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Original Contribution

Tracheal ultrasonography and ultrasonographic lung sliding for confirming endotracheal tube placement: Speed and Reliability

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ABSTRACT

Background: In this study we aimed to evaluate the success of ultrasonography (USG) for confirming the tube placement and timeliness by tracheal USG and ultrasonographic lung sliding in resuscitation and rapid sequence intubation.

Materials and methods: This study was a prospective, single-center, observational study conducted in the emergency department of a tertiary care hospital. Patients were prospectively enrolled in the study. Patients who went under emergency intubation because of respiratory failure, cardiac arrest or severe trauma included in the study. Patients with severe neck trauma, neck tumors, history of neck operation or tracheotomy and under 18 years old were excluded from the study.

Results: A total of 115 patients included in the study. The mean age was 67.2 ± 17.1 with age 16–95 years old. Among 115 patients 30 were cardiac arrest patients other 85 patients were non-cardiac arrest patients intubated with rapid sequence intubation. The overall accuracy of the ultrasonography was 97.18% (95% CI, 90.19–99.66%), and the value of kappa was 0.869 (95% CI, 0.77–0.96), indicating a high degree of agreement between the ultrasonography and capnography. The ulrasonography took significantly less time than capnography in total.

Discussion: Ultrasonography achieved high sensitivity and specificity for confirming tube placement and results faster than end-tidal carbon dioxide. Ultrasonography is a good alternative for confirming the endotracheal tube placement. Future studies should examine the use of ultrasonography as a method for real-time assessment of endotracheal tube placement by emergency physicians with only basic ultrasonographic training.

1. Introduction

Intubation is a challenging procedure in emergency departments (EDs) because of the uncontrolled nature of the environment and a lack of team preparedness and may lead to the development of complications, such as unrecognized esophageal intubation [1], which can cause high rates of mortality and morbidity.

Many techniques have been described for the confirmation of endotracheal tube placement [2], although chest radiography is considered the most reliable method. In general, chest auscultation is used for confirming tube placement, but unfortunately, 55% of one-lung intubations are misdiagnosed by auscultation [3]. The 2010 American Heart Association Cardiopulmonary Resuscitation Guidelines state that quantitative waveform capnography is the gold standard method for confirming tube placement [4], but this method has some limitations, particularly in cardiac arrest patients, such as the need for epinephrine use, low pulmonary flow and low cardiac output [5].

Ultrasonography (USG) has a wide range of uses in EDs. It is non-invasive, occurs in real time and thus improves the confidence of the physician in determining tube placement [6]. Tracheal ultrasonography images are not affected by very low pulmonary flow, contrary to capnography, and ultrasonographic detection of esophageal intubation can be performed prior to ventilation of the patient. Earlier detection of esophageal intubation could prevent ventilation of the stomach and its associated complications, namely emesis and aspiration.

In this study, we aimed to evaluate the success of USG for confirming tube placement and to evaluate the timeliness involved in tracheal USG and ultrasonographic lung sliding for patients undergoing resuscitation or rapid sequence intubation.

2. Materials and methods

This study was a prospective, single-center, observational study conducted in the ED of a tertiary care hospital. The study was conducted between September 1, 2013, and September 1st, 2014, and was approved by the hospital ethics committee.

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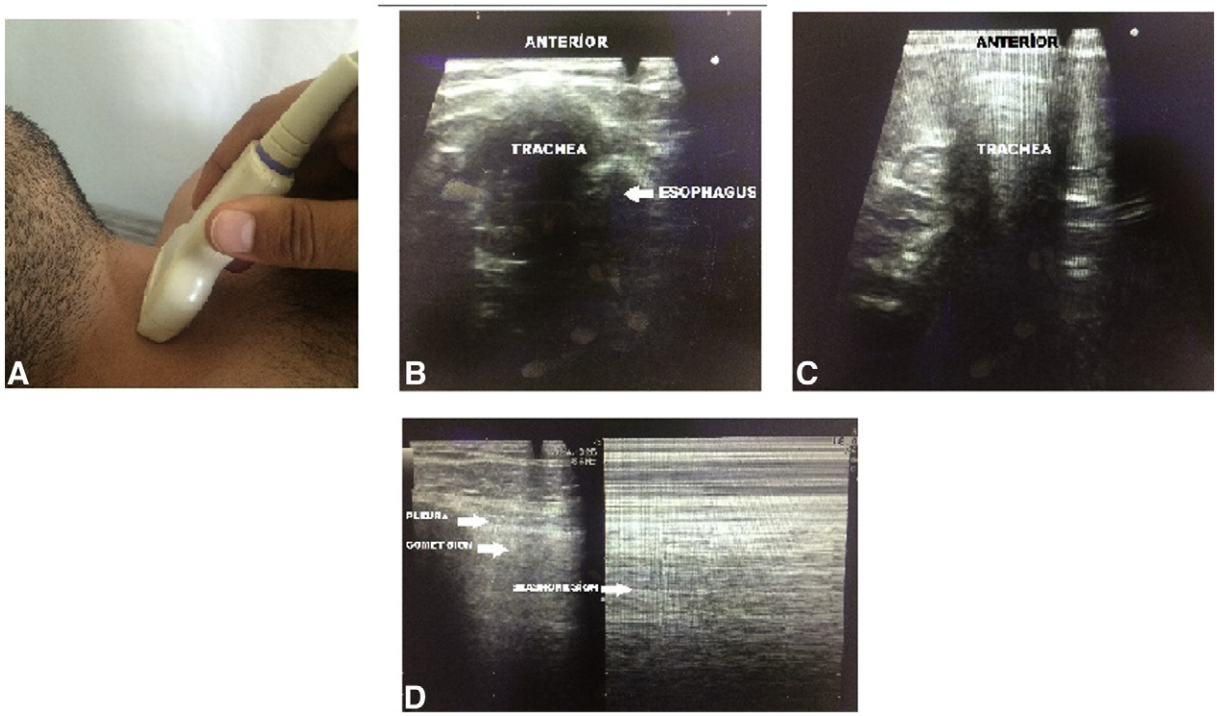

Fig. 1. (A) Demonstration of transducer placement just superior to the suprasternal notch. (B) Ultrasonographic image of esophageal intubation (C) Ultrasonographic image of tracheal intubation. (D) Longitudinal scan over an intercostal space, pleural lines, Dynamic lung sliding generated sandy pattern over M-mode, generally called a seashore sign.

Patients were prospectively enrolled in the study. In particular, patients who underwent emergency intubation due to respiratory failure, cardiac arrest or severe trauma were included in the study.

In contrast, patients with severe neck trauma, neck tumors, history of neck operation or tracheotomy, and under 18 years of age were excluded from the study.

The patients enrolled in the study were separated into 2 groups: The first group consisted of cardiac arrest patients who underwent emergency intubation during cardiopulmonary resuscitation (CPR), and the second group consisted of non-cardiac arrest patients who received rapid sequence intubation (RSI).

Emergency intubations were performed by first-year emergency medicine residents. Tracheal and lung sliding USG were performed concurrently with intubation by 2 emergency medicine specialists who had completed a USG training course developed by the Emergency Medicine Physicians Association of Turkey.

Post-intubation confirmation of endotracheal tube placement was performed using a capnometer (EMMA Mainstream Capnometer).

A Toshiba Aplio500 USG device and a 7.5 mHz linear probe were used for USG. The transducer was placed transversely on the anterior neck just above the suprasternal notch. The position of the trachea was demonstrated by the appearance of a "comet-tail artifact", specifically a hyperechoic air-mucosa (A-M) interface with a posterior reverberation artifact. To identify bilateral lung sliding over the lungs after intubation, the identified endotracheal tube position was defined as "endotracheal" if only one A-M interface with a comet-tail artifact was observed or "intraesophageal" if a second A-M interface, mimicking a second airway (double-tract sign), appeared after the transducer was placed on both sides of the chest in the mid-axillary line near the fourth to fifth intercostal space (Fig. 1). The sonographers were not involved in the patients' care and not aware of the waveform capnography results.

One emergency medical technician measured the durations from completion of the endotracheal tube insertion to the time when sonographer had interpreted the sonographic results and to the time at which the capnography results were obtained.

A data collection form was created to record the patients' age, gender, capnography results, USG results and elapsed time prior to tube placement confirmation.

2.1. Statistical analysis

Various test characteristics, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and positive and negative likelihood ratios, were calculated using standard formulas for a binominal proportion, and the corresponding 95% confidence intervals (CIs) were calculated using the Wilson interval method. All statistical analyses were performed using SPSS statistical software, version 18.0 (SPSS Inc, Chicago, IL, USA) and SAS system ver. 8.2 (SAS Institute Inc, Cary, NC, USA). $P < .05$ was considered statistically significant.

3. Results

A total of 115 patients were included between September 1st, 2013 and September 1st, 2014. The patient ages ranged from 16 to 95 with a

Table 1
Ultrasonographic detection of tracheal or esophageal intubation

	Total		RSI		Cardiac arrest	
	n = 115		n = 85		n = 30	
	Tracheal	Esophageal	Tracheal	Esophageal	Tracheal	Esophageal
USG tracheal	69	5	56	0	13	5
USG esophageal	2	39	0	29	2	10

USG, Ultrasonography; RSI, Rapid Sequence Intubation.