Original Research Article

Prediction of paediatric micro-cuff endotracheal tube size by ultrasonography and its comparison to standard age-based formula

K R Chandrakala[1], Kavya Upadhya[2*]

[1]Associate Professor, [2]Resident, Department of Anaesthesiology, Indra Gandhi Institute of Child Health, South Hospital Complex, Dharmaram College Post, Bangalore 560029
Email: chandrakalakr@yahoo.com

Abstract

Background and Aims: Over the years conventional formulas based on age, height or weight is being used for endotracheal tube (ETT) selection in paediatrics. Ultrasound is gaining popularity as an easy, simple and non-invasive aid with good reliability in the assessment of ETT tube size. The aim of the study was to compare the appropriateness of micro-cuffed ETT size selected based on ultrasound assessment of subglottic diameter and ETT size as predicted by Motoyama formula in children undergoing surgical procedures under general anesthesia. **Methods:** A total of 80 patients belonging to ASA1 and ASA 2 aged between 2 to 12 years of either gender posted for elective surgery under general anaesthesia were included in the study. In all the participants, the subglottic diameter which was measured by the ultrasound was considered as the outer diameter of maximal allowable ETT. Leak test was performed to assess the appropriateness of ETT size selected. The other parameters studied were ETT size based on Motoyama formula and post-operative complications. The Statistical software namely SPSS 18.0, and R environment ver.3.2.2 were used for the analysis of the data. Student t test (two tailed, dependent) has been used to find the significance of study parameters on continuous scale within each group. Bland and Altman was performed to measure the agreement of parameters studied. Pearson correlation between study variables was performed to find the degree of relationship. **Results:** The incidence of appropriate tube selected based on ultrasound assessment of subglottic diameter was 96.3% compared to only 36.3% when Motoyama formula was applied. There was a strong correlation between outer diameter of the optimal ETT used and the ultrasound assessed subglottic diameter. **Conclusion:** Ultrasonographic assessment of the subglottic diameter is a better tool in predicting the appropriate size micro-cuff ETT when compared to Motoyama's formula.

Key Word: Airway management, Anesthesia, Intubation, Pediatrics, Ultrasonography

***Address for Correspondence:**
Dr. Kavya Upadhya, Department of Anaesthesiology, Indra Gandhi Institute of Child Health, South Hospital Complex, Dharmaram College Post, Bangalore 560029
Email: chandrakalakr@yahoo.com

Received Date: 05/01/2019 Revised Date: 19/02/2019 Accepted Date: 14/03/2019
DOI: https://doi.org/10.26611/10159318

Access this article online

Quick Response Code:

Website: www.medpulse.in

Accessed Date: 26 March 2019

INTRODUCTION

One of the greatest challenges in paediatric airway management is selecting the appropriate size endotracheal tube. The use of cuffed or uncuffed endotracheal tubes in children has its own advantages and disadvantages. Uncuffed endotracheal tubes (UETTs) are traditionally used for intubation in all children under 8 years of age, irrespective of the indication and duration of intubation.[1,2,3] To circumvent the problems of uncuffed tubes we decided to use micro-cuff endotracheal tube.[3,4,5] Ultrasonography(USG)has recently gained popularity for perioperative airway management and selecting appropriate endotracheal tube size. Till date, no prospective study has compared the age-based formula to that of USG-based method for prediction of appropriate size micro-cuffed ETT. Therefore we tested the hypothesis that the subglottic diameter as measured by

How to site this article: K R Chandrakala, Kavya Upadhya. Prediction of paediatric micro-cuff endotracheal tube size by ultrasonography and its comparison to standard age-based formula. *MedPulse International Journal of Anesthesiology*. March 2019; 9(3): 247-250.
http://medpulse.in/Anesthsiology/index.php

ultrasound better predicts optimal ETT size than age based Motoyama formula in children more than 2 years undergoing surgical procedures under general anaesthesia. The primary objective of our study wasto assess the utility of ultrasonography for selection of micro-cuffed endotracheal tube in paediatric population based on subglottic diameter and compare it to age-based formula (Motoyama formula). The secondary objective was to assess leak, airway pressures, adequate ventilation and post-operative complications.

METHODS

After institutional ethical committee approval (dated 07/05/18) and with parental consent, 80 ASA I and II patients of either gender between 2 to 12 years of age, undergoing various elective surgeries under general anaesthesia were selected. Patients with recent history of the upper respiratory infection, undergoing emergency surgeries, any anatomical deformity of upper airway, previous surgery involving upper airway and any obvious scars, mass or ulcer in the neck which would interfere with the ultrasound examination were excluded from the study. After pre-anaesthetic checkup and standard anaesthesia machine check protocol, patients were pre-medicated with intravenous (IV) or oral midazolam. Standard monitors (NIBP, ECG, Pulse oximetry, capnometer) were attached. General anaesthesia was induced with IV thiopentone 5 milligram per kilogram (mg/kg) and IV fentanyl 2 microgram per kilogram (µg/kg). In patients with no iv line, anaesthesia was induced with sevoflurane. Neuromuscular blockade was achieved with IV atracurium 0.5mg/kg. Motayama formula was used as a standard age-based formula to compare with USG based method. Samsung PT60A ultrasound with a linear frequency probe (5-12 MHz) was used to assess the tracheal diameter in this study. After induction of anaesthesia, the subglottic diameter was estimated with a high-resolution B-mode linear frequency probe (USG- Samsung PT60A, frequency range of 5–12 MHz).The probe was positioned at the anterior aspect of neck in the midline with the head extended and neck flexed soon after induction of anaesthesia. Ultrasound probe was placed transversely infront of the neck. Indicator to the patient’s right. The standard scanning plane was predetermined to prevent any examination bias and artefacts. USG began with location of the true vocal cords before paralysis, seen as paired hyperechoic linear mobile structures and then moved caudally to visualize the cricoid arch to avoid any confusion between the cricoid cartilage and the tracheal ring. The cricoid cartilage is seen as a hump in the transverse view (i.e., round hypoechoic structure with hyperechoic edges); the posterior surface of its anterior wall is delineated by a bright air-mucosal interface as well as reverberation artefact. The transverse air column diameter was measured after three minutes of paralysis at the lower edge of the cricoid cartilage, and recorded as the subglottic diameter. The measurement was made without ventilation or positive end expiratory pressure to minimize fluctuation in tracheal diameter and was considered as apnoea time. Kimberly Clark micro cuffed endotracheal tubes (Kimventmicrocuff tube, Kimberly clark, USA) were used uniformly in all patients. Depending upon ultrasound measurement of subglottic diameter, ETT was chosen. The manufacturer-provided ETT outer diameter (Table 1) was used to convert the measured subglottic airway diameter to the ETT internal diameter (ID) with which the trachea was intubated. The outer diameter of ETT was smaller than measured subglottic diameter and was never exceeded. Another senior anesthesiologist who was not involved in the study did the air leak test in all the patients. The air leak test was done after successful intubation. Resistance to tube advancement or absence of an audible leak at an airway pressure of >20 cm H2O prompted the replacement of the original tube with another tube with an ID 0.5 mm smaller. Conversely, if a leak was audible at an airway pressure of <10 cm H2O or if a cuff pressure =20 cm H2O (i.e. with cuff inflated) was not enough to achieve a seal, the tube was changed to a one size larger ETT. The ETT cuff pressure was monitored and maintained below 20 cm H2O using an automatic manometer. The size of ET tube was considered optimal when leak was detected at an inflation pressure of 10-20 cm of water. The predicted ET tube size by ultrasound was compared with that calculated by age-based formula. As the age taken in this study was between 2-12 years Motoyama formula used was as follows, Microcuff ETT size = Age (in years) / 4 + 3.5 Other parameters like tidal volume, airway pressures, apnea time and post-operative complications like edema/stridor/sore throat were also recorded. The Statistical software namely SPSS 18.0, and R environment ver.3.2.2 were used for the analysis of the data. Microsoft word and Excel were used to generate graphs, tables. Descriptive and inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented as Mean · SD (Min-Max) and results on categorical measurements are presented as Numbers (%). Significance was assessed at 5 % level of significance. Student t test (two tailed, dependent) has been used to find the significance of study parameters on continuous scale within each group. Bland and Altman was performed to measure the agreement of parameters studied. Pearson correlation between study variables was performed to find the degree of relationship.

RESULTS

The distribution of demographic data in terms of age and weight is shown in Table 2 and 3. The apnoea time during performance of ultrasound was less than 20 seconds in all patients. The ETT size predicted by ultrasound assessment of subglottic diameter was appropriate in 77 out of 80 patients while Motoyama formula predicted appropriate ETT size in only 29 out of 80 patients. We also found that neither the age based nor the ultrasound based method predicted appropriate endotracheal tube size in one patient. (Table 4) Endotracheal tube was changed to a larger size in one patient and to a smaller size in another patient as the size didn't correlate with ultrasound measurement of subglottic diameter. Adequate tidal volume was not achieved in 15 patients and we had to inflate the cuff in these patients. Pearson correlation analysis of the appropriate ETT size and the ETT size predicted by ultrasound showed a high degree of correlation. (Table 5) The linear regression equation model of outer diameter of the appropriate tube used, and the ultrasound measured diameter of subglottic region was statistically significant (R2=93.6%; SE=0.156). Bland Altman analysis showed a good agreement between clinically used ETT and subglottic diameter measured by ultrasound. (Figure 1) None of the patients developed any post-operative complications except one who had throat irritation post-operatively.

Regression Analysis: OD of the ET tube which we used=0.697+0.874* SUBGLOTTIC diameter measured by USG R^2=93.6%; SE=0.156

Table 1: Outer Diameter(OD) And Internal Diameter(ID) of the micro-cuff endotracheal tube used in our study (Kimberly Clark micro-cuff)

OD (mm)	**6.3**	**6.7**	**7.3**	**8**	**8.7**
ID (mm)	4.5	5	5.5	6	6.5

Table 2: Age distribution of patient studied

Age in years	No. of patients	%
2-5	44	55.0
6-10	31	38.8
11-12	5	6.3
Total	80	100.0

Mean ± SD: 5.65±2.64

Table 3: Weight (kg) distribution of patients studied

Weight (kg)	No. of patients	%
<10	4	5.0
10-20	60	75.0
21-30	16	20.0
Total	80	100.0

Mean ± SD: 16.05±5.40

Table 4: Method which correctly predicted ETT size

Which was the correct method in this particular child	No. of patients	%
Only USG	50	62.5
Both	27	33.8
Only Age based	2	2.5
Neither	1	1.3
Total	80	100.0

Table 5: Pearson correlation for correlating the ET Size based on age and ET Size Based on USG with ETT which we actually used

	r value	P value
ET Size based on age versus ET tube which we actually used	0.889	<0.001**
ET Size Based on USG versus ET tube which we actually used	0.983	<0.001**

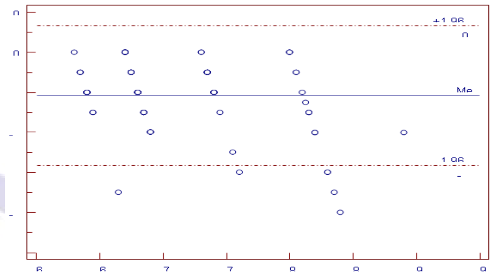

Figure * ARABIC 1: Bland Altman analysis: rate of agreement of OD of the ETT which we used and subglottic diameter measured by ultrasonography

X axis: mean of the OD of the ETT which we used and subglottic diameter measured by USG

Y axis: difference of the OD of the ETT which we used and subglottic diameter measured by USG

DISCUSSION

The commonly used formulas based on weight, height and age generally predict either a smaller or a larger size ETT than clinically used optimal ETT in paediatric population.[6] These methods have many limitations because these formulas cannot consider variation in the growth of various internal organs.[7] In this study, we used direct ultrasound measurement of the subglottic diameter to identify cuffed tube size with a first attempt success rate of 96.3% (62.5% USG only+33.8% both). Our first attempt success rate with direct measurement is higher than that of two previous studies[8, 9], yet lower than that of studies conducted by Shibasaki *et al* and Gupta *et al*[7,10]. The uniqueness of our study compared to earlier studies was that we used micro-cuff endotracheal tubes. Till date, no study has compared the ultrasound method with age-based formula for assessing micro-cuff endotracheal tube size in paediatrics. The ETT which we used clinically in our patients were based on the subglottic diameter measured by ultrasound. We used Kimberly Clark micro-cuff ETT tubes in all the patients as the wall thickness may affect the tube size ID for a given OD. The advantage of using micro-cuff was that if there was a leak <10 cm of water we could inflate the cuff instead of a repeat attempt at laryngoscopy. In all our patients we monitored cuff pressure and made sure it didn't exceed 20 cm of water. Studies done on the feasibility of ultrasonography to examine the subglottic diameter showed a strong correlation between ultrasonography and MRI measurements of the transverse subglottic diameter and concluded that ultrasound could determine the subglottic diameter adequately.[12,13] MRI scan can give additional information on the AP diameter of trachea but in our clinical settings MRI and CT cannot be done because of high cost and feasibility. The limitations of our study are that ultrasound is an operator dependent technique. However in our study an anaesthesiologist experienced with ultrasound performed all the measurements. It should be noted that ultrasound can accurately measure airway diameter in the transverse, but not in the antero-posterior direction[14] This could result in underestimation of the actual tracheal diameter and selection of a smaller ETT. However this can be advantageous for cuffed ETTs when one considers that the deflated cuff thickness is not included in the outer diameter of the ETT. Randomized controlled study would have been the ideal method instead of observational study to provide level 1evidence. The leak test was assessed clinically and interobserver or intra-observer variability in leak test has not been ruled out.

CONCLUSION

Ultrasound is a safe, reliable, non-invasive tool for selection of appropriately sized endotracheal tube for clinical use.Our study validated that USG assessment of the subglottic diameter at the cricoid region is a better tool in predicting the appropriate size micro-cuff ETT than the age-based Motoyama formula. Financial support: None

REFERENCES

1. Motoyama EK. Endotracheal intubation. In: Motoyama EK, Davis PJ, editors. Smith's Anesthesia for Infants and Children. 5th ed. St Louis, MO: C.V. Mosby; 1990. p. 269‑75.
2. Fisher DM. Anesthesia equipment for pediatrics. In: Gregory GA, editor. PediatricAnesthesia, 3rd ed. New York: Churchill Livingstone; 1994. p. 197‑25.
3. Bhardwaj N. Pediatric cuffed endotracheal tubes. J Anaesthesiol Clin Pharmacol. 2013;29:13–8
4. Dullenkopf A, Gerber A, Weiss M. Fluid leakage past tracheal tube cuffs: evaluation of the new Microcuff endotracheal tube. *Intensive care med*. 2003;29(10):1849-1853
5. Dullenkopf A, Gerber A, Weiss M. Fit and seal characteristics of a new paediatric tracheal tube with high volume–low pressure polyurethane cuff. *Acta anaesth Scand*. 2005; 49(2):232-237.
6. Eck, JB, De Lisle Dear, G, Phillips-Bute, BG, and Ginsberg, B. Prediction of tracheal tube size in children using multiple variables. *PaedAnaesth*. 2002; 12: 495–498
7. Shibasaki M, Nakajima Y, Ishii S, Shimizu F, Shime N, Sessler DI. Prediction of pediatric endotracheal tube size by ultrasonography. Anesthesiology 2010; 113: 819-24.
8. Bae JY, Byon HJ, Han SS, Kim HS, Kim JT. Usefulness of ultrasound for selecting a correctly sized uncuffed tracheal tube for paediatric patients. Anaesthesia 2011; 66: 994-8.
9. Schramm C, Knop J, Jensen K, Plaschke K. Role of ultrasound compared to age-related formulas for uncuffed endotracheal intubation in a pediatric population. PaediatrAnaesth 2012; 22:781-6.
10. Gupta K, Gupta PK, Rastogi B, Krishan A, Jain M, Garg G.Assessment of the subglottic region by ultrasonography for estimation of appropriate size endotracheal tube: A clinical prospective study. Anesth Essays Res 2012; 6:157‑60.
11. Holzki J, Brown KA, Carroll RG, Cot_e CJ. The anatomy of the pediatric airway: Has our knowledge changed in 120 years? A review of historic and recent investigations of the anatomy of the pediatric larynx. PediatrAnaesth. 2018; 28:13–22.
12. Raphael PO, Thasim E, Simon BP, Rajagopal P. Comparative study on prediction of paediatric endotracheal tube size by ultrasonography and by age based formulas. Int J Res Med Sci 2016; 4:2528-32
13. Hatfield A, Bodenham A. Ultrasound: an emerging role in anaesthesia and intensive care. Br J Anaesth. 1999; 83:789-800.
14. Altun D, Sungur MO, Ali A, Bingül ES, Seyhan TÖ, Çamcı E. Ultrasonographic measurement of subglottic diameter for paediatric cuffed endotracheal tube size selection: feasibility report. Turk J AnaesthesiolReanim. 2016; 44:301–5. doi: 10.5152/TJAR.2016.60420.

Source of Support: None Declared
Conflict of Interest: None Declared