Comparison of Percutaneous and Surgical Tracheostomies*

Yaakov Friedman, MD, FCCP; John Fildes, MD; Barry Mizock, MD; Jacob Samuel, MD; Subash Patel, MD; Samuel Appavu, MD, FCCP; and Roxanne Roberts, MD

**Objective:** To compare the safety and efficacy of percutaneous dilational tracheostomy (PDT) with surgical tracheostomy (ST).

**Design:** Prospective randomized trial.

**Setting:** Public urban teaching hospital.

**Patients:** Twenty-six patients were randomized to undergo PDT and 27 patients to ST.

**Results:** The time from randomization into the study until tracheostomy was performed was 28.5±27.9 h in the PDT group and 100.4±95.0 h in the ST group (p<0.001). PDT was performed in 8.2±4.9 min vs 33.9±14.0 min for ST (p<0.0001). There was no significant difference in intraprocedural complications between the groups. Postprocedural complication rates were 12% for PDT and 41% for ST (p=0.008).

**Conclusion:** PDT is superior to ST logistically. PDT can be performed at the bedside eliminating the risks of patient transport. Because operating room scheduling is not necessary, PDT can be performed earlier once the decision to do a tracheostomy is made, which will improve ICU utilization. PDT is a faster procedure to perform and has fewer postprocedural complications.

(*CHEST 1996; 110:480-85*)

**Key words:** complications; intensive care; surgery; tracheostomy

**Abbreviations:** OR=operating room; PDT=percutaneous dilational tracheostomy; SaO2=arterial oxygen saturation; ST=surgical tracheostomy

During the polio epidemic of the 1950s, physicians realized that positive pressure ventilation could be applied through artificial airways in a variety of conditions.1 This led to the beginning of ICUs, and the rapid growth and development of ICUs has created a large population of patients who require artificial airways for prolonged periods. In 1959, more than 150 tracheostomies were performed for prolonged airway management at Massachusetts General Hospital (MGH),2 where none had been performed previously for this indication. Although endotracheal intubation is the initial procedure of choice for airway management, tracheostomy is considered the procedure of choice for long-term airway management.3

The standard procedure for surgical tracheostomy (ST) was described by Jackson.4 Although ST is considered a simple, safe procedure, complication rates range from 6 to 66%.5-13 Also, more severely ill patients are surviving to require tracheostomy. Therefore, a simpler procedure that could be performed at the bedside to eliminate the risks involved in transporting critically ill patients and simplify scheduling of the procedure was needed.

These considerations led to the development by Toye and Weinstein14 in 1969 of the Seldinger technique of percutaneous tracheostomy. This procedure was modified in 1985 by Ciaglia et al15 as percutaneous dilational tracheostomy (PDT).

In several series, PDT appears to be associated with the same or fewer complication as ST.16-20 To date and to our knowledge, there has been only one prospective, randomized comparison of PDT and ST that demonstrated a lower complication rate with PDT.30 To evaluate the potential logistic benefits and to confirm the relative safety of PDT, we performed a randomized, prospective comparison of ST and PDT.

**MATERIALS AND METHODS**

This study was approved by the Institutional Review Board and written informed consent was obtained from each patient. All patients were at least 18 years of age and required a tracheostomy for long-term ventilator support or airway protection. Patients were excluded from the study if any of the following criteria were present:

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clinical instability, positive end-expiratory pressure greater than 15 cm H2O, uncorrectable coagulopathy, previous tracheostomy or neck surgery, thymomycelal, anatomic distortion of the tracheal region, or skin or soft-tissue infection at the proposed tracheostomy site. Eligible patients were randomized using random number tables to receive PDT or ST. PDTs were performed at the patient’s bedside in either the medical, surgical, trauma, or neurosurgical ICUs. All PDTs were performed or supervised by one of the two intensivists and all STs were performed by one of the four surgeons.

PDT was performed as described previously.31 Patients were placed on a regimen of 100% fraction of inspired oxygen, and local anesthesia and IV sedation were given to control pain and anxiety. The endotracheal tube was repositioned above the site of the proposed tracheostomy. A guidewire was placed in the trachea at the level of the first or second tracheal interspace. A 1-cm incision was made at the site of the skin puncture. A series of dilators were introduced over the guidewire to enlarge the stoma. The tracheostomy tube was inserted and secured with fabric tape tied around the neck.

STs were performed in the operating room (OR) under general anesthesia as described by Jackson.4 An incision was made anteriorly at the level of the second or third tracheal interspace. The trachea was exposed using sharp and blunt dissection, a stoma was created using a U-shaped flap technique, and the endotracheal tube was repositioned above this site. The tracheostomy tube was inserted under direct vision, sutured to the skin, and secured with fabric tape tied around the neck.

The following data were recorded: age; sex; race; reason for intubation; reason for tracheostomy; hospital day of the tracheostomy; acute physiology and chronic health evaluation II score; hours from randomization to tracheostomy; procedure duration; lowest intraprocedural arterial oxygen saturation (SaO2) and BP; intraprocedural complications such as paratracheal intubation, subcutaneous emphysema, bleeding, or loss of the airway for greater than 20 s; postprocedural complications such as accidental decannulation, bleeding, and infection; mortality; decannulation; duration of the tracheostomy; and days to tracheal and stomal closure postdecannulation. The procedure duration was from the infiltration of local anesthesia (PDT) or the skin incision (ST) until the tracheostomy tube was secured in place.

Complications were defined as follows: Hypotension was a systolic BP less than 90 mm Hg. Hypoxia was an SaO2 less than 90%. Bleeding was classified as small (25 to 100 mL), moderate (100 to 250 mL), or severe (>250 mL). A wound/stoma infection was present when there was purulent drainage from the site with greater than 1 cm of surrounding erythema.

The data from the PDT and ST groups were compared using the paired Student’s t test, χ2 test, or Fisher’s Exact Test as appropriate, with a p value <0.05 indicating significance.

**RESULTS**

Clinical characteristics of the two groups are shown in Table 1. Several patients had multiple reasons for intubation and/or tracheostomy. The duration from when patients were randomized into the study until the tracheostomy was performed was significantly shorter in the PDT group. Additionally, PDT took significantly less time to perform than ST. Intraprocedural oxygen saturation was statistically lower in the ST group, but at a level that lacks clinical significance.

Intraprocedural complications are listed in Table 2. Simultaneous occurrence of multiple complications in the same patient from a single cause was recorded under the most severe complication. There were two major complications that led or could have led to significant problems.

The tracheostomy tube was initially inserted paratracheally in one PDT patient. This was immediately recognized as there was difficulty bagging the patient and the tracheostomy tube was removed. Tube insertion was noted to have been forced as the skin incision was not adequate. The incision was enlarged slightly and the tracheostomy tube was reinserted without

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**Table 1—Patient Characteristics**

<table>
<thead>
<tr>
<th>Tracheostomy Type</th>
<th>Percutaneous</th>
<th>Surgical</th>
</tr>
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<tbody>
<tr>
<td>Male/Female</td>
<td>14/12</td>
<td>17/10</td>
</tr>
<tr>
<td>White/black/Hispanic</td>
<td>2/20/4</td>
<td>0/24/3</td>
</tr>
<tr>
<td>Age, yr, mean±SD</td>
<td>56±20</td>
<td>53±17</td>
</tr>
</tbody>
</table>

Reason for intubation:
- Respiratory failure: 15/19
- Airway protection: 7/3
- CPR: 2/2
- Shock: 4/2
- Other: 5/3

Reason for tracheostomy:
- Prolonged intubation: 23/22
- Airway protection: 8/6
- Pulmonary toilet: 0/1
- Airway obstruction: 1/2

Days intubated prior to tracheostomy:
- Percutaneous: 17.2±7.5
- Surgical: 21.3±26.2

Hospital day tracheostomy:
- Percutaneous: 24.5±20.1
- Surgical: 18.5±11.8

APACHE II score:
- Percutaneous: 18.0±7.8
- Surgical: 14.8±6.5

PT, s:
- Percutaneous: 13.1±1.8
- Surgical: 12.4±1.0

PTT, s:
- Percutaneous: 35.9±5.8
- Surgical: 35.5±6.9

Platelet count, x1,000:
- Percutaneous: 307.7±163.1
- Surgical: 323.2±163.2

Hours from randomization to tracheostomy:
- Percutaneous: 28.5±27.9
- Surgical: 100.4±95.0

Lowest intraprocedural SaO2:
- Percutaneous: 97.6±3.1
- Surgical: 95.4±3.9

*p<0.001.
**p<0.0001.
^p<0.05.

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**Table 2—Intraprocedural Complications**

<table>
<thead>
<tr>
<th>Complication</th>
<th>Percutaneous</th>
<th>Surgical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=26</td>
<td>n=27</td>
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</tbody>
</table>

Major:
- Paratracheal insertion: 1 (4)
- Other: 1 (4)

Minor:
- Transient hypotension: 4 (15)
- Transient hypoxia: 0 (0)
- Subcutaneous emphysema: 3 (13)
- Small bleed: 3 (13)
- Loss of airway >20 s: 0 (0)
- Total: 9 (35)

*Numbers in parentheses denote percent.
difficulty. The patient did not encounter problems due to the paratracheal insertion; vital signs remained stable and there was no oxygen desaturation, pneumothorax, or subcutaneous emphysema.

After the tube was inserted without difficulty in another PDT patient, there was significant resistance to bagging, the breath sounds were distant, and the BP decreased. Due to concern that the tracheostomy tube was inserted paratracheally, it was removed and the patient was ventilated via the still-in-place endotracheal tube. Significant resistance to bagging was also encountered via this route and high airway pressures were noted. Intratracheal endotracheal tube placement was confirmed bronchoscopically. Massive tongue and noncrepitant anterior chest wall swelling and wheezing were noted. The patient was believed to be having an anaphylactic reaction and was given steroids, antihistamines, and epinephrine. She became normotensive and progressively easier to ventilate. The tracheostomy tube was reinserted without difficulty with bronchoscopic confirmation. A left-sided simple pneumothorax was seen on chest radiograph and a chest tube was inserted. The patient subsequently had negative allergy testing to lidocaine. She recovered uneventfully.

Transient hypotension was temporally related to the administration of the anesthetic agent in these critically ill and often hypovolemic patients and responded rapidly to the anesthetic wearing off and/or the administration of fluid. The transient hypoxia, subcutaneous emphysema, and loss of airway did not lead to any serious sequelae. The small, insignificant bleeding was usually from the skin edge and resolved with continuation of the procedure and consequent tamponade of the bleeding or cautery.

Postprocedural complications are given in Table 3. The overall complication rate was significantly lower in the PDT group.

Accidental decannulation was believed to be a major complication due to the risk for airway compromise. The tube was reinserted rapidly without complications in the PDT patient and two of the ST patients. One ST patient had an extremely obese neck. Despite the tracheostomy tube being sutured to the skin, it came out when she was turned 2 h after her return to the ICU. Even though retention sutures had been placed, the tracheostomy tube could not be reinserted. Endotracheal intubation was unsuccessful; the patient became hypoxic, had a cardiac arrest, and died. The other accidental decannulation occurred in a patient with a wound infection. His tube came out a week after ST and was reinserted rapidly. Two days later his tube again came out and was unable to be reinserted due to the anatomic distortion caused by the wound infection.

<table>
<thead>
<tr>
<th>Major</th>
<th>Percutaneous n=26</th>
<th>Surgical n=27</th>
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</thead>
<tbody>
<tr>
<td>Accidental decannulation</td>
<td>1 (4)</td>
<td>4 (15)</td>
</tr>
<tr>
<td>Moderate bleed (150-250 mL)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Severe bleed (&gt;250 mL)</td>
<td>1 (4)</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Minor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small bleed (25-100 mL)</td>
<td>1 (4)</td>
<td>3 (11)</td>
</tr>
<tr>
<td>Wound/stomal infection</td>
<td>0</td>
<td>4 (15)</td>
</tr>
<tr>
<td>Total</td>
<td>3 (12)</td>
<td>12 (41)*</td>
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</tbody>
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*Numbers in parentheses denote percent.  
*p=0.008.

Reintubation was unsuccessful, he had a cardiac arrest, and died.

Bleeding from the tracheostomy wound edges began 2 h after a PDT (at which time the operator was not informed) and lasted for 15 h. The bleeding stopped immediately after circumferential infiltration of lidocaine with epinephrine around the wound. The patient required transfusion of 2 U of packed RBCs. An ST patient died of massive hemorrhage from the tracheostomy tube 6 weeks after tracheostomy, presumed to be from a tracheoinnominate fistula. One PDT patient and three ST patients had small skin-edge bleeding that resolved with pressure, instillation of lidocaine and epinephrine, or packing. Four patients had wound and/or stomal infections, one of which contributed to death as described above.

Outcome is given in Table 4. The number of days for tracheal and stomal closure was not statistically significant due to the small number of patients who were decannulated. However, there was a trend toward earlier tracheal and stomal closure in the PDT group.

**DISCUSSION**

ICU growth and improvements in technology have led to increasing numbers of critically ill patients who require prolonged mechanical ventilation, most appropriately managed with tracheostomies. Until recently, ST performed in the OR was the only option available. However, ST morbidity ranges from 6 to 66% and mortality ranges from 0 to 5%. Complications resulting from ST performed in the ICU are comparable to those performed in the OR.

Previous series of PDT showed complication rates

<table>
<thead>
<tr>
<th>Table 3—Postprocedural Complications*</th>
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<td>Total</td>
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</table>

*Numbers in parentheses denote percent.  
*p=0.008.

<table>
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<th>Table 4—Outcome of Tracheostomy</th>
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<tr>
<td>Duration of tracheostomy, d</td>
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<tr>
<td>Overall mortality (%)</td>
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<tr>
<td>Number decannulated</td>
</tr>
<tr>
<td>Days to tracheal closure</td>
</tr>
<tr>
<td>Days to stomal closure</td>
</tr>
</tbody>
</table>

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that are comparable to or lower than those of ST.\textsuperscript{16-29} One previous prospective randomized comparison of PDT and ST found that PDT had a lower complication rate than ST.\textsuperscript{30}

Our series demonstrated that PDT is logistically superior to ST. As OR time does not need to be scheduled, PDT can be performed sooner once the decision to do a tracheostomy is made. This is due to scheduling problems in our hospital that presumably exist in many other hospitals. This results in earlier establishment of a more secure airway that increases patient comfort.\textsuperscript{3}

Since PDT is performed in the ICU, complications related to patient transport\textsuperscript{22,34} are eliminated. As PDT does not require use of the OR, which may not be immediately available, coagulopathies can be corrected and the tracheostomy performed before the effects of the correction disappear. Also, PDT is a more rapid procedure, which is beneficial to unstable, critically ill patients. ICU utilization may be improved as the earlier tracheostomy insertion may allow more aggressive and potentially more rapid weaning or may allow earlier transfer of a patient with a more secure airway.

PDT was initially believed to be contraindicated in emergencies; when patients are markedly obese, have anatomic abnormalities such as thyromegaly or neck cancer, or have uncorrectable coagulopathies; and in children.\textsuperscript{15} Recently, PDT has been described in all these subgroups.\textsuperscript{28,35-37} Toursarkissian et al.\textsuperscript{129} have stated that PDT is the preferred method of tracheostomy placement in patients who have difficult anatomy, although large goiter is still a relative contraindication.

Complication rates in this series are within the range reported in other series of tracheostomies. The relatively high rate of complications may be due to the strict definitions used and the fact that we were looking intensively for complications. This led to including complications with minimal clinical significance such as transient hypotension and hypoxia and minimal bleeding. Complication rates will vary in different series depending on the diligence used in definition and detection. Thus, we believe that our complication rates should be considered only between the two groups in this study.

The intraprocedural complication rates of PDT and ST were not significantly different. ST did not have any major intraprocedural complications. PDT did have one paratracheal insertion, recognized and corrected immediately without significant sequelae. The other major intraprocedural complication was believed by the operators to be an anaphylactic reaction due to the ease of insertion of the tracheostomy tube coupled with the hypotension, bronchospasm, and noncrepitant edema and tongue swelling that rapidly responded to epinephrine and steroids. Others believed that the negative allergy testing to lidocaine made paratracheal insertion more likely. In any event, the patient fully recovered without sequelae.

Paratracheal insertion is extremely unlikely during ST. The incidence of paratracheal insertion is approximately 1\% in PDT.\textsuperscript{16,20-24,26-30} Also, the risk of paratracheal insertion is essentially eliminated when PDT is performed under bronchoscopic guidance.\textsuperscript{21,28}

PDT was also superior to ST as it had a lower overall postprocedural complication rate. Although no single complication reached statistical significance, the absence of wound or stomal infections and few bleeding complications in PDT is clinically significant. The lack of bleeding is most likely due to the minimal tissue disruption and tamponading effect of the tight fit of the dilators and tracheostomy tube. The minimal tissue disruption and consequent decreased exposure of raw skin surfaces is likely the reason for the decreased wound and stomal infections. The minimal tissue disruption may also be the reason for the clinically significant more rapid tracheal and stomal closure in the PDT patients who were decannulated.

The three mortalities directly related to the tracheostomy were all in ST patients. The late hemorrhage was presumably due to a tracheoinnominate fistula and was most likely related to the duration and not the type of tracheostomy. Two other deaths were due to accidental decannulation. The first occurred immediately after the procedure and was due to placement of a tube that in retrospect was too short for the patient. While the tube may also have become displaced if PDT had been performed, the tight fit of the tracheostomy tube should decrease the incidence of accidental decannulation. Also, although ST allows direct visualization of the tube placement and retention sutures were placed in all ST patients to allow for replacement of a dislodged tracheostomy tube, the decannulation was not prevented. The other mortality from accidental decannulation was due to severe anatomic distortion from a wound infection where the tracheostomy tube was unable to be reinserted.

ST allows greater procedural variation than PDT in the incision, construction of the tracheostomy site, and management of the skin wound. We did not anticipate these differences and by the time we realized that they could be affecting the data (eg, the incidence of wound infections), we were too far along to change the study. The greater procedural variation of ST may have contributed to the increased postprocedural complications. PDT, however, offers fewer procedural variations. This is a potential benefit in teaching tracheostomies as PDT.
Bedside ST is an alternative when performing tracheostomy in critically ill patients. This would theoretically eliminate the problems of scheduling OR time and would reduce costs as there would not be charges for use of the OR. However, the need to bring OR equipment and nurses to assist in the procedure is likely to obviate these benefits. Additionally, the complication rates and cosmetic result would be the same as ST performed in the OR.

In conclusion, PDT offers many advantages over ST. It is a procedure that can be performed in the ICU, eliminating the need for patient transport to the OR with its associated complications. It can be performed more expeditiously than ST, with a savings of 3 days in this study, which will likely improve ICU utilization. Intraprocedural complication rates are similar and postprocedural complication rates lower for PDT in this and the only other prospective randomized trial of PDT and ST. The cosmetic result of PDT may also be better than that of ST as a result of the minimal tissue disruption. Finally, the costs of PDT have been reported to be less than that of ST, which is important in today's economic era.

PDT does have an operative learning curve and should be performed by physicians trained in the technique. As it is a Seldinger technique, most intensivists could be trained in its performance. For all of these reasons, we believe that PDT is the procedure of choice for most patients in the ICU who need a tracheostomy.

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REFERENCES
39 Imami E, Martin M. Conventional open versus percutaneous tracheostomy: experience in 110 patients with cost analysis. Presented at the meeting of the Royal College of Physicians and Surgeons, Toronto, Canada, September 15, 1994

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