Percutaneous tracheostomy

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Key points

Percutaneous tracheostomy is a safe and widely performed procedure on the intensive care unit (ICU).

Major complications are uncommon, but tend to relate to loss of airway and can occur at any stage.

Recent randomized controlled trial evidence suggests that there is no benefit from performing early tracheostomy to reduce mortality, ICU length of stay or rates of ventilator-associated pneumonia in general ICU patients.

Complications resulting from tracheostomy insertion may be potentially life threatening and experienced operators should always be involved during the procedure to ensure patient safety.

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Percutaneous tracheostomy has become a well-established procedure on the intensive care unit (ICU) for patients requiring prolonged invasive mechanical ventilation (MV). Tracheostomy offers a number of potential benefits such as increased patient comfort, reduced sedation requirement, and a decrease in dead space, all of which may aid the weaning process. Percutaneous dilatational tracheostomy (PDT) using a Seldinger-based insertion method was developed by Ciaglia and colleagues[1] in 1985 and since then has been widely adopted. Over the last 10 years data on newer methods of insertion, timing, safety profile and complication rates have been published, which have greatly improved our understanding of this procedure.

Percutaneous *vs* surgical tracheostomy

PDT is generally preferred to surgical tracheostomy (ST) in intensive care patients as it can be performed more readily on the ICU, thus eliminating the logistic problems that may occur when transferring a ventilated patient to the operating theatre. The procedure can be performed by intensive care physicians at the bedside and so does not depend on the availability of a surgeon or operating theatre time. The main benefits are outlined in Table 1. ST may be preferred in patients with difficult anatomy, those who have had previous neck surgery or radiotherapy, patients with unstable cervical spine injuries, and in centres lacking local expertise or resources to perform PDT in the ICU. While large well-conducted randomized controlled trials comparing PDT with ST are lacking, several studies and meta-analyses have compared the rates of complications—both at the time of insertion and longer term—between ST and PDT. Overall complication rates are similar for PDT and ST, with a reduced incidence of infection for PDT and similar rates of bleeding. PDT performed on the ICU may be associated with a reduced complication rate when compared with ST performed in theatre, but not when both procedures are performed on ICU, suggesting that transfer to theatre has an associated morbidity and mortality. While an early meta-analysis found an increased incidence of perioperative death for the PDT group, subsequent meta-analyses and studies have not found any difference in ICU mortality between PDT and ST groups.[2–6]

Patient assessment

Before tracheostomy, a thorough patient assessment is performed looking for anatomical features that suggest that the procedure may be difficult or that a ST may be preferred (see Table 2) to reduce the risk of procedural complications. Further investigations such as radiographs, computed tomography (CT), ultrasound, and magnetic resonance imaging (MRI) may need to be undertaken if clinically indicated. PDT is usually a planned elective procedure, and it is good practice to discuss the merits and risks of the procedure with the patient's family and members of the multi-disciplinary team (MDT). In some situations, it may be possible to include the patient in the discussions, conscious level, and capacity permitting.[7]

Technique for insertion of PDT

There are several techniques that can be used to undertake PDT. Adequate preparation is vital (see Table 3). The techniques described below all use the Seldinger method to insert a guide wire into the trachea. PDT requires at least 3 people, an anaesthetist/endoscopist, an operator, and an assistant such as an ICU nurse or technician. Capnography is now considered mandatory as it allows detection of accidental extubation, assessment of ventilation, and confirmation of correct tracheostomy placement.[7] The risk of inadvertent complications can be reduced by the use of a fibreoptic bronchoscope. Using this approach, the tracheal tube is pulled back by the endoscopist either under direct vision with a

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Table 1 Potential benefits of percutaneous tracheostomy over ST

Performed on ICU avoiding transfer to theatre
Shorter operative time
Fewer intra- and early postoperative problems
Improved cosmetic results
Reduced incidence of wound infection

Table 2 Anatomical indicators of potentially difficult PDT

Overlying scar tissue
Previous neck radiotherapy
Overlying blood vessels
Thyroid goitre
Tracheal deviation
Obesity
Fixed flexion of the neck
Unstable cervical spine
Burns
Difficult to identify surface landmarks

Table 3 Preparation before PDT. NG, nasogastric; USS, ultrasound scan; PEEP, positive end expiratory pressure.

Initial checks: correct patient, correct equipment available, consent obtained, nasogastric feed stopped, anticoagulation stopped and clotting profile acceptable, monitoring connected (capnography mandatory, invasive blood pressure monitoring preferable), consider ultrasound scan of neck
Increase sedation to anaesthesia levels
Neuromuscular block with neuromuscular blocking agent
Ventilate with 100% oxygen and adequate positive end expiratory pressure
Optimize neck position for access (a pillow beneath the shoulders will help extend the head)
Check airway with a direct laryngoscope, clear secretions within the oropharynx with suction, and make an assessment of ease of intubation
Pull back the tracheal tube under direct vision or with the bronchoscope when operator is ready and re-secure so the tip of the tube lies superior to the operative site (cuff lies within or above the larynx)
Insert bronchoscope through angle piece and orientate the view so that the operator can *identify the desired entry point*

laryngoscope or with the aid of the bronchoscope until it lies at the level of the laryngeal inlet. The operator should employ an aseptic technique and prepare the skin overlying the neck with a chlorhexidine or iodine preparation. The area should be draped and local anaesthetic with epinephrine infiltrated subcutaneously, which will act to reduce bleeding. The anatomical landmarks of the cricoid cartilage and the sternal notch should be identified. A 1.5–2 cm horizontal (or less commonly vertical) skin incision is made midway between these points, with blunt dissection of the subcutaneous and deeper tissues performed allowing palpation of the trachea (this is a matter of preference and some operators may prefer to cannulate before making a skin incision). A cannula or needle is then inserted into the trachea usually at the level of the second and third tracheal rings until air is aspirated. The bronchoscope improves the safety of the procedure by facilitating direct internal visualization of the needle or cannula in the tracheal lumen and optimal positioning, which should ideally be between tracheal rings in the midline at the '12 o'clock position' and observation of the posterior tracheal wall during tracheal dilatation. At the end of the procedure, fibreoptic bronchoscopy also allows the tracheostomy to be checked from above to ensure that the tube is adequately positioned with the cuff lying within the trachea and via the tracheostomy to ensure sufficient distance from the tip of the tracheostomy tube to the carina.

The Ciaglia serial dilatational technique

In this technique, a cannula or needle is inserted into the trachea as described previously. The guide wire is then passed in a caudal direction before a primary dilator is passed over the wire to begin dilatation of the tract. A white plastic sheath is positioned over the wire to act as a guide for the dilators. The dilator must be inserted over the guiding catheter up to a safety ridge, this is necessary to prevent damage to the curved dilator tip and kinking of the guiding catheter. Dilators of increasing size are used and once the tract is sufficiently dilated, a tracheostomy tube loaded onto the appropriately sized dilator is passed over the guide wire and plastic sheath into the patient's trachea.

Single tapered dilatational technique

This is a modification of the Ciaglia technique and uses a single tapered dilator (STD). The one-step dilatation is faster and is the commonest method of PDT used in the UK.[8]

Guide wire forceps (Griggs technique)

This method was first described by Griggs and colleagues[9] whereby following insertion of the guide wire, dilator forceps are advanced alongside the wire and into the trachea. These forceps are then opened splitting the tracheal membrane to the desired diameter to allow insertion of the tracheostomy tube. This method had a low complication rate in a series reported from a large European centre.[10]

Balloon dilatational technique

This is a relatively new method and involves the same initial stages as the STD technique, but instead of a curved dilator a pressurized balloon is used to dilate the trachea to allow passage of the tracheostomy tube (Fig. 1). It is thought to reduce the incidence of posterior tracheal wall injury because of the radial rather than co-axial forces generated. However, a recent study comparing the two techniques found that the Balloon Dilatational technique took longer to complete with increased intra-tracheal bleeding.[11] The authors hypothesized that the technique may be indicated in the presence of conditions of the trachea and oesophagus where co-axial forces are undesirable, such as cervical spine injuries or recent spinal surgery.

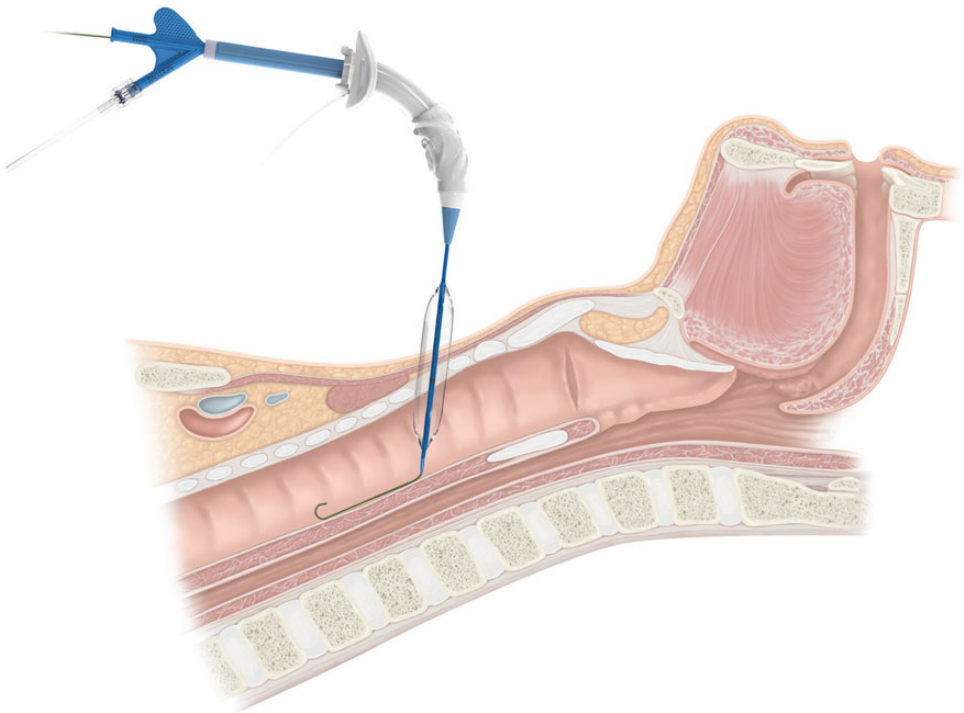

Fig 1 The Blue dolphin balloon dilatation percutaneous tracheostomy. (Permission for use granted by Cook Medical Incorporated, Bloomington, IN, USA.)

Translaryngeal tracheostomy (Fantoni technique)

Translaryngeal tracheostomy (TLT) or the Fantoni technique,[12] though not technically a percutaneous method, should also be mentioned. In this technique, after insertion of the cannula or needle into the tracheal lumen the guide wire is directed cranially and out through the mouth. The tracheal tube is replaced by a narrower tube to maintain ventilation. A special tracheostomy device is attached to the guide wire and drawn back internally through the airway and out to the surface of the neck through the opening formed by the introducer needle. The tracheostomy tube is separated from the device and rotated 180° so the open end faces down towards the carina. This technique is not widely practised and there is limited evidence to suggest that it is superior to PDT or ST. At the time of writing, a National Institute for Health and Care Excellence consultation document stated that clinicians wishing to undertake TLT should receive specific training and be experienced in using the procedure as it requires different skills compared with other methods of percutaneous tracheostomy (http://www.nice.org.uk/guidance/index.jsp?action=article&o=63758).

Timing of tracheostomy

The optimal timing of tracheostomy insertion has been widely debated. The problems associated with prolonged tracheal intubation are well recognized; however, tracheostomy is not without risk. The argument for early tracheostomy (Days 2–5) *vs* late (Days 8–10) is centred on whether early tracheostomy reduces the duration of MV and complications such as ventilator-associated pneumonia (VAP) or mortality. The evidence has been conflicting and is affected by heterogeneity in study populations and method of insertion. A retrospective review of more than 10 000 MV patients found that earlier tracheostomy (before Day 10) was associated with a modest survival benefit, weaning from MV occurred more quickly, and ventilator-free days were more frequent.[13] A meta-analysis in 2005 concluded that although early tracheostomy (up to Day 7) led to reduced ventilator days and ICU length of stay there was no effect on the incidence of VAP or mortality.[14] A further meta-analysis of seven randomized controlled trials also found no reduction in the incidence of VAP or mortality with early tracheostomy (before Day 9) and no marked reduction in duration of MV, sedation, or ICU length of stay.[15] The TracMan study included 909 patients from 87 UK hospitals comparing early (Days 1–4) *vs* late (Day 10 or more) tracheostomy. The authors found no significant difference in antibiotic use, VAP rates, or ICU/hospital length of stay and only a moderate reduction in sedative requirement in the early group. The mortality in the early and late tracheostomy groups was similar at 30 days and at 2 yr post-randomization, with a 74% follow-up rate.[16] There were, however, fewer tracheostomies performed in the late group because a significant number of patients were successfully extubated without a tracheostomy being necessary. This finding was also seen in an Italian study that again found no improvement in the incidence of VAP.[17] Although tracheostomy has many benefits for intensive care patients, early tracheostomy to facilitate faster weaning and reduction of VAP cannot be recommended.

Complications

There are a number of complications that may occur as a consequence of PDT insertion; they can be categorized as immediate, early, and late (Table 4). Complications are usually minor, but life-threatening bleeding, hypoxia, and airway obstruction have all been reported. There is no standard definition of a tracheostomy-related complication and this is reflected in the reported complication rate in the literature, which varies from 2.1% to more than 20%. There have been several large cohort studies that have reported a major complication rate of ~5%.[18,19] Because complications may be potentially life threatening, the procedure should be carried out or supervised only by appropriately trained personnel.

Immediate complications

Damage to nearby structures during PDT insertion can cause major bleeding, pneumothorax, and posterior tracheal wall damage. Tracheal ring fracture, although thought to be a minor complication may result in granulation tissue formation because of the exposed cartilage and may predispose to tracheal stenosis. In the Royal College of Anaesthetists National Audit Project 4 (NAP 4) of major airway complications in the UK, there was one case of failed PDT insertion that resulted in brain damage.[20] The PDT was placed into a false passage; it is not known whether capnography or bronchoscopy was used. However, the relatively low complication rate of PDT insertion means that it is a safe and reliable procedure when performed on the ICU.

Complications in patients with a tracheostomy

The displaced or blocked tracheostomy tube may cause dyspnoea, hypoxia, and rapid deterioration especially in critical care patients.

Table 4 Complications of PDT

Complications	Immediate	Early	Late
Minor bleeding	✓	✓	✓
Major bleeding	✓	✓	✓
Hypoxia from loss of airway	✓	✓	✓
Tracheal cartilage fracture	✓		
Surgical emphysema	✓	✓	
Posterior tracheal wall injury	✓		
Paratracheal placement	✓		
Pneumothorax	✓	✓	
Laryngeal nerve damage	✓		
Blockage		✓	✓
Displacement		✓	✓
Local infection		✓	✓
Voice changes			✓
Tracheal stenosis			✓
Persistent stoma			✓
Dysphagia			✓
Disfiguring scar			✓
Tracheomalacia			✓
Death	✓	✓	✓

There were 14 cases of displaced tracheostomies reported to NAP 4 with half of these resulting in death. Displacement often occurred during movement of patients, and a lack of capnography was seen as contributing to delays in recognition of there being a problem. Obese patients were found to be particularly at risk and problems with standard tracheostomy sizes were highlighted. If a PDT is displaced within a week of insertion, a stable tract may not have been formed making re-insertion of the tracheostomy tube difficult and potentially hazardous. The safest option for managing the airway in such circumstances is to reintubate the trachea orally and reinsert the tracheostomy using a dilatational technique with bronchoscopic guidance. Secretions, blood, or foreign bodies may cause tracheostomy blockage. The insertion of a tracheostomy with a removable inner is now recommended as it allows the tube to be easily changed and patency of the airway to be re-established in a controlled and safe manner.[7] The use of standard operating procedures for the management of the displaced or blocked tracheostomy tube and algorithms with which staff looking after patients with tracheostomies should be familiar with is advised.[21] Good communication and team working is important when undertaking PDT and even more so when managing complications; simulation may have a role in developing this.

Long-term complications

All patients who have PDT should be followed up after decannulation.[7] The follow-up rates in the literature vary widely and many studies do not follow-up patients beyond insertion, which is reflected in our limited knowledge regarding long-term complications. Tracheal stenosis is the most serious complication and may originate from the cuff site—although regular cuff pressure monitoring may help to reduce this—or more usually the site of the stoma. Patients may present with stridor or dyspnoea although many are asymptomatic. Tracheal stenosis may not become clinically apparent until the patient is well enough to exercise and generate increased airflow within the trachea. As such, symptoms may be gradual in onset and not initially attributed to the PDT. Referral to an ear nose and throat (ENT) specialist may be needed for further imaging, pan-endoscopy, and in some cases, tracheal reconstructive surgery.[22] The presence of scar tissue, wound infection, and a persistent stoma may cause problems post-decannulation. Difficulty swallowing, voice changes, and poor cough have also been reported but often improve with conservative measures.

Conclusions

PDT performed on the ICU is a safe and reliable procedure. Major tracheostomy-related complications are uncommon, but displaced and blocked tracheostomies are a cause of significant morbidity and mortality. While the insertion of a tracheostomy has the potential to improve some aspects of patient care, it is not without risk and should be carefully considered in all cases. There is little evidence to recommend early PDT in critically ill patients to facilitate weaning, reduce rates of VAP, or improve patient mortality.

Declaration of interest

None declared.

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Please see multiple choice questions 13–16.