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Confirming Endotracheal Tube (ETT) Position in Pediatric and Neonatology Using a Bedside Ultrasound (Us); an Emerging Tool

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Abstract

US have a promising alternative mean for quick confirmation of the ETT placement. However, small and few studies have shown that the sensitivity of this tool to accurately assess the ETT placement relative to chest XR or capnography is approximately 91-100%. The overall accuracy of this method is very interesting as it reaches 89-98% in some studies. An additional advantage of this method as suggested by some of these studies is the rapid assessment of the ETT position; this can be as quick as 17 seconds using an US curvilinear probe. Understandably, the confirmation of the ETT position was somewhat challenging in short neck patients and in those wearing cervical collars. I believe that using this method is worth looking into in the near future. Although most of the subjects of these studies were adults and children, I don't see a limitation to use this tool in neonatology, especially if the waiting time between intubation and doing confirmatory XR in some facilities is long.

Based upon various small observational studies, bedside US can be used to

1. Direct visualization of the ETT in the trachea

2. Showing lung sliding

3. Diaphragmatic Excursion

Keywords: Endotracheal tube; Ultrasound

Endotracheal Tube (ETT) Position in Pediatric and Neonatology

Following intubation, all possible steps are taken by the health-care providers to correctly confirm the catheterization and placement of the endotracheal tube (ETT) in the trachea using various tools. The clinical tools for correct checking of the ETT position placement include:

- Visible symmetrical chest rising with positive pressure ventilation through ETT.

- Auscultation of symmetrical breath sounds in both axillae, and negligible breath sound heard over the stomach.

- Adequate oxygenation saturation appropriate for age and gestation is confirmed through the use of continuous pulse oximetry.

- Appearance of mist in the ETT resulted from lung ventilation.

Despite the usage of all these tools, the clinical impression of the ETT position is not always absolutely correct. Various other confirmatory tools are implemented to detect the correct ETT position [1]. These are

- Detecting CO_2 using End-tidal CO_2. The CO_2 detector is of two types; a colorimetric device and capnography. The CO_2 detector is considered the most definitive tool to confirm correct ETT placement in the trachea [2,3]. Disposable CO_2 detector is a qualitative tool that uses a colorimetric scale to detect CO_2 presence in the ETT that is exhaled by proper lung ventilation. Once the trachea is correctly catheterised then the colorimetric CO_2-detector is attached, after about 6 positive pressure breaths are delivered using either self or flow inflated bag, the color typically changed from purple to yellow during exhalation if CO_2 is present in a correctly intubated trachea. This tool can confirm the correct ETT placement in the trachea in patients with a good perfusion from a normal beating heart. Capnography, on the other side, demonstrates ventilation through a continuous tracing of CO_2 levels. This device shows a regular waveform which indicates correct ETT position. By default, the CO_2 capnography is the most accurate tool to correctly confirm the ETT position. A flat wave generally means the presence of the ETT in the esophagus. However, other clinical situations like prolonged cardiac arrest, inadequate pulmonary blood flow from poor chest compressions, ETT obstruction, airway obstruction distal to the ETT, technical malfunction of the monitor or the tubing circuit may also show a flat wave pattern.

- In older children, especially those above 20 kg, a self-inflating bulb can be used, and may be particularly useful for confirming the ETT position in patients with poor perfusion resulted from cardiac arrest.

- Interestingly, preliminary evidence suggests that a bedside US can be used to rapidly confirm the ETT placement if used properly by trained physicians.

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US have a promising alternative mean for quick confirmation of the ETT placement. However, small and few studies have shown that the sensitivity of this tool to accurately assess the ETT placement relative to chest XR or capnography is approximately 91-100%. The overall accuracy of this method is very interesting as it reaches 89-98% in some studies. An additional advantage of this method as suggested by some of these studies is the rapid assessment of the ETT position; this can be as quick as 17 seconds using an US curvilinear probe. Understandably, the confirmation of the ETT position was somewhat challenging in short neck patients and in those wearing cervical collars.

I believe that using this method is worth looking into in the near future. Although most of the subjects of these studies were adults and children, I don't see a limitation to use this tool in neonatology, especially if the waiting time between intubation and doing confirmatory XR in some facilities is long.

In a pilot study to evaluate the accuracy of US to confirm the ETT placement, Werner et al found that for each physician, the sensitivity for identifying the first intubation was 100% (95% confidence interval [CI]77-100%) with a specificity of 100% (95% CI 82%-100%). In this study, one ETT was unintentionally placed twice in the esophagus, but both tube placements were identified as an esophageal by the emergency physicians. In this study, two emergency physicians experienced in US accurately detected placement of the ETT with an US in selected patients, in a controlled environment of the operating room [4].

In a total of 112 patients included in the analysis, 17 (15.2%) had esophageal intubations, Chou et al. found that the overall accuracy of the Tracheal Rapid US exam (T.R.U.E.) was 98.2% (95% confidence interval [CI]: 93.7-99.5%). The kappa (κ) value was 0.93 (95% CI: 0.84-1.00), indicating a high degree of agreement between the TRUE and capnography. The sensitivity, specificity, positive predictive and negative predictive values of the TRUE were 98.9% (95% CI: 94.3-99.8%), 94.1% (95% CI: 73.0-99.0%), 98.9% (95% CI: 94.3-99.8%) and 94.1% (95% CI: 73.0-99.0%).

The median operating time of the TRUE was 9.0s (interquartile range [IQR]: 6.0, 14.0). They concluded that the application of the TRUE to examine the ETT placement during emergency intubation is feasible and can be rapidly performed [5].

Sim et al. demonstrated in 115 patients, the overall accuracy of US to confirm proper ETT placement was 88.7% (95% confidence interval (CI): 81.6-93.3%). The positive predictive value was 94.7% (95% CI: 87.1-97.9%) in the cardiac-arrested group and 100% (95% CI: 87.1-100.0%) in the non-cardiac-arrested group. The median operating time of the US was 88 seconds (interquartile range [IQR]: 55.0, 193.0), and of chest XR was 1349 s (IQR: 879.0, 2221.0) post intubation [6].

In another study, Galicinao et al. found in a two-phase study that the correct ETT placement was detected in all 99 patients by using bedside US. They required two views to accurately detect the position of the ETT in the trachea.

The visualization was feasible in all cases. However, there was an understandable difficulty in short necks and cervical collared patients. The acquisition of best and high-quality images was in the sniffing position in this study. Despite its less ideas size, the linear transducer provided the best images but with difficulty. Thus, the curvilinear transducer was used exclusively in phase II of this study. In this phase, the mean time to acquire bedside US images of the ETT through the cricothyroid membrane compared to obtain a chest XR were 17.1 s and 14.0 min, respectively. In 3 cases of this study, the bedside US images were invaluable when the colorimetric end-tidal-CO_2 detector yielded false- negative or equivocal results [7].

Kerrey et al. concluded that the diaphragmatic US was not equivalent to chest XR for detecting the ETT placement. But, US results were available in short time, detected more misplacements than standard confirmation tools alone, and were highly reproducible between operators [8].

Finally, in another study of infants who had a mean gestational age of 30.2 ± 4.9 (SD) weeks and mean birth weight of 1,595.2 ± 862 g, the US images were taken in a mean time of 2.9 ± 2.2 h after the XRs. The ETT was visualized by US in all new-borns examined. This study observed a good correlation between the ETT tip-to-carina distance on US and XR (r(2)=0.68) with minimal bias. Each US procedure took less than 5 min to obtain the images without any clinical deterioration. They concluded that bedside US can visualize the anatomic position of the ETT in preterm and term infants [9].

Waiting further studies, I do not see big limitations to implement US (direct visualization of the ET tube in the trachea, lung sliding, and diaphragmatic excursion) tool in neonatology. As the time of ventilation is a factor in the development of neonatal complications especially chronic lung disease (CLD), this tool may reduce this time factor. Depending on the facility this waiting time can vary up to 30 min. Therefore, ready to use bedside US can tremendously reduce this time factor. In addition, the hazard of exposure to radiation form the use of XR for the staff and new born infants can be hugely reduced.

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