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The effectiveness of a short training course for emergency medicine residents to confirm tracheal tube placement by ultrasound

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Abstract

***Objective*: The present study aimed to evaluate the performance of tracheal ultrasound by novice emergency medicine residents after participating in a short training course.**

***Methods*: This was an observational prospective study conducted between July 2016 and September 2017 at three university-affiliated emergency departments in Tehran, Iran. Adult patients (over 18 years of age) who needed emergency intubation were included. Investigators were emergency medicine residents who did not have prior experience in tracheal ultrasound. Training course consisted of 40 minutes of theoretical education and three days of hands-on training. Immediately after intubation by treating physicians, two investigators evaluated the placement of the tracheal tube simultaneously. One investigator used tracheal ultrasound and the second investigator used quantitative wave form capnography. The registrant was a nurse who was asked to record the results of each investigator in the following format: 1. Correct tracheal intubation, 2. Esophageal intubation, and 3. Time spent to complete the evaluation. Finally, the ultrasound results were compared with those of capnography.**

***Results*: Ninety patients were included in the study. Based on the capnography results, there were three (3.3%) esophageal intubations and 87 (96.6%) tracheal intubations. Investigators reported the same results by tracheal ultrasound. The mean±SD time spent to complete the evaluation was 32±10 seconds for capnography and 48±15 seconds for tracheal ultrasound (p value of 0.0001).**

***Conclusion*: Emergency medicine residents with basic knowledge of ultrasound can learn tracheal ultrasound techniques through a short training course.**

Key words: Ultrasound, emergency medicine, residency, endotracheal intubation, trachea.

Introduction

Reports indicate that the possibility of inadvertent esophageal intubation can be as high as 16% in emergency departments, and cardiac arrest will occur in 2.9-16.7% of these cases. (1,2)

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There are currently several methods to confirm the accuracy of endotracheal tube placement, including physical examination (observing chest expansion and auscultation) as well as the use of suction devices, post-intubation chest X-rays, colorimetric carbon dioxide detectors, continuous waveform capnography, fibreoptic visualization of the trachea, and bedside ultrasound imaging of the trachea and lungs.

According to the American Heart Association, quantitative waveform capnography is the gold standard method to confirm tracheal tube placement. (3) Nevertheless, this method may fail as an assessment tool for tracheal tube placement in the clinical settings of cardiac arrest or hypoperfusion. (4)

Today, ultrasound is also being successfully recruited to evaluate the location of the endotracheal tube. (5,6) Thus far, the direct method of tracheal ultrasound or the indirect method of looking for pleural sliding and the motion of the diaphragm have been used to confirm correct tracheal tube placement. (7-9) The direct method can be performed either dynamically (performing a tracheal intubation while simultaneously performing a tracheal ultrasound in real time) or statically (performing a tracheal ultrasound after the tracheal intubation). (2,10)

Although both methods are accurate, the indirect method requires the lungs to be evaluated through the chest, which would be difficult while performing chest compressions. In comparison, direct tracheal ultrasound does not interfere with chest compressions. (11)

Although, there have been many reports in favor of using ultrasound to confirm tracheal tube placement, the accuracy of ultrasound depends on the skills of the sonographer and the learning curve of the tracheal ultrasound has not yet been clearly defined.

The present study aimed to evaluate the performance of tracheal ultrasounds by novice emergency medicine residents after they participated in a short training course.

Methods

Study design and setting

This was an observational prospective study conducted between July 2016 and September 2017 at three university-affiliated emergency departments (EDs) in Tehran, Iran.

Selection of participants

Adult patients (over 18 years of age) who needed emergency intubation were included by convenient sampling. Since all of the patients needed emergency intubation, informed consent was obtained from the patients' companions. The Local Ethics Committee of Tehran University of Medical Sciences approved the conduct of the study.

Exclusion criteria consisted of: 1. Deformity of the neck or trachea, 2. Neck trauma that would obstruct the ultrasound examination, 3. Subcutaneous emphysema in the neck, 4. Morbid obesity, 5. Neck tumors, and 6. A history of neck surgery or tracheostomy.

The investigators were emergency medicine residents who had basic knowledge of ultrasound in the emergency department, including ultrasound machine knobology and using ultrasound in a focused assessment with sonography for trauma (FAST) exam; however, they were novices in tracheal ultrasound.

Interventions

The tracheal ultrasound training course consisted of 30 minutes of theoretical training and the viewing of a 10-minute video on tracheal ultrasound. After the theoretical training, the participants underwent a three-day, hands-on tracheal ultrasound training course in the ED. To become certified, each resident had to perform five successful ultrasound examinations of tracheal intubation observed by a board-certified emergency medicine attending who was an expert in the field of emergency ultrasound.

The emergency physicians who performed the tracheal intubations were not part of the research team and patients were intubated based on the judgment of the treating physicians.

Measurements

Immediately after intubation, two investigators on the research team simultaneously evaluated the placement of the tracheal tube. One certified emergency resident evaluated the location of the tube using tracheal ultrasound. A high-frequency linear transducer (SonoScape A6, SonoScape Medical Corp, Shenzhen, China) was placed over the cricothyroid membrane in both the transvers and longitudinal planes (Figures 1 and 2). In case of only one lumen on the ultrasound image, the tracheal tube would be slowly moved by the researcher under Doppler ultrasound examination in order to detect doppler waves between the trachea and the tube (Figure 3). The identification of two lumens was considered as esophageal intubation. The time spent to confirm tracheal intubation was recorded as well.

At the same time, the position of the tube was also evaluated by a second investigator using physical examination (observing the expansion and auscultation of the chest) and quantitative waveform capnography. Since the two investigators conducted their evaluations at simultaneously, neither was aware of the other's results. In the interests of patient's safety, the maximum permitted time to perform the evaluation was two minutes and the final result was not announced until the end of the evaluation. A flowchart of the study is demonstrated in **Figure 4**.

Outcomes

Quantitative waveform capnography is considered as the gold standard method for correct tracheal intubation. A positive test is defined as the detection of more than 4 mmHg of carbon dioxide after five breaths, along with normal capnogram waves.

The data were gathered and registered by a third investigator. The registrant was a nurse who was asked to record the results of each investigator in the following format: 1. Correct tracheal intubation, 2. Esophageal intubation, and 3. Time spent to complete the evaluation. Finally, the ultrasound results were compared with the capnography.

Analysis

The SPSS program (Version 17, SPSS Inc., Chicago, IL, USA) was used to analyze the study data. The students' t-tests were applied to compare the time spent to accomplish the evaluations of tracheal tube placement by ultrasound and capnography. A p value of below 0.05 was considered as a statistically significant result.

Results

Of the 108 patients evaluated through convenient sampling, a total of 90 were included in the study (**Figure 4**). The demographics and clinical data of the study participants are illustrated in **Table 1**.

Tracheal ultrasound was performed by trained emergency medicine residents consisting of five second-year (PGY2) postgraduates and five PGY3 residents.

All of the trained residents could correctly perform an ultrasound examination irrespective of their residency level. Based on the results of quantitative waveform capnography, there were three (3.3%) esophageal intubations and 87 (96.6%) tracheal intubations. The investigators reported the same results using tracheal ultrasound (**Table 2**). So, the sensitivity and specificity of the tracheal ultrasound method in comparison with quantitative waveform capnography was 100%. The mean±SD time spent to complete the evaluation of tracheal tube placement was 32±10 seconds for the quantitative waveform capnography and 48±15 seconds for the tracheal ultrasound, resulting in a p value of 0.0001.

Discussion

The results of the present study showed that participating in a short tracheal ultrasound training course enables emergency medicine residents to reliably confirm tracheal intubation using ultrasound.

Recently, Checkin et al (12) reported that a brief online training course paired with the execution of two hands-on ultrasound-guided tracheal intubations enables emergency physicians to correctly interpret recorded video clips of tracheal ultrasounds.

In a study of 33 patients, Warner et al (13) reported that the tracheal ultrasound method had an 100% sensitivity and specificity rating when used by expert emergency physicians to detect tracheal tube placement.

In another study of 40 patients, tracheal ultrasounds carried out by expert emergency physicians had a sensitivity and specificity rating of 100% and 97%, respectively, for in the diagnosis of esophageal intubation. (14)

Considering the low cost and convenience of ultrasounds, as well as the fact that tracheal ultrasound can be used without interrupting chest compressions during cardiac resuscitation, it is an effective method to confirm tracheal intubation in the ED. (15)

In a recent 2016 study, Karacabey et al (16) reported that in cardiopulmonary resuscitation, ultrasound can confirm tracheal intubation faster than capnography.

However, based on our results, the time spent to confirm tracheal intubation was significantly longer than the gold standard method. Having said that, it should be noted that our participants did not have prior experience of performing tracheal ultrasound and more training could have enabled them to perform the evaluation even faster.

Currently, capnography is the gold standard technique to confirm tracheal intubation. (3) However, this method requires the lungs to be properly ventilated and oxygenated. For example, in cardiopulmonary resuscitation, certain situations such as airway obstruction, weak pulmonary blood circulation or vasoconstriction due to the epinephrine may influence the results of capnography. (17,18) In addition, CO_2 may be falsely detected in esophageal intubation, for example, when the contents of the stomach contain CO_2. (17) None of these factors influences tracheal ultrasound.

One of the false positive results that can be obtained through tracheal ultrasounds is when the tracheal tube has been placed in the esophagus, yet behind the trachea. (15) Therefore, as in the present study, different planes should be used in order to confirm the placement of the tracheal tube. (5,13)

Even though tracheal ultrasound is an accurate method of confirming tracheal tube placement, physicians should be cautious of confirming tracheal tube placement with ultrasound only. In suspicious cases, other means of evaluation (capnography, chest x-ray, and physical examination) must be recruited along with the ultrasound in order to confirm tracheal tube placement.

Limitations

Although our results were encouraging, but a larger sample size is required in order to more precisely define the learning curve of tracheal ultrasound to confirm tracheal tube placement. In addition, we did not evaluate the outcomes of the ultrasound guided tracheal intubation such as position of the endotracheal tube in relation to the carina or the possibility of main stem bronchus intubation. These are important factors that still necessities a post intubation chest radiograph.

Conclusion

Our study showed that emergency medicine residents with basic knowledge of ultrasound can learn tracheal ultrasound techniques through a short course consisting of a brief theoretical training session plus a three-day hands-on training experience and examination in an ED environment.

Competing interests

The authors declare that they have no conflict of interest.

Table 1. Demographics and underlying clinical problems of the patients

Age (years, mean±SD)	59.27±2.25
Gender (n%)	
- Male	53 (58.9)
- Female	37 (41.1)
Underlying disease (n%)	
- Severe trauma	11 (12.2)
- Loss of consciousness	56 (62.2)
- Septic shock	12 (13.4)
- Diabetic ketoacidosis	2 (2.2)
- Myasthenia crisis	2 (2.2)
- Pulmonary disease	7 (7.8)

Table 2. Comparing the results of tracheal ultrasound and quantitative waveform capnography

Location of the tracheal tube	Ultrasound result	Capnogram result
Tracheal placement	87	87
Esophageal placement	3	3
Time taken to confirm tube position (mean±SD)	32±10 seconds	48±15 seconds

Figure 1. Location of the ultrasound probe on patient neck: transvers (A) and longitudinal (B)

Figure 2. A: Ultrasound shows tracheal tube and comet tail artefact (arrow head) inside the trachea (arrow), B: Longitudinal view of tracheal tube (arrow) inside the tracheal

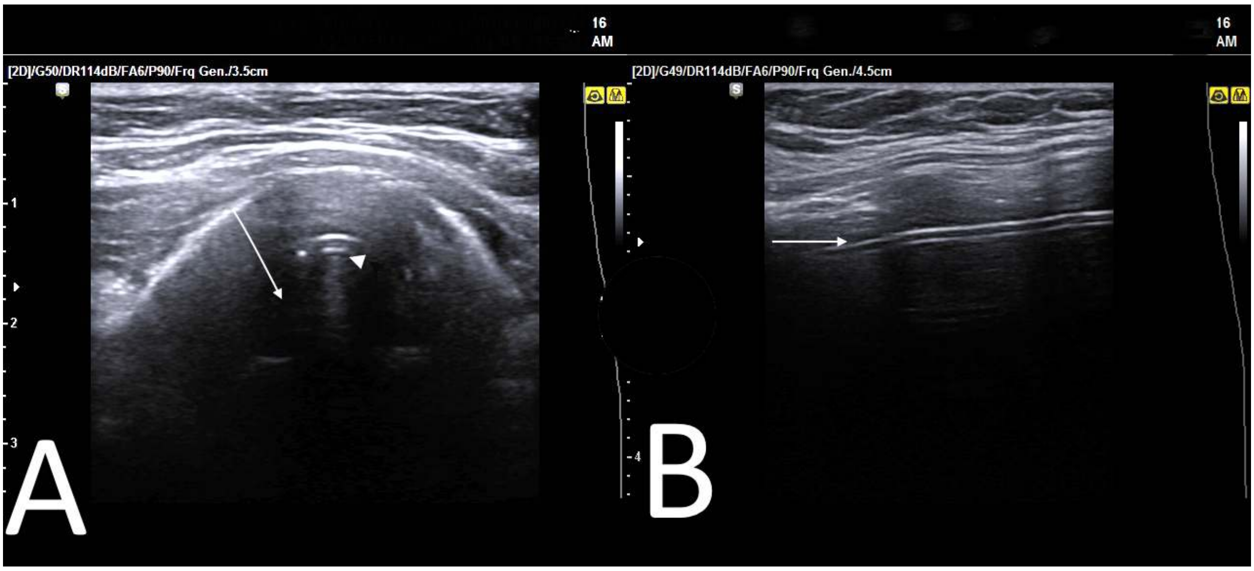


Figure 3. Color Doppler ultrasound detects movement of tracheal tube inside the trachea

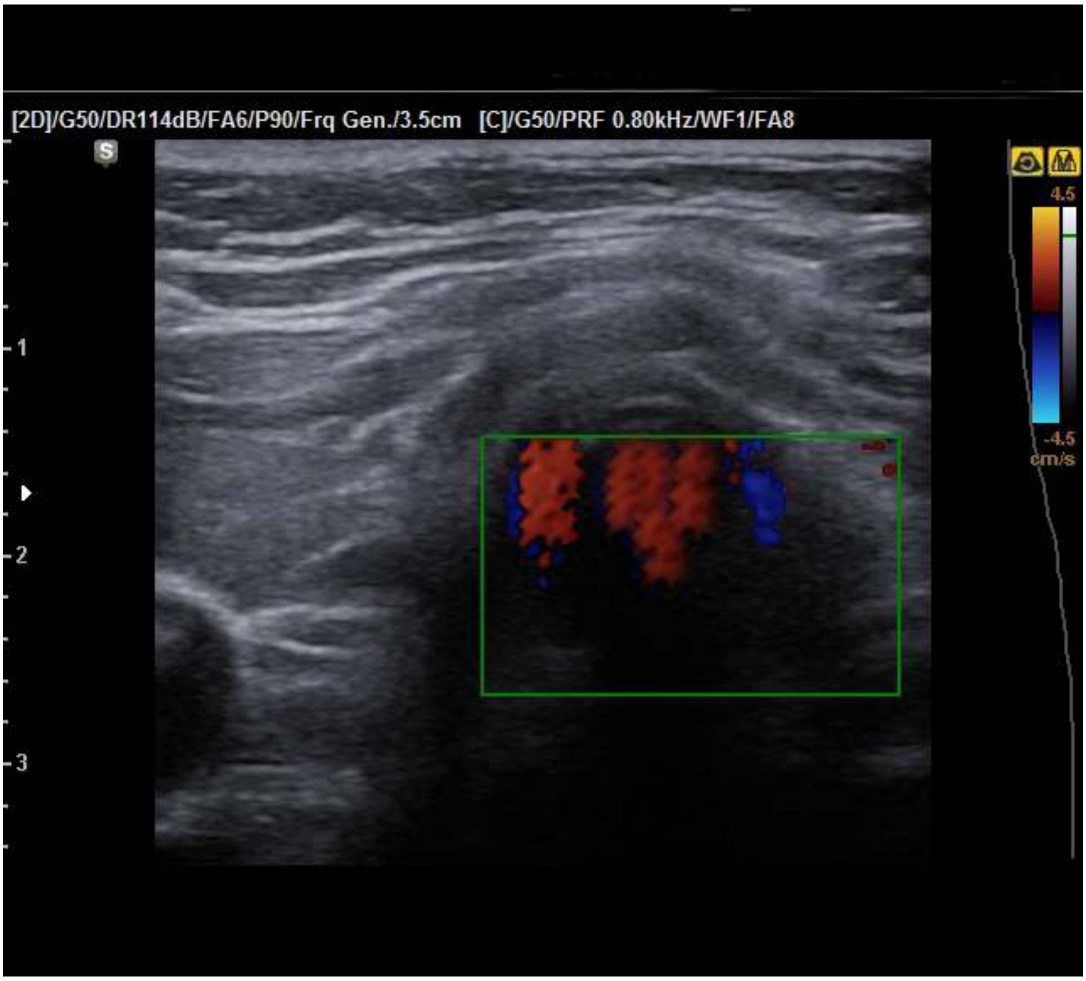
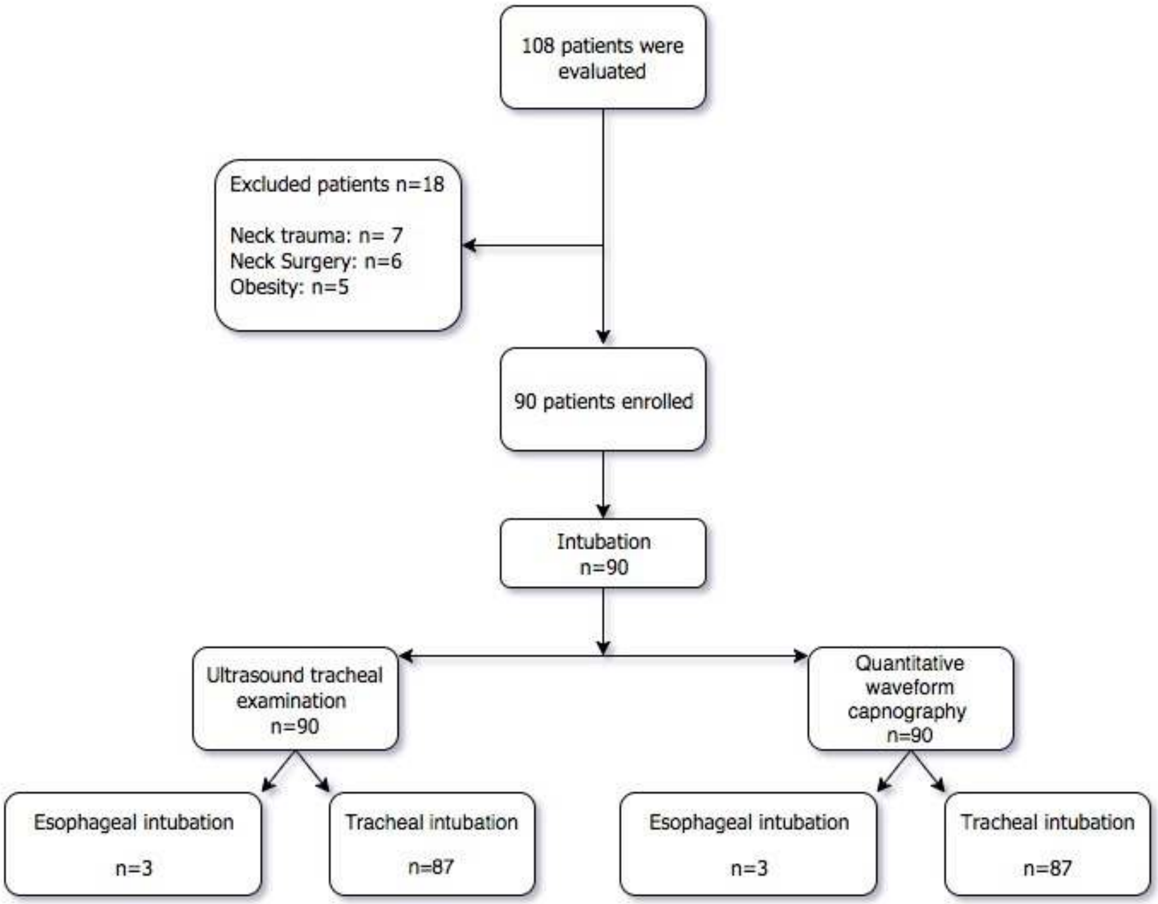


Figure 4. Participant's flow chart



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