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Complications of bronchoscopically guided percutaneous dilational tracheostomy: beyond the learning curve

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Abstract *Objective*: To assess the complication rate of bronchoscopically guided percutaneous dilational tracheostomy (PDT), with tracheal tube suture fixation and no elective tracheostomy tube exchange, after experience had been gained. *Design*: Prospective clinical study. *Setting*: Anaesthesiological ICU with mixed surgical and medical patients in a university hospital. *Patients*: Hundred thirty-three mechanically ventilated patients (mean age: 54.8 years, range: 13–87 years) with indication for PDT, many with thrombocytopenia and/or coagulation deficits. *Interventions*: Hundred thirty-six consecutive PDTs performed by residents under bronchoscopic guidance with stepwise dilation (n=114, Ciaglia's conventional system) or conic dilation (n=22, "Blue Rhino" approach) and supervision of experienced staff anaesthesiologists. Tracheostomy tubes were fixed to the skin with a suture and no routine exchange of tracheostomy tubes was performed. Complications were categorised and the results were also compared to an earlier prospective study. *Results*: The incidence of tracheostomy tube-related complications (hypoxaemia, cannula misplacement, accidental decannulation, cuff rupture and hernia, or posterior tracheal wall lesion) was low (0.7%) and significantly less (6.2%, p=0.01) than in our earlier study. No patient died of PDT-associated complications. We recorded four (2.9%) clinically relevant bleeding episodes. Insertion of tracheal tubes was easy or only moderately difficult in 86.7%. *Conclusion*: With experience in performing PDT, fixation of the tracheal cannula, and omission of routine change of tracheostomy tubes complication rate of PDT is low.

Keywords Bronchoscopy · Complications · Tracheostomy tube fixation · Suture · Tracheal ring fracture

Introduction

Percutaneous dilational tracheostomy (PDT) has been recommended as the procedure of choice for elective tracheostomy in selected critically ill patients, since it appears to be associated with a lower overall incidence of post-interventional complications, bleeding, and stomal infections [1, 2].

In an initial prospective study [3] we reported two procedure-related deaths and four episodes of severe hypoxaemia, three of them being directly related to problems with insertion or exchange of the tracheostomy tube [3]. Furthermore, we documented a 6.2% incidence of tracheostomy tube-related complications. To minimise tracheostomy tube-related complications, we started to fixate the tracheostomy tube to the skin with a suture and to omit routine exchange of tracheostomy tubes, in more than 300 patients, after completing the former study.

We conducted the present prospective study to evaluate the complication rate of PDT under these conditions and after having gained experience with the procedure.

Material and methods

During the period of prospective data acquisition (September 1998–January 2001), 1960 patients were treated. Hundred thirty-six consecutive PDTs were performed in 133 patients. Three patients were tracheostomised twice. The PDTs were performed by senior residents and supervised by two staff anaesthesiologists with experience of more than 100 PDTs performed personally. All patients with anticipated prolonged dependency on mechanical ventilation were included. Patients less than 13 years old, those with unstable cervical spine injuries, those requiring selective bronchial intubation and those with non-palpable landmarks due to extremely short neck, tumour or large goitre were excluded (*n*=9).

All tracheostomies were performed at the bedside under anaesthesia with fentanyl, midazolam, and pancuronium. During PDT patients received 100% oxygen without changing the respirator's settings. Arterial oxygen saturation, heart rate (ECG) and arterial blood pressure (electromanometry) were monitored continuously, with resuscitation and intubation equipment at the bedside. The orotracheal tube was withdrawn under bronchoscopic guidance to just below the vocal cords and, following surgical washing and draping, the trachea was punctured near the midline between the first and fourth tracheal ring. For PDT, we used either a stepwise dilation (*n*=114, "Ciaglia Percutaneous Tracheostomy Introducer Set") or a single conic dilator (*n*=22, "Blue Rhino", Cook, Mönchengladbach, Germany). The whole procedure, from puncture of the trachea until ventilation over the tracheostomy tube, was performed under continuous bronchoscopic visualisation.

Of note, following PDT the trachea and larynx proximal to the PDT site were inspected bronchoscopically via the remaining orotracheal tube to detect any obvious fractures of tracheal rings or other abnormalities. Finally, the tracheostomy tube was fixed to the skin with two sutures to prevent dislocation.

Assessment of percutaneous dilational tracheostomy-related complications

Complications related to PDT such as death, hypoxaemia, pneumothorax, bleeding, tracheal injuries (posterior wall perforation, fractures of tracheal rings), cannula dislocation, premature decannulation, and stomal infections were documented and categorised as early (within 24 h) or late (after 24 h). The extent of intra- and extra-bronchial bleeding was graded as mild (1–2 blood-covered sponges or presence of some blood on the posterior tracheal wall), moderate (PDT site blood-covered or segmental bronchus obstructed by blood), or severe (extratracheal bleeding greater than of moderate degree or main stem bronchus obstructed by blood, respectively). Insertion of the tracheostomy tube was graded as easy, moderately difficult, very difficult, or impossible. All complications associated with insertion, exchange and repositioning of the tracheostomy tube were categorised as cannula-related, whereas bleeding complications and infections were termed procedure-related.

Statistical analysis

Data are presented as means ± standard error of the mean (SEM) unless stated otherwise. We tested the null hypothesis that the changed practice of fixing the tracheal cannula to the skin and omission of routine exchange of tracheostomy tubes did not change the cannula-related complication rate by comparing (chi-squared test) data from this study with our previous data set [3]. Statistical significance was assumed with an α-error (p) of less than 5%.

Results

Fifty-three (39.9%) patients with PDT died from their underlying disease in the ICU, but none due to complications of PDT. Almost half of the patients suffered from thrombocytopenia and/or coagulation deficits. The time for preparing PDT averaged 23 min, whereas the time for performing the procedure averaged 7 min (Table 1).

The vast majority (86.7%) of PDT tube insertions were graded as easy or moderately difficult (Table 2). In

Table 1 Data of patients undergoing percutaneous dilational tracheostomy

	Means ± SEM	Range
Age (years)	54.8±1.5	13–87
Ventilator days before PDT	6.6±0.3	0–25
Ventilator days after PDT	16.6±1.1	1–80
Time preparing PDT (min)	23.3±0.8	10–45
Time performing PDT (min)	7.2±0.3	1.3–20
Gas exchange characteristics before PDT		
PaO_2/FIO_2 (mmHg)	272±7.1	83–500
PEEP (mbar)	11.1±0.5	5–30
$PaCO_2$ (mmHg)	39±0.6	26–66
Coagulation characteristics		
Platelet count (×1,000/µl)	148±10.6	15–790
Platelets ≤100,000/µl (*n*=60)		
Platelets ≤60000/µl (*n*=37)		
Platelets ≤ 50000/µl (n=18)		
Partial thromboplastin time (s)	41±1.4	21–180
Prothrombin time (% normal reference)	85±1.5	36–120

Data from 133 patients undergoing 136 percutaneous dilational tracheostomies (means ± SEM, range)

Table 2 Overview of techniques required during percutaneous dilational tracheostomy (*PDT*)

	n	%
Number of tracheal punctures required		
One	94	69.1
Two	37	27.2
More than two	5	3.7
Puncture site between		
$1^{st}/2^{nd}$ ring	30	22.1
$2^{nd}/3^{rd}$ ring	80	58.8
$3^{rd}/4^{th}$ ring	26	19.1
Difficulty of insertion		
Easy	83	61.0
Moderately difficult	35	25.7
Very difficult	14	10.3
Impossible	4	2.9
Tracheostomy tube used		
8 mm ID	109	80.1
9.3 mm ID	27	19.9
With stepwise dilation PDT	114	83.3
PDT with conic dilation	22	16.2

Table 3 Complications of percutaneous dilational tracheostomy

	Early (<24 h)	Late (>24 h)
Complication [*n* (%)]		
Death	0	0
Cardiac arrest	2 (1.5)	0
Pneumothorax	1 (0.7)	0
Endotracheal bleeding		
None to mild	100 (73.5)	0
Moderate	32 (23.5)	2 (1.5)
Severe	4 (2.9)	0
Extratracheal bleeding		
None to mild	93 (68.4)	0
Moderate	39 (28.7)	1 (0.7)
Severe	4 (2.9)	0
Major bleeding (surgery required)	1 (0.7)	0
Clinically relevant bleeding	4 (2.9)	2 (1.5)
Dislocation/accidental decannulation	1 (0.74)	0
Posterior tracheal wall lesion	0	0
Fracture of tracheal rings	32 (23.5)	–
With stepwise dilation PDT	23/114 (20.2)	–
With conic dilation PDT	9/22 (40.9)	–
Stomal infection (purulent)	–	2 (1.5)

Table 4 Comparison of complications between this and earlier prospective study

	Present study	Previous study [3]
Number of PDT (*n*)	136	337
Total cannula-related complications	1*	21
Death	0	1
Hypoxaemia (SaO_2 <80%)	1	3
Misplacement	0	2
Accidental decannulation	1	6
Cuff rupture	0	5
Cuff hernia	0	1
Posterior tracheal wall lesion	0	3
Total procedure-related complications	3	6
Death	0	1
Hypoxaemia (SaO_2 <80%)	2	4
Major bleeding (surgery required)	1	1
Stomal infection (purulent)	2	4

*p=0.01 compared to previous study

four patients (3%) the initial attempt to insert the tracheostomy tube failed and made a change in procedure necessary. In two of these patients (1.5%) the primary attempt to insert a 9.3 mm ID tube failed, but a 8.0 mm ID tube could be inserted easily. In the third case, a 19-year-old woman, dilation with the conic dilator proved impossible, most likely due to her very elastic pretracheal fascia or trachea, but the PDT proceeded uneventfully using stepwise dilation (Tables 2 and 4).

While there were no deaths associated with PDT, two patients suffered from cardiac arrest. In one patient the tracheostomy tube had dislodged (suture missing) and caused tension pneumothorax within 2 h after tracheostomy. Following immediate orotracheal intubation and chest tube insertion, the patient recovered without sequelae. The other patient experienced obstruction of both main stem bronchi by blood and very thick mucus. An emergency bronchoscopy normalised his cardiorespiratory situation. In one patient profuse bleeding from a torn thyroid vein made a surgical tracheostomy necessary.

No or only mild endotracheal and extratracheal bleeding was observed in 73.5% and 68.4% of the cases, respectively (Table 3). “Moderate” bleeding observed both endotracheally (23.5%) and extratracheally (28.7%) stopped immediately after insertion of the tracheostomy tube and had no apparent effect on the further clinical course. Eight bleeding events graded “severe” (5.9%) were recorded. However, in all but two the bleeding stopped immediately after the tracheostomy tube had been placed and compression of the bleeding site had been performed (Table 3). These two patients (1.5%) showed persistent extratracheal bleeding from the tracheostomy associated with coagulation abnormalities (one with congenital thrombocytopathy and the other under high dose heparin for recurrent venous thromboembolism during extracorporeal membrane oxygenation). Local compression, suturing, and local application of fibrin-covered material stopped the bleeding within 2 days.

We recorded a total of 32 bronchoscopically detected fractures of tracheal rings (23.5%). Surprisingly, the incidence of fractured tracheal rings associated with the conic dilation (9 out of 22 procedures, 40.9%) was significantly (p=0.036) greater than with the stepwise dilation (23 of 114 procedures). We recorded two (1.5%) purulent stomal infections (Table 3). The total cannula-related complication rate was significantly (p=0.01) less in the present study, when compared to our previous study (1/136 versus 21/337), as shown in Table 4.

Discussion

Under the setting described the overall complication rate of PDT was low, even when performed by residents under the supervision of experienced staff. Furthermore, omission of routine tracheostomy tube exchange and fixing the tracheal tube to the skin with a suture markedly decreased cannula-related complications. Finally, conic dilation increased the incidence of tracheal ring fractures.

Bleeding complications vary widely with a reported incidence from 0 to 5.5% [2, 4, 5, 6]. In contrast, we detected 26.9% endotracheal and 31.3% extratracheal bleeding episodes considered moderate or severe. While

this incidence may appear high compared to other studies [4, 5], it is most likely due to our sensitive definition of bleeding. In fact, all except three bleeding complications were terminated by insertion of the tracheostomy tube. Of these three, two persistent bleedings occurred in patients with bleeding disorders and only the third required ligation of a torn thyroid vein followed by a surgical tracheostomy. Thus, clinically important bleeding is a rather rare event, even in patients with thrombocytopenia. The incidence of clinically relevant bleeding episodes (2.9%) is consistent with the incidences reported [4, 5, 6].

As recently noted by Byhan et al. [7], in a smaller group of patients, PDTs performed with a conic dilator evoked bronchoscopically detected tracheal ring fractures significantly more frequently than those performed with stepwise dilation. This confirms that the "Blue Rhino" approach is associated with a doubling of tracheal ring fractures.

In summary, in a large prospective study we have defined the incidence of PDT-related complications, when the procedure was performed by senior residents supervised by staff anaesthesiologists experienced in PDT and with measures taken to minimise cannula-related complications such as fixing the tracheostomy tube to the skin with a suture. In this setting, and with the background of a large body of experience of staff physicians with PDT, the complication rate of PDT is low even in patients with thrombocytopenia.

References

1. Freeman BD, Isabella K, Lin N, Buchman TG (2000) A meta-analysis of prospective trials comparing percutaneous and surgical tracheostomy in critically ill patients. Chest 118:1412–1418
2. Cheng E, Fee WE (2000) Dilatational versus standard tracheostomy: a meta-analysis. Ann Otol Rhinol Laryngol 109:803–807
3. Walz MK, Peitgen K, Thürauf N, Trost HA, Wolfhard U, Sander A, Ahmadi C, Eigler FW (1998) Percutaneous dilatational tracheostomy – early results and long-term outcome of 326 critically ill patients. Intensive Care Med 24:685–690
4. Manara AR (1994) Experience with percutaneous tracheostomy in intensive care: the technique of choice? Br J Oral Maxillofac Surg 32:155–160
5. Hill BB, Zweng TN, Maley RH, Charash WE, Toursarkissian B, Kearney PA (1996) Percutaneous dilational tracheostomy: report of 356 cases. J Trauma 41:238–243
6. Kahveci SF, Goren S, Kutlay O, Ozcan B, Korfali G (2000) Bedside percutaneous tracheostomy experience with 72 critically ill patients. Eur J Anaesth 17:688–691
7. Byhahn C, Wilke HJ, Halbig S, Lischke V, Westphal K (2000) Percutaneous tracheostomy: Ciaglia Blue Rhino versus the basic Ciaglia technique of percutaneous dilational tracheostomy. Anesth Analg 91:882–886