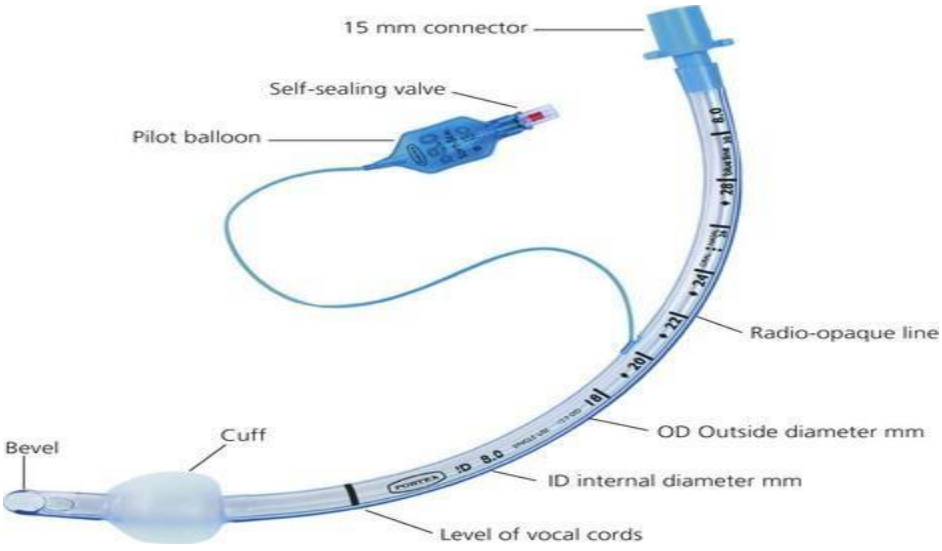
Tracheal tubes

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.
In the past, tracheal tubes used to be made of rubber allowing them to be reused after cleaning and autoclaving.



FEATURES OF TRACHEAL TUBES

- The *'size'* of a tracheal tube refers to its *internal diameter* which is marked on the outside of the tube in millimeters. 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. A size 4mm tracheal tube has 16 times more resistance to gas flow than a size 8-mm tube. 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. There are various methods or formulae used to determine the size of paediatric tracheal tubes. A commonly used formula is:

$$\text{Internal diameter in mm} = \frac{\text{age in years}}{4} + 4$$

Age	Weight (kg)	Size (ID mm)	Length (cm)
Neonate	2–4	2.5–3.5	10–12
1–6 months	4–6	4.0–4.5	12–14
6–12 months	6–10	4.5–5.0	14–16
1–3 years	10–15	5.0–5.5	16–18
4–6 years	15–20	5.5–6.5	18–20
7–10 years	25–35	6.5–7.0	20–22
10–14 years	40–50	7.0–7.5	22–24

- The *length* (taken from the tip of the tube) is marked in centimeters on the outside of the tube. The tube can be cut down to size to suit the individual patient. If the tube is cut too long, there is a significant risk of it advancing into one of the main bronchi (usually the right one). 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 leftfacing 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*

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.

1. The cuff is connected to its *pilot balloon* which has a self-sealing valve for injecting air. The pilot balloon also indicates whether the cuff is inflated or not. After intubation, the cuff is inflated until no gas leak can be heard during intermittent positive pressure ventilation (IPPV).

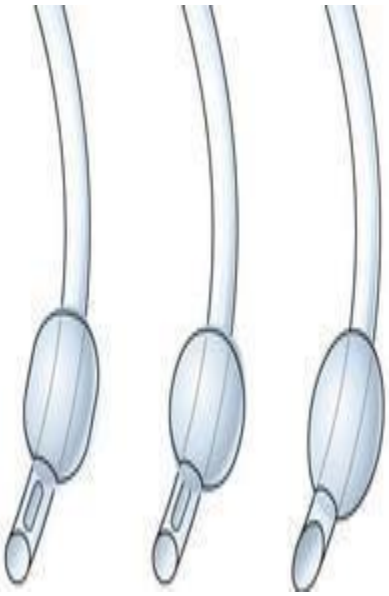
2. The *narrowest point* in the *adult's airway* is the (*glottis)*. In order to achieve an air-tight seal, cuffed tubes are used in adults.
3. The *narrowest point* in a *child's airway* is the (*cricoid cartilage)*. Since this is essentially circular, a correctly sized uncuffed tube will fit well.

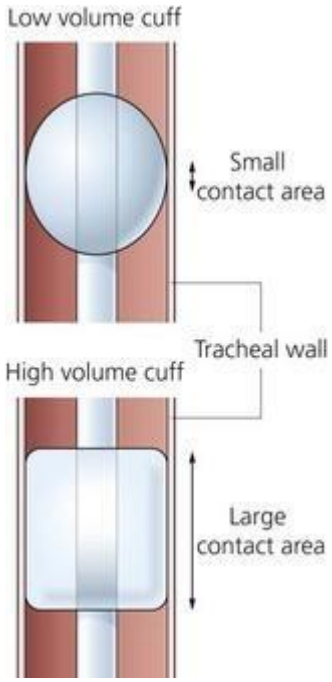
- Because of the narrow upper airway in children, post-extubation subglottic oedema can be a problem. In order to minimize the risk, the presence of a small leak around the tube at an airway pressure of 15 cm H2O is desirable.

4. Cuffs can either be:

a) high pressure/low volume

b) low pressure/high volume.





High-pressure/low-volume cuffs

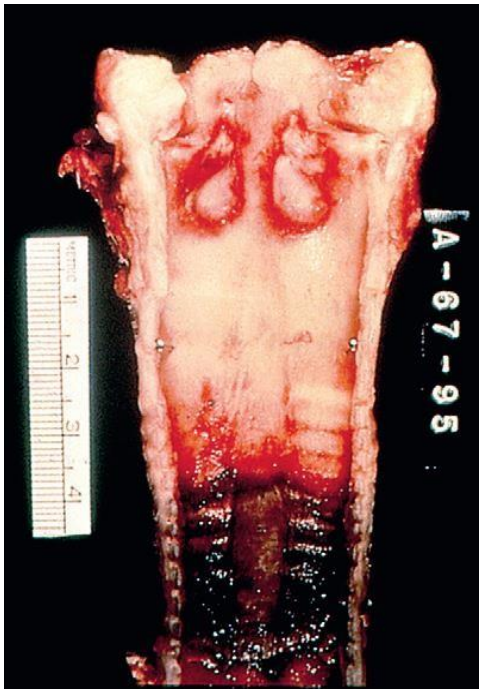
1. These can prevent the passing of vomitus, secretions or blood into the lungs.
2. At the same time, they exert a high pressure on the tracheal wall. If left in position for long periods, they may cause necrosis of the tracheal mucosa.

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.

Cuff pressure gauge



tracheal necrotic area long-term pressure

A postmortem specimen. Note the black which was caused by intubation with a high-cuffed tube.

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

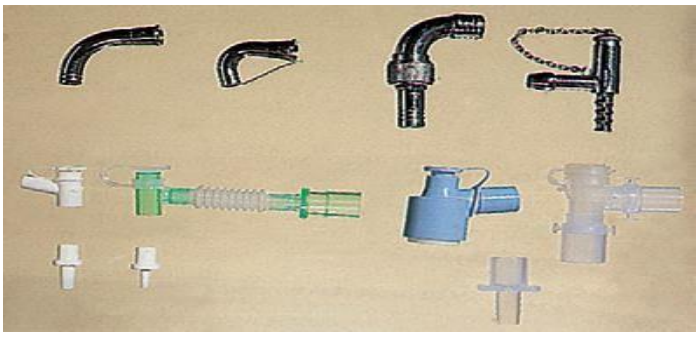
b) long-term ventilated patients on intensive care units. Patients tolerate a nasal tube better, and cannot bite on the tube. However, long-term nasal intubation may cause sinus infection.

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.

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 15mm 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. Some designs have an extra port for suction.



(A range of tracheal tube connectors)

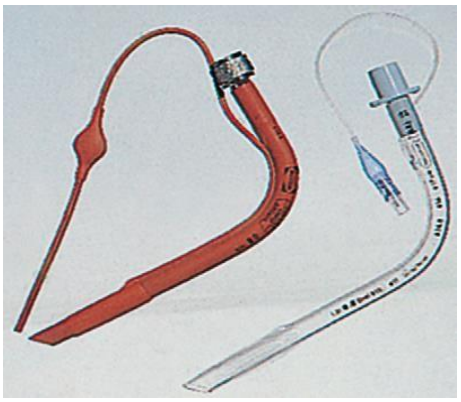
Problems in practice and safety features

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. Esophageal 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.



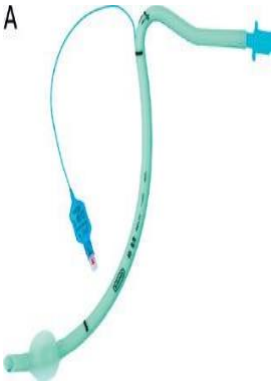
- ARMOURED TRACHEAL TUBE

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.

- *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.

  - 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. 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.



(cuffed nasal north facing)

(non-cuffed nasal north facing)

(cuffed oral south-facing)

(non-cuffed oral north-facing)

LASER RESISTANT TRACHEAL TUBES

These tubes are used in anaesthesia for laser surgery on the larynx or trachea. They are designed to withstand the effect of carbon dioxide and potassium titanyl- phosphate (KTP) laser beams, avoiding the risk of fire or damage to the tracheal tube. One design has a flexible stainless-steel body. 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.

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

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.

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 embedded in the tracheal tubes above the cuff where they are in contact with the vocal cords, these electrodes are connected to a nerve stimulator.