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Percutaneous dilatational tracheostomy in a medical ICU

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Abstract *Objective*: To evaluate the safety of percutaneous dilatational tracheostomy.
Design: A prospective clinical study.
Setting: The intensive care unit of a university medical clinic.
Patients: 137 critically ill patients admitted between May 1993 and September 1996.
Intervention: Percutaneous dilatational tracheostomy at the bedside.
Results: The median duration of translaryngeal intubation prior to tracheostomy was 8 days. Tracheostomy was carried out within 12.8 min (range 7 –30 min). Acute complications were documented in 11.0 % of the patients. There was one case of severe bleeding with transient asphyxia. Four patients had tracheal mucosal laceration treated conservatively. The postoperative in-hospital complication rate was 5.1 %, the sole problem being stomal bleeding. Only two cases of stomal infection were documented. There was no procedure-related mortality.
Conclusion: In the hands of the experienced, percutaneous dilatational tracheostomy is a safe and quick bedside procedure. It is also less expensive and incurs minimal stress for the patient compared with the surgical method. The technique can be easily mastered by non-surgical physicians and we feel that it is the method of choice for elective tracheostomy in the majority of intensive care patients.

Key words Percutaneous · Tracheostomy · Critically ill · Bleeding · Tracheal injury

Introduction

Tracheostomy is frequently performed in the critically ill patient if it is expected that prolonged mechanical ventilation will be necessary and/or long-term maintenance of a free airway as well as bronchial toilette is required, such as in patients with marked neurological deficits due to apoplectic insult or hypoxic brain damage. It prevents complications associated with prolonged translaryngeal intubation, eases the process of weaning from mechanical ventilation and improves the care of the ventilated patient.

The decision on when to perform a tracheostomy has always been controversial [1]. This should depend on the clinical situation and prognosis of the patient, but not on a dogmatic time limit. Surgical tracheostomy has the disadvantages of transporting the critically ill patient to the operation theatre as well as costly operating room time and personnel for such a relatively small and simple procedure. Even if performed at the bedside, it is usually associated with inconvenient operating conditions. Reported complication rates vary considerably depending on the criteria applied [2–6].

Various percutaneous tracheostomy techniques have been described in the past [7–12]. The percutaneous dilatational tracheostomy method using the Seldinger guidewire technique, as described by Ciaglia et al. [11, 12], has gained popularity in recent years. It can be performed safely and rapidly at the patient's bedside with minimal skin incision [11–18]. There is no study on its

use in emergency cases. In this paper, we report our experience with this technique as an elective procedure in a medical intensive care unit.

Materials and methods

Between May 1993 and September 1996, elective percutaneous dilatational tracheostomy (PDT) was performed in 137 critically ill patients in the Medical Intensive Care Unit of the University of Leipzig, Germany. The procedure was undertaken at the bedside using the Ciaglia Percutaneous Introducer Set (Cook Critical Care Ltd., Bjaeverskov, Denmark). In accordance with the regulations of the institutional review board, informed consent was obtained from either the patient or first degree relatives. Hundred nine of the tracheostomies were performed by the authors, the first an internist and the second an internist as well as anaesthesiologist. The remaining 28 PDTs were carried out by internists working in the unit. Major indications for tracheostomy were prolonged mechanical ventilatory support in 111 patients (81.0%) and the need for long-term maintenance of a free airway as well as tracheobronchial care in 26 patients (19.0%). In five leukaemia patients with pneumonia and sepsis, severe mucositis with oropharyngeal bleeding and necrosis was considered as an indication for early tracheostomy. Contraindications were goitre, unstable cervical vertebrae and infection at the site of a tracheostomy. Short neck per se was not a contraindication as long as the tracheal rings were palpable with the head of the patient adequately hyperextended. Anticoagulant therapy was discontinued 3 h before beginning with the procedure. In patients with haematological neoplasms suffering from severe thrombocytopenia, substitution was performed to achieve a platelet count of at least 30,000/mm^3. This was arbitrarily considered sufficient to prevent eventual bleeding during PDT. In patients with disseminated intravascular coagulopathy (DIC) ($n = 30$), the plasmatic clotting disorder was corrected before beginning with the dilatation procedure.

Patients received adequate analgo-sedation with either a midazolam/ketamine or midazolam/fentanyl combination (the standard analgo-sedation of ventilator-dependent patients in our unit). Neuromuscular relaxation was achieved with either pancuronium or vecuronium when necessary to avoid a cough reflex, which may lead to accidental laceration of the posterior tracheal wall during PDT. All patients were ventilated with 100% oxygen throughout the procedure. Continuous ECG and blood pressure monitoring as well as pulse oxymetry were routinely carried out.

After proper skin disinfection and palpation of the trachea, a vertical or horizontal skin incision (depending on the preference of the physician in charge) of about 2 cm was performed over the area between the first and second, or second and third, tracheal rings. Blunt dissection of the pretracheal tissue was not routinely performed. Without interruption of mechanical ventilation, a trained physician was assigned to withdraw partially and hold the orotracheal tube proximal to the site of tracheostomy (usually with the cuff at the level of the vocal cords) so that puncture into the free tracheal lumen was guaranteed. While advancing the needle, the free hand was used to stabilise the trachea in the midline in order to ensure a central puncture. The needle was advanced slowly under continuous aspiration to avoid inadvertent insertion and possible damage to the posterior tracheal wall. When air was aspirated, the guide wire was inserted immediately and the needle removed. Introduction of the guidewire and dilatation of the trachea were then performed as described by Ciaglia et al [11, 12]. The procedure was performed in the first five patients under bronchoscopic view to verify a midline insertion of the guidewire. This was performed in our learning phase to acquaint ourselves with the technique. Thenceforth, this was not considered necessary *during* the procedure. After proper dilatation, a tracheostomy tube, mostly with inner diameter (ID) of 9 mm, was inserted. In three patients a tube with ID of 8 mm had to be used due to difficulties to insert a 9 mm ID tube and further manipulation being considered risky and unnecessary. The endotracheal tube was then removed after the position of the tracheostomy tube was confirmed by auscultation.

Fibreoptic bronchoscopy was carried out through the tracheostomy tube as well as translaryngeal *at the end* of the procedure to document possible complications and ensure suction of blood possibly aspirated during PDT. Stomal inspection and care as well as the documentation of complications were performed regularly. Moderate stomal oozing was defined as a blood loss of about 50–100 ml, whereas severe bleeding was a loss of more than 100 ml. Moderate aspiration was defined as the occlusion of segmental bronchi with blood or coagula without resultant reduction of arterial oxygen saturation, whereas severe aspiration was major bronchial occlusion resulting in hypoxia.

Results

A total of 137 patients were included in this report. The mean age of the patients was 60.5 years (18–88 years) with 82 (59.9%) males and 55 (40.1%) females. Relevant disease processes during tracheostomy are listed in Table 1. There were two patients with acute myeloblastic leukaemia, one with acute lymphoblastic leukaemia, three with chronic myelogenous leukaemia, three cases of lymphoma, and two with plasmocytoma, all of whom had severe pancytopenia. The median duration of translaryngeal intubation prior to tracheostomy was 8 days (1–61 days). The patient with the longest endotracheal intubation period had a submandibular and neck abscess extending into the upper mediastinum, which prevented an earlier tracheostomy.

The procedure (from skin incision to insertion of the tracheostomy tube) was performed within 12.8 min (7–30 min). Intraoperative complications are listed in Table 2. There was a total complication rate of 11.0%.

Table 1 Relevant diagnoses during percutaneous dilatational tracheostomy ($n = 137$, *ARDS* acute respiratory distress syndrome)

Diagnosis	No. of patients	%
Pneumonia	46	33.6
Sepsis	32	23.4
Protracted cardiac failure	31	22.6
Hypoxic brain damage	29	21.2
Chronic obstructive pulmonary disease	23	16.8
Apoplectic insult and intracranial bleeding	18	13.1
ARDS	16	11.7
Severe mucositis	5	3.7
Others	9	6.6

Table 2 Acute complications of percutaneous dilatational tracheostomy ($n = 137$)

Complications		No. of patients
Bleeding	moderate	3
	severe	1
Aspiration:	moderate	3
	severe	1
Subcutaneous emphysema alone		1
Subcutaneous and mediastinal emphysema		2
Tracheal mucosal lacerations:		
	anterior	1
	posterior	3
Total		15 (11.0%)

The rate of acute complications in the first 2 years of our performing the technique was 18.5% (10/54), which dropped to 6.0% (5/83) in the last 2 years. Hundred eighteen procedures were performed by senior physicians, the remaining 19 by physicians with less expertise in invasive techniques. Of the acute complications, 60% (9/15) were caused by less experienced physicians, whereas experienced physicians were accountable for the rest. Moderate stomal oozing was treated with simple compression during tracheostomy. The patient with severe bleeding had liver cirrhosis with sepsis and DIC. The bleeding could be stopped with local compression only. Vessel damage could not be identified. However, the patient aspirated a significant amount of blood resulting in transient hypoxia and asystole. The cause of aspiration was most probably bleeding in the tracheostomy canal, which could not be stopped by compression from outside only. Immediate bronchoscopic suction was carried out and the patient was resuscitated successfully. The percutaneous tracheostomy could be completed 24 h later uneventfully.

The emphysemas were minimal and subsided within a few days without any specific treatment. The mechanism of damage to the mucosa of the anterior tracheal wall in one patient was not quite clear, although the tracheostomy had been performed in this particular patient under bronchoscopic view. In this case, the cuff of the tracheostomy tube was positioned distal to this lesion. Bronchoscopic control a week later showed complete healing. In the three patients with posterior tracheal wall mucosal laceration, particular care was taken during routine tracheobronchial suction. No further treatment was necessary.

Postoperative in-hospital complications were documented in seven (5.1%) patients. This was diffuse stomal bleeding observed in one patient on the 1st day, in another patient on the 2nd day, in two patients on day 3, in two patients on day 4, and in one patient on day 7. While one patient was managed with the tracheostomy tube in situ, we removed it in the other six patients and performed an orotracheal intubation for a better inspection of the stoma in order to localise possible vessel damage. There was diffuse local bleeding; vessel damage could not be identified. The bleeding was controlled with local compression. Blood transfusion was not necessary. The tracheostomy tube could be reinserted after 48 h of observation. All but one patient were suffering from sepsis with DIC.

Late complications have not been completely and systematically documented, since bronchoscopic control was not performed unless clinically justified and several patients were lost to follow-up. A total of 42 patients were either transferred to other wards or rehabilitation centres. Reports on successful decanulation are available to us in 18 cases (the mean duration with tracheostomy was 31.5 days, range 15–100 days). Clinical signs of tracheal stenosis or ugly tracheostomy scars were not observed in these patients. Inspiratory stridor ensued in one patient when the tracheostomy tube was finally removed. This patient, with a short neck, actually had a coniotomy performed by mistake, instead of the standard tracheostomy, due to difficulties in palpating the tracheal rings. The unusually proximal tracheostomy location was documented on bronchoscopy, but the transcricoidal placement was unfortunately overlooked. This most probably led to pressure damage of the cricoid with resultant subglottic stenosis. A Montgomery tube was inserted and the patient was referred to the ENT clinic of our university for further special treatment and follow-up. The patient with the longest period of endotracheal intubation (61 days) already had significant tracheal stenosis documented during tracheostomy. There were only two stomal infections (after 2 months with tracheostomy tube). These were treated with local antiseptics. There was no procedure-related mortality. In our series, the mean duration with tracheostomy for artificial ventilation and/or optimal tracheobronchial toilette was 19 days (range 1–100 days).

Discussion

Percutaneous dilatational tracheostomy has gained popularity as an elective procedure, particularly in the intensive care setting. There is, however, a learning curve as in any other invasive procedure. In our series, the yearly complication rate decreased considerably. Of our acute complications, 60% occurred during procedures performed by less experienced physicians. Their training included live demonstrations and detailed explanation by senior physicians. Frequent complications by less experienced physicians were subcutaneous and mediastinal emphysemas as well as tracheal mucosal lacerations. The reasons were that they tended to make

the initial puncture too tangential, thus missing the trachea. Even after proper insertion of the guide wire, some performed the dilatation with the dilators held too tangentially for fear of damaging the posterior tracheal wall, resulting in a kinking of the guide wire and dilatation of the pretracheal tissue. Furthermore, slow reaction during the introduction of the tracheostomy tube contributed to the development of the emphysemas observed. The other extreme was too steep and inadvertent insertion of the puncture needle and too deep introduction of the dilators, which probably led to damage of the posterior tracheal wall. Our data on complication rates among physicians with varying degrees of experience is not large enough to allow us any definite conclusion. Neither was it among our aims in this study. However, we believe that intraoperative bronchoscopic control is necessary for training purposes, though this cannot completely solve the inherent problems of training in invasive procedures.

In experienced hands and with proper patient selection, the complication rate of PDT is low, so that it can be recommended as a method of choice in the majority of elective cases. Stomal oozing was the most frequent complication in our series. This observation is fairly comparable with that of other authors [6, 14, 15]. Except for one patient, the haemorrhage was not serious and it could be handled conservatively. Most of these patients were suffering from sepsis with multi-organ dysfunction, though the plasmatic clotting disorder had been corrected prior to PDT. Particular care is thus necessary in patients with DIC, as is the case in any other invasive procedure. In general, a clotting disorder is an absolute contraindication to PDT as long it is not adequately corrected.

Subcutaneous and mediastinal emphysemas resulted in two cases due to improper dilatation technique and difficulties during insertion of the tracheostomy tube, and in one case due to high PEEP ventilation. Tracheal mucosal lacerations were mainly due to improper application of the technique, particularly inadvertent insertion of the needle or the dilators. Three out of the four tracheal wall lacerations were observed in the 1st year we started with PDT. Therefore, with adequate expertise such complications can be avoided, or at least held to a minimum. From our observation, we conclude that PDT using Ciaglia's technique can be performed without bronchoscopic guidance in the majority of cases. However, it is *mandatory* to have a bronchoscope at hand in case complications ensue. The case of the patient with subglottic stenosis demonstrates that in patients with short necks or when there are difficulties in palpating the tracheal rings properly, PDT should be performed under bronchoscopic guidance or conventional surgical tracheostomy should be preferred.

Our observation shows that the procedure can also be safely performed in patients with severe pancytopenia. Among our patients with leukaemia and lymphomas, there was not a single case of bleeding complication or local infection. A striking observation in our patient population is the very low rate of stomal infection (2/137), whereas this is significantly higher in surgical tracheostomies [3, 5, 6 and personal observation]. Among those patients with successful decanulation, clinical signs of tracheal stenosis or ugly tracheostomy scars were not observed. Since bronchoscopic control was not routinely performed in these patients, a concrete statement on long-term local changes on the inner tracheal wall cannot be made in our series. We feel, however, that there is no justification for an invasive diagnostic procedure as long as there is no clinical correlate.

In conclusion, PDT is safe and easy to perform at the bedside. Even if its complication rate might be found not to be lower than that of the surgical technique, it is less expensive [14, 16, 19] and it can be performed with a minimum of stress to the patient. However, a cautionary note is appropriate: the simplicity of a procedure should never lead to its misuse.

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