Ultrazvočno vodena perkutana dilatacijska traheotomija: hitra in varna tehnika oskrbe dihalne poti

Preliminarno poročilo o novi tehniki

Ultrasound-guided Percutaneous Dilatational Tracheotomy: A fast and safe technique for airway management

Preliminary Report of a Novel Technique

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Izvleček

Namen: *Prikazati prilagojeno tehniko perkutane dilatacijske traheotomije (PDT), ki morda nudi pomembne prednosti v primerjavi z doslej uporabljano tehniko.*

Metode: *Raziskava je potekala na živalih z uporabo ultrazvoka za PTD. Po predhodni ultrazvočni preiskavi in pod stalno ultrazvočno kontrolo, je bila narejena punkcija traheje z vodilno iglo. Vstavljena je bila dihalna cevka s Seldingerjevo tehniko in uporabo Ciaglia dilatatorja. Raziskava je potekala v živalskem laboratorijskem centru Univerzetne bolnišnice Würzburg na 11 prašičih s težo 26 do 36 kg.*

Rezultati: *Uspešna traheotomija je bila narejena pri vseh 11 prašičih. Povprečno trajanje postopka je bilo 20 sekund od predrtja kože do vstavitve dihalne cevke. Pri enem prašiču je prišlo do predrtja zadnje stene traheje.*

Abstract

Purpose: *To describe a modified technique for percutaneous dilational tracheotomy (PDT) offering possible significant advantages over currently used procedures.*

Methods: *An observational animal study using ultrasound for PDT was performed. After pre-incisional ultrasonic examination, and with continuing ultrasound guidance, the trachea was punctured with an 18-gauge introducer needle and a tracheal tube was inserted using the Seldinger technique and a Ciaglia single dilator.*
Setting: University Hospital animal laboratory center.
Subjects: 11 pietrain pigs (weight 26–36 kg).

Results: *Successful tracheotomy was accomplished in all 11 pigs. The mean duration of the procedure was 20 seconds from skin penetration to guide wire placement. In one pig,*

Zaključek: *Nov postopek predstavlja preprosto in učinkovito tehniko vstavitve dihalne cevke z metodo PDT.*

the dorsal wall of the trachea was punctured.

Conclusion: *This novel procedure is a simple and effective technique for PDT tube placement.*

Introduction

Percutaneous dilational tracheotomy (PDT) is a standard procedure in critical care medicine and an effective method of airway management in patients requiring long-term ventilatory support in an intensive care unit (ICU) [1]. Studies indicate that PDT is an efficient, cost effective and safe alternative to surgical tracheostomy [2,3] and performance at the bedside offers logistical advantages [4].

However, PDT is not without risk. Bleeding occurs in about 3% of patients [5] and a cadaver study suggests that up to one-third of catheters puncture the thyroid isthmus [6]. A serious late complication is significant tracheal stenosis, mostly due to placement of the tracheotomy tube above the first tracheal ring. So-called cranial misplacement is found in approximately 17% of patients [7] – in fact, only 9 of 20 catheters enter the trachea at the intended site [5].

To avoid inappropriate placement of the tracheal tube, clear identification of the cricoid cartilage is necessary. To achieve this goal, endoscopic guidance is recommended. Pre-incisional ultrasound examination [4] and ultrasound guided PDT are interesting alternatives [8]. In the present animal study, ultrasound guided PDT was performed with continuous visual monitoring of the anatomical landmarks, and the rates of serious complications and misplacement were assessed.

Matherial & Methods

Two anesthesiology residents, with 1 year and 4 years of training respectively, and one fourth-year medical student took part in the study. Eleven four-month-old pietrain pigs were used as an animal model. The animals were euthanized with T61 (Intervet, Wiesbaden, Germany) under adequate anesthesia. Immediately after death the pigs were put in a supine position and the anterior neck region was shaved. The animals were intubated with a 7.5 mm Murphy tube (Convidien, Neuburg, Germany) and mechanically ventilated (Servo 900C, Siemens, Erlangen, Germany) with an oxygen/air mixture (50%/ 50%). Ventilator settings were adjusted to a respiratory rate to 12/min, tidal volume of 10 mL/kg, and positive end-expiratory pressure of 5 mm Hg.

After palpation of the anatomy of the neck, ultrasound was used (Sonosite 180, linear head 10 MHz; Sonosite Inc. Bothell, WA, USA) to identify the important landmarks (thyroid, cricoid cartilage, first tracheal ring, jugular vein and carotid artery) and to measure the distances between these. The cuff of the endotracheal tube was then deflated and the tube was withdrawn under ultrasonic control until the tip of the tube entered the cricoid cartilage. The cuff was then carefully re-inflated to allow proper ventilation.

After confirmation of the appropriateness of the puncture site, an ultrasound transducer was rotated for a transverse view of the trachea and uses to guide placement of an 18-gauge needle, which punctured the middle of the trachea between the third and fourth tracheal ring. A customized stiff guide wire (0.38 mm) was placed, and the needle removed. Deviation of the tracheal puncture site from the midline of the trachea was measured by ultrasound and documented.

The ultrasound transducer was rotated again to gain a longitudinal view of the trachea. Following incision of the skin, a Ciaglia single dilator was placed over the wire under constant ultrasonic control. The cuff of the newly inserted 7.5 mm tracheotomy tube (Ciaglia Blue rhino; Cook, Frankfurt, Germany) was inflated with air and the tube was connected to the ventilator. Successful ventilation was confirmed by inspection of chest wall movement, auscultation of air entry and measurement of expiratory volume. Finally, the orotracheal tube was removed.

At post-procedural dissection, the trachea was removed en bloc and dissected. Tracheotomy tube placement in relation to the cricoid cartilage and the tracheal rings was evaluated and the trachea was scrutinized for lesions.

Because of the small sample size, the data were considered to be non-parametric and are therefore reported as median and interquartile ranges.

Results

Eleven pigs underwent ultrasound guided PDT endotracheal tube placement. All animals were successfully ventilated after the procedure. The mean time from penetration of the skin with an 18-gauge needle to placement of the guide wire was 20 seconds (range 16–23). The further placement of the tube was uneventful in all animals.

The distance between the midline of the trachea and the position where the guide wire entered the trachea was 0.09 cm (range 0.05–0.2).The distances between the important landmarks are shown in Table 1.

Post-procedural dissection confirmed proper tracheal placement of all endotracheal tubes. Seven of 11 tubes were placed between the third and fourth tracheal rings, three between the fourth and fifth rings, and one each between the second and third rings. In one pig, the posterior wall was perforated with the 18-gauge needle; however, this was recognized during the procedure and the guide wire was re-positioned in the trachea for further uneventful tracheal tube placement.

Table 1: *Anatomic landmarks measured by ultrasound before percutaneous dilational tracheotomy*

	Measurements - cm (range)
Tracheal diameter	0.89 (0.88–0.958)
Distance: cricoid cartilage–skin	1.39 (1.22–1.55)
Distance: trachea–right IJV	2.35 (2.15–2.58)
Distance: trachea–right CCA	1.89 (1.74–2.12)
Distance: trachea–left IJV	2.88 (2.33–3.31)
Distance: trachea–left CCA	2.06 (1.85–2.53)

CAC: *common carotid artery;* IJV: *internal jugular vein*

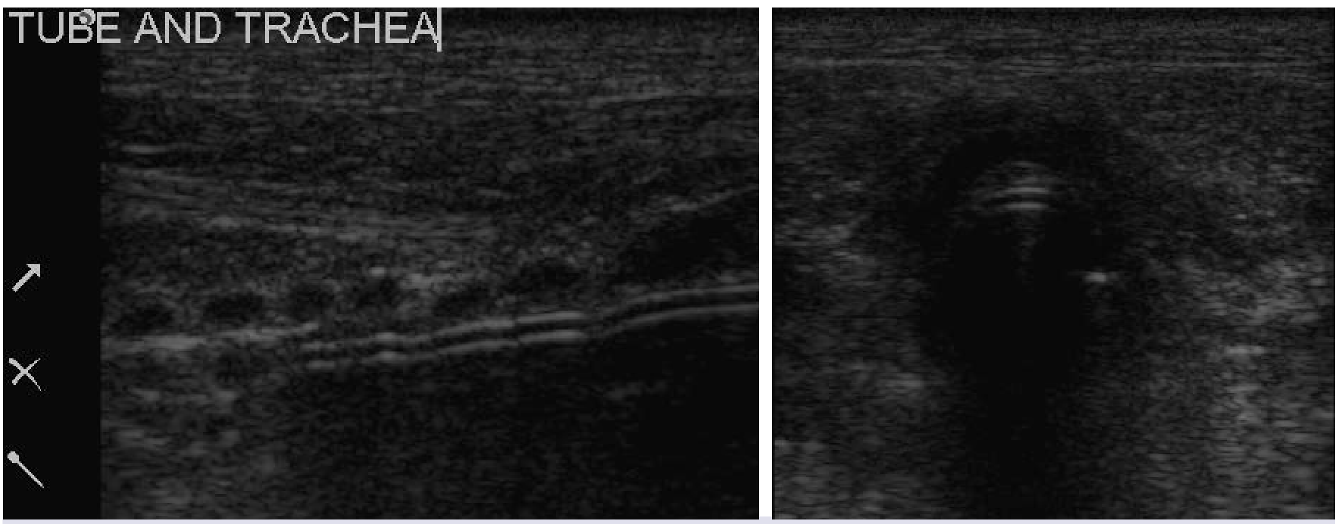
Discussion

In all eleven pigs ultrasound guided PDT endotracheal tube placement was successful. Ventilation was not discontinued at any time. This animal model was chosen because the porcine tracheal anatomy is similar to that of humans, although more difficult to define by palpation. The average diameter of the trachea at the third tracheal ring was 0.89 cm in our cohort, while the median saggital diameter of an adult human trachea is larger, about 1.6 cm [9]. In most human patients, the distance from skin to trachea at the third tracheal ring is 1–2 cm 10; in our study, the depth of the cricoid cartilage was 1.39 cm, which is similar. However, in pigs the trachea has a sharp dorsal flexion right below the cricoid cartilage, so that the actual distance at the tube placement site was greater than 2 cm, suggesting that this technique may also be feasible in obese patients.

PDT is a well established and safe procedure with a death rate of 0.4% 4. Complications usually result from the force applied to the surrounding tissue [11]. To prevent such damage it is necessary to identify important landmarks. In obese patients or in patients with altered anatomy from tumor, surgery or radiation, these landmarks are often difficult to identify by palpation. In a previous investigation, ultrasound was used to identify these structures prior to PDT [12]. A standard pre-incisional ultrasound of the neck would also identify unexpected anatomical variations, such as aberrant blood vessels. Prior to the procedure, distances between the puncture site and vulnerable structures (thyroid, cricoid cartilage, tracheal rings, bilateral internal carotid arteries and internal jugular veins) can be evaluated.

Compared to a pre-incisional examination alone, continuous ultrasound can better help operators avoid damaging these structures because their position can be altered by movement of the patient or manipulation of the neck. Additionally, both cranial and caudal tube misplacement are associated with complications (placement above the first tracheal ring is associated with tracheal stenosis; placement next to the cricoid cartilage exposes the subglottic larynx to scarring and contracture; and placement below the third tracheal ring can lead to erosion of the brachiocephalic artery [4]) but ultrasound provides good visualization of the trachea and rings and so helps avoid misplacement.

Endoscopic guidance is regularly used to identify the correct position for placement of the guide



Figures 1 and 2. *Trachea with endotracheal tube: saggital and transverse views* wire. However, bronchoscopic tracheoscopy requires a second trained examiner. A second disadvantage is that only the trachea itself can be inspected, not the surrounding structures. It is yet to be established that ultrasound can confirm the correct puncture site as well as bronchoscopy, but it is more widely available and easier to perform.

Continuous ultrasound guidance leads to a relatively fast procedure. In our study, the guide wire was placed within 20 seconds. Because the tracheal tube was visualized and its correct position at the cricoid cartilage confirmed, there was a secure airway throughout the procedure. Ventilation did not have to be discontinued at any time, an advantage for patients with pulmonary compromise.

In our study three different examiners – a first-year and a fourth-year anesthesiology resident and a fourth-year medical student – performed the procedure. Only one of the residents had performed PDT in human patients before. The medical student had no prior experience using ultrasound. Our new method can easily be learned and safely performed, even without prior practice of sonography, and after the study all three operators were confident of their ability to perform the procedure again.

Figure 3. *Guide wire in the trachea (arrow): lateral view*

In conclusion, we successfully used a modified method of percutaneous dilatational tracheotomy with constant ultrasound guidance to place endotracheal tubes in an animal model. This technique can be easily learned and performed. It is less invasive and probably faster to perform than the conventional surgical approach and the ultrasound guidance may decrease the risk of serious complications. Whether this procedure offers real advantages over conventional techniques requires further study. •

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