

COMPARISON OF PERCUTANEOUS DILATATIONAL TRACHEOSTOMY WITH SURGICAL TRACHEOSTOMY

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Abstract

Rationale: Tracheostomy is done mostly in critically ill patients, many of whom may not survive. We still do not know the long term complications of tracheostomy itself; tracheal and subglottic stenosis, and tracheomalacia.

Objectives: To compare the complications of surgical tracheostomy (ST) versus percutaneous dilatational tracheostomy (PDT) by means of MRI control up to 1 month after closed tracheostomy.

Results: There was no death related to tracheostomy. In both groups there were two preoperative complications: one minor hemorrhage and one subcutaneous emphysema in the ST group, and one minor bleeding and one puncture of endotracheal tube cuff in the PDT group. When the early and the late postoperative complications of the two groups were compared, it was observed that in the ST group, five early (one minor bleeding, three stomal infections and one accidental decannulation), and two late (one peristomal granuloma and one persistent stoma) postoperative complications had occurred. In the PDT group, four early (minor bleeding) and two late postoperative complications (two minor bleeding) were observed. MRI of

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two patients in the PDT group demonstrated tracheal stenosis.

Conclusions: PDT is as safe and as effective as ST. Although the early and late postoperative complication rates were not significant in the PDT group, we believe that further investigations with larger groups are necessary to find long-term outcome following PDT. MRI scanning provides an excellent non-invasive method of assessing the tracheal lumen.

Keywords: Surgical tracheostomy, percutaneous dilatational tracheostomy.

Introduction

Surgical tracheostomies (ST) are often performed in critically ill patients who need prolonged respiratory care. In 1976, Brantigan and Grow³ presented encouraging results with elective surgical cricothyroidotomy, a procedure that has been frequently used in intensive care units. The main advantages of the cricothyroidal approach are its simplicity, speed and low rate of complications. However, some authors, mostly otolaryngologists, disagree with the elective use of cricothyroidotomy and recommend it only as an emergency procedure because of the subglottic stenosis and vocal cord paralysis that may ensue. In addition, to facilitate the insertion of the tracheostomy tube, conventional surgical techniques require large cutaneous incision and wide dissection of the anterior structures of the neck, procedures that may cause some complications²⁰.

Surgical tracheostomy (ST) is one of the oldest surgical procedures and has probably been existing for more than 3000 years. The technique of surgical tracheostomy (ST) was standardized by Chevalier Jackson, and published its operative details. The standard surgical tracheostomy (ST) technique has a complication rate of up to 66%¹. Although the mortality rate, associated with the ST itself is very low, the postoperative complications such as bleeding, cellulites-infection of the stoma and bad cosmetic results still exist and relatively frequent.

In contrast to the ST, some authors have substantiated the reduced incidence of bleeding and stomal infections with percutaneous dilatational

tracheostomy (PDT). In 1985, Ciagla et al.⁷ described a technique of PDT using a needle, guide wire and multiple sequentially larger dilators. In 1989, Schachner et al.²⁹ developed a single dilation tracheostomy forceps over a guide wire. In 1990, Griggs et al.¹⁹ developed another guide wire dilating forceps with a smooth, rounded tip for percutaneous tracheostomy.

The aim of our study was to compare the PDT technique with that of the ST in intensive care patients who required tracheostomy for respiratory management. Late complications of PDT have not been extensively studied. Our study is the first report of stenosis of the cervical trachea following PDT, as visualized by magnetic resonance imaging (MRI).

Methods & Materials

A prospective non-randomized study was undertaken to compare the safety and utility of surgical tracheostomy (ST) and percutaneous dilatational tracheostomy (PDT) techniques performed on patients in intensive care. The study was undertaken between Jan. 1999-Jan. 2001. It included thirty critically ill patients (22-76 years, median 49 years) in ICU who required tracheostomy for prolonged ventilatory support, airway protection, pulmonary toilette, or facilitation of weaning from the ventilator. The indications for tracheostomy in each group are shown in Table 1.

Table 1
Indications for tracheostomy

	PDT n = 15	ST n = 15
Hypoxic brain damage with coma	6	1
Head injury with coma	1	1
Bulbar paralysis		2
Sepsis	1	
Upper airway obstruction		3
Chronic obstructive lung disease	2	1
ARDS	1	2
Cerebrovascular disease	2	3
Potential postoperative obstruction	2	2
TOTAL	15	15

Exclusion criteria consisted of infection of tracheostomy site, known or expected difficult endotracheal intubation, distorted anatomy with unidentifiable anatomic land marks, previous surgery at the site, bleeding diathesis, unstable cervical spine, and age < 18 yr. Informed written consents were obtained from the relatives and the study was prospectively approved by the Hospital's Ethics Committee for human studies.

Percutaneous tracheostomies (PDTs) were performed by one IC specialist in 15 patients (6 females, 9 males). Standard surgical tracheostomies (STs) were performed by one surgeon in 15 patients (8 females, 7 males).

The procedure was successful in all patients.

Initially, all patients were intubated orotracheally and all tracheostomies were performed under I.V. general anesthesia using midazolam, fentanyl, and cis-atracurium. All patients received controlled ventilation of lungs with an inspired oxygen concentration (FIO₂) of 100%. Arterial blood pressure, electrocardiography, pulse oximetry were continuously monitored.

Surgical tracheostomies (ST) were performed by surgical specialists who used standard surgical technique. PDTs were performed in all other patients by IC care specialist using the Griggs' guidewire dilating forceps (GWDF) technique.

All PDTs were performed by the same anesthesia intensivists and were carried out at bedside in the ICU. A 15 cm horizontal skin incision was made over the first and third tracheal rings. The pretracheal tissues were dissected with a forceps and the trachea was cannulated with 14-G cannula between the first and the second, or the second and third tracheal rings. Aspiration of air through the cannula reaffirms correct placement. The J guidewire was inserted down the cannula into the bronchi and the cannula removed. A 14-G dilator is passed over the guidewire to start stomal formation in the anterior tracheal wall. The guidewire dilating forceps is based on the design of "Howard Kelly" clamp and is locked in the closed position to pass over the guidewire. The proximal end of the guidewire was

held while the guidewire dilating forceps was advanced until resistance was felt at the anterior tracheal wall. Opening the forceps at this point dilates the pretracheal tissues sufficiently to allow subsequent passage of the tracheostomy tube. The forceps was then closed again, reapplied on guidewire and advanced until the jaws pass through the anterior tracheal wall, where a loss of resistance was felt. The handles of the forceps can then be raised to align the jaws in the long axis of the trachea and guidewire dilating forceps was opened to dilate the anterior tracheal wall in one step. After dilatation, the forceps was removed in the open position. The tracheostomy tube was mounted on a specially designed obturator and advanced over the guidewire into the trachea. The obturator and guidewire were removed and tracheal suction of blood and secretions carried out. Cuff inflation and connection to the ventilator allowed auscultation of the lungs and tracheostomy tube was stitched and tied in place with tapes.

The times of tracheal intubation, oxygenation parameters, per and post interventional complications were recorded and compared. The lesion was then visualized by magnetic resonance imaging (MRI) for the investigation of late complications of PDT, one month after tracheostomy closure.

All data were presented as mean \pm standard deviation or median and range when appropriate. Calculation and data analysis were performed using a statistical package. Statistical significance was determined with the Mann-Whitney U test. Differences were considered to be statistically significant if $p < 0.05$.

Results

Demographic data are shown in Table 2. Patients had already received assisted ventilation in ICU for a range of 7-24 days (mean: 12.56 days).

There was no mortality related to both tracheostomy techniques. A total of 12 of 30 patients died because of progression of their underlying diseases while the tracheostomy was functioning well. For those 10 patients who survived up to decannulation, the time from institution of tracheostomy to decannulation ranged from 7 to 30 days with a mean of

16.5 days. Eight patients survived with their tracheostomies and probably will never be decannulated due to primary diseases such as one with who had the tracheostomy for five years, 4 with cerebrovascular disease and the rest with severe chronic respiratory condition.

Table 2
Demographic Data

	PDT n = 15	ST n = 15	P value
Age (years) median (range)	50 (22-76)	49 (25-75)	NS
Sex (n) male/female	9/6	7/8	NS
Duration of intubation mean (range)	13.05 (7-24)	12.06 (7-20)	NS
APACHE II score median (range)	19 (10-31)	15 (5-30)	NS

PDT: Percutaneous Dilatational Tracheostomy.

APACHE II: Acute Physiology and Chronic Health Evaluation NS: not significant.

Complications are shown in Table 3. None of the complications resulted in significant morbidity such as, poor oxygenation, requirement for blood transfusion or aspiration of gastric contents.

There were no statistical differences between the two groups in terms of demography or complication rates. One obese, short necked patient in the surgical (ST) group had accidental tracheal decannulation during change of posture on the third day of tracheostomy.

After tracheal decannulation, the stoma closed completely within 48-72 h in both groups. A remaining patient in the ST group was cannulated for 75 days and had a small persistent stoma which needed surgical closure. The most important early postoperative complication was stomal infection in three patients in the surgical group. MRI of two patients in the PDT group demonstrated tracheal stenosis.

Table 3
Tracheostomy complications

	PDT n = 15	ST n = 15	P value
<i>Perioperative</i>			
Hemorrhage	1	1	NS
False passage	0	0	NS
Pneumothorax	0	0	NS
Deaths	0	0	NS
Subcutaneous emphysema	0	1	NS
Puncture of endotracheal tube cuff	1	0	NS
<i>Postoperative</i>			
Hemorrhage (minimal)	4	1	NS
Significant bleeding	0	0	NS
Stomal infection	0	3	NS
Peristomal granuloma	0	1	NS
Persistent stoma	0	1	NS
Accidental decannulation	0	1	NS
Tracheal stenosis	2	0	NS
<i>Total complication</i>	8	9	NS

PDT: Percutaneous Dilatational Tracheostomy.

NS: not significant.

Discussion

Elective surgical tracheostomy (ST) in patients on long term ventilatory support is a widely accepted procedure in the ICU. However, after the advent of the Seldinger guidewire technique, PDT has almost replaced (ST)^{1,33}. Despite the long experience with ST, the technique still has many complications, with an overall incidence of 6%-66%, including pneumothorax or subcutaneous emphysema (4%-17%), tube dislodgement (0%-7%), local hemorrhage (3%-37%), stomal infection (17%-36%) and a mortality rate of 0%-5.3%. PDT, on the other hand, requires only a small skin incision, minimal blunt dissection of the anterior tracheal structures, takes only 1-10 min to perform and is commonly performed at

bedside^{20,15}.

In our series of 30 patients (15 patients in each study group), the PDT was not associated with clinically important hemorrhage (blood loss requiring blood transfusion or surgical intervention), purulent infection at the stoma, or any lethal complication. The ST group had 3 patients with stomal infection which may have been potentiated by the widespread tissue dissection required for the surgical technique.

Complications associated with the various PDT techniques have been reported. The overall incidence varies from 0%-25%, and includes tracheal cuff laceration (0%-9%), tracheal tube misplacement (0%-6%), local hemorrhage (0%-3.6%), pneumothorax or subcutaneous emphysema (0%-54%) and a mortality rate of 0%-2%²⁰.

In our study, one patient from PDT group had puncture of the cuff of the endotracheal tube and one patient in ST group had subcutaneous emphysema in the perioperative period.

Griggs et al.²⁰ found that the PDT technique was associated with a shorter procedure time and a significantly fewer morbidity, in comparison to the standard ST technique.

A meta-analysis of studies comparing PDT versus ST has been published in which PDT was found to be associated with an increased incidence of perioperative complications. However, in that meta-analysis, the authors did not take into account the different techniques used, or the fact that each technique has its own method and complications rates^{10,16}.

Escarment et al.¹¹ reported that two to three forceps dilatations were required in two-thirds of patients to achieve successful insertion of the tracheostomy tube, and they found that insertion of a tracheostomy tube is rarely achieved on the first attempt with the GWDF. In contrast, our study had only three patients from the PDT group who required a second dilatation and none required a third dilatation, before successful insertion of the tracheostomy tube.

The strength and experience of the operator may also influence the formation of tracheal stoma. Nates et al.²⁶ postulated that excessive

bleeding and other surgical complications of the GWDF technique were caused by uncontrolled dilatation of the trachea. The main advantage of PDT is its application in the ICU as a bedside procedure which prevents unnecessary delays and risks of transfer to the operating room. The long-term sequelae of the complications need to be evaluated^{3,21,2}.

Recently, prospective studies suggested that, the serious complication rate of the single step techniques are less than 3%^{33,4}.

The PDT was performed only in elective cases. It is not recommended, in its present form, in emergencies, of overlying enlarged thyroid glands, in marked obesity, in children, and whenever the cricoid cartilage cannot be definitely palpated. The perioperative complications are few and minor⁶. PDTs, however, have significant advantages when compared with the standard techniques of tracheostomy (ST)^{9,5,32}.

Griggs et al.¹⁹ developed an instrument that facilitates the operation of percutaneous tracheostomy which increased the simplicity and safety of the procedure.

More than three hundred years have passed since Sanctorious invented percutaneous tracheotomy. Recent modifications of the instruments used have made this old technique suitable for modern surgery and percutaneous tracheotomy has become a technique that is frequently used¹².

All developments aim to reduce potential problems with percutaneous tracheostomy methods. Serial dilator methods involve multiple insertions and the associated deforming and traction on the trachea may increase the risk of subsequent stenosis⁵.

An important issue in the development of the PDT technique is the question of who should perform percutaneous tracheostomy. Leinhardt et al.²³ recommended to keep this technique in the domain of surgery. He also pointed out that some doctors in non-surgical specialties, such as intensive care and anesthesia, have already been skilled in vascular access using the Seldinger technique, they could also be trained to perform percutaneous tracheostomy. In our study, all PDTs were performed by the same anesthesia intensivist and were carried out at bedside in the intensive care unit. The

success of the PDT technique has caused gradual abandoning of the surgical procedure in adult ICU patients.

The technique of tracheostomy in general presents a large number of advantages compared to conventional prolonged endotracheal intubation; improvement of patient's comfort and the avoidance of laryngeal, cricoidal and high-tracheal injury. Conventional ST is still associated with a remarkable number of complications in the ICU, which the PDT have partially eliminated¹⁷.

Tracheal stenosis is a late complication following any tracheostomy and long term intubation. The late complications in PDT, however, have not been extensively studied. Klusmann et al.²² reported a total atresia of the subglottic larynx and cervical trachea after PDT. We found two severe late complications. Two patients had tracheal stenosis in the PDT group. Both stenosis were asymptomatic. Gambale et al.¹⁸ reported low rate of complications with PDT techniques.

Although rare, complications may arise several weeks or months after decannulation: stenosis of the trachea, changes in voice and fistula formation between the trachea and skin. Therefore a strict surveillance protocol is needed to recognize and treat late complication⁹. Fikkers et al.¹⁴ reported a single patient with a tracheal stenosis as a major late complication. Sustic et al.³⁰ demonstrated that ultrasound-guided PDT with regards to complications was at least equally safe as ST; at the same time, it is a quicker method, probably with less late infections of the stoma. Oeken et al.²⁷ found no tracheocutaneous fistulas or tracheostenoses, scars were unobtrusive with Fantoni translaryngeal tracheotomy technique. Melloni et al.^{24,25} concluded that PDT was a simpler and quicker procedure than ST and that it had a lower rate of early postoperative complications. Late tracheal complications were more frequent, although the difference was not statistically-significant, in the PDT group. Further investigations of long term outcome following PDT are therefore necessary.

There is a trend to replace the ST by the PDT. However, according to the potentially jeopardizing complications, PDT should be done by an experienced operator with the help of a continuous endoscopic

guidance^{8,28}.

It is unknown at which moment tracheostomy can best be performed in the translaryngeally intubated patient. There are theoretic arguments for both early and late tracheostomy. The excellent results of PDT may influence the decision to perform a tracheostomy rather early, but prospective randomized studies are required to gather the necessary evidence³¹. Fischler et al. reported that despite its frequency, tracheostomy in Swiss ICUs is far from being standardized with regard to indication, timing and choice of technique¹³.

We conclude that PDT is as safe and effective as ST. Although early and late postoperative complications rates were not statistically significant in the PDT group, further investigations of long-term outcome following PDT are therefore necessary. The percutaneous technique has a lower rate of early infections complications than the ST. Tracheal stenosis is a late complication for any tracheostomy or long term intubation. MRI scanning provides an excellent non-invasive method of assessing the tracheal lumen.

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