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Bedside percutaneous dilational tracheostomy with endoscopic guidance: experience with 71 ICU patients

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Abstract. *Objective:* To assess the value of endoscopic guidance in bedside percutaneous dilational tracheostomy.
Design: The medical critical care unit of a large community hospital.
Setting: 71 consecutive adult patients who required prolonged mechanical ventilation.
Interventions: 72 elective percutaneous dilational tracheostomies using the Ciaglia technique were performed under view of a flexible fiberoptic bronchoscope.
Measurements and results: Patients were examined during tracheostomy and on days 2 and 7 after the procedure, at discharge and after half a year if they were still alive. A correct median puncture was observed by endoscopic control in 59 interventions. An initial paramedian puncture was detected in 13/72 (18%) procedures and was corrected by renewed insertion in all cases. No severe complications related to percutaneous dilational tracheostomy were noticed. Minor complications occurred in 4/71 (5.6%) patients including minor bleeding in 2, inflammatory infiltration in 1 and one superficial lesion of the posterior tracheal mucosa. Long-term follow-up revealed stomal granulation in 3 patients including one at the tracheal site. At the end of the observation period the tracheostomy still was in use in 14/71 (20%) patients and 12/71 (17%) patients were decannulated. Due to their severe underlying diseases 45/71 (63%) patients had died. To facilitate weaning from the tracheostomy a minitracheostomy tube was used in 3 patients.
Conclusion: Percutaneous dilational tracheostomy is a simple bedside procedure associated with a low complication rate. We recommend the use of endoscopic guidance to increase the safety of tracheal puncture and dilation procedure.

Key words: Percutaneous – Dilational – Tracheostomy – Endoscopy – Complications – Minitracheostomy

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Respiratory failure requiring mechanical ventilation needs safe and reliable access to the airways. Endotracheal translaryngeal intubation for respiratory therapy of a few days duration is the method of choice. In prolonged respiratory care tracheostomies may be preferred to minimize laryngeal injury. Both methods, however, have a considerable rate of early and late complications [1]. Instead of standard surgical tracheostomy recent reports presented new tracheostomy methods, which seem to provide some remarkable advantages: performance at bedside, short duration of intervention, easy handling, less complications and cost-effectiveness [2–5].

For these reasons we performed percutaneous dilational tracheostomy (PDT) as described by Ciaglia [6]. To increase safety the procedure was guided by endoscopy, which also provided identification of the appropriate tracheostomy site and correct placement of the dilators and tracheostomy tube. Marelli and Paul introduced endoscopy in PDT [7, 8], but since then no other reports on the use of bronchoscopy in PDT have been published. We conducted a prospective study to assess the value of endoscopic guided PDT paying special attention to tracheal puncture as well as early and long-term complications.

Patients and methods

Subjects in this prospective study were consecutive adult patients of the medical ICU who required prolonged mechanical ventilation and thus were candidates for standard surgical tracheostomy. All patients who had translaryngeal intubation for at least 7 days or were judged to require artificial airways over prolonged time underwent PDT. The complete procedure of elective PDT including bronchoscopy was performed in sterile conditions at the bedside by 2 intensive care specialists. Local anaesthesia and a standard tracheostomy kit (Cook, Bloomington, IN) were used, based on the technique previously described by Ciaglia [6]. The ventilator was adapted for bronchoscopy and SaO_2 was measured continuously by peripheral pulse oximetry.

According to the description of Ciaglia et al. [6] and the manufacturers of the PDT kit, PDT should be performed in the space between the cricoid and the first tracheal cartilage or between the first and second tracheal cartilages. To minimize the risk of perichondritis of the cricoid cartilage which could lead to significant laryngeal stenosis, we performed PDT in the space between first and second tracheal ring. We

thereby avoided direct injury to the cricoid cartilage during the procedure.

For PDT the patient was positioned with the neck extended to widen the intercartilagineous spaces of the trachea. The space between the first and second tracheal cartilage was located by palpation. Under view of a flexible fiberoptic bronchoscope the endotracheal tube was withdrawn to just below the vocal cords. When tracheoscopic transillumination demonstrated tube and endoscope position cranial to the second intercartilagineous space, a 15 mm skin incision was made at the puncture site. The trachea was then punctured in the midline by a cannula. Lateral puncture was easily detected by endoscopy and a new puncture could be directed towards the correct site. A 0.052 J-guidewire was inserted through the cannula, the cannula was then removed and a guiding catheter placed over the guidewire. Dilators were placed above them subsequently and inserted. Dilations started with a 12Fr dilator, increasing to a size of 32Fr. Finally a 8 mm inner diameter tracheostomy tube was positioned on an appropriately sized dilator and both were inserted over the guidewire into the trachea. After this the guidewire, the guiding catheter and dilator were removed and the tracheostomy tube was connected to the ventilator. During the whole procedure the bronchoscope was positioned just above the puncture site to notice any adverse effects and to arrange corrections if necessary.

The tracheostomy tubes were changed after 2 days. A safe first tube change was ensured by inserting a guidewire-guiding catheter assembly beforehand.

Follow-up investigations were performed on days 2 and 7 after PDT, as well as at discharge and after half a year if patients were still alive. The tracheostoma or scar after decannulation was inspected diligently. In decannulated patients the quality of life, voice and breathing was examined and the tracheal site was checked by laryngo-tracheoscopy.

Results

From June 1990 to May 1992 there were 71 patients admitted to the study and 72 PDT were performed. PDT was repeated after decannulation in one patient because recurrence of his original disease had occurred. The main characteristics and primary diseases are shown in Table 1. Early PDT was performed in several patients with persistent vegetative coma after hypoxic brain damage. Five patients had previous operations at or near the PDT site: three patients had undergone thyroidectomy, one patient had a scar after conventional surgical tracheostomy and another patient had an endoscopic treated tumor of the larynx. PDT was also performed in a patient after leftside pneumonectomy.

In 59 of 72 attempts a correct median puncture of the trachea was observed by endoscopy. Deviation from the midline was detected in 13 of 72 punctures (18%) and could be readily corrected in each case. In average ICU patients the mean duration of the entire intervention was 9 ± 3 min. The procedure was prolonged in very obese persons.

Complications occurred in 4 of 71 patients (Table 2). There was minor bleeding in 2 cases which stopped by the local pressure of the tracheostomy tube placed in the tracheostomy at the end of procedure. In both cases the bleeding did not require transfusion. During the first tube change 2 days after PDT bleeding recurred in both patients, but could easily be stopped by reinsertion of the new tube. The next tube change 5 days later was uneventful. One of the haemorrhages occurred in an obese woman of 136 kg with an extremely short neck.

In one patient 2 days after intervention the tissue around the PDT site was erythematous and swollen due to inflammation. The infiltration readily resolved by parenteral treatment with antibiotics. In one patient the mucosa was scratched due to a deep puncture of the posterior tracheal wall and tilting of the needle caused oozing as the only consequence.

To date 12 of 71 patients (17%) were decannulated and discharged from hospital. In these patients the median duration of utilization of the tracheostomy was 22 days (range: 12–60 days). There were 45/71 (63%) patients who died 1 to 51 days after PDT due to their underlying diseases. All tracheostomies had been functioning well until decannulation or death. There are 14 patients (20%) still alive with their tracheostomy in use for up to 16 weeks. Follow-up examinations showed that the only complication in these patients was stomal granulation in 2 cases which was treated locally with silver nitrate solution (Table 3).

After decannulation the tracheostoma closed spontaneously whithin 3 to 9 days in all but one case. In this patient the tracheostomy had been in use for 60 days and a small lumen of 1 mm diameter persisted because of epithelialisation of the tracheostomy channel. One of 12 decannulated patients suffered from cough due to recurrent tracheal granulation. Microlaryngoscopical laser therapy was performed 3 times during a 14 month period. The other 10 patients had an unreactive cutaneous and mucosal tracheostomy scar without significant stenosis.

Table 1. Patient data, underlying disease

71 patients	43 male 28 female
Median age (range):	62 (30–88) years
Endolaryngeal intubation:	12 (3–33) days
	n
Medical diseases:	
Myocardial infarction	20
Ventricular fibrillation	6
Sepsis	6
COPD, pneumonia	7
Intoxication	2
Neurological diseases:	
Subarachnoidal haemorrhage	17
Intracranial haemorrhage	7
Cerebrovascular occlusion	3
Tumor	3

Table 2. Perioperative complications of PDT (72 procedures)

	n
Haemorrhage/minor	2
major (transfusion)	0
Inflammatory infiltration	1
Superficial injury of dorsal tracheal mucosa	1
Tube misplacement	0
Pneumothorax	0
Subcutaneous emphysema	0
Death related to PDT	0
Total	4/72 (5.5%)

Table 3. Follow-up investigations/late complications (53 patients)

	n
Stomal granulation	2
Wound infection	0
Tube displacement	0
Decannulated patients ($n = 12$)	
Laryngo-tracheal stenosis	0
Granulation/mucosal site	1
Fistula	1
Ugly scar	0

In 3 of 12 patients who could be weaned from prolonged tracheostomy, a minitracheostomy cannula (Minitrach II, Portex, Hythe Kent, England) was inserted instead of the standard tracheostomy tube [9, 10]. The reason for the procedure was to allow bronchial suction in the case of abundant mucus production. The minitracheostomy cannula could be removed after 2 to 5 days.

Discussion

The reported overall incidence of complications after standard surgical tracheostomy varies from 6–66% [1, 3, 5, 11, 12]. The published data on PDT, so far, present a lower complication rate of 3.9–28% (Table 4). Cumulated data from 834 patients reveal complications in 9.7%.

Some PDT complications such as misplaced puncture or paratracheal tube insertion leading to subcutaneous emphysema or pneumothorax may be avoided when discovered immediately. In some reports endoscopy was performed when problems had already occurred; a tracheal tear or mucosal flap as a trigger for life-threatening complications was detected after PDT [13, 14]. In these cases, however, PDT was performed by using the Rapi-trac technique. Thus supervising the entire procedure by endoscopy increases safety of PDT. At the beginning of the intervention the endotracheal tube can be withdrawn exactly to the laryngeal level preventing inadvertent extubation. The puncture, dilation procedure, and tube insertion are then directed by endoscopy. In our study group 18% of the PDT had an initially paramedian tracheal puncture, which was easily corrected by a repeated puncture. The most aberrant entrance site was a completely lateral one, which might have remained unnoticed without endoscopy.

When analysing the occurrence of paramedian punctures we found 8 initial paramedian punctures in the first 36 interventions and 5 in the second. Despite increasing experience paramedian puncture could not be avoided completely, especially in obese patients whose trachea could be palpated only with difficulty. Endoscopic guidance is of special value for those who start using PDT technique and in patients with an abnormal anatomy.

Occurrence of subcutaneous emphysema, pneumothorax and paratracheal tube insertion was described by study groups using blind PDT techniques in up to 12% [2, 14–16]. In both endoscopic guided PDT studies, that of Marelli et al. [7] and in ours, these complications were not noticed.

In our series 2 patients suffered from haemorrhage during PDT as well as during the first tracheostomy tube change. Minor bleeding can be controlled readily by local pressure or by the pressure of the inserted tracheostomy tube as we demonstrated in both cases. We routinely change the tracheostomy tube 2 days after PDT to inspect the tracheostomy site and to have a clean tube free from incrustation in the fresh tracheostomy wound. We suggest that in cases of primary haemorrhage the tube should be removed the first time not earlier than 5–7 days after PDT to prevent recurrent bleeding.

To minimize risk of bleeding patients with aberrant jugular veins should be rejected from PDT and should undergo standard surgical tracheostomy. In selected cases, however, the aberrant vein can be pushed aside. Detection of abnormal veins is facilitated by institution of PEEP ventilation and horizontal position, the head only slightly extended, so that the veins are filled-out with blood.

One of our patients presented with inflammation approximatively 3 cm around the PDT site. This definite infection has to be differentiated from a slight reddening of 1 to 5 mm width around the tracheostomy which was seen in about half of the patients (38/71, i.e. 54%). This circumscribed erythema was interpreted as cutaneous reaction to dilation and pressure of the tracheostomy tube and did not require antibiotic treatment.

Injury of the tracheal mucosa at its posterior part by the cannula which caused oozing was observed by endoscopy in one patient. This problem can be avoided by gentle puncture and gentle advancing of the needle. Further introduction should be stopped as soon as the cannula is detected in the tracheal lumen through the bronchoscope and airbubbles can be aspirated. Other reports fail to mention the frequency of posterior tracheal wall injury because it could not be assessed without endoscopy. Oesophageal perforation due to too deep a puncture was reported in minitracheostomy, a procedure similar to PDT [17].

PDT seems to be favourable for the healing process after removal of the tracheostomy tube. In long-term fol-

Table 4. Complication rates of PDT reported in the literature

Author (reference)	*n*	Complications	Endoscopy
1986 Toye [21]	100	14 (14%)	No
1988 Hazard [16]	55	7 (12.7%)	No
1989 Cook [19]	21	2 (9.5%)	No
1989 Schachner [15]	80	14 (17.5%)	No
1990 Marelli [7]	61	5 (8.2%)	Yes
1991 Bodenham [4]	20	1 (5%)	No
1991 Griggs [3][a]	153	6 (3.9%)	No
1991 Hazard [5][a]	22	3 (13.6%)	No
1992 Ciaglia [2]	165	12 (7.3%)	No
1992 Ivatury [20]	61	6 (10%)	No
1992 Leinhardt [14]	25	7 (28%)	No
present study	71	4 (5.6%)	Yes
Cumulative	834	81 (9.7%)	

[a] Controlled trial

low-up the scar was judged to be satisfactory even by the patients themselves. We may conclude from one observation in 12 decannulated cases, that long time insertion of a tracheostomy tube seems to increase the risk of developing a fistula after tube removal.

No laryngo-tracheal stenosis was detected by laryngoscopy. In the follow-up study of Ciaglia et al. tracheal stenosis was not seen in 52 decannulated patients [2]. In this study, however, tracheal tomography or bronchoscopy were not performed and in some cases mild tracheal stenosis might have remained undetected obscured by respiratory symptoms of coexisting respiratory disease. Hazard et al. tried to identify tracheal stenosis after PDT using tracheal tomography and noted a small incidence of tracheal narrowing (2 of 11 decannulated patients), which was remarkably lower in relation to operative tracheostomy [5]. In our patients no specialized studies were performed to exclude occult nonsymptomatic stenosis. One of our decannulated patients complained of nonproductive cough caused by granulation at the tracheal PDT scar, requiring laser treatment. Granulation at the tracheostomy or its scar is not a PDT-specific problem; it is also seen after standard surgical tracheostomy or any other cutaneous lesion.

Some patients with spontaneous breathing produced great amounts of mucus. To facilitate weaning from tracheostomy we exchanged the normal tracheostomy tube with a minitracheostomy tube in 3 patients. The minitracheostomy tube has an inner diameter of 4 mm allowing suction when necessary as well as spontaneous breathing and speech through the physiological airways. Maintained cough function is desirable in patients with a minitracheostomy [18].

The short duration of PDT and the ease of the procedure based on Seldinger wire technique are of special note. Endoscopy prolongs the duration of PDT only minimally. The procedure is prolonged in very obese persons. Patients with abnormal anatomy of the neck and enlarged thyroid gland are not suited for PDT.

As a bedside method PDT offers great advantages in the ICU. Critically ill patients on respirator therapy and treatment with vasoactive drugs do not have to leave the ICU for operation. Furthermore, standard surgical tracheostomy requires an anaesthesist, surgeon and an operating room nurse. PDT eliminates the trouble of transportation and may favour cost-effectiveness, as well.

In conclusion we suggest that PDT is a simple bedside procedure and an appropriate alternative to standard surgical tracheostomy. PDT is associated with a low complication rate. We recommend the usage of endoscopy to increase the safety of puncture and dilation. Insertion of a minitracheostomy tube facilitates the weaning process in cases with mucus retention.

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