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Safety and complications of percutaneous tracheostomy in a cohort of 800 mixed ICU patients

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Summary

Percutaneous tracheostomy is used primarily to assist weaning from mechanical ventilation in the intensive care unit. We report our experiences of 800 such procedures performed in the intensive care unit by a collaborative team (critical care and ENT specialists). Most procedures (85.6%) were performed by residents supervised by the intensive care unit staff. Complications occurred in 32 patients (4%). Intraprocedural complications occurred in 17 patients (2.1%), early postprocedural complications in six (0.75%), and late postprocedural complications in nine (1.1%). No deaths were directly related to percutaneous tracheostomy. The incidence of complications was greater in percutaneous tracheostomy performed by the residents during their initial five attempts compared to their later attempts (9.2% vs 2.6%, $p < 0.05$). The low incidence of complications indicates that bedside percutaneous tracheostomy can be performed safely as a routine procedure in daily care of intensive care unit patients.

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Advances and improvements in treating critically ill patients have resulted in greater numbers requiring prolonged mechanical ventilation and many of these patients are candidates for tracheostomy [1]. In 1909, Jackson described the standard surgical tracheostomy [2]. Percutaneous tracheostomy (PCT) was introduced in the mid-1980s as an alternative and has gained widespread acceptance over the past decade.

Benefits of a tracheostomy in long-term ventilated patients include improved airway suctioning and mouth care, better patient comfort, fewer laryngeal complications and the possibility of speech, and oral nutrition [3]. The main complications of prolonged tracheal intubation are ventilator-associated pneumonia and the adverse effects associated with prolonged sedation. The optimal timing of tracheostomy in critically ill patients remains controversial and it is a subject of debate and continued investigation. The current trend seems to perform the tracheostomy early (within 10 days) to prevent laryngeal injury [4]. However, the standard of care should be adapted to each patient and pathology, balancing the expected recovery course, risk of prolonged translaryngeal intubation and surgical risk of procedure [1]. A number of studies have shown that PCT is a simple, fast, and safe procedure that is associated with lower morbidity than standard surgical tracheostomy [1, 5], although there is a wide variation with respect to the timing and insertion rates [6].

The aim of this study was to evaluate the safety of PCT performed at the bedside by intensive care unit (ICU) staff physicians and residents in the last two years of fellowship training. A secondary objective was to assess the learning curve associated with insertion of PCT.

Materials and methods

The participants in this prospective observational study were 800 consecutive adult patients (570 men, 230 women) with a median age of 62 years [range 13–91 years], admitted to the ICU between May 1995 and November 2006, who were thought suitable for PCT because of a likely requirement for intubation of at least

15 days. The study was conducted in an Intensive Care Service responsible for 28 beds for the management of coronary, medical and trauma patients, as well as neurosurgery, thoracic surgery, and cardiovascular surgery patients of the Hospital Universitario Marqués de Valdecilla in Santander, Spain. The study population accounted for 2.7% of all patients admitted to the ICU during the study period. Exclusion criteria included an enlarged thyroid gland, acute burns, or evidence of coagulopathy defined as platelet count < 30 000 mm^{-3} or prothrombin time > 2 times control. Informed consent was obtained from the patient or the patient's family if the patient was not mentally competent.

The need for PCT was always determined by an attending critical care doctor. Most of the procedures (n = 685, 85.6%) were performed at the bedside by residents in the critical care and ear, nose and throat (ENT) specialties in the last 2 years (fourth and fifth years) of fellowship training under direct supervision of an experienced critical care physician. The Ciaglia progressive dilatational tracheostomy technique was used in the first 51 patients and the Griggs technique in the remaining 749 patients. Patients received intravenous analgesia, sedation and paralysis (midazolam or flunitrazepam, propofol, fentanyl and pancuronium or atracurium). The patient was positioned in the ICU bed with the neck hyperextended and the operative area prepared. The patient's lungs were ventilated with 100% oxygen. The tracheal tube was repositioned above the site of the proposed tracheostomy. Blood pressure, cardiac rhythm and pulse oximetry were continuously monitored during the procedure. A 2-cm horizontal incision was made between the cricoid cartilage and the suprasternal notch in the area between the first and second, or the second and the third tracheal rings. The trachea was then punctured in the midline by a cannula. Correct positioning was confirmed by easy aspiration of air. The guidewire was then passed and the percutaneous dilators (starting with a 12 Fr dilator increasing to a size of 38 Fr) or the dilatating forceps inserted until the required size tracheostomy tube could be placed. The Ciaglia technique was performed using the Ciaglia multiple dilator kit (Ciaglia Percutaneous Tracheostomy Introducer Set; William Cook Europe, Bjaeverskov, Denmark). The Griggs technique was performed using the Percutaneous Tracheostomy kit (Portex Ltd, Hythe, Kent, UK).

Bronchoscopy was only used in 35 procedures. Because no difference in the rate of complications with and without bronchoscopy was observed, bronchoscopy was not routinely performed in order to reduce the time of the PCT procedure.

All patients had chest X-rays performed immediately after the procedure. The first change of the tracheostomy tube was performed after 15 days. Intraprocedural and early (within the first 6 days) and late (within the first 6 months) postprocedural complications were recorded. Patients were evaluated by an ENT doctor at regular intervals after discharge. Telephone interviews were occasionally required to ask for the patient's condition in those who failed to attend follow-up appointments. Bleeding was classified as small (25–100 ml), moderate (100–250 ml) and severe (> 250 ml). The chi-square (χ^2) test was used for the comparison of categorical data. Statistical significance was set at $p < 0.05$.

Results

Of the 800 patients included in the study, reasons for tracheostomy included prolonged intubation for mechanical ventilation in 798 (99.7%) and urgent relief of airway obstruction in two patients. Reasons for admission to the ICU are shown in Table 1. Brain injury was the most frequent underlying conditions which required PCT. The median APACHE II score was 14 [range 2–45] at the time of ICU admission and 12 [range 1–40] before PCT. The median duration of preceding translaryngeal intubation was 9 days [range 0–83 days]. The median length of ICU stay was 21 days [range 1–368 days].

Table 1 Reasons for ICU admission in 800 patients undergoing percutaneous tracheostomy.

Reason for ICU admission	No. patients	%
Intracerebral haemorrhage	132	16.5
Head injury	100	12.5
Postoperative care after cardiac surgery	65	8.1
Polytrauma	64	8.0
Severe sepsis	61	7.6
Pneumonia	56	7.0
Cerebral anoxia	54	6.8
Lung transplantation	36	4.5
Acute myocardial infarction	27	3.4
Multisystem dysfunction	27	3.4
Postoperative care after lung surgery	26	3.2
Cardiac arrest	21	2.6
Ischaemic stroke	17	2.1
Postoperative care after neurosurgery	17	2.1
Chronic obstructive pulmonary disease	16	2.0
Postoperative care after abdominal surgery	12	1.5
Solid tumours	11	1.4
Heart failure	8	1.0
Peritonitis	8	1.0
Encephalitis	3	0.4
Acute gastrointestinal bleeding	3	0.4
Drug intoxication	3	0.4
Pulmonary thromboembolism	3	0.4
Tetanus	3	0.4
Tetraplegia	3	0.4
Miscellaneous	24	3.0

Table 2 Complications of percutaneous tracheostomy in 800 patients.

Events	No. patients
Intra-operative complications, *n* = 17	
Small bleeding (25–100 ml)	13
Paratracheal insertion	1
Injury to the anterior jugular vein	1
Displacement of the tracheal tube, hypoventilation and ventricular tachycardia	1
Fatal pulmonary thromboembolism	1
Early post procedural complications, *n* = 6	
Accidental decannulation	2
Massive haemoptysis	1
Occlusion of the cannula	1
Passage of the cannula into the mediastinum	1
Fatal pulmonary thromboembolism	1
Late post procedural complications, *n* = 9	
Occlusion of the cannula	3
Tracheo-oesophageal fistula	1
Persistent infection of the stoma	1
Dysphagia	1
Accidental decannulation	1
Tracheal stenosis	1
Granuloma	1

We observed complications in 32 patients (4%). Intraprocedural complications occurred in 17 patients (2.1%). Early postprocedural complications were recorded in six patients (0.75%). Late postoperative complications occurred in nine patients (1.1%). Details of complications are given in Table 2.

Percutaneous tracheostomies were performed by five critical care physicians and 39 residents during their last 2 years of fellowship training. Residents performed a median of 14 procedures, [range 6–20]. The number of complications was higher in PCTs performed by residents during their initial five attempts (18 complications in 195 attempts, 9.2%) than in the procedures performed thereafter (13 complications in 490 attempts, 2.6%) ($p < 0.05$). One complication was observed in a procedure performed by a staff physician.

A total of 240 (30%) patients died during their stay in the ICU. Causes of death were unrelated to the PCT procedure, although one patient with cerebral anoxia after cardiac arrest secondary to acute myocardial infarction developed clinical signs of pulmonary thromboembolism during the procedure and died 6 h later. A second patient presented with a pulmonary thromboembolism 2 h after the procedure and died.

Discussion

Although the benefits of performing elective tracheostomies in the ICU have been established in recent series, there are widely divergent opinions on the importance of principal indications. In fact, in a recent analysis of the data derived from the American College of Surgeons National Trauma Databank registry (106 centres) showed a wide unexplained variation in the rates of tracheostomy in critically injured patients with acute respiratory failure [6].

The bedside tracheostomy systems, including percutaneous dilatational tracheostomy and the guidewire dilating forceps can be considered the procedure of choice for performing elective tracheostomies in critically ill adult patients. Several studies have demonstrated that PCT is quicker, less traumatic, associated with fewer early and late complications, and more cost-effective than surgical tracheostomy. In a systematic review and meta-analysis involving 1212 patients, PCT resulted in a lower incidence of bleeding and death compared with surgical tracheostomy [7]. Overall, PCT was associated with a significant reduction in wound infection and was found to be equivalent to surgical tracheostomy for major peri-procedural and long-term complications [7]. In the present clinical series of 800 patients, there were no deaths directly related to the procedure.

Bleeding is probably the most frequent complication associated with PCT, although it appears to be less frequent in PCT compared with surgical tracheostomy. Intraprocedural bleeding complication was the commonest complication in our patients, although in all cases it was small or moderate and no transfusion was required. Depending on the definition of bleeding, the rate of this complication varies greatly in the literature, from 0% to 20%. In several prospective randomised studies, haemorrhage was only considered as a complication when transfusion was necessary [8, 9]. Other authors of randomised studies defined minor bleeding (20% of cases) as bleeding that could be controlled by digital pressure or local compression and major bleeding (0% of cases) as bleeding that required additional measures to control [10, 11]. Freeman et al. [12] analysed five prospective studies with 236 patients and observed that the operative bleeding rate ranged between 0% and 20% and the postoperative bleeding between 0% and 12%. We consider the definition of the amount of bleeding proposed by Friedman et al. [13] as small (25–100 ml), moderate (100–250 ml) and severe (> 250 ml) is the most appropriate.

The lower incidence of bleeding in PCT is explained by minimal disruption of tissues, the tamponade effect of the tightly fitting tracheostomy tube, and the vasoconstrictor effect of adrenaline in the local anaesthetic used to infiltrate the skin. In a recent report the incidence of acute bleeding was increased in those patients with an activated partial thromboplastin time above 50 s, a platelet count below 50 000 ml^{-1} and in the presence of two or more abnormal coagulation variables [14]. Cases of acute fatal haemorrhage during PCT in association with

aberrant arterial anatomy have been reported [15, 16]. Likewise, the small incision reduces bacterial colonisation and infection of the stoma. Stoma healing was satisfactory and cosmetic results were good. In other studies definitions of complications are lacking. In the meta-analysis conducted by Freeman et al. [12] (five prospective studies with 236 patients), the incidence of stomal infections ranged between 0% and 10%. Most authors consider that PCT is safe and is associated with a low rate of complications. Large series have reported an incidence of moderate or serious complications around 3–4% [17, 18]. The most serious complications associated with PCT are most often reported in anecdotal case reports and small series [1, 19].

Intensive care unit expansion and improvements in technology have led to increasing numbers of critically ill patients who require prolonged mechanical ventilation, most appropriately managed with tracheostomies. PCT is easy and safe, and can be performed at the bedside in the ICU, avoiding the risks associated with transport of critically ill patients to the operating room [20, 21]. Moreover, it is a simple procedure to learn and, in our experience, a minimum of five to ten procedures under the supervision of an expert physician are advisable to achieve adequate training. PCT is usually performed by two physicians at the bedside, one takes care of the patient's airway and the other performs the procedure, although a single physician could perform the procedure when necessary. Further advantages include lower costs compared with surgical tracheostomy [5, 22], and the fact that PCT can be performed sooner once the decision to do a tracheostomy is made [23].

The effect of a PCT learning curve has been reported in the literature by several authors. There is an increase in perioperative complications and mortality in studies in which PCT was performed by inexperienced physicians [24]. However, Liao et al. [25] considered 10 attempts were sufficient to learn how perform this procedure. Other authors considered that the technique could be mastered more easily and 20 procedures performed among all physicians was enough experience in a Department to reduce significantly the overall rate of complications [26]. Petros and Engelmann [27] observed a three fold reduction in the complication rate after 2 years of practicing. Our results are consistent with previous reports. Residents performed a median of 14 procedures in their last 2 years of fellowship training and the rate of complications showed a threefold reduction after their first five procedures. The low rate of complications and the high number of PCTs performed by residents rather than by ICU staff physicians indicates that PCT can be performed safely and can be considered a routine procedure in the care of ICU patients in daily practice.

While tracheostomy indications have remained unchanged, the timing of elective tracheostomy for the ventilated patient has been questioned. Guidelines of the American College of Chest Physicians, the American Association for Respiratory Care, and the American College of Critical Care Medicine indicate that tracheostomy should be considered after an initial period of stabilisation on the ventilator, usually between 3 and 7 days, when it becomes apparent that the patient will require prolonged ventilator assistance [28]. Several prospective randomized studies have shown that early PCT (within 48 h) resulted in a shorter time of mechanical ventilation, pneumonia and mortality compared to delayed PCT [29, 30]. However, there remains considerable variation in the timing of tracheostomy between centres [31, 32].

We used two different techniques for PCT. We changed to the Griggs technique because, in our opinion, the Ciaglia technique seemed to require greater manipulation of the airway. Also, the Griggs technique has been the most commonly used in Spanish ICUs over the last decade [33]. However, most studies have shown similar results and complication rates between the two techniques. In a prospective, randomised study in critically ill patients who required tracheal intubation for longer than 15 days and were consecutively selected to undergo tracheostomy by the percutaneous dilatational technique or guidewire dilating forceps, no statistical differences between observed complications was found. However, the surgical time required for the Griggs technique was shorter than that for Ciaglia technique [34]. We previously observed that the Griggs method requires less time than Ciaglia technique [23]. Moreover, PCT performed using the Griggs technique may be used in selected cases to establish an emergency airway in patients with complete upper airway obstruction [35].

We conclude that PCT has a steep learning curve but can be mastered quickly. The low incidence of complications indicates that bedside PCT can be performed safely and can be considered a routine procedure in the management of ICU patients in daily practice.

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