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Research Article

## Ultrasonography for Endotracheal Tube Placement Confirmation in an Emergency Setting - A Prospective Study in a Tertiary Hospital

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#### ABSTRACT:

**Background:** Ultrasonography, clinical methods and capnography are used to confirm the proper placement of endotracheal tube. Ultrasonography was thought to have high sensitivity and specificity and took less when compared with other two methods.

**Aims:** To compare ultrasonography with the traditional clinical methods and the gold standard quantitative waveform capnography in confirming the proper placement of endotracheal tube.

**Materials and Methods:** We carried out a prospective cohort study on 120 patients who were indicated for intubation in an emergency department of a tertiary care hospital, Chalmeda Anand Rao Institute of Medical Sciences, Karimnagar, Telangana State, India. The study was carried out from June 2017 to December 2017. The confirmation of endotracheal tube placement was identified by three methods, ultrasonography, quantitative waveform capnography (end-tidal carbon dioxide) and traditional clinical method. The parameters recorded by three methods were confirmation of tube placement and time taken for tube placement.

**Results:** Out of the 120 intubation attempts, six (5 %) had esophageal intubations. Ultrasonography produced a sensitivity and specificity of diagnosis of 98.63% and 100%, respectively, which was statistically comparable with the other two methods. When the time taken to confirm tube placement was compared, it was found that ultrasonography took significantly less time. The time taken by ultrasonography, waveform capnography and clinical methods was  $8.13 \pm 1.27$ ,  $17.86 \pm 2.34$  and  $20.13 \pm 2.72$  seconds respectively.

**Conclusion:** The endotracheal tube placement was confirmed by ultrasonography with comparable sensitivity and specificity to other two methods i.e. quantitative waveform capnography and clinical methods and it took less time.

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**Key words :** Emergency, Endotracheal tube Capnography, Intubation, Ultrasonography.

#### Introduction:

A secure airway and effective ventilation are key components of resuscitation. Unrecognized misplacement of endotracheal tube (ETT) can lead to morbidity and mortality. Unrecognized airway accidents such as esophageal intubation tend to occur more in emergency settings, where it is reported as 6%-16%.<sup>1</sup>

Many traditional methods, including direct visualization of the vocal cords, observation of chest expansion and chest auscultation, can be used to confirm ETT position, but each of these methods has limitations. Chest auscultation is the most

common method used to confirm ETT placement, but it usually requires interruption of chest compressions during examination. Quantitative waveform capnography is recommended as the gold standard for confirming correct ETT placement in the 2010 American Heart Association (AHA) Guidelines for CPR and Emergency Cardiovascular Care (ECC).<sup>2</sup>

However, it has some well-known limitations in patients in cardiac arrest, and can be affected by low cardiac output, low

pulmonary flow, airway obstruction, or epinephrine use. Waveform capnography works on the principle of detection of carbon dioxide. This is only possible when there is sufficient pulmonary blood flow. In conditions where pulmonary blood flow is compromised such as massive pulmonary embolism and cardiac arrest, capnography is not reliable.<sup>3,4</sup>

Ultrasound is a noninvasive, real-time diagnostic tool commonly used during resuscitation. Real-time airway sonographic approaches could enhance physician confidence and decision-making in relation to tracheal tube placement, and may have a role in combination with continuous capnography in patients with an emergency. Ultrasound is emerging in most emergency departments as it is used in point of care imaging for trauma as well for guided interventions. Various studies have shown that ultrasound is a potential method to confirm proper ETT placement.<sup>5-10</sup>

We carried out our study to compare ultrasonography with the traditional clinical methods and the gold standard quantitative waveform capnography in confirming the proper placement of endotracheal tube.

**Materials and Methods:**

After obtaining clearance from the Institutional Research and Ethics Committee, we carried out a prospective cohort study on 120 consecutive patients who were indicated for emergency intubation in an emergency department of a tertiary care hospital, Chalmeda Anand Rao Institute of Medical Sciences, Karimnagar, Telangana State, India. The study was carried out from June 2017 to December 2017. The confirmation of ETT placement was identified by three methods, ultrasonography, quantitative waveform capnography (end-tidal carbon dioxide) and traditional clinical method and the time taken for the placement was also recorded.

**Exclusion Criteria:**

1. Patients with significant neck pathologies
2. Patients with significant lung pathologies

We followed the methodology of **Thomas VK et al (2017)**.<sup>11</sup> Tracheal sonography was performed using a SonoSite M-Turbo linear probe (13-6 MHz). A Philips M-20 monitor with a mainstream ETCO 2 analyzer was used for capnography. The parameters recorded by three methods were confirmation and time taken for tube placement. Intubation was performed as per the standard hospital protocol which includes confirmation by quantitative waveform capnography and clinical methods looking for bilateral chest rise and 5- point auscultation. The tube was deemed as endotracheal if a typical square waveform capnography was observed along with detection of carbon dioxide of more than 4 mmHg after five breaths.

The sonographer identified the placement of tube as tracheal or esophageal as follows:

1. Tracheal intubation if only one air-mucosal (A-M) interface with reverberation artifact and posterior shadowing was observed
2. Esophageal intubation if two A-M interfaces posterior shadowing were noted, which is called a double tract sign.

**Results:**

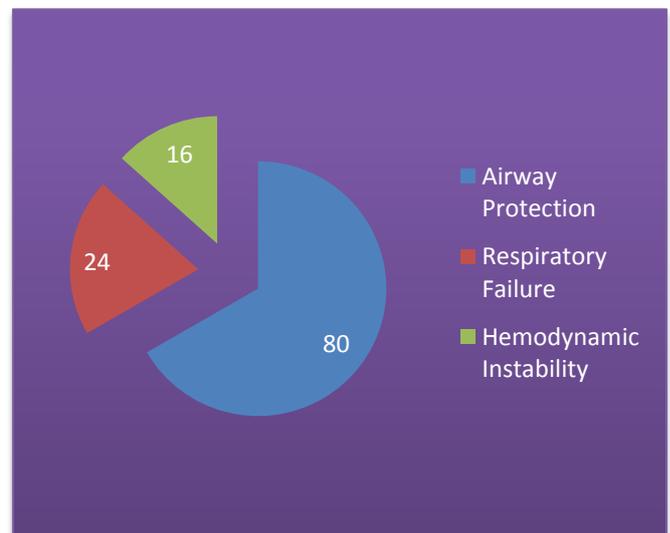
From the history and the standard proforma designed by us, we could obtain the following demographic data. Among the 120 patients who underwent intubation,

1. 66 were males and 54 were females, with a ratio of 1.22 :1.
2. The mean age was 48.63 ± 18.03 years.
3. In majority of cases, the indication for intubation was for airway protection (66.66%), followed by respiratory failure (20%) and for hemodynamic instability (13.34%) (Table 1 and Graph 1).
4. 95% were tracheal and 5% were esophageal.
5. Tracheal ultrasonography correctly detected all 5% of esophageal intubations but misinterpreted 1% of tracheal intubations as esophageal.

**Table 1: Indications for Airway Protection**

Indication	Number	Percentage
Airway Protection	80	66.66
Respiratory Failure	24	20
Hemodynamic Instability	16	13.34

**Graph 1: Indications for Airway Protection**



The sensitivity, specificity, positive predictive value, and negative predictive value of the ultrasound method are shown in Table 2.

**Table 2: Sensitivity and Specificity of Ultrasonography**

	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
USG Vs Clinical	98.84	100 %	100 %	70.63
USG Vs ETCO2	98.84	100 %	100 %	70.63

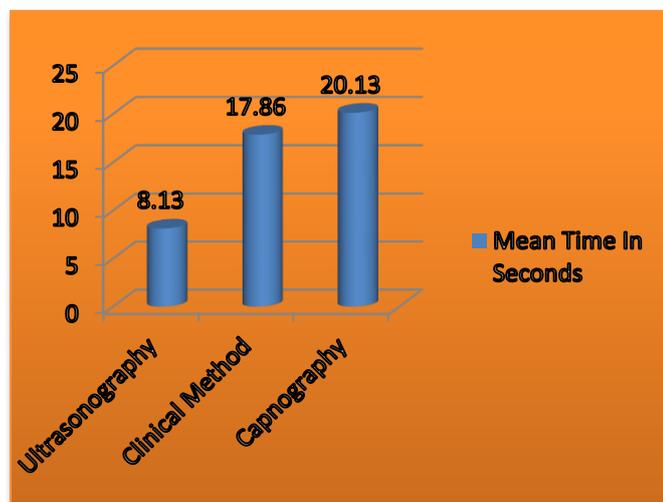
The sensitivity of the ultrasonography technique was compared with that of the other two modalities using McNemar test (two tail) which showed statistically insignificant difference between the groups ( $P=0.52$ ).

When the operating time of the three methods was compared ultrasonography method took significantly less time compared to clinical and waveform capnography (Table 3 and Graph 2: Student's  $t$ -test  $P < 0.001$ ).

**Table 3: Time taken by three methods**

Method	Mean Time In Seconds	Standard Deviation
Ultrasonography	8.13	1.27
Clinical Method	17.86	2.34
Capnography	20.13	2.72

**Graph 2: Time taken by three methods**



**Discussion:**

Numerous studies have compared methods used for distinguishing between endotracheal and esophageal placement of the tube. Visual confirmation during laryngoscopy, expansion of the chest wall during ventilation, auscultatory method, capnography, and chest X-ray are modalities currently used in practice. These techniques vary in their degree of accuracy.<sup>12, 13</sup>

Generally accuracy of any method or technique is expressed in the terms of its sensitivity and specificity.<sup>14</sup> Basically the detection of proper placement of ETT has been reliant on the skill of airway specialist's in visualizing the vocal cords and also on clinical methods that see for equal air entry on both lungs. However in many instances the vocal cords may not be visualized, especially in difficult airway and emergency conditions. Hence newer methods have been designed to predict to detect the proper placement of ETT. Several methods have been developed, but still none of the methods has proved to be 100% reliable in differentiating between tracheal and esophageal intubations.<sup>15</sup>

The Advanced Cardiac Life Support (ACLS) 2015, recommended many techniques for detection of proper ETT placement including ultrasonography by placing a transducer

transversely on the anterior part of the neck above the suprasternal notch. Apart from this the lung sliding sign on ultrasound of the thoracic cavity can recognize movement of the lung. It may also help in detecting endobronchial intubation.<sup>16</sup>

The other method of detection of ETT placement considered as gold standard by few specialists, Quantitative waveform capnography is not commonly available in EDs.<sup>17</sup>

American National Emergency Airway Registry survey reported that 77% of physicians in their series reported the availability of colorimetric ETCO<sub>2</sub> detectors, with only 25% of them using continuous quantitative capnography. Therefore there was a necessity of a different confirmation technique with easily available equipment in emergency departments. Ultrasound is frequently used in EDs for purposes like focused intensive care echocardiography, focused assessment of sonography in trauma, and for vascular access. Recently USG is being used in ED for the confirmation of proper ETT placement.<sup>18-20</sup>

The advantages of USG to confirm ETT placement are<sup>21, 22</sup>

1. Portability and repeatability
2. High sensitivity and specificity
3. Ultrasonographic images are not affected by low pulmonary blood flow as compared to capnography.
4. Tracheal ultrasound detects esophageal intubation even before ventilating the patient, which prevents unnecessary forced ventilation to the stomach and its associated complications.

The two main objectives of our study were

1. The sensitivity and specificity of ultrasonography compared with the traditional clinical methods and the gold standard quantitative waveform capnography.
2. The time taken for each method to confirm tube placement in an emergency setting.

Using ultrasonography, ETT placement can be confirmed using tracheal, lung, or diaphragmatic scanning, but till date very few studies have been carried out to compare the accuracy of different sonographic features. We carried our study by using tracheal sonography which is the most common ultrasound modality used for the same. Studies have shown that transtracheal ultrasound has a sensitivity of 95.7%-100% and a specificity of 96.3%-100% in identifying ETT placement.<sup>23-26</sup>

We found esophageal intubations in six cases (5%). Our findings are in accordance with previous similar studies.<sup>7, 27</sup> Tracheal ultrasonography had detected 10% or more esophageal intubations with a high sensitivity and specificity in earlier studies.<sup>8, 28-30</sup>

Few other studies used different methods to confirm ETT placement. **Hosseini JS** et al (2013) used diaphragmatic movement to confirm tube placement and found 21% esophageal intubation, with a lower sensitivity (91.7%) and

specificity (95.6%).<sup>8</sup>

**Goksu E** et al (2010) and **Ma G** et al (2007) using cadaveric models had higher esophageal intubation rates of 37%-50%. This lower rates of sensitivity and specificity might be due to the inexperience of operators being residents with less than 12 months.<sup>23, 31</sup>

**Weaver B** et al (2006) had sensitivity and specificity of 100%. The high sensitivity and specificity was most likely due to the fact that the operators were qualified emergency medicine physicians and the study was conducted in a planned laboratory setting.<sup>32</sup>

One of the most important criteria to be considered while confirming ETT intubation is the time required. Transtracheal ultrasound can be used for verification while the intubation is being performed or upon completion. It was found that real-time sonographic imaging during intubation had higher sensitivity for detection of esophageal intubation than post-intubation scanning.<sup>23-26</sup>

It was found that USG confirmation took less time than ETO<sub>2</sub> as for capnography, the patient's lungs must be ventilated five times for confirmation. Several studies reported that the time required to perform transtracheal ultrasound ranged from 5 to 45 seconds.<sup>25, 26</sup>

**Pfeiffer et al (2011)** compared timeliness of ultrasound with that of capnography and found that the median verification time with ultrasound was significantly shorter than with capnography.<sup>33</sup>

#### Conclusion:

In our study we found that ultrasonography, end-tidal capnography and conventional clinical methods have comparable sensitivity and specificity in identifying tracheal or esophageal position of ETT. But USG detected the tube placement faster than the other two methods, the time difference being statistically significant, hence has clinical importance. We recommend multi-centric trials with larger patient samples to confirm our findings before the routine use of this modality.

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