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Review Article

Tracheostomy from Insertion to de cannulation

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ABSTRACT

Tracheostomy is a common surgical procedure, and is increasingly performed in the intensive care unit (ICU) as opposed to the operating room. Procedural knowledge is essential and is therefore outlined in this review. We also review several high-quality studies comparing percutaneous dilational tracheostomy and open surgical tracheostomy. The percutaneous method has a comparable, if not superior, safety profile and lower cost compared with the open surgical approach; therefore the percutaneous method is increasingly chosen. Standard and specialized varieties of tracheostomy tubes are available and the appropriate type is determined by patient anatomy and the indication for the tracheostomy. Fibre optic endoscopic evaluation of swallowing should be considered in assessment of bulbar function and tracheostomy weaning. A patient with a tracheostomy who develops respiratory

Distress during the ward weaning process should be investigated for upper airway pathology. Studies comparing early versus late tracheostomy suggest morbidity benefits that include less nosocomial pneumonia, shorter mechanical ventilation and shorter stay in the ICU. However, we discuss the questions that remain regarding the optimal timing of tracheostomy. We outline the potential acute and chronic complications of tracheostomy and their management, and we review the different tracheostomy tubes, their indications and when to remove them.

1. Introduction

Reports of surgically securing the airway date back to ancient times.[1] However, Chevalier Jackson is credited with the first clear open surgical (OS) description in 1909,[2] and Ciaglia is credited with the first percutaneous dilatational tracheostomy (PDT) in 1985.[3] A procedure that previously required an operating room (OR) is now commonly performed in the Intensive Care Unit (ICU).[4,5]

The present review will focus on tracheostomy as a nonemergency procedure for stable ICU patients on mechanical ventilation. A tracheostomy provides many other beneficial effects for the patient when compared with tracheal intubation. These include allowance of speech, increased comfort with oral hygiene care and suctioning, and earlier commencement of oral nutrition. We outline the insertion techniques, review the literature comparing the OS and PDT techniques and explore optimal timing of insertion.[4,6,7] We also summarize potential complications and their treatments, and the types of tubes and their optimal management. Finally we discuss when removal (i.e., decannulation) can be considered.

2. Procedural Notes

Both the OS and the PDT require similar anesthesia, analgesia, positioning and sterile preparation. The patient is positioned supine with a sandbag placed transversely behind the shoulders to extend the neck and provide optimal exposure (unless the patient requires cervical spine precautions). The head of the bed is typically elevated 15°–20° to decrease venous engorgement. Pre-procedural antibiotics are generally not given.[8]

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3. Open Surgical Technique

A 2–3 cm vertical or horizontal skin incision is made midway between the sternal notch and thyroid cartilage (approximate level of the second tracheal ring).[9,10] After division of the skin and underlying platysma, blunt dissection is continued longitudinally. Separation of the strap muscles (i.e., sternothyroid, sternohyoid) and lateral retraction exposes the trachea and overlying thyroid isthmus. The isthmus may be mobilized and retracted superiorly or divided.[11] Nearby vessels can bleed substantially, and hemostasis is achieved with electrocautery or suture ligation. Pretracheal fascia and fibrofatty tissue are cleared bluntly and the second to fifth anterior tracheal rings can be visualized. A cricoid hook can provide upward traction on the trachea, thereby improving exposure. Lateral tracheal stay sutures at the third or fourth tracheal rings can provide lateral traction and stabilization and help to define the stoma.[9]

Once hemostasis and exposure are optimized, the trachea is opened vertically or transversely with a scalpel.[10,11] A distally based tracheal-wall flap (Bjork flap) may be created or a section of the anterior tracheal wall removed. Pole retractors in the stoma maintain patency, and the endotracheal tube is withdrawn under direct vision. A suction catheter placed into the open airway can be used as a guide for tracheostomy tube insertion. Correct placement is confirmed by direct visualization, end-tidal CO_2, ease of ventilation and adequate oxygen saturation.[9] Flexible video bronchoscopy offers adjunctive confirmation and helps bronchial clearance.

4. Percutaneous Dilational Technique

Several proprietary techniques exist, but all employ a modified Seldinger technique.[12] Concomitant bronchoscopy adds a “tracheal view” that helps reposition the endotracheal tube (ETT) above the incision and helps to visualize needle placement and subsequent stomal dilatation. Bronchoscopy can also reduce posterior tracheal wall injury, confirm tube placement and help airway toilet. It is therefore strongly recommended.[13–15]

The cricoid is palpated and a 2-cm transverse skin incision made at the level of the second tracheal ring. Blunt vertical dissection is followed by tracheal puncture with a 22-gauge seeker needle followed by an adjacent 14-gauge needle connected to a saline-filled syringe.[3] Aspiration of bubbles suggests appropriate tracheal puncture. This leads to guide wire insertion followed by needle removal.

Subtle differences now distinguish the ways of creating a stoma. The Ciaglia technique uses sequential tracheal dilators (Cook Critical Care Inc.) over the guide wire. Variations of this include the Per-fit percutaneous tracheostomy introducer set (Smiths Medical) and the Percu-Twist (Meteko Instrument). The Portex Griggs guidewire dilating forceps technique (Smiths Medical) uses dilating forceps over the guidewire. The Fantoni translaryngeal technique (Mallinckrodt) requires retrograde passage of a wire parallel to the ETT. The tube is then attached to the wire. By pulling the wire and using digital counter pressure, the tube is introduced orally and placed through the anterior tracheal wall.[8] Regardless of technique, recent observational data suggest routine radiography has low yield and rarely changes management.[16]

5. Percutaneous Dilational Versus Surgical Tracheostomy

Freeman and colleagues[7] performed a meta-analysis of 5 small controlled studies comparing OS and Ciaglia PDT tracheostomy. Pooled analysis of 236 ICU patients showed no statistical difference in overall complications. However, PDT was associated with less postprocedure bleeding and stomal infections, although the definition of infection was variable. In addition, PDT was quicker than OS by 9.8 minutes. Freeman concluded that PDT is preferential in appropriately selected ICU patients.

Subsequently, Delaney and colleagues[4] performed a more in-depth systematic review and meta-analysis comparing PDT and OS. They identified 17 randomized controlled trials (involving 1212 ICU patients), evaluated trial quality and validity and performed more detailed data extraction. Nearly all PDTs (94%) took place in the ICU. For both procedures, about 50% were performed by trainees and 53% used adjuvant video bronchoscopy. Seventy-one percent of PDTs used the Ciaglia technique. Pooled analysis showed no statistical difference in mortality or major complications. The overall rate of wound and/or stoma infections, defined as those requiring systemic antibiotics, was relatively low (6.6%), but PDT had significantly less infections compared with OS (odds ratio 0.28, 95% confidence interval [CI] 0.16–0.49). Clinically relevant bleeding occurred in 5.7%, with no statistical difference between groups. Interestingly, subgroup analysis did suggest an increased risk of bleeding and death with OS compared with PDT when OS was performed in the OR. However, it was unclear if differences were from the OR transfer of unstable patients or from the procedure itself.

Another meta-analysis comparing PDT and OS[6] included pooled data on 973 patients from 15 randomized trials. Again, there were fewer complications with PDT than OS. However, this meta-analysis also found that PDT reduced long-term scarring and cost compared with OS.17 However, there was no statistical difference in peri procedural complications when both PDT and OS were performed in the ICU.

The most recent meta-analysis published to date is that by Oliver and colleagues.[17] They compared bedside PDT, operating room OS and bedside OS. Analyzing all prospective study designs revealed no difference between

PDT and OS in terms of early and late complications, but they reported a shorter procedure duration with PDT compared with OS (14 v. 24 min).

Overall, high-quality evidence confirms that PDT can be performed in the ICU at least as safely as OS. However, long-term follow-up is needed, and patients excluded from PDT owing to anatomy or coagulopathy remain inadequately studied, although emerging evidence suggests the procedure is safe in this population.[18,19] Evidence suggests that an estimated 7% of elective PDTs require conversion to OS.[6]

6. Timing of Tracheostomy

In 1989, consensus guidelines from the journal Chest recommended trans laryngeal mechanical ventilation when an artificial airway was anticipated for less than 10 days and tracheostomy when a duration of more than 21 days was anticipated.[20] They otherwise recommended daily assessmnt. Studies have included patients with burns[21] or trauma,[22] those admitted to a medical ICU[23] or those admitted to a mixed medical/surgical ICU.[5]

Rumbak and colleagues[23] performed a prospective multi centre randomized trial of 120 patients assigned to early PDT (< 48 h following ICU admission) or delayed PDT (> 14 d). They found that early tracheostomy was associated with significantly less mortality, nosocomial pneumonia, unplanned extubation, oral and laryngeal trauma and a shorter duration of mechanical ventilation and ICU admission. Prospective studies by Rodriguez,[24] Bouderka[25] and Arabi[26] and their respective colleagues showed a decreased duration of mechanical ventilation with earlier tracheostomy, although they reported no difference in mortality.

To pool data from these small heterogeneous trials, Griffiths and colleagues[5] performed a systemic review and meta-analysis of 5 randomized trials comparing early and late tracheostomy in the ICU. There was no difference in the rates of mortality or nosocomial pneumonia. However, early tracheostomy was associated with 8.5 fewer days of mechanical ventilation and 15 fewer days in the ICU.

It is surprising that, given the putative benefits of subglottic ventilation, the scientific evidence is not even more in favor of early tracheostomy. Overall, the current evidence suggests consistent morbidity benefits but not mortality benefits; however, more research is needed. Availability of PDT has played a role in promoting tracheostomy. There are several ongoing clinical trials to clarify the optimal timing of tracheostomy.[27–29] Until such data become available, we recommend that tracheostomy be performed in those patients who have an anticipated translaryngeal mechanical ventilation duration of more than 10 days. One case series reported morbidity of 4%–10% and mortality of less than 1%.[30] However, any discussion should contrast the risks of tracheostomy versus the risks of continued translaryngeal mechanical ventilation. For example, up to 19% of patients who have translaryngeal mechanical ventilation for 1–14 days experience significant laryngeal injury.[31] Furthermore, inadvertent extubation/decannulation occurs in 8.5%–21% of these patients compared with 1% of tracheostomy patients,[30] 30%–70% of whom experience adverse cardiopulmonary effects.[32]

A rare but serious early complication of tracheostomy is puncture or laceration of the posterior tracheal wall. During PDT, concomitant bronchoscopy is recommended to reduce its occurrence.[33] Airway fire is an extremely rare complication limited to open tracheostomy. Its risk can be minimized by avoiding electro-cautery when opening the tracheal wall, filling the ETT balloon with saline and using an $F_IO_2 < 100\%$.[34]

The late post-procedural complication rate is as high as 65%, but is substantially affected by the period of preceding translaryngeal mechanical ventilation.[35] Granulation tissue, with resultant tracheal stenosis, is the most frequent late complication. Most symptoms develop within 6 weeks of decannulation. Stenosis is thought to follow bacterial infection and chondritis, which weakens the anterior and lateral tracheal walls.[35,36] Although some degree of stenosis may occur, clinically important symptoms do not typically develop until the luminal diameter is reduced by 50%,[36] and the incidence of clinically important tracheal stenosis (i.e., stridor cough or dyspnea at rest or on exertion) has been reported to be between 5% and 11% at up to 1 year follow-up.[37–39] Treatment typically requires surgery; therefore, prevention is preferable. Measures include limiting the stomal size, avoiding cartilage fracture, preventing mechanical irritation of the tube on the trachea, preventing infections and keeping cuff pressures to 20 mm Hg or less.[35]

Tracheomalacia occurs in a similar fashion to tracheal stenosis, but usually with destruction and necrosis of the supporting cartilage. This loss of airway support can cause expiratory airway collapse.[35] Treatment depends on severity, but includes a longer tracheostomy tube to bypass the area, bronchoscopic stenting, surgical resection and tracheoplasty.[35] Tracheoesophageal fistula occurs in less than 1% of patients and results from damage to the posterior tracheal wall. This complication is usually caused by perioperative laceration or erosion following excessive cuff inflation, tube abrasion or a rigid esophageal nasoenteric tube.[35,36] Treatment typically requires either surgery or stenting of both the trachea and the esophagus.[35,36]

Tracheoarterial fistula is the most lethal late complication of tracheostomy, occurring in 0.6%–0.7% of patients.[40] It can occur as early as 30 hours[41] and as late as years after the procedure;[40] however, it occurs within 3 weeks about 70% of the time. Warning signs include a sentinel bleed (in up to 50%) and a pulsating tube.[40] If left untreated, mortality is 100%, and even when treated urgently about 20% of patients survive.[41] The innominate artery is, by far, the most common site, but left innominate vein, aortic arch and right common carotid artery fistulae also occur.[41] Persistent tracheal stoma (> 3 mo after the tube removal)[42] usually occurs following prolonged tracheostomy such that the tract epithelializes. Surgical closure typically requires tract débridement and multilayer closure, sometimes incorporating a muscle flap.[42]

7. Tracheostomy Tubes and Their Care

There are many different types and manufacturers of tracheostomy tubes and it is important to assess each patient carefully before planning a tracheostomy procedure. It is important to note the actual outer diameter dimensions rather than the notional size of the tube because different manufacturers produce tubes with different outer diameters. In the increasingly obese population, longer length tubes, such as the Bivona or Portex adjustable

flange tubes, are commonly required. These have a moveable flange that allows the distance between the skin surface and distal end of the tube to be adjusted according to an individual

patient's neck anatomy, so that the tube tip sits at an appropriate position in the trachea. Such tubes are usually of the single-lumen variety, although double cannula longer length adjustable flange tubes are now being produced. In addition to adjustable flange tubes, longer length standard double cannula tubes, such as the Traceo twist plus^{TM} tube, are also available. These can be used in patients with large necks and also have the additional options of both inner cannulae, fenestrations, and may be cuffed or cuff less to aid weaning.

7.1. *Other commonly used specialized tubes include*

1. **Moore tube**: This device is a soft cuff less tube that lies flush with a patient's skin surface. It is used as an airway after tracheal reconstruction and in patients with tracheal stenosis.
2. **Montgomery T tube**: This is a silicone T tube, used in specialist ENT surgery, which acts as both an airway and a tracheal stent. Like the Moore tube, it will not fit a standard catheter mount or other connectors, and therefore requires specialist knowledge and care to maintain its function.
3. **Long-term tracheostomy tubes**: Some patients require softer, shorter cuffed or un-cuffed tracheostomy tubes to facilitate management in the community or long-stay institutions. The most commonly used are the Tracoe comfort long-term tube, which is made of a soft, flexible PVC material and provides options of fenestrated and cuff less varieties, and the silver Negus cuff less tube which is a thin walled sterling silver cuff less tube that provides an option for an inbuilt. Cuffs are typically low-pressure high-volume, and ideally, cuff pressures should not exceed 25 cm H_20. Higher pressures can decrease capillary blood flow and cause mucosal ischemia.[43]

Fenestrated tubes have an additional opening in the posterior portion above the cuff.[43] This should permit upper airway airflow and facilitate speech.[44] For proper fit, the patient's stoma should be measured, and the distance from the flange to the fenestration should be 1 cm longer than that of the stoma tract.[45]

7.2. *Weaning From Tracheostomy*

As with ETT extubation, the most reliable indication for tracheostomy Dec annulation is when there is no longer a need for airway protection or mechanical ventilation. To minimize the risk of blockage, national guidance dictates that single-lumen tubes should be changed every 10–14 days, and double-lumen tubes monthly unless they are specifically designed for long-term use (e.g. the silver tracheostomy tubes). Over time, patients may have their tracheostomy tubes downsized or changed to a fenestrated or cuffless tube. These measures increase air flow through or around the tube, respectively. This in turn enables sufficient air flow to permit the external tracheostomy to be capped-off or "corked" and facilitate speech.[45] Patient speech may well increase motivation and speed recovery. It can also be promoted by placing a 1-way valve over the tracheostomy to permit laryngeal airflow during expiration. The most common example is the Passy–Muir tracheostomy speaking valve (Passy–Muir Inc.).

The steps in a typical tracheostomy weaning programme are cuff deflation, restitution of supra-glottic airway through the use of a one-way valve and/or cap, and de-cannulation. A cap occludes the tracheostomy and restores normal airflow, whereas a one-way valve opens during inspiration to allow inhalation of air via the tracheostomy tube and closes during expiration to allow air to be shunted supra-glottically. A tracheostomy team ideally comprises a physician (e.g. anaesthetist or ENT specialist), physiotherapist, speech and language therapist, and nurse.

An instrumental technique, fibre optic endoscopic evaluation of swallowing, is a bedside procedure that can be used to detect the presence of pharyngo-laryngeal secretions which may be undetected with normal bedside (clinical) assessment. This method yields a more accurate diagnosis of the extent of bulbar dysfunction and guides clinicians with regard to weaning goals. If bulbar function is assessed to be poor pre-tracheostomy insertion, suction-aid tube may be useful to assist with suctioning of saliva that becomes pooled above the cuff. Such devices may increase the tolerance of cuff deflation trials and enable the weaning process to be commenced earlier.

Some patients may be de-cannulated within a few days of initial cuff deflation, whereas others may take weeks or months to progress to 24 h cuff deflation. The progress through a weaning pathway depends on a number of factors such as cough strength, bulbar function, airway patency, endurance, and fatigue. Optimal pulmonary hygiene, inspired gas humidification, and oxygenation are critical to provide the most favorable conditions for weaning. Importantly, a non-fenestrated tube must never be capped without deflating the cuff, nor should a speaking valve be applied to a trachesotomy with an inflated cuff: this causes complete airway obstruction.

Exchanging tracheostomy tubes is typically straightforward, but requires trained personnel. Life-threatening complications include innominate artery rupture (massive hemorrhage) and tube displacement (loss of airway).[46] When exchanging a tracheostomy tube, place the patient supine with neck extension. The "classical technique" involves simple removal and insertion of a new tracheostomy tube. The "railroad technique" uses a guide, historically a suction catheter, and modified Seldinger technique.

De-cannulation before a mature tract has formed is potentially disastrous. Rapid airway loss can occur as the stoma closes. Furthermore, blind reinsertion attempts are at risk of going pretracheal. If inadvertent de-cannulation occurs before the maturation of the tract (typically 7–10 d postprocedure) then immediate preparations should be made for orotracheal mechanical ventilation. This is categorically the first and safest approach after accidental de-cannulation. The patient's neck should be extended and the tapes and skin sutures cut for better exposure. If stay-sutures are present, then gentle traction may expose the tract and stabilize the trachea for attempted re-cannulation. A laryngoscope with an infant blade offers a lighted retractor to explore the wound. Placing its blade in the trachea and lifting upward may aid reinsertion under direct vision. Alternatively, digital exploration and insertion of a suction catheter or direct bronchoscopy through the stoma can facilitate tracheostomy reinsertion via the railroad method.[46] Again, trans laryngeal mechanical ventilation is recommended.

8. Conclusion

The increasing use of tracheostomy means that comprehensive knowledge is important for modern surgeons as well as those physicians involved in the creation of and care for tracheostomies. This is underscored by the fact that tracheostomy is increasingly performed outside of an OR, and increasingly by a PDT rather than the traditional OS method. Although procedural dexterity is as important as ever, surgeons will also be expected to apply the medical literature to determine the optimal technique and timing for individual patients. With the potential for complications and the myriad of devices available, for tracheostomy, as with all surgery, "it is preferable to use superior judgement to avoid having to use superior skill."[47] procedure performed as soon as such a clinical course is identified.

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None.

10. Conflict of Interest

None.

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