Interventional Pulmonology in the Intensive Care Unit: Percutaneous Tracheostomy and Gastrostomy

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Abstract

Bedside percutaneous tracheostomy and gastrostomy tube placement are cost-effective and safe techniques employed in the management of critically ill patients requiring prolonged mechanical ventilation. Both procedures have been well characterized and studied in the surgical and gastroenterology literature. Recently the performance of these procedures by interventional pulmonologists have been reported. This review focuses on the role of the interventional pulmonologist in the ICU, specifically in regard to the placement of percutaneous tracheostomies and gastrostomy tubes. We will discuss the techniques available and the relevant background data regarding choice of method and its integration into clinical practice. In addition, we discuss the creation of a multidisciplinary tracheostomy care team, its effect on patient care, hospital finances, and the interventional pulmonologists role.

Keywords

- percutaneous dilational tracheostomy
- percutaneous endoscopic gastrostomy
- interventional pulmonology
- endoscopy

Percutaneous dilational tracheostomy (PDT) and endoscopic gastrostomy (PEG) tube placement are well studied procedures which have been adopted by some interventional pulmonologists (IPs) in the treatment of critically ill patients requiring prolonged mechanical ventilation. The field of interventional pulmonology has placed itself in a unique position to adopt these procedures due to its knowledge of tracheal anatomy, rigid bronchoscopic airway management, and advanced endoscopy gained during subspecialty fellowship training.[1,2] Approximately 10% of the patients requiring mechanical ventilation will undergo tracheostomy,[3–5] with slightly more than half also having PEG placement for long-term nutrition.[6] Recent publications have illustrated that PDT and PEG are safely and effectively performed by IPs and that development of a multidisciplinary team of providers can not only improve identification of patients in need of intervention but result in a cost benefit to the institution.

Percutaneous Dilational Tracheostomy

History

Performance of PDT was first reported in 1955 by Shelden et al, whose initial report described a technique which could provide a rapidly obtained and stable airway in patients with severe head trauma. Their method involved a fixation needle, finder needle, and cutting trocar which introduced the tracheostomy tube.[7] Reports of injuries to the trachea and aorta related to the new technique suggested that the force required to place the tracheostomy via this method may have led to adverse outcomes.[8,9] Toy et al presented a similar device in 1969 which combined dilation and cutting into one instrument with the addition of a guide wire; however, the technique was never widely adopted.[10] The modern PDT era began when Ciaglia et al published their experience using serial tracheal dilations over a wire in 1985.[11]

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Surgical Tracheostomy versus Percutaneous Dilational Tracheostomy

Since its introduction, many studies, including meta-analyses have been published which have repeatedly demonstrated the superiority of PDT over surgical tracheostomy in suitable patients.[12–15] The two most recent and statistically robust meta-analyses included over 1,000 patients, with both showing a significant reduction in the risk of wound infection and length of procedure time associated with PDT. In addition, no difference in bleeding risk or mortality was noted when comparing modalities.[13,14] One of the two meta-analyses found an increased risk of decannulation and obstruction associated with PDT. The authors noted however, that complication severity was not recorded or reported.[14]

Cost has been shown to be one of the most strongly differentiating factors between PDT and surgical tracheostomy. In a single center prospective evaluation of cost-effectiveness using charge generation as a surrogate for cost, Freeman et al, showed significantly decreased costs associated with PDT.[16] In a large meta-analysis, Higgins et al, also found decreased cost associated with PDT.[14] Several authors have suggested that a substantial portion of the cost savings associated with PDT results from the avoidance of the operating room and its associated costs.[16,17]

Current Techniques for Percutaneous Dilational Tracheostomy

No consensus for performing PDT exists; however, standard practice is to perform the procedure on electively paralyzed patients under general anesthesia. This is done to reduce the risk of posterior tracheal injury.[18] When possible, the patient is positioned with the neck hyperextended and the pretrachea is evaluated for vessels traversing the working space. The cricoid and laryngeal cartilages are palpated and an insertion site between the second and third tracheal ring is selected. The pretrachea is infiltrated with lidocaine and epinephrine to promote hemostasis and provide some immediate post-procedure analgesia. Insertion is then performed using one of the following techniques.

Cialgia Technique

Ciaglia et al first reported their percutaneous technique in 1985 using a modified percutaneous nephrostomy tube placement setup. The originally proposed insertion site for the tracheostomy tube was the space separating the cricoid cartilage and first tracheal ring or the first intertracheal ring space. The site was identified by palpation and an incision made. After blunt dissection the endotracheal tube (ETT) was withdrawn to a point immediately distal to the vocal cords. A needle was then used to puncture the trachea and the ETT was manipulated. If the needle moved with ETT movement the process was repeated after further retraction of the ETT tube until there was no movement of the needle with ETT manipulation and air flowed freely through the needle. A cannula was then inserted followed by a guide wire and dilation with several additional dilators. Finally, the tracheostomy tube was introduced over a dilator and secured in place.[11]

The original technique has been further refined since its original report with regard to the dilation method and site placement. Two commercially available kits—the Ciaglia Blue Rhino (BRPDT, Cook Medical, Bloomington, IN) and Ciaglia Blue Dolphin (Cook Medical) (►**Fig. 1**)—have replaced serial dilation with a single hydrophilic dilator or an expandable balloon for dilation, respectively. Two small single-center, randomized trials comparing the Blue Rhino single dilation kit to a traditional multiple dilation kits found that the single dilation technique with the Ciaglia Blue Rhino resulted in shorter procedure time and was not associated with an increase in the complication rate.[19,20] A large multicenter study of 500 consecutive patients with a before and after design found a decrease in the complication rates after switching the multiple dilator to single insertion technique (13.6–6.5%).[21]

In a recent, small, single-center, randomized comparison of the BRPDT and Blue Dolphin, Cianchi et al, found a longer

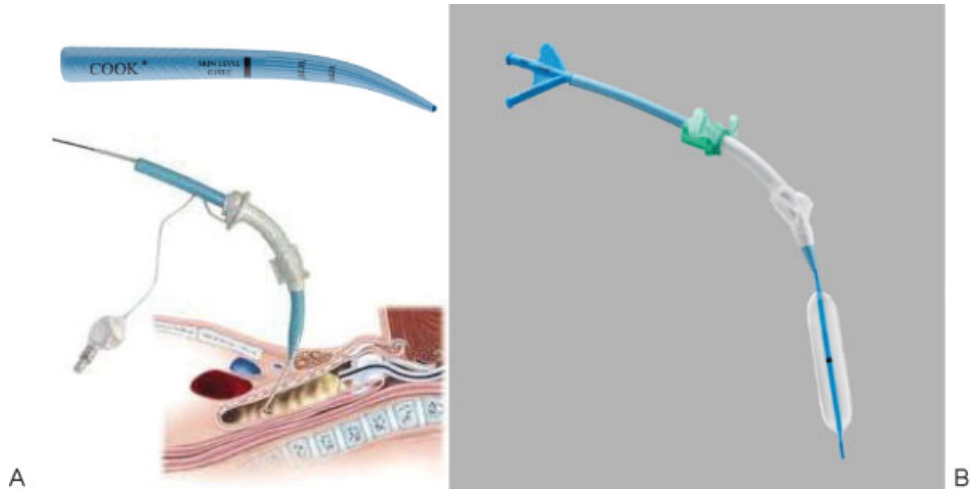

Fig. 1 (A) Blue Rhino percutaneous dilational tracheostomy introducer and procedure illustration. (B) Blue Dolphin percutaneous dilational tracheostomy introducer. Image courtesy of Cook Medical.

Fig. 2 Griggs forceps tray. Image courtesy of Smiths Medical.

procedure time, increased incidence of difficulty passing the tracheostomy tube, and an increased risk of minor bleeding associated with the use of the Blue Dolphin kit.[22]

Griggs Technique

In 1994, Griggs et al, introduced a new PDT technique which substituted a modified Howard-Kelly forceps—the Griggs forceps—designed to slide over a guide wire for the serial dilators used in the Ciaglia method (►**Fig. 2**). The initial portion of the procedure is identical to the Ciaglia method in terms of patient preparation, position, initial incision, finder cannula placement, and guide wire placement. After removing the Seldinger needle and after passage of the guide wire into the trachea the Griggs forceps are passed over the wire and used to dilate the pretracheal soft tissues and then the tracheal tissues to the appropriate diameter. A tracheostomy tube is then inserted over the wire loaded on an appropriately sized dilator. Two single-center prospective trials comparing the original serial Ciaglia dilation technique to the Griggs technique both found that the serial dilation technique took longer than the Griggs' technique.[23,24] The small, nonrandomized trial did not find any statistically significant differences in complication rates between the two methods.[23,25] The larger, randomized trial found an increase in minor and major complications (including pneumothorax, posterior tracheal injury, loss of a stable airway, and conversion to a different procedure) using the progressive dilation method.[24] Several randomized, longitudinal trials comparing the single dilation Ciaglia technique and the Griggs technique have also been conducted.[26–30] A meta-analysis of these trials found evidence of superiority of the Ciaglia technique using a combined endpoint representing procedural difficulties and bleeding.[31]

Rapitrac System

Introduced in 1989, the "Rapitrac" system utilized a dilating tool of a beveled metal cone attached to handles.[32] The method has fallen out of favor and as of the time of this writing is not widely available.

Fantoni Translaryngeal Method

In 1997, Fantoni et al, introduced a new method of PDT which represented a radical departure from the conventional methodologies to date. The impetus to develop a new technique was their desire to reduce the risk of injury to the tracheal wall and to reduce the incidence of the creation of false passages. Their method involves the introduction of a rigid tracheoscope through the vocal cords, the application of slight pressure to tent the trachea and direct visualization of the needle puncture directed cranially into the tracheoscope. A guide wire is then passed through the needle, tracheoscope, vocal cords, and out of the mouth. The needle and tracheoscope are then removed and a specialized ventilation catheter is placed into the distal trachea and its balloon inflated; ventilation is then possible while the remainder of the procedure is completed. A specialized dilation device attached to a cannula is then secured to the wire and pulled through the mouth toward the neck to dilate the stoma with the assistance of small skin incisions. Once the cannula is properly positioned the tracheostomy is secured in place.[33] In 2009, Divisi et al, reported the results of a retrospective comparison of Fantoni tracheostomy to BRPDT. They showed both techniques could be performed easily and safely, but that BRPDT was associated with fewer complications and a significant cost benefit.[34]

PercuTwist Technique

Recently, Frova et al, introduced a method of PDT aimed at reducing the risk of posterior tracheal wall injury by obviating the need for posteriorly directed force during dilation, the PercuTwist (Rüsch, Kernen, Germany). After gaining access and threading a guide wire into the trachea, a self-tapping screw is used to create the anterior tracheotomy. The procedure is conducted under direct visualization and then terminated once the widest part of the dilation tool is clearly seen.[35] The dilation tool is then removed and the tracheostomy tube is inserted. A trial comparing this method to the BRPDT reported more total complications and significantly more failed tracheostomy cannula insertions requiring a change of method associated with the use of the PercuTwist.[36]

Bronchoscopy during Percutaneous Dilational Tracheostomy

The role of bronchoscopy during PDT has evolved considerably since its introduction. Many of the initial PDT reports did not utilize direct bronchoscopic visualization; however, cadaveric evidence has suggested that blindly inserted tracheostomy finder needles are frequently misplaced.[37] Few comparisons of PDT with and without bronchoscopy are available. In one small retrospective study, Jackson et al; did not detect a significant difference in early or late complication rates when comparing PDT with and without bronchoscopy.[38] An earlier study from 2009 found that the use of video bronchoscopy was associated with a slight reduction in procedure time and a reduction in the complication rates.[39] A multicenter prospective study of conventional directly visualized bronchoscopy versus video bronchoscopy found an increased subjective feeling of operator safety using video

bronchoscopy and a reduction in complication rates.[40] In an informal aggregate comparison of 15 studies involving 1,385 patients, Hsia et al, reported a reduction in PDT procedural complication rates when using bronchoscopy (16.8 vs. 8.7%).[41]

Despite the relative paucity of comparative data, survey data show that more than 70% of the European intensive care units perform PDT with video-bronchoscopic guidance.[42–45] Data quantifying the frequency with which bronchoscopic guidance is used in the United States is lacking. Though the evidence does not strongly support the use of bronchoscopy during PDT, data exist that its use potentially reduces complication rates with no real associated increase in risk.

Complications of Percutaneous Dilational Tracheostomy

Although safe and effective, PDT is not without risk. Of complications known to be associated with PDT, trachea-innominate artery fistulas and posterior tracheal injury tend to be the most feared.[46–48] Other rare complications include loss of the airway during placement, errant placement of the tracheostomy tube, subcutaneous emphysema, pneumomediastinum, pneumothorax, infection, tracheal stenosis, significant bleeding, and death.[49–51] As with other procedures, prevention is paramount and the risks of performing PDT on the critically ill patient should be weighed carefully against the benefits. The proceduralist should carefully consider the ventilator settings, coagulation parameters, airway land marks, hemodynamics, and integrity of the superficial tissue before proceeding with PDT.

Percutaneous Endoscopic Gastrostomy

History

Like tracheostomy, gastrostomy tube placement was originally a purely surgical procedure associated with initially high mortality rates.[52] In 1980, Gauderer et al reported the first successful percutaneous placement of gastrostomy tubes in both children and adults.[53] PEG placement has subsequently replaced surgical gastrostomy placement as the procedure of choice for chronic enteral access.[54] The focus of this review will be on endoscopic methods; however, radiology-guided methods are available as well.[55]

Current Techniques for Percutaneous Endoscopic Gastrostomy Placement

As with PDT there is no uniform standard method for PEG placement. While often performed under general anesthesia and paralysis as a result of placement after PDT, this is not necessarily required for PEG placement. Antibiotic prophylaxis with cefazolin or vancomycin, the latter if there is a risk of methicillin-resistant *Staphylococcus aureus*, is recommended.[56] The two primary means of PEG placement which we will discuss are as follows: the "pull" and "introducer" techniques.

Pull Technique

Originally, this method involved using anatomic landmarks to determine a puncture site, however, this has largely been replaced by the use of transillumination of the abdominal wall and finger indentation via direct endoluminal visualization.[57] After insertion of an endoscope into the stomach, insufflation and subsequent identification of an insertion site, local anesthesia is infiltrated subcutaneously. A skin incision is then made and a needle-catheter combination is inserted across the stomach wall under direct visualization. The needle is then removed; a loop is inserted through the catheter and grabbed by a wire loop. The loop is then dragged up the esophagus and out of the mouth where it is attached to the gastrostomy tube and pulled back down the esophagus to the stomach then through the skin and secured in place.[53]

Introducer Technique

The "introducer" method is similar to the original pull technique. A suitable puncture site is identified using transillumination and the stomach is insufflated. After obtaining access with a finder needle, a peel-away sheath is then placed. The PEG tube is fed through the peel-away sheath and the retention balloon inflated. The sheath is then peeled away and the tube secured in place.[57]

Technique Comparison

The comparative literature on the various PEG placement methods as well as to surgical placement is not as robust as that available for PDT. Few randomized controlled trials comparing PEG tube placement versus traditional surgical gastrostomy have been published. Those that have been published have found no differences in safety or complication rates.[58,59]

Complications of Percutaneous Endoscopic Gastrostomy Placement

PEG placement has been shown to be safe and effective; however, the risks specific to the procedure exist and include intraperitoneal and portal venous gas, colon injury or fistula, small bowel injury, liver injury, splenic injury, bleeding, and catastrophic hemorrhage.[60,61] Postprocedural PEG tube maintenance is necessary to avoid local complications[60]; the specifics of proper postprocedure tube care are beyond the scope of this review.

Role of the Interventional Pulmonologist in PDT and PEG Tube Placement

As experts in endoscopic manipulation of the airway, PDT and PEG are natural procedures for the IP. While this may be true, only recently the data has been reported to support this idea. In regards to PDT, a recent retrospective analysis of the IPs performance of the procedure reported no difference in complications and a trend toward decreased time to PDT after consultation for PDT placement when comparing patients undergoing PCT performed by IPs and their surgical counterparts.[62] IP PEG placement has also recently been evaluated. Yarmus et al reported data from a prospective study specifically addressing the safety of PEG tubes placed by IPs. The study showed a 97.2% success rate at placement with a 1.4% complication rate. The only complication was minor.[6]

These studies provide early evidence that IPs can safely perform both PDT and PEG placements.

Multidisciplinary Tracheostomy Service

Recent data have reported on the creation of a multidisciplinary tracheostomy care team at a large tertiary care academic hospital aimed at improving patient care and the financial profile of PDT and PEG placement.[63,64] This service consists of proceduralists (otolaryngologists, trauma surgeons, and IPs), anesthesiologists, a nurse practitioner, a coordinator, an equipment specialist, nurses, respiratory therapists, and speech and language pathologists. The service monitors potential tracheostomy patients (defined as intubation for $\geq$ 96 hours) and begins following the patients from the time the procedure is requested by the primary care team to the time of patient discharge. Implementation of the service has resulted in a marked decrease in major complications (25.4% preimplementation and 4.9% postimplementation), a reduction in wait time for the performance of tracheostomy (2.6 ± 3.0 days preimplementation and 1.3 ± 1.9 days postimplementation), an increase in frequency of the performance of PDT (46.8% preimplementation and 77.2% postimplementation) and a net positive financial effect for the hospital.[64] Other similar programs have been reported but no results are available to date.[65] Several other reports of tracheostomy-centered multidisciplinary teams have been published and appear to support the recent findings.[66–69]

Conclusion

PDT and PEG placement are safe and cost-effective procedures performed on patients requiring prolonged mechanical ventilation a typically in the intensive care setting. The IP as a pulmonary and critical care practitioner with specialized training in endoscopic procedures and airway management is a natural fit to perform these procedures. In addition, the formation of a multidisciplinary team of providers appears to be associated with improved outcomes, wait times for patients, and hospital financial data.

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