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Percutaneous Tracheostomy at the Bedside: 13 Tips for Improving Safety and Success

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Abstract

We have developed a set of routines and practices in the course of performing a large series (n = 70) of percutaneous dilational tracheostomy (PDT). The 13 tips discussed in this review fall into 4 categories. System factors that facilitate training, patient safety, and avoidance of crises including the use of appropriate personnel, importance of timing, use of premedication, and the utility and content of a preprocedure briefing. Suggestions to prevent loss of the airway include tips on airway assessment, preparation of airway equipment, and use of exchange catheter techniques. Strategies to avoid and manage both microvascular and large-vessel bleeding are discussed. We also discuss the management of common postprocedure problems including tracheostomy tube obstruction, malposition requiring tube exchange or replacement, and air leak. The practical considerations for successful execution of PDT involve common sense, thorough planning, and structured approaches to prevent adverse effects if the procedure does not go as smoothly as expected. These strategies will aid anesthesiologists and intensivists in improving their comfort level, safety, and competence in performing this beside procedure.

Keywords

percutaneous dilational tracheostomy, percutaneous tracheostomy, Blue Rhino, bedside tracheostomy, safety, procedure checklist, ICU tracheostomy

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Introduction

Percutaneous dilational tracheostomy (PDT) has gained acceptance as an alternative to surgical tracheostomy for providing a long-term secure airway to facilitate rehabilitation and discharge of critically ill patients. It can be performed at the bedside by critical care physicians with minimal additional resource utilization and has a safety and efficacy profile comparable to surgical tracheostomy,[1] even in obese patients.[2] In most settings, it is more cost effective than the latter due to elimination of the need for transport to and from the operating room (OR) as well as the need and expense of scheduling and coordinating OR, nursing, and surgeon availability.[3]

Expansion of the skill set of physicians to include PDT can increase their efficiency and flexibility in providing comprehensive care to the critically ill patient. Instead of waiting until a consulting service that does not know the patient is available to perform a procedure, the intensivist adds this to the realm of the care they are already providing. However, manipulation of the airway while sacrificing a functional ventilation system constitutes a high-risk endeavor that may deter the provider from learning and performing this procedure. With great respect for the inherent risks, we have developed a set of routines and practices in the course of performing a large series of PDT which can be easily incorporated into practice and which we believe increases the safety margin of this procedure.

Case Series Description

The PDT was performed 70 times by a single anesthesiology-trained intensivist (GKL) in a single institution between 2004 and 2010. In this case series, 70 (100%) patients were male.

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Table 1. Case Series Outcomes and Complications.

	N	%
Procedure successfully performed at bedside	69	99
#8 tube on initial placement	65	93
Report of tight fit	6	9
#6 tube on initial placement	5	7
#6 tube changed to #8	2	3
Mild bleeding	6	9
Portable cautery used	4	6
Ligation of vessels required	2	3
Moderate bleeding	1	1
Major bleeding	0	0
Preprocedure transfusion of FFP or platelets	5	7
Loss of airway requiring reintubation	0	0
Total	70	

Age (mean ± standard deviation) was 68 ± 10.1 years; body mass index was 26 ± 6.5 kg/m^2.

The procedure consisted of a single step over dilation technique under fiberoptic guidance using a commercial kit (Blue Rhino; Cook Critical Care, Bloomington, Indiana) based on the procedure initially described by Ciaglia et al.[4] Our standard practice includes the following amendments. The procedure is performed with the maximal tolerable degree of neck extension. A full-body drape and standard chlorhexidine gluconate (CHG; 2%) skin preparation are used. Analgesia is provided by a combination of deep intravenous sedation and 1.5% lidocaine with epinephrine 1:2 00 000. Enteral feeds and anticoagulants are held as in operative cases, and whenever possible, nasoenteral feeding tubes are left in place. After hemostasis is achieved following subcutaneous dissection of the neck through a 1- to 1.5-cm skin incision and prior to needle entry into trachea, muscle relaxation consisting of 5 to 10 mg cisatracurium is given to facilitate reintubation if needed and to minimize patient motion. After placement, the bronchoscope is passed through the lumen of the tracheostomy to confirm the position, and the wings of the tracheostomy are secured with 4 interrupted sutures. If the procedure cannot be performed successfully and safely, the backup plan is for surgical tracheostomy in the OR, and a surgical team is made aware of each scheduled percutaneous procedure.

In this case series, PDT was performed successfully in 69 (99%) of the 70 patients. Outcomes including complications are shown in Table 1. The vast majority of our patients received a #8 Shiley tracheostomy tube. As shown, a few received a #6 tube due to tracheal resistance on insertion, but 40% of the latter required upsizing to a #8 due to poor tracheal fit and leaks—presumably resulting from tracheal widening of the existing tracheal tube.

Minor bleeding was defined as microvascular bleeding that could be controlled by injection of lidocaine with epinephrine, direct manual pressure, use of portable electrocautery, or tamponade by insertion of the tracheostomy tube. Bleeding was defined as moderate if it required clamping and ligation of a ruptured blood vessel to obtain control. This situation occurred in 1 patient with dilated neck veins from an unappreciated superior vena cava clot—the only case that we chose to defer completion at the bedside. After hemostatic control, the neck incision was closed, and the procedure was resumed 2 days later in the OR. In another patient, a prominent vein crossing the incision was ligated with sutures to prevent rupture. Major bleeding was defined as hemorrhage requiring transportation to the OR or consultation of a surgical service to obtain control or hemorrhage requiring periprocedural use of blood products. This latter complication did not occur in our series.

The rate of complications experienced in our series is consistent with that reported by Cosgrove et al[5] in a large case series of PDT using the Blue Rhino system: a 3% rate of major complications (bleeding requiring surgery, desaturation, tension pneumothorax, or false passage) and a 18% rate of minor complications (bleeding controlled by pressure, tracheal tube or cuff puncture, air leakage, tracheal wall injury or subcutaneous emphysema, hypotension, or difficult tracheostomy placement).

Discussion: 13 Things You Need to Know to Perform PDT

There is still a lack of consensus regarding the optimal technical and practical aspects of PDT. A recent systematic review revealed a wide range of procedural techniques, with the suggestion that better outcomes are achieved with single-step dilation (compared to guide wire dilating forceps, rotational dilation, retrograde tracheostomy, and balloon dilation techniques).[6] However, this remains suboptimal evidence. In our view, the most important consideration is to use a technique with which you are comfortable.

Our experience is based on the exclusive use of the Blue Rhino system as described above; however, our experience is applicable to any percutaneous technique.

Although no serious complications were encountered, the occurrence of minor complications (desaturation, minor bleeding, hypotension, and endotracheal tube cuff rupture) and other colleagues' reports of near-miss problems with communication and preparedness led us to formulate the following guide to improving performance of and comfort with PDT. Our suggestions fall into 4 categories: (1) system factors that facilitate training, patient safety, and avoidance of crises, (2) suggestions to prevent loss of the airway, (3) suggestions avoidance and management of excess bleeding, and (4) strategies to manage common postprocedure problems.

Tips for Creating a Safe System

Our general philosophy is that we are not only performing an important procedure but also instituting a system of care that needs to assume responsibility for its training, complications, and overall reputation.

Use Appropriate Personnel

We believe that 2 skilled proceduralists are necessary for PDT to be performed safely. One is the primary operator in charge of the tracheostomy. The second skilled position is a provider capable of expert, independent airway management and will be entirely dedicated to this task during the procedure. He or she will operate the fiberoptic bronchoscope, reposition the endotracheal tube, assess oxygenation and ventilation during the procedure, manage problems of air leak, cuff rupture, and endotracheal tube malpositioning, and be empowered to pause the procedure to reintubate if the current airway is inadequate. Since the tracheal tube is withdrawn to the level of the vocal cords during the procedure, we prefer to have a respiratory therapist present to hold the tube, while the primary airway manager is manipulating the bronchoscope; however, it is our view that it is unsafe to have a respiratory therapist or bedside nurse in charge of the airway or a proceduralist to be trying to perform or supervise this role at the same time, as he or she is trying to perform the tracheostomy. We also use a second operator, typically a fellow or a senior resident, who is learning the procedure under the guidance of the attending/primary operator.

Pick a Safe Time

Schedule the procedure in the daytime, when additional assistance will be available, if needed. In many settings, it will be convenient to schedule it immediately after intensive care unit (ICU) rounds. Earlier in our experience, we discussed contingency plans with the ear, nose, and throat (ENT) service, and from these discussions, we chose to perform the procedure on days when ENT had block time in the OR and therefore were available to assist, although they were not at the bedside for every procedure. On one occasion, a senior ENT surgeon was asked to provide advice on improving exposure and access to the tracheal rings. This facilitated successful completion of a procedure that otherwise would have been aborted in favor of surgical tracheostomy in the OR. Depending on the hospital environment, trauma surgery may be a more reliably available consulting service to be available to assist, if ENT services are not always available in-house.

Premedications

Due to the creation of a passage between the oropharynx and the upper trachea, we have developed the empiric practice of administering CHG (1%) mouthwash within 30 minutes of the procedure. Although there are no specific data demonstrating a decrease in infectious complications of PDT, oral CHG-reduced colonization and ventilator-associated pneumonia[7,8] are now part of the standard infection control bundles in many ICUs.

Sedatives and analgesics are administered by boluses and infusions in preparation of the procedure to render the patient barely responsive to painful stimulation. As a final test of sedation depth, 5 to 7 mL of 1.5% lidocaine with epinephrine is injected to the lower neck and suprasternal area corresponding to the area of skin incision. This verifies the quality of analgesia as well as allows additional soak time for the epinephrine to minimize the microvascular bleeding. It should be noted that the benefits of vasoconstriction from the use of an anesthetic solution that contains epinephrine should be balanced with the potential concern for the hemodynamic effects of intravascular injection or absorption. The local anesthetic in the kit is used later, if additional local analgesia or vasoconstriction is needed.

Conduct a Preprocedure Briefing

Prior to the procedure start, we conduct a briefing and a dry run through of the procedure to clearly establish the roles and communication pathways during the procedure. This process supplements the usual procedural time-out. Common complications are reviewed during the briefing, with explicit planning for how the team will recognize and respond to the following:

1. inadequate ventilation
2. excess bleeding
3. hypotension
4. inadequate analgesia

All fellows who are performing the procedure for the first time are required to watch an instructional film prepared by the manufacturer (available at Cook Critical Care website as well) and to review the kit and its contents prior to performing the procedure with an attending. Both the film and a demonstration kit are kept in the ICU. Simulation has been increasingly used to prepare fellows for their first procedure,[9] and we believe this option will improve the education and safety as more practitioners incorporate PDT into their skill set.

Minimizing Airway Compromise

In the course of tracheostomy placement, the endotracheal tube is untaped and withdrawn, and it is subject to rupture of the distal cuff by entry of finder and guidewire needles in the anterior trachea. We consider it imperative to regain the airway at all phases of the operation. A number of techniques are utilized to assure this goal.

Assess the Airway

Review records from prior intubations and assess the degree to which intercurrent clinical events may have changed the patient's airway. If the patient was previously intubatable via direct laryngoscopy (DL), then we believe it is important to paralyze the patient and repeat a diagnostic DL immediately prior to the PDT procedure, with the current endotracheal tube in situ. This maneuver will help reveal the degree to which common airway changes associated with critical illness (eg, secretions, blood, and edema) have altered the airway anatomy. Theoretically, paralysis is not necessary for PDT, but we believe its routine use adds a margin of safety by permitting effortless laryngoscopy and reintubation.

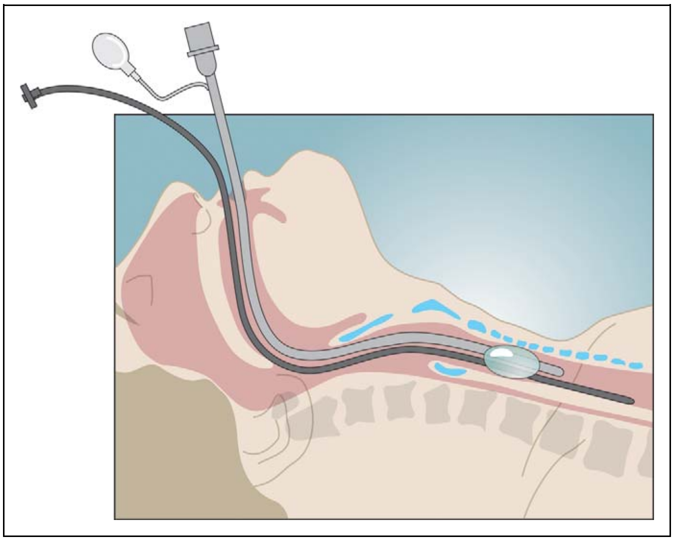

Figure 1. Saggital section of head and neck demonstrating the extraluminal exchange catheter technique. The trachea is intubated with the exchange catheter under direct vision or with a videolaryngoscope. Ideal catheter position is just proximal to the main carina; this is confirmed by fiberoptic scope inspection during the procedure.

Have Airway Equipment Within Reach

A laryngoscope with appropriate blade and a tested, styletted tracheal tube are immediately available. We are aware of other providers who have ruptured a tracheal tube cuff during the procedure but did not have equipment readily available to perform reintubation. Acquisition of equipment and reintubation can prove to be a terrifying experience in this instance. We find that with an experienced airway manager and anticipation of this complication, it can be handled calmly as a minor complication when it does occur. In all cases of cuff rupture in our hands (approximately 10% of procedures), we found the leak tolerable and of negligible ventilatory significance wherein tube replacement was not required. Still, we leave it up to the airway manager to constantly assess the adequacy of airway and ventilation and reintubate if needed. A bronchoscopic tower is part of our ICU's difficult airway cart, so with its presence, we have backup airway equipment, including a laryngeal mask airway, additional laryngoscopes and endotracheal tubes, and any additional airway equipment that would be routinely available in managing an ICU intubation.

Prevent Difficult Airway Crises

Our first 30 PDT procedures were conducted on a patient who had airways that were not considered difficult. Patients with known or anticipated difficult intubation were referred for open surgical tracheostomy. With experience, we determined that the use of an airway exchange device adds an adequate margin of safety to allow PDT even in patients with a difficult airway. The DL is performed, and a Bougie or airway exchange catheter is placed alongside the tracheal tube through the larynx and inserted to a depth of 1 cm above the carina to provide a stable conduit for reintroducing a backup tube, if needed (Figure 1). The position is confirmed with fiberoptic inspection through the existing tracheal tube; the catheter is not inserted blindly or to excessive depth, to avoid the risk of airway perforation. Depth is maintained with careful attention to printed depth guides and a pen mark made at the level corresponding to the teeth. The diameter of the exchange catheter does not interfere with the placement of the tracheostomy tube or dilators. The exchange device is withdrawn once the location of the tracheostomy tube has been verified by bronchoscopic inspection. This inspection should include examination of the area above and immediately below the carina to exclude any evidence of trauma from the Bougie or exchange catheter. If any difficulty was encountered in maintaining controlled depth or any significant force was used during insertion of the Bougie or catheter, a more thorough examination of the distal airways should be performed to rule out airway perforation.

Tips for Avoiding Hemorrhage

Avoid Microvascular Bleeding

There are no specific consensus guidelines regarding acceptable coagulation thresholds for the performance of PDT, but a recent review of coagulation parameters in bedside procedures (percutaneous gastrostomy and PDT) found a minor bleeding rate of 5.1% in PDT. There was no association of bleeding complications with coagulation parameters (prothrombin time, international normalized ratio [INR], or partial thromboplastin time), but they did observe a lower average platelet count in those patients who experienced a bleeding complication.[10] Our practice has been to use similar thresholds for other invasive procedures (eg, INR < 1.5 and platelet count > 50 000), and when in doubt as to the clinical relevance of a coagulopathy, perform a simple bedside clotting test consisting of placing 5 mL of whole blood in a red top tube. If it produces visible clot in less than 5 minutes (others have proposed a threshold of 10 minutes), the clinical ability to form clot is adequate. As discussed above, all procedures are preceded by preinjection of lidocaine with epinephrine to maximize vasoconstriction.

Avoid Arterial and Venous Bleeding

Our single complication in this series of PDTs was venous bleeding in a fairly obese patient who had superior vena cava syndrome. All neck vessels were dilated and fragile. Identified veins were suture ligated, and the procedure was aborted. Surgical tracheostomy was performed in the OR 2 days later, at which time the surgical team noted it to be technically challenging for similar reasons of vascularity. A brief bedside ultrasound examination with color Doppler can be conducted prior to the procedure to identify and allow marking of superficial vessels near the midline. To minimize vascular injury, we adopted a practice of using a vertical midline incision rather than the manufacturer-recommended horizontal incision.

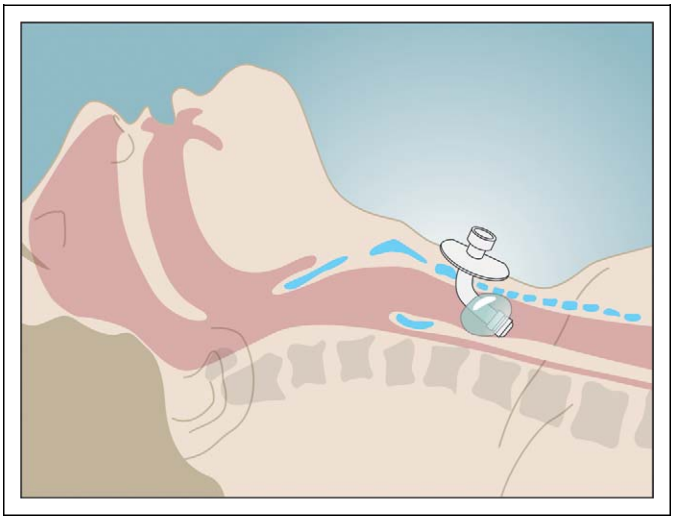

Figure 2. Obstruction from malseated tracheostomy tube. The solution to this problem is often performing a reseating of the tracheostomy tube using an in-and-out rocking motion over an exchange catheter.

Have a "Bleeding Kit" Ready to Use

Following skin incision, subcutaneous tissue is spread by a combination of blunt and sharp dissection using small clamps in the tracheostomy kit. Occasionally, a blood vessel is encountered, which bleeds despite injection of epinephrine. Although it is likely that the tracheostomy tube will eventually create enough pressure around the area to stop bleeding, we have a disposable, battery-powered electrocautery unit ready to use in this situation. This instrument is kept in a sterile package at the bedside and is not opened unless needed. In the preprocedure briefing, we identify that the cautery is present and may be requested. Additional components of our bleeding kit are small right-angle forceps and 3.0 silk ties, which are used to tie off any large visible vessels encountered during dissection. In our series, silk ties were used once (1%) and electrocautery in 4 (6%) patients.

Managing Postprocedure Problems

In our experience, the 2 most common postprocedure problems are obstruction and leak. With a patient sedated and paralyzed for the procedure, presence of these problems may not be apparent until the patient begins to move around or sit up.

Managing Obstruction

Obstruction commonly occurs due to a poorly seated tracheostomy tube, with cuff malposition such that the cuff partially occludes the airway distal to the tracheostomy lumen (see Figure 2). It is common for obstruction to worsen with greater cuff inflation. The first step is to place a bronchoscope through the tracheostomy lumen. Often, the distal lumen will be observed to be opposed to the posterior tracheal wall. A simple fix is often achieved by deflating the tracheostomy cuff and reseating it with an in-and-out rocking motion. Resuturing may be necessary. If there is any question regarding position, this and other manipulations are best done with an intraluminal bronchoscope to confirm placement and prevent loss of the immature tracheostomy tract.

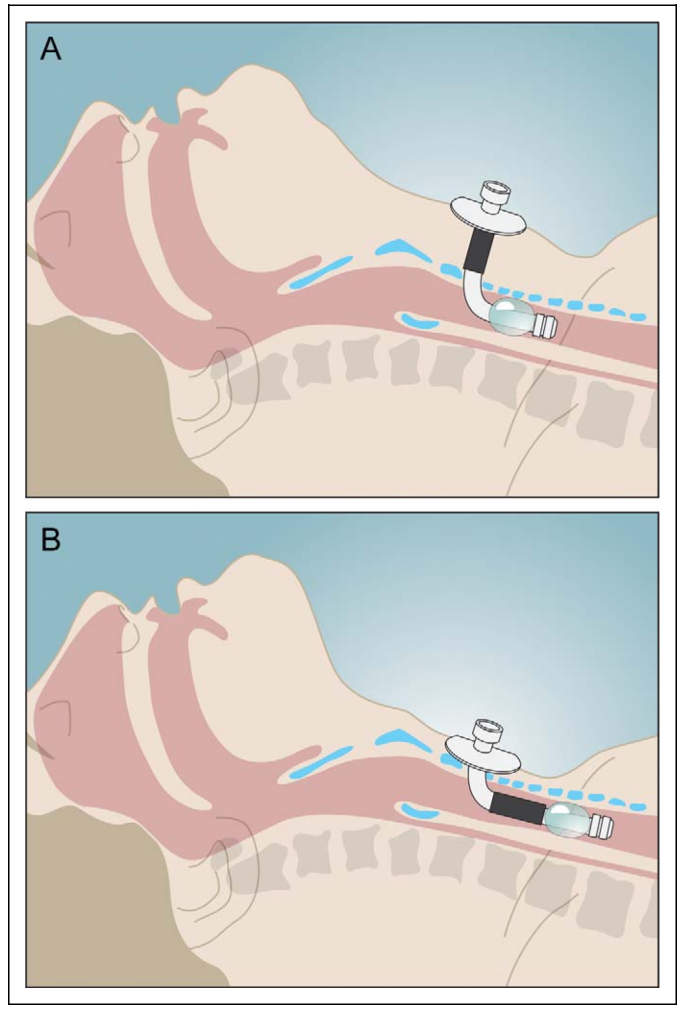

Figure 3. Persistent leaks and obstruction of the newly placed tube sometimes require replacing the initial tube with those featuring either proximal extension (A) or distal extension (B). The black section of each tube indicates the additional length.

If this is unsuccessful, it may be the case that the tracheostomy needs to be exchanged for a proximal extension device (Figure 3A). This is a common occurrence in obese patients, in whom the skin-to-airway is increased such that the angle of the preformed tracheostomy cannula with a relatively short skin-to-airway distance causes the lumen to become posteriorly directed (as in Figure 2). These modified tracheostomy tubes are commercially available (for instance, Bivona TTS Adjustable Neck Flange Hyperflex tubes); custom dimensions can also be fitted to an individual patient. If adequate ventilation cannot be obtained during the process of obtaining the proper size proximal extension tracheostomy tube, temporary replacement of the tracheostomy with a regular endotracheal tube may be necessary.

Managing Leak

Persistent leak despite increased or repeated cuff inflation is often a result of tracheomalacia, which can be a common finding in critically ill patients in whom an endotracheal tube has been in place for weeks. The solution to this problem is often replacing the tracheostomy tube with a distal extension tube (Figure 3B) or a adjustable-length tube (as above). As with patients who require a proximal extension tube, a regular endotracheal tube can be used temporarily while an appropriate proximal extension device is obtained, with the cuff placed more distally to bypass the dilated area and achieve adequate seal.

A Tip for Safe Replacement of Tubes

Current models of proximal and distal extension tracheostomy tubes generally lack the smooth tapered leading edge that facilitates smooth passage through the interring space over a properly sized introducer. As poorly fitted tracheostomy tubes typically become problematic prior to the formation of a stable tracheostomy tract, there is some risk of having the extension tubes getting caught, failing to pass during replacement. Exchange can be performed under local analgesia to maintain spontaneous ventilation. We use a more flexible exchange device in the awake patient: an orogastric tube cut to a length of 20 cm, which can also function as a conduit for emergent oxygen administration. The incoming tracheostomy tube is prewarmed in saline to improve malleability, lubricated, and guided over the orogastric tube into the trachea.

Conclusions

The PDT is a technique that can be performed safely and easily at the bedside in the ICU and can offer patients significant benefits in accomplishing tracheostomy with a shorter wait times and equivalent or fewer complications. As is often the case, key considerations in the practical execution of this task involve common sense, thorough planning, and structured approaches to prevent adverse effects if the procedure does not go as smoothly as expected. Anesthesiologists and intensivists can use the clinical pearls offered in this study to improve the care offered to their critically ill patients; this expert opinion level of evidence may also guide further studies of PDT techniques.

Declaration of Conflicting Interests

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