

Inflating the endotracheal tube cuff with saline to confirm correct depth using bedside ultrasonography

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ABSTRACT

Although bedside ultrasonography can accurately distinguish esophageal from tracheal intubation, it is not used to establish the correct depth of endotracheal tube insertion. As indirect sonographic markers of endotracheal tube insertion depth have proven unreliable, a method for visual verification of correct tube depth would be ideal. We describe the use of saline to inflate the endotracheal cuff to confirm correct endotracheal tube depth (at the level of the suprasternal notch) by bedside ultrasonography during resuscitation. This rapid technique holds promise during emergency intubation.

RÉSUMÉ

Bien que l'échographie au chevet des patients permette de distinguer nettement l'intubation œsophagienne de l'intubation endotrachéale, elle n'est toutefois pas utilisée pour déterminer si la sonde a été posée à la bonne profondeur dans la trachée. Comme on ne peut se fier aux marqueurs échographiques indirects de vérification de la profondeur de pénétration de la sonde endotrachéale, l'idéal serait de procéder par vérification visuelle. Il sera question ici du gonflement du ballonnet endotrachéal avec une solution saline pour confirmer l'introduction de la sonde à la bonne profondeur (à la hauteur de la fourchette sternale) par échographie au chevet des patients durant les manœuvres de réanimation. Cette technique rapide se révèle prometteuse dans le contexte des intubations d'urgence.

Keywords: bedside ultrasonography, endotracheal tube, intubation

Bedside ultrasonography has proven useful in distinguishing between tracheal or esophageal location of an endotracheal tube (ETT).¹⁻⁸ Air transmits the ultrasound beam poorly, leading to an artifact called “dirty shadowing.” With or without an ETT in place, the

trachea appears as an area of dirty shadowing on a sonogram because it is filled with air. An ETT incorrectly placed into the esophagus can be detected on a sonogram because two areas of dirty shadowing will then be seen: air within the trachea and within the ETT in the esophagus, which normally contains no air.

Bedside ultrasonography is not used to detect the depth of endotracheal intubation (with the exception of newborns, who possess relatively uncalcified sternal bones, allowing for high-resolution imaging of the distal trachea⁹⁻¹¹) as the dirty shadowing of air within the ETT cannot be distinguished from the dirty shadowing of air in the trachea beyond the ETT tip. Indirect ultrasound surrogates of correct ETT insertion depth (e.g., bilateral lung sliding and diaphragm movement) are less reliable than chest radiography¹²⁻¹⁴ and are not useful in cases of pneumothorax, subcutaneous emphysema, pleural scarring, pleural effusion, pulmonary malignancies, or ETT obstruction.¹²

Previous reports suggest that inflating the ETT cuff with liquid rather than air (an established and safe practice with applications in many areas of medicine¹⁵⁻²⁶) allows the cuff to be visualized on a sonogram.^{27,28} An ETT cuff at the level of the suprasternal notch correlates with correct depth of the tip (i.e., just deep to the clavicles.²⁹⁻³² Therefore, sonographic identification of a liquid-filled cuff at the suprasternal notch should confirm the correct depth of intubation. Previous reports of this technique have been limited to cadaver studies²⁸ or the operating room and a single radiologist.²⁷ We describe filling the ETT cuff with saline to verify both endotracheal position and correct endotracheal depth during emergency resuscitation.

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CASE REPORT

A 50-year-old man in status epilepticus underwent rapid sequence intubation for airway protection in our emergency department. Bedside ultrasonography in the transverse plane at the suprasternal notch revealed a single area of dirty shadowing, confirming tracheal rather than esophageal intubation. Bilateral breath sounds were noted, and capnography revealed the presence of exhaled carbon dioxide. The cuff of the ETT was inflated with 10 mL of air, and a portable chest radiograph was ordered.

As the effect of the paralytic agent subsided, the tonic-clonic activity resumed, followed by brief oxygen desaturation. Concerned that the convulsions may have dislodged the ETT, bedside ultrasonography was attempted to confirm the position of the ETT.

A sonogram of the anterior neck was performed at the level of the suprasternal notch (Figure 1). With the probe in a longitudinal orientation, the characteristic appearance of the thyroid cartilage and tracheal rings was observed, with an underlying column of air that, as expected, obscured any evidence of the ETT or cuff (Figure 2). The cuff was deflated, with no significant change noted in the appearance of the ultrasound image (Figure 3).

The cuff was then inflated with 7 mL of saline while the probe was held in a transverse orientation at the

suprasternal notch. The cuff was readily visualized as an expanding anechoic sphere transiently containing hyperechoic bubbles (Appendix, online version only), in the single area of dirty shadowing corresponding to the trachea. The probe was returned to the longitudinal orientation, revealing the presence of two hyperechoic parallel lines within the trachea (Figure 4). These lines represent the outer and inner surfaces of the anterior aspect of the ETT.⁶ The saline within the cuff acted as an acoustic window allowing visualization of the tube, which had not been possible when the cuff was filled with air. When the saline was evacuated, these parallel lines disappeared. Finally, the cuff was reinflated with air, which was left in place for the duration of the patient's intubation. The sonographic examination was completed in less than 2 minutes.

The subsequent chest radiograph confirmed that the tip of the ETT was correctly positioned just deep to the inferior border of the clavicles, at the level of the T3 vertebra.

DISCUSSION

ETT malposition remains a significant issue in emergency intubation, occurring in 20% of cases.^{33,34} Inadvertent endobronchial intubation is associated with serious complications, such as hypoxemia and

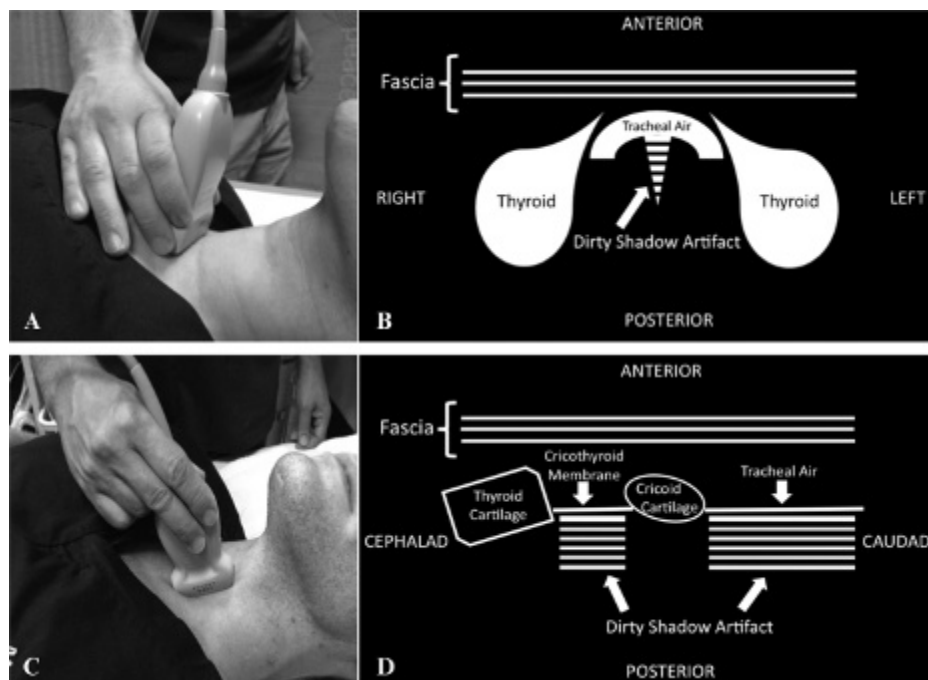


Figure 1. Technique for ultrasound confirmation of endotracheal tube placement. *A*, Transverse transducer position. The probe is held perpendicular to the anterior neck at the level of the suprasternal notch. The probe marker is toward the patient's right. *B*, Diagram of airway structures as they appear on ultrasound imaging in the transverse plane. *C*, Longitudinal transducer position. The probe is held perpendicular to the anterior neck, over the trachea. The probe marker is toward the patient's head, whereas the unmarked side of the probe rests in the suprasternal notch. *D*, Diagram of airway structures as they appear on ultrasound imaging in the longitudinal plane.

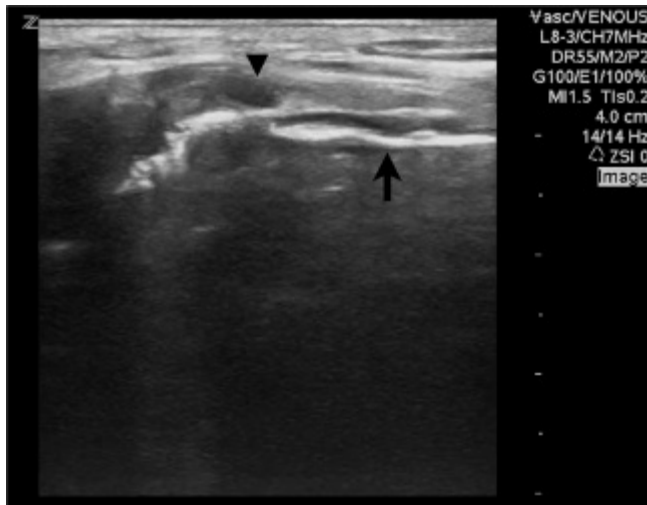


Figure 2. Longitudinal view of the intubated trachea, with the cuff of the endotracheal tube inflated with air. The ultrasound probe marker is toward the patient's head. The hypoechoic ovoid structure indicated by the *arrowhead* corresponds to the anterior cricoid cartilage in cross-section. The hyper-echoic horizontal line indicated by the *arrow* represents the air-mucosa interface of the anterior trachea. Neither the endotracheal tube nor its cuff is visible on the sonogram.

barotrauma. On the other hand, an ETT placed too high in the trachea carries risks of accidental extubation and cuff-induced vocal cord injury. Confirmation of correct position can be difficult in the emergency department: background noise interferes with auscultation,^{35–37} capnography does not distinguish between endobronchial and endotracheal intubation,^{38,39} and radiographic studies entail some finite delays.¹² Direct or fibre-optic visualization is also imperfect.⁴⁰

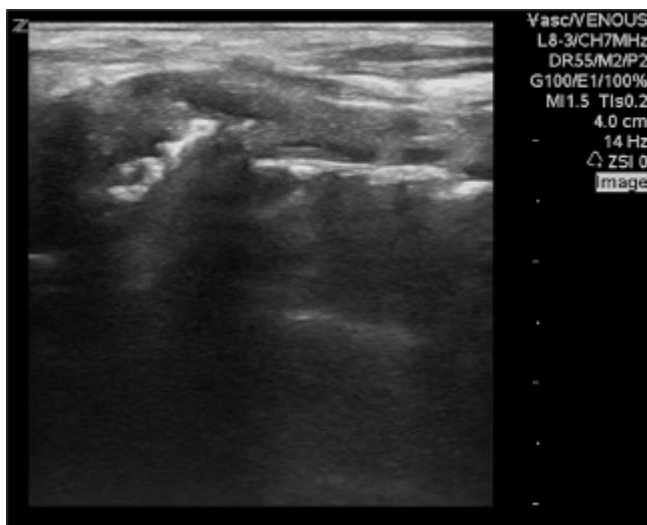


Figure 3. Longitudinal view of the intubated trachea, with the endotracheal tube cuff deflated. There is no notable difference compared to Figure 2.

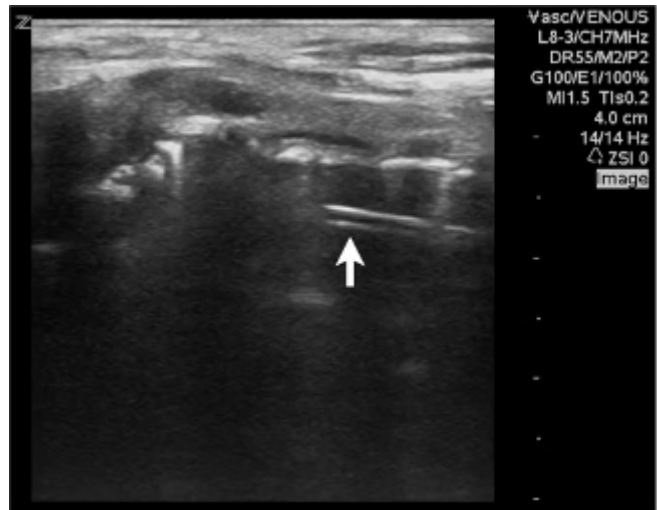


Figure 4. Longitudinal view of the intubated trachea, with the cuff of the endotracheal tube inflated with saline. The saline in the anterior portion of the cuff provides an acoustic window through which the anterior wall of the endotracheal tube can be seen (the two hyperechoic parallel lines indicated by the *arrow*).

The bedside ultrasound technique described here allowed rapid confirmation of correct ETT insertion depth during resuscitation.

The optimal depth for the tip of the ETT is at the midpoint of the trachea, halfway between the vocal cords and the carina.⁴¹ In practice, 5 ± 2 cm from the carina is commonly used as a range for acceptable depth of the ETT tip.⁴² An ETT tip at the level of the inferior border of the clavicles will fall within this acceptable range.

Chest radiography is the most commonly used test to confirm ETT depth but has a number of drawbacks besides delay. It requires lifting of the patient to place the x-ray film under them, a procedure well known for causing dislodgment of the ETT.^{9,27} It requires interruption of chest compressions during resuscitation and involves ionizing radiation. The chest x-ray result also only reflects the position of the ETT at the time of the radiograph, and the tip is known to move 1 ± 4 cm during flexion and extension of the neck.⁴³

Bedside ultrasonography involves no radiation, requires no patient repositioning, gives an instantaneous result, and can be repeated as needed. It is already established as an accurate test to differentiate tracheal from esophageal intubation.^{1–8}

An ETT cuff that is located at the level of the suprasternal notch correlates to correct depth of ETT insertion.^{29–32} A cuff filled with air, however, cannot be reliably distinguished from the surrounding air-filled

trachea. A pioneering anesthesiology study in 1987 reported the use of saline rather than air to allow cuff visualization by ultrasonography.²⁷ This technique was not adopted into clinical practice, however, perhaps due to the limited availability of bedside ultrasonography at the time. A more recent report in a cadaver study showed that novice sonographers could accurately identify a saline-inflated ETT cuff at the level of the suprasternal notch.²⁸ We report temporarily inflating an ETT cuff with saline to directly confirm correct ETT depth during resuscitation.

The bedside ultrasound examination described above is easy to learn, provides an immediate result, and has the potential to replace many of the chest radiographs that are performed solely for ETT placement confirmation. This technique does require temporary deflation of an ETT cuff. We recommend suctioning the oropharynx prior to performing this technique to limit the risk of secretion aspiration.

CONCLUSION

This case report describes the temporary inflation of an ETT cuff with saline to allow sonographic confirmation of correct depth of ETT insertion during resuscitation. This technique holds promise as a primary confirmation method for ETT placement.

Competing interests: None declared.

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APPENDIX: Video of the Endotracheal Tube Cuff during Inflation with Saline. Transverse View of the Intubated Trachea at the Level of the Suprasternal Notch.