The Diagnostic Accuracy Of Ultrasonography In Predicting Endotracheal Tube Size In Pediatric Patients_ An Observational Study

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Abstract

The purpose of the study was to determine the diagnostic accuracy of ultrasonography in predicting Endotracheal Tube Size in pediatric patients and to compare it with physical indices based formula.

Objective: To determine the diagnostic accuracy of ultrasonography in predicting endotracheal tube size in pediatric patients.

Methodology: 201 patients posted for surgeries under general anesthesia in Department of Anesthesia, Government Medical College, Thiruvananthapuram, who have given informed written consent were the source of data after obtaining the Institutional Ethics Committee clearance. Results were recorded using a preset proforma.

Result: 189 (94%) of our 201 patients were intubated on the first attempt. 12 (6%) patients changed tube size with USG. Comparing USG-calculated endotracheal tube size to real size, 189 (94%) patients utilised the same size tube, 8 (4%) used a smaller size, and 4 (2%) used a larger size. Comparing ETT size using age-based formula with actual tube size, 152 (75.6%) patients used the same size tube, 6 (3%) used a smaller tube, and 43 (21.4%) used a larger tube. USG estimates ETT size at 5.51 with a standard deviation of 0.78, while age-based formula estimates at 5.66 with 0.89. The mean difference of ETT size calculated by USG and age-based formula was -0.157 with standard deviation of 0.349, paired t value 6.372, and p value <0.001.

Conclusion: This study found that 94 %of children in our study had their tube size correctly predicted by ultrasound. When deciding on an endotracheal tube size for a child, ultrasonography is preferable to using age-based formulae. In children, USG is reliable for determining the best Endotracheal Tube size.

Key words: Diagnostic criteria, Endotracheal tube, Pediatric airway, Tracheal diameter, Ultrasound

INTRODUCTION

The airway in Pediatric patients, because of the anatomical and physiological differences than adults, pose many challenges, one of the challenge is in selecting a proper sized endotracheal tube for endotracheal intubation during GA.Selecting a correct ETT size is important in paediatric patients because an overtly large sized tube might cause damage to airway, post extubation stridor, subglottic oedema and stenosis. On the other hand, a smaller or undersized tube would increase the resistance to gas flow, risk of aspiration, insufficient ventilation, underestimation of end tidal gases, leakage of gases and the need to re-intubate with a different size of endo tracheal tube. Hence an optimal sized endotracheal tube selection is very important for an anaesthesiologist for a safe conduct of general anaesthesia. Age based formulas are less predictive in determining appropriate size uncuffed Endotracheal tube in paediatric patients.(1). Cricoid cartilage is the narrowest portion of upper airway in children because of its inability to get distended in a way similar to vocal cords (2, 3, and 4).

GENERAL GUIDELINES FOR SELECTING PROPER SIZE IN CHILDREN:

There is considerable variation in pediatric tracheal tubes and subglottic diameters in children.

- For children below 6 years of age : age in years / 3 + 3.75
- Children older than 6 years of age : age in years / 4 + 4.5 (6)
- ID = age in years /4 + 4 or 3.5 (7,8)
- ID = 3 mm for those 3 months of age and younger
- = 3.5 mm for those from 3 to 9 months of age

- = (age in years+ 16)/4 over 9 months of age (9,10)
- (age in years + 16) / 4 (11)
- Based on body length measurement (12,13,14)
- In these studies indicated that this method of selecting tube size based on distal phalanx of little finger or index finger size corresponding to external diameter of tracheal tube might be less accurate (15,16,) but useful in case of an unknown child.
- ID = 2.44 + (age * 0.1) + (height in cm * 0.02) + (weight in kg * 0.016). (17).

MATERIALS AND METHODS

The aims of the study was to determine the diagnostic accuracy of ultrasonography in predicting Endotracheal Tube Size in pediatric patients and to compare it with physical indices based formula. To determine the diagnostic accuracy of ultrasonography in predicting endotracheal tube size in pediatric patients. 201 patients posted for surgeries under general anesthesia in Department of Anesthesia, Government Medical College, Thiruvananthapuram, who have given informed written consent were the source of data after obtaining the Institutional Ethics Committee clearance. Results were recorded using a preset proforma. It was a Diagnostic Test Evaluation – An observational study.

Inclusion Criteria: Paediatric patients of American Society of Anaesthesiologists Physical status (ASA) I and II patients scheduled for elective surgery under general anaesthesia .

Exclusion Criteria: Paediatric patients with anticipated difficult airway, delayed milestones, pre-existing laryngeal or pharyngeal pathology, unstable cardiopulmonary conditions or presence of any neck mass. All consecutive patients eligible for study as per inclusion and exclusion criteria were enrolled till the required sample size of 201 was achieved. Study variables: Exposure variables Age, Gender, Weight, and ASA grade, Subglottic diameter, Outcome variables: Endotracheal Tube Size.

Pre-anesthetic ultrasonography was performed on every patient at the anterior side of neck over the subglottic region. The tracheal subglottic diameter was estimated to select ETT size for cuffed and uncuffed tubes .The subglottic diameter was determined using a high resolution linear probe of ultrasound machine placed on the midline of anterior neck with head extended and neck flexed .To prevent artefact and bias ,standard plane of scanning was maintained. Procedure was be performed by an Anesthesiologist experienced in ultrasound .The cricoid arch is visualized as a round hypoechoic structure with hyperechoic edges .The transverse air column diameter was measured at the lower edge of the cricoid cartilage which is considered as the subglottic tracheal diameter. The Endotracheal tube size estimated by ultrasonography was used for endotracheal intubation. Endotracheal tube size was be confirmed by performing leak test. ETT tube size will be considered optimal when tracheal leak is detected at an inflation pressure of 10 – 20 cm of H20,if there is no audible leak, when the lungs inflated to a pressure of 20 – 30 cm of H20 or when there is a resistance to the passage of ETT tube into the trachea, the tube will be exchanged with a 0.5 mm larger tube .The recorded data include ETT tube size determined by ultrasound imaging and clinically used ETT tube for intubation during GA. Measures of outcome: Subglottic diameter, Outer diameter of ETT, Number of attempts, Change in size of tube. Statistical analysis: The data was analyzed using SPSS version 18.0.Results are expressed in form of Quantitative variables as mean +/- standard deviation Qualitative variables as proportion. Independent t –test was used for comparison of internal diameter with different methods and p-value <0.05 was considered statistically significant.

RESULTS:

In this study 201 patients were included. The age of patients ranged from 2- 14 years. Eighty six patients were within 5 years of age, ninety one patients within 6 – 10 years of age and twenty four patients more than 10 years of age. 147 (73.1%) of the 201 patients were male, while 54 (26.9%) were female.(table 1)

Table 1 : Age and Gender Distribution

Characteristics	Variables	Frequency	Percent
Age in years	≤5 **years**	86	42.8
	6-10 **years**	91	45.3
	>10 **years**	24	11.9
Gender	Male	147	73.1
	Female	54	26.9
	Total	**201**	**100**

NUMBER OF ATTEMPTS:

Out of 201 patients, 189 (94 %) patients were intubated in the first attempt, 12 (6%) patients were intubated in the second attempt based on tube size selected using ultrasonography by calculating subglottic diameter. By using ultrasonography out of the tube size selected, Change in size of tube was happened for 12 (6%) patients. (Table 2)

Table 2: Number of attempts

Characteristics	Variables	Frequency	Percent
Number of attempt	1	189	94
	2	12	6
Change in tube size	Yes	12	6
	No	189	94
	Total	201	100

Comparing endotracheal tube size calculated using ultrasonography with the actual tube size,same size of tube used for 189 (94%) patients, lesser size tube used for 8 (4%) patients, larger size tube used for 4 (2%). Comparing endotracheal tube size calculated using age based formula with the actual tube size, same size tube was used for 152 (75.6%) patients, smaller size tube used for 6 (3%) patients, larger size tube used for 43 (21.4%) patients were used. (Table 3)

Table 3: Comparison of USG based ETT size with actual tube size

Characteristics	Variables	Frequency	Percent
Comparison of USG based ETT tube size with Actual Tube size	Same	189	94
	smaller size	8	4
	larger size	4	2
Comparison of Age based ETT tube size with Actual Tube size	Same	152	75.6
	smaller size	6	3
	larger size	43	21.4
	Total	201	100

The difference between USG based ETT tube size and actual tube size is – 0.5 mm in 4 (2%) patients, 0 mm in 189(94%), 0.5mm 8(4) patients. The difference between age based endotracheal tube size and actual tube size is -1.5 mm in 3(1.5%),-1 mm in 16(8%), -0.5 mm in 24(11.9), 0 mm in 152 (75.6 %), 0.5 mm in 6 (3%) patients. (Table 4)

Table 4: Difference between USG based ETT and Actual tube size

Characteristics	Variables	Frequency	Percent
Difference between USG based ETT tube Size and Actual Tube size	-0.5 mm	4	2
	0 mm	189	94
	0.5 mm	8	4
Difference between Age based ETT tube Size and Actual Tube size	-1.5 mm	3	1.5
	-1mm	16	8
	-0.5mm	24	11.9
	0mm	152	75.6
	0.5mm	6	3
	Total	201	100

Table 5: Mean difference of ETT size used clinically on OT table and by USG

Variables	N	mean	SD	Mean difference	SD of difference	Paired t	P
ETT size used clinically on the OT table (in mm)	201	5.52	0.79	0.010	0.122	1.156	0.249
ETT size estimated by USG (in mm)	201	5.51	0.78				

Endotracheal Tube size used clinically on the OT table has a mean of 5.52 with standard deviation of 0.79, endotracheal tube size estimated by USG has a mean of 5.51 with standard deviation 0.78. The mean difference of ETT size used clinically on table and ETT size estimated by USG was 0.010 with standard deviation of 0.122 which is not statistically significant. (Table 5)

Table 6: Mean difference of ETT size used clinically on OT table and by age based formula

Variables	N	Mean	SD	Mean difference	SD of difference	Paired t	p
ETT size used clinically on the OT table (in mm)	201	5.52	0.79	-0.147	0.360	5.780	<0.001
ETT size derived from age based formula (in mm)	201	5.66	0.89				

ETT tube size used clinically on the OT table has a mean of 5.52 with standard deviation of 0.79. ETT tube size derived from age based formula has a mean of 5.66 with standard deviation of 0.89. The mean difference of ETT tube size used

clinically on OT table and ETT tube size derived from age based formula was -0.147 with standard deviation difference was 0.360 with p value<0.001 which is statistically significant. (Table 6)

Table 7 : Mean difference of ETT size by USG and age based formula

Variables	N	Mean	SD	Mean difference	SD of difference	Paired t	p
ETT size estimated by USG (in mm)	201	5.51	0.78	-0.157	0.349	6.372	<0.001
ETT size derived from age based formula (in mm)	201	5.66	0.89				

ETT tube size estimated by USG has a mean of 5.51 with standard deviation of 0.78 and ETT tube size derived from age based formula has a mean of 5.66 with standard deviation of 0.89. The mean difference of ETT tube size estimated by USG and ETT tube size derived age based was -0.157 with standard deviation difference of 0.349 , paired t value 6.372 , with p value <0.001 which is statistically significant. (Table 7)

DISCUSSION

Most remarkable achievement in the anesthesia over last century is the safety which has made the utmost surgical interventions possible. Endotracheal intubation is one of the factors which has made safe induction of anesthesia possible. In pediatric anesthesia, selection of properly sized ETT is critical for successful intubation. Various studies conducted to determine the method for accurate prediction of ETT size especially in children. Age-based formulae, such as those of modified Cole's, Motoyoma and Khine's have been used to estimate optimal ETT size more commonly. Body length is the easiest parameter to be obtained under emergency conditions, when other parameters like age or weight are unavailable. The length-based formula internal diameter in mm = 2+ (body length in cm/30) has been shown to be accurate in predicting the appropriate ETT size according to Shih MH et al., in Chinese children (18) . Hence, we used it in our study for comparison in the Indian population. Only one study has compared the uncuffed ETT size and cuffed ETT size estimation by ultrasound in Japanese children. Not many studies like ours have been done on Indian children with uncuffed and cuffed ETT size estimation by USG. Jagadish suttagati et al also studied the comparison of endotracheal tube size estimated by USG and by physical indices based formula.

Gupta K and co-researchers compared the size of ETT predetermined by USG and estimated by age based formula with clinically used ETT for intubation during general anaesthesia and found that there was high correlation between clinically used ETT and predetermined ETT by USG than predicted by age based formula. Their study also showed that direct measurement of the subglottic diameter by USG predicted the appropriate ETT size. Our study results were comparable with their findings. However, their study does not clearly indicate whether cuffed or uncuffed ETT was used. (19).

Bae JY et al., in a study concluded that USG was a better means of estimation of ETT size in paediatric patients than the age based formula. However, only uncuffed tubes were used in this study unlike our study. Also, USG was performed after induction of anaesthesia in this study (2). But in our study, USG for ETT size estimation was done by an experienced anaesthesiologist did the assessment of appropriateness of the ETT size. All this was done to avoid operator variability. Raphael PO et al., found that determination of cuffed ETT size by ultrasound was a good predictor of appropriate sized ETT in paediatric patients when compared with age based formula. They performed USG guided estimation of tracheal diameter after induction of anaesthesia during mask ventilation of patient (3) .But in our study USG measurement of subglottic diameter was done before induction of patient. (20)

Khine et al., found that modified Khine formula predicted 99% of cuffed ETT and that Cole's formula predicted 77% of uncuffed tubes as appropriate in young children. Our study also showed, the age based formula for cuffed tubes predicted ETT tube size, whereas for uncuffed ETT formula predicted ETT size larger than used clinically. (21).

In our study out of 201 patients 189 (94 %) patients were intubated in the first attempt, based on tube size selected using USG by calculating subglottic diameter. By using USG out of tube size selected, change in size of tube was happened for 12 (6%) patients. Comparing Endotracheal Tube size calculated using USG with the actual size, same size tube used for 189 (94 %) patients, smaller size tube used for 8 (4%) patients, larger size tube used for 4 (2%) patients. Comparing ETT size using age based formula with actual tube size , same size tube used for 152(75.6%) patients, smaller size tube used for 6 (3%) patients, larger size tube used for 43 (21.4%) patients were used. ETT size estimated by USG has a mean of 5.51 with standard deviation of 0.78 and ETT size estimated by age based formula has a mean of 5.66 with standard deviation of 0.89. The mean difference of ETT size used estimated by USG and ETT size derived by age based formula was -0.157 with standard deviation difference of 0.349 , paired t value 6.372 , with p value <0.001 which is statistically significant.

CONCLUSION

This study found that 94 %of children in our study had their tube size correctly predicted by ultrasound. When deciding on an endotracheal tube size for a child, ultrasonography is preferable to using age-based formulae. In children, USG is reliable for determining the best Endotracheal Tube size.

Conflict Of Interest:

nil

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