

Use of ultrasound to confirm tracheal intubation and for supervising a trainee performing tracheal intubation in real time

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ABSTRACT

Introduction: Accidental oesophageal intubation is a significant cause of death or neurological injury during anaesthesia in the perioperative period, making it crucial to confirm the correct placement of the tracheal tube immediately. In the operating room, anaesthesiologists typically use indirect methods to verify tracheal tube positioning. Ultrasonography (USG) can be employed to confirm whether the endotracheal tube (ETT) is correctly placed in the trachea. This study evaluates the use of USG in supervising a trainee during intubation and also examines the time it takes for USG to identify the tube's entry into the trachea or oesophagus in real-time.

Materials and Methods: The study included 90 patients with ASA physical status 1 and 2 who were scheduled for elective surgeries under general anaesthesia. Preoperative data were collected on patient characteristics, airway measurements, and baseline haemodynamic parameters. Anaesthetic management was kept consistent across all participants. The 90 patients were divided into three groups of 30 each, with intubation performed by either an intern, resident, or faculty member, assigned through computer-generated randomisation. A high-frequency linear ultrasound probe (9-14MHz) was placed at the suprasternal notch and slightly moved to the left. In this view, at the level of the suprasternal notch, the oesophagus appears posterolateral to the trachea. During laryngoscopy, the Cormack-Lehane grade was recorded. The anaesthesiologist performing the ultrasound simultaneously measured the time taken to confirm endotracheal intubation. In cases of oesophageal intubation, the "double track" sign was used for identification, and the time required to make this identification was recorded. The times for confirming intubation into the trachea and oesophagus were documented for all three groups. SPSS Version 20.0 software was used for statistical analysis. The study employed mean, standard deviation, chi-square test, ANOVA, and Duncan Multiple Range Test (DMRT) for data analysis.

Results: The patient characteristics and demographic data showed no significant statistical differences. Oesophageal intubation was detected as quickly as 2 seconds, and the average time in seconds to confirm endotracheal tube placement was recorded for each group as follows: Faculty

< Resident < Intern (Mean time: 17.5 < 26.8 < 53.6 seconds). The ANOVA test indicated statistically significant differences in tracheal intubation times among the three groups. Further analysis with the Duncan Multiple Range Test (DMRT) confirmed that the timing differences between the groups were statistically significant.

Discussion: Ultrasound is a valuable tool in training scenarios where a physician supervises less experienced practitioners. It provides a fast and reliable method for confirming correct endotracheal intubation.

KEYWORDS:

Ultrasonography, Capnography, Tracheal Intubation Confirmation, Oesophageal Intubation

INTRODUCTION

Mastering airway management in both emergency and elective surgical cases involves a significant learning curve. Ultrasonography (USG) can be utilised in real-time to assess the proficiency of both trainees and trainers in securing the airway. Accidental oesophageal intubation is a leading cause of death and neurological injury, with oesophageal intubation identified as the cause in 69% of anaesthesia-related fatalities.¹ Therefore, it is crucial to confirm the correct placement of the tracheal tube immediately. Studies by Werner et al. and Marciniak et al. demonstrated that sonography has a 100% sensitivity and specificity rate in accurately identifying the endotracheal tube (ETT) in both adults and children.^{2,3} Ultrasound machines are relatively inexpensive, safe, portable, and widely accessible, making them an effective and rapid tool for confirming tracheal intubation.^{1,4,5} In the operating room, anaesthesiologists typically rely on indirect methods, known as criterion standards, to verify the correct placement of the tracheal tube. However, these methods require lung ventilation and are not entirely foolproof.¹

USG, being non-invasive, is becoming increasingly available to anaesthesiologists in the operating room, Intensive Care Unit (ICU), and emergency settings.¹ If ultrasound is as sensitive and specific as the waveform capnography, it can be used instead, even if waveform capnography is available.^{4,5} This study evaluates the use of USG in supervising a trainee during intubation and examines the time it takes for USG to

This article was accepted: 14 April 2025

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detect whether the tube has entered the trachea or oesophagus in real-time. This study explores the use of USG for supervising trainees during intubation procedures. Its aim is to confirm whether the intubation is successful in the trachea or if the tube has entered the oesophagus. In cases where oesophageal intubation occurs, the study measures the time taken for USG to detect this misplacement in real time. Additionally, it evaluates the duration required to confirm proper tracheal intubation using ultrasound. The goal is to assess the effectiveness and efficiency of USG in providing immediate feedback on tube placement, thereby enhancing training and safety in intubation practices.

MATERIALS AND METHODS

The study protocol received approval from the university's scientific review board. Following ethical committee approval and obtaining written informed consent from all participants, the study included American Society of Anaesthesiologist (ASA) physical status 1 to 2 patients aged 10 to 70 years scheduled for elective general anaesthesia. The study was conducted at Saveetha Medical College and Hospital, S.I.M.A.T.S, Thandalam, from 2016-2023. This prospective, single-centre, parallel-group study comprised 90 participants, divided into three groups of 30 each. Intubation was performed by either an intern, resident (under supervision), or faculty member, with assignments made through computer-generated randomisation. Demographic information such as age, sex, education, weight, height, body mass index (BMI), clinical diagnosis, and the planned surgical procedure were recorded.

Interns were medical students in their compulsory rotating internship or clerkship in the anaesthesia department. They received one hour of audiovisual training and three hours of hands-on practice in a simulation centre under the supervision of an anaesthesiologist. They performed laryngoscopy and intubation under controlled conditions in the operating room with a qualified anaesthesiologist present. Residents were postgraduate students with at least six months of experience in providing general anaesthesia. Faculty members were qualified anaesthesiologists with a minimum of one year of post-qualification experience.

Preoperatively, patient characteristics and airway measurements were documented. Anaesthesia management was standardised (Tables I and II). Before induction, patients were monitored with ECG, pulse-oximetry, non-invasive blood pressure (NIBP), temperature, and capnography. An ultrasound machine was positioned on the left side near the head of the patient. The settings for depth (5 cm), focus (3 cm), and gain were adjusted, and a linear high-frequency probe (9-14 MHz) was prepared. Ringer's lactate was administered at a rate of 75 cc per hour through an IV line, which was secured before the patient was transferred to the operating room. The patient's head and neck were positioned in a supine, neutral position. Premedication with intravenous Glycopyrrolate, Midazolam, and Fentanyl was administered according to body weight. Preoxygenation with 100% FiO₂ was done for five minutes, followed by induction with Intravenous (IV) Propofol (2.5 mg/kg) and verification of mask ventilation with visible chest rise and ETCO₂ tracing. After confirming adequate ventilation, patient was paralysed

with a non-depolarising muscle relaxant, IV Vecuronium at 0.1 mg/kg. The patient was ventilated with 100% FiO₂ for three minutes. Haemodynamic parameters, including systolic and diastolic blood pressure, mean arterial pressure, heart rate, and pulse-oximetry readings, were recorded at baseline and at intervals of 2, 5, 10, 15, 20, 25, and 30 minutes.

An anaesthesiologist experienced in ultrasonography placed the transverse linear probe at the level of the thyroid cartilage, with the probe's marker facing the right side. The thyroid cartilage appeared as an inverted V shape, within which the true and false vocal cords were visible. The probe was moved caudally to the suprasternal notch to identify the trachea, appearing as an inverted U shape with a hyperechoic A-M interface and reverberation artifact. The thyroid gland was visible as a homogeneously hyperechoic structure with a finely speckled appearance on the anterolateral aspect of the trachea. The probe was then shifted slightly to the left and tilted so that the marker faced the right nipple, allowing visualisation of other neck structures, including the oesophagus (posterior to the left thyroid globe), internal carotid artery, and vertebral body (posterior to the oesophagus). The oesophagus appeared posterolateral to the trachea in the transverse view at the suprasternal notch level and could be further identified by asking participants to swallow, which showed peristaltic movement of the oesophageal lumen (Figure 1).

The anaesthesiologist performing the ultrasound and the one carrying out laryngoscopy and intubation did not communicate visually or verbally. The time taken to confirm tracheal intubation or detect oesophageal intubation using ultrasound in real-time was recorded for all three groups. After intubation, the scheduled surgery proceeded, and post-surgery, patients were reversed, extubated, and transferred to the recovery room.

Ethical Statements

The study was approved by the ethical committee of Saveetha Institute of Medical and Technological Science (S.I.M.A.T.S) with number: 009/12/2021/IEC/SMCH.

RESULTS

The patient characteristics and demographic profile were found to be statistically similar. There were no significant haemodynamic changes of more than 20% from baseline values of the observed values until 30 minutes after initiating the intubation process. (Time 'Zero') of the study. The time taken to identify oesophageal intubation by "double Track" sign (Fig.2) in seconds (as early as 2 sec) and the average time taken in seconds to confirm ETT placement in all three groups were noted Faculty<Resident<Intern (Mean time in seconds-17.5<26.8<53.6) respectively (Table II).

Among the three groups, the time taken to confirm ETT placement into trachea was quicker in Faculty <Resident<Intern. (Mean time in seconds-17.5 < 26.8 <53.6).

The three groups' timings were different, and the difference was statistically highly significant. (p<0.001)- by ANNOVA method.

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Table I: American Society of Anaesthesiology (ASA), Mallampatti classification, Cormack Lehane grading, use of Backward Upward Rightward Pressure (BURP) and Bougie among three groups

		Group			Total	p-value
		Faculty	Resident	Intern		
American Society of Anaesthesiologist (ASA)	1	22	26	18	66	0.065
	2	8	4	12	24	
	Total	30	30	30	90	
Mallampatti classification	1	19	15	9	43	0.119
	2	11	14	20	45	
	3	0	1	1	2	
	Total	30	30	30	90	
Cormack Lehane grading	1	18	24	19	61	0.475
	2	10	5	10	25	
	3	2	1	1	4	
	Total	30	30	30	90	
Use of Backward Upward Rightward Pressure (BURP)	yes	2	2	5	9	>0.05
	no	28	28	25	81	
	total	30	30	30	90	
Use of Bougie	Yes	1	1	1	3	>0.05
	No	29	29	29	87	
	total	30	30	30	90	

Table II: Number and time taken (mean) for Oesophageal intubations and ultrasound (USG) confirmation among Faculty, Residents and Interns

	Faculty	Resident	Intern
A. In to Oesophagus			
Number	0	2	8
Time in seconds (mean)	None	29	10.9
B. USG confirmation of ETT into Trachea			
Number	30	30	30
Time in seconds (mean)	17.5	28.43	51.77

Table III ANNOVA Test and DMRT (DUNCAN)

Time to confirm Tracheal intubation in seconds	Group	N	Mean	Standard deviation (SD)	p-value
BY USG	Faculty	30	17.5	6.74 ^a	<0.001**
	Resident	30	28.43	19.25 ^b	
	Intern	30	51.77	26.15 ^c	
BYETCO2	Faculty	30	41.63	8.52 ^a	<0.001**
	Resident	30	52.23	22.11 ^b	
	Intern	30	80.73	25.11 ^c	

NOTE: Different alphabet among Groups denotes significance at the 5% level using Duncan Multiple Range Test (DMRT); **denotes significance at the 1% level.

DMRT-Duncan Multiple Range Test (DMRT) was carried out among three groups and found that the three groups' timing were different from each other. (Statistically Different)

DISCUSSION

Tracheal intubation is performed to secure and protect the airway during anaesthesia, but accidental oesophageal intubation remains a significant risk, often leading to death or neurological damage.¹ Traditional indirect methods for confirming correct tube placement, such as visualising the tube passing through the glottis, auscultation of lung and stomach areas, and measuring end-expired carbon dioxide (CO₂), are not completely reliable and require lung ventilation.^{7,8} This study involved 90 patients scheduled for

elective surgery, who were divided into three groups of 30 each. Intubation was performed by an intern, resident, or faculty member, with assignments determined by computer-generated randomisation.

An experienced anaesthesiologist used an ultrasound machine with preset depth, focus, and gain settings to monitor intubation. The presence of a "double track" sign indicated oesophageal intubation, with the time to detect this noted in seconds. The absence of this sign was used as an indirect confirmation of tracheal intubation, and the time taken to confirm endotracheal tube placement in the trachea using ultrasound was recorded. The study found that the skill and experience levels of the three groups significantly affected intubation times, with faculty members being the

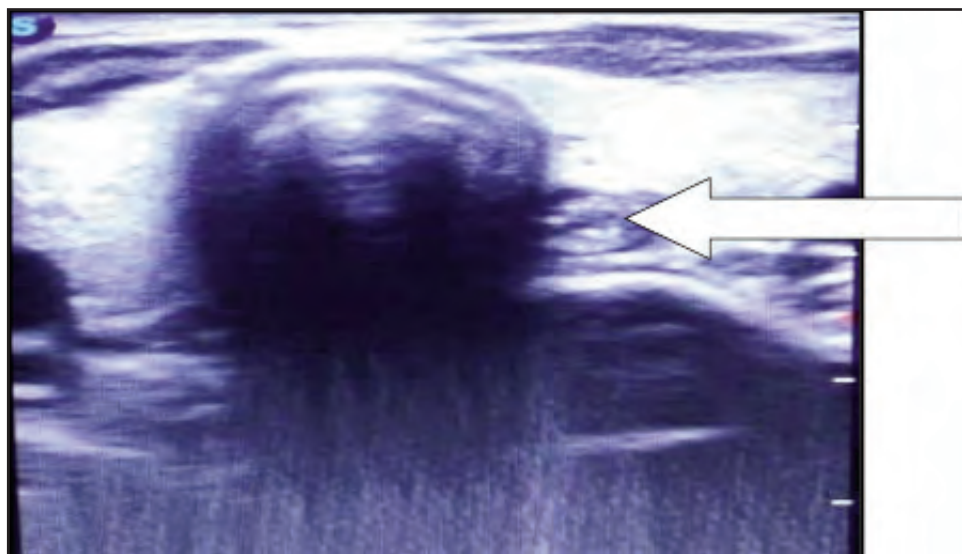


Fig. 1: Transverse probe on Suprasternal notch tilted slightly towards left side, oesophagus posterolateral to trachea as depicted by the arrow

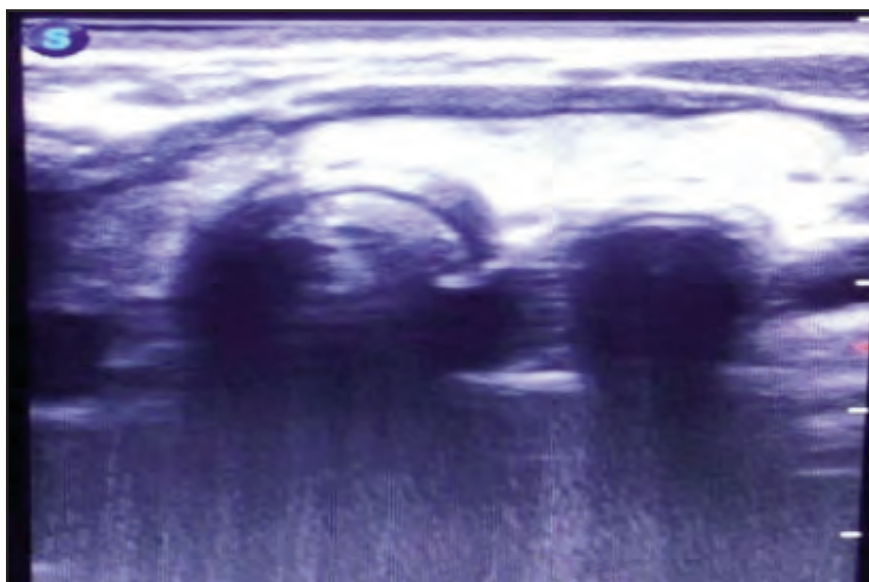


Fig. 2: Double track appearance indicating Oesophageal intubation

fastest, followed by residents and interns. The mean times for confirming tracheal intubation were 17.5 seconds for faculty, 26.8 seconds for residents, and 53.6 seconds for interns, with these differences being statistically significant.

End-tidal CO₂ detection is a highly reliable method for confirming tracheal intubation, with high specificity and positive predictive value.⁹ However, it has variable sensitivity and can be affected by factors such as low blood flow or contamination of the CO₂ detector.¹⁰⁻¹³ In contrast, ultrasound offers several advantages: it is portable, repeatable, cost-effective, and not affected by low pulmonary flow.¹⁴ Ultrasound can also detect oesophageal intubation before ventilation, reducing the risk of stomach complications. Ultrasonography can be used to position ETT above suprasternal notch. (Rule out right main bronchus). Fiber-

optic scope can be passed through ETT to identify tracheal rings.¹⁵

The study acknowledges that ultrasound is a dynamic technique dependent on the operator's experience, and while the learning curve is not well-defined, it can be mastered with proper training. The relatively low number of oesophageal intubations observed and the potential limitations in patients with neck tumours or trauma were noted. Nonetheless, ultrasound can be a valuable tool for confirming endotracheal tube placement, especially in training scenarios. It offers real-time visualisation that can assist both trainers and trainees in improving their skills and could become an essential tool alongside traditional methods in anaesthesia practice.

CONCLUSION

Ultrasound proves to be an effective tool for training and skill assessment during endotracheal intubation. It provides a rapid and reliable means of confirming proper tube placement, potentially becoming a crucial addition to the anaesthesiologist's toolkit. As its use becomes more widespread, portable ultrasound devices may soon complement traditional equipment like stethoscopes, enhancing safety and efficiency in perioperative and emergency settings. It can be used as a POCUS tool in ETT placement confirmation. Training situations, where a physician is supervising a less-experienced performer, direct dynamic ultrasound visualisation of the endotracheal tube passing through the trachea may be particularly helpful to both the trainer and trainee in evaluation of skill over a period of time in live patients in real time. This methodology can be utilized in a simulation lab for training. This method can be found useful in clinical scenarios with difficult airway and subset of patients who would not tolerate even brief period of hypoxia, like in syndromic child with difficult airway.

FINANCIAL DISCLOSURE

None

CONFLICT OF INTEREST

None

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