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Role of Point of Care Ultrasound in Confirmation of Endotracheal Tube Placement in Children

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Background: In the emergency department (ED), During airway management, tracheal intubation (TI) is a routine procedure in neonatal and pediatric critical care units, as well as the delivery room. The location of the endotracheal tube (ETT) should be confirmed as soon as possible since tube malposition is linked to severe complications such as aspiration, air leak syndromes, and oesophageal intubation. In perioperative, emergency, and critical care settings, ultrasound (US) gives point-of-care dynamic images of the airway.
Objective: The goal of this study is to evaluate the results of utilizing Trans-tracheal POCUS to confirm ETT implantation with other confirmatory procedures including colorimetric capnography and direct viewing.
Methods: The study was done at Al-Azhar & Tanta University Emergency Hospital and was a prospective observational study. To locate the tube, we employed tracheal sonography and an

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ETCO2 analyzer for capnography. We evaluated the amount of time required and the accuracy of the findings.
Results: There were a total of 40 children that required emergency endotracheal intubation. Endotracheal ETT was found in 37 (92.5%) of the patients, while esophageal ETT was seen in three (7.5%) patients. The capnography was the standard for detecting the ETT placement correctly. In 97 percent of patients, ultrasound was able to identify all esophageal intubation and confirm the insertion of an endotracheal tube (ETT) with a sensitivity of 100 percent and a specificity of 97.5 percent. The clinical assessment had misunderstood 16.2 percent of tracheal intubations and 2 out of 3 esophageal intubations.
Conclusion: POCUS is considered an accurate method in endotracheal tube insertion confirmation, resulting in safe, fast, and reliable airway management approaches.

Keywords: Endotracheal intubation; children; point of care; ultrasound.

1. INTRODUCTION

Accurate assessment and confirmation of the endotracheal tube (ETT) location or depth is important to avoid problems and morbidities associated with incorrect insertion [1]. Tube malposition is linked to several severe outcomes such as hypoxemia, right upper lobe collapse, atelectasis, air leak syndromes, and esophageal intubation, therefore it's important to confirm the position of the endotracheal tube ETT as soon as possible [2]. Esophageal intubation was found to occur 6 percent of the time in emergencies and 1.75 percent of the time in elective situations. Esophageal intubation is one of the most common causes of accidents that result in brain injury or death [3]. Several studies have examined the strategies for determining whether the ET tube should be placed endotracheally or in the esophagus [4]. Capnography, the auscultatory technique, visual confirmation during laryngoscopy, chest wall expansion during ventilation, and chest X-rays are all modalities that are now employed in practice [4]. Although the accuracy of these techniques varies, capnography is the most accurate approach for confirming endotracheal tube insertion in the prehospital scenario [5]. Nevertheless, there are situations in which these methods may be inaccessible, impractical, or even fail or mislead the provider, such as capnography, which, despite its high sensitivity and specificity, can produce false-negative results in serious airway obstructions, low cardiac output, serious hypotension, and pulmonary emboli, and is also freely available in operating rooms but not in many Ed [6]. Ultrasound, on the other hand, is becoming more used in most EDs as a point-of-care imaging tool for trauma and guided treatments. Ultrasound machines are portable, non-invasive, and the pictures are easily repeatable [7]. Ultrasound is a convenient, fast, portable, typically acceptable, pain-free, and secure technique for confirming ETT regardless of the patient's physiology. Ultrasound may partially or totally see all upper airway segments. It can also quickly and efficiently observe the movements of the diaphragm and pleura, which are indirect indications of lung expansion [7]. Recent systematic reviews have revealed the benefits of point-of-care ultrasound pocus in confirming proper ETT location and avoiding esophageal intubation, however, there is a paucity of data concerning the gold-standard technique for confirming ETT position [5].

1.1 Aim of the Work

The purpose of this study is to evaluate the results of utilizing Trans-tracheal POCUS to confirm ETT placement with other confirmatory procedures including colorimetric capnography and direct viewing.

2. PATIENTS AND METHODS

This was prospective observational research that took place at Al-Azhar University Emergency Hospital and Tanta University Emergency Hospital. This research was run from December 2019 until December 2020. Over the course of a year, forty children require urgent endotracheal intubation. Patients under the age of 18 and those who had endotracheal intubation in the emergency room were both eligible. Patients with severe neck or lung disease were excluded from the study. This project was launched.

Capnography was conducted using an ETCO2 analyzer and tracheal sonography. As follows, the sonographer determines whether the tube should be placed in the trachea or the esophagus. During intubation, the linear probe was positioned transversely over the trachea between the suprasternal notch and the cricothyroid membrane, and snowstorm sign (disturbance of the tracheal air-mucosa interface "A-M" with comet tail artifacts) was recorded Fig 1.

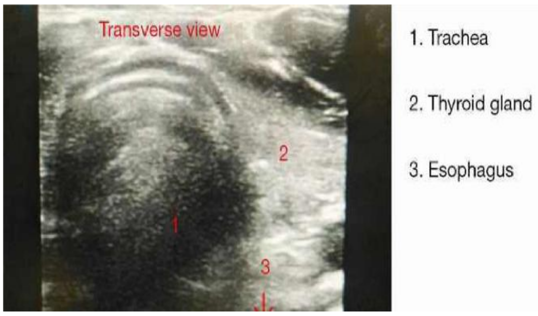

Fig. 1. Transverse view of trachea (snowstorm sign)

On ultrasonography, attempts were made to detect esophageal opening, and esophageal intubation was detected by the presence of a double-track sign and the lack of a snowstorm sign.

The tube was fixed after endotracheal intubation was verified using waveform capnography. Following tube fixation, sagittal plane ultrasonography of the trachea was done to detect the cricoid cartilage and tracheal rings. The 12 ETT cuff was deflated fully and then re-inflated with 10cc normal saline. The ETT cuff was discovered to be an anechoic shadow in the trachea. The cuff's upper end was fastened at the 3rd or 4th tracheal ring. After the tube was in place, the saline from the ETT cuff was suctioned out and the cuff was re-inflated with air.

On a chest X-ray AP view with the neck in a neutral posture and the bed in a semi-recumbent position, the final location of the tube tip was confirmed. On x-ray, the ETT tip had to be between the sternoclavicular joint superiorly and 4 cm above the carina inferiorly to determine the tube's appropriateness. By using a digital caliper, the distance between the ETT tip and the carina on an X-ray chest AP view was measured. If the ETT location was discovered to be incorrect, the ETT was adjusted and the discovery was recorded for further investigation. Any issues that arose during the intubation were also documented. Heart rate, blood pressure, and oxygen saturation were all constantly measured during the research.

The arterial blood gases were examined before and after the previous test. The research was called off if any of the participants' respiratory or hemodynamic conditions worsened. In the supine posture, auscultation was done over both lungs in the infra-clavicular fossa and the fifth intercostal space in the midaxillary line, as well as over the epigastrium.

2.1 Statistical Analysis

Data were coded, gathered, and put into the Statistical Package for Social Science (IBM SPSS) version 20 for statistical analysis.

The qualitative data are given as numbers and percentages, while the quantitative data are presented as mean, standard deviations, and ranges, with a parametric distribution and median.

The chi-square test for categorical variables and the students' test for continuous variables are used to compare various approaches. A P value of less than 0.05 on both sides is deemed statistically significant.

3. RESULTS

The research included a total of 40 children's patients. The study population varied in age from 3 to 16 years old (Mean SD = 9.82 3.60 years), with 23 of them (57.5%) being males. The primary reason for intubation was to preserve the airway. All of the research participants' blood pressure, oxygen saturation, and heart rate were constant. Arterial blood gas tests before and after the research revealed no significant differences. In none of the cases was the research forced to be stopped early due to difficulties. Table 1 lists the baseline characteristics of all of the patients who were included in the study.

As indicated in Fig. 2, ETT was endotracheal in 37 (92.5%) patients, whereas it was esophageal in three (7.5%) individuals. Capnography was the standard method for recognizing all of both tracheal and esophageal intubations accurately. All 7.5 percent of esophageal intubations were accurately identified by tracheal ultrasonography, but one tracheal intubation was mistaken as esophageal. Clinical evaluation incorrectly interpreted 16.2% of tracheal intubations and 2 out of 3 esophageal intubations.

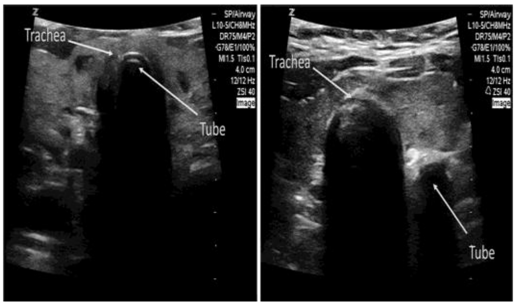

Fig. 2. Ultrasound images of endotracheal and esophageal intubations. On the (left) image, a normal endotracheal intubation is shown with the echogenic semicircular tube visible within the lumen of the trachea. On the (right) one, an esophageal intubation can be identified by the presence of a 'double tract sign' with a second semi-circular acoustic shadow appearing outside of the trachea

Capnography had Sensitivity 100%, Specificity 100%, Positive Predictive value (PPV) 100%, Negative Predictive value (NPV) 100%. US had Sensitivity 100%, Specificity 97.5%, Positive Predictive value (PPV) 97.2%, Negative Predictive value (NPV) 100%. clinical assessment had Sensitivity 93.9%, Specificity 14.5%, Positive Predictive value (PPV) 83.7%, Negative Predictive value (NPV) 33.4%. The comparison presented in Table 2.

The time needed by the US to detect the ETT placement ranged from 5 to 12 sec with (mean $\pm$ SD) = (8.42 ± 2.28) sec. The time needed by the capnography to detect the ETT placement ranged from 13 to 28 sec with (mean $\pm$ SD) = (18.97 ± 4.25) sec The time needed by the clinical methods to detect the ETT placement ranged from 10 to 30 sec with (mean $\pm$ SD) = (20.02 ± 5.13) sec.

Table 1. Baseline characteristic of study group

Characteristics	**N = (40)**
Age	
Mean + SD	(9.82 ± 3.60)
Range	(3 – 16)
Sex	
Male	23 (57.5%)
Female	17 (42.5%)
Indication of Intubation	
Respiratory failure	23 (57.5%)
Airway protection	9 (22.5%)
Dynamic instability	8 (20%)
Monitoring Data	
Heart Rate (beat/min)	(104 ± 17.69)
Blood pressure (mmhg)	
- Systolic BB	(105.12 ±12.53)
- Diastolic BB	(68.37± 9.36)
O2 saturation (%)	**(93.27 ± 2.39)**

Table 2. Comparison of ETT placement confirmation tools

Outcomes of tracheal US	**Result**
Sensitivity	100%
Specificity	97.5%
Positive Predictive value	97.2%
Negative Predictive value	100%
Outcomes of capnography	**Result**
Sensitivity	100%
Specificity	100%
Positive Predictive value	100%
Negative Predictive value	100%
Outcomes of clinical assessment	**Result**
Sensitivity	93.9%
Specificity	14.5%
Positive Predictive value	83.7%
Negative Predictive value	33.4%

Table 3. Comparison of time needed to confirm ETT placement

Time taken (in seconds)	Min-Max	Mean ± SD	
Time taken by US (T1)	5 – 12	8.42 ± 2.28	
Time taken by Capnography (T2)	13 – 28	18.97 ± 4.25	
Time taken by Clinical methods (T3)	10 – 30	20.02 ± 5.13	
Comparison	**Differences**	***t*-statistics**	**P value**
T1 – T2	10.55	13.83	$p > 0.0001$*
T1 – T3	11,60	13.6	$p > 0.0001$*
T2 – T3	1.05	0.99	$p > 0.321$

P value is significant P>0.05

4. DISCUSSION

Although numerous procedures have been developed, no single approach is regarded to be 100 percent accurate in distinguishing between tracheal and esophageal intubations [4]. Ultrasonography is one of the many ways for identifying ETT implantation. In addition, the lung sliding sign-on thoracic ultrasonography can detect lung movement and may aid in the detection of endobronchial intubation [8]. Quantitative waveform capnography is not commonly used in emergency departments. As a result, it's preferable to discover another validation method that uses readily available technology. Ultrasound has recently been utilized in the ED to confirm ETT implantation. Ultrasound is appealing for confirming ETT implantation because of its mobility and reproducibility, as well as its sensitivity and specificity [4]. Our research employed tracheal sonography, which is the most often used ultrasound modality for the same [6,9,10]. Transtracheal ultrasonography has a sensitivity of 95.7 percent to 100 percent and a specificity of 96.3 percent to 100 percent in identifying ETT insertion, according to Sun et al [10]. Other studies use various sonographic characteristics to distinguish between tracheal and esophageal intubations, however, a closer look at the ultrasound pictures reveals that almost identical aspects are characterized differently [5,9]. Lately, research has been lacking indirect comparisons of the precision of various sonographic characteristics [11]. When compared to other trials, ours had a 12.5 percent rate of esophageal intubations. Ultrasonography recognized every esophageal intubation with 97% sensitivity and 100% specificity, compared to capnography, which detects 80% with a sensitivity of 83 percent, and clinical techniques, which detect 60% with a sensitivity of 80%. Using tracheal ultrasonography, several studies were able to detect 10% or more esophageal intubations with excellent sensitivity and specificity. Three of these investigations were carried out in the emergency department by emergency medicine residents, while one was carried out in the operating room by anesthesiologists [9,**1**2,**1**3]. Esophageal intubation was found with a lower sensitivity (91.7%) and specificity (91.7%) in one research that employed diaphragmatic movement to confirm tube insertion (95.6%) [12]. One research had a 100 percent sensitivity and specificity. The high sensitivity and specificity were most likely attributable to the fact that the operators were competent EM doctors and the investigation was carried out in a controlled laboratory setting, or due to the sample size [14]. The fact that the operators in the other two studies had lower sensitivity and specificity could be because they were residents with less than a year of experience, indicating operator dependence. The time required to confirm ETT intubation is an important consideration for any method used Trans-tracheal ultrasonography can be used to confirm intubation while it's being done or after it's finished. In our investigation, the average time for tracheal ultrasonography was 8.42 seconds, compared to 18.97 seconds for capnography and 20.02 seconds for clinical techniques. During intubation, real-time sonographic imaging exhibited a greater sensitivity for detecting esophageal intubation than post-intubation scanning [6,9,**1**0].

The patient's lungs would have to be evacuated 5 times using capnography for confirmation [6]. As a result, transtracheal ultrasonography can detect ETT intubation more quickly t han capnography. Transtracheal ultra-sonography takes anywhere between 5 and 45 minutes, according to several studies [11,15].

The median confirmation time with ultrasonography was substantially shorter than the median confirmation time with capnography, according to two investigations [4].

5. CONCLUSION

Ultrasound offers many benefits for airway imaging: it is safe, portable, and readily available, and it produces static and dynamic pictures that are useful for a variety of clinical reasons in airway management.

6. RECOMMENDATION

There is a need to include upper airway US education and training of workers responsible for perioperative airway management, given the expanding body of data in various clinical applications. POCUS of the airway should also be utilized as a non-invasive first-line airway evaluation.

CONSENT

As per international standard or university standard, patients' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

The study protocol has been approved by the local Research Ethical Committee of Tanta faculty of medicine, Quality Assurance Unit, Faculty of Medicine (code no 33504/11/19).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. IBARRA-SARLAT, Maribel, et al. Endotracheal Intubation in Children: Practice Recommendations, Insights, and Future Directions. Bedside Procedures. 2018:51.
2. SHARMA, Deepak; TABATABAII, Seyyed Ahmad; FARAHBAKHSH, Nazanin. Role of ultrasound in confirmation of endotracheal tube in neonates: a review. The Journal of Maternal-Fetal & Neonatal Medicine. 2019;32.8: 1359-1367.
3. ABHISHEK, Chintamani, et al. End-tidal capnography and upper airway ultrasonography in the rapid confirmation of endotracheal tube placement in patients requiring intubation for general anaesthesia. Indian Journal of Anaesthesia. 2017;61.6:486.
4. THOMAS, Vimal Koshy, et al. Reliability of ultrasonography in confirming endotracheal tube placement in an emergency setting. Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine. 2017;21.5: 257.
5. ELBAHNASAWY, Mohamed, et al. The Accuracy of Barcode Sign in Diagnosis of Pneumothorax Associated with Acute Respiratory Failure in Emergency Department. Int. J. Curr. Microbiol. App. Sci. 2019;8.6:989-994.
6. DAS, Saurabh Kumar, et al. Transtracheal ultrasound for verification of endotracheal tube placement: a systematic review and meta-analysis. Canadian Journal of Anesthesia/Journal Canadien d'anesthésie. 2015;62.4:413-423.
7. ZAKY, Samy, et al. Utility of Lung Ultrasound in Decision making to prioritize hospital admission for COVID-19 patients: A Developing Country Perspective. Current Medical Imaging, 2021.
8. LINK, Mark S., et al. Part 7: adult advanced cardiovascular life support: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2015;132(18_suppl_2): S444-S464.
9. CHOU, Hao-Chang, et al. Real-time tracheal ultrasonography for confirmation of endotracheal tube placement during cardiopulmonary resuscitation. Resuscitation. 2013;84.12:1708-1712.
10. SUN, Jen-Tang, et al. Ultrasonography for proper endotracheal tube placement confirmation in out-of-hospital cardiac arrest patients: two-center experience. Journal of Medical Ultrasound. 2014;22.2:83-87.
11. ADI, Osman; CHUAN, Tan Wan; RISHYA, Manikam. A feasibility study on bedside upper airway ultrasonography compared to waveform capnography for verifying endotracheal tube location after intubation. Critical Ultrasound Journal. 2013;5.1:1-11.
12. HOSSEINI, Javad Seyed, et al. Secondary confirmation of endotracheal tube position by diaphragm motion in right subcostal ultrasound view. International Journal of Critical Illness and Injury Science. 2013;3.2:113.

13. SAĞLAM, Caner; ÜNLÜER, Erden Erol; KARAGÖZ, Arif. Confirmation of endotracheal tube position during resuscitation by bedside ultrasonography. The American Journal of Emergency Medicine. 2013;31(1):248-250.
14. WERNER, Sandra L., et al. Pilot study to evaluate the accuracy of ultrasonography in confirming endotracheal tube placement. Annals of Emergency Medicine. 2007;49(1):75-80.
15. SAĞLAM, Caner; ÜNLÜER, Erden Erol; KARAGÖZ, Arif. Confirmation of endotracheal tube position during resuscitation by bedside ultrasonography. The American Journal of Emergency Medicine. 2013;31(1): 248-250.

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