use of oral tubes. Also laryngeal injury may be more common with oral, as opposed to nasal, intubation (Stauffer et al., 1981). The choice of route in an individual patient often depends largely on the experience and preference of a particular unit, but currently the oral route is usually preferred in adults.

**TRACHEOSTOMY**

**INDICATIONS** (Table 7.4)
The only indication for immediate tracheostomy is a life-threatening obstruction of the upper respiratory tract that cannot be bypassed with an endotracheal tube. Tracheostomy performed under these circumstances can be extremely hazardous, mainly because of engorgement of the blood vessels in the neck. An emergency tracheostomy may also be necessary to secure the airway in patients with head and neck injuries, including burns to the face and upper airway.

As well as providing a secure artificial airway for prolonged respiratory support, tracheostomy may be required for the long-term control of excessive bronchial secretions, particularly in those with a reduced conscious level, and/or to maintain an airway and protect the lungs in those with impaired pharyngeal and laryngeal reflexes. It is important to appreciate that, when patients are extubated following an extended period of translaryngeal intubation, their ability to cough may be impaired by oedema and rigidity of the vocal cords. This may influence the decision to perform a tracheostomy, particularly in those who continue to produce excessive secretions and/or are unable to cooperate fully with physiotherapy.

Potential benefits of tracheostomy include:
- reduced oropharyngeal and laryngeal injury;
- reduced dead space and airway resistance with reduction in the work of breathing;
- facilitates control of secretions;
- improved patient comfort and communication;
- reduced requirement for sedation;
- facilitates mobilization to chair and ambulation;
- oral nutrition may be possible.

Conventionally translaryngeal tracheal intubation is recommended for up to 10 days, whilst tracheostomy is preferred when the need for an artificial airway exceeds 21 days. There is now some evidence, however, that earlier tracheostomy (within 7 days) may be beneficial by reducing sedation requirements and days on the ventilator and in intensive care (Griffiths et al., 2005). The increasing use of percutaneous tracheostomy (see below) may encourage this approach. Certainly when prolonged dependence on an artificial airway can be confidently predicted (e.g. traumatic cervical cord injury, severe ARDS) early tracheostomy (within 3–5 days) should be seriously considered. The appropriate timing of tracheostomy has, nevertheless, yet to be precisely defined. In an individual patient the decision is governed by a number of considerations, including the presence of relative contraindications to tracheostomy, the degree of discomfort caused by the presence of the endotracheal tube, the extent of difficulties related to tracheal toilet and the anticipated duration of the need for an artificial airway.

**CONTRAINDICATIONS**
Relative contraindications to tracheostomy include:
- local inflammation, infection or burns injury;
- severe coagulopathy;
- cardiovascular or respiratory instability.

**COMPLICATIONS**
The incidence of the large number of adverse events which can complicate tracheostomy varies widely between different reports. Many authors have reported a small but significant perioperative mortality associated with tracheostomy (up to 3%), although more recently deaths directly attributable to tracheostomy have become extremely rare (Dulguerov et al., 1999). Potentially lethal perioperative events include hypoxaemia, hypotension, cardiac arrhythmias, immediate or delayed haemorrhage.

**Early complications**
The tracheostomy tube is easily misplaced in the pretracheal subcutaneous tissue, particularly during emergency reinsertion in the early postoperative period, leading to mediastinal or subcutaneous emphysema. This danger may be minimized by using a Bjork flap (see below). The tube may obstruct if tilted, and leaks around the cuff can give rise to surgical emphysema. Pneumothorax, pneumomediastinum and perioperative haemorrhage are other well-recognized complications (Stauffer et al., 1981).

**Intermediate complications**
As with translaryngeal tracheal intubation, ulceration of the tracheal mucosa may occur at the level of the cuff and, because a tracheostomy tube is prone to tilting, the mucosa may also be damaged by the tip of the tube. Erosion of the tracheal cartilages and neighbouring structures may lead to fatal haemorrhage from the innominate artery or to a tracheoesophageal fistula.

Tracheostomy wounds are usually colonized with resident bacteria which are often resistant to the commonly used antibiotics. These may cause local infection, sometimes with
extensive necrosis of the anterior neck, with or without systemic sepsis.

Late complications
Tracheal narrowing or stenosis may occur at the level of the stoma, the cuff or the tip of the tube; sometimes, the tracheal rings collapse at stomal level, a tracheal granuloma may develop or there may be delayed healing with a persistent sinus at the tracheostomy stoma. Cosmetic deformity is common. The incidence of these complications may be decreased by preserving as much tracheal cartilage as possible at operation, correct positioning of the tube and minimizing movement of the tube relative to the trachea.

TECHNIQUES
Surgical
It is important to avoid damaging the cricoid cartilage or first tracheal ring since this renders the larynx unstable. On the other hand, a low tracheostomy increases the risk of erosion of the innominate artery. The trachea should therefore be opened through the second, third and fourth tracheal rings. Ligation and division of the thyroid isthmus are not usually necessary. Duke’s modification of the Bjork flap, in which an inverted U incision is made in the trachea and the flap is sutured to the lower skin edge, remains a popular technique. It has the advantages of supporting the tracheostomy tube, thereby minimizing erosion of the lower border of the trachea and facilitating reinsertion. Alternatively, a simple window of tracheal wall can be removed. Both these methods weaken the tracheal wall and a vertical slit is now preferred, the edges of which are held apart with hooks while the tracheostomy tube is inserted. Some use a T-shaped incision. In general, however, there are a large number of surgical approaches and there is little information concerning the influence of these various techniques on the incidence of long-term complications. Although most surgeons prefer to perform the procedure in an operating theatre, surgical tracheostomy can be performed safely at the bedside in the ICU.

Percutaneous tracheostomy
Elective percutaneous tracheostomy should be performed with the patient heavily sedated and following administration of a muscle relaxant. Analgesia and sedation may be supplemented by local infiltration with lidocaine. The patient is positioned with a roll between the shoulders to extend the neck; the anterior neck is then cleansed and painted with antiseptic. A transverse incision (approximately 2.5 cm) is made through the skin and subcutaneous tissues midway between the cricoid cartilage and the sternal notch. Curved forceps can be used for blunt dissection of the cervical fascia anterior to the trachea. When using the sequential dilatation technique the trachea is punctured with an introducer needle (e.g. 16–17G) between the first and second or second and third tracheal rings. After introducing the catheter into the tracheal lumen the needle is withdrawn and a J-tipped guidewire is threaded through the catheter. It is recommended that the position and depth of the tracheal puncture, as well as the position of the guidewire, are checked by an assistant with a bronchoscope. A guiding catheter can then be advanced over the guidewire, followed by serial dilatation of the stoma with dilators of increasing size. Finally the tracheostomy tube, preloaded on to a dilator of the appropriate size, is advanced over the guidewire and guiding catheter into the tracheal lumen. More recently, a single tapered (conic dilator – the Blue Rhino) has been introduced and has been shown to be safe, with an acceptably low incidence of major complications (Fikkers et al., 2002).

The forceps dilatational technique involves introducing the forceps over the guidewire and opening the handles of the forceps with the blades in the soft tissue anterior to the trachea. The forceps are then inserted into the trachea and the stoma fully dilated. The tracheostomy tube, mounted on a plastic trochar, is then passed over the guidewire into the trachea. With the translaryngeal technique the guidewire is passed retrogradely into the oropharynx, parallel to or within the endotracheal tube. The patient is then reintubated using the small internal diameter tube provided and the wire is connected to the pointed head of the tracheal cannula. The cannula is advanced through the pharynx into the trachea; the pointed head is pulled through the tracheal wall and skin. The pointed head is then cut off, the tracheal cannula is straightened and rotated with an obturator and the smaller endotracheal tube is removed.

Relative contraindications to percutaneous tracheostomy include:
- difficult-to-identify anatomy;
- short neck/rigid cervical spine;
- severe coagulopathy;
- raised intracranial pressure.

The percutaneous technique has a number of potential advantages when compared to the surgical approach. The skin incision is small, disruption of deeper tissues is minimized and there is no tracheal resection. The risk of bleeding, the incidence of infection and scar formation may therefore be reduced. Percutaneous tracheostomy is quicker (average 11.7 minutes) than surgical tracheostomy (average 26.9 minutes) (Dulguerov et al., 1999), is technically easier and can be performed at the bedside, thereby avoiding the hazards of transportation. Fewer personnel and less equipment are required and costs are reduced. It has also been claimed that percutaneous tracheostomy is associated with fewer operative and long-term complications, although when compared to a more recent series of surgical tracheostomies, perioperative complications are in fact more common, whereas postoperative complications are less frequent with the percutaneous approach (Dulguerov et al., 1999). In particular, and perhaps not surprisingly, percutaneous tracheostomy is more frequently complicated by difficulty with tube placement, creation of a false passage and subcutaneous emphysema. Indeed, one meta-analysis has
indicated that serious perioperative complications, including operative mortality and cardiorespiratory arrest, may be more common with percutaneous tracheostomy (Dulgurov et al., 1999). On the other hand this review confirmed the reduced incidence of bleeding and infection with percutaneous tracheostomy, but suggested that tracheal stenosis and damage to the tracheal cartilages may be more common with this approach.

Bronchoscopic guidance increases the safety of percutaneous tracheostomy and in particular minimizes the risk of posterior tracheal wall injury. The highest complication rates are associated with techniques not involving progressive dilatation (Dulgurov et al., 1999). Certainly the translaryngeal technique has been associated with a high incidence of unsolvable technical difficulties and serious complications (Cantais et al., 2002). In a large series of bronchoscopically guided, percutaneous dilational tracheostomies there were no procedure-related deaths, the incidence of clinically relevant bleeding was 2.9% and insertion of the tracheostomy tube was easy, or only moderately difficult in 86.7% of cases. The incidence of tracheostomy tube-related complications (defined as hypoxaemia, cannula misplacement, accidental decannulation, cuff rupture and herniation, or posterior tracheal wall lesions) was only 0.7%. The incidence of tracheal ring fracture was higher with conic than with stepwise dilatation (Beiderlinden et al., 2002). These authors also emphasized the importance of avoiding early routine tracheostomy tube changes, which can be particularly difficult following percutaneous tracheostomy, and of secure fixation of the tracheostomy tube.

The use of dilatational techniques for reformation of healed tracheostomies, where distorted anatomy increases the risk of bleeding from major vessels, is controversial. Percutaneous tracheostomy may also be a useful means of rapidly securing the airway in an emergency.

**Cricothyroidotomy**

The technique of cricothyroidotomy is simple and quick; it is usually reserved for emergencies. A large-bore needle and cannula (e.g. 14G) can be inserted percutaneously via the cricothyroid membrane to provide a temporary route for oxygenation, although ventilation is inefficient and a surgical tracheostomy will normally be required within 30–45 minutes to avoid hypercarbia.

Alternatively a surgical approach via a transverse skin incision allows insertion of a size 6 or 7F tracheostomy or endotracheal tube under direct vision. The percutaneous dilatational technique described above (Barrachina et al., 1996) or the Penlon cricothyrotomy cannula can also be used. The latter technique involves extending the patient’s head, making a small skin incision and pushing the cannula blade through the cricothyroid membrane into the trachea. The blade is then retracted and the integral metal dilators advanced and opened, allowing insertion of a tracheostomy tube.

Because the cricothyroid membrane is a relatively avascular area, serious bleeding is rarely a problem with this technique. Pneumothorax is also unusual because of the high approach. Some believe that the incidence of subglottic stenosis and vocal cord paralysis is unacceptably high with cricothyroidotomy.

**Minitracheostomy** (Ryan, 1990)

A small-diameter (e.g. 4.0-mm) uncuffed tube can be inserted percutaneously via the cricothyroid membrane following infiltration with local anaesthetic. A Seldinger technique, in which the minitracheostomy and a dilator are inserted over a guidewire, is probably safer and less traumatic. This provides a route for repeated tracheobronchial suction using a 10 FG catheter and for the administration of oxygen, while being comfortable and allowing the patient to speak and eat. This technique has also been used in the emergency management of upper-airway obstruction, to administer HFJV and in obstructive sleep apnoea.

Complications include haemorrhage, misplacement in the mediastinum, displacement and surgical emphysema. Minitracheostomy should not be used in patients who are unable to protect their airway or in those with coagulopathy.

**TRACHEOSTOMY TUBES**

During mechanical ventilation, and for protection against aspiration, a cuffed tracheostomy tube is clearly required. As with endotracheal tubes for long-term use, these should be constructed of non-irritant material and have low-pressure, high-volume cuffs. The tip is normally cut square, rather than bevelled, to decrease the risk of obstruction and mucosal injury.

When the patient’s condition has improved, it is usual to deflate the cuff and later change to an uncuffed tube. Traditionally, these were made of silver, which is non-irritant and bactericidal. They had an inner tube which could be removed for cleaning at regular intervals. They could also be modified with a fenestration at the angle of the tube and a one-way flap valve to allow the patient to speak. Plastic uncuffed tubes are now available, some with disposable inner cannulae, both with and without fenestrations. In some cases a cuffed fenestrated tube with an inner cannula may be preferred as a means of protecting the airway while allowing the patient to speak intermittently. Various tracheal ‘buttons’ are also available to maintain patency of the tracheostomy and provide a route for endotracheal suction. In an attempt to enable mechanically ventilated patients to phonate with the cuff inflated, tracheostomy tubes are available that incorporate an additional small lumen, which allows a separate gas flow to be diverted through the larynx (Fig. 7.14a). One-way Passy–Muir speaking valves can also be used in ventilated patients, as well as in those breathing spontaneously (Fig. 7.14b). Alternatively, the patient can simply use a finger to occlude the tracheostomy temporarily (Fig. 7.14c and d).

**MANAGEMENT**

A postoperative chest X-ray should be obtained to confirm correct positioning of the tube and exclude a pneumothorax.
Tracheostomy tubes must be securely fixed, a split-gauze dry dressing is used and the wound cleaned with saline. Wound swabs should be cultured regularly. The tube is left in place for 7 days and then changed every 5–6 days, depending on local policy. Emergency equipment must always be available at the bedside and should include a tracheostomy tube of the same size and one size smaller, as well as a tracheal dilator.

**Decannulation**

Decannulation is associated with an increase in dead space and a significant increase in the work of breathing (Chadda et al., 2002). Following removal of the tracheostomy tube the stoma should be covered by a dry occlusive dressing and allowed to heal spontaneously. This usually occurs rapidly and within 1–2 days reinsertion of a similar-sized tracheostomy tube is likely to be extremely difficult.

---

**Fig. 7.14** (a) A modified tracheostomy tube which can allow phonation during mechanical ventilation. (b) A Passy–Muir speaking valve with fenestrated tube and cuff deflated. (c) The patient or member of staff can use a finger to occlude the tube during speech, in this case via a fenestrated tube with the cuff inflated. (d) Tracheostomy tube with cuff deflated.


