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The Application of Point-of-Care Ultrasound in ED Intubations and Airway Access: A Systematic Review

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Abstract:

Intubation is an essential procedure performed on a routine basis in the emergency room. Unsuccessful intubations are associated with deleterious outcomes. A systematic review was performed to investigate the accuracy of point of care ultrasound (POCUS) in successful Endotracheal Tube (ET) tube confirmation, utilizing ultrasonography, identification of the cricothyroid membrane utilizing ultrasound, and dynamically during use of ultrasonography in the process of intubation. This review demonstrated high sensitivity and specificity for ultrasound confirmation of ET tube placement, high success rate in ultrasound-guided intubation, and lower than expected accuracy in identifying the cricothyroid membrane. Ultrasonography should be considered for ET tube confirmation in patients in cardiac arrest and future applications of ultrasound may include dynamically during the process of intubation. intubation in real-time.

Introduction:

Securing an airway is a critical procedure completed performed routinely in the Emergency Department (ED). Failing to obtain an airway carries severely adverse consequences which can resulting in significant morbidity and death. Traditional methods of confirming endotracheal tube placement include auscultation for bilateral breath sounds as well as ascertaining for tube condensation. However, these findings have been found to be unreliable.1 Many consider end-tidal waveform capnography to be the gold standard to confirm ET tube placement, however in a patient in cardiac arrest, the sensitivity of this method deceases significantly.2 A procedure that is not routinely performed but can be critical to establishing an airway is cricothyroidotomy. Success of a cricothyrotomy is dependent on accurate identification of the cricothyroid membrane. Identifying the cricothyroid membrane by inspection and palpation is significantly low, especially in patients that are obese. 3,4 In the review, we will discuss the accuracy of ET tube confirmation utilizing ultrasonography, identification of the cricothyroid membrane utilizing ultrasound, and use of ultrasonography in the process of intubation.

Materials and Methods:

This review is structured in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines for systematic reviews (P.R.I.S.M.A) guidelines.[5] A search was conducted of PubMed from inception to March 8, 2021. Bibliographies of selected studies were reviewed to ascertain for further relevant articles of interest. Inclusion criteria consisted of all case-studies, prospective trials, randomized controlled trials, and meta-analysis assessing ultrasound applications during intubation, confirmation of tube placement following intubation as well as identification of cricothyroid membrane. All included studies must have provided data regarding success or failure of ultrasound applications discussed above. Any not pertinent to the subject matter were excluded as well as duplicates.

Results:

A total of 193 studies were found. PubMed yielded 162 studies with other sources providing an additional 31 studies. After removal of duplicates, 157 studies were screened. Twenty studies were selected. Five studies were case reports. Three studies were meta-analysis. Ten studies were randomized controlled trials and two were review articles. This systematic review included 3,483 participants.
Two thousand nine hundred eighty-eight participants involved confirmation of endotracheal tube following intubation, 246 participants were involved identification of the cricothyroid membrane, and 269 participants were involved in ultrasound application in real-time intubation.
The overall sensitivity to confirm ET tube placement utilizing ultrasonography was 96.4% (95% CI 96.3975 ± 3.544). Specificity was 98.0% (95% CI 98.025 ± 1.364). Limitations were techniques utilized to confirm tube placement as well as sonographer training prior to studies. Accuracy of identification of cricothyroid membrane was 85.5% (95% CI 85.5 ± 8.82). Limitations was the variability in defining "accuracy", ultrasound method utilized, and study populations. Study subjects who are morbidly obese will cause significant differences between accuracy of ultrasound and external palpation.[6] The overall success rate of ultrasound-guided intubation was 98% (95% CI 98 ± 1.96). Limitations was the variability is the study populations, methods of utilizing ultrasound throughout the intubation, limited sample size, and contexts in which studies were performed.

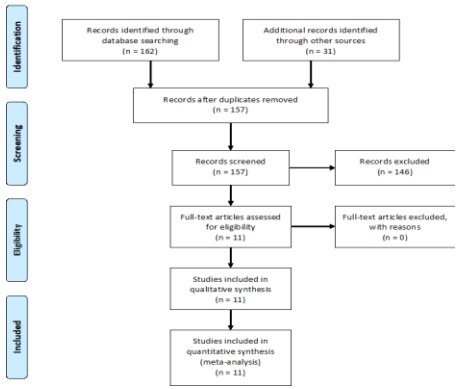

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-analysis Diagram

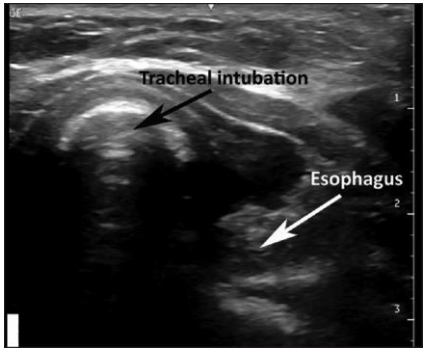

Figure 2: Confirming Tracheal Intubation

Discussion:

This systematic review demonstrates that ultrasonography is very accurate in confirming intubation Figure 2, 7. This correlates with previous studies demonstrating high efficacy in this respect.[7] Given capnography has been shown to be inaccurate in patients in cardiac arrest or massive pulmonary embolism and tube condensation has been shown to be a poor predictor of correct tube placement, ultrasound can be a useful modality to confirm endotracheal tube placement.[1,8]
The traditional method of ascertaining bronchial placement of endotracheal tube has been auscultation of bilateral lungs sounds. However, recent studies have demonstrated auscultation of bilateral breath sounds is not specific for correct tube placement.[9] Ultrasound may also be a useful means to help demonstrate ventilation of both lungs. If ET tube is in correct position, bilateral equal motion of the diaphragm toward abdomen can be observed as well as bilateral lung sliding sign at the chest wall surface. If endobronchial placement is present, absence or restricted movement of the diaphragm as well as absence of lung sliding sign would be present on the non-ventilated side.[10]
Ultrasound may also be used to perform intubation in real-time and a high rate of success with this method has been demonstrated. Marcinitak et al. demonstrated characteristic real-time ultrasound findings throughout intubation.[11] These included identification of trachea and tracheal rings, visualization of vocal cords, widening of glottis as tracheal tube passes through, tracheal tube positioning above carina and chest wall movement upon ventilation. Esophageal intubation can be readily recognized by visualizing tube in the paratracheal space. Other studies have demonstrated ultrasound-guided tracheal intubation with a styleted tracheal tubes.[12, 13]
The accuracy of identifying the cricothyroid membrane was lower than expected. This may be secondary to the studies of interest were completing in those with difficult airways and morbid obesity. It can therefore postulate that this accuracy would be higher in those individuals with normal airways. The definition of accuracy was also very stringent in these studies, some only allowing success if identified with 5mm of actual cricothyroid membrane. The actual clinical significance of performing an incision greater than 5mm from actual cricothyroid membrane on the cricothyroidotomy success rate is unknown.
Overall, this systematic review provides evidence demonstrated high sensitivity and specificity for ultrasound confirmation of ET tube placement, high success rate in ultrasound-guided intubation, and lower than expected accuracy in identifying the criocothyroid membrane. Ultrasonography should be considered for tube confirmation in patients in cardiac arrest and future applications of ultrasound may include intubation in real-time.

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