Percutaneous Tracheostomy Tube Obstruction*

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Study objectives: To determine the patency of standard and modified Portex tracheostomy tubes inserted by the percutaneous dilatational technique.

Design: Prospective observational study.

Setting: Medical-surgical ICUs in a tertiary care community hospital.

Patients: Medical-surgical ICU patients requiring tracheostomy.

Interventions: Consecutive medical-surgical ICU patients requiring tracheostomy were eligible for the study. Percutaneous tracheostomy tubes were inserted using the percutaneous dilatational technique with bronchoscopic guidance. The study population consisted of the following two groups: group 1 (receiving the standard Portex Per-fit percutaneous tracheostomy tube); and group 2 (receiving the modified Portex Per-fit percutaneous tracheostomy tube). Patients underwent daily fiberoptic evaluation to assess tracheostomy tube patency following the first 72 h after the tracheostomy tube placement. Demographic data and clinical signs or symptoms of airway obstruction were recorded.

Measurements and results: Thirty-seven patients received the standard percutaneous tracheostomy tube (group 1), and 17 patients received the modified percutaneous tracheostomy tube (group 2). Partial tracheostomy tube occlusion (> 25%) was observed in 21 of 37 group 1 patients (57%) and in 1 of 17 group 2 patients (6%; p < 0.005). Fifteen of 37 group 1 patients (41%) and none of the group 2 patients sustained a ≥ 40% occlusion of the distal tracheostomy tube opening (p < 0.005). One patient from group 1 had clinical manifestations of tracheostomy tube obstruction. None of the patients in group 2 experienced signs or symptoms of airway obstruction.

Conclusions: The standard Portex Per-fit percutaneous tracheostomy tubes used in this study were associated with partial airway obstruction. Modifications of the standard Portex percutaneous tracheostomy tube markedly decreased the airway obstruction. Due to the findings in this study, the authors recommend abandoning the continued use of the Portex Per-fit percutaneous tracheostomy tube in its current configuration and replacing it with the modified tracheostomy tube described in this study. (CHEST 2002; 122:1377–1381)

Key words: airway obstruction; complications; percutaneous; percutaneous dilatational tracheostomy; tracheostomy tube

Abbreviation: SIMS = Smiths Industry Medical Systems

In many institutions, percutaneous tracheostomy has evolved into the procedure of choice for performing a tracheostomy in selected ICU patients. The technique of percutaneous dilatational of tracheostomy was first described by Ciaglia et al in 1985. Subsequently, several prospective, randomized, controlled trials have documented an equal or lesser number of complications with the percutaneous dilatational technique compared to the open surgical technique of tracheostomy.

In 1987, we reported two cases of symptomatic percutaneous tracheostomy tube obstruction. In 1999, Nates et al reported on a series of patients, one of whom may have expired from tracheostomy tube obstruction. Our experience and support from the literature prompted an evaluation to determine the patency of percutaneous dilatational tracheostomy.
tomy tubes placed at our institution.8–10 The study was divided in two parts. The first part of the study assessed the patency of a standard Portex Per-fit percutaneous tracheostomy tube (Smiths Industries Medical Systems [SIMS] Portex Inc; Keene, NH). Due to the initial findings of this study, a second part assessing the patency of a modified Portex Per-fit percutaneous tracheostomy tube was performed.

Materials and Methods

The study was performed in a medical-surgical ICU at a tertiary care teaching community hospital. The hospital’s institutional review board approved the study, and informed consent was obtained from each patient or next of kin. The operating surgeons were trained and experienced in the percutaneous dilatational technique using the SIMS Portex Per-fit Percutaneous Tracheostomy Kit. Mechanically ventilated medical-surgical ICU patients who were at least 18 years of age and required a tracheostomy were eligible for the study. Patients with any of the following criteria were excluded from the study: (1) prior tracheostomy; (2) hemorrhagic disorders (ie, platelet count, < 50,000 cells/μL; international normalized ratio, ≥ 2.0; or activated partial thromboplastin time, ≥ 1.5 times the control value); (3) marked anatomic abnormalities of the trachea or cervical region; (4) clinical evidence of infection at the trachea puncture site; (5) clinical suspicion or evidence of increased intracranial pressure; (6) documentation or clinical suspicion of cervical injury; or (7) the need for an emergent airway. Demographic data were collected on all study patients.

Initially, the study patients undergoing percutaneous dilatational tracheostomy received a standard Portex Per-fit tracheostomy tube (group 1). The standard Portex Per-fit tracheostomy tube (Fig 1) is flexible with a tapered ending, a flat balloon profile; and a left bevel. The purported benefit of these features is to facilitate the insertion of the tracheostomy tube during percutaneous dilatational tracheostomy.

Due to the findings of partial tracheostomy tube obstruction in group 1 patients, a second study phase was developed. The investigators believed that the partial tracheostomy tube obstruction might be due to the current tracheostomy tube design. The partial tracheostomy tube obstruction appeared to be due to the posterior membranous tracheal wall encroaching on the tracheostomy tube lumen. Therefore, the standard tracheostomy tube was modified to include a shortened posterior bevel (ie, the longest portion of the tracheostomy tube posteriorly) and a decreased length and angle of the tracheostomy tube (Fig 1). These features would theoretically enhance the anterior orientation of the tracheostomy tube.

Patients received midazolam and fentanyl, and underwent neuromuscular blockade with pancuronium for the procedure. Full mechanical ventilator support with volume control ventilation, at a fraction of inspired oxygen of 1.0 atm, and arterial saturation monitoring with pulse oximetry were provided. Prior to the percutaneous tracheostomy procedure, bronchoscopic airway inspection and pulmonary toilet were performed. Subsequently, the endotracheal tube was positioned in the subglottic space above the percutaneous entry site by transillumination. The bronchoscopist confirmed airway placement of the introducer needle and guidewire with a guiding catheter. The size of the tracheostomy tube inserted was left to the discretion of the operating surgeon. A Portex Per-fit percutaneous tracheostomy tube was inserted following the recommended manufacturer guidelines accompanying the tracheostomy tube kit. Immediately following the tracheostomy tube insertion, the bronchoscope was inserted through the tracheostomy tube to visualize the distal opening and airway. Following the insertion of the percutaneous tracheostomy tube, the patient underwent clinical monitoring and daily fiberoptic inspection of the airway using a 2-mm

Figure 1. Standard (left) and modified (right) Portex Per-fit percutaneous tracheostomy tubes.
endoscope (Angiodynamics, Rockingham, VT) for 3 days. A still photograph was obtained with the use of a video bronchoscope. Daily evaluations and clinical signs or symptoms of airway obstruction (i.e., increased airway pressures, decreased tidal volumes, development of air trapping or auto-positive end-expiratory pressure, and the ease of inserting a suction catheter) were recorded.

Statistical analysis was performed using the \( \chi^2 \) analysis, and a \( \text{p} \) value of < 0.05 was considered to be significant.

**RESULTS**

Fifty-four medical-surgical ICU patients were enrolled into the study. The following two groups of patients were studied: group 1 received a standard Portex Per-fit percutaneous tracheostomy tube; and group 2 received a modified Portex Per-fit percutaneous tracheostomy tube.

Thirty-seven patients were enrolled in group 1, which consisted of 12 women and 25 men with an average (±SD) age of 51 ± 20 years who had received the following diagnoses: closed head injury, 15 patients; ARDS, 7 patients; pneumonia, 5 patients; CNS hemorrhage, 4 patients; COPD, 3 patients; vocal cord paralysis, 1 patient; cerebral vascular accident, 1 patient; and Guillian-Barré syndrome, 1 patient. Seventeen patients were enrolled in group 2, which consisted of 10 women and 7 men with an average age of 58 ± 20 years who had received the following diagnoses: closed head injury, 5 patients; ARDS, 3 patients; CNS hemorrhage, 4 patients; COPD, 2 patients; pneumonia, 1 patient; cerebral vascular accident, 1 patient; and pulmonary embolism, 1 patient. Twenty-one of 37 patients (57%) in group 1 were documented to have a ≥ 25% partial occlusion of the tracheostomy tube compared to 1 of 17 patients in group 2 (\( \text{p} < 0.005; \text{Fig 2} \)). Fifteen of 37 patients (41%) in group 1 were documented to have ≥ 40% partial occlusion of the distal tracheostomy tube opening compared to none of the patients in group 2 (\( \text{p} < 0.005 \)). The average tracheostomy tube size in group 1 was 8.2 mm (9 mm, 14 patients; 8 mm, 20 patients; 7 mm, 3 patients), and in group 2 it was 8.1 mm (9 mm, 2 patients; 8 mm, 14 patients; 7 mm, 1 patient).

The partial occlusion of the tracheostomy tube was secondary to the posterior membranous portion of the trachea and the lateral tracheal wall encroaching on the distal lumen. The partial occlusion of the tracheostomy tube was accentuated with increases in intrathoracic pressure. One patient in group 1 sustained clinical symptoms of tracheostomy tube obstruction. This patient was obese with a large neck. On evaluation, it was discovered that the tracheostomy tube was not long enough to fit properly into the trachea. The tracheostomy tube was changed to a standard endotracheal tube through the stoma without incident. The other 36 patients in group 1 had no clinical signs or symptoms that were consistent with tracheostomy tube obstruction.

Due to the findings documented in the first 37 patients, the investigators recommended that modifications be made to the Per-fit tracheostomy tube that would theoretically diminish the amount of tracheostomy tube obstruction. Specifically, the orientation of the tracheostomy tube bevel was changed from left to posterior. This would result in the greatest length of the tracheostomy tube to be positioned posteriorly. In addition, the tracheostomy tube was slightly shortened and the angle of the
tracheostomy tube curve was decreased. Theoretically, this would place the tracheostomy tube opening in a more anterior position. These changes were incorporated into the tracheostomy tubes used in the group 2 patients. Seventeen patients underwent percutaneous dilatational tracheostomy with the modified Per-fit percutaneous tracheostomy tube (group 2). One of 17 patients (6%) sustained a ≥ 25% partial occlusion. None of the patients in group 2 had clinical signs or symptoms of tracheostomy tube obstruction.

**Discussion**

Over the past several years, percutaneous tracheostomy has evolved as the procedure of choice for selected medical-surgical ICU patients requiring tracheostomy. Several studies have described the advantages and complications of percutaneous tracheostomy. Unfortunately, detailed data evaluating the complication of tracheostomy tube obstruction following percutaneous insertion are difficult to secure. The reported incidence of percutaneous tracheostomy tube obstruction ranges from 0 to 3.5%, according to the literature. Details regarding the diagnosis, etiology, and treatment of obstructions have been inconsistently reported. The interpretation of such data is fraught with difficulties. Not all studies have reported tracheostomy tube obstruction as a complication following percutaneous tracheostomy, including a meta-analysis of prospective trials comparing percutaneous and surgical tracheostomies. In addition, percutaneous tracheostomy tube obstruction has been reported following several different techniques of insertion involving several types of tracheostomy tubes.

The investigators’ experience and the supportive literature prompted a quality improvement exercise evaluating percutaneous dilatational tracheostomy patients for tracheostomy tube obstruction. Surprisingly, 57% of the patients initially evaluated had a ≥ 25% obstruction of their tracheostomy tube. Of more concern was the ≥ 40% tracheostomy tube obstruction visualized in 41% of the initial study patients (Fig 2, top). The cause of the partial tracheostomy tube obstruction was the membranous posterior tracheal wall encroaching on the tracheostomy tube lumen. In addition, several patients displayed a dynamic component to their obstruction. That is, when the patient’s intrathoracic pressure increased, the degree of obstruction also increased. One study patient displayed clinical signs and symptoms of tracheostomy tube obstruction. This patient was obese and had a large neck, and it became obvious that the tracheostomy tube that had been selected was too short for this particular patient. This episode reinforces the notion that patient selection remains critical for the success and safety of the percutaneous dilatational tracheostomy procedure.

Due to these findings, the investigators recommended that modifications be made to the existing Portex percutaneous tracheostomy tube in an attempt to lessen the degree of partial tracheostomy tube obstruction. Theoretically, these changes would improve the tracheostomy tube positioning within the trachea. The modifications are described in the “Materials and Methods” section. The next 17 patients received the modified Portex percutaneous tracheostomy tube. Partial tracheostomy tube obstruction (ie, 25% of the lumen) was observed in one of these patients. The modifications have improved dramatically the degree of percutaneous tracheostomy tube obstruction (Fig 2, bottom).

Based on a MEDLINE search, this appears to be the first series describing the finding of partial percutaneous tracheostomy tube obstruction due to the posterior tracheal wall in patients undergoing percutaneous tracheostomy. Despite the several weaknesses of this study, including the lack of randomization, the observational nature of the study, and the limited period of observation, the results warrant attention. Modifications in the existing percutaneous tracheostomy tube improved the position of the tracheostomy tube intratracheally. Lessening the degree of partial tracheostomy tube obstruction will enhance patient safety. Due to the findings in this study, the authors recommend abandoning the continued use of the Portex Per-fit percutaneous tracheostomy tube in its current configuration and replacing it with the modified tracheostomy tube described in this article or with a tracheostomy tube encompassing similar characteristics.

**References**

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