Audit of over 500 percutaneous dilational tracheostomies

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ABSTRACT

Aim: To review immediate procedure-related complications of percutaneous dilational tracheostomy (PDT) in relation to patient characteristics, technique and seniority of operator.

Design: Retrospective audit of all tracheostomies performed in our ICU over 10 years.

Method: Data were derived from a prospectively maintained tracheostomy logbook and, when necessary, from patients' case notes. Data were compiled to determine demographic characteristics, diagnosis on admission, indication for tracheostomy, technique used, seniority of operator, and complications related to the procedure.

Results: 581 tracheostomies (501 PDT and 80 surgical) were performed between January 1995 and December 2004. A written protocol was followed with standardisation of indication, authorisation and supervision by consultant, antibiotic prophylaxis and anaesthetic technique. Mean patient age was 67.6 (SD, 15.7 years) (PDT group) and 52.1 (SD, 12.4) (surgical group). Mean Apache II score was 20.6 (SD, 7.9) (PDT) and 19.7 (SD, 6.8) (surgical). The PDT techniques used were Griggs' forceps dilatation (85%), Ciaglia's multiple sequential dilator technique (15%), and Ciaglia's Blue Rhino single dilator technique (0.2%). Prolonged respiratory weaning was the most common indication (42%), followed by head injury and other neurological causes (31%). The surgical group comprised patients with multiple trauma and those deemed to have difficult anatomy, with 11 PDTs being converted to surgical tracheostomies. In the PDT group, bleeding was the most common complication (4.3%), followed by desaturation (1.0%), bradycardia (1.0%) and hypotension (0.8%). Two patients in the PDT group needed surgical control of bleeding. There was one death, 11 days after PDT, caused by secondary haemorrhage. Complications were not related to operator seniority.

Conclusion: Our findings are comparable with those of other published case studies, with low complication rates for PDT. This audit supports our structured training program, policies on procedure, and quality audit process.

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Tracheostomy is a common procedure in ICU patients. The history of tracheostomies dates back many centuries, with the surgical technique well described by Jackson in 1909;[1] it has changed little since then. Percutaneous tracheostomy was first described by Shelden et al in 1955.[2] In 1985, Ciaglia et al introduced a technique involving serial tracheal dilators over a Seldinger-type wire (Cook, Denmark).[3] In 1990, Griggs et al described a Seldinger-based single dilatation technique using modified Howard Kelly forceps (Sims Portex, UK).[4] Subsequently, Ciaglia's multiple dilators were modified to a single graded tracheal dilator called the Blue Rhino[5,6] (Cook, Denmark).

At our hospital, percutaneous dilational tracheostomy (PDT) has been used extensively for over a decade. Our preferred method has been the Griggs' forceps dilatation.[4] The aim of this study was to audit immediate procedure-related complications, in relation to patient characteristics, procedure and operator. A prospective log book of all ICU tracheostomies had been maintained with such a quality audit in mind.

Methods

Data were reviewed for all tracheostomies performed in ICU patients from January 1995 to December 2004. The data were collected from the prospectively maintained logbook and, when necessary, from patients' clinical notes. The logbook documentation included patient characteristics, indication for tracheostomy, procedure used (percutaneous or surgical), method used if it was a percutaneous tracheostomy, seniority of operator (consultant or registrar), immediate procedure-related complications and number of percutaneous tracheostomies requiring conversion to surgical tracheostomy. Surgical tracheostomies on ICU patients were also recorded.

All percutaneous tracheostomies were performed as a bedside procedure following a strict protocol. All percutaneous procedures were authorised by the intensive care consultant and performed either by the consultant or by a senior registrar (ie, a senior vocational ICU trainee) under scaled supervision. Patient coagulation parameters were checked before the procedure; if the international normalised ratio (INR) was >1.5, or the platelet count was $<40\times 10^9$/L, the defect was corrected before the procedure by infusion of appropriate blood products. All procedures were performed with general anaesthesia and local infiltration of lignocaine (1% with 1:100 000 adrenaline). A consultant or senior registrar was designated exclusively to managing the airway, and all patients were monitored with

electrocardiography, pulse oximetry, invasive arterial blood pressure monitoring and measurement of end-tidal CO_2. All patients received 100% inspired oxygen during the procedure and, according to unit guidelines, a single dose of intravenous antibiotic, based on current microbiological surveillance. Tracheostomy tube placement was confirmed by end-tidal CO_2 measurement, and all patients had a post-procedure chest x-ray to rule out pneumothorax.

All surgical tracheostomies were performed in the operating theatre by an otolaryngologist or a trauma surgeon. On return to the ICU, all patients received a chest x-ray to rule out pneumothorax and confirm tube position. Indications for surgical tracheostomy included midline neck mass, obese and short neck limiting identification of surface landmarks, local infection, cervical spine fractures, head and facial trauma requiring surgery, difficult-to-correct coagulopathy and failed PDT.

An immediate complication was one that occurred between the time of surgery and the time the chest x-ray was performed. Complications were defined as:

- desaturation — SpO_2 < 90%;
- hypotension — fall in mean arterial pressure below 60 mmHg or need to increase existing vasopressor infusion rate;
- bradycardia — heart rate < 40 beats per minute;
- bleeding — blood loss > 50 mL; and
- loss of airway — dislodgement of the endotracheal tube at any time during the procedure before placement of the tracheostomy tube.

Results

During the 10-year period, 581 tracheostomies were performed: 501 PDTs and 80 surgical tracheostomies. Patient characteristics are shown in Table 1.

In the PDT group, the preferred technique was Griggs' forceps dilatation (426 patients) followed by Ciaglia's multiple dilator technique (74 patients); one procedure was performed with the Blue Rhino single step dilator. Around 12% of tracheostomies performed each year were surgical, with a declining trend in this procedure (Figure 1). In the PDT group, registrars performed 278 procedures, and consultants performed 223. Bronchoscopy was not routinely used to guide PDT.

The indications for PDT are shown in Table 2 and for surgical tracheostomy in Table 3. The most common indication for PDT was prolonged respiratory weaning (42%), followed by traumatic brain injury (17%). The most common indication for surgical tracheostomy was unfavourable local anatomy (26%).

Complications occurred in 44 patients (8%) in the PDT group (Table 4). The most common was bleeding (blood loss > 50 mL), in 24/501 (4.3%). Two of these patients needed surgical control of bleeding. Desaturation (SpO_2 < 90%)

Figure 1. Annual numbers of percutaneous dilational (PDT) and surgical tracheostomies

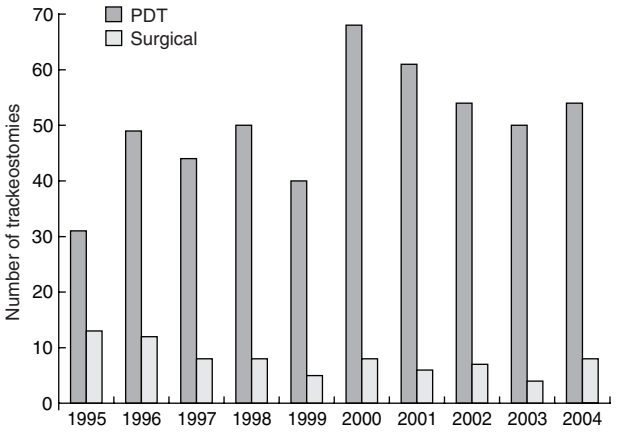

Table 1. Characteristics of patients who underwent PDT or surgical tracheostomy

	PDT (*n* = 501)	Surgical (*n* = 80)
Age (years): mean (SD)	67.6 (15.7)	52.1 (12.4)
Male:female ratio	1.5:1	0.8:1
APACHE II score: mean (SD)	20.6 (7.9)	19.7 (6.8)

PDT = percutaneous dilational tracheostomy

Table 2. Indications for percutaneous dilational tracheostomy

Indication	Patients (*n* = 501)
Prolonged respiratory weaning	210 (42%)
Traumatic brain injury	84 (17%)
Intracerebral pathology	73 (14%)
Sepsis with multi-organ failure	65 (13%)
Upper gastrointestinal surgery	22 (4%)
Spinal pathology	16 (3%)
Other*	32 (6%)

* Including pulmonary hygiene and neuromuscular disorders (eg, Guillain–Barré syndrome).

occurred in five patients (1%), and bradycardia in five (1%), but both conditions were transient and resolved spontaneously. Four patients (0.8%) developed transient hypotension during the procedure, three (0.7%) developed subcutaneous emphysema, which resolved spontaneously over a few days, and two patients (0.5%) had loss of airway during the procedure, but were easily reintubated orotracheally. One patient (0.2%) developed a pneumothorax 4 hours after the procedure. Of the 44 complications, 23 occurred with a registrar as the operator, and 21 with a consultant as the operator ($P = 0.68$, χ^2 test).

There was one death, 11 days after PDT, caused by secondary haemorrhage. The patient had cachexia and severe lung disease with cor pulmonale, and was receiving high-dose corticosteroids.

Table 3. Indications for surgical tracheostomy

Indication	Patients ($n = 80$)
Unfavourable local anatomy	21 (26%)
Head and facial trauma	15 (19%)
Coagulopathy	12 (15%)
Local infection	10 (13%)
Cervical spine fracture	9 (11%)
Surgical preference	2 (3%)
PDT converted to surgical*	11 (14%)

PDT = percutaneous dilational tracheostomy. * Conversion from PDT was due to bleeding in 7 patients and unfavourable anatomy in 4.

Discussion

Elective tracheostomy is widely used in ICU patients who require prolonged ventilation. PDT has almost replaced elective surgical tracheostomy in ICU patients. There have been concerns about surgical tracheostomy, including patient safety during transport to the operating theatre,[7-9] and delay before the procedure because of its semi-elective nature.[10] Although a number of percutaneous techniques have been developed, Ciaglia's[3] and Griggs'[4] techniques are most popular. In 1998, Ciaglia's multiple dilators were modified to a single tapering dilator with a hydrophilic coating permitting complete dilatation in a single step. The single dilator technique has now almost completely replaced multiple dilator techniques.

In our audit, mean age in the PDT group was 67.6 years, versus 52.1 years in the surgical tracheostomy group. Most of those who underwent surgical tracheostomy had head or spine trauma (30% in total); these types of patients tend to be younger. The mean APACHE II score in both groups was comparable to that found in other studies.[11,12] These features are typical of patients in the modern ICU.

In our institution, Griggs' technique has been the preferred method of PDT, because of the expertise and experience of senior medical staff in its use since it was introduced in Australia. There has been a structured teaching program for trainees to learn the technique, with specialists personally demonstrating and subsequently supervising each procedure. In the latter half of the audit, a computerised tutorial was produced and provided for all trainees. The importance of a senior medical practitioner exclusively focused on managing the airway[13] is also emphasised, and all standard monitoring is used for each procedure.

The most common indication for PDT in our patients was respiratory failure and weaning from ventilation, followed by neurotrauma and intracerebral pathology. Many studies have reported respiratory failure and weaning as a major indication for tracheostomy.[12-15] Antonelli et al found that 34% of their tracheostomy patients were admitted to ICU with a neurosurgical cause, while 25% had respiratory failure.[15] Ambesh et al also reported difficulty in weaning from mechanical ventilation as a leading indication for tracheostomy.[12]

Generally, the limitations or contraindications for PDT provide the indications for surgical tracheostomy.[11,14-16] In our audit, unfavourable local anatomy, followed by head and facial trauma, was the most common indication for surgical tracheostomy. In a prospective review of 500 patients undergoing PDT, Kost listed contraindications for PDT as a midline neck mass, difficulty in identifying or palpating local anatomy, and coagulopathy.[14] We have been following a similar practice for identifying patients who need surgical tracheostomy. Eleven of our patients had PDT converted to open tracheostomy, because of bleeding in seven and unfavourable anatomy in four. In a review of 100

Table 4. Complications of percutaneous dilational tracheostomy

Complication	Patients ($n = 501$)
Bleeding > 50 mL	24 (4.3%)
Desaturation	5 (1.0%)
Bradycardia	5 (1.0%)
Hypotension	4 (0.8%)
Subcutaneous emphysema	3 (0.7%)
Loss of airway	2 (0.4%)
Pneumothorax	1 (0.2%)

patients, Massick et al identified 17 patients with unfavourable anatomy; in three of these, PDT had to be converted to open surgical tracheostomy.[17] Similarly, Graham et al reported two patients converted to open tracheostomy out of 31 undergoing PDT.[18]

The overall complication rate for PDT in our audit was 8%. The most common complication was bleeding, followed by transient desaturation and bradycardia. In a prospective review of 500 cases of endoscopically guided PDT, Kost reported an overall complication rate of 9.2%, with desaturation and bleeding being the most common complications.[14] Holdgaard et al, in a comparison of 60 patients undergoing surgical tracheostomy or non-endoscopically guided PDT, reported a 20% incidence of bleeding during the PDT procedure.[19] In a similar comparison, Friedman et al reported a 13% incidence of bleeding and no cases of transient hypoxia in the PDT group.[10] The meta-analysis by Freeman et al concluded that PDT had a lesser incidence of both perioperative bleeding and stomal infection.[16] Kost found that use of endoscopic guidance reduced the complication rate from 16.8% to 8.3%.[14] Our complication rate was similar to that in Kost's endoscopically guided group. We believe that routine use of bronchoscopy may add time, cost and complexity to the procedure and has its own complications, such as partial occlusion of the airway and CO_2 retention. These factors should be considered if adopting bronchoscopy as routine, and we recommend further study of its true place in PDT.

Hypotension related to the procedure was transient and quickly responded to intravenous fluids. We attributed the hypotension to administration of anaesthetic drugs. Three patients developed subcutaneous emphysema, which resolved spontaneously. Friedman et al reported one case of surgical emphysema in their surgical group and none in their PDT group,[10] while Graham et al reported one in each group.[18] Escarment et al, in a review of 162 patients, reported one with subcutaneous emphysema.[13]

Loss of airway occurred in two patients in our PDT group. In a study of 24 patients, Porter and Ivatury reported a trend towards loss of airway in their PDT group (using bronchoscopy) compared with the surgical tracheostomy group, with 8% incidence of loss of airway in the PDT group.[20] In contrast, Friedman et al reported no loss of airway in their PDT group.[10] We believe that the low incidence of loss of airway in our patients, and lack of any significant complications related to this, was a result of assigning an experienced practitioner exclusively to managing the airway.

Although our audit assessed only procedure-related complications, we detected one delayed pneumothorax (after 4 hours) and one death (after 11 days, caused by secondary haemorrhage). We found that complications occurred independently of operator seniority, which again highlights the success of our institution's program of supervision and training for vocational trainees and consistency of approach to the procedure within our ICU.

Conclusion

Our experience with PDT is comparable to that in other published studies. Bleeding was the most common complication of PDT. Unfavourable anatomy, and head and facial trauma were the most common indications for performing surgical tracheostomy rather than PDT. The complication rate related to the procedure was low, and was not determined by the seniority of the operator. The results of this audit support our structured training program and scaled supervision of trainees.

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