Ultrasound-guided percutaneous dilatational tracheostomy: a safe method to avoid cranial misplacement of the tracheostomy tube

Abstract The aim of this investigation was to evaluate the role of ultrasonography in avoiding cranial misplacement of the tracheostomy tube and tracheal ring fractures during percutaneous dilatational tracheostomy (PDT). The tracheas of 26 consecutive ICU patients who had undergone PDT but who later died were removed en bloc at autopsy. The tracheas were opened along the membranous portion and the condition of tracheal rings and the site of tracheostomy macroscopically evaluated. The patients were divided in two groups: group A with 15 patients who underwent “blind” PDT and group B with 11 patients who underwent ultrasound-guided PDT. In five (33%) patients from group A, autopsy revealed that the tracheostomy tube was placed between the cricoïd cartilage and the first tracheal ring (cranial misplacement) and in six (43%) patients a fracture of one tracheal ring was found. Cranial misplacement of the tracheostomy tube in patients from group B was not found ($P < 0.05$) and four (36%) patients had a broken tracheal ring ($P = NS$). The authors maintain that by using ultrasound-guided PDT cranial misplacement of the tracheostomy tube may be entirely avoided.

Key words Ultrasound · Percutaneous dilatational tracheostomy · Pathoanatomical study

Introduction Percutaneous dilatational tracheostomy (PDT) is a widely used and accepted method for long-term ventilation of critically ill patients in many intensive care units (ICU). Numerous recent studies have reported that this technique, as regards short-term results, is at least equal to conventional tracheostomy. However, a detailed prospective analysis of long-term results is not as yet available in the literature. Significant tracheal stenosis remains the most serious late complication of PDT, probably due to high tracheal (above the first tracheal ring) placement of the tracheostomy tube (cranial misplacement). In the two recently published studies by Van Huern et al., and Walz and Schmidt on autopsy material the authors found cranial misplacement in approximately 17% of patients [1, 2]. On the basis of personal experience, Walz and Schmidt recommend obligatory identification of cricoïd cartilage before starting the procedure, and claim that without clear recognition of this important landmark PDT is contraindicated [2]. To avoid inappropriate placement of tracheal tube Walz and Schmidt suggest endoscopic guidance of PDT [2]. As an alternative to endoscopic guidance we have re-
cently recommended ultrasound-guided PDT (USGPDT) in difficult cases [3, 4, 5]. The aim of this study was to compare macropathological findings on the autopsy material of patients who underwent USGPDT vs those in whom “blind” PDT (BPDT) was performed.

Materials and methods
In the period from April 1998 to January 2000, post-mortem examinations were performed on 26 unselected critically ill adult patients under different medical and surgical specialties who had undergone PDT but who later died due to causes unrelated to PDT. All PTDs were done with the dilatation forceps method (Portex) by an experienced operator who had performed over 30 PTDs before undertaking this study (A.S.). In all cases a tracheal tube with inner diameters between 8 ID (female) and 8–9 ID (male) was used, and all patients were cannulated until death. The patients were divided in two groups: group A with 15 patients (11 M, 4 F; age: 56 ± 12.5 years) who underwent BPDT, and group B with 11 patients (7 M, 4 F; age: 49 ± 17.9 years) who underwent USGPDT. In group A were the patients in whom the site of tracheal puncture and the insertion of the tracheostomy tube was done “blindly”, i.e., on the basis of anatomic landmarks and palpation, while in group B were the patients who had undergone the tracheal puncture guided by ultrasonography. The indication for USGPDT (group B) were all cases in whom cricoid cartilage could not be clearly defined by palpation and/or where anatomic landmarks were altered i.e., in patients with a short, fat neck, with enlarged thyroid gland or who had undergone previous neck surgery, etc.

The mean duration of translaryngeal intubation, prior to PDT, in group A was between 3 and 12 days (median: 6) and cannulation lasted from 7 to 69 days (median 14). In group B, the mean time of translaryngeal intubation was 4–15 days (median 9) and the duration of cannulation from 8 to 44 days (median 16).

Ultrasonic-guided PDT technique: after standard preparation of the patient (with or without hyperventilation of neck) and of the operation field, with sterile linear transducer (7.5 MHz, Hitachi EUB 405) the trachea is presented by vertical medial section (Fig. 1). Following a clear ultrasound verification of thyroid and cricoid cartilage and tracheal rings, the site of puncture is determined (usually between 2nd and 3rd tracheal ring). The ultrasound transducer is pulled cranially until the lower edge of the transducer is placed above the tracheal ring, below which the trachea puncture will be performed. After infiltration anaesthesia (Xylocaine with adrenaline: 1: 200,000), a transversal, 1–2 cm incision into the skin and subcutis is made, parallel and as close to the lower edge of the transducer as possible. Through incision the trachea is punctured in the median line. After placing the guide-wire through the puncture cannula the procedure continues in the conventional manner [6].

At autopsy the trachea was removed en bloc and opened along the membranous portion. The pathologist and maxillofacial/ENT surgeon, who were not previously informed about the technique used, evaluated the intercartilaginous space of placement of the tracheostomy tube as well as macroscopic findings of cricoid cartilage and tracheal rings.

Both groups (A vs B) were compared by using Fischer’s exact test and a P value less then 0.05 was considered statistically significant. This investigation was done with the assent of the University Hospital Ethical Board.

Results
The results are presented in Table 1. In five (33%) patients from group A autopsy revealed that the tracheal tube was placed between the cricoid cartilage and first tracheal ring (cranial displacement). In six (43%) patients from the same group, vertical fracture of tracheal ring was found. In patients from group B, cranial misplacement of the tracheal tube was not found (P < 0.05) and four (36%) patients from this group had a broken tracheal ring (P = NS). There were no cases of cricoid cartilage fracture, nor more than one fractured tracheal ring in patients from both groups.

Discussion
Percutaneous dilatational tracheostomy is widely used as alternative to surgical tracheostomy in critically ill patients. Although recommended as a safe method in ICU, severe late tracheal stenosis after PDT were found in 1.8%–3.7% of cases [7]. Theoretically, the main rea-

Table 1 Incidence of cranial misplacement of the tracheostomy tube and fracture of the tracheal ring in patients with “blind” and ultrasound-guided percutaneous dilatational tracheostomy (PDT)

<table>
<thead>
<tr>
<th></th>
<th>No of patients</th>
<th>Cranial misplacement of tracheostomy tube</th>
<th>Fracture of tracheal ring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blind PDT</td>
<td>15</td>
<td>5 (33%)b</td>
<td>6 (43%)b</td>
</tr>
<tr>
<td>Ultrasound-guided PDT</td>
<td>11</td>
<td>0a</td>
<td>4 (36%)b</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>5 (19%)</td>
<td>10 (38%)</td>
</tr>
</tbody>
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a P < 0.05
b P = NS