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Determining the diagnostic value of tracheal intubation by palpation and auscultation methods compared to the chest X-ray method in children

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Background: It is important to determine the proper location of tracheal tube for proper ventilation. In this study, we compared the diagnostic value of tracheal intubation with two methods of palpation and auscultation with chest X-ray (CXR) method in pediatric.

Methods: In this interventional study, 80 patients under 6 years of age were included. After tracheal intubation appropriate depth of tracheal tube was determined by auscultation and recorded, then by palpation depth of tracheal tube determined and tube was fixed. The length of the tube was calculated with the standard formula based on age. After surgery, CXR was taken and, according to the landmark, the distance from the end of the tube to the anterior lower tooth was recorded.

Results: Interclass correlation coefficient (ICC) between the palpation method and the standard method in the number of fixing tracheal intubation was 0.573, which shows the average and significant correlation between these two methods in determining the fixed number of tracheal intubation. ICC between the auscultation and the standard method in fixing tracheal intubation number was 0.430, which shows the average and significant agreement between these two methods in determining the fixed number of tracheal intubation. There is no significant relationship between sex and the average number of fixing tracheal intubation in all methods.

Conclusions: This study has shown that both palpation and auscultation methods are appropriate, but with a slightly higher palpation ICC, the palpation can be considered relatively better.

Key Words: auscultation; chest X-ray; palpation; pediatrics

Original Article

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INTRODUCTION

Intubation is a common method in anesthesia. The tracheal intubation is the main method of placing a definite and reliable airway; hence, a complete evaluation of its location should be performed as soon as the tracheal tube is placed. Local anesthesia could be unsuitable for many ill children for whom general anesthesia with endotracheal tubes is used. Being short for children, tracheal tube is hard to locate [1,2]. Lack of proper intubation can increase the risk of hypoxia, pneumothorax, lung collapse, and barotrauma, leading to nerve damage, and

death [1,3]. Evaluation of tracheal tubes at the patient's bedside is performed through primary and secondary methods. Primary methods include the chest inspection to see bilateral dilation and symmetry, bilateral lung auscultation, and cuff palpation at the suprasternal notch. Secondary methods, on the other hand, are Continuous-waveform capnography, ultrasound, chest X-ray (CXR), and bronchoscopy [1,4,5].

Although secondary methods are aggressive, time-consuming, and costly, they are precise methods for locating the endotracheal tube. The gold method for determining the proper depth of tracheal tube is CXR. Other disadvantages of these methods are that they are not always available [6] and since a proper position is needed for radiography, locating the tube might encounter problem [7].

In case of emergency inside or outside the hospital, there is no opportunity and availability of methods such as radiology or bronchoscopy to determine the appropriate location of the endotracheal tube. In the operating room and after induction of anesthesia and patient intubation, it is not possible to routinely use CXR to determine the appropriate location of the endotracheal tube. CXR, on the other hand, exposes patients to X-rays. The use of fiberoptic bronchoscopes in children, especially infants, requires special equipment and skills due to the miniaturization of the airways. The use of ultrasound at the patient's bedside to determine the proper location of the endotracheal tube requires further study [8].

In this study, we decided to evaluate the efficiency of auscultation and touch methods in determining the appropriate depth of the tracheal tube and compare it with the calculation method. Furthermore, because the tracheal tube was fixed by touch method, we examined the location of the tip of that with the CXR.

KEY MESSAGES

- Due to the higher interclass correlation coefficient of palpation method than auscultation one, the palpation method was found to be relatively better than the auscultation method.
- In the present study, height was the most effective variable in locating the tracheal tube in the auscultation method.

MATERIALS AND METHODS

The present project was approved by the Ethics Council of the Faculty of Medicine of the Isfahan University of Medical Sciences with the code of 68255. Written consent was obtained from the parents of all children in the study, assuring them that taking part in the study was completely optional and refusing to participate in the study would not disrupt the children's treatment process.

The present interventional study was conducted at Chamran Hospital of Isfahan, Iran between April and July 2019. The sampling method was sequential non-probability. Eighty patients younger than 6 years who needed intubation for elective heart surgery were selected using convenience sampling and included in the study with parental consent. Sampling was continued until the required number of samples was completed. Patients with preoperative respiratory distress symptoms, a history of respiratory disease, congenital malformations of the neck and upper airways, and cervical spine abnormalities were not included in the study.

Patients were visited the night before surgery. They received similar premedication. In the operating room, they were also equally monitored and underwent anesthesia induction. First, the patient was intubated (by an anesthesiologist, who had no role in the study) with an appropriately-sized endotracheal tube, and the endotracheal tube depth was determined and recorded by auscultation so that the left lung was first blocked; next, while the patient's lungs were being ventilated and the earphone was on the left hemithorax, the tracheal tube gradually came out of the trachea until no breathing sound was heard in the left lung. It was the location of the carina of trachea. Then, one centimeter of the tube was pulled out from the point and the distance from the end of the tube to the lower anterior tooth was measured and its number was recorded. Thereafter, the project executive anesthesiologist determined and recorded the appropriate location of the tracheal tube by palpation and fixed the tracheal tube without knowing the location of tracheal tube fixed by the auscultation method. To this end, the anesthesiologist first placed the index finger of the non-dominant hand in the suprasternal notch and palpated the tracheal tube with slight pressure, and gradually pulled the tracheal tube out of the endotracheal with the dominant hand while the pressure continued. The movement of the tracheal tube was easily felt. As soon as the anesthesiologist's finger felt nothing under the finger, the removal of the tracheal tube was stopped, entered one centimeter of the tracheal tube into the trachea, fixed the tube and measured, and recorded the distance from the end of the tube to the lower anterior tooth. We had no cases of extubation in the operating room.

After the operation and transferring the patients to Intensive Care Unit, the tracheal tube tip position was determined by CXR that was usually taken from patients [9].

All patients underwent laryngoscopy with curved laryngoscope (Macintosh) blade number 1 and intubated by uncuffed tracheal tube. The following formula used to determine the length of the tracheal tube based on children' age [10]. The tracheal tube depth was calculated for patients: 12+age/2.

Finally, the correlation of the obtained depths was specified. It was also determined which of the first two methods was closer and more relevant to the age-based formula and the available criteria in the graph. Data were analyzed using IBM SPSS ver. 26 (IBM Corp., Armonk, NY, USA) as well as descriptive statistical tests, the independent t-test, Pearson correlation, and the interclass correlation coefficient (ICC). The significance level was P<0.05.

RESULTS

In this study, 80 patients, who were candidates for elective heart surgery were examined. In all of them, the distance from the end of the tube to the lower anterior teeth was measured and recorded using the auscultation and palpation methods.

Mean depth of tracheal tube fixation in the three methods (calculation, palpation, and auscultation) was also examined according to the patients' sex and there was no significant relationship between sex and mean depths of tracheal tube fixation in all three methods. In other words, no significant difference was found between men and women in mean depth of tracheal tube fixation in all three methods (P> 0.05) (Table 1).

The research results further indicated a statistically significant relationship between the variable related to the difference in the depths of tracheal tube fixation in the palpation method with the calculation method in terms of weight. The calculation method had a significant positive relationship with age (P=0.001), weight (P=0.004), and height (P=0.001).

To put it differently, all the three contextual variables of heights, age, and weights of children showed significant relationships with tracheal tube fixation number. The difference in tracheal tube fixation depths by palpation method using the calculation method showed a significant and positive relationship with age (P=0.001), weights (P=0.003), and heights (P=0.001) in children. In other words, the patients' age, weights, and heights directly affected the difference between the calculation and palpation methods in terms of tracheal tube fixation number. The difference between the tracheal tube fixation numbers between the auscultation and calculation methods of all three underlying variables, age (P=0.001), heights (P=0.024), and weights (P=0.001) in children showed a significant and positive relationship. In other words, the patients' age, heights, and weights directly affected the difference between the calculation and auscultation methods in terms of the tracheal tube fixation number (Table 2). In the palpation method, furthermore, the mean distance from the end of the tracheal tube to the carina of trachea was 2.5 cm with a standard deviation of 0.750, indicating a difference of one centimeter with the mean standard distance (1.5 cm from the carina of trachea) [9].

Table 3 containing the frequency of the location of the end of the tracheal tube in the palpation method in CXR indicates that in 95.9% of patients, the end of the tracheal tube is located in the standard distance from T2 to T4. The ICC between the palpation and calculation methods in terms of tracheal tube fixation number was 0.573 (95% confidence interval [CI],

Table 1. Comparison of the mean depth of tracheal tube fixation in the calculation, palpation, and auscultation methods according to sex

Tracheal tube fixation model	Male	Female	P-value[a]
Calculation			0.28
Median (interquartile range)	12.54 (1.22)	12.29 (0.43)	
Mean±SD	13.01±1.07	12.66±0.87	
Palpation			0.76
Median (interquartile range)	12 (2.50)	11.5 (2.25)	
Mean±SD	11.98±1.75	11.82±1.90	
Auscultation			0.70
Median (interquartile range)	14 (3.63)	13.5 (3.25)	
Mean±SD	14.07±1.98	14.32±2.54	

SD: standard deviation.
[a]Inter-group comparisons by the independent t-test.

Table 2. The correlation between tracheal tube fixation method and contextual variables

Variable	Pearson correlation coefficient		
	Age	Weight	Height
Calculation	1.000	0.377	0.851
P-value	0.001	0.004	0.001
δa^a	0.462	0.258	0.687
P-value	0.001	0.003	0.001
δp^b	0.501	0.319	0.796
P-value	0.001	0.024	0.001

[a]The difference between the tracheal tube fixation number by the auscultation method with the calculation; [b]The difference between the tracheal tube fixation number by the palpation method with the calculation.

Table 3. Frequency of the end location of the tracheal tube in the palpation method in chest X-ray

The end location of the tracheal tube in the palpation method in chest X-ray	Frequency (%)
T1	4.1
T2	53.1
T3	34.7
T4	8.2

Table 4. The correlation between the palpation and auscultation methods with the calculation method in tracheal tube fixation

Variable	ICC	95% Confidence interval	P-value
Palpation method	0.573	0.140–0.785	0.001
Auscultation method	0.430	0.026–0.683	0.001

ICC: interclass correlation coefficient.

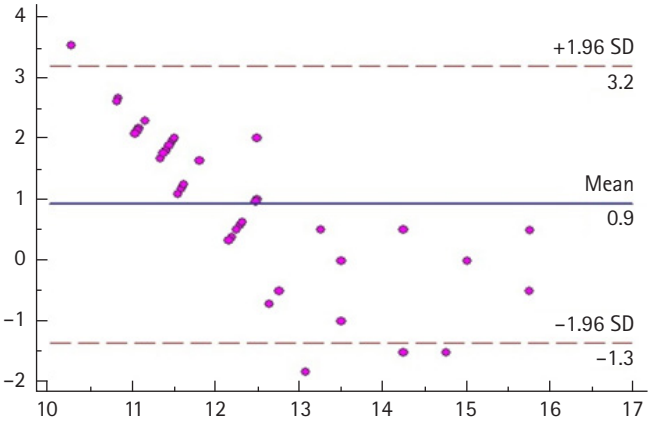

Figure 1. The Bland-Altman plot for correlation of the mean tracheal tube fixation numbers by the calculation and palpation methods. Horizontal line: the mean tracheal tube fixation numbers in the calculation and palpation methods; Vertical line: the difference in mean tracheal tube fixation numbers (calculation-palpation methods). SD: standard deviation.

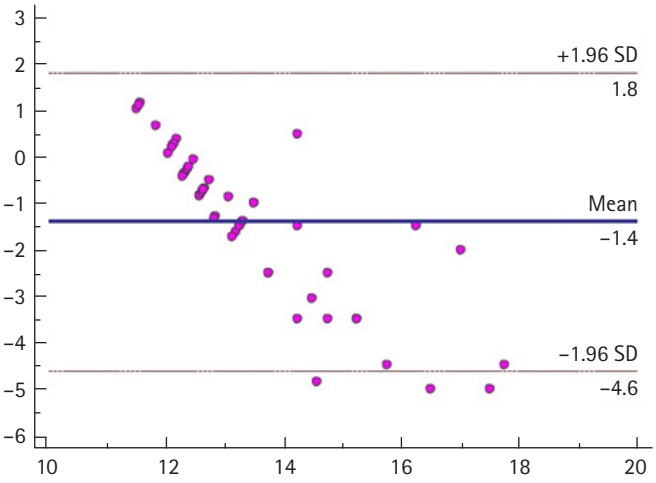

Figure 2. The Bland-Altman plot for correlation of the mean tracheal tube fixation numbers by the calculation and auscultation methods. Horizontal line: the mean tracheal tube fixation numbers in the calculation and auscultation methods; Vertical line: the difference in mean tracheal tube fixation numbers (calculation-auscultation methods). SD: standard deviation.

0.140–0.785), indicating a moderate and significant agreement between the two methods in determining the tracheal tube fixation number.

Furthermore, ICC between the auscultation and calculation methods in tracheal tube fixation number was 0.430 (95% CI, 0.026–0.668), indicating a moderate and significant correlation between the two methods in determining the tracheal tube fixation number (Table 4).

The Bland-Altman plot was used to match the measured items with the calculated values (palpation and auscultation methods with the calculation method). The horizontal axis of the plot is the mean of the measurements, while its vertical axis is the difference between the measurements. The dashed line on the plot is the 95% CI for the differences, meaning that if at least 95% of the points are in the distance between the two lines, the measurements are correlated. Figures 1 and 2 separately show the difference between the tracheal tube fixation numbers using the palpation and auscultation methods with the calculation method. In this regard, the difference between the mean of the palpation and calculation methods was 0.9, whereas the difference between the mean of the auscultation and calculation methods was −1.4. According to Figures 1 and 2, both palpation and auscultation methods are correlated with the calculation method in terms of the tracheal tube fixation number.

DISCUSSION

In our study, both palpation and auscultation methods showed moderate and significant correlations with the calculation method in locating the tracheal tube based on the ICC. Due to the higher ICC of palpation method than auscultation one, the palpation method was found to be relatively better than the auscultation method. In a study by Maleki et al. [11], who compared the palpation method and ID formula in children to determine the appropriate depth of tracheal tubes, the palpation method was more acceptable and successful. Moreover, in a study by Okuyama et al. [12], who examined the

palpation method to locate the tracheal tube, palpation was reported as a fast, safe, and simple method for this purpose. In another study by Moll et al. [13], who compared palpation and markers of tracheal tubes, the location determined by palpation was more appropriate. Furthermore, in a study by Yoo et al. [14], who examined the palpation, auscultation, and nerve cord landmark methods to assess the proper location of the tracheal tubes in children, the auscultation method showed the deeper location of the tracheal tube and was associated with higher risk.

In the present study, there was not any significant relationship between the patients' sex and the mean depth of tracheal tube fixation in the auscultation and palpation methods, meaning that sex did not affect the length of tracheal tube. In a study by Yoo et al. [14], who examined the palpation, auscultation, and landmark of vocal cord methods to assess the proper location of the tracheal tubes in children, there was not any significant relationship between sex, and all three methods and sex was not an effective factor. Additionally, McKay et al. [15], who studied the palpation method for evaluating tracheal tubes in adults, found no significant relationship between sex and palpation method, meaning that sex was not an effective factor.

In the current study, unlike sex, there was a significant relationship between weight and the mean depth of tracheal tube fixation in the auscultation and palpation methods, meaning that the more the patient's weight was, the longer the tracheal tube was. However, the variable of weight was not effective in comparing the two methods. In a study by Saboo et al. [16], who examined palpation as a method of locating the tracheal tube in children, there was a significant relationship between weight and palpation method, and weight was an effective factor. Bloch et al. [17], who compared the auscultation method with CXR, stated that weight is not an effective factor in comparing the auscultation method with the CXR in terms of locating the tracheal tube. In line with the present study, Hofer et al., who examined the effect of weight on the tracheal tube length, declared that there is a significant relationship between weight and tracheal tube length [18].

Regarding height, on the other hand, we observed a significant relationship between this variable and the mean depth of tracheal tube fixation in the auscultation and palpation methods, meaning that taller patients needed longer tracheal tube. Nonetheless, height was not an effective factor in comparing the two methods. Similarly, in a study by Yoo etal. [14], who examined the palpation, auscultation, and landmark of vocal cord methods to assess the proper location of the tracheal tube in children, there was not any significant relationship between height and comparison of the three methods, and height was not an effective factor. Even though, in the present study, height affected the location of tracheal tube fixation, Eagle found a weak correlation between tracheal tube length and the patients' height by performing a study on adults to examine the same correlation through computed tomography scan [19].

The last examined variable in the present study was age. In this regard, findings revealed a significant relationship between the participants' age and the mean depth of tracheal tube fixation in both auscultation and palpation methods, meaning that younger patients needed shorter tracheal tube. However, age was not considered an effective factor when the two methods were compared. In a study by Maleki et al. [11], who compared the palpation method in children to determine a proper depth of the tracheal tube, age was not effective in locating the tracheal tube.

In the present study, height was the most effective variable in locating the tracheal tube in the auscultation method. In agreement with the current research, Bloch et al. [17], who examined the auscultation method in determining the appropriate location of the tracheal tube, found that height are more effective in locating the tracheal tube.

The present research indicated the suitability of both palpation and auscultation methods for locating the tracheal tube in children, but due to the slightly higher ICC of the palpation method, it can be considered a relatively better method to locate the tracheal tube in children. According to the results, both palpation and auscultation methods have proper diagnostic values for tracheal intubation, but the palpation method can be considered a better method due to the higher ICC.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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AUTHOR CONTRIBUTIONS

Conceptualization: GM. Formal analysis: OF. Methodology: GM, MM. Project administration: OF. Writing–original draft: GM, MM. Writing–review & editing: all authors.

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