Tracheal tubes

Tracheal tubes provide a means of securing the patient's airway. These disposable plastic tubes are made of polyvinyl chloride (PVC) which could be clear, ivory or siliconized. As plastic is not radio-opaque, tracheal tubes have a radio-opaque line running along their length, which enables their position to be determined on chest X-rays. The siliconized PVC aids the passage of suction catheters through the tube. In the past, tracheal tubes used to be made of rubber allowing them to be reused after cleaning and autoclaving.

1. The **Size** of a tracheal tube refers to its **internal diameter** which is marked on the outside of the tube in millimetres. Narrower tubes increase the resistance to gas flow, therefore the largest possible internal diameter should be used. This is especially important during spontaneous ventilation where the patient's own respiratory effort must overcome the tube's resistance. Usually, a size 8.5–9-mm internal diameter tube is selected for an average size adult male and a size 7.5–8-mm internal diameter tube for an average size adult female. Paediatric sizes are determined on the basis of age and weight. Tracheal tubes have both internal diameter (ID) and outside diameter (OD) markings.

2. The **length** (taken from the tip of the tube) is marked in centimetres on the outside of the tube. The tube can be cut down to size to suit the individual patient. Black intubation depth markers located 3 cm proximal to the cuff can be seen in some designs. These assist the accurate placement of the tracheal tube tip within the trachea. The vocal cords should be at the black mark in tubes with one mark, or should be between marks if there are two such marks. However, these are only rough estimates and correct tracheal tube position depth should always be confirmed by auscultation.

The bevel

1. The bevel is left-facing and oval in shape in most tube designs. A left-facing bevel improves the view of the vocal cords during intubation.

2. Some designs have a side hole just above and opposite the bevel, called a Murphy eye. This enables ventilation to occur should the bevel become occluded by secretions, blood or the wall of the trachea.

The cuff

1. Tracheal (oral or nasal) tubes can be either cuffed or uncuffed. The cuff, when inflated, provides an air-tight seal between the tube and the tracheal wall. This air-tight seal protects the patient's airway from aspiration and allows efficient ventilation during IPPV.

2. The narrowest point in the adult's airway is the glottis (which is hexagonal). In order to achieve an air-tight seal, cuffed tubes are used in adults.

3. The narrowest point in a child's airway is the cricoid cartilage. Since this is essentially circular, a correctly sized uncuffed tube will fit well. Because of the narrow upper airway in children.

4. Cuffs can either be:

a) High pressure/low volume

b) Low pressure/high volume.

High-pressure/low-volume cuffs

1. These can prevent the passing of vomitus, secretions or blood into the lungs.

2. At the same time, they exert a high pressure on the tracheal wall. If left in position for long periods, they may cause necrosis of the tracheal mucosa.

Low-pressure/high-volume cuffs

1. These exert minimal pressure on the tracheal wall as the pressure equilibrates over a wider area. This allows the cuff to remain inflated for longer periods.

2. They are less capable of preventing the aspiration of vomitus or secretions. This is due to the possibility of wrinkles forming in the cuff. The pressure in the cuff should be checked at frequent and regular intervals. The pressure may increase mainly because of diffusion of nitrous oxide into the cuff. An increase in pressure of about 10–12 mmHg is expected after 30 minutes of anaesthesia with 66% nitrous oxide. A more recent design cuff material (Soft Seal, Portex) allows minimum diffusion of nitrous oxide into the cuff with a pressure increase of 1–2 mmHg only. The pressure may decrease because of a leak in the cuff or pilot balloon's valve.

Route of insertion

1. Tubes can be inserted orally or nasally.

2. The indications for nasal intubation include:

a) Surgery where access via the mouth is necessary, e.g. ENT or dental operations

b) Long-term ventilated patients on intensive care units. Patients tolerate a nasal tube better, and cannot bite on the tube. However, long-term nasal intubation may cause sinus infection.

3. Nasal intubation is usually avoided, if possible, in children up to the age of 8–11 years. Hypertrophy of the adenoids in this age group increases the risk of profuse bleeding if nasal intubation is performed.

4. Ivory PVC nasotracheal tubes cause fewer traumas to the nasal mucosa.

Connectors

These connect the tracheal tubes to the breathing system (or catheter mount). There are various designs and modifications. They are made of plastic or metal and should have an adequate internal diameter to reduce the resistance to gas flow. On the breathing system end, the British Standard connector has a 15-mm diameter at the proximal end. An 8.5-mm diameter version exists for neonatal use. On the tracheal tube end, the connector has a diameter that depends on the size of the tracheal tube. Connectors designed for use with nasal tracheal tubes have a more acute angle than the oral ones (e.g. Magill's connector). Some designs have an extra port for suction.

Problems in practice and safety features

1. Obstruction of the tracheal tube by kinking, herniation of the cuff, occlusion by secretions, foreign body or the bevel lying against the wall of the trachea.

2. Oesophageal or bronchial intubation.

3. Trauma and injury to the various tissues and structures during and after intubation.

Specially designed tracheal tubes

OXFORD TRACHEAL TUBE

This anatomically L-shaped tracheal tube is used in anaesthesia for head and neck surgery because it is non-kinking. The tube can be made of rubber or plastic and can be cuffed or uncuffed. The bevel is oval in shape and face posteriorly and an introducing stylet is supplied to aid the insertion of the tube. Its thick wall adds to the tube's external diameter making it wider for a given internal diameter. This is undesirable especially in paediatric anaesthesia. The distance from the bevel to the curve of the tube is fixed. If the tube is too long, the problem cannot be corrected by withdrawing the tube and shortening it because this means losing its anatomical fit.

ARMOURED TRACHEAL TUBE

Armoured tracheal tubes are made of plastic or silicone rubber. The walls of the armoured tube are thicker than ordinary tracheal tubes because they contain an embedded spiral of metal wire or tough nylon. They are used in anaesthesia for head and neck surgery. The spiral helps to prevent the kinking and occlusion of the tracheal tube when the head and/or neck is rotated or flexed so giving it strength and flexibility at the same time. An introducer stylet is used to aid intubation. Because of the spiral, it is not possible to cut the tube to the desired length. This increases the risk of bronchial intubation. Two markers, situated just above the cuff, are present on some designs. These indicate the correct position for the vocal cords.

POLAR AND RAE TRACHEAL TUBES

The **polar tube** is a north- or south-facing preformed nasal cuffed or uncuffed tracheal tube it is used mainly during anaesthesia for maxillofacial surgery as it does not impede surgical access. Because of its design and shape, it lies over the nose and the forehead. It can be converted to an ordinary tracheal tube by cutting it at the scissors mark just proximal to the pilot tube and reconnecting the 15-mm connector. An oral version of the polar tube exists. The **RAE (Ring, Adair and Elwyn) tube** has a preformed shape to fit the mouth or nose without kinking. It has a bend located just as the tube emerges, so the connections to the breathing system are at the level of the chin or forehead and not interfering with the surgical access. RAE tubes can be either north or south-facing, cuffed or uncuffed. Because of its preformed shape, there is a higher risk of bronchial intubation than with ordinary tracheal tubes. The cuffed RAE tracheal tube has one Murphy eye whereas the uncuffed version has two eyes. Since the uncuffed version is mainly used in paediatric practice, two Murphy eyes ensure adequate ventilation should the tube prove too long. The tube can be temporarily straightened to insert a suction catheter.

LASER RESISTANT TRACHEAL TUBES

These tubes are used in anaesthesia or laser surgery on the larynx or trachea. They are designed to withstand the effect of carbon dioxide and potassiumtitanyl-phosphate (KTP) laser beams, avoiding the risk of fire or damage to the tracheal tube. One design has a flexible stainless steel body. Reflected beams from the tube are defocused to reduce the accidental laser strikes to healthy tissues. Other designs have a laser resistant metal foil wrapped around the tube for protection. The cuff is filled with methylene blue coloured saline. If the laser manages to damage the cuff, the colouring will help identify rupture and the saline will help

prevent an airway fire. Some designs have two cuffs. This ensures a tracheal seal should the upper cuff be damaged by laser. An air-filled cuff, hit by the laser beam, may ignite and so it is recommended that the cuffs are filled with saline instead of air.

EVOKED POTENTIALS TRACHEAL TUBES

These tubes are used in a number of surgical procedures that have the risks of damage to nerves, e.g. thyroid surgery. Bipolar stainless steel contact electrical electrodes are embebded in the tracheal tubes above the cuff where they are in contact with the vocal cords. These electrodes are connected to a nerve stimulator. An additional earth electrode is attached to the skin of the patient. The use of such tubes allows continuous nerve monitoring throughout surgery providing visual and audible warnings.

MICROLARYNGEAL TUBE

This tube allows better exposure and surgical access to the larynx. It has a small diameter (usually 5-mm ID) with an adult sized cuff. Its length is sufficient to allow nasal intubation if required. The tube is made of ivory PVC to reduce trauma to the nasal mucosa.

Tracheostomy tracheal tubes

These are curved plastic tubes usually inserted through the second, third and fourth tracheal cartilage rings.

Components

1. An introducer used for insertion.

2. Wings attached to the proximal part of the tube to fix it in place with a ribbon or suture. Some designs have an adjustable flange to fit the variable thickness of the subcutaneous tissues.

3. They can be cuffed or uncuffed. The former have a pilot balloon.

4. The proximal end can have a standard 15-mm connector.

5. The tip is usually cut square, rather than bevelled. This is to decrease the risk of obstruction by lying against the tracheal wall.

6. A more recent design with an additional suctioning lumen which opens just above the cuff exists. The cuff shape is designed to allow the secretions above it to be suctioned effectively through the suctioning lumen.

7. There are different sizes of tracheostomy tubes to fit neonates to adults.

8. Some designs have a one-way flap valve and a window at the angle of the tube to allow the patient to speak.

Tracheostomy tubes are used for the following:

1. Long-term intermittent positive pressure ventilation.

2. Upper airway obstruction that cannot be bypassed with an oral/ nasal tracheal tube.

3. Maintenance of an airway and to protect the lungs in patients with impaired pharyngeal or laryngeal reflexes and after major head and neck surgery (e.g. laryngectomy).

4. Long-term control of excessive bronchial secretions especially in patients with a reduced level of consciousness.

5. To facilitate weaning from a ventilator. This is due to a reduction in the sedation required, as the patients tolerate tracheostomy tubes better than tracheal tubes. Also, there is a reduction in the anatomical dead space.

Problems in practice and safety features

The complications rate is higher in the intensive care unit and emergency patients. The complications can be divided into:

1. Immediate:

(a) Haemorrhage. (b) Tube misplacement (e.g. into a main bronchus). (c) Occlusion of tube by cuff herniation. (d) Occlusion of the tube tip against carina or tracheal wall. (e) Pneumothorax.

2. Delayed:

(a) Blockage of the tube by secretions which can be sudden or gradual; this is rare with adequate humidification and suction. (b) Infection of the stoma. (c) Over inflation of the cuff leads to ulceration and distension of the trachea. (d) Mucosal ulceration because of excessive cuff pressures, asymmetrical inflation of the cuff or tube migration.

3. Late:

(a) Granulomata of the trachea may cause respiratory difficulty after extubation. (b) Persistent sinus at the tracheostomy site. (c) Tracheal dilatation. (d) Tracheal stenosis at the cuff site. (e) Scar formation.

Fig. 1. Features of a cuffed tracheal tube. Some designs have the markings of IT (implantation tested)

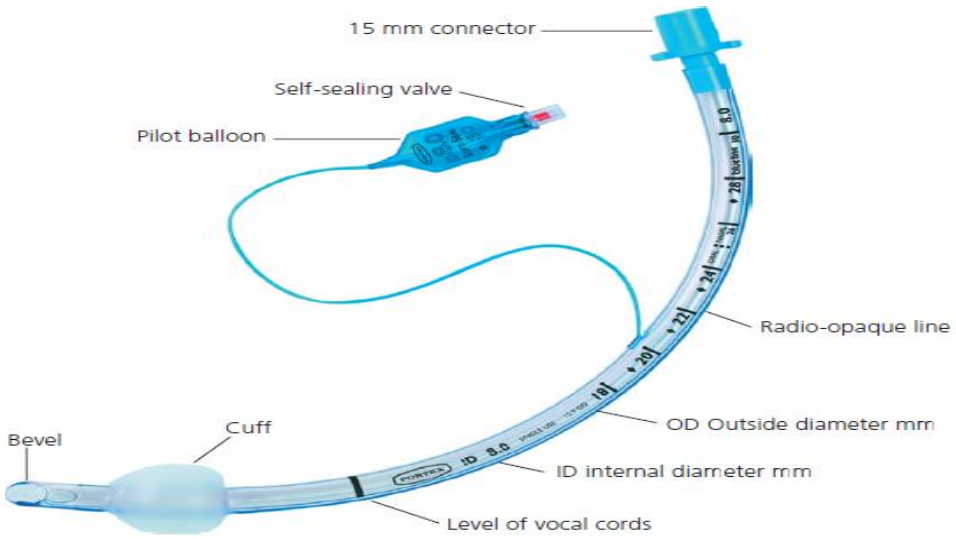

Fig. 2 (A) Correctly positioned tracheal tube. (B) The tracheal tube has been advancedtoo far, into the right main bronchus.

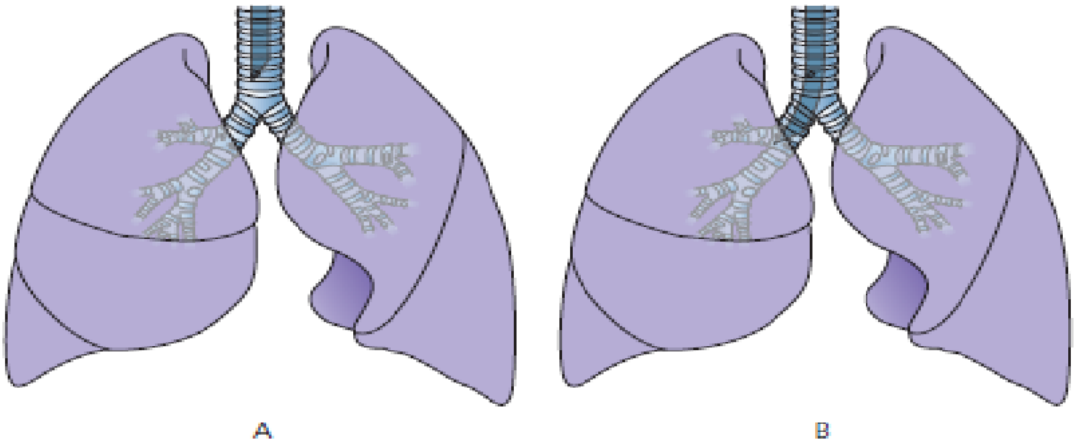

Fig.3. Different types of tracheal tube cuffs. High volume (left), intermediate volume (centre), low volume (right).

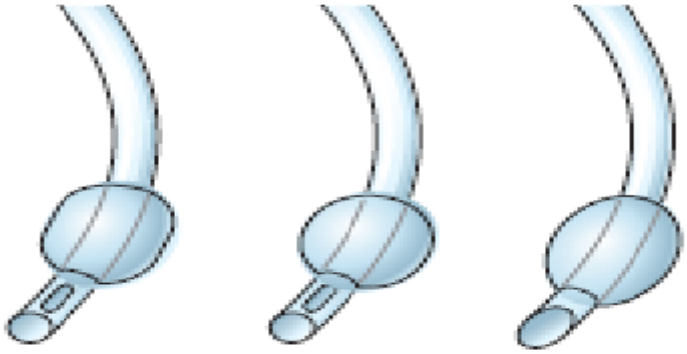

Fig. 5.3 Diagram showing a tracheal tube with an obstructed bevel againstthe trachea wall but a patent Murphey's eye so allowing ventilation.

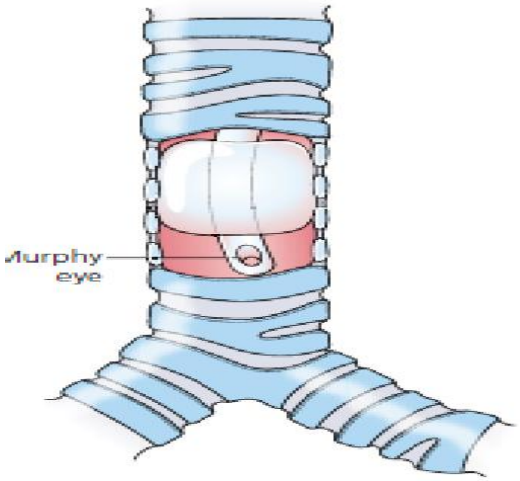

Fig. Cuff pressure gauge.

Fig. A non-cuffed oral/nasal tracheal tube.

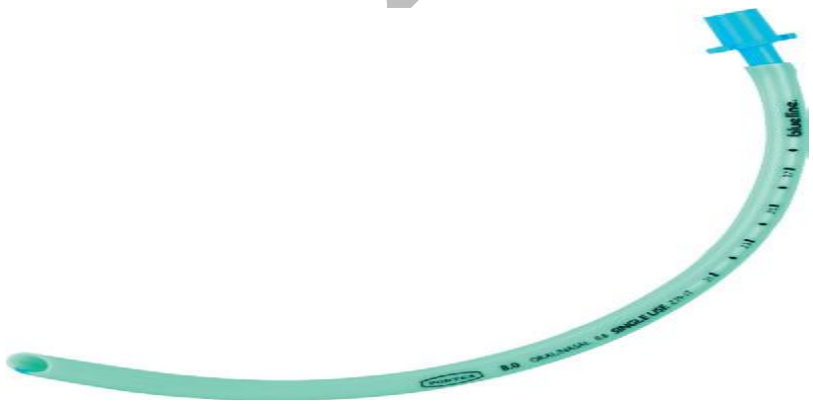

Fig. A range of tracheal tube connectors. Top row from left to right: Magill oral, Magill nasal, Nosworthy, Cobb suction. (Note the Magill nasal connector has been supplied with a piecem of wire threaded through it to demonstrate its patency.) Bottom row: Paediatric 8.5-mm connectors (left), standard 15-mm connectors (right).

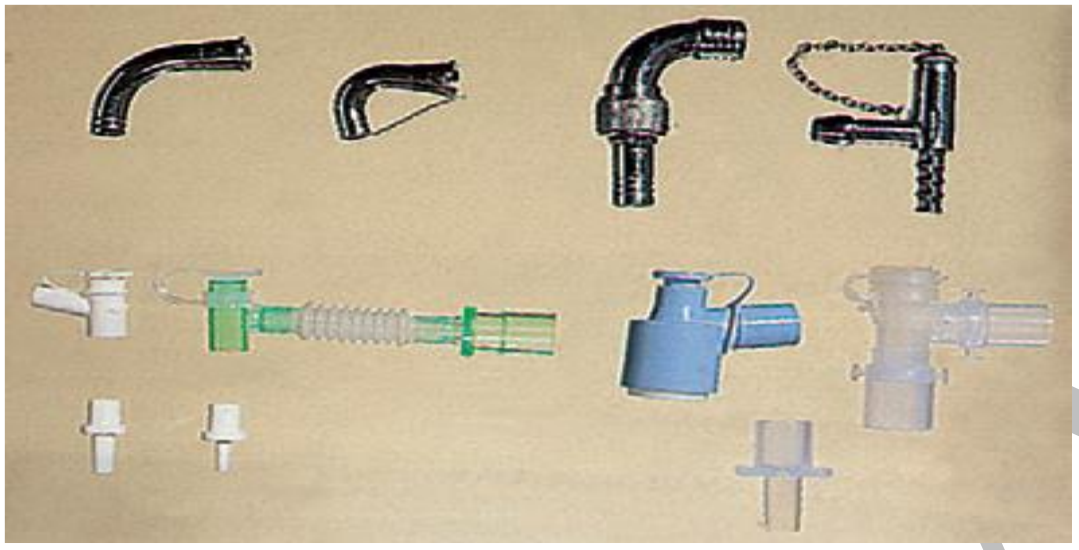

Fig. The Oxford tracheal tube, red rubber (left) and plastic (right).

Fig. Armoured cuffed tracheal tube.

Fig. Polar and RAE tracheal tubes: (A) cuffed nasal north facing; (B) non-cuffed nasal north facing; (C) cuffed
oral south-facing; (D) non-cuffed oral north-facing.

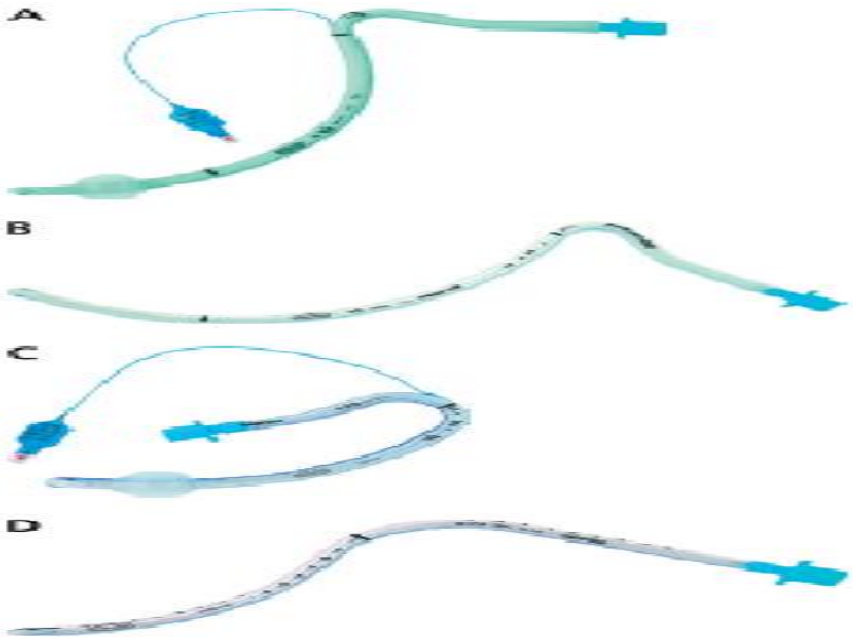

Fig. Laser resistant tracheal tubes. Note the stainless steel tube (left) with two cuffs. The tube on the right is covered with laser protective wrapping.

Fig. Microlaryngeal tracheal tube.

Fig. Cuffed tracheostomy tube.

Fig. Evoked potential tracheal tube. Note the electrodes (just above the cuff) with their cables. The other cable is earth.

Fig. Adjustable flange tracheostomy tube

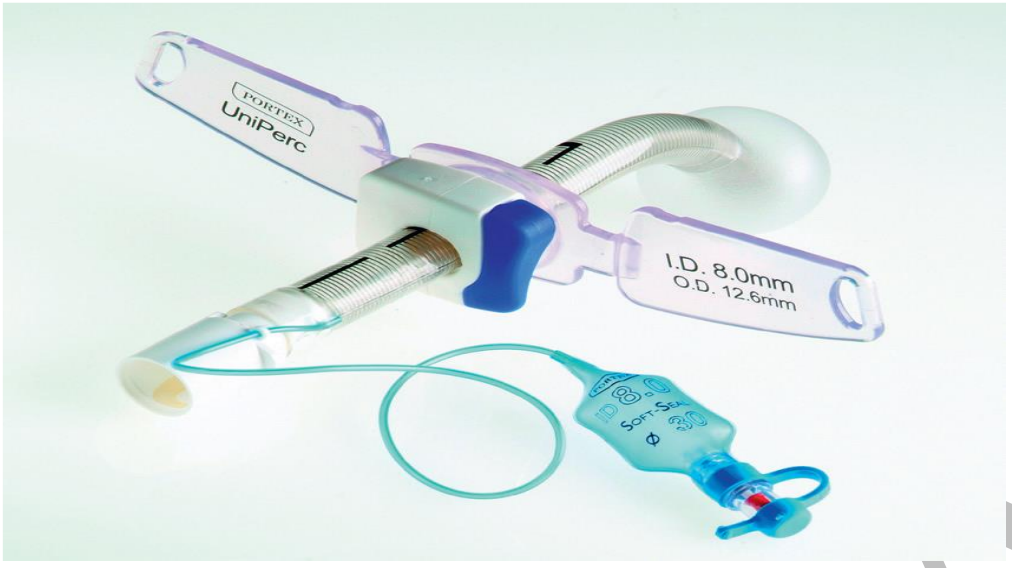

Fig. Smith's Portex tracheostomy tube with an above-cuff suction facility.

Fig. A Portex unfenestrated inner cannula (left), fenestrated inner cannula (middle) and Blue Line Ultr fenestrated tracheostomy tube with Soft-Seal cuff (right).