Performance of the first tracheostomy is accredited to Asclepiades of Persia at around 124 AD but Thomas Feyens (1567–1631) was the first to use the term. The Italian surgeon, Sanctorio Sanctorius, first described percutaneous tracheostomy in 1626 at the University of Padua. An American surgeon, Pasquale Ciaglia, modified and popularised the percutaneous dilational technique in 1985.

Benefits of tracheostomy
In patients who require prolonged ventilation, tracheostomies provide many benefits compared with conventional intubation. The benefits described in Table 1 facilitate the weaning process and, in addition, allow bronchial toilet to continue into the post-weaning period, thereby potentially reducing intensive care unit (ICU) stay, need for re-intubation and ICU re-admission rates.

Surgical versus percutaneous tracheostomy
The mortality risk associated with surgical tracheostomy has declined from 3–4% quoted in studies before 1985 to < 1%. The total complication rate has also declined over the same period from up to 90% to < 40%. The complication rate is doubled in ICU versus non-ICU patients and in tracheostomies performed in emergency situations. This is mainly due to an 8-fold increase in the intra-operative (as opposed to postoperative) complication rate, which itself is dependent on the surgical specialty performing the procedure.

Most studies comparing percutaneous and surgical tracheostomies have shown that the operative time is halved with the percutaneous technique. The recent trend towards a single dilator technique may reduce the operative time further. Percutaneous tracheostomies are associated with less intra- and early postoperative complications including fewer stoma infections and reduced bleeding problems due to the tamponade effect of the tightly fitting tracheostomy tube. Long-term complications of tracheostomies are more difficult to assess. Cosmetic results are improved in the percutaneous group and it appears that clinically significant long-term sequelae are no more frequent than with surgical tracheostomies. However, further studies are awaited.

An important advantage of the percutaneous procedure is that it is usually performed in the ICU, eliminating the risk of transferring ventilated patients to and from the operating department.

However, percutaneous tracheostomy does have some disadvantages compared with the open procedure. It was first described as a ‘blind’ technique with the risk of malpositioning the tracheostomy tube but bronchoscopic guidance has been shown to reduce this complication and is strongly advised. Although less likely to become dislodged than a surgical tracheostomy, the re-insertion of a dislodged percutaneously fashioned tube can be more difficult as the stoma may close immediately. Trainees should be encouraged to intubate these patients orally in the emergency situation.

Table 1: Benefits of tracheostomy

- Increased patient comfort
- Less need for sedation
- Improved oral hygiene
- Possibility of oral nutrition
- Bronchial toilet aided
- Reduced dead space
- Reduced airway resistance
- Reduced risk of glottic trauma

Key points
Percutaneous dilator techniques have revolutionised tracheostomy in critically ill patients.
Percutaneous tracheostomy is now an established procedure.
Percutaneous tracheostomies augment the weaning process and shorten intensive care stay.
There is no need for an operating theatre.
To date, studies on long-term outcome have been unable to demonstrate significant morbidity.

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There have been two recent meta-analyses comparing percutaneous and surgical tracheostomy. The first found greater perioperative complication and mortality rates in the percutaneous group with a significantly increased incidence of cardiorespiratory arrest. No comment was made on pre-operative risk assessment (e.g. ASA grading, ICU patients) and the various percutaneous techniques were not differentiated. The authors themselves stated the need for caution in interpreting their findings. The second meta-analysis pooled data from only prospective studies comparing surgical tracheostomy with Ciaglia’s percutaneous dilational technique in ICU patients. The authors could include only 5 relatively small studies and found reduced peri- and postoperative complication rates associated with the percutaneous technique. Adequately powered studies are awaited to confirm these findings.

**Assessment**

Careful pre-operative assessment is crucial in detecting potential problems; indications and contra-indication are shown in Table 2. Neck examination should reveal anatomical abnormalities. Patients with short necks in whom the cricoid cartilage cannot be palpated above the sternum, even in the fully extended position, should be referred for open surgical tracheostomy. Tracheal deviation can render insertion difficult and may also adversely affect ventilation via the tracheostomy tube due to partial or total occlusion of the distal end of the tracheostomy by the deviated tracheal wall. Similarly, aberrant vessels or goitres overlying the proposed puncture site may contra-indicate percutaneous formation of the tracheostomy.

A previous history of surgery or radiotherapy to the neck and diseases affecting the cervical spine should be sought. Chest and cervical spine radiography, ultrasound, computer tomography or even MRI scanning may be indicated in the assessment of abnormal findings.

**Technique**

Percutaneous tracheostomy is performed in the ventilated, anaesthetised and paralysed patient, who should be starved and the stomach emptied. Monitoring and intravenous access will be in place and the inspired oxygen concentration should be increased to 100%. At least two doctors are required, one being responsible for anaesthesia and performance of bronchoscopic guidance, the other performing the tracheostomy. A third person, able to administer the anaesthetic, is deemed necessary by some.

The patient is positioned supine, with the neck extended (a sandbag or pillow is placed under the shoulders to facilitate this). The endotracheal tube is withdrawn under laryngoscopy until the cuff is visible between the cords. This should result in the distal tip of the endotracheal tube to be above the proposed puncture site of the trachea. Alternatively, exchange for a laryngeal mask will eliminate the risk of puncturing the tube or the tip of the bronchoscope. The area is prepared and draped, the thyroid cartilage palpated and the cricoid ring identified below. The operative field is infiltrated with local anaesthetic, which should include epinephrine to reduce the risk of bleeding. A horizontal skin incision of 1.5–2 cm is made.

These basic preparations apply to all percutaneous tracheostomy techniques. Ciaglia’s dilational technique is the most commonly used and is described in more detail below. Other techniques include Griggs’ rapid tracheal dilation using modified Howard Kelly forceps introduced via a guide wire, Fantoni’s retrograde translaryngeal technique and the Rapitrac Kit, which uses a cutting tracheotome. However, the high complication rate with the Rapitrac Kit has led to its withdrawal in the UK. Another technique is a ‘percutwist’ device which uses a large gauge thread to create the dilation.

**Ciaglia’s technique**

Ciaglia’s dilational tracheostomy is a Seldinger wire technique (Fig. 1). Following the horizontal skin incision, blunt dissection of the pre-tracheal tissues is used to identify the tracheal rings and a cannula (over needle) introducer is inserted into the trachea in the midline, aiming posteriorly and slightly caudad.
Ciaglia described insertion between the cricoid cartilage and the first tracheal ring. However, insertion below the first but above the fourth tracheal cartilage reduces the risk of tracheal stenosis reported with higher insertions and avoids the greater risk of bleeding at the lower levels. Similarly, the skin incision was originally described as vertical but increased complications with respect to healing were noted.

Once air is aspirated, the cannula is advanced and the needle withdrawn. A syringe should be connected to the remaining cannula to confirm that air can still be aspirated. The guide wire is introduced without resistance through the cannula, which is then removed. A 14-French primary dilator is advanced over the guide wire until loss of resistance is felt. This dilator is then removed whilst maintaining the guide wire position. A white plastic sleeve is then positioned over the wire to act as a guide for the curved dilators. The first curved dilator is positioned over the guiding catheter up to the safety ridge. The assembly of guiding catheter and dilator is railroaded over the guide wire until the proximal mark on the wire aligns with the proximal end of the guiding catheter (this is important, as it prevents the guiding catheter extending the J-tip of the wire with the risk of trauma). The black marker on the curved dilator should be level with the skin edge. A good contact between the curved dilator tip and the safety ridge of the guiding catheter is important, as this will prevent damage of the curved dilator tip and kinking of the guiding catheter. Dilators of increasing size are used in a similar fashion up to the size of the chosen tracheostomy tube. One of the smaller dilators is then lubricated and inserted into the lumen of the chosen tracheostomy tube to act as an introducer (e.g. a 24-French dilator fits into a 8-mm tracheostomy tube).

In 1999, a modification of the Ciaglia technique was introduced. The Blue Rhino dilator (Cook Critical Care, Bloomington, IL, USA) uses a rapid, one-step dilation using a single, curved hydrophilic-coated dilator. Early studies have suggested that the procedure is faster and possibly safer than the multiple dilator technique.

Complications and risks

Although percutaneous tracheostomy is a safe procedure with several advantages, it remains an invasive technique with potential complications. These are usually divided into peri-operative, and early or late postoperative complications.

The procedure-related mortality for percutaneous tracheostomy is < 0.5%. The overall complication rate is most frequently quoted as 10–15% but can be reduced by operator experience and fibre-optic guidance. Bronchoscopy allows visualisation of the puncture site, ensuring the correct level and orientation and should prevent serious complications such as posterior tracheal wall damage and para-tracheal placement.

Peri-operative complications

Hypoxaemia, due to repeated airway obstruction, decreased minute ventilation and loss of PEEP, is common. However, it is not usually followed by long-term sequelae. Haemorrhage is a relatively common complication (approx. 5%) but is usually minor and easily controlled without the need for blood transfusion. Major haemorrhage is rare but may require operative intervention and conversion to formal tracheostomy. Surgical emphysema can occur but normally does not require intervention. Other serious complications are rare and include pneumothorax, para-tracheal placement, tracheal tears and laryngeal nerve damage.

Early postoperative complications

Blockage of the tracheostomy tube is a relatively common complication, often associated with blood clots, secretions or,
much less frequently, a mucosal flap. The latter may cause complete upper airway obstruction with fatal consequences if not recognised and treated promptly.

A percutaneously fashioned tracheostomy is less likely to become displaced compared with a tracheostomy performed by an open surgical procedure. However, re-insertion within the first 10–14 days is more difficult and may be impossible if the stoma closes immediately. Emergency oral intubation is required before re-insertion of another tracheostomy.

Localised stomal infection is less common in percutaneous (<5%) compared with surgical tracheostomies (up to 30%) and does not usually have any systemic sequelae. Vessel erosion causing secondary haemorrhage is rare and conventional intubation may tamponade the bleeding point. However, surgical repair is likely to be required.

Late complications

There are limited data available on late complications due to the high mortality rate in decannulated critically ill patients and the difficulty in diagnosing long-term complications with simple methods (e.g. questionnaire, lung function tests). In almost all the studies available, the Ciaglia technique was used. Minor and easily diagnosed late complications include voice changes (10–25%) and disfiguring scars; the latter are less common with the use of horizontal incisions.

A serious late complication is tracheal stenosis. Patients are usually asymptomatic until 50–75% of the trachea is occluded. Stridor may occur when the tracheal diameter is reduced to 5 mm. Radiological examination by magnetic resonance imaging showing a reduction of 15% in tracheal diameter, in either the AP or lateral views, is regarded as significant stenosis. Asymptomatic tracheal stenosis may not represent a clinical problem. However, patients who are clinically asymptomatic at rest may develop symptoms in extreme situations, at which time intubation can also be more difficult. Smaller endotracheal tubes should be considered when intubating any patient with a history of previous tracheostomy. Generally, the incidence of tracheal stenosis post percutaneous tracheostomy is lower than for the surgical procedure and quoted as 6–7%, although this figure can rise to 40% if asymptomatic patients are included in follow-up studies.

Key references
