Section: Anaesthesia

Original Research Article

TO ASSESS THE EFFECTIVENESS OF POINT OF CARE ULTRASONOGRAPHY IN ACCURATELY DETERMINING THE PLACEMENT OF TRACHEAL TUBES DURING GENERAL ANAESTHESIA

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Abstract

Background: To assess the effectiveness of point of care ultrasonography in accurately determining the placement of tracheal tubes during general anaesthesia. **Materials and Methods:** The study was an observational investigation conducted within the department of Anesthesiology. A cohort of 100 patients was recruited, all of whom were scheduled to undergo elective surgery that necessitated the use of general anaesthesia and oro-tracheal intubation. In order to assess the reliability of ultrasound-guided intubation as a method for verifying endotracheal intubation, an evaluation is required. This study included patients who met the following criteria: ASA grade 1 and 2, MPS class I and II, aged between 20 and 65 years, of either gender, and scheduled for general anaesthesia with orotracheal intubation. **Result:** Ultrasonography exhibited sensitivity, specificity, and accuracy rates of 98%, 76%, and 98% respectively in the detection of accurate ETT placement. The table above provides information on the specificity, sensitivity, and accuracy of capnography in accurately detecting the correct placement of an ETT. The sensitivity, specificity, and accuracy of capnography in correctly identifying the placement of an ETT were all found to be 100%. The specificity, sensitivity, and accuracy of auscultation in correctly identifying the placement of an ETT. The auscultation method exhibited sensitivity, specificity, and accuracy rates of 74%, 43%, and 69% correspondingly in identifying the accurate positioning of the ETT. **Conclusion:** It is imperative to ascertain the placement of an ETT through the utilisation of auscultation, ultrasonography, or capnography, as relying solely on standard auscultatory confirmation may lead to a significant number of false diagnoses. The utilisation of bed-side ultrasonography is recommended as an essential component of theatre equipment whenever feasible due to its ease, accuracy, and efficiency in comparison to standard auscultation and capnography, which is considered the gold standard.

INTRODUCTION

The management of the airway is a crucial and indispensable aspect of the practise of emergency medicine.[1] This practise entails the utilisation of a complex skill that is frequently employed in less than ideal conditions, with the objective of guaranteeing sufficient ventilation and oxygenation in patients who are severely ill. In order to achieve optimal results, it is imperative that each step is executed with both efficiency and accuracy. Due to the aforementioned challenges, the process of emergency airway management can be considered a procedure with a high level of risk, potentially resulting in significant morbidity and mortality in cases involving difficult intubations.[2] The prevalence of complications and adverse events during the process of airway management is substantial, as evidenced by a reported rate of complications in emergency departments (ED) in the United States, where up to 12% of intubations have been found to result in such complications.[3] The utilisation of point-of-care ultrasound (POCUS) has experienced a surge in popularity in recent years, becoming a prevalent tool in emergency departments (EDs) for diagnostic purposes and as an aid in guiding various medical

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procedures.[4] Due to its inherent portability and notable diagnostic accuracy across a diverse range of applications, Point-of-Care Ultrasound (POCUS) is regarded by Emergency Medicine (EM) practitioners as an essential element in the process of resuscitation.[5] The utilisation of ultrasound has emerged as a promising method for the evaluation and treatment of airway conditions. This is primarily attributed to its widespread usage, ease of access, safety, and non-invasive characteristics. The utilisation of objective measurements of airway parameters and dynamic real-time images can aid physicians in accurately identifying pertinent anatomy and effectively guiding airway interventions.[6,7] The utilisation of qualitative colour capnography, a prevalent method for verifying the placement of the endotracheal tube, has been observed to yield inconclusive or unreliable results in a significant proportion of patients in emergency department settings. In addition, the utilisation of capnography requires the administration of ventilations to the individual, thereby heightening the potential for aspiration in the event that the tube is incorrectly positioned within the oesophagus. Given that no airway confirmation device has proven to be completely accurate in all patient scenarios, it is advisable for emergency physicians to utilise multiple confirmation techniques in order to reduce the risk of failing to detect an esophageal intubation.[8,9] Auscultation has conventionally served as the established technique for ascertaining the placement of the endotracheal tube, receiving endorsement from esteemed organisations like the American Heart Association and prominent literature in the field of Anesthesiology and Perioperative Care. Nevertheless, the accuracy of auscultation in differentiating between tracheal and bronchial intubation is limited, with a sensitivity ranging from 60% to 65%.[10,11] Point-of-care ultrasound (POCUS) is a medical imaging technique that involves the utilisation of real-time ultrasound scans conducted and analysed by the healthcare provider directly at the patient's bedside. The utilisation of handheld ultrasound devices has facilitated the widespread availability of a rapid and cost-effective technique in clinical settings where endotracheal intubation is conducted. Recent evidence has provided support for the utilisation of point-of-care ultrasound in the identification of esophageal versus tracheal intubations. This method has demonstrated a sensitivity and specificity of 100% in adult patients undergoing surgical procedures. In patients undergoing cardiopulmonary resuscitation, the reported sensitivity and specificity are 100% and 86% respectively.[12]

MATERIALS AND METHODS

The study was an observational investigation conducted within the department of Anesthesiology. A cohort of 100 patients was recruited, all of whom were scheduled to undergo elective surgery that necessitated the use of general anaesthesia and oro-tracheal intubation. In order to assess the reliability of ultrasound-guided intubation as a method for verifying endotracheal intubation, an evaluation is required. This study included patients who met the following criteria: ASA grade 1 and 2, MPS class I and II, aged between 20 and 65 years, of either gender, and scheduled for general anaesthesia with orotracheal intubation. The study excluded patients who exhibited predictors of difficult intubation, including Modified Mallampati class 3 and 4, thyromental distance less than 6.5 cm, negative upper lip bite test, restricted neck mobility, and a previous history of difficult intubation.

Methodology

Prior to the commencement of surgical procedures, patients underwent a comprehensive examination aimed at gathering demographic information and evaluating their clinical status in order to ascertain their eligibility based on predetermined inclusion and exclusion criteria. Prior to the surgical procedure, non-invasive assessments were conducted to obtain baseline hemodynamic measurements, encompassing systolic, diastolic, and mean arterial pressure. Furthermore, the measurement of arterial peripheral oxygen saturation was conducted utilizing pulse oximetry. All participants were administered a standardized anaesthetic protocol, consisting of premedication with Fentanyl (2 μg/kg) and Propofol (2 mg/kg) for the induction of anaesthesia, followed by Atracurium (0.5 mg/kg) to aid in tracheal intubation.

The upper airway ultrasonography was conducted using an M-Turbo Ultrasound system equipped with a 6-13 MHz linear ultrasound transducer. The transducer probe was positioned in a transverse orientation on the neck, specifically in an anterior and superior location relative to the suprasternal notch, prior to the intubation procedure. Following the process of intubation, the probe was employed to visually examine the tracheal tube from both longitudinal and transverse perspectives. Subsequently, the probe was repositioned towards the left in order to conduct an examination of the oesophagus, with the objective of ascertaining its state of emptiness or potential distension caused by the presence of the tube. The findings derived from ultrasonography were juxtaposed with the affirmative findings derived from quantitative conventional techniques, including waveform capnography and auscultation. The duration required for ultrasonography to verify tracheal intubation was also documented.

In the event that the endotracheal tube is observed to exhibit movement towards, contact with, or passage through the oesophagus, the observer promptly issues instructions to the resident to redirect the endotracheal tube towards the trachea. Following the process of intubation, a secondary individual verified the positioning of the ETT within the trachea through the utilisation of quantitative waveform

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capnography. This involved observing and recording the time at which the initial and sixth capnography waveforms became evident. A third party conducted chest auscultation at five specific sites to assess the presence of bilateral air entry, while also recording the corresponding time.

The confirmation of ETT placement was conducted in all patients through the utilisation of three distinct methods, namely ultrasonography, waveform capnography, and chest auscultation for the detection of air entry. The study recorded several parameters, including the time it took to confirm intubation using ultrasound, the time it took to confirm intubation based on the appearance of the first waveform on capnography, the time it took to confirm intubation based on the appearance of the sixth waveform on capnography, the time it took to confirm intubation by auscultating air entry on all five sites of the chest, the time it took to confirm intubation by auscultating air entry on both sides of the chest, the number of instances where the ETT made contact with the oesophagus or any other structure, and the occurrence of peripheral oxygen saturation (SpO2) desaturation below 95%.

Statistical Analysis

The data underwent analysis using IBM SPSS Statistics version 25.0. The reliability of ultrasonography as a method for confirming correct placement of the ETT was assessed through the utilisation of Pearson's correlation test and reliability analysis, specifically employing the calculation of the interclass correlation coefficient. This validation process involved comparing ultrasonography with capnography and chest auscultation. The confirmation of ultrasonography was compared to the confirmation of capnography, with emphasis on the visual analysis of the initial waveform.

RESULTS

The data from our study indicates that a significant proportion of the patients were male, accounting for 63% of the total sample. Based on the aforementioned analysis, it was determined that there was no statistically significant distinction observed between male and female patients in terms of age (p value = 0.26). The study included a sample of 100 patients ranging in age from 20 to 65 years. The findings of our study indicate that the age group with the highest representation was 25-35 years, accounting for 52% of the patients. This was followed by the age group of 35-45 years, which constituted 25% of the participants. The age group of 45-55 years accounted for 12% of the patients, while the age group below 25 years had the lowest representation at 3%. The mean age of the participants was calculated to be 37.29±4.85 years. The average values of anthropometric parameters among the participants of the study. The average height, weight, and body mass index (BMI) were recorded as 163.59±4.85 cm, 65.01±3.94 kg, and 24.51±2.58 kg/m2, respectively. The data indicates that a significant proportion of the study participants were classified as belonging to MMP Class II, comprising 66% of the total sample.

Table 1: Basic parameter of the patients

Gender	Number	Percentage	P value
Male	63	63	0.26
Female	37	37	
Age			0.19
Below 25	3	3	
25-35	52	52	
35-45	25	25	
45-55	12	12	
Above 55	8	8	
Anthropometric parameter			0.41
Height	163.59±4.85		
Weight	65.01±3.94		
BMI	24.51±2.58		
Modified Mallampati (MMP)			0.61
Class I	34	34	
Class II	66	66	

Table 2: Mean Duration in correct placement of ETT

Parameter	Mean
Ultrasound	15.19±2.81
Capnography	28.07±2.96
Chest Auscultation	44.61±2.89

The average duration for confirming endotracheal intubation using Ultrasonography was found to be 15.19±2.81 seconds. Confirmation of capnography using the appearance of the first waveform was observed with a mean time of 28.07±2.96 seconds. Additionally, confirmation through chest auscultation for air entry demonstrated a mean time of 44.61±2.89 seconds. The average discrepancy in duration required to verify the accurate positioning of an endotracheal tube (ETT). Upon conducting an analysis using an unpaired t-test, we observed a statistically significant difference between the methods of ultrasound and capnography, ultrasound and auscultation, and

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capnography and auscultation. This study examines the correlation between the mean time difference of ultrasonography, capnography, and auscultation using Pearson's correlation coefficient. The results of Pearson's correlation test revealed a robust positive correlation between ultrasonography, capnography, and chest auscultation.

Table 3: Correlation between Ultrasonography, Capnography & Auscultation

	Ultrasound	Crapnography	Auscultation
Ultrasound			
Pearson Correlation	1.24	0.69	0.34
P Value	0.04	0.04	0.001
Crapnography			
Pearson Correlation	0.26	1.24	0.22
P Value	0.04	0.05	0.03
Auscultation			
Pearson Correlation	0.33	0.37	1.18
P Value	0.001	0.03	0.04

Table 4: Ultrasonography, Capnography and Auscultation in detecting correct placement of the ETT

Ultrasonography	Percentage
Sensitivity	98
Specificity	76
Positive Predictive Value	99
Negative Predictive Value	76
Accuracy	98
Capnography	
Sensitivity	100
Specificity	100
Positive Predictive Value	100
Negative Predictive Value	100
Accuracy	100
Auscultation	
Sensitivity	74
Specificity	43
Positive Predictive Value	85
Negative Predictive Value	28
Accuracy	69

The table provided above presents the metrics of specificity, sensitivity, and accuracy pertaining to the utilization of ultrasonography for the purpose of identifying the accurate positioning of an endotracheal tube (ETT). Ultrasonography exhibited sensitivity, specificity, and accuracy rates of 98%, 76%, and 98% respectively in the detection of accurate endotracheal tube (ETT) placement. The table above provides information on the specificity, sensitivity, and accuracy of capnography in accurately detecting the correct placement of an endotracheal tube (ETT). The sensitivity, specificity, and accuracy of capnography in correctly identifying the placement of an endotracheal tube (ETT) were all found to be 100%. The table above provides information on the specificity, sensitivity, and accuracy of auscultation in correctly identifying the placement of an endotracheal tube (ETT). The auscultation method exhibited sensitivity, specificity, and accuracy rates of 74%, 43%, and 69% correspondingly in identifying the accurate positioning of the endotracheal tube (ETT).

DISCUSSION

Point-of-care ultrasound (POCUS) has garnered growing recognition as a valuable modality for confirming the successful placement of an endotracheal tube during intubation. One potential method is the transtracheal technique, which involves the placement of a transducer by a healthcare professional across the patient's neck after intubation. This allows for the visualization of the ETT within either the trachea or oesophagus. The creation of a motion artifact can be achieved by delicately rotating the ETT. According to a recent systematic review and meta-analysis, transtracheal ultrasound demonstrated a sensitivity of 99% and specificity of 97% in accurately confirming endotracheal tube (ETT) placement in adult patients.[13] A comparable study conducted on paediatric patients yielded results indicating that Point-of-Care Ultrasound (POCUS) demonstrated a sensitivity ranging from 92% to 100% and a specificity of 100%. Furthermore, research has indicated that the precision of measurements remains constant irrespective of the size of the endotracheal tube (ETT) or the type of transducer used. Moreover, it has been proposed that the learning curve for discerning the placement of

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ETT using transtracheal point-of-care ultrasound (POCUS) is relatively brief. Significantly, this modality presents a distinct advantage in that it does not necessitate positive pressure ventilation, thereby reducing the potential for additional exposure to healthcare personnel.[14] The research was carried out within the Department of Anaesthesiology. The individuals were assigned appointments for elective surgical procedures that necessitated the administration of general anaesthesia, along with the insertion of an oro-tracheal tube. The study included a sample size of 100 patients, ranging in age from 20 to 65 years. The data from our study indicates that a significant proportion of the patients were male, comprising 63% of the total sample. Based on the conducted analysis, it was determined that there was no statistically significant distinction observed between male and female patients in terms of age (p value = 0.26). The study included a sample of 100 patients, ranging in age from 20 to 65 years. The findings of our study indicate that the age group with the highest representation was 25-35 years, comprising 52% of the patient population. This was followed by the age group of 35-45 years, which accounted for 25% of the patients. The age group of 45-55 years constituted 12% of the patients, while the age group below 25 years was the least common, with only 3% representation. The mean age of the patients was calculated to be 37.29±4.85 years. A study conducted by Abhishek C et al.[15] revealed that the average age distribution was 38.87 ± 11.969 years. This study examines the mean levels of anthropometric parameters among the study subjects. The average height, weight, and body mass index (BMI) were recorded as 163.59±4.85 cm, 65.01±3.94 kg, and 24.51±2.58 kg/m2, respectively. The data indicates that a significant proportion of the study participants were classified as MMP Class II, comprising 66% of the total sample. The average duration for confirming endotracheal intubation using Ultrasonography was found to be 15.19±2.81 seconds. Confirmation of capnography using the appearance of the first waveform was observed with a mean time of 28.07±2.96 seconds. Additionally, confirmation through chest auscultation for air entry demonstrated a mean time of 44.61±2.89 seconds. The average discrepancy in duration required to verify the accurate positioning of an endotracheal tube (ETT). In a study conducted by Apala Roy Chowdhury et al.[16] it was observed that the average duration for confirming endotracheal placement using ultrasound was significantly shorter at 36.50 ± 15.14 seconds, compared to confirmation using unilateral chest auscultation (with an average duration of 50.29 ± 15.50 seconds; resulting in a time difference of 13.79 ± 4.12 seconds compared to ultrasound). Additionally, confirmation using bilateral chest auscultation for air entry took an average of 51.90 ± 15.18 seconds, resulting in a time difference of 15.41 ± 4.22 seconds. The esophageal intubation was identified by ultrasound in a cohort of five patients. The current study provides evidence that ultrasound verification of proper ET placement is significantly quicker than capnography, even when considering the initial waveform. Additionally, capnography depends on physiological variables such as ventilation, sufficient pulmonary perfusion, and gas exchange in order to provide confirmation. In situations characterised by compromised airflow such as bronchospasm, as well as insufficient blood flow to the lungs as seen in cardiac arrest or pulmonary embolism, capnography may exhibit limitations in accurately detecting the placement of an endotracheal tube.[17]

The current study observed a mean difference in the duration required to confirm the accurate placement of an ETT. Upon conducting an analysis using an unpaired t-test, it was observed that there existed a statistically significant difference between the use of ultrasound and capnography, ultrasound and auscultation, as well as capnography and auscultation. This study examines the Pearson's correlation coefficient to assess the relationship between the average time difference observed in ultrasonography, capnography, and auscultation. The results of Pearson's correlation test revealed a robust positive correlation between ultrasonography, capnography, and chest auscultation. A comparative analysis was conducted on a sample of 25 patients scheduled for elective surgery to examine the efficacy of lung ultrasound in confirming endotracheal intubation, as opposed to the traditional method of auscultation. The median duration required for verification through lung ultrasound was observed to be 40 seconds, as compared to 42 seconds for auscultation alone. This resulted in a mean difference of 0.88 seconds, indicating a slight advantage in favour of lung ultrasound.[18] The authors conducted a lung ultrasound and compared auscultation with the duration required for bilateral pleural sliding sign to be detected. The results did not reveal a substantial difference in the amount of time required. In the current study, the technique of auscultation was employed alongside real-time transcricoid ultrasonography to visualise the passage of the endotracheal tube. This approach resulted in a notable time delay. The duration of ultrasonography confirmation for endotracheal intubation was found to be 15.19±2.81 seconds. Confirmation of capnography using the appearance of the first waveform was observed with a mean time of 28.07±2.96 seconds. Additionally, confirmation through chest auscultation for air entry demonstrated a mean time of 44.61±2.89 seconds. In a blinded prospective randomised study conducted by Muslu et al., a cohort of seventy-five adult patients scheduled for elective surgery were included. During the study, the anaesthesiologists performed random intubations of the trachea or oesophagus using direct laryngoscopy. Subsequently, the sonographers were tasked with identifying the intubation location using ultrasound, with the transducer placed transversely on the neck above the suprasternal notch. A study was conducted in an urban teaching hospital in New

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York to assess the feasibility of using bedside upper airway ultrasonography as a means of confirming the placement of an endotracheal tube, in comparison to the use of continuous capnography. The study's findings indicated that bedside upper airway ultrasonography is indeed a viable method for verifying endotracheal tube placement.[19] In their study, Pfeifer et al. conducted a comparative analysis of the temporal correlation between ultrasound with chest auscultation and capnography in the assessment of ETT placement within an emergency medical context. The researchers discovered that ultrasound exhibits a higher rate of speed when compared to the conventional techniques of auscultation and capnography.[20] In their study, Adi et al conducted a comparative analysis to assess the viability of bedside upper airway USG as a means of confirming ETT placement following intubation, in comparison to capnography. The researchers observed a significant level of concordance between both modalities across a diverse patient population, encompassing individuals of different ages, ethnic backgrounds, and indications for intubation. Additionally, they emphasised the significance of USG in the process of ruling out esophageal intubation. The researchers demonstrated that upper airway USG provides real-time visualisation of the upper airway and accurately distinguishes between the trachea and oesophagus when assessing tube placement. This study elucidates the significance of comprehensive airway ultrasound (US) training for emergency physicians, highlighting its utility as a point-of-care modality for patients presenting in emergency settings.[21] Chun et al conducted an evaluation of a portable handheld ultrasound machine to assess its efficacy in accurately confirming the placement of an ETT. The researchers documented the bilateral recording of the interface between the visceral and parietal pleura of the chest wall, known as the chest wall visceral parietal pleural interface (VPPI), in patients throughout all stages of airway management. The researchers reached the conclusion that thoracic sonography could potentially serve as a valuable method for verifying the placement of an ETT, particularly in challenging circumstances like aerospace medical transport, where alternative techniques like capnography may be unavailable and auscultation may not be practical.[22] Brunel W et al. employed the modality known as TRUE in their study. A convex transducer was positioned above the suprasternal notch; however, the lower frequency of the convex transducer posed challenges in interpreting the superficial structures of the airway, such as the trachea and the interface between the air and mucosa.[11] The aforementioned observations were found to be consistent with those made by Ramsingh et al., wherein the patients under study were subjected to endotracheal intubation. The sensitivity of the lung sliding sign was found to be 93%, indicating its ability to accurately detect the presence of lung sliding. Similarly, the specificity of the sign was determined to be 96%, reflecting its ability to correctly identify the absence of lung sliding. The PLUS examination demonstrated enhanced efficacy in identifying both right and left bronchial intubation compared to the use of auscultation. The table provided above presents the metrics of specificity, sensitivity, and accuracy pertaining to the utilisation of ultrasonography for the purpose of detecting the accurate positioning of an ETT. Ultrasonography demonstrated a sensitivity of 98%, specificity of 76%, and accuracy of 98% in accurately identifying the correct positioning of an ETT. The table above provides information on the specificity, sensitivity, and accuracy of capnography in accurately detecting the correct placement of an ETT. Capnography demonstrated a sensitivity, specificity, and accuracy of 100% each in accurately identifying the appropriate positioning of an endotracheal tube (ETT). The table provided above presents the metrics of specificity, sensitivity, and accuracy pertaining to the utilisation of auscultation for the purpose of identifying the accurate positioning of an ETT. The auscultation method exhibited sensitivity, specificity, and accuracy rates of 74%, 43%, and 69% correspondingly in identifying the accurate positioning of the endotracheal tube (ETT). The findings of other studies yielded similar results.[23]

CONCLUSION

It is imperative to ascertain the placement of an ETT through the utilisation of auscultation, ultrasonography, or capnography, as relying solely on standard auscultatory confirmation may lead to a significant number of false diagnoses. The utilisation of bed-side ultrasonography is recommended as an essential component of theatre equipment whenever feasible due to its ease, accuracy, and efficiency in comparison to standard auscultation and capnography, which is considered the gold standard.

REFERENCES

1. Lin J, Bellinger R, Shedd A, Wolfshohl J, Walker J, Healy J, Taylor J, Chao K, Yen YH, Tzeng CT, Chou EH. Point-of-Care Ultrasound in Airway Evaluation and Management: A Comprehensive Review. Diagnostics (Basel). 2023 Apr 25;13(9):1541.
2. Ahn JH, Park JH, Kim MS, Kang HC, Kim IS. Point of care airway ultrasound to select tracheal tube and determine insertion depth in cleft repair surgery. Sci Rep. 2021 Feb 26;11(1):4743.
3. Brown C.A., 3rd, Bair A.E., Pallin D.J., Walls R.M., Near III Investigators Techniques, success, and adverse events of emergency department adult intubations. Ann. Emerg. Med. 2015;65:363–370.e1.
4. Diaz-Gomez J.L., Mayo P.H., Koenig S.J. Point-of-Care Ultrasonography. N. Engl. J. Med. 2021;385:1593–1602.
5. Ultrasound Guidelines: Emergency, Point-of-Care and Clinical Ultrasound Guidelines in Medicine. Ann. Emerg. Med. 2017;69:e27–e54.
6. Gottlieb M., Holladay D., Burns K.M., Nakitende D., Bailitz J. Ultrasound for airway management: An evidence-based review for the emergency clinician. Am. J. Emerg. Med. 2020;38:1007–1013.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

7. Gomes S.H., Simoes A.M., Nunes A.M., Pereira M.V., Teoh W.H., Costa P.S., Kristensen M.S., Teixeira P.M., Pego J.M. Useful Ultrasonographic Parameters to Predict Difficult Laryngoscopy and Difficult Tracheal Intubation-A Systematic Review and Meta-Analysis. Front. Med. 2021;8:671658.
8. Li J Capnography alone is imperfect for endotracheal tube placement confirmation during
9. emergency intubation. J Emerg Med 2001; 20(3):223–229.
10. Guidelines for cardiopulmonary resuscitation and emergency cardiac care. Emergency Cardiac Care Committee and Subcommittees, American Heart Association. Part I. Introduction. JAMA 1992; 268:2171–83
11. Stone D, Gal T: Anesthesia, Airway Management, 5th edition. Edited by Miller RD. Philadelphia, Churchill Livingstone, 2000
12. Brunel W, Coleman DL, Schwartz DE, Peper E, Cohen NH: Assessment of routine chest roentgenograms and the physical examination to confirm endotracheal tube position. Chest 1989; 96:1043–5
13. Sitzwohl C, Langheinrich A, Schober A, Krafft P, Sessler DI, Herkner H, Gonano C, Weinstabl C, Kettner SC: Endobronchial intubation detected by insertion depth of endotracheal tube, bilateral auscultation, or observation of chest movements: Randomised trial. BMJ 2010; 341:c5943
14. Gottlieb M, Holladay D, Peksa GD. Ultrasonography for the confirmation of endotracheal tube intubation: a systematic review and meta-analysis. Ann Emerg Med. 2018;72(6):627-36.
15. Gottlieb M, Holladay D, Nakitende D, et al. Variation in the accuracy of ultrasound for the detection of intubation by endotracheal tube size. Am J Emerg Med. 2019;37(4):706-9
16. Abhishek C, Munta K, Rao S M, Chandrasekhar C N. End-tidal capnography and upper airway ultrasonography in the rapid confirmation of endotracheal tube placement in patients requiring intubation for general anaesthesia. Indian J Anaesth 2017;61:486-9.
17. Apala Roy Chowdhury, Jyotsna Punj, R. Pandey, V. Darlong, Renu Sinha, and D. Bhoi, "Ultrasound is a reliable and faster tool for confirmation of endotracheal intubation compared to chest auscultation and capnography when performed by novice anaesthesia residents - A prospective controlled clinical trial"Saudi J Anaesth. 2020; Jan-Mar; 14(1): 15–21.
18. Takeda T, Tanigawa K, Tanaka H, Hayashi Y, Goto E, Tanaka K. The assessment of three methods to verify tracheal tube placement in the emergency setting. Resuscitation. 2003;56:153–7.
19. Pfeiffer P, Rudolph S, Børglum J, Isbye D. Temporal comparison of ultrasound vs. auscultation and capnography in verification of endotracheal tube placement. ActaAnaesthesiol Scand. 2011;55:1190–5.
20. Milling TJ, Jones M, Khan T, Tad-y D, Melniker LA, Bove J, et al. Transtracheal 2-D ultrasound for identification of esophageal intubation. J Emerg Med. 2007;32:409–14.
21. Kaplan MB, Ward DS, Berci G. A new video laryngoscope-an aid to intubation and teaching. J ClinAnesth. 2002;14:620–6.
22. Adi O, Chuan TW, Rishya M. A feasibility study on bedside upper airway ultrasonography compared to waveform capnography for verifying endotracheal tube location after intubation. Crit Ultrasound J. 2013;5:7.
23. Chun R, Kirkpatrick AW, Sirois M, Sargasyn AE, Melton S, Hamilton DR, Dulchavsky S. Where's the tube? Evaluation of hand-held ultrasound in confirming endotracheal tube placement. Prehosp Disaster Med 2004;19:366–9.
24. Ramsingh D, Frank E, Haughton R, Schilling J, Grimenez K, Banh E, et al. Auscultation versus point of care ultrasound to determine tracheal versus bronchial intubation: A diagnostic accuracy study. Anesthesiology 2016;124:1012-20.

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