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Short Textbook of Anesthesia

As per the Competency Based Medical Education Curriculum (NMC)

Ajay Yadav

7th Edition

JAYPEE

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CHAPTER 3

Equipment

EQUIPMENT FOR AIRWAY MANAGEMENT

AIRWAYS

The aim of airway is *to prevent the tongue fall.* Most commonly used is *Guedel airway* **(Fig. 3.1)**. The tip, inserted between tongue and posterior pharyngeal wall prevents tongue falling back on posterior pharyngeal wall, and thus maintaining the patency of airway. Airways are available in many sizes. The appropriate length is the distance between tip of nose and tragus plus 1 cm or from angle of mouth to angle of jaw.

Nasal airways are also available which are inserted through nostril.

FACEMASKS (FIG. 3.2)

Facemask is used to ventilate the patient without intubation. They are available in sizes from 0 (smallest) to 6 (largest). Facemask should be made of antistatic rubber. At the bottom of mask, there is air-filled cuff which has soft cushioning effect.



Fig. 3.1: Guedel's oropharyngeal airway. *(For color version, see Plate 1)*



Fig. 3.2: Facemask. *(For color version, see Plate 1)*

As the plastic masks are transparent allowing visualization of cyanosis and secretions, they are preferred over rubber masks.

The technique to hold mask often referred as CE technique involves thumb and index finger holding the mask over face (forming inverted C) while other 3 fingers (forming E) is used to lift the mandible **(Fig. 3.3)**.

As mask ventilation carries many disadvantages, it can be used only as a tide over phase till definite airway (intubation) is accomplished. The *disadvantages* of mask ventilation are:

- Dead space volume is increased
- Mask holding requires some expertise.
- Ventilation with mask is tiring

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Fig. 3.3: Mask holding technique.

- A significant amount of air leaks into esophagus and can easily increase the intragastric pressure significant enough (>28 cm H_2O) to cause *aspiration.*

AMBU BAG RESUSCITATOR (FIGS. 3.4 AND 3.5)

AMBU stands for artificial manual breathing unit. It is used to ventilate the patient. The AMBU unit consists of one self-inflating bag made up of rubber or silicone, a non-rebreathing valve and a mask. Non-breathing valve closes the expiratory port when the bag is manually squeezed letting the air inside the bag to pass to facemask. During expiration, bobbin of valve comes to normal position letting the expired air to void to atmosphere.

- AMBU bags are available in a capacity of 1,200 mL for adults, 500 mL for children and 250 mL for newborns.
- 100% oxygen can be delivered by AMBU bag by attaching oxygen source and oxygen reservoir.



Fig. 3.4: Components of AMBU bag.



Fig. 3.5: AMBU bag (Note there is an option for attaching reservoir bag and oxygen supply). *(For color version, see Plate 2)*

LARYNGOSCOPES (FIGS. 3.5 TO 3.10)

Laryngoscope is used for visualizing the glottis to facilitate intubation. Laryngoscopy may be direct where glottis is directly visualized or indirect where glottis is visualized through optic channels. Based on method of laryngoscopy, laryngoscopes has been classified as: (1) Direct rigid laryngoscopes; (2) Indirect (fiberoptic) rigid laryngoscopes; (3) Flexible (fiberoptic) laryngoscopes.

Direct Rigid Laryngoscopes

Direct rigid laryngoscope consists of a handle (containing 2 batteries), a blade with a bulb. They are named on the shape of the blade. Although there are number of laryngoscopes available in the market, however, the most common in use are:

- **Macintosh (Fig. 3.6):** *It is most commonly used.* It has *curved blade* and is available in 4 sizes; smallest for children and largest for adults with long necks. It is the preferred blade for adults however can be used in pediatric patients also.
- **McCoy:** It has got a movable tip, which can be used to maneuver the glottis **(Fig. 3.7)**.

Blades for Pediatric Patients

Miller: It has a straight blade with little curve at the tip **(Fig. 3.8)**.

As epiglottis in children is large, leafy and more anterior, therefore it need to be lifted

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Fig. 3.6: Macintosh laryngoscope.
(For color version, see Plate 2)



Fig. 3.7: McCoy laryngoscope.
(For color version, see Plate 2)



Fig. 3.8: Miller blade.

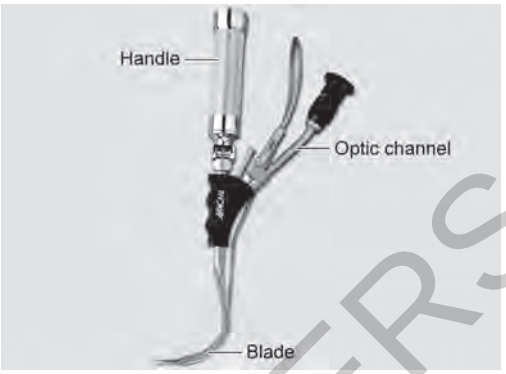


Fig. 3.9: Bullard laryngoscope.
(For color version, see Plate 2)

by straight blade to visualize glottis (Adult's epiglottis just need to be pushed anteriorly, therefore curved blade is used). That's why Miller is the preferred blade for pediatric patients of all age groups including a newborn or neonate. It is the preferred blade for children however can be used in adults also.

Indirect Rigid Laryngoscopes (Fiberoptic)

In this technique, the glottis is not visualized directly but through the fiberoptic channels. The classical example of such laryngoscope is *Bullard laryngoscope* **(Fig. 3.9)**. WuScope is another commonly used indirect laryngoscope, which has a channel for guiding endotracheal tube.

Video Laryngoscopes (Fig. 3.10)

Video laryngoscopes (VLs) are just one step ahead, where the video of the real time refracted image of glottis is obtained on a screen. Some of the video laryngoscopes have the option to obtain the image on any laptop or smart phone screen.

Studies have reported intubation success rates of 94–99% for video laryngoscopy as a rescue modality after failed direct laryngoscopy.

Although like direct laryngoscopes, video laryngoscopes are also available in different shapes of blades such as highly curved or distally angulated, however, the *most commonly used and prototype is C-MAC* the design of which is based on the Macintosh blade **(Fig. 3.10)**.

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Fig. 3.10: C-MAC laryngoscope and picture of glottis seen on screen. *(For color version, see Plate 2)*

Flexible Laryngoscopes/Bronchoscopes (Fiberoptic) (Fig. 3.11)

Intubation done under the guidance of fiberoptic laryngoscope/bronchoscope is called as flexible scope intubation (FSI). It is considered as *gold standard technique for the management of difficult/failed intubation.* It is less traumatic, does not require any specific position of neck and can be performed in awake patients. The limitations are cost, technical expertise and time consuming.

Complications of Laryngoscopy

- **Dental injury:** *Most vulnerable are upper incisors.*
- Damage to soft tissues and nerves.
- Injury to cervical spinal cord in case of aggressive manipulation of pre-existing injury.



Fig. 3.11: Flexible fiberoptic laryngoscope.

- **Hemodynamic alterations:** Tachycardia, hypertension and cardiac arrhythmias.
- Breakage and aspiration of bulb.

SUPRAGLOTTIC AIRWAY DEVICES

As the name suggests these devices are placed above glottis for airway management. These devices serve as a niche between facemask and endotracheal tubes. They are so commonly used in current day practice that we can say that it is an era of supraglottic devices. The most popular and most commonly used supraglottic device used is laryngeal mask airway.

Laryngeal Mask Airways

Laryngeal mask airways (LMA) has been classified as 1st generation and 2nd generation LMA.

First Generation LMA

Classical LMA: Discovered by Archie Brain, therefore also called as *Brain Mask*. It is placed blindly in oropharynx and the cuff is inflated with large volume of air (30 to 40 mL for adult size) **(Fig. 3.12)**. Inflated cuff seals the lateral and posterior pharyngeal walls, and patient can be ventilated through ventilation ports.

LMA are available in 7 different sizes (in some countries 8th size is also available)—the smallest one for neonate and largest for large adults.

Size	*Indication (is on basis of weight)*	*Cuff volume*
1	Up to 5 kg	4 mL
1.5	5–10 kg	7 mL
2	10–20 kg	10 mL
2.5	20–30 kg	14 mL
3	30–50 kg	20 mL
4	50–70 kg	30 mL
5	> 70 kg (or 70–100 kg)	40 mL
6 (only available in few countries)	> 100 kg	50 mL

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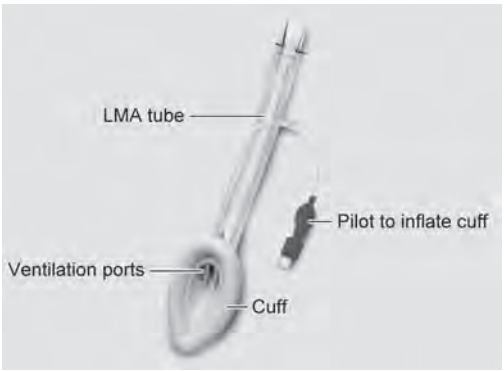


Fig. 3.12: Laryngeal mask airway (classic).
(For color version, see Plate 2)

Indications
- As an alternative to intubation where difficult intubation is anticipated.
- Securing airway in emergency situations where intubation and mask ventilation becomes impossible.
- As an elective method for minor-to-moderate surgeries where anesthetist electively wants to avoid intubation.
- As a conduit for bronchoscopes, small size tubes and gum elastic bougies.

Advantages
- Easy to insert (even paramedical staff can insert).
- Does not require any laryngoscope and muscle relaxants.
- Does not require any specific position of cervical spine, therefore can be used in cervical injuries.
- Less sympathetic stimulation as compared to intubation.
- Complications of intubation can be avoided.
- Patient awakening is smooth as compared to intubation.
- Reusable (up to 40 times)

Disadvantages/Complications
- As air can leak into the esophagus, *LMA increases the risk of aspiration.*
- Can cause *laryngospasm* and airway obstruction, if displaces anteriorly.
- Trauma to oral cavity and injury to hypoglossal and lingual nerve, if excessive pressures are being used. The cuff pressure for LMA should be kept between 40–60 cm H_2O.
- Sore throat—incidence is 10–20%.

Contraindications
- Full stomach patients.
- Hiatus hernia, pregnancy (where chances of aspiration are high).
- Oropharyngeal abscess or mass.

LMA unique: It is single use disposable LMA.

LMA flexible: The tube of LMA is enforced with a wire making it flexible, i.e., nonkinkable making it useful for head and neck surgeries.

Second Generation LMA

The major disadvantage of 1st generation LMA is aspiration, Moreover, if there occurs gastric distension due to leakage of air in esophagus, it is not possible to decompress the stomach as there is no place to pass suction catheter/Ryles tubes because of the occupation of oropharynx by the cuff of LMA.

Second generation LMA solves this problem because they have an extratubing for stomach decompression. Moreover, better seal *thereby decreasing the chances of aspiration.*

Although there are many types of second generation available, the common one in use are:
- **Proseal LMA:** It can be considered as prototype of second generation LMA. It has larger cuff plus there is additional posterior cuff, which provides better seal. The separate drain tube can be used to deflate the stomach **(Fig. 3.13)**.
- **Supreme LMA:** Supreme LMA is like Proseal with a bite block to avoid damage to LMA tube, if the patient bites **(Fig. 3.14)**.
- **LMA C-Trach:** Like video laryngoscopy, the LMA is attached to a video screen to visualize the structures **(Fig. 3.15)**.
- **Intubating LMA (also called as LMA Fastrach):** Up to 8 no. endotracheal tube can be guided through it **(Fig. 3.16)**.

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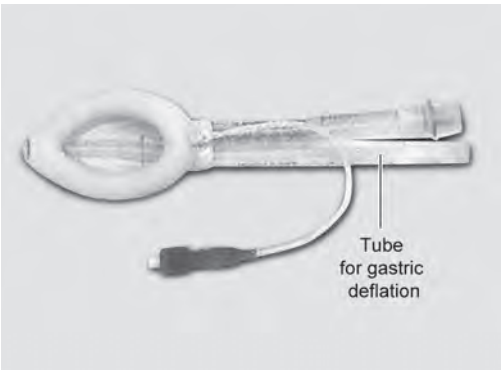


Fig. 3.13: Proseal LMA.

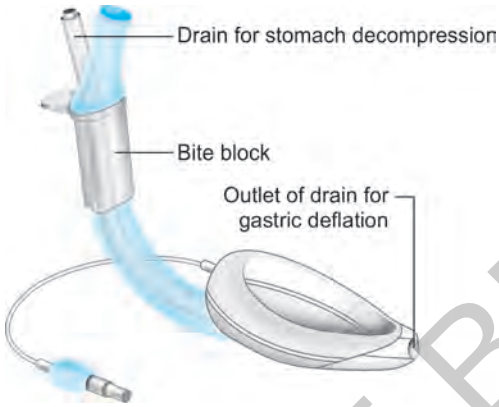


Fig. 3.14: LMA supreme.



Fig. 3.15: LMA C-Trach.
(For color version, see Plate 3)

Laryngeal Masks

They are exactly same like second generation LMA however due to copy right of brand they are classified under a separate category of Laryngeal masks. Again many types of



Fig. 3.16: Intubating LMA (note a single port which allows the passage of endotracheal tube).

laryngeal masks are available in market however the most commonly used are:

- **I-gel:** I gel can be considered as prototype of cuffless laryngeal masks. As the name suggests the cuff is prefilled with gel avoiding the complications of air-filled cuff such as cuff leakage, damage and puncture. Like Proseal, I-gel also contains a drain tube, which can be used to deflate the stomach **(Fig. 3.17)**. I-gel is very commonly used in India.
- **Baska:** Baska (after the name of place in eastern Europe) is another type of cuffless laryngeal mask used in practice **(Fig. 3.18)**

Other Supraglottic Devices

The success of LMA has led to manufacturing of number of similar devices but none could



Fig. 3.17: I-gel. *(For color version, see Plate 3)*

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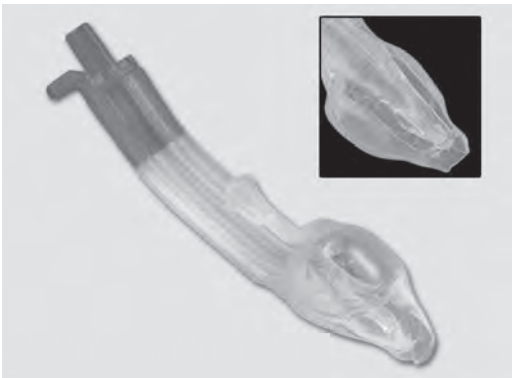


Fig. 3.18: Baska.

replace LMA. Out of >10 kind of supraglottic devices, few which are used are:

- **Peripharyngeal airway (Cobra-PLMA) (Fig. 3.19):** It has high volume oval cuff, which seals the hypopharynx while patient can be ventilated through the ventilation slots present in distal.
- **Combitube (Fig. 3.20):** It is double lumen tube used for providing patent airway in emergency and difficult intubation. It was popular in past but due to high rate of complications, it is hardy used nowaday



Fig. 3.19: Peripharyngeal airway.



Fig. 3.20: Combitube.

INFRAGLOTTIC AIRWAY DEVICES

As the name suggests, they are placed below the glottis. These devices are further classified as definitive and emergency airway management devices. *Definitive airway management devices include endotracheal tube and tracheostomy,* while infraglottic emergency airway includes cricothyroidotomy.

Definitive Airway Management Devices

Endotracheal Tubes

Endotracheal tubes have two ends, proximal end (machine end) and distal end (patient end). Patient end is beveled with angle of 45° in oral tubes and 30° in nasal tubes. They are mainly of two types, red rubber and PVC **(Table 3.1)**.

The endotracheal tubes may be uncuffed or cuffed **(Figs. 3.21A and B)**.

Technique of Intubation

The patient should lie supine. *There should be extension at atlanto-occipital joint and flexion at cervical spine* **(Fig. 3.22)**. This position is also called as morning sniffing position and achieved by putting a 6 to 8 cm thick pillow under the occiput. The laryngoscope blade should be inserted from right side of mouth and advanced slowly displacing the tongue to left until epiglottis is visualized. Once the epiglottis is visualized the tip of blade should move forward to be positioned in vallecula. Once the tip is in vallecula, a forward (anterior) force at 45° is applied. This anterior force will lead to indirectly lifting of epiglottis by tensing the hypoepiglottic ligament.

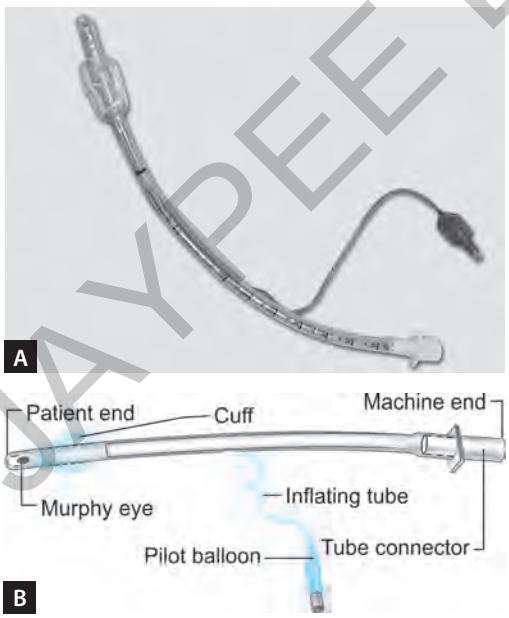
This force should be applied by using arm (not by radial flexion of the wrist). Wrist flexion will lead to lifting the tip of blade taking leverage from handle which not only causes the injury to incisors but will also deteriorate the view.

If the straight blade (Miller) is used then the tip should be positioned in the midline of posterior surface of epiglottis and epiglottis is lifted directly to visualize the glottis.

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TABLE 3.1: Comparison of red rubber and PVC endotracheal tubes.

Red rubber	*PVC*
Costlier	Cheap
Reusable (can be autoclaved up to 6 times without damage)	Disposable
Cuff: High pressure and low volume. Because of this high pressure cuff chances of tracheal injury is more	*Cuff: Low pressure and high volume.* Because of the low pressure, these tubes produce less tracheal injury
Radiolucent	Contains a radiopaque line therefore can be visualized in X-ray
Nontransparent	Transparent therefore secretions and mist can be visualized
No Murphy eye is present	Contains an additional hole near the tip called as Murphy's eye so that if main lumen gets stuck to the tracheal wall, patient can still be ventilated through Murphy's eye
Slightly more rigid so does not conform to the anatomy of airways	Easily conforms to the anatomy of airways
Less incidence of sore throat	High incidence of sore throat (because of large cuff)
It contains preservative lead (which imparts red color to these tubes)	—



Figs. 3.21A and B: Cuffed endotracheal tube (PVC type). *(For color version, see Plate 3)*



Fig. 3.22: Position for laryngoscopy (extension at atlanto-occipital joint and flexion at cervical spine).

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Only after visualizing the vocal cords the endotracheal tube should be passed between the cords.

The cuff is inflated and the cuff should be 2–3 cm below the vocal cords in adults. *The position of tube is verified by capnography* and *auscultation* over chest for air entry. The tube should be well secured at the angle of mouth with adhesive tape or bandage.

Cuff

The aim of inflating the cuff is to prevent aspiration. Usually, 4–8 mL of air is required to fill the cuff. During cuff inflation, ensure cuff pressure remains between 15–25 mm Hg. Pressure > 25 mm Hg increases the risk of tracheal ischemia while pressure <15 mm Hg increases the risk of aspiration.

Cuff should be filled with saline (instead of air) when tube is used for laser surgeries, surgeries at mines and when hyperbaric oxygen is used. The cuff should be *2–2.5 cm below the vocal cords.*

The traditional approach of not using cuffed tubes in children up to 10 years does not hold true in present day practice (for details see Chapter 29, page 261).

Endotracheal Tube and Dead Space

As the endotracheal tube by passes the dead space constituted by nasal pathways, reducing the *anatomical dead space by almost 50% (70 mL).*

Deciding the Size of Endotracheal Tube

For a normal healthy male usually 8 number (means internal diameter 8.5 mm) tube is used, while for normal healthy female usually 7.5 number tube is used. In children, the size of endotracheal tube is as follows:

- Prematures : 2.5 no.
- 0–6 months : 3–3.5 no.
- 6 months to 1 year : 3.5–4 no.
- For children 1 year to 14 years, the size is calculated by formula:

$$\frac{\text{Age (in years)}}{4} + 4.5$$

For example, for a 5-year-old child, the tube size required will be:

5/4 + 4.5 = 1.25 + 4.5 = 5.75 (means 5.5 number tube).

Smallest size of tube available is 2.5 mm and the largest is 10.5 mm.

Deciding the Length of Tube

Optimal length is the length at which air entry is equal on both sides of the chest which means that tube has not gone far into bronchus. Usually, the length is 23 cm in adult males and 21 cm in adult females.

In children, the length of oral tube is calculated by formula:

$$\frac{\text{Age (in years)}}{2} + 12 \text{ cm}$$

For calculating length for nasal intubation 3 cm is added to oral length.

Example: For 5-year-old child length will be: 5

$$= \frac{5}{2} + 12$$

$$= 2.5 + 12 \text{ cm}$$

$$= 14.5 \text{ cm.}$$

Reflex Response to Laryngoscopy and Intubation

- During laryngoscopy, there occurs sympathetic stimulation which can cause tachyarrhythmia and hypertension.
- Intubation can precipitate laryngospasm, particularly if airways are hyper-reactive or patient is in light anesthesia.
- **Methods which can be used to blunt these responses are:** Adequate depth of anesthesia, opioids, intravenous/topical lignocaine, β-blockers (esmolol)/calcium-channel blockers.

Other Types of Tubes in Common Use

RAE preformed tubes (RAE after the name of 3 scientists—Ring, Adair and Elwyn). Due to the angulations, these tubes can be used for oral surgeries. Two type of RAE tubes used are:

1. **South facing (Fig. 3.23):** Used for upper lip, palate and upper dental surgery.

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2. **North facing (Fig. 3.24):** Used for lower lip, tongue or lower dental surgery.

Spiral embedded (Fig. 3.25): Presence of metallic wire in the lumen of tube (and that's why also called as flexometallic tube) make them *nonkinkable, noncollapsible,* and therefore are very useful for *head and neck surgeries where acute flexion/extension of neck is required.*



Fig. 3.23: South facing RAE tube.



Fig. 3.24: North facing RAE tube.



Fig. 3.25: Flexometallic tube.

Microlaryngeal and laryngotracheal surgery tube (MLT, LTS tubes): Used for Microlaryngeal surgeries (these are small size tubes with cuff).

Double Lumen Tubes (Fig. 3.26)

Double lumen tubes (DLT) are used when one lung ventilation/lung separation is required. They have two lumens, tracheal lumen and bronchial lumen. Based on bronchial lumen, they are named right sided (means bronchial lumen in right bronchus) or left-sided (means bronchial lumen in the left bronchus).

Indications for One Lung Ventilation/ Lung Separation

Absolute: (1) To prevent spillage of contents of one lung (like pus, blood) to other side; (2) Unilateral lavage to prevent spillage of lavage fluid to healthy lung; (3) Massive bronchopleural fistula or large cyst/bulla where positive pressure ventilation can cause pneumothorax.

Relative: Any surgery on the lung (or thoracic aorta or esophagus) is considered as relative.

Complications of Double Lumen Tubes

- **Hypoxia:** *The most common cause of hypoxia is ventilation perfusion mismatch* (nonventilated lung behaves like shunt).



Fig. 3.26: Double lumen tube (Note 2 cuffs, 2 pilot system and 2 ventilation ports). *(For color version, see Plate 3)*

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Malposition of tube (bronchial lumen in wrong bronchus) used to be the most common cause of hypoxia however the *confirmation of position of Double lumen tube by bronchoscopy* has significantly reduced the incidence of malposition.
- **Trauma to larynx.**
- **Bronchial rupture:** Due to over inflation of cuff in bronchus.

NASAL INTUBATION

Indications for Nasal Intubation

- Oral surgery however due to availability of special oral tubes (RAE preformed tubes) nasal intubation is hardly done for oral surgeries in modern day practice.
- Oral mass
- Inadequate mouth opening due to any cause like fracture mandible, temporomandibular joint ankylosis, Ludwig angina, quinsy, tetanus, postburn contractures.
- For awake intubation, nasal intubation is preferred over oral intubation.
- When tube is to be kept for prolonged periods in intensive care units (ICU) and patient is going to remain awake most of the time nasal tube is preferred because it is better tolerated by patient. However, this approach is almost obsolete in modern day practice.

Advantages of Nasal Intubation Over Oral Intubation

- Better fixation and therefore less chances of accidental extubation.
- No possibility of tube occlusion by biting.
- Oral hygiene can be better maintained.
- Better tolerated by the patient.

Disadvantages

- Increased chances of bleeding and trauma to nasal structures (to avoid trauma to inferior turbinate bevel of the tube should be towards the septum).
- Increased chances of bacteremia (sinusitis, otitis, meningitis).
- Nasal deformities on long-term use.

Contraindications for Nasal Intubation

- Basal skull fractures and CSF rhinorrhea (there have been case reports of tube slipping into cranium and also CSF leak into nose can cause meningitis).
- Bleeding disorders (nasal and septal mucosa are highly vascular areas).
- Nasal polyp, abscess, foreign body.
- Adenoids
- Previous nasal surgery (relative contraindication).

Contraindications for Both Nasal and Oral Intubation

As such, there is no absolute contraindication to intubation. The very simple rule is "intubate where you can", therefore the relative contraindications are:
- Laryngeal edema—may get aggravated by intubation
- Acute epiglottitis and laryngotracheobronchitis—As airways are hyper-reactive, intubation can precipitate laryngospasm.

Checking for Correct Position of Tube

- Auscultation of chest for air entry.
- Characteristic feel of bag.
- Chest inflation on positive pressure.
- **Capnography (measuring end tidal CO_2):** It is the *surest sign.*
- **Fiberoptic bronchoscopy:** It is also confirmatory but practically not feasible in every case.

Complications of Intubation

Perioperative

- **Esophageal intubation:** This is a hazardous complication. If not detected in time can cause severe hypoxia and death.
- Ischemia, edema and necrosis at local site (especially with red rubber tubes).
- Aspiration (if cuff is not properly inflated).
- Bronchial intubation and collapse of other lung.
- Tracheal tube obstruction by secretions, kinking. If not detected in time can cause hypoxia.

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- Accidental extubation.
- Trauma to gums, lip, epiglottis, pharynx, larynx and nasal cavity (in nasal intubation).
- Reflex disturbances such as laryngospasm, bronchospasm, tachyarrhythmia and hypertension

Postoperative

- **Sore throat (pharyngitis, laryngitis):** This is the *most common postoperative complication.* It usually subsides in 2–3 days without any treatment.
- Laryngeal edema (usually present after 1 to 2 hours).
- Laryngeal nerve palsies.
- Surgical emphysema, mediastinal emphysema.
- **Infection:** Pneumonia, lung abscess, mediastinitis.
- Lung atelectasis.

Delayed Complications

- Vocal cord granuloma.
- Laryngotracheal web.
- Subglottic or tracheal stenosis.
- Tracheal collapse.

Delayed complications usually occurs after prolonged intubation in intensive care patients. Therefore, *maximum permissible time for which an endotracheal tube can be kept is 14 days.*

Extubation

Extubation is performed when adequacy of respiration is maintained. *Extubation should be performed during inspiration* (when the laryngeal opening is maximum).

Complications at the Time of Extubation

- Aspiration.
- Laryngospasm and bronchospasm.
- Trauma to airways.
- Hypoxia (If extubation is premature).



Fig. 3.27: Percutaneous tracheostomy set.

Tracheostomy (Fig. 3.27)

Tracheostomy can done surgically or percutaneously through special sets.

Indications

- As an elective procedure where prolonged ventilation is required.
- As a switch over procedure from intubation.
- Excessive secretions leading to blockage or frequent change of endotracheal tube.
- As an alternative when intubation is not possible.
- Upper airways obstruction due to laryngeal edema, impacted foreign bodies, laryngeal trauma, Vocal cord paralysis, Ludwig angina, quinsy, laryngitis.
- For laryngeal surgeries.

Tracheostomy Tubes

- **Silver tubes:** Not used nowadays.
- **Cuffed plastic tubes:** These are most commonly used. Cuffs should be *high volume, low pressure*
- **Montgomery T-tube or olympic tracheal button:** These devices have no cuff, so they produce less tracheal injury and allow air to pass through mouth for speech.
- Fenestrated tubes for speaking.

Complications

Early Complications

- Malpositioning of the tube during insertion.
- Hemorrhage.

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