increased difficulty in airway management.**
- **Does the patient have a beard?** A beard may obscure chin abnormalities.
- **Does he have facial trauma , neck surgeries, dentures**
- **Jaw movement:**
  - ◆ **Receding mandible?** Can patient sublux their lower incisor beyond upper incisor?
  - ◆ **Protruding maxillary teeth (buck teeth)**



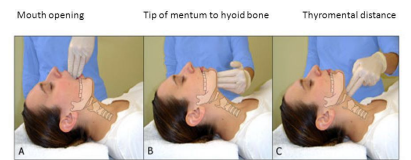
<sup>3</sup> The sequence from up down: hyoid , thyroid, cricoid

<sup>4</sup> epiglottis is important landmark in anesthesia , it is a movable leaflet like structure, once you see it it means it's safe to intubate, it covers the airway during swallowing = prevent aspiration, if aspiration happens > pneumonitis > acute respiratory distress syndrome

→ **Evaluate (3-3-2 rule)**

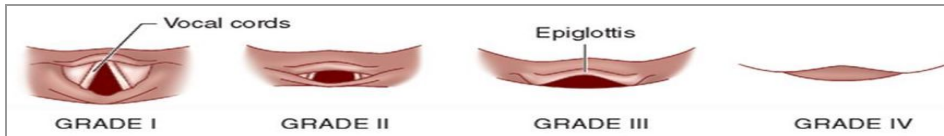
1. Interincisor distance: should fit >3 fingers (>6 cm).
2. Hyoid-mental distance: should fit >3 fingers (>6 cm).
3. Thyroid-hyoid distance: should fit >2 fingers (>4 cm)

**Assessment for Difficult Intubation:  
Evaluate: 3-3-2 Rule**



Access to airway and obtaining glottic view  
Can tongue be deflected to accommodate laryngoscope  
Predicts location larynx to base of the tongue. If larynx high angles difficult

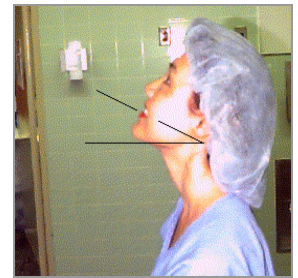
★ **Laryngoscopy:** Grade according to the **Cormack and Lehane system**<sup>5</sup>, as follows<sup>6</sup>



Where grades III and IV possess difficulty in intubation.

★ **Assess the 3 joints' movement:**

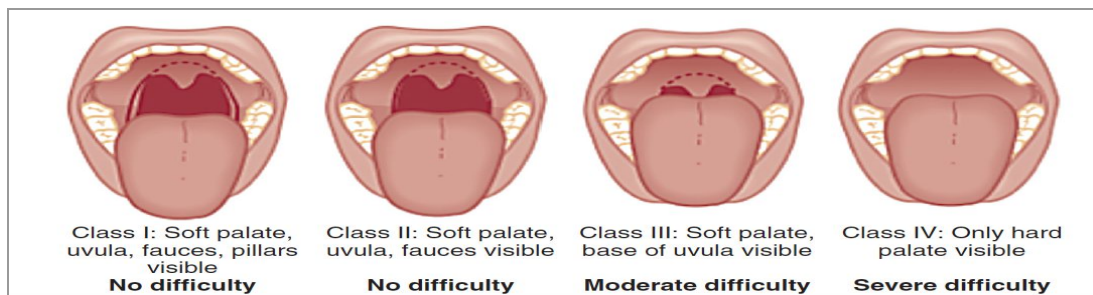
- ↪ **Atlanto Occipital joint.** Presence of a gap bet the occiput and C1 is essential (15-20 Degrees).
- ↪ **Cervical spine.**
- ↪ **Temporomandibular joint.**



→ **Mallampati Score**<sup>7 8</sup> **(OSCE)**

- In a sitting position, ask the patient to open their mouth maximally and protrude their tongue **without** saying AHH! (you need to be at the same level as the patient)
- Then you classify according to the structures visible where:
  - ↪ Class I → Hard & soft palate, tonsils and uvula.
  - ↪ Class II → Hard & soft palate, upper part of tonsils and uvula.
  - ↪ Class III → Hard & soft palate and the base of the uvula. (or Soft palate)
  - ↪ Class IV → Hard palate only.

If the patient said AHH in mallampati he will get score 1 or 2



If you found patient mallampati 3 or 4, and he's designed to undergo herniorrhaphy (lower abdominal operation) . What are you going to do next? **ask for help!** And think of giving the patient regional anesthesia instead of general anesthesia to avoid intubation<sup>9</sup>.

<sup>5</sup> if i forget to do the mallampati evaluation and the patient is lying in the OR what should I do ? Do the Cormack and Lehane system


<sup>6</sup> Grade I = vocal cords are visible, Grade II = half/anterior part is visible, Grade III = posterior part is visible

<sup>7</sup> Based on the hypothesis that when the base of the tongue is disproportionately large it will overshadow the larynx.


<sup>8</sup> But, Moderate S&S (12% false+ve), inter observer variation and Phonation increases false negative view that's **why should not say Ahhhh.**


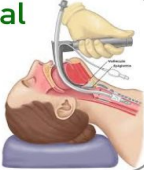
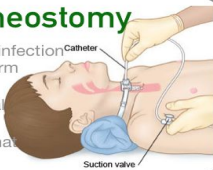


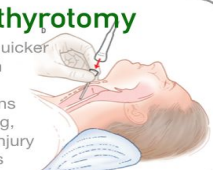

<sup>9</sup> but this is not a guarantee because the regional may fail so PLAN B is general = I have to call the expert doctor

- **Obstruction**
- Look for excessive secretions, stridor, muffled voice or masses like a goitre.
- **Neck Mobility**
- Movement restriction due to arthritis or trauma. previous surgery and short muscular neck.



# Types of Airway



Supraglottic	Infraglottic	Surgical
<p><b>1. Nasopharyngeal</b></p> <ul style="list-style-type: none"> <li>★ Tolerated at lighter anesthesia</li> <li>★ Allows suction of pharynx</li> <li>★ Major drawback: possible hemorrhage during insertion</li> </ul> 	<p><b>1. Orotracheal intubation</b></p> <ul style="list-style-type: none"> <li>★ Remains the gold standard</li> </ul> 	<p><b>1. Tracheostomy</b></p> <ul style="list-style-type: none"> <li>★ Less risk of infection</li> <li>★ Rare long term complications include tracheal stenosis and tracheoinnominate fistulas.</li> </ul> 
<p><b>2. Oropharyngeal</b></p> <ul style="list-style-type: none"> <li>★ AKA Guedel airway</li> <li>★ Prevents the tongue from closing the airway</li> <li>★ Chin to tragus distance estimates the right size</li> </ul> 	<p><b>2. Nasotracheal intubation</b></p> <ul style="list-style-type: none"> <li>★ Used in the case of intramural surgery</li> <li>★ Also used in fiberoptic intubation</li> </ul> 	<p><b>2. Cricothyrotomy</b></p> <ul style="list-style-type: none"> <li>★ Easier and quicker to perform than tracheotomy</li> <li>★ Complications include bleeding, infection, and injury to surroundings</li> </ul> 
<p><b>2. Laryngeal Mask</b></p> <ul style="list-style-type: none"> <li>★ AKA LMA airway</li> <li>★ Allows hands free maintenance anesthesia</li> <li>★ Easily inserted</li> </ul> 		

- Note that a cricothyrotomy is done at the level of the cricothyroid membrane.
- A cricothyrotomy<sup>10</sup> is an emergency procedure done to bridge to a tracheostomy or fiberoptic intubation.

## What's a difficult airway?

- Hx of difficulty (the **most important** predictor)
- Mallampati of III or IV
- Cormack Lehane of III or IV
- Thyromental distance of <6 cm
- Interincisor gap of <3 fingers
- Abnormalities in one or more of the 3 joints (TMJ, AOJ, C-Spine)

In a suspected difficult airway, you intubate while the patient is awake.

## Orotracheal Intubation:

### ★ Indications for intubation (the 5 Ps)

- **Patency of airway required**
  - ↳ Decreased level of consciousness (LOC)
  - ↳ Facial injuries
  - ↳ Laryngeal edema (e.g. burns and anaphylaxis)
- **Protecting lungs from aspiration**
  - ↳ In the absence of protective reflexes (e.g. coma or cardiac arrest)

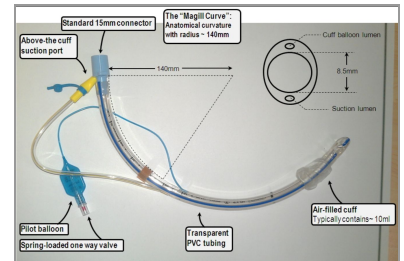
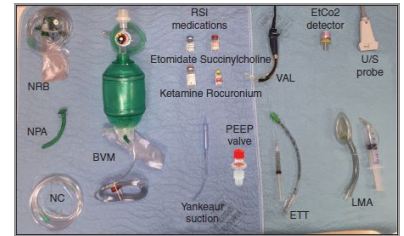
<sup>10</sup> Incise skin vertically → Feel cricothyroid membrane → Horizontal incision at lower cricothyroid membrane border → Insert tube

- **Positive pressure ventilation<sup>11</sup>**
  - ↳ Hypoventilation
  - ↳ Apnea (e.g. during general anesthesia<sup>12</sup>)
  - ↳ When using muscle relaxants
- **Pulmonary toilet (bronchoalveolar lavage)**
  - ↳ A procedure done to clear the bronchopulmonary tree from secretions
- **Pharmacology**
  - ↳ A route of administration for some drugs: **Endotracheal medication** If vascular access is unavailable, Are:
    - Bronchodilator “beta agonist- Ventolin or salbutamol” / Oxygen /aminophylline,
    - Lidocaine “local anaesthetic”
    - Epinephrine for resuscitation if there was no IV line
    - Sodium bicarb for bronchoalveolar lavage

## ★ Intubation Equipment

- **Bag and mask apparatus** (e.g. laerdal/ambu)
- **Pharyngeal airways** (oral and nasal)
- **Laryngoscope**
  - ↳ Macintosh → Curved blade (best for adults)
  - ↳ Magill/Miller<sup>13</sup> → Straight blade (best for children)
- **Trachelight:** may be used in difficult airways.
- **Fiberoptic scope:** for difficult and complicated intubations.
- **Endotracheal tube (ETT) imp**
  - ↳ **Inflatable cuff at tracheal end → Provides a seal to permit positive pressure ventilation (PPV) and prevent aspiration.**
  - ↳ Pediatric ETT → No cuff as the cricoid cartilage acts as a seal.
  - ↳ The size measures the internal diameter (IT) in millimeters (mm), 7-8 mm for adult female, 8-9 mm for adult male and for a child ( $\text{age}/4 + 4$ ) or the size of their little finger for approximation.
  - ↳ A nasotracheal tube should be 1-2 mm less in diameter and 5-10 cm longer
  - ↳ Smaller ETTs should always be available on site.
- **Malleable stylet:** inserted into the ETT for more stability and ease in changing angles, can be removed after passing the cords.
- **Lubricant and local anesthetic** (optional)
- **Magill forceps:** used in nasotracheal intubation
- **Suction:** a catheter and a pharyngeal rigid tip (yankauer)
- **Syringe:** to inflate the cuff
- **Stethoscope and capnography detector:** to verify placement of ETT
- **Tape:** to secure ETT and close eyelids.

Remember “**SOLES**” (**S**uction, **O**xygen, **L**aryngoscope, **E**TT, **S**tylet|**S**yringe”



APPROXIMATE CUFFED ENDOTRACHEAL TUBE SIZES FOR FULL-TERM INFANTS AND CHILDREN	
AGE	SIZE (INTERNAL DIAMETER mm)
0–4 months	3.0
4 months–12 months	3.5–4.0
10 months–2 years	4.0
2–3 years	4.5
3–5 years	5.0
6–10 years	5.5
10–14 years	6.0
15–18 years	6.5–7.0

<sup>11</sup> Positive pressure ventilation Vs. Negative pressure ventilation:

**PPV:** is basically forcing air into the lungs using a ventilator, done primarily for people who cannot breathe on their own (e.g. paralysed diaphragm as in the use of muscle relaxants)

**NPV:** the physiologic breathing mechanism that is happening in your lungs right now, it's basically the spontaneous entrance of air into your lungs as a result of the negative pressure created by the expanded chest from diaphragm contraction.

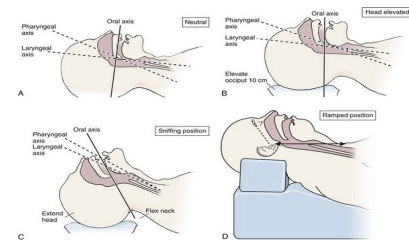
<sup>12</sup> Why do we intubate with anesthesia? Because with anesthesia, soft tissues relax and airway patency may be lost especially in the absence of protective reflexes (e.g. cough reflex)

<sup>13</sup> Also If the Pt has enlarged epiglottis

## ★ Positioning

Elevate the patient's head 10 cm to align the pharyngeal and laryngeal axes, then flex their neck and extend their head to align the oral axis along, this is called the “**sniffing position**”<sup>14</sup>.

## ★ Confirmation of ETT placement mainly by the 2 highlighted methods the other are adjuvant.



→ Direct:<sup>15</sup> visualization of tube placement through the cords by laryngoscopy.

→ Indirect: one measure is not enough

1. Continuous tracing of capnography normally it is 35-45 mmHg. More than 45 mmHg means that the patient is hypoventilating (hypercapnia). Less than 35 mmHg means that the patient is hyperventilating (hypocapnia).
2. Auscultation in 5 areas for equal breath sounds (to exclude endobronchial intubation) and the absence of breath sounds (if it was placed in the esophagus) :  
Right and left infraclavicular, right and left axillary (5th intercostal space), epigastrium.
3. Chest movement and no abdominal distention.
4. Feeling lung compliance while bagging the patient.
5. Condensation of water vapor in the tube.
6. Refilling of reservoir bag during exhalation.
7. For 100% confirmation we can do:
  - AP CXR: seeing the tip of ETT at the midpoint of thoracic inlet and carina.
  - Fiberoptic bronchoscopy (enter the bronchial tree)

After confirming the tube position we have to confirm the level to avoid endobronchial intubation of one side of the lung (usually the right side) then secure the airway.

→ When to suspect esophageal intubation?

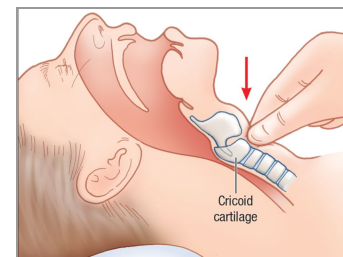
- Capnography shows end tidal CO<sub>2</sub> of zero or near zero. (may be placed in the esophagus?)
- Abnormal sounds during assisted ventilation.
- Impairment of chest excursion.
- Hypoxia or cyanosis.
- Presence of gastric contents in ETT.
- Epigastric distention with ventilation.

## ★ Rapid Sequence Induction: mostly performed in the ER

→ How is RSI performed?

Classic" RSI involves pre-filling the patient's lungs with a **high concentration of oxygen gas**, followed by applying **cricoid pressure (Sellick's manoeuvre)**<sup>16</sup>, administering rapid-onset sedative or hypnotic and neuromuscular-blocking drugs (succinylcholine) that induce prompt unconsciousness and paralysis, inserting an endotracheal tube with minimal delay, and then releasing the cricoid pressure.

- Modified rapid sequence induction is different from rapid sequence induction by the using of muscle relaxant rocuronium instead of sux.



<sup>14</sup> optimum/best position. Except for morbidly obese or female, it is hard

<sup>15</sup> assured sign

<sup>16</sup> Allow potency in the trachea & Compress oesophagus to prevent aspiration

→ Indications:

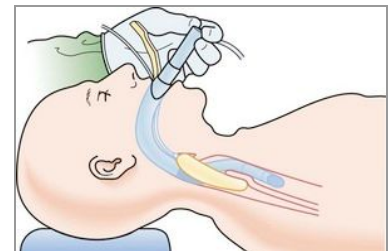
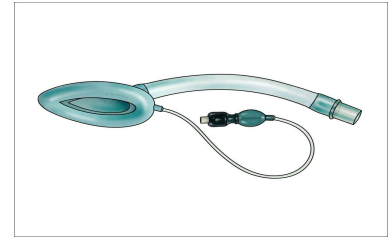
Used in situations where aspiration/regurgitation is a risk such as:

- Emergency operations or trauma including acute abdomen (patient hasn't fasted)
- Bowel obstruction.
- Reflux disease, hiatus hernia.
- Obesity
- Pregnancy
- Recent meal <6 hr. Preop

Intubation Type	Depth of insertion (cm) at lips or nares	
	Neonate	Child
Oral	Weight in kg + 6	Age in years/2 + 12
Nasal	Weight in kg + 7	Age in years/2 + 15

## Laryngeal Mask Airway (LMA)

- A reusable device that can be used as an alternative to both mask ventilation and endotracheal intubation in appropriate patients.
- Useful in managing a difficult airway.
- When appropriately placed, the LMA tip rests over the upper esophageal sphincter, cuff sides lie over the pyriform fossae and the cuff's upper border rests against the base of the tongue. Such positioning allows for effective ventilation with minimal inflation of the stomach.



LMA SIZES FOR CHILDREN		
LMA SIZE	APPROPRIATE WEIGHT (kg)	CUFF VOLUME (mL)
1	<5	2-5
1.5	5-10	3-8
2	10-20	5-10
2.5	20-30	10-15
3	30-50	15-20
4	50-70	25-30

### ★ Indications

- As an alternative to mask ventilation or ETT. The LMA is not a replacement for ETT when ETT is indicated.
- In the management of a known or unexpected difficult airway.
- During the resuscitation of an unconscious patient.
- In the case of surgeries done on the face (e.g. eye surgery) why?  
Because clumsy surgeons tend to place their hands on patients' noses or mouths, manipulating the position of the ETT.

### ★ Complications of Intubation

Mechanical:

- Dental damage (chipped teeth)
- Lacerations (lips, gums, tongue, pharynx, esophagus)
- Laryngeal trauma
- Esophageal or endobronchial intubation

Systemic:

- Activation of sympathetic nervous system (HTN, tachycardia, dysrhythmias) since tube touching the cords is stressful. **With multiple reintubation**
- Bronchospasm **in asthmatics**. **One of the most common**

## Needle cricothyroidotomy:

It is an emergency procedure done to bridge for a fixed tracheostomy or fiber-optic intubation .

To summarise before extubation:

Pt is fully awake

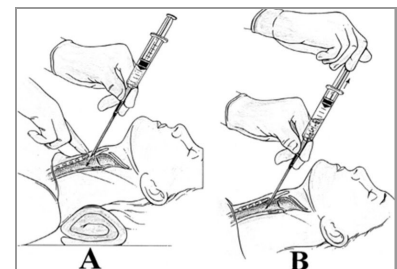
good Oxygen saturation

Tidal volume "5-7ml/Kg"

RR "<20/min"

Pain free

End tidal CO2 monitoring





## Extubation:

### ★ Guidelines to extubation:

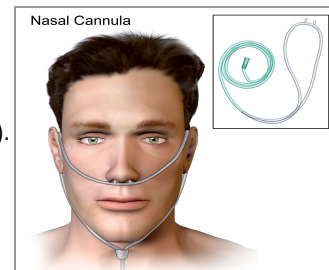
- Normal neuromuscular function and hemodynamic status.
- Patient must be breathing spontaneously with adequate RR and tidal volume.
- Allow the patient to breathe 100% O<sub>2</sub> for 3-5 minutes.
- Suction secretions from pharynx.
- Deflate cuff, remove ETT on inspiration (when vocal cords are abducted).
- Ensure adequate breathing after extubation.
- Apply face mask for O<sub>2</sub> delivery.
- Position the patient during transfer to recovery room in sniffing position or side lying.

### ★ Complications discovered at extubation:

Early	Late
<ul style="list-style-type: none"> <li>• Aspiration.</li> <li>• Laryngospasm</li> </ul>	<ul style="list-style-type: none"> <li>• Transient vocal cord incompetence.</li> <li>• Glottic/subglottic edema. Characterized by a stridor</li> <li>• Pharyngitis/tracheitis.</li> <li>• Damage to the neuromuscular pathway (CNS, PNS and respiratory muscular function) therefore no spontaneous ventilation occurs post extubation.</li> </ul>

### ★ Recommendations

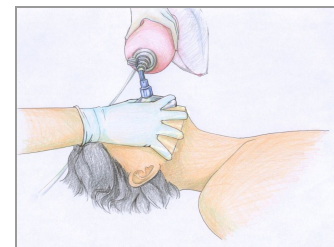
- Adequate airway assessment to pick up expected DA (difficult airway) to be secured awake
- Difficult intubation cart always ready.
- Pre oxygenation as a routine (to give long period with apnea without hypoxia especially pediatric).
- Maintenance of oxygenation not the intubation should be your aim.
- Use the technique you are familiar with.
- Always have plan B,C,D in unexpected difficult airway.



## Types of oxygen delivery systems (from 433)

### ★ Nasal cannula

- Inspired oxygen concentration is dependent on the O<sub>2</sub> flow rate, the nasopharyngeal volume and the patient's inspiratory flow rate.
- Increases inspired oxygen concentration by 3- 4%.
- Oxygen flow rates greater than 3 liters are poorly tolerated by patients due to drying and crusting of the nasal mucosa.
- In Recovery Room Or In The Ward After Extubation



### ★ Face masks: Holding the mask in C-E maneuver →

#### 1. Open facemasks

- Are the most simple of the designs available.
- They do not provide good control over the oxygen concentration being delivered to the patient causing variability in oxygen treatment
- A 6 L/min flow rate is the minimum necessary to prevent the possibility of rebreathing.
- Maximum inspired oxygen concentration ~ 50-60%.



## 2. Venturi facemasks

- They should be used in patients with COPD/emphysema where accurate oxygen therapy is needed.
- Arterial blood gases can then be drawn so correlation between oxygen therapy for hypoxemia and potential risk of CO<sub>2</sub> retention can be made.
- Masks are available for delivering 24%, 28%, 35%, 40%, 50%

## 3. Non rebreathing facemasks

- Have an attached reservoir bag and one- way valves on the sides of the facemask.
- With flow rates of 10 liters an oxygen concentration of 95% can be achieved.
- These masks provide the **highest** inspired oxygen concentration for non-intubated patients.
- If not responding we will go for CPAP or re-intubation.

### Extra (mentioned by the doctor):

- Pregnant women are at increased risk of regurgitation. The risk during general anesthesia for cesarean section is approximately 5 times higher than in the general surgical population.
- In the peripartum period there is a chance of requiring general anesthesia and therefore a risk of pulmonary aspiration and chemical pneumonitis (**mendelson's syndrome**).
- Acute respiratory distress syndrome most common in pregnant that's why Now it is recommended that all pregnant ladies undergoing cesarean section receive regional or neuraxial anaesthesia.

**Q1: Which one of the following is the most sensitive to confirm the position of the ETT?**

- A. Chest x-ray
- B. Continuous tracing of capnography
- C. Use of esophageal detector device
- D. Presence of mist in the tube

**Q2: Which one of the following is the indication of cricoid pressure?**

- A. To prevent vomiting
- B. To improve viewing of the glottis
- C. To increase tone of the lower esophageal sphincter
- D. To prevent aspiration of gastric contents

**Q3: What is the thyromental distance indicating an easy intubation?**

- A. 3 cm
- B. 4 cm
- C. 5 cm
- D. 7 cm

**Q4: A 25 year old patient morbidly obese booked for laparoscopic sleeve gastrectomy under GA, mouth opening showed soft palate and hard palate. Which one of the following is the mallampati's classification for this patient?**

- A. I
- B. II
- C. III
- D. IV

**Q5: Which one of the following is the indication of using capnography?**

- A. Ventilator disconnection
- B. Oxygen consumption
- C. Depth of anesthesia
- D. Temperature

**Q6: Which one of the following devices can deliver 100% oxygen?**

- A. Face mask
- B. Nasal cannula
- C. Venturi mask
- D. Ambu bag

Q1: B | Q2: D | Q3: D | Q4: C | Q5: A | Q6: D |