ORIGINAL RESEARCH

Ability of Critical Care Medics to Confirm Endotracheal Tube Placement by Ultrasound

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ACLS: Advanced Cardiac Life Support
ETT: endotracheal tube

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Abstract

Introduction: The Advanced Cardiac Life Support (ACLS) guidelines were recently updated to include ultrasound confirmation of endotracheal tube (ETT) location as an adjunctive tool to verify placement. While this method is employed in the emergency department under the guidance of the most recent American College of Emergency Physicians (ACEP; Irving, Texas USA) guidelines, it has yet to gain wide acceptance in the prehospital setting where it has the potential for greater impact. The objective of this study to is determine if training critical care medics using simulation was a feasible and reliable method to learn this skill.

Methods: Twenty critical care paramedics with no previous experience with point-of-care ultrasound volunteered for advanced training in prehospital ultrasound. Four ultrasound fellowship trained emergency physicians proctored two three-hour training sessions. Each session included a brief introduction to ultrasound "knobology," normal sonographic neck and lung anatomy, and how to identify ETT placement within the trachea or esophagus. Immediately following this, the paramedics were tested with five simulated case scenarios using pre-obtained images that demonstrated a correctly placed ETT, an esophageal intubation, a bronchial intubation, and an improperly functioning ETT. Their accuracy, length of time to respond, and comfort with using ultrasound were all assessed.

Results: All 20 critical care medics completed the training and testing session. During the five scenarios, 37/40 (92.5%) identified the correct endotracheal placements, 18/20 (90.0%) identified the esophageal intubations, 18/20 (90.0%) identified the bronchial intubation, and 20/20 (100.0%) identified the ETT malfunctions correctly. The average time to diagnosis was 10.6 seconds for proper placement, 15.5 seconds for esophageal, 15.6 seconds for bronchial intubation, and 11.8 seconds for ETT malfunction.

Conclusions: The use of ultrasound to confirm ETT placement can be effectively taught to critical care medics using a short, simulation-based training session. Further studies on implementation into patient care scenarios are needed.

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Introduction

The Advanced Cardiac Life Support (ACLS) guidelines were recently updated to include ultrasound confirmation of endotracheal tube (ETT) location as an adjunctive tool to verify placement.[1] While this method is employed in the emergency department under the guidance of the most recent American College of Emergency Physicians (ACEP; Irving, Texas USA) guidelines,[2] it has yet to gain wide acceptance in the prehospital setting where it has the potential for greater impact. Previously accepted confirmatory methods such as auscultation, capnography, and radiographic imaging may not be applicable in the out-of-hospital environment.[3,4]

Despite these recommendations, there are several barriers to increasing the use of ultrasound for advanced airway confirmation in the prehospital setting.[4] Two of the most obvious are the lack of available training opportunities and a paucity of in-vivo cases to attempt this technique. Therefore, the hypothesis is that critical care medics, novice to ultrasound, can successfully identify correct ETT placement and recognize improper placement in the esophagus or the right main stem bronchi following a standardized training approach.

Materials and Methods

Subjects included critical care paramedics who volunteered to participate. The medics have an expanded scope of practice with focus on ACLS, air medical response, and acute

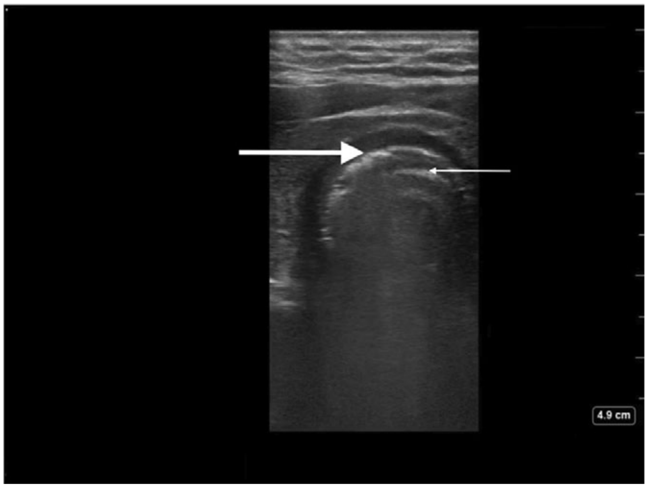

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Figure 1. Ultrasound Image Showing the Typical Appearance of a Trachea (big arrow) with Endotracheal Tube Inside (small arrow).

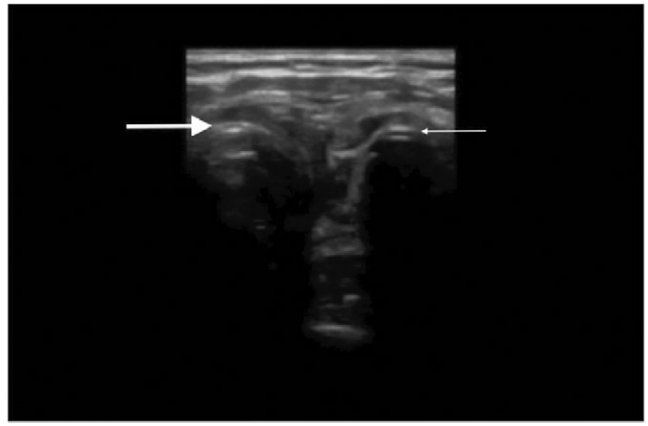

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Figure 2. Ultrasound Image Showing the Typical Appearance of the "Double Trachea Sign." Note: The trachea (big arrow) with a similarly appearing structure adjacent to it, which is the esophagus with an endotracheal tube inside it (small arrow).

inter-facility transport. There were no specific exclusion criteria. Four emergency physicians with advanced training in ultrasound served as course instructors. A teaching module was developed that included brief introduction to ultrasound basics and how to properly image the neck and lungs to confirm correct ETT placement. Two "X-Porte" (FUJIFILM; Sonosite, Inc.; Bothell, Washington USA) ultrasound machines were utilized to train the medics during hands-on sessions, which followed the learning module. Live volunteer models were used for the hands-on training session and recorded ultrasound clips displayed on the machines were used to display pathology.

The Virginia Commonwealth University (VCU; Richmond, Virginia USA) Institutional Review Board approved this study (HM20006091). The training was carried out over two separate days. Each day encompassed ten different medics. A short, didactic lecture was presented that covered the basics of the ultrasound exam for ETT placement, including how to visualize the trachea, esophagus, and lung fields. Specific instances where this type of tube confirmation would be beneficial were also presented. Both normal and abnormal findings were presented with opportunity for questions. Following this, the medics were shown how to perform this exam on live models. Each participant would scan the neck and identify the esophagus and trachea. Esophagus identification was augmented by having participants swallow soda to show the transit of bubbles. Normal lung anatomy was also demonstrated and participants were shown how to determine if there was lung sliding. M-mode was utilized to help further identify pleural motion.

Following this, each medic was individually presented with five different cases. For each case, the medic was instructed that the patient had just been intubated, and that an ultrasound was performed to determine the location of the tube. The simulated ultrasounds were then presented to them. For each case, three video images were used on one screen, including one of the neck and two lung fields, clearly identifying left and right. The medics were then asked to interpret where the tube was located based on these findings. Two normal findings were presented, which included a trachea with an ETT in it (Figure 1) and bilateral lung sliding. One esophageal intubation was presented, which included a double trachea sign (Figure 2) and two images of lungs with no lung sliding. One right main-stem tube was presented, which included a trachea with an ETT and only lung sliding on the right. One final case was presented which showed the tube in the trachea, but no lung sliding in either lung. For this final image, acceptable answers included: bilateral pneumothorax, malfunctioning tube, or obstructed tube. This resulted in 20 properly placed and 60 misplaced simulated ETT cases. Since this study was observational in design, percent correct measures were determined as well as time to correct identification of ETT location.

Participants then completed a brief post-session survey that included three different questions on perceived usefulness to their practice. Answers were recorded using a ten-point Likert scale.

Results

Twenty critical care medics completed the training and testing session. The medics correctly identified 37/40 (92.5%; 95% CI, 0.80-0.98) of the correct endotracheal placements, 18/20 (90.0%; 95% CI, 0.68-0.99) of the esophageal intubations, 20/20 (100.0%; 95% CI, 0.83-1.0) of the ETT malfunctions, and 18/20 (90.0%; 95% CI, 0.68-0.99) of the bronchial intubations correctly. The average time to diagnosis was 10.6 seconds for proper placement, 15.5 seconds for esophageal placement, 11.8 seconds for ETT malfunction, and 15.6 seconds for right main stem placement.

Following the testing session, all participants were asked to complete a brief survey regarding the testing session and its applicability to practice. All 20 medics "agreed" or "strongly agreed" that this simulation was useful for their practice, that they would use ultrasound to confirm ETT placement, and that simulation provided a realistic view of potential pathology encountered during ETT placement.

Discussion

Ultrasound has been examined extensively as a valid method to confirm ETT placement.[5-11] Subsequent to this, the American Heart Association (AHA; Dallas, Texas USA) included ultrasound confirmation of ETT placement into the advanced airway section of their ACLS guidelines.[1] These new guidelines, combined with the fact ultrasound machines continue to increase in portability and ease of use, create a powerful tool to confirm ETT placement in the prehospital setting. However, this requires the dissemination of instructional protocol to prehospital providers. Prior studies have examined the ability of providers to use ultrasound to confirm ETT placement, in both static and dynamic fashions, on a variety of models including operative cases and cadavers.[12,13] This study is the first to introduce an instructional and testing protocol that examines the ability of medics to diagnose common errors associated with ETT placement in a simulated environment, including esophageal intubation, bronchial intubation, and equipment malfunction.

These results show that after a brief didactic session, that participants identified esophageal intubations and other pathologies with 93.0% accuracy. They identified normal intubations with 92.5% accuracy. While 100.0% accuracy for all normal and pathological intubations would be ideal, this study showed good results with just a brief, one-hour teaching session. Accuracy would likely increase with longer sessions or multiple sequential sessions.

Limitations

The simulated nature of this study is the main limitation, as it is not yet demonstrated if these new skills are now translatable to patient encounters. However, given that endotracheal intubation is one of the most potentially hazardous procedures performed by prehospital providers, it is appropriate to first train and assess retention in the simulated environment. The aim of this study was only to determine if this aspect of it was feasible, and these results show that the skill itself is easily trainable to those with very little ultrasound experience.

A second limitation is the small amount of cases presented due to time constraints. While the images presented were all chosen for their quality, it may be more difficult to interpret on images that have more variability. This is a limitation for all point-of-care ultrasound providers, and as this method of ETT confirmation gets implemented, quality assurance programs and continued training will be required.

Finally, this was not a random sample of prehospital medics. The paramedics were self-selected and volunteered to participate in this study, which may lead to self-selection bias.

Conclusions

Based on this pilot study, critical care medics can be taught to correctly interpret ultrasound images of ETT placement using a short instruction model. Further studies on the ability to obtain the images, as well as implementation into patient care scenarios, are needed.

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