*Original Article*

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# Evaluation of Time Taken to Confirm Tracheal Intubation in Real Time by Ultrasound versus Capnography in Elective General Anaesthesia Cases

**Ashok Kumar Balasubramanian[1], Gunasekeran Kaliyaperumal[2]**

[1]Assistant Professor, [2]Associate professor, Department of Anaesthesiology, Critical care and Pain management, Saveetha medical college Hospital, Saveetha University, Thandalam, Chennai 602105, Tamil Nadu, India.

**Abstract**

*Aim:* 1. To study, the use of Ultrasound in confirming tracheal intubation. 2. To identify Oesophageal intubation and time taken for it. 3. Subsequent, evaluation of the time taken to confirm tracheal intubation by Ultrasound and Capnography. *Methods and Material*: 30 patients with ASA physical status 1 and 2, scheduled to undergo elective surgeries under general anesthesia were included in the study. The patient's characteristics, airway measurements and baseline hemodynamic parameters were recorded preoperatively. Anesthetic management was standardized. The ultrasound transverse high frequency linear probe (9.3MHz-15MHz) was kept on suprasternal notch and moved slightly towards left. The esophagus on this view at the level of suprasternal notch lied posterolateral to the trachea. When, laryngoscopy was performed, the cormack-lehan grade was noted. The anesthesiologist doing ultrasonography, simultaneously evaluates the time taken to confirm endotracheal intubation by Ultrasonagraphy and Capnography. In case of oesophageal intubation,it is identified by appearance of "double track" sign. The time taken to identify the same is noted. *Statistical Analysis Used:* Mean, standard deviation, difference in mean. *Results:* The patient characteristics and demographic profile were found to be statistically similar. In our study, oesophageal Intubation is identified by ultrasound as early as 2 seconds in one case. The mean time taken to confirm endotracheal intubation in the rest of 29 patients by ultrasound was 17.5 seconds and by capnography was 41.63 seconds.The confirmation of endotracheal intubation by USG was on average 24 seconds earlier than by Capnography. *Conclusions:* Ultrasound is a rapid and reliable way to confirm proper endotracheal intubation.

**Keywords:** Ultrasonagraphy; Capnography; Confirmation of Tracheal Intubation; Oesophageal Intubation.

## Introduction

Ultrasound is a safe, portable, relatively inexpensive, and easily accessible imaging modality [1-3]. It is a fast and effective technique for confirming tracheal intubation [4]. An investigation of anesthesia mortality revealed that 69% of the deaths were related to airway management, with esophageal intubation identified as a contributing factor [4]. Therefore, confirmation of a correct tracheal tube position is required immediately. The correct tracheal tube position is routinely established by indirect methods known as criterion standards in the operating room. None of these indirect methods are absolutely reliable, and they require ventilation of the lungs [4]. Intra-operative Ultrasound can be used to dynamically observe tube passage into the trachea or oesophagus in real time, providing an additional method of confirmation.

## Subjects and Methods

This is a prospective single centre observational study. The study protocol got approval of university scientific review board. The patients included in the

**Corresponding Author: Ashok Kumar B.,** Assistant Professor, Department of Anaesthesiology, Critical Care and Pain Management, Saveetha Medical College Hospital, Saveetha University, Thandalam, Chennai 602 105, Tamil Nadu, India. E-mail:drmbashok@rocketmail.com.

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study were asked to sign a written informed consent. The patients with ASA physical status 1 to 2, aged 10-70 years, scheduled to undergo elective surgeries under general anesthesia were included in the study. Demographic profile was noted. Patient's characteristics and airway measurements (LEMON) were recorded preoperatively. Anesthetic management was standardized. Before induction, patient was attached to standard monitors including ECG, Pulseoximetry, NIBP, temperature and Capnography. An 18 gauze venflon was secured over the non dominant hand. Patient's head and neck was placed in supine neutral position. The patients were premedicated just before induction with intravenous injection Glycopyrolate 0.005 microgram per kg, Inj. Midazolam 0.03 to 0.05 mg per kg and Inj. Fentanyl at 2 microgram per kg. Premedication was followed by preoxygenation with 100% Fio2 for 5 minutes in Sniff's position. Induction of the patient was carried out by IV Inj.Propofol at 2.5 mg per kg dose slowly over a period of 30 seconds. The ability to ventilate the patient with visible chest rise and $ETCO_2$ tracing with face mask was checked. After ascertaining adequate mask ventilation, a nondepolarising muscle relaxant Inj.Vecuronium at 0.1 mg per kg dose was given IV rapidly. The timer was started and until 3 and half minutes patient was ventilated with 100% $Fio_2$. Baseline hemodynamic parameters like systolic BP, Diastolic BP, Mean arterial BP, Heart rate and Pulse oximetry readings were recorded. An anesthesiologist with experience in using ultrasongraphy in Operating Room places the transverse linear probe at the level of Thyroid cartilage with marking on the probe facing right side.

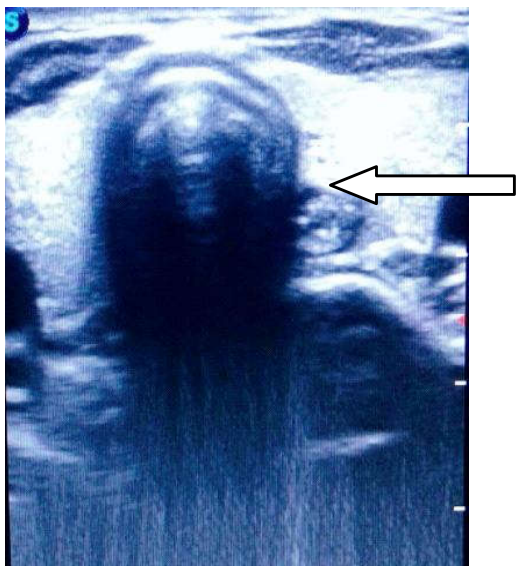

**Fig. 1**: Oesophageal view-Transverse probe on Suprasternal notch slightly towards left side. (Arrow shows Oesophagus posterolateral to trachea)

**Fig. 2**: Oesophageal intubation, "double track" appearance

The thyroid cartilage appears like an inverted V shaped, within which the true and false vocal cords were visible. The probe is moved caudally to suprasternal notch which identifies trachea by inverted U shape of the tracheal ring highlighted by a linear hyperechoic A-M interface and reverberation artefact posteriorly. The thyroid gland appears as homogenously hyperechoic with finely speckled appearance on anterolateral aspect of trachea.The probe then moved slightly towards left side and tilted in a way that marker on the probe faces right nipple. The esophagus on the transverse view at the level of suprasternal notch lies posterolateral to the trachea. The esophagus could be further identified by asking the participants to swallow, which resulted in visible peristaltic movement of the esophageal lumen. Few studies show that, in 10 percent of cases oesophagus are found on right side of tracheae. Hence if there is difficult in viewing oesophagus on left side occurs this fact should be thought of. The anaesthesiologist who did ultrasonography and the one who is assigned to do laryngocopy and intubation did not communicate visually or verbally. After 3 minutes of ventilating the patient with nondepolarising muscle relaxant, laryngoscopy was performed by an anesthesiologist. The cormack-lehan grade was noted. The time of initiation of laryngoscopy by the person intubating was taken as time "zero" for study purpose. Intubation was carried out with an appropriate ETT size. Similtaneously,the anaesthesiologist doing ultrasonography does following tasks:

1. Study, the use of Ultrasound in confirming tracheal intubation.
2. Identify esophageal intubation by appearance of "double track" sign. The time taken to identify the same was noted in seconds.
3. Evaluation of the time taken in seconds to confirm ETT placement in trachea by: USG (indirectly by non appearance of double tract and directly by movement artifact at trachea while rotating the ETT by intubating person) versus ETCO2-immediatly after placement of ETT tube, it was connected to closed circuit and ventilation was carried out at the rate of 15 breaths per minute(one breath every 4 seconds). The clinical supervisor noted the time taken in seconds for the appearance of 6 square wave forms in Capnography. This was taken as the time taken to confirm ETT placement by ETCO2. The hemodynamic parameters were recorded at 0, 1,2,3,5 and10 minutes. Intraoperative hemodynamics was uneventful. At the end of the surgery, patient were reversed, extubated and shifted to PACU and monitored for one hour before shifting to post operative ward. No untoward events were noted.

## Results

The patient characteristics and demographic profile were found to be statistically similar. No untoward events were noted during study. In our study, oesophageal Intubation is identified by ultrasound as early as 2 seconds in one case. The mean time taken to confirm endotracheal intubation in the rest of 29 patients by ultrasound was 17.5 seconds and by capnography was 41.63 seconds. The confirmation of endotracheal intubation by USG was on average 24 seconds earlier than by Capnography.

**Table 1:** demograpic profile, n=30

| Age | | | | | | Sex | | BMI | Education | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Under 20 | 21-30 | 31-40 | 41-50 | 51-60 | 61-70 | Male | Female | | Illiterate | School | College Geraduate |
| 9 | 6 | 9 | 2 | 2 | 2 | 17 | 13 | Mean 21.82 | 15 | 9 | 6 |

**Table 2**: Physical and airway characteristics of the group n=30

| ASA | | Mallampati Classification | | | Carmack Lehan Grade | | | Use of Burp | | Use of Bougie | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | YES | NO | YES | NO |
| 22 | 8 | 19 | 11 | 0 | 18 | 10 | 2 | 2 | 28 | 1 | 29 |

Thyromental distance in all 30 pts were >66.5 cm.
Mouth opening for all 30 cases were >3.5 cm.
No post operative complication in all 30 cases.

**Table 3:** The number of oesophageal intubation and time taken for the same.

| | Faculty, N=30 |
|---|---|
| Number | 1 |
| Time in seconds | 2 |

The identification of oesophageal intubation by real time ultrasound was done as early as 2 seconds.

**Table 4**: Time taken to confirm Tracheal intubation by USG and ETCO2.

| Time to confirm tracheal intubation in seconds. | N=30 | Mean | Standard Deviation |
|---|---|---|---|
| By Ultrasound | 29 | 17.5 | 6.75 |
| By Capnography | 29 | 41.63 | 8.52 |

The time taken in seconds to confirm ETT placement in trachea by USG was faster than by Capnography (by 41.5-17.5=24 seconds).

## Discussion

Tracheal intubation is generally performed to maintain and protect the airway during anaesthesia. Accidental Oesophageal intubation is one of the main causes of death or neurologic damage [1,2]. Therefore, confirmation of a correct tracheal tube position is required immediately. None of the indirect methods are absolutely reliable, and they require ventilation of the lungs [8,9]. Therefore, an adjunctive method is needed for tracheal tube placement confirmation. The ideal method should be fast, simple, and non-invasive. In our study, intraoperative Ultrasound is used to dynamically observe tube passage into the trachea or oesophagus, providing an additional method of confirmation. The correct tracheal tube position is routinely established by, direct visualization of the tracheal tube passing through the glottis, auscultation of the stomach area and some lung regions and measurement of end expired carbon dioxide. These indirect methods are known as criterion standards in the operating room. In our study, 30 patients coming for elective surgery were subjected to laryngoscopy and intubation. An anaesthesiologist experienced in performing ultrasound uses a transverse linear probe with preset settings like depth, focus and gain. During, laryngoscopy and intubation simultaneously,

1. He identifies esophageal intubation by appearance of double track sign. The time taken to identify the same was noted in seconds. The absence of appearance of double track sign is an indirect way of confirming tracheal intubation.
2. Evaluates the time taken in seconds to confirm ETT placement in trachea by: USG versus ETCO2- immediatly after placement of ETT tube. The time taken in seconds for the appearance of 6 square wave forms in Capnography was taken as the time taken to confirm ETT placement by ETCO2.

In our study, 30 patients with ASA physical status 1 and 2, scheduled to undergo elective surgeries under general anesthesia were included. The patient characteristics and demographic profile were found to be statistically similar. No untoward events were noted during study. In our study, oesophageal Intubation is identified by ultrasound as early as 2 seconds in one case. The mean time taken to confirm endotracheal intubation in the rest of 29 patients by ultrasound was 17.5 seconds and by capnograpy was 41.63 seconds. The confirmation of endotracheal intubation by USG was on average 24 seconds earlier than by Capnography.

CO2 detection in exhaled air using Capnograph after six manual ventilations through ET tube is used to confirm tube placement. End tidal CO2 detection is highly reliable in identification of tracheal and esophageal intubation in patients with spontaneous circulation [9]. Specificity (Percentage of in correct esophageal placement detected when no CO2 is detected) is 97% to 100% and Positive predictive value (Probability of ET tube placement if CO2 is detected) is 100 % are high. Whereas, Sensitivity (Percentage of correct ET tube Placement detected when CO2 is detected) is 33 to 100 % and negative predictive value (Probability of esophageal placement if no CO2 is detected) is 20-100%. The threshold to detect exhaled CO2 is seen at much lower levels of CO2 with Capnography [10]. Capnography is the most reliable method for detecting tube position, independent of user's experience [11]. The waveform capnography is very useful to monitor tube position continuously. Consumption of large amount of carbonated liquids may cause false positive reading in esophageal intubation [12]. Failure to detect CO2 when tube is in the trachea( False negative reading) may be due to Low Blood flow and CO2 delivery to lung (CPR), Pulmonary embolism – decreased pulmonary blood flow,contaminated detector – gastric content and acidic drugs like epinephrine when administered through trachea, IV epinephrine will reduce elimination and detection of CO2 [13], severe airway obstruction, status asthmatics and pulmonary edema.

The use of ultrasound to confirm endotracheal tube placement is attractive due to the following reasons. First, ultrasound is portable, repeatable, cost-effective, and widely available in many operation theatres, EDs, critical care areas, and even outside of the hospital [1-3]. Ultrasound is as sensitive and specific as the waveform Capnography and it can be used instead, if waveform capnography is not available [5,6]. Second, ultrasonographic images are not affected by low pulmonary flow, as compared to capnography. Third, tracheal ultrasound can detect esophageal intubation even before ventilating the patient, which prevents unnecessary forced ventilation to the stomach and its associated complications.

So if CO2 is not detected, a second method should be used to confirm endotracheal tube placement. Few studies show the usage of USG, to confirm tube placement [4]. Controlled studies in the literature using ultrasonography for tracheal tube placement are sparse. In adults and children, respectively, Werner et al [5] and Marciniak et al [6] showed that ultrasonography was 100% sensitive and 100% specific in determining the tracheal position of the tube during intubation. In doubtful cases a fiber-optic

scope can be passed though ETT to identify tracheal rings, a gold standard for confirmation of tracheal placement [19]. Ultrasonography can be used not only to detect endotracheal tube position in the trachea not in the oesophagus but also to detect the position of ETT inside the trache above suprasternal notch or below (above carina not in the right main bronchus).

The limitations of the study are: First, ultrasound is a dynamic exam and depends on sonographer experience. Although the learning curve of tracheal ultrasound has not been specified, there is the potential that it can be performed by every clinician after proper training. Second, the number of esophageal intubations was relatively low. Third, because tracheal ultrasound imaging depends on the direct anatomical change by esophageal intubation, the application in patients with neck tumors or trauma could not be assessed.

Ultrasound evaluation of endotracheal intubation should be performed in: Any patient undergoing intubation, to instantly determine the location of the endotracheal tube, prior to bagging one that is incorrectly placed into the esophagus and in training situations, where a physician is supervising a less-experienced performer. Direct ultrasound visualization of the endotracheal tube passing through the trachea may be particularly helpful for physicians who are supervising a trainee performing an intubation, allowing Real-time confirmation of correct placement.

## Conclusion

Ultrasound is a rapid and reliable way to confirm a proper endotracheal intubation. In our study, oesophageal Intubation is identified by ultrasound as early as 2 seconds. We believe that ultrasound can be the third eye of the anaesthesiologist that helps in the conventional methods of Endo tracheal intubation. Ultrasound is helpful for physicians who are supervising a trainee performing an intubation, allowing real-time confirmation of correct placement.

*Key Messages*

Ultrasound is a safe, portable, relatively inexpensive, and easily accessible imaging modality [1-3]. It is a fast and effective technique for confirming tracheal intubation [4]. Controlled studies in the literature using ultrasonography for tracheal tube placement are sparse. In adults and children, respectively, Werner et al [5] and Marciniak et al [6] showed that ultrasonography was 100% sensitive and 100% specific in determining the tracheal position of the tube during intubation.

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