EXPERIENCE WITH PERCUTANEOUS DILATIONAL TRACHEOSTOMY

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Percutaneous dilational tracheostomy (PDT) has gained popularity among critical care specialists in the past 10 years. The initial studies in our specialty resulted in essentially banning the procedure as a dangerous substitute for standard operative tracheostomy. Despite this action, more than 1,100 cases of percutaneous tracheostomy have been reported with details on complications. We reviewed all published data and studied 311 patients of our own. A prospective study was performed in 3 groups of patients: 1) 50 patients scheduled for PDT performed in the operating room by a head and neck surgeon (group 1); 2) 50 patients who underwent standard operative tracheostomy performed by the same surgeon (group 2); and 3) 211 patients who underwent bedside PDT by critical care physicians (group 3). The intraoperative complication rates were 0% in group 1, 2% in group 2, and 4% in group 3; the postoperative complication rates were 13%, 4%, and 12%, respectively. There were 2 deaths in group 3, and none in groups 1 or 2. The statistically significant differences among the groups were the superiority of group 1 over group 3 in intraoperative complications, as well as the lower postoperative complication rate of the standard tracheostomy group. These results show that PDT can be performed with acceptable morbidity rates in relation to published complication rates of standard tracheostomy, but it has no advantage over standard tracheostomy with respect to postoperative morbidity. When they are performed by a head and neck surgeon, the morbidity associated with both standard and percutaneous tracheostomies can be reduced.

KEY WORDS — airway management, percutaneous tracheostomy, tracheostomy complications.

INTRODUCTION

The standard surgical tracheostomy described by Chevalier Jackson[1] in 1909 has long been the procedure of choice for long-term airway management. Modifications of tracheostomy have sought to decrease the morbidity associated with the procedure. The rate of complications of standard tracheostomy, such as bleeding, infection, and pneumothorax, has ranged widely, from 2% to 66%, with the higher rates occurring in earlier series.[2-7] This discrepancy probably reflects variations in surgical skills, patient characteristics, monitoring, and technique that occurred over time.

Percutaneous tracheostomy was introduced in 1955[8] and then further developed by Toye and Weinstein,[9] influenced by the Seldinger technique, in 1969. In 1985, Ciaglia et al[10] originated the technique known as percutaneous dilational tracheostomy (PDT). The procedure is designed to be simply and rapidly performed in a monitored setting such as the intensive care unit (ICU). In addition to decreased morbidity, the potential advantages of PDT include reductions in cost and surgical time that are realized when the procedure is performed at the bedside.

Since its introduction, PDT has gained widespread use in the ICU by critical care physicians. The immediate popularity of PDT resulted in complication rates as high as 58%,[11-15] with paratracheal insertion, severe bleeding, and death more common in the early studies. These initial results contributed to doubts regarding the safety and relative advantages of the procedure.

Although previous studies have compared PDT with standard tracheostomy (ST),[15-17] the procedures were not performed by the same physician. Our objective was to compare the results of PDT and ST when performed by a single head and neck surgeon with the results of PDT routinely performed by a non–surgically trained intensivist.

MATERIALS AND METHODS

Study Population. We performed a prospective study of consecutive adult patients who underwent elective tracheostomy for long-term airway manage-

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ment during a 2-year period at Illinois Masonic Medical Center in Chicago, Illinois. All procedures were performed in the operating room by a single head and neck surgeon (M.F.) who was experienced in both PDT and ST. All patients were intubated before the procedure. By study design, the first 50 patients with an indication for tracheostomy were assigned to undergo PDT and constituted group 1. Group 2 consisted of the next 50 patients, who were assigned to undergo ST.

Group 3 consisted of 211 consecutive adult patients who underwent PDT at Cook County Hospital and Provident Hospital in Chicago over a 3-year period. All patients were intubated before the procedure. The procedures were performed in an ICU by a critical care specialist or by a critical care fellow under the specialist's direct supervision.

In both PDT groups, significant anatomic abnormalities, such as thyromegaly or distortion of the tracheal region, were considered contraindications to the procedure. Patients with these abnormalities were excluded from the PDT groups. In group 1, if clear anatomic landmarks could not be identified, the patient was reassigned to group 2.

The 3 groups were compared with respect to intraoperative and postoperative complication rates.

Techniques. For PDT procedures in groups 1 and 3, the Cook percutaneous tracheostomy introducer set (Cook Critical Care, Bloomington, Ind) was used. Either general anesthesia or local anesthesia with intravenous sedation was used to control pain and level of consciousness. Patients were given 100% oxygen. The endotracheal tube was repositioned above the proposed site of tracheostomy.

A 22-gauge needle was introduced into the trachea through the first or second tracheal interspace. After aspiration of air to confirm placement, 3 to 5 mL of 1% lidocaine hydrochloride was injected into the tracheal lumen. During the procedure, the endotracheal tube was rotated as necessary to ensure that the cuff was not impaled. A 15-gauge needle with an outer Teflon sheath was then introduced into the trachea. After the needle was removed, a J-tipped guide wire was threaded through the Teflon sheath (see Figure, A). An 11F punch dilator was inserted into a 1-cm vertical midline incision made at the skin puncture site. An 8F clear plastic guiding catheter was placed over the guide wire to increase the wire's stiffness and facilitate dilator insertion over the wire (see Figure, B). The tract was progressively enlarged with a series of dilators to allow placement of the tracheostomy tube (see Figure, C,D).

The STs in group 2 were performed as previously described.[18] In brief, the neck was hyperextended, unless there was a concurrent cervical spine injury. A 3- to 4-cm horizontal incision was made through the skin and platysma. A vertical midline incision through the fascia permitted lateral retraction of the strap muscles. The third tracheal ring was then identified. If found overlying the intended tracheal ring, the thyroid isthmus was bluntly dissected off the trachea and retracted upward after cauterization of the inferior thyroid vein. A tracheal hook was inserted under the cricoid cartilage to stabilize the trachea and pull it up into the field. A portion of the third tracheal ring was excised to create the window for a No. 6 Shiley nonfenestrated, low-pressure cuffed tracheostomy tube. Hemostasis was obtained before insertion of the tube.

We compared the 3 groups with regard to the indication for tracheostomy, as well as the type and frequency of perioperative complications. A 2-sided Fisher's exact test was used for statistical comparison.

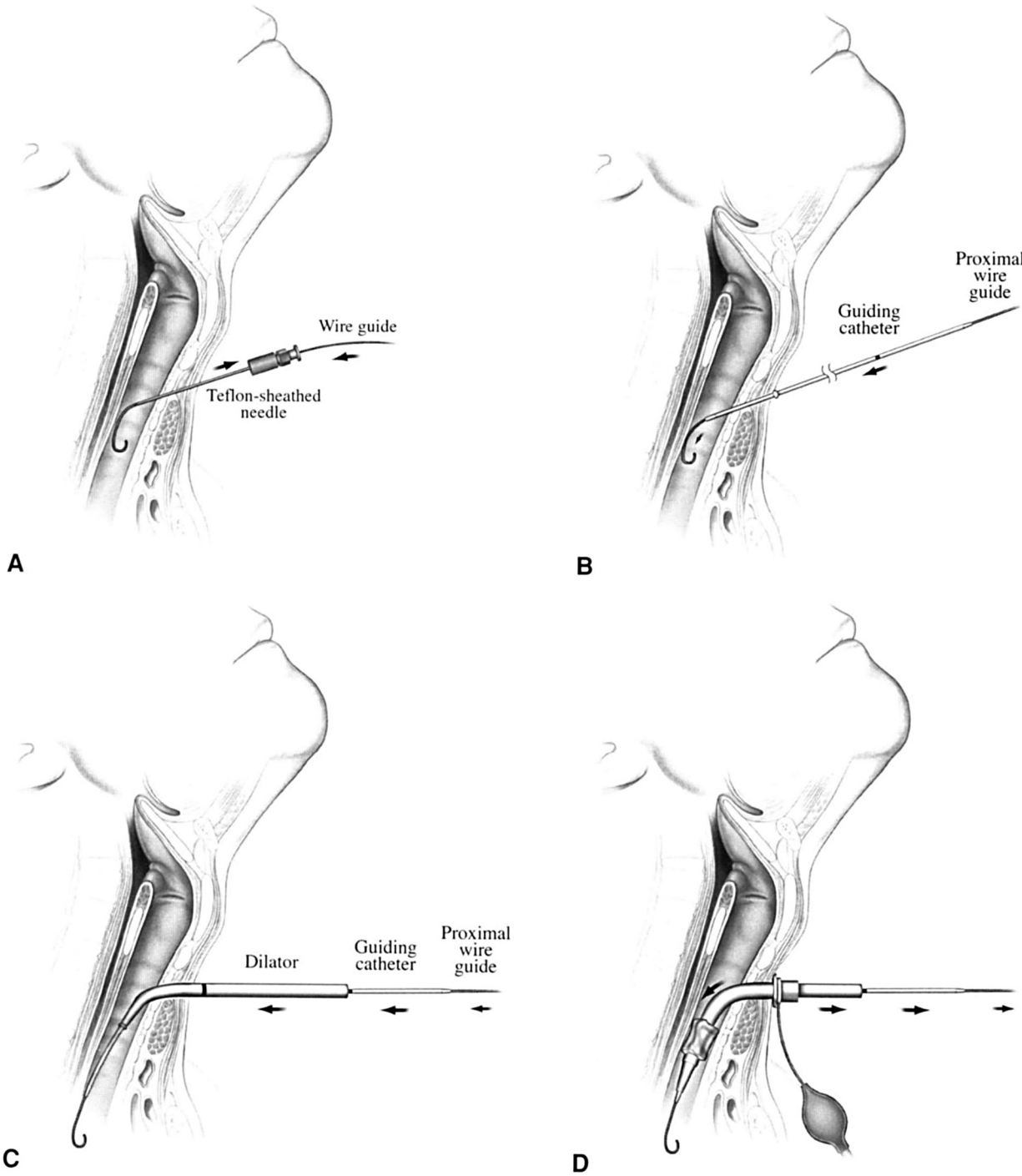
All perioperative complications were recorded. Intraoperative complications such as hypotension, oxygen desaturation, paratracheal insertion, bleeding, and loss of the airway for more than 20 seconds were noted. The postoperative complications included bleeding, subcutaneous emphysema, pneumothorax, accidental decannulation, and stomal infection.

Hypotension was defined as a systolic blood pressure of less than 90 mm Hg. Hypoxia was defined as oxygen saturation of less than 90%. Bleeding was classified as minor (25 to 100 mL), moderate (100 to 250 mL), or severe (>250 mL). Stomal infection was considered present when there was purulent drainage from the site with more than 1 cm of surrounding erythema and induration.

RESULTS

Groups 1 and 2 were comparable with respect to indications for tracheostomy. These included prolonged ventilator dependence, resection of head and neck carcinoma, and airway protection. In all but 1 of the patients with cancer, there was no involvement of the trachea, subglottic larynx, thyroid, or soft tissues of the anterior part of the neck. Of the 50 patients initially assigned to group 1, 11 were reassigned to the ST group because of abnormal cervical anatomy.

In group 3, which contained 250 patients, the reasons for tracheostomy included prolonged intubation, airway protection, and pulmonary toilet. Thirty-nine of these patients were disqualified because of abnormal anatomy, leaving 211 patients who underwent



Procedure of percutaneous dilational tracheostomy. A) J-tipped wire guide inside tracheal lumen after having been threaded through Teflon sheath. B) Guiding catheter with wire guide in position. C) Dilator and wire guide inside tracheal lumen. D) Tracheostomy tube in position before removal of wire guide and guiding catheter.

PDT. Two patients had previously undergone tracheostomy.

The complication rates in the 3 groups are shown in Table 1. No intraoperative complications occurred in the 39 patients in group 1 who underwent PDT. Postoperative complications occurred in 5 patients (13%): minor bleeding occurred in 3 patients (8%) and was controlled with packing, and subcutaneous emphysema developed in 2 patients (5%) and resolved spontaneously. There were no deaths related to the procedure.

In the ST group (n = 50), the intraoperative complications were limited to 1 case of transient hypotension (2%). Two patients (4%) had moderate postoperative bleeding. One of these patients had chronic renal failure and coagulopathy; the bleeding was

TABLE 1. COMPLICATION RATES FOR PDT AND ST GROUPS

Complications	*Group 1*	*Group 2*	*Group 3*
Intraoperative	0*	1 (2%)	8 (4%)
Postoperative	5 (13%)	2 (4%)†	25 (12%)

Group 1 — percutaneous dilational tracheostomy performed by a single head and neck surgeon (n = 39); group 2 — standard tracheostomy performed by same surgeon as group 1 (n = 50); group 3 — percutaneous dilational tracheostomy performed by a non-surgeon (n = 211).

*Statistically significantly superior to group 3 (p = .039 by Fisher's exact *t*-test).

†No statistically significant difference between group 2 and other groups (p = .158).

stopped with packing and transfusion of platelets. The second patient had a locally invasive carcinoma and required postoperative neck exploration for control. There were no deaths related to the procedure.

For the 211 patients in group 3, the intraoperative complication rate was 4%; transient oxygen desaturation occurred in 4 patients (2%), transient hypotension in 3 (1.5%), and paratracheal insertion in 1 (0.5%). One of the cases of hypoxia occurred as a result of extubation during the procedure. The postoperative complication rate was 12%; bleeding occurred in 19 patients (9%), stomal infection in 3 (1.5%), subcutaneous emphysema in 2 (1%), and tracheostomy tube dislodgment in 1 (0.5%). There was minor to moderate bleeding controlled with packing in 16 patients, 5 of whom required transfusions of packed red blood cells. Two of the 3 patients who had severe bleeding died. In 1 patient, a trachea–innominate artery fistula was presumed to have developed 6 days after PDT. In the other case of massive hemoptysis, no cause was clearly demonstrated on postmortem examination. The third patient was found to have a benign exophytic lesion above the tracheostomy. One case of stomal infection contributed to systemic sepsis 22 days after the procedure. All cases of subcutaneous emphysema resolved spontaneously. Two patient deaths occurred within a 6-day postoperative period. Table 2 shows the major and minor complications in each group.

A statistical comparison of the complication rates between the groups, using a 2-sided Fisher's exact test, yielded 1 significant difference between groups: the intraoperative complication rate in group 2 was significantly lower than that in group 3 (p = .039). The postoperative complication rates for the ST and PDT groups were comparable (p = .158). However, group 3 experienced major perioperative complications not seen in the other 2 groups. The only deaths occurred in group 3.

DISCUSSION

Both ST and PDT are associated with known complications, which include local bleeding, pneumothorax, and infection. Tracheal stenosis has also been reported as a late complication. Although open tracheostomy remains the standard for long-term airway management, PDT has rapidly gained wider use because of its potential economic and logistic advantages.

TABLE 2. PERIOPERATIVE COMPLICATIONS

Complications	*Group 1*	*Group 2*	*Group 3*
Major			
Paratracheal insertion	0	0	1
Severe bleeding	0	0	3
Death	0	0	2
Minor			
Transient hypotension	0	1	3
Transient hypoxia	0	0	4
Subcutaneous emphysema	2	0	2
Minor to moderate bleeding	3	2	16
Tube dislodgment	0	0	1
Stomal infection	0	0	3
Total	5 (13%)	3 (6%)	35 (17%)

The initial reports in the otolaryngological literature were discouraging, with high complication rates. Wang et al[14] reported their experience with a small group of patients who underwent percutaneous tracheostomy. The authors emphasized the need to identify the ideal patient with optimal cervical anatomy. In patients with these characteristics, PDT is superior to ST in terms of speed and simplicity. However, the authors clearly emphasized the need for thoroughly training physicians to perform the procedure and minimize morbidity. Because of the high complication rate in their study, which included 1 death, the recommendation was that the technique be abandoned.

Two distinct differences exist between this study and our own. First, the Shiley kit used in the study by Wang et al[14] has been discontinued owing to the high complication rate. The Cook kit is the dilational unit most commonly used today. Second, the site of entry into the trachea (midway between the cricoid cartilage and the sternal notch) used in the earlier study is imprecise and appears to be lower than the one used in our procedures. Low in the neck, the trachea is deeper from the point of entry during PDT. Thus, the likelihood of bleeding or creation of a false passage is increased. As more experience is accumulated, the appropriate applications and optimal technique are becoming better defined. In more recent studies, including our own, the complication rates have been acceptable and comparable with those of ST.[15,16,19] In addition to a shorter procedure time, the other advantages of PDT that have been cited are decreased costs for patient transport,[20] avoidance of

complications associated with transport from the ICU to the operating room,[21] and less time between the decision for and the performance of tracheostomy.

Several potential disadvantages of PDT need to be addressed. First is the possibility of accidental dislodgment of the tracheostomy tube after the procedure. In that event, it may be difficult to find the opening into the tracheal lumen. In contrast, with the ST, the tracheal window can be identified by a fingertip technique[22] or by using stay sutures left in position at the time of the original procedure. In our study, no instances of dislodgment occurred in groups 1 and 2. In group 3, the single episode of accidental decannulation was resolved uneventfully with immediate reinsertion of the tube.

Second, because PDT is performed in a "blind technique," paratracheal insertion, bleeding, and injury to the posterior tracheal wall are recognized possible complications. The use of endoscopic guidance with PDT has been advocated to avoid injury and ensure correct tracheostomy position.[23-25] In a prospective study of 76 patients by Berrouschot et al,[25] the perioperative complication rates of PDT groups with and without bronchoscopy were similar (6% and 7%). However, the more severe complications (massive intratracheal bleeding, pneumothorax, and tracheal injury) occurred in the group that underwent PDT without endoscopic guidance. There was 1 death in each group. The endoscopy is relatively simple to perform without impairing access during the procedure.

In our study, endoscopic guidance was not used. No intraoperative complications occurred in the PDT-surgeon group, and no major complications or deaths occurred in the surgeon groups. The lower intraoperative complication rate in group 1 and the larger number of major complications in group 3 may indicate the more judicious selection of patients for PDT by the head and neck surgeon, as well as interoperator variability. Positioning of the patient was not a determining factor, because during the PDTs performed in the operating room or in the ICU, the patients remained stabilized in their beds and were not transferred to an operating room table.

Certain contraindications to the use of the procedure have been identified, such as a large thyroid goiter or other neck mass, marked obesity, coagulopathy, inadequate access to the trachea, previous cardiac procedures, and neck traumas, including burns.

Also, PDT has traditionally not been recommended in children.[11] However, Toursarkissian et al[26] reported favorable results in the use of PDT in children and teenagers. In that study, 11 children 10 to 20 years of age (average, 16 years) underwent PDT for prolonged ventilator support or pulmonary toilet access with the Cook kit. The average endolaryngeal intubation period was 12 days. Nine of the patients were decannulated with evidence of tracheal stenosis after an average follow-up of 39 weeks (range, 4 to 73 weeks). Stenosis was evaluated on the basis of symptoms alone. Aside from this sole review, further examination of the effects of PDT in children should be conducted before the traditional recommendation is changed.

The PDT method compares favorably with the standard technique, but ST has wider applicability, as 20% of our patients in group 2 were moved to that group because of anatomic abnormalities. The key to safe and effective airway management with PDT is appropriate patient selection. A surgeon skilled in both techniques would enjoy a significant advantage, particularly because the use of PDT in the ICU has been well established. The PDT method, however, shows a major disadvantage in the study. No deaths occurred in groups 1 and 2 (head and neck surgeon groups), compared with 2 perioperative deaths in group 3. Morbidity and mortality rates were not studied for tracheostomy procedures performed at the same institution in which the group 3 patients were treated (a city teaching hospital), but morbidity and mortality rates of ST have been previously published.[15,16,19]

CONCLUSION

Percutaneous dilational tracheostomy should be recognized as a valid technique in adult airway management. Our study indicates that ST or PDT performed by a surgeon results in lower perioperative morbidity and mortality rates when compared with PDT performed by a critical care specialist. Although PDT performed by a critical care specialist has complication rates comparable with published rates for ST, PDT was associated with postoperative death, which is not frequently reported with ST.

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