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Ultrasound guided percutaneous dilatational tracheostomy using needle guidance technology (eZGuide)

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Abstract

Tracheostomy has become routine procedure performed in Intensive Care Units (ICU). Nowadays it is performed ≤ 10 days (early PDT) or > 10 days (late PDT) of mechanical ventilation. It has many advantages over endotracheal tube: 1) reduction in sedation requirements, 2) facilitation of weaning from respirator, 3) help in bronchial secretions clearing and bronchial tree toilet, 4) VAP (Ventilator-associated pneumonia) prevention to name a few. Due to the fact that it is often done in borderline patients verging on the cardiopulmonary collapse strict adherence to specific procedure indications and contraindications must be observed. Both classic and percutaneous tracheostomy (PT) are associated with the risk of potentially fatal complications such as loss of airway patency, bleeding, infection, mediastinothorax or pneumothorax, tracheomalacia, damage to the posterior tracheal wall with or without esophagus puncture. Comparing with classical method, PT is associated with lower risk of bleeding, tracheal stenosis and infectious complications but carries higher risk of mischoosing entry point, misplacement of tracheostomy tube either subcutaneously and further into mediastinum or even into esophagus through damaging of posterior tracheal wall with all its consequences. Although bronchoscopy guided PT can help to reduce the risk of puncturing the posterior tracheal wall, increasing to certain extend overall safety of the procedure itself, it is not helpful in identifying pretracheal anatomy with its unpredictable vascularity, thyroid gland extend or tracheal rings level and thus does not reduce the risk of bleeding or mischoosing entry point. Ultrasound imaging on the other hand can help to evaluate pretracheal anatomy delineating out thyroid gland, tracheal rings, vascular course and thus to reduce the risk of bleeding as well as to determinate the appropriate level of the insertion of tracheostomy. It seems then that combining bronchoscopy and ultrasound into so called dual guidance technique during performing PT can ensure uppermost safety of the procedure and should be the method of choice. *Anestezjologia i Ratownictwo 2018; 12: 402-406.*

Keywords: percutaneous dilatational tracheostomy, ultrasound imaging, needle guidance technology

Introduction

With the widespread use of modern invasive procedural techniques seen this day and age, percutaneous tracheostomy (PT) has become almost routine procedure performed in intensive care units (ICUs) [1].

In comparison with the surgical method, PT is associated with 3-times less risk of bleeding complications, tracheal stenosis and infectious complications.

On the other hand, PT, comparing to surgical tracheostomy, does not allow to obtain a stable tracheostomy channel, which can result in accidental removal or dislocation of the tracheostomy tube and can cause a loss of airway potency, especially when the tube has been moved in the early post-access period.

At the moment, there are many methods and sets available for PT on the market. Techniques developed by Ciagia (classic PT or the Ciaglia blue rhino method), Frova and Quintel (percu twist), Griggs, and Zgoda and Berger (Ciaglia blue dolphin) were have become the most popular [2].

The apparently various techniques for performance of any kind of PT are based essentially on the method of Seldinger wherein after identification of tracheal puncture by bubbling of water in the syringe attached to the puncturing needle, a guidewire is introduced and pre-tracheal tissues and tracheal anterior wall are spread apart with dilatator. Next the tracheostomy tube is threaded into trachea over guidewire. In order to avoid posterior tracheal wall puncture and to confirm proper tracheostomy tube placement, bronchoscopy guided technique should be used in all cases [3]. At the end, the bronchoscope is inserted again through the tracheostomy tube to check and confirm its proper location.

The incidence of significant complications seen in percutaneous tracheostomy (PT) is generally small and fatal complications are reported in 0.17% (1:600) of cases mainly due to vascular injury and respiratory complications [4]. The most notorious complications referred to in the literature are bleeding, infections, tracheal damage, esophagus puncture, pneumothorax, mediastinothorax, subcutaneous emphysema, tracheal stenosis and loss of airway patency.

Bronchoscopy guided PT has become a gold standard and it reduces the risk of serious complications such as damage of posterior tracheal wall, misplacement of the tube to into the mediastinum, esophagus or subcutaneously and it is also useful in confirming proper tracheal position of the tube. However, bronchoscopy does not identify pretracheal anatomy with its vascularity or the thyroid gland extend, and thus does not prevent from vascular or thyroid damage with ensuing serious bleeding likely. Ultrasound imaging then just before PT gives us unique opportunity to prepare an objective evaluation of the anatomy of the trachea, thyroid gland, vascularity and it can reduce the risk of vascular and thyroid puncture with its aftermath [5-8].

According to some studies in blind or anatomic landmarks guided percutaneous technique just in 45% of cases the guidewire is introduced at the intended level of the trachea and in 30% of cases PT is performed above the firs ring of the trachea [9]. In these cases, ultrasound can be also useful in choosing an optimal entry point of the needle with the proper level of tracheostomy introduction performance. Ultrasound imaging benefits patients with potential technical difficulties and distorted anatomy seen in obesity, neck immobility in cervical spine fractures or neck scarring upon surgery, burns or radiation [9-11].

However, when it comes to the pinpoint precision of needle tip position using traditional ultrasound technology it is frequently difficult and unreliable with possible serious injury resulting from inadvertent damaging of adjacent vital structures.

Constant development in ultrasound imaging and progress to overcome the above mentioned needle tip position identification problems has led to introduction of needle guided technology enabling us to track trajectory of the needle in real time as it approaches the target. It can be applied in any real-time ultrasound guided procedures where visualization of the needle tip position and its trajectory does matter.

Needle guided technology

Needle navigation technology offered in the eZono ultrasound machines (termed‘eZGuide’) allows the clinician to manipulate the needle in any plane and to receive real-time, color-coded feedback on its position relative to the transducer. The technology involves the use of magnetic sensors in the transducer and requires the clinician to magnetize the needle immediately before commencing the procedure using a single-use, sterile plastic cup that contains two magnets in its walls (‘eZMag’). There are no specific restrictions on needle type or manufacturer. However, the needle must contain sufficient ferrous content so as to be magnetizable. When the magnetic field of the needle approaches the magnetic field of the transducer, there is a distortion in the latter, based on the pattern of transducer field disturbance, the software is able to determine the orientation and position of the polarized needle in 3D space in relation to the transducer head. The technology is designed to permit reliable needle position estimation from any angle with respect to the transducer and show significant improvement in needle accuracy and safety in central vein cannulation as well as can be of huge benefit in fine needle biopsy, regional anesthesia [12-14] and other real-time ultrasound procedures including PT.

Technique, sonoanatomy

Before the procedure, make sure to provide all necessary equipment, drugs and an emergency tray. The procedure requires three persons: an operator, an assistant, and an anesthesiologist who controls the airways and bronchoscopy.

Place the patient in a supine position with a shoulder roll beneath, unless there is a contraindication, to extend patient's neck. Use in-hospital surgical skin antisepsis protocol to prep and drape the operational area. Start the examination with landmark palpation and after it, use ultrasound to check and confirm the anatomy. Use linear probe with a sterile sheath to scan the neck. Start with a midline longitudinal probe position (figure 1) to visualize thyroid, cricoid and tracheal cartilages. Cricoid and tracheal cartilages in longitudinal view are seen as "string of beads". Then, place the probe in a transverse position at the cricoid cartilage level (figure 2) and move the probe in caudal direction. In sonoanatomy, identify the cricoid and the tracheal cartilages, which are inverted U-shaped (figure 3), the thyroid gland and the isthmus (figure 3) and the carotid and jugular vessels bilaterally. The linear hyperechoic line seen posteriorly to trachea is formed by reverberation artifacts from air-mucosal interface. Using ultrasound, choose the best level of entry. In the transverse view and out-of-plane technique supported by needle guided technology, track and place the needle in the correct position. **Because of the presence of the acoustic shadow after passing the anterior tracheal wall, the needle tip is not visible in standard real time ultrasound imaging**. To confirm the correct needle position, needle guidance technology (figure 4) or bronchoscopy is necessary. Provide the correct position of the needle using needle guidance technology. **Remember to use color Doppler to identify and avoid any vessels. Also, ultrasound can be used to estimate the thickness of soft tissue between the skin and the trachea and the internal diameter of the trachea to determine the best size and length of the tracheostomy tube** (figure 5).

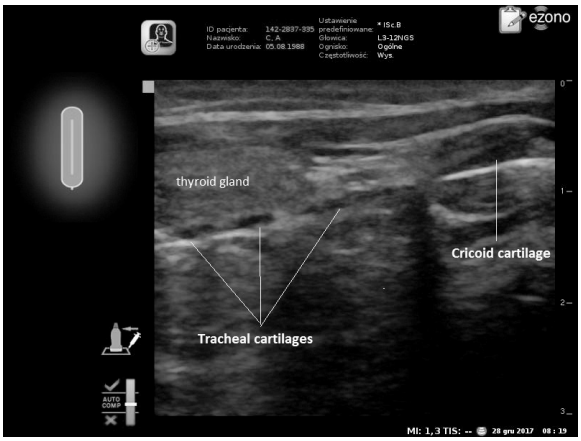

Figure 1. Midline longitudinal view

Figure 2. Transverse view at the level of cricoid cartilage

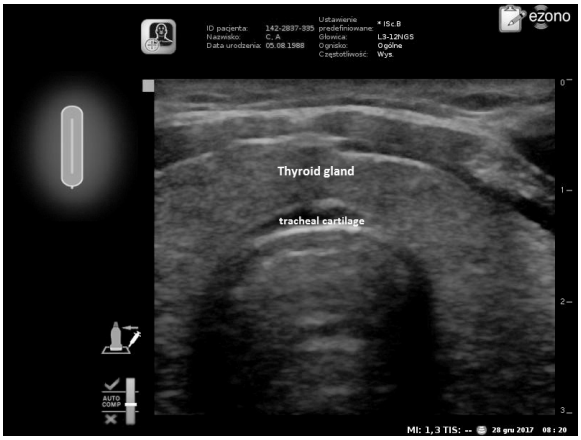

Figure 3. Transverse view at the level of tracheal cartilage

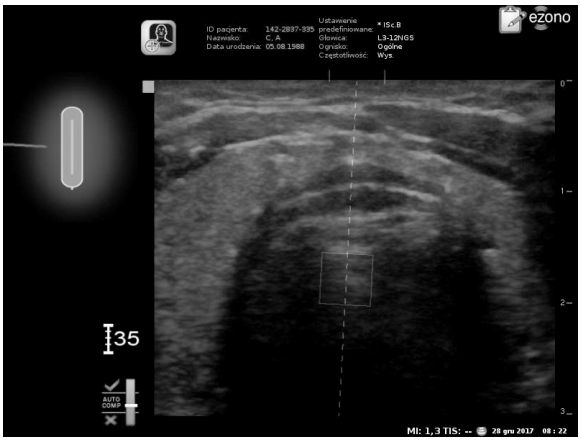

Figure 4. The red square shows the needle tip target when using needle guidance technology

Figure 5. Thickness of soft tissue between the skin and the trachea and the internal diameter of the trachea

Conclusions

Ultrasound imaging gives us additional benefits and increases the security and the efficiency during performing percutaneous dilatational tracheostomy. The use of ultrasound provides better understanding of the anatomy of the neck, vascularity, trachea and thyroid gland, lowers the risk of vessel or thyroid puncture and it also may benefit in choosing the proper level of needle introduction. Additional use of needle-guidance technology may provide better needle adjustment and increase efficiency of the procedure.

In conclusion, dual guidance technique with bronchoscopy and real time ultrasound imaging should be a method of choice in PT, especially in expected technical difficulties.

Conflict of interest
The lead author points out the following conflict of interest: the industrial partner eZono Ag Jena provided the needed ultrasound system for my studies gratuitously.

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