One Thousand Bedside Percutaneous Tracheostomies in the Surgical Intensive Care Unit: Time to Change the Gold Standard

Lucy Z Kornblith, MD, Clay Cothren Burlew, MD, FACS, Ernest E Moore, MD, FACS, James B Haenel, RRT, Jeffrey L Kashuk, MD, FACS, Walter L Biffl, MD, FACS, Carlton C Barnett, MD, FACS, Jeffrey L Johnson, MD, FACS

BACKGROUND: Bedside percutaneous tracheostomy (BPT) is a cost-effective alternative to open tracheostomy. Small series have consistently documented minimal morbidity, but BPT has yet to be embraced as the standard of care. Because this has been our preferred technique in the surgical ICU for more than 20 years, we reviewed our experience to ascertain its safety. We hypothesize that BPT has acceptably minimal morbidity, even in high-risk patients.

STUDY DESIGN: Patients undergoing BPT from January 1998 to June 2008 were reviewed. High-risk patients were defined as those with cervical collar or halo, cervical spine injuries, systemic heparination, positive end-expiratory pressure > 10 cm H2O or fraction of inspired oxygen > 50%.

RESULTS: During the study period, 1,000 patients underwent BPT (74% men; mean ± SEM age 46 ± 0.6 years; 70% trauma). BPT was performed 8.9 ± 0.2 days (mean ± SEM) after admission. Patients remained ventilator dependent for an additional 9.7 ± 0.4 days (mean ± SEM). There were 482 (48%) patients undergoing BPT who were considered high-risk: 1 risk category, 273 patients; 2 risk categories, 139 patients; 3 risk categories, 56 patients; 4 risk categories, 12 patients; 5 risk categories, 2 patients. Complications occurred in 14 (1.4%) patients. Early complications included tracheostomy tube misplacement requiring revision (n = 4), bleeding requiring intervention (n = 2), infection (n = 1), and procedure failure requiring cricothyroidotomy (n = 1). Late complications included persistent stoma requiring operative closure (n = 4) and subglottic stenosis (n = 2). There were 6 complications (1.2%) in normal risk and 8 complications (1.7%) in high-risk patients. There were no deaths related to BPT.

CONCLUSIONS: BPT in the surgical intensive care unit is a safe procedure, even in high-risk patients. We believe BPT is the new gold standard for patients requiring tracheostomy for mechanical ventilation. (J Am Coll Surg 2011;212:163–170. © 2011 by the American College of Surgeons)

Tracheostomy was popularized by Chevalier Jackson in the early 20th century, and it is now considered the standard of care for patients requiring long-term mechanical ventilation. Bedside percutaneous tracheostomy (BPT), as described by Ciaglia and colleagues in 1985, is a cost-effective alternative to open tracheostomy. In addition to being a more cost-effective procedure than open tracheostomy, the safety of BPT has been shown in a series of populations including critically ill patients, trauma patients, cardiothoracic patients, neurosurgical patients, and otolaryngology patients. Additionally, BPT can be performed rapidly and early in the patient’s ICU course. We adopted BPT as our routine approach in 1990. Despite multiple studies reporting that percutaneous tracheostomy is a safe and cost-effective procedure when performed at the bedside, its use has yet to be embraced by the surgical community as the standard of care. Because this has been the preferred technique in our surgical ICU since 1998, we critically reviewed our experience to ascertain its relative safety, particularly in high-risk patient populations. We hypothesize that BPT has acceptably minimal morbidity, even in high-risk patients and should be the standard of care.

Disclosure Information: Nothing to disclose.
Presented at the American College of Surgeons 95th Annual Clinical Congress, Chicago, IL, October 2009.
Received August 11, 2010; Revised September 22, 2010; Accepted September 22, 2010.
From the Department of Surgery, Denver Health Medical Center and the University of Colorado, Denver, CO. Correspondence address: Clay Cothren Burlew, MD, FACS, Department of Surgery, Denver Health Medical Center, 777 Bannock St, MC 0206, Denver, CO 80204. email: clay.cothren@dhha.org

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METHODS

Denver Health Medical Center is a state-certified and American College of Surgeons-verified level I regional trauma center and integral teaching facility of the University of Colorado School of Medicine. Patients undergoing BPT from January 1998 to June 2008 were reviewed. The BPT technique was performed by the trauma/acute care surgeons as previously described, with a change from the sequential multidilator technique to the single dilation Rhino technique occurring in July 1999.

The BPT technique is initiated after appropriate sedation (100 to 200 mcg fentanyl and 1 to 2 mg midazolam) and paralytics (typically 0.1 mg/kg vecuronium unless contraindicated) are given to the patient. In addition to the procedure kit (Ciaglia Blue Rhino Percutaneous Tracheostomy, Cook Medical), instruments often used (Adson pickups, DeBakey’s pickups, Seine retractors, needle driver, scissors, snaps) are packaged in a reusable kit (Fig. 1). An intrascapular rolled-up towel is used to “bump” the patient to facilitate hyperextension of the neck for adequate exposure; patients with cervical spine injuries are maintained in spine neutral position. The anterior neck is cleaned with Hibiclens (Mölnlycke), but the technique is not considered sterile. A vertical 1.5-cm incision is made just beneath the cricoid cartilage after infiltrating with 1% lidocaine with epinephrine (Fig. 2). Blunt dissection is performed with a snap until the tracheal rings are identified by palpation (Fig. 3). Just before inserting the needle, the endotracheal tube is pulled back under direct vision using a laryngoscope until the balloon reaches the cords (Fig. 4). Leaving the bronchoscope within the tracheal lumen or inside the endotracheal tube increases the possibility of damaging the scope with the needle and impairs ventilation. Once the needle is placed into the lumen of the airway between the first and second tracheal rings (Fig. 5), with aspiration of air through the saline in the attached syringe confirming intraluminal placement, the wire is advanced into the trachea (Fig. 6). At this point, bronchoscopic confirmation is performed. Three confirmatory steps must be verified before dilating the trachea:

Abbreviations and Acronyms

BPT = bedside percutaneous tracheostomy
FiO₂ = fraction of inspired oxygen
PEEP = positive end-expiratory pressure

Figure 1. The Ciaglia Blue Rhino Percutaneous Tracheostomy kit and often used instruments (Adson pickups, DeBakey’s pickups, Seine retractors, needle driver, scissors, snaps) are readied at the bedside.

Figure 2. A vertical 1.5-cm incision is made just inferior to the cricoid cartilage.

Figure 3. Blunt dissection is performed until the tracheal rings are identified by palpation.
the wire is within the lumen of the trachea down to the
carina; the wire does not go through the Murphy eye of
the endotracheal tube; and the wire goes into the ante-
rior surface of the trachea between the 11 o’clock and 1
o’clock positions and between the first and second or
second and third tracheal rings (approximately a finger
tip should fit between the cricoid and the wire insertion
point) (Fig. 7). The surgeon should not confuse a prom-
inent thyroid isthmus with the cricoid cartilage. Before
Rhino dilation, 3 additional steps must be performed
using the pneumonic of the 3 S’s: “seated” – the tip of
the Rhino dilator should be seated on the white inner
cannula; “sauter” – the sauter mark on the wire should
be lined up with the distal portion of the white inner
cannula; and “skin” – the skin mark on the Rhino dilator
should be observed because this is the limit of insertion
into the trachea (Fig. 8). After Rhino dilation, the tra-
cheostomy tube, with its balloon tested and appropri-
ately loaded on the blue dilator, is readied for insertion
(Fig. 9). The final 3 S’s are verified: “seated,” “sauter,”
and “syringe.” Clearly, steps 1 and 2 are identical, and
step 3 ensures that a 10-mL syringe is available to inflate
the tracheostomy tube balloon after insertion. Using an
overhand pass, the tracheostomy tube is placed inside
the airway, the introducer and wire are removed, and
bronchoscopy via the newly placed tube again confirms
proper placement within the trachea. The tracheostomy
is then sutured into placed by the 4 corners (Fig. 10) and
a tracheostomy tie is positioned. At this point, the bron-
choscope is reinserted to assess airway patency and pro-
vide for airway clearance. The endotracheal tube is not
removed until the tracheostomy tube is confirmed to be
satisfactory. Chest radiograph is not routinely per-
formed postprocedure.

Patients considered at high risk were defined as those
in a cervical collar or a halo, those with documented
cervical spine injuries, those requiring systemic heparin
drips, and those requiring ventilatory parameters with a
positive end expiratory pressure (PEEP) >10 cm H₂O
or a fraction of inspired oxygen (FiO₂) > 50%. Patient
demographics and outcomes were recorded; review of
outpatient clinic notes was included in the review to
identify late complications. Defined complications in-
cluded in the analysis were tracheostomy misplacement,
bleeding requiring intervention, wound infection, loss
of airway requiring emergent cricothyroidotomy, persist-
tent tracheal stoma, and subglottic stenosis. Statistical
analysis was performed using SAS for Windows (SAS
Institute). The Colorado Multi-Institutional Review
Board approved this study.
RESULTS

During the study period, 1,000 patients underwent BPT. The majority (74%) of patients were men with a mean age of 46 ± 0.6 years, and 70% of the study population were trauma patients. BPT was performed 8.9 ± 0.2 days after admission. Patients remained ventilator-dependent for an additional 9.7 ± 0.4 days. Total ventilator days were 21 ± 0.6, ICU length of stay was 29 ± 0.6 days, and hospital length of stay was 35 ± 0.8 days. Overall mortality was 12%.

There were 482 (48%) patients undergoing BPT who were considered high risk, with some patients falling into more than 1 high-risk category: 1 risk category, 273 patients; 2 risk categories, 139 patients; 3 risk categories, 56 patients; 4 risk categories, 12 patients; and 5 risk categories, 2 patients (Fig. 11). Risk categories included 272 patients in a cervical collar or halo, 150 patients with an FiO2 > 50%, 110 patients with a PEEP > 10 cm H2O, and 102 patients on a systemic heparin infusion.

Complications occurred in 14 (1.4%) patients. Early complications included misplacement requiring operative revision (n = 4), bleeding requiring intervention (n = 2), wound infection (n = 1), and procedure failure requiring cricothyroidotomy (n = 1). In the 4 patients with misplacement, all tracheostomies were placed too low, as suspected by end-of-procedure bronchoscopy or chest radiography; formal revision with placement between tracheal rings 1 and 2 or rings 2 and 3 was performed. These cases occurred in the early years of BPT experience. The 2 cases of bleeding included 1 patient with large anterior jugular veins requiring ligation and 1 patient requiring embolization of a left superior thyroid arteriovenous fistula on postprocedure day 3. The wound infection was treated successfully with antibiotics and did not require operative intervention. One patient with bilateral LeFort III frac-
atures experienced inadvertent extubation while pulling the endotracheal tube back to the level of the glottis; oral reintubation was attempted but was not successful, and emergent cricothyroidotomy was performed. Late complications included persistent tracheal stoma (n = 3), subglottic stenosis (n = 2), misplacement requiring revision (n = 2), and a wound infection (n = 1). There were no deaths related to BPT.

DISCUSSION

Percutaneous tracheostomy was originally described by Sheldon and colleagues in 1955; however, it was not routinely used until the dilatational technique was reported by Ciaglia and associates in 1985. Since its introduction, multiple studies have validated this technique as equivalent to or better than open tracheostomy. Compared with surgical tracheostomy, percutaneous tracheostomy has several advantages. It is relatively simple to perform with shorter procedure time. The ability to perform a
bedside procedure obviates the potential morbidity as well as the considerable cost associated with transport of critically ill patients to the operating room. Several studies have shown percutaneous tracheostomy to be more cost effective than surgical tracheostomy, with similar or lower complication rates. Despite the literature to date, there appear to be many institutions that have not adopted BPT as the technique of choice.

Our experience over the past decade has yielded several instructional points on the technique. We use a team of 3 practitioners to perform bedside tracheostomy. Our operating team consists of a respiratory therapist trained in airway management, an attending surgeon, and a second-year surgical or emergency department resident. Alternatively, an anesthesiologist, surgical attending, or nurse anesthetist could manage the airway and endotracheal tube positioning. One operator could perform the procedure, but in our academic teaching hospital, resident training is incorporated in the operating team. Although we do scrub the patient’s skin with Hibiclens before incision, we do not use a full sterile field as one might in the operating room. Because the surgical site is contaminated after incision of the trachea, the use of sterile gown and gloves is, in our opinion, costly and ineffective to prevent infection. The incidence of wound infection in this series was 0.1%. We believe bronchoscopy is essential to the procedure to confirm that the wire is in the trachea and not through the Murphy eye of the endotracheal tube or the back wall of the trachea into the esophagus. On a few occasions we have blindly yet successfully placed the wire through the Murphy eye; if this had not been detected by bronchoscopy before dilation and placement of the tracheostomy tube, decannulation of the endotracheal tube would become impossible. We do not use bronchoscopy to determine how far back to pull the endotracheal tube, choosing instead to do this under direct vision with laryngoscopy; by using bronchoscopy alone, proper positioning of the cuff cannot be assessed. With performance of bronchoscopy at the end of the procedure to confirm tracheostomy tube placement and provide pulmonary toilet, a postprocedure radiograph is not obtained unless the patient does not return to baseline ventilatory settings.

In analyzing our complications, we identified several additional illustrative points. First, the use of bronchoscopy to determine how far back to pull the endotracheal tube should be avoided due to potential loss of the airway. When looking at the distal airway via the bronchoscope, the cuff is above the area of visualization, so if the cords are visualized, the cuff is above the cords. In patients with an edematous airway, complex facial fractures, or previous difficult intubation, such as the patient who lost his airway and required an emergent cricothyroidotomy in our series, use of the bronchoscope as an airway stent maneuver should be considered. Additionally, in manipulating the endotracheal tube, the tube should not be pulled back until just before needle insertion into the trachea, and once pulled back, meticulous attention to maintaining its position will prevent accidental extubation. In patients with misplacement of the tracheostomy, 2 learning points were gleaned. First, attending oversight with direct palpation of the anterior surface of the airway to confirm the wire exits the trachea no more than a fingertip from the cricoid cartilage is critical. The bronchoscope may be used to confirm that the catheter inserts in the anterior trachea and does not enter through the side of the trachea; however, direct palpation should also confirm location. Second, the thyroid isthmus can be mistaken for the cricoid cartilage; direct visualization to better delineate the tracheal rings can be performed with Bovie electrocautery division of the isthmus. As one might expect, limiting dissection, staying in the midline, and good attention to hemostasis should limit bleeding complications. Elucidating the cause of the persistent stoma in 4 patients, subglottic stenosis in 2 patients, and wound infection in 1 patient was difficult to discern in this review.

One area of controversy is who should be doing these procedures and in what patient populations. In our current practice there are few absolute contraindications to bedside tracheostomy. Any patients with an unstable cervical spine without fixation (collar, halo, or operative) should have their tracheostomy delayed until the spine team determines stabilization. Clearly any patient with an indeterminate spine status should not undergo tracheostomy until imaging is complete and necessary.
treatment is instituted. In patients undergoing anterior operative fixation of spinal fractures, we wait until 5 days postprocedure to perform BPT to prevent contamination of the operative site and potential hardware infection. BPT should likely be delayed in patients with borderline oxygenation on an FiO₂ ≥ 80% and a PEEP ≥15 cm H₂O. Likewise, uncontrolled coagulopathy or patients with supratherapeutic partial thromboplastin time levels on heparin drips should likely be corrected before the procedure. Attending surgeons actively participate in the BPT with junior residents. To our knowledge, there is minimal discussion in the literature regarding experiential quotas or credentialing. Although one can always argue that “more is better” when it comes to experience, completing 12 to 20 BPTs as senior residents would likely enable surgeons to feel competent to perform this procedure when their training is complete.

To our knowledge, this is the largest single-institution experience of BPT reported to date. Additionally, use of BPT in several different types of high-risk patients has not been previously analyzed. There are several limitations to this study. Although each patient’s chart was individually reviewed in detail, there are inherent limitations in any retrospective analysis. There is also the possibility that a patient developed a late complication that was treated at another facility.

In our experience, percutaneous tracheostomy can be safely performed at the bedside in the ICU, and may be performed, even in high-risk patients, with minimal morbidity. The overall complication rate in all patients was 1.4%, and there was no difference in complication rates between normal-risk and high-risk patients. Moreover, there were no deaths due to BPT. We submit that these findings indicate that BPT should be considered the gold standard in patients requiring nonemergent tracheostomy in the ICU.

Author Contributions
Study conception and design: Kornblith, Burlew, Haenel, Moore
Acquisition of data: Kornblith, Burlew, Haenel
Analysis and interpretation of data: Kornblith, Burlew, Haenel
Drafting of manuscript: Kornblith, Burlew
Critical revision: Moore, Johnson, Kashuk, Biffl, Barnett

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