Comparison Between Ultrasonography and Capnography in the Assessment of Endotracheal Tube Placement after General Anesthesia

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Abstract

Background: Verification of endotracheal tube placement is of vital importance and can prove rapidly fatal. Because the placement of unrecognized esophageal tubes is so obviously detrimental, several instruments and techniques have been investigated to get rid of such fatal complications. While there are numerous methods and devices utilized for verifying endotracheal tube placement, none have been shown to be completely reliable. In the present study, we compared the upper airway ultrasound with capnography so as to assess endotracheal tube placements rapidly and accurately following general anesthesia (GA).

Aim of the study: The aim is to examine how much fast and accurate the ultrasound in comparison with capnography for assessing the endotracheal tube placement after general anesthesia.

Patients and methods: This prospective cross-sectional study was conducted on (100) patients requiring tracheal intubation under general anesthesia by using ultrasonography for confirming the endotracheal tube position compared to capnography.

Results: Significant differences were found in the meantime for the group (A) between ultrasound (US) and capnography. But in the group (B), there was no significant difference between means of time for confirmation by U/S and capnography. A P-value less than (0.05) was considered significant.

Conclusion: In confirming the position of the tracheal tube, the real-time US was shown to be similar to capnography in accuracy.

Key words: endotracheal tube, capnography, ultrasonography, general anesthesia

Introduction

In operation theatre settings, tracheal intubation is generally performed to maintain and protect the airway during general anesthesia. Confirmation of correct endotracheal tube (ETT) placement is essential immediately after intubation. Failure to diagnose esophageal intubation can be disastrous. The incidence of esophageal intubation was reported at 2-6% in emergency conditions and 1.75% in the elective setting [1]. Esophageal intubation is one of the main causes of accidents leading to death

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or neurologic damage. An investigation of anesthesia mortality revealed that 69% of the deaths were related to airway management, with esophageal intubation as one of the contributing factors [2]. Direct visualization of the ETT passing through the glottis is often applied in practice, but it is not always possible, especially if laryngoscopy is difficult. The alternative methods of confirmation include auscultation, observation of chest movements, observation of condensation in the ETT and increasing heart rate.

None of these indirect methods have been proven to be fully reliable, especially under emergency conditions. Given the efficacy of devices such as the electronic end-tidal carbon dioxide ($Etco_2$) detector in the operating suite, the American Society of Anesthesiology has included $Etco_2$ detection in their Standards for Basic Intra-operative Monitoring. This action, combined with the ready availability of inexpensive devices, has established Etco2 detection as the standard of care for endotracheal intubation in the hospital[3]. So, it is the gold standard for identifying esophageal intubation. Capnography has also been found to be the best method for rapid assessment of ETT position [4]. Capnography has 100% sensitivity and 100% specificity in verifying the correct ETT location which shows that waveform capnography can be considered as the standard method for the primary verification of ETT location [5]. Several studies of upper airway ultrasonography (USG) confirmation of ETT position provided promising results in a cadaver model or in patients under controlled operating room conditions [6-8].

In this prospective observational study, we have compared upper airway USG with reference to capnography (the gold standard method) for rapid confirmation of endotracheal tube placement after general anesthesia. The reason for this research is important; it is to show that ultrasound is in good agreement to waveform capnography which is the gold standard in the immediate confirmation of endotracheal intubation. Not all hospitals have the facilities of Etco2, but all district hospitals at least have U/S at their disposal. If this is successful, we could train all health care providers whose involved in life threatening situations to use U/S to confirm ETT placement and thus reduce incidences of unrecognized esophageal intubation which are sometimes difficult to detect clinically but may cause substantial morbidity and mortality.

Confirmation of tube placement is a dynamic process requiring ongoing patient assessment. In order to mechanically ventilate the patients, an endotracheal tube (ETT), the most commonly used artificial airway, has to be inserted into the patient's trachea [9]. Intubation has been classified as a highly technical and clinical skill that is accompanied by the danger of complications. These complications can occur during the intubation procedure, while the ETT is in place or after the ETT has been removed. Incorrect placement of the ETT may lead to inadequate ventilation, displacement, aspiration, ineffective oxygenation, hypoxia, hypotension and esophageal intubation. Verification of the ETT in mechanically ventilated patients is therefore important [10-13].

Capnography is a continuous measurement and graphic display of exhaled carbon dioxide. It is noninvasive method to assess the ventilation and cardiac output. Most commonly infrared light absorption by CO2 is the method used to determine the CO2 concentration. It is a plot of the partial pressure of carbon dioxide against time. It may be classified as main stream or side stream, depending on the part of the breathing system that the gas sampled from [14].

Patients and Methods

After obtaining the approval of the Iraqi council of anesthesia and intensive care, the current prospective, cross sectional study was carried out in general surgical operation theaters of Baghdad teaching hospital, during the period from January to august 2018.

In this study, 100 patients who need direct laryngoscopy were enrolled. Before their enrollment in this study, written informed consents were taken from the patients. All the patients were undergone surgical operation under general anesthesia and divided into two groups according to time of operation. Group (A) included patients studied in first four months and Group (B) included patients studied in the second four months of the study.

Patient scheduled for elective surgeries under

general anesthesia with direct laryngoscopic tracheal intubations, were included, whereas pediatric age groups and patient's refusals were excluded from our study.

After taking a history and examining the patient, intravenous line was established and the patient was connected to the monitor. Data were collected using pre-constructed form sheet & information about age, weight and height. General anesthesia was performed for all patients. By a help of another anesthesia and intensive care resident who was holding the mask during giving anesthesia and doing ETT insertion. Tracheal ultrasonography was performed in real-time as the endotracheal tube is passed by using Sonosite S-Nerve ultrasonography machine with a high frequency linear probe (6-12MHz) and depth sufficient to see posterior to trachea directly after intubation and the cuff inflated. The probe was ready to use with jell and by suprasternal notch approach transversely putting the probe during insertion of the endotracheal tube start counting the time needed to verify tube position and then go to esophagus in same time to be sure it is empty, then the patient was connected to a circuit with a side stream capnography & start counting a time needed by capnography by another resident.

Statistical analysis

The SPSS version (25) was used for the statistical analysis of data. Independent t-test (two tailed) was used to compare the continuous variables among study groups accordingly. Pearson's Chi–square test was used to assess statistical association between time for confirmation by U/S and general characteristics. Pearson correlation coefficient (r) measures the strength and direction of a linear relationship between time for confirmation by U/S with age and BMI. The P value (≤0.05) was regarded as significant significant.

Results

The study included (100) patients. All of them were undergone surgical operation under general anesthesia and divided into two groups according to time of operation. Group (A) included (56) patients studied in first four months and Group (B) included (44) patients studied in the second four months of the study as shown in table (1).

Table (1): Distribution of patients according to operation time

Groups	(n=100)	Percentage (%)
Group A (1st four months)	56	56
Group B (2nd four months)	44	44

The comparison between study groups according to age and BMI is shown in table (2). In this study, no significant differences observed between study groups according to age and BMI (P ≥ 0.05).

Table (2): Comparison between the study groups according to age and BMI

Variables	Study groups		P-value
	Group A Mean± SD	Group B Mean± SD	
Age (years)	42.27±11.4	39.82 ± 14.97	0.173
BMI	31.84 ± 5.05	29.56 ± 7.51	0.091

Sensitivity of U/S trans-tracheal was 99%, and accuracy was 99%, while specificity could not be evaluated as shown in table (3).

Table (3): Sensitivity, specificity and accuracy of U/S trans-tracheal for evaluation of ETT placement

Assessment by U/S	Assessment by Capnography		Total (n=100)
	Confirmed ETT placement	Doubt ETT placement	
Confirmed ETT Placement	99	0	99
Doubt ETT Placement	1	0	1
Total	100	0	100

The comparison in mean time for confirmation between U/S and Capnography is shown in table (4). It was observed that the mean time for confirmation was significantly higher in U/S than that in capnography in group (A) (13.95 versus 9.27 sec, P= 0.001).

In group (B), no significant difference was detected between means of time for confirmation in U/S from that in capnography (10.07 versus 9.56 sec, P= 0.079).

Table (4): Comparison in mean time for confirmation between U/S and Capnography

Variable	Time for confirmation (sec)		P-Value
	By U/S Mean ± SD	By Capnography Mean ± SD	
Group A	13.95 ± 1.18	9.27 ± 0.49	0.001
Group B	10.07 ± 1.44	9.56 ± 1.23	0.079

Table (5) shows the correlations between time for confirmation by U/S with age and BMI in group (A). There is a significant moderate positive correlation between BMI and time for confirmation by U/S (r = 0.619, P= 0.001).

Regarding age, no significant correlation noticed with time needed for confirmation by U/S (r= - 0.009, P= 0.952) , Also showed the correlations between time for confirmation by U/S with age and BMI in group (B). There is a significant strong positive correlation between BMI and time for confirmation by U/S (r = 0.751, P= 0.001). A significant weak positive correlation was found between age and time for confirmation by U/S (r = 0.456, P= 0.001).

Table (5): Correlation between time for confirmation by U/S with age and BMI in group A and B

Variable	Group A		
	Time for confirmation by U/S (sec)		P-Value
	By U/S Mean ± SD	By Capnography Mean ± SD	
	R		
Age (years)	-0.009		0.952
BMI (kg/m^2)	0.619		0.001
	Group B		
Age (years)	0.456		0.001
BMI (kg/m^2)	0.751		0.001

Discussion

From the data analyzed, two techniques were used to prove ETT placement in adult mechanically ventilated patients. The perfection of any method to recognize correct ETT placement is based on its sensitivity (ability to detect whenever tracheal intubation does occur) and specificity (ability to detect whenever tracheal intubation does not occur). Both techniques are time-saving, safe and faster than other techniques such as chest radiographs [15].

This study covers a variety of patients who vary significantly in age, weight and surgeries they underwent, most of them same type (laparoscopic surgeries 82%).

Capnography is also a straight method that detects the amount of carbon dioxide in the exhaled air (Etco 2), detection can result in a false negative finding, which can give rise to unwarranted reintubation attempts [16]. Thus, upper airway U/S might be the technique of choice in the primary verification of ETT position in upper airway in such conditions [17].

Upper airway U/S additionally has few disadvantages as seen in the study. In this study, upper airway USG misidentified one tracheal

intubation (one false negative) which was identified as positive by waveform capnography. This subject was found to be overweight or obese (230 kg) with more subcutaneous fat in the neck region which might have made identification of the hyperechoic comet tail shape, posterior shadowing in the transverse view difficult and therefore the ETT placement was not detected. However, one study showed that in overweight and obese patients, upper airway USG has been shown to be superior to auscultation in speed and accuracy in detection of placement of endotracheal [18].

Another restriction is that upper airway USG is operator dependent; hence, its repeatability and generalizability needs to be further studied. In this study the evolution of skills were apparent on time taken to verify the ETT, and our results showed that the time for identification was less in group (B) than in group (A).

The reliability of capnography is distrusted in some conditions which are mentioned previously, and they will not disturb upper airway USG view. Thus, the upper airway US can be used in such conditions to confirm the placement of ETT.

This study specified that the use of upper airway ultrasonography to verify endotracheal tube location in the primary verification process is feasible and can be performed rapidly and easily. This technique is rapid, safe, portable, repeatable, widely obtainable and provides real time dynamic image suitable for many airway management aspects. Also, we noticed that the ultrasonography method have a good accuracy, good correlation, good agreement and quick confirmation times.

In the management of upper airway, particularly in emergency conditions, the ultrasound has become very important, since it is easily carried out, relatively inexpensive, has a confirmed safety record and does not cause pain [19]. Capnography is not always obtainable in emergency settings and peripheral centers. In such situations, ultrasound can be used for the verification of ETT placement. U/S have some definite advantages over existing method of verification. U/S can detect endotracheal tube position simultaneously with intubation or just after it, which is faster than any other methods [20].

The detection of Etco2 with quantitative or semi-quantitative techniques were shown to be dependable methods to confirm tracheal positions by endotracheal tube, with the quantitative waveform capnography is regarded as a goal standard technique. Nevertheless, such instruments, particularly the waveform quantitative capnography are not always found in several intensive care units [21].

Conclusion

The real-time tracheal sonography is also accurate like capnography to confirm tracheal intubations. The real-time USG may be applied in immediate observation of whether the tubes enter the esophagus or trachea by putting the US probes transversely on the neck at the level of the suprasternal notch during intubation, thus confirming intubation without the need for ventilation or circulation.

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