Techniques for Performing Tracheostomy

Charles G Durbin Jr MD FAARC

One of the most commonly performed procedures in the critically ill, tracheostomy has been described and used for lifesaving treatment of upper-airway obstruction for at least 3,500 years. The procedure can be performed surgically in the operating room or at the bedside in the intensive care unit. Recently, percutaneous techniques performed by a variety of specialists have become popular alternatives to open surgical tracheostomy. Various devices have been developed to minimize identified risk and improve the simplicity of the procedure. These techniques and devices are described in this paper. *Key words: tracheostomy, percutaneous, intensive care unit, surgical technique, medical devices*. [Respir Care 2005;50(4):488–496.

Introduction

History of Tracheostomy

Besides being one of the most frequently performed procedures today, tracheostomy is one of the oldest described surgical procedures. It has been performed for over 3,500 years. Although it is not known when the first tracheostomy was actually placed, the procedure was probably performed by the ancient Egyptians. Possibly the earliest written descriptions are of tracheotomies performed in sheep, reported in the Babylonian *Talmud* and a similar account in the *Rig Veda*, the sacred Hindu book. The eminent Greek physician Galen credited Asclepiades with originating tracheostomy for the treatment of upper-airway obstruction due to pharyngeal inflammation in the 2nd century BC. Later physicians also performed the procedure, including Antyllus in the 2nd century AD. Successes were uncommon, and the procedure seems to have been abandoned in humans until the 1500s, when Brasavola (1546) reported a survivor. This patient was almost dead, suffering from an abscess of the windpipe; the operation was performed with a vertical incision and a tube was inserted.[1]

A major interest in tracheostomy developed during the 19th century, after Napoleon Bonaparte's nephew died of diphtheria in 1807. Research into the technique occurred, with resurrection of some of the old instruments, and use of tracheostomy for treatment of airway obstruction for diphtheria became accepted. Bretonneau and Trousseau demonstrated and popularized the technique. At this time mortality from the procedure was considered acceptable if 25% of the patients survived.[1]

Chevalier Jackson standardized the indications for tracheostomy, the technique itself, and the instruments used,

Charles G Durbin Jr MD FAARC is affiliated with the Department of Anesthesiology, University of Virginia Health Science Center, Charlottesville, Virginia.

Charles G Durbin Jr MD FAARC presented a version of this paper at the 20th Annual New Horizons Symposium at the 50th International Respiratory Congress, held December 4–7, 2004, in New Orleans, Louisiana.

Correspondence: Charles G Durbin Jr MD FAARC, Department of Anesthesiology, University of Virginia Health Science Center, PO Box 800710, Charlottesville VA 22908-0170. E-mail: cgd8v@virginia.edu.

around the turn of the 20th century. He developed anatomically correct tracheostomy tubes, recommended a "high" tracheostomy location (ring 2 or 3), and condemned cricothyroidotomy because of its high complication rate.[2] He is considered the father of the surgical specialty of ear, nose, and throat surgery, which has recently been reborn as otorhinolaryngology/head-and-neck surgery.

Percutaneous Tracheostomy

Placement of a tracheostomy percutaneously is not a new idea; pictures of devices that appear to have been developed for this purpose date back to the middle ages. A modern percutaneous tracheostomy device was developed by Toye and Weinstein in 1969, and its use in 100 trauma patients was reported in 1986.[3,4] The wire-guided percutaneous technique for percutaneous tracheostomy was developed and reported in the same year by the American surgeon, Ciaglia, who combined the Seldinger wire nephrostomy tube multiple-dilator placement technique with a special, low-profile tracheostomy tube.[5] Several variants on the percutaneous tracheostomy technique have been developed, including a wire-guided sharp forceps (Griggs technique),[6] performance of the procedure under bronchoscopic control, using a single, tapered dilator (Blue Rhino),[7] passing the dilator from inside the trachea to the outside (Fantoni's technique),[8] and using a screw-like device to open the trachea wall (PercTwist).[9] Each of these variations came about as an attempt to improve some aspect of another technique. The classical surgical approach and percutaneous techniques will be described in this paper.

Techniques of Performing an Open or Surgical Tracheostomy

Surgical tracheostomy (ST) is usually performed in the operating room on a patient under general anesthesia, but it may be performed at the bedside in the intensive care unit. Usually the airway has been secured by a cuffed endotracheal tube; however, patients with partially obstructing pharyngeal or laryngeal tumors may undergo tracheostomy with light (or no) sedation and local anesthesia. The patient's shoulders are elevated with head extension (unless cervical disease or injury is present), elevating the larynx and exposing more of the upper trachea. Prophylactic antibiotics specific for skin pathogens should be administered 30–60 min prior to skin incision. The skin from the chin to below the clavicles is sterilely prepared. If excessive hair is present, it should be removed with electric clippers immediately prior to skin preparation. Sterile drapes are placed, creating an opening from the top of the larynx to the suprasternal notch.

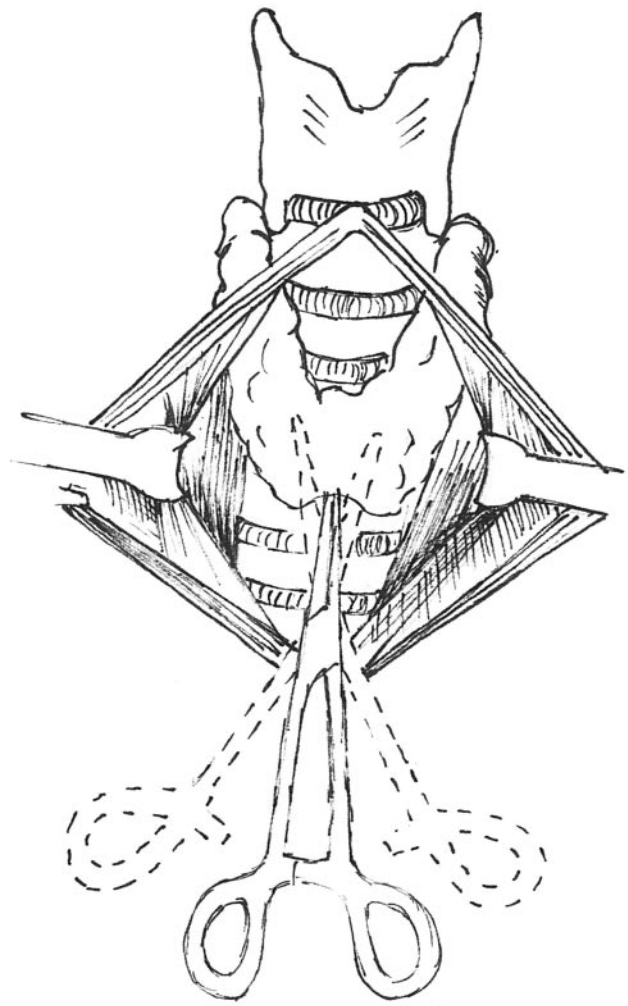


Fig. 1. Creating a surgical tracheostomy. After incising the skin and dividing the strap muscles of the neck, the thyroid isthmus is mobilized with a hemostat.

Local anesthesia with a vasoconstrictor is usually infiltrated into the skin and deeper tissues to reduce the amount of bleeding during the procedure. The skin of the neck over the 2nd tracheal ring is identified, and a vertical incision about 2–3 cm in length is created. Care to avoid cutting deeper than the subcutaneous tissues must be exercised to avoid lacerating the thyroid isthmus or a large neck vein. Sharp dissection following the skin incision is used to cut across the platysma muscle, with bleeding controlled by hemostats and ties or electocautery. Blunt dissection parallel to the long axis of the trachea is then used to spread the submuscular tissues until the thyroid isthmus is identified (Fig. 1). If the gland lies superior to the 3rd tracheal ring, it can be bluntly undermined and retracted superiorly to gain access to the trachea. If the isthmus overlies the 2nd and 3rd ring of the trachea, it must be mobilized and either a small incision made to clear a space for the tracheostomy (Fig. 2) or complete

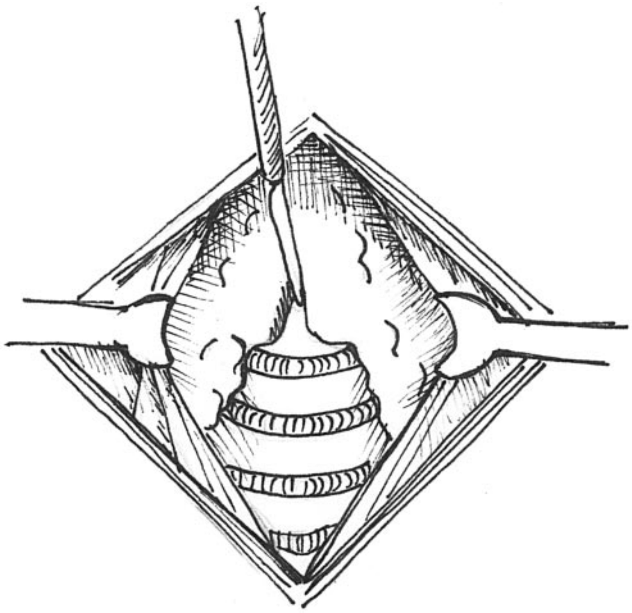


Fig. 2. Creating a surgical tracheostomy. If the thyroid cannot be retracted either superiorly or inferiorly to reveal the 2nd and 3rd tracheal rings, a small incision in the gland may be created to allow access to the trachea.

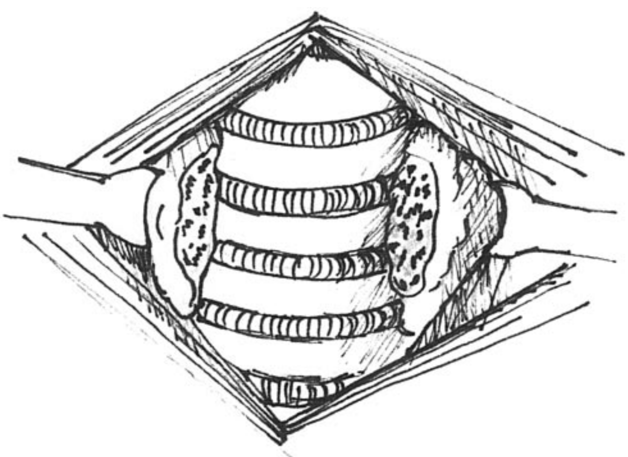


Fig. 3. Creating a surgical tracheostomy. If the thyroid isthmus remains in the way of the site of the tracheostomy, it may be completely divided, carefully ensuring there is no bleeding. This is the most common approach and gives the greatest access to the trachea.

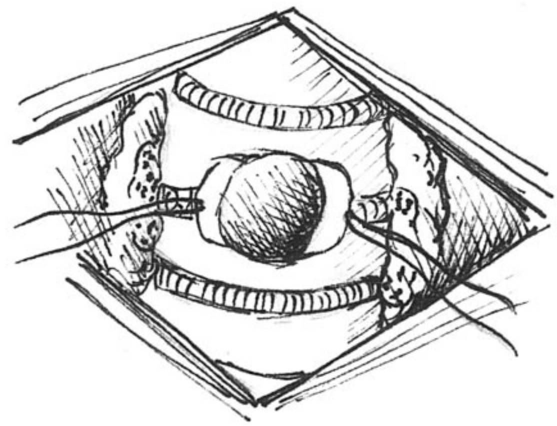


Fig. 4. Creating the tracheal portal. There are 2 basic approaches to tracheal entry. As illustrated here, the 2nd tracheal ring is divided laterally and the anterior portion removed. Lateral sutures are used to provide counter traction during tracheostomy-tube insertion. These are left uncut to provide assistance should the tube be accidentally dislodged later.

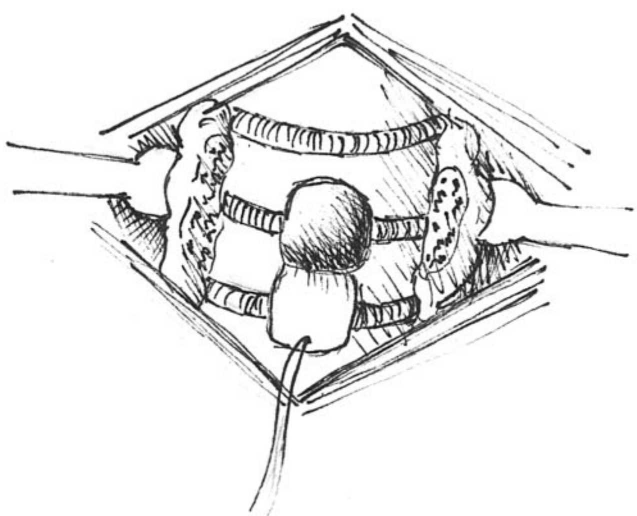


Fig. 5. Creating the tracheal portal. Instead of resecting and removing the tracheal ring, it can be used to create a flap, which can be attached to the skin. This method, described by Björk,[10] creates a stable tract for tube reinsertion.

transection of the isthmus must be accomplished (Fig. 3). Blunt dissection is continued longitudinally through the pretracheal fascia, and the desired ring (usually the 2nd ring) is identified.

One of 2 types of tracheal entry is usually used for ST. These are: complete removal of the anterior part of one of the tracheal rings to create the stoma, and creation of a flap with the severed part of the ring. In the ring-removal approach, the ring is lifted with a tracheal hook and 2 circumferential sutures are placed around the ring laterally. The portion of ring between the secured sutures is then cut and removed, leaving a hole in the anterior tracheal wall for the tracheostomy tube. The sutures are left in place and used to provide counter traction on the trachea as the tube is forced into the lumen. This is illustrated in Figure 4. The ring sutures are cut long and left out of the wound or used to secure the tracheostomy tube. These sutures can be used to identify the trachea and reinsert an inadvertently dislodged tracheostomy tube. After placement of an ST, the

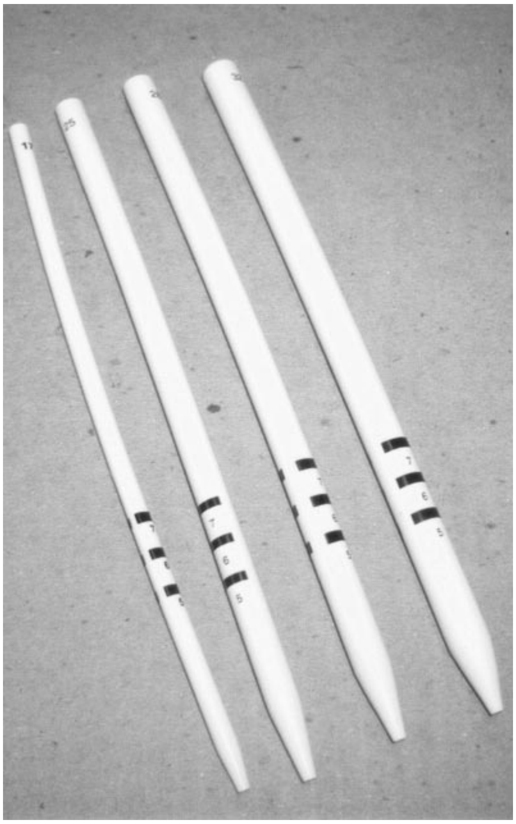


Fig. 6. Using the Ciaglia method, a series of tapered dilators are sequentially inserted over the guide wire to create the stoma for placement of the tracheotomy tube.

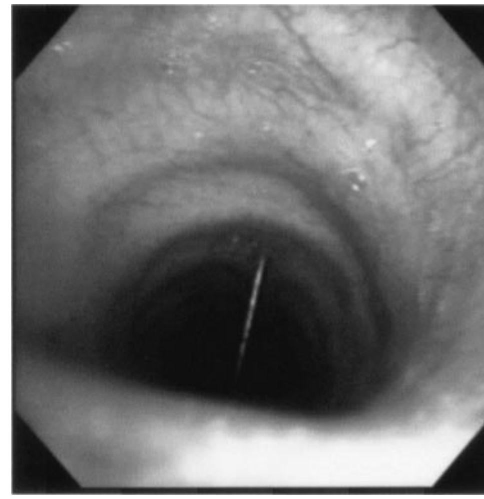


Fig. 7. Fiberopic bronchoscopy is used to help place the guide wire correctly for PDT. Here the wire is seen in the anterior part or the trachea, passing between the 2nd and 3rd tracheal rings.

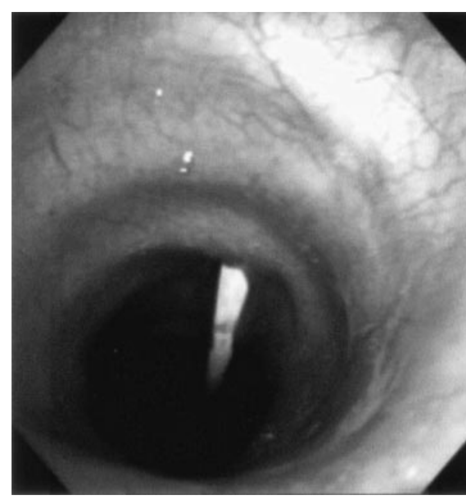


Fig. 8. Here is the bronchoscopic view of the tip of a dilator entering the trachea over the guide wire during placement of a percutaneous dilational tracheostomy.

fistula tract is not stable for at least 4–5 days, and a tube dislodged soon after placement often cannot be reinserted through the fistula into the trachea. The ring sutures may help if this situation occurs.

A second method for entry into the trachea involves creating a tracheal wall flap sutured to the skin. This is done by incising the fascia over the superior ring and entering the trachea along its inferior margin. This becomes the outer lip of the flap. Lateral cuts through the lower ring complete the sharp dissection. The flap thus created is reflected downward and attached with several sutures to the skin of the neck. This is shown in Figure 5.[10] This fistula is truly a "stoma," with tracheal mucosa approximated to the skin. The stability of this tract is believed to be superior to the ring resection-removal technique; however, no study has convincingly demonstrated this.

Percutaneous Dilational Tracheostomy

As mentioned, an alterative to ST is percutaneous dilational tracheostomy (PDT), which has become a very common method of placing a tracheostomy in critically ill patients in the intensive care unit. It is rapid, simple, easy to learn, and cost-effective. While it seems superior to ST in some respects, some studies suggest a higher incidence of short-term but important problems. Long-term problems such as scar development, tracheal cutaneous fistula, and tracheal stenosis may be less with PDT, but more data will be needed to fully assess these risks.

There are several different methods of performing PDT, the most common is that of Ciaglia,[5] in which a guide wire is placed between the first and second or second and third tracheal rings, and a series of stiff plastic dilators are sequentially forced into the tracheal wall over the guide wire

Fig. 9. Important injuries to the vocal cords are often visualized during bronchoscopy through a laryngeal mask airway.

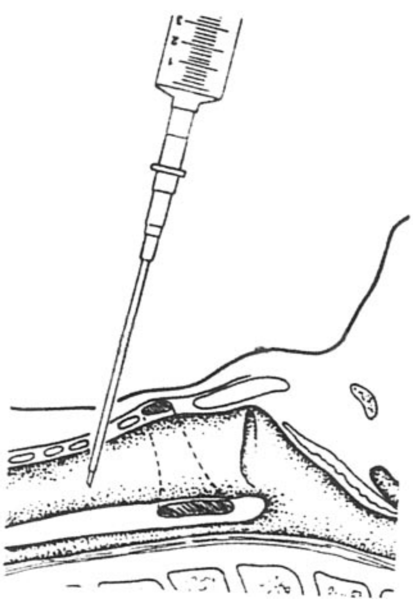


Fig. 10. An alternative to the sequential dilator technique was developed by Griggs. The trachea is entered between the appropriate tracheal rings with an intravenous catheter, with aspiration of air to confirm correct location. The needle is withdrawn and the catheter left in place as a conduit for the guide wire. (From Reference 6, with permission.)

until a stoma of sufficient size to accommodate the desired tracheostomy tube is created (Fig. 6). As with placement of an ST, a PDT is usually performed in an anesthetized patient, can be done in the intensive care unit or operating room, and requires neck extension and a sterile field. Whether prophylactic antibiotics are useful for PDT is not yet known; however, one report suggests that they should be used and be tailored to the known flora of the tracheobronchial tree.[11,12]

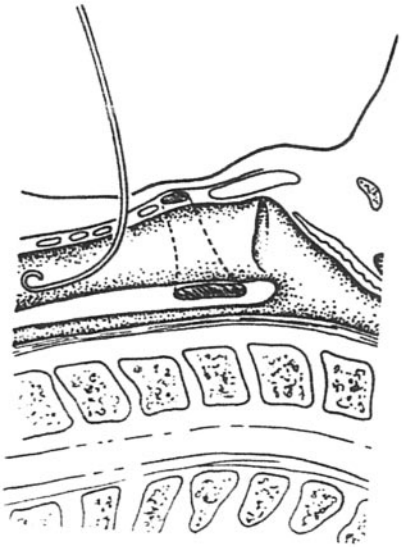


Fig. 11. The guide wire is threaded through the catheter to act as a guide for the dilating forceps. (From Reference 6, with permission.)

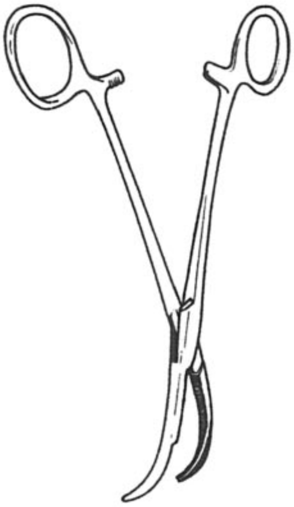


Fig. 12. This drawing depicts the sharp-tipped dilating forceps, with a channel for the guide wire developed by Griggs. (From Reference 6, with permission.)

While some clinicians continue to perform PDT blindly, most have adopted a technique of observing and directing the needle and wire placement, using fiberoptic bronchoscopy.[13] This may help prevent inadvertent injury of the membranous tracheal (posterior) wall or too lateral a location of the tracheostomy.[14] In order to visualize the upper rings of the trachea with the bronchoscope, the endotracheal tube must be withdrawn until the tip is just in the larynx. This creates a substantial gas leak, as the cuff is no longer in the trachea. Patients experiencing severe hypoxic respiratory failure may deteriorate during this time and

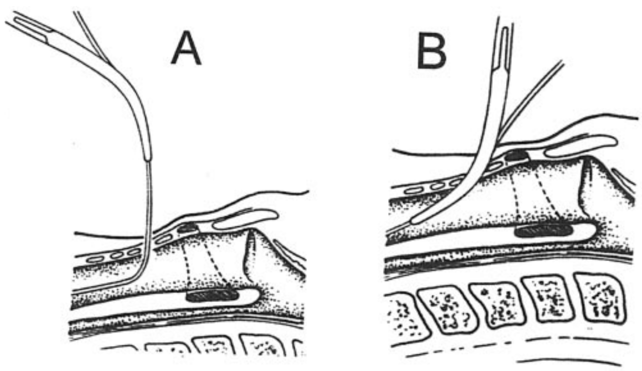


Fig. 13. Griggs forceps are passed over the guide wire and spread in the skin and soft tissues of the neck (A) and into the trachea and spread again (B), to create a route though which the tracheostomy tube is inserted. (From Reference 6, with permission.)

may benefit from conversion to ST rather than persistence with PDT.

Patients requiring a tracheostomy only for airway access or protection often can have a laryngeal mask airway replace the endotracheal tube to provide the route for bronchoscopic visualization. The view of the larynx is unhampered when performed this way, making accurate identification of the tracheal rings easy. The bronchoscopic view of the wire being placed, seen in Figure 7, was obtained this way. In Figure 8 the dilator can be seen being passed over the wire. In addition to facilitating PDT, bronchoscopy through a laryngeal mask airway often reveals important pathology of the vocal cords (Fig. 9).

An alternative to the sequential dilator technique was developed by Griggs et al.[6] Using a tracheal spreader modified to thread over the wire, this technique involves forceps dilation to create the skin path and tracheal stoma. As with the Ciaglia technique, the trachea is entered between

Fig. 14. The Blue Rhino is a single dilator that can be used instead of the sequential dilators of the Ciaglia method. The outer surface of the dilator is very slippery, making insertion very easy. The size of the stoma must be carefully controlled by limiting the depth of insertion of the dilator.

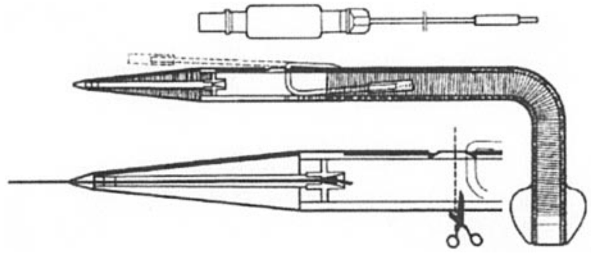


Fig. 15. Fantoni's translaryngeal placement of percutaneous dilational tracheostomy consists of a special tapered, flexible tracheostomy tube, the tip of which is cut off after placement, with the pilot balloon port secreted inside. (From Reference 8, with permission.)

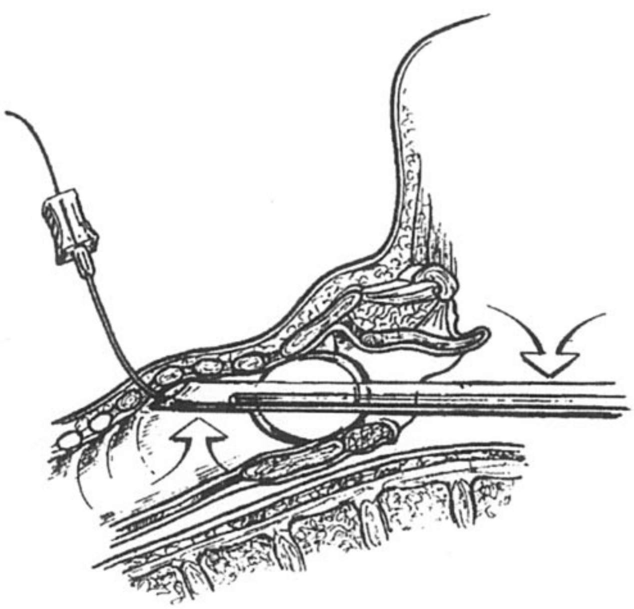


Fig. 16. After the guide wire is placed, a fiberoptic scope is used to direct the retrieval of the wire and bring it out of the endotracheal tube in Fantoni's technique. (From Reference 8, with permission.)

the appropriate tracheal rings with an intravenous catheter (Fig. 10). Aspiration of air confirms tracheal entry. Bronchoscopy can also be used to prevent incorrect placement. The guide wire is threaded through the catheter (Fig. 11). The sharp-tipped dilating forceps (Fig. 12) are passed over the wire and spread in the skin and soft tissues of the neck (Fig. 13A) and into the trachea and spread again (see Fig. 13B). A tracheostomy tube is placed over the guide wire and through the passage created. Tracheal injury may be higher with this technique (especially if performed without bronchoscopy) than the other PDT techniques.

The Blue Rhino dilator is a single, tapered dilator that is used instead of the sequential dilators of Ciaglia (Fig. 14).[15] It has a slippery coating that makes insertion very easy. It is softer and therefore (probably) less likely to damage the membranous tracheal wall. Since there is only a single dilator to pass, insertion is more rapid.[16]

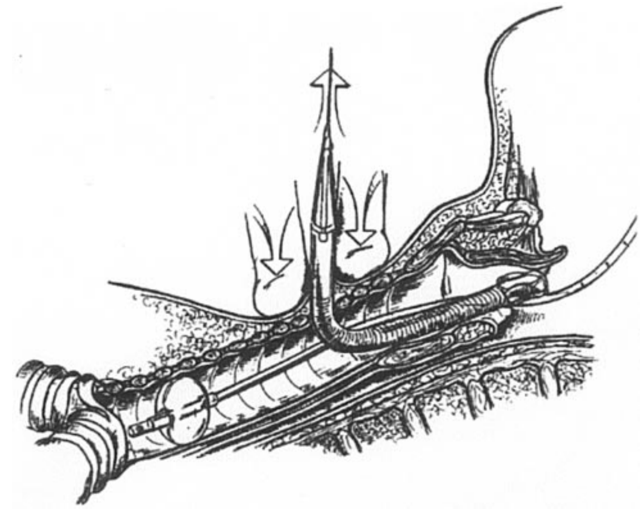


Fig. 17. The special tube is pulled from the inside through the trachea and dilates its own path. Digital counter-pressure provides tracheal stability. During placement, a small-diameter cuffed endotracheal tube can be used to support gas exchange while dilation is being performed. After placement, the dilating tip is removed, the upper part of the tube reversed in the trachea and the cuff inflated. (From Reference 8, with permission.)

A substantial amount of force is needed to insert the dilators and tracheostomy tube, which often collapses the trachea and fractures a tracheal ring. The importance of ring fracture is not known. In an attempt to prevent membranous tracheal (posterior) wall injury and protect the anterior rings from fracture, Fantoni devised a special dilating tube that is placed translaryngeally through the trachea and pulled out rather than forced in. The technique, illustrated in Figures 15–17, is complicated and there are mixed reports regarding its success at protecting the trachea.

Another attempt to solve the excessive-force problem with PDT is the PercTwist, a screw-action dilator that was designed to allow dilation with twisting while lifting the trachea rather than pushing down (Fig. 18). Reports with this method are preliminary and few.[17]

Choosing a Technique

The determining factors in deciding whether to use an ST or PDT in a particular situation include available resources (are there experienced clinicians available for either technique?) and patient factors. While there are no hard rules, some reasonable guidelines might include:

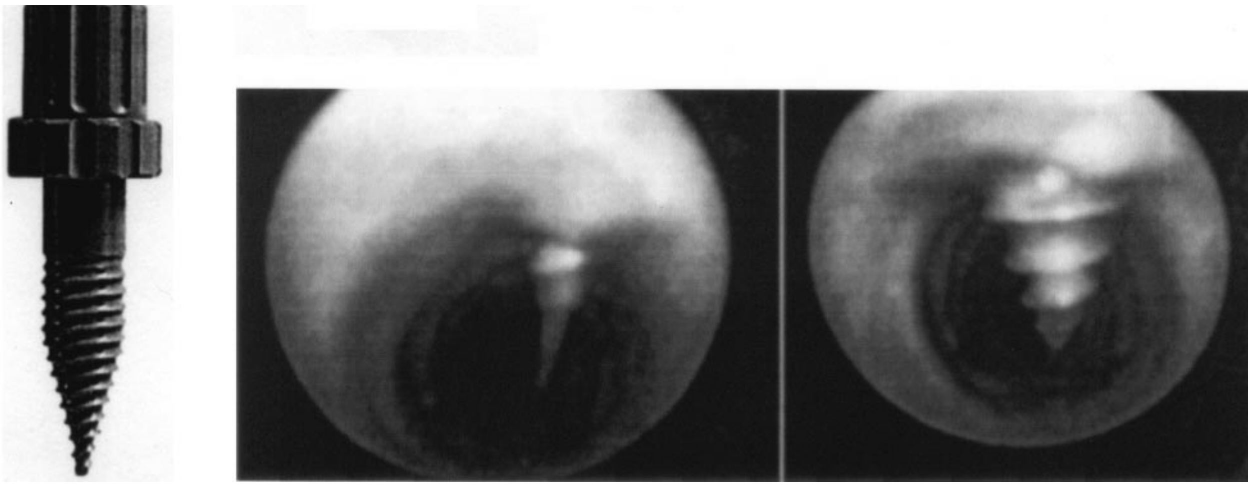


Fig. 18. The PercTwist is a screw-like dilating device, created to limit the amount of posterior force on the trachea during dilation. Here the device is shown, and what would be observed with a bronchoscope during the procedure. (From Reference 16, with permission.)

1. Coagulation abnormalities favor ST over PDT, since bleeding vessels are more easily controlled under direct vision. Limits on "how abnormal" should be in line with those set for other invasive procedures.

2. High levels of support need for oxygenation would favor ST over PDT (ie, fraction of inspired oxygen ≥ 0.7 and positive end-expiratory pressure ≥ 10 mm Hg have been suggested).

3. Patients with unstable or fragile cervical spines would favor ST over PDT.

4. Patients having recent surgical repair of neck injuries may benefit from PDT because of its lower wound-infection rate.

5. Patients with "unfavorable" neck anatomy would favor ST over PDT (ie, previous surgery, neck masses, poor neck mobility, or obesity may be more complicated for PDT).

Summary

ST has been performed for thousands of years to relieve upper airway obstruction; however, only in the past 200 years has survival of the operation been adequate to recommend its use. Currently, tracheostomy is performed in many situations and in critically ill patients with low morbidity. New percutaneous techniques offer advantages over standard open ST. However, operator experience and individual patient issues should control which technique is employed. PDT techniques are evolving and improving with time.

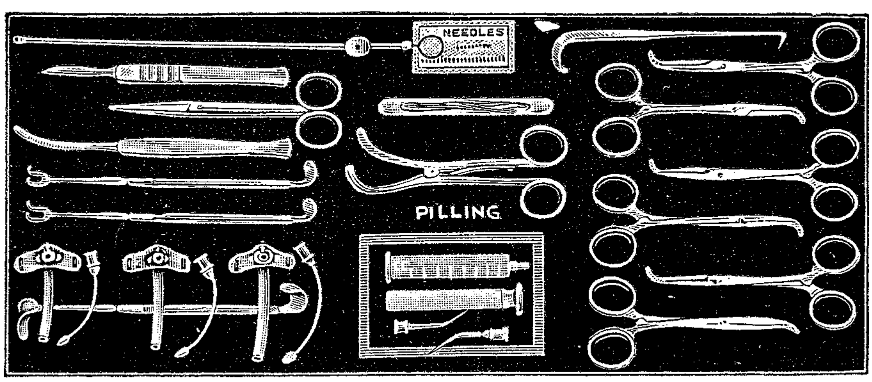
ACKNOWLEDGMENT

The author wishes to thank Brandy Durbin for her rendering of Figures 1–5.

REFERENCES

1. Borman J, Davidson JT. A history of tracheostomy: Si Spiritum Ducit Vivit (Cicero). Br J Anaesth 1963;35:388–390.
2. Jackson C. Tracheotomy. Laryngoscope 1909;19:285–290.
3. Toy[sic] FJ, Weinstein JD. A percutaneous tracheostomy device. Surgery 1969;65(2):384–389.
4. Toye FJ, Weinstein JD. Clinical experience with percutaneous tracheostomy and cricothyroidotomy in 100 trauma patients. J Trauma 1986;26(11):1034–1040.
5. Ciaglia P, Firsching R, Syniec C. Elective percutaneous dilatational tracheostomy: a new simple bedside procedure; preliminary report. Chest 1985;87(6):715–719.
6. Griggs WM, Worthley LI, Gilligan JE, Thomas PD, Myburg JA. A simple percutaneous tracheostomy technique. Surg Gynecol Obstet 1990;170(6):543–545.
7. Ambesh SP, Pandey CK, Srivastava S, Agarwal A, Singh DK. Percutaneous tracheostomy with single dilatation technique: a prospective, randomized comparison of Ciaglia Blue Rhino versus Griggs' guidewire dilating forceps. Anesth Analg 2002;95(6):1739–1745.
8. Fantoni A, Ripamonti D. A non-derivative, non-surgical tracheostomy: the translaryngeal method. Intensive Care Med 1997;23(4): 386–392.
9. Westphal K, Maeser D, Scheifler G, Lischke V, Byhahn C. PercuTwist: a new single-dilator technique for percutaneous tracheostomy. Anesth Analg 2003;96(1):229–232.
10. Björk VO. Partial resection of the only remaining lung with the aid of respirator treatment. J Thorac Cardiovasc Surg 1960;39:179–188.
11. Jacobs S, Al Rasheed AM, Abdulsamat W, Al Barrak A, Al Omer NF, Tjan D, et al. Effects of a simple protocol on infective complications in intensive care unit patients undergoing percutaneous dilatational tracheostomy. Respir Care 2003;48(1):29–37.
12. Durbin CG Jr. Bacteremia, infection, and antibiotic choices. Respir Care 2003;48(1):22–23.
13. Oberwalder M, Weis H, Nehoda H, Kafka-Ritsch R, Bonatti H, Prommegger R, et al. Videobronchoscopic guidance makes percutaneous dilational tracheostomy safer. Surg Endosc 2004;18(5):839–842.
14. Fernandez L, Norwood S, Roettger R, Gass D, Wilkins H 3rd. Bedside percutaneous tracheostomy with bronchoscopic guidance in critically ill patients. Arch Surg 1996;131(2):129–132.

15. Bewsher MS, Adams AM, Clarke CW, McConachie I, Kelly DR. Evaluation of a new percutaneous dilatational tracheostomy set apparatus. Anaesthesia 2001;56(9):859–864.
16. Byhahn C, Wilke HJ, Halbig S, Lischke V, Westphal K. Percutaneous tracheostomy: Ciaglia Blue Rhino versus the basic Ciaglia technique of percutaneous dilational tracheostomy. Anesth Analg 2000; 91(4):882–886.
17. Frova G, Quintel M. A new simple method for percutaneous tracheostomy: controlled rotating dilation: a preliminary report. Intensive Care Med 2002;28(3):299–303.



EMERGENCY TRACHEOTOMIC SET

Emergency Tracheotomic Set. *Pilling Eye, Ear, Nose, Throat and Bronchoscopic Instruments and Equipment.* Philadelphia PA: George P Pilling & Son Co 1932.
Courtesy Health Sciences Libraries, University of Washington