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COMPARATIVE STUDY BETWEEN MEASUREMENT OF SUBGLOTTIC TRANSVERSE TRACHEAL DIAMETER BY ULTRASONOGRAPHY AND AGE BASED FORMULA FOR PREDICTION OF ENDOTRACHEAL TUBE SIZE IN PEDIATRIC PATIENTS SUBMITTED TO GENERAL ANESTHESIA

By

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ABSTRACT

Background: Choosing the correct endotracheal tube (ETT) size is important in pediatrics patients as an inappropriately large sized tube may cause damage to the airway and subglottic stenosis. On the other hand, a smaller tube will increase the resistance to gas flow, risk of aspiration, insufficient ventilation, and the need to re-intubate with a different size of tracheal tube.

Objective: To compare the accuracy of measurement of subglottic transverse tracheal diameter using ultrasonography and aged based formula for prediction of uncuffed endotracheal tube size in children aged 2-12 years submitted to general anesthesia.

Patients and Methods: After approval of scientific and ethical committees, 88 children aged 2- 12 years submitted to general anesthesias in Al-Azhar University Hospitals were enrolled in this study from May 2019 to May 2021. Children were allocated in two groups: Group I where subglottic transvers tracheal diameter, outer diameter of ETT, inner diameter of ETT, inspiratory tidal volume, expiratory tidal volume, leak volume and leak % were measured and calculated after induction of general anesthesia and Group II where inner diameter of uncuffed ETT was calculated according to cole formula (0.25 (age in years) + 4.

Results: Ultrasonography (USG) was more accurate in prediction of uncuffed ETT size with sensitivity 86.4%, while the sensitivity of the age based formula was 68.2%.

Conclusion: The sensitivity of ultrasonography in prediction of ETT size was superior to age based formula Ultrasonography was more sensitive in yonger children than in older children.

Keywords: Subglottic transverse tracheal diameter, age based formula, endotracheal tube size, pediatric patients, general anesthesia.

INTRODUCTION

Choosing the correct ETT size is important in pediatrics patients because an inappropriately large sized tube may cause damage to the airway, post extubation stridor and subglottic stenosis. On the other hand, a smaller tube increases the resistance to gas flow, risk of aspiration,

insufficient ventilation, and the need to re-intubate with a different size of tracheal tube *(Jagadish et al., 2017).*

We usually depend on age based formulae for selecting appropriate sized ETT. However, these formulae which are based on age are often unreliable and may end up in repeated laryngoscopy for selecting the correct sized ETT. This could lead to more chances of airway trauma and other complications *(Paul et al., 2016).*

With the aid of USG, we could measure the air-column width at the level of the cricoid cartilage and select the optimal sized ETT for intubation in less than 2 minutes *(SchrammC et al., 2012).*

The aim of this study was to determine the accuracy of USG to assess the appropriate ETT size and compare it with age based formula based on air leak test.

PATIENTS AND METHODS

After obtaining approval from the Research / Ethics Committee and written consents from parents of the children submitted to elective operations at Al-Azhar University Hospitals from May 2019 to May 2021, where 88 children were enrolled in the prospective observational study and children were randomly allocated into two equal groups:

Group I: Children scheduled for prediction of uncuffed endotracheal tube size via measurement of subglottic transverse tracheal diameter using USG.

Group II: Children scheduled for prediction of endotracheal tube size using age based formula according to Cole formulae: uncuffed ETTs size in children aged 2 yrs. or older the: ID in mm = 0.25(age in years) + 4.

Inclusion criteria: American Society of Anesthesiologists (ASA) I and II children aged 2 to 12 years of both sex scheduled for various elective surgeries under general anesthesia with orotracheal intubation with uncuffed ETT.

Exclusion criteria: Children with an anticipated difficult airway, children with pre-existing laryngeal or pharyngeal pathology such as tracheostomy and pharyngeal surgery, children with delayed milestones, children with unstable cardiopulmonary conditions, children with any neck masses, children were submitted to emergency surgeries, children with any facial abnormalities, children with body mass indices above the 85th percentile (overweight) or below the 5th percentile (underweight).

Preoperative assessment:

A. Medical history:

1. Current medical illness.
2. Past history of operations or previous hospitalization.
3. Past anesthetic history with impact on:

- Previous airway problems during previous surgeries
- Past history of difficult intubation.

B. Physical Examination:

1. Body weight.
2. General examination and vital signs (blood pressure, pulse, respiratory rate and temperature).
3. Heart, chest and abdominal examination.

C. Airway assessment for anticipated difficult intubation Ultrasonographic examination of the airway: 2 mg/kg propofol and 0.6 mg/kg rocuronium bromide intravenous were used to achieve anesthesia induction. The children were ventilated via facemask during US measurements. Ultrasound (US) probe was placed on the anterior neck, then proceeding in the caudal direction to visualise the cricoid cartilage and vocal cords. The cricoid arch was visualised as a round hypoechoic structure with hyperechoic edge and the subglottic airway transverse diameter were measured in the brightness (B) mode using the linear probe, while the child was placed in the supine and neutral head positions. The transverse air-column diameter was measured at the lower edge of the cricoid cartilage which was considered as the subglottic tracheal diameter. Subglottic tracheal diameter measured was used to select the ETT with similar outer diameter. Since the outer diameter of ETT differs among different manufacturers, single type of ETT (ultramed) was used for our study. Patients were intubated with uncuffed ETT by size that was pre-determined by USG. Child was mechanicaly ventilated by pressure controlled ventilation that guarantees TV 8-10 ml/kg. Air leak test was used to choose the optimum size of the ETT. Six succesive expiratory tidal volumes were recorded, and the average of the lowest three expired tidal volumes was calculated and considered as the exiratory tidal volume .If the leak volume (difference between deliverd and expired TV) was 10–15% of the delivered TV, ETT size was considered optimal. If the leak volume was less than 10 % of the delivered TV, ETT size was considered large and the tube was exchanged with one that is 0.5 mm smaller. In contrast, if the leak volume was more than 15% of the delivered TV, ETT size was considered small and the tube was exchanged with one that was 0.5 mm larger. The same procedures were repeated with the replaced ETT.

In group II, the trachea of 44 children were intubated, and ETT size was selected according to Cole formulae: uncuffed ETT size in children aged 2 yrs. or older the: ID in mm = 0.25 (age in years) + 4.

Air Leak test was used to choose the optimum size of ETT.

A comparison of ETTs size estimated by USG, and ETTs size estimated by age-based formulae were done. All ETTs that were exchanged because it may be small (high leak volume) or large (low leak volume). When leak test was repeated, it was optimum (ranged from 10% to 15%).

Statistical analysis: Statistical presentation and analysis of the present study was conducted, using (IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp). Quantitative data used presented as, mean and standard deviation (SD) , median and interquartile range were compared by Mann-Whitney test. Qualitative data were presented as frequency and percentage and were compared by Chi-square (X2) test. P value < 0.05 was considered significant.

RESULTS

The two groups were compared according to children demographic data (age, sex and weight) and inner diameter of ETT inserted. There was no statically significant difference between group I and group II **(Table 1)**.

Table (1): Comparison between the two groups according demographic data and inner diameter of ETT inserted

Parameters \ Groups	Group I (N=44)	Group II (N=44)	P-value
Age (years)	2-12 (7.5) 7.24±3.22	2-12 (7) 6.93±3.08	0.686
Sex			
Female	19(43.2%)	21(47.7%)	0.669
Male	25(56.8%)	23(52.3%)	
Weight (kg)	11.95-36.61(23) 23.44±7.61	11.50-36.95(21) 22.65±7.39	0.713
Inner diameter of ETT(mm)	4-7 (6) 5.67±0.76	4.5-7 (5.5) 5.57±0.80	0.463

The two groups were compared according to inspiratory tidal volume, expiratory tidal volume, leak volume and leak %. There was no statically significant difference between group I and group II **(Table 2)**.

Table (2): Comparison between the two groups according to inspiratory tidal volume, expiratory tidal volume, leak volume and leak %

Parameters \ Groups	Group I (N=44)	Group II (N=44)	P-value
Inspiratory tidal volume(ml)	105-313(201) 206.07±65.56	102-327(187.5) 197.86±63.37	0.548
Expiratory tidal volume (ml)	93-274(177) 178.36±55.60	91-284(163) 171.95±54.79	0.534
Leak volume (ml)	9-59(25.5) 27.70±11.85	11-65(24) 25.91±11.53	0.387
Leak %	7-20.2(13) 13.16±2.61	7.5-20.2(13) 12.95±3.04	0.799

In group I, 38 out of 44 children showed positive leak test with sensitivity of 86.4% while in group II, 30 out of 44 children showed positive leak test with sensitivity 68.2%. There was statistically significant difference between group I and group II. There was no statistically significant difference between group I and group II according to % of positive and negative leak test in children aged (2-4 years), (5-8 years) and (9- 12 years) **(Table 3)**.

Table (3): Comparison between the two groups according to % of positive and negative leak test in all children and in children aged (2-4 years), (5-8 years) and (9- 12 years)

Groups / Parameters	Group I		Group II		P-value
	N	%	N	%	
(All children N= 44)					
Positive Leak	38	86.4	30	68.2	0.042
Negative Leak	6	13.6	14	31.8	
Sensitivity	**86.4**		**68.2**		
(2-4 years)					
Positive Leak	12	92.3	11	84.6	0.539
Negative Leak	1	7.7	2	15.4	
Sensitivity	**92.3**		**84.6**		
(5-8 years)					
Positive Leak	14	93.3	13	72.2	0.117
Negative Leak	1	6.7	5	27.8	
Sensitivity	**93.3**		**72.2**		
(9-12 years)					
Positive Leak	12	75.0	6	46.2	0.111
Negative Leak	4	25.0	7	53.8	
Sensitivity	**75**		**46.2**		

There was no statistically significant difference between group I and group II according to % of high and low leak test in all children and in children aged (9-12 years) **(Table 4)**.

Table (4): Comparison between the two groups according to according to % of high and low leak test in all children and in children aged (9-12 years)

Groups / Parameters	Group I		Group II		P-value
	N	%	N	%	
Negative Leak test					
Low leak	1	16.7	7	50	0.378
High leak	5	83.3	7	50	
9-12 years					
Low leak	0	0.0	3	42.9	0.308
High leak	4	100.0	4	57.1	

DISCUSSION

In group I, our study's findings indicated that the leak test was positive (leak % was 10 -15%) in 38 children and was negative (leak % was below 10% or above 15%) in 6 children with total sensitivity 86.4%. Only one child of the 6 children with the negative leak test showed low leak test (leak % was below 10%) and the other 5 children showed high leak test (leak % was more than 15%).

This result was consistent with a study done by *Demet et al. (2016)* in which, fifty children aged (1-10 years) were enrolled in the study. The success rate of the USG was 86.4% and the ETT was replaced in five children with a tube one

size larger and in two patients with a tube one size smaller. They concluded that the subglottic transverse airway diameter measured by USG was a reliable predictor in estimating the appropriate pediatric ETT size.

Jagadish et al. (2017) reported that USG predicted the optimal ETT in children 89.33 %of children.

Rahul, et al. (2018) stated that the success rate of USG was 87.8% while the success rate of age based formula was 26.5%.

Essam Mahran and Suzan Adlan (2017) did not justify the routine use of ultrasound for calculating ETT size for intubation in pediatric patients.

In group II, the leak test was positive in 30 children and was negative in 14 children with total sensitivity 68.2. 50% of the children with negative leak test (7 children) showed high leak test and the other 50% showed low leak test.

These results were against a study done by *Demet et al. (2016)* who concluded that Ultrasonographic estimation of subglottic diameter is useful for optimal pediatric ETT size selection than age based formula. The difference in the sample size may be the cause of this disagreement.

Our study's findings indicated that the sensitivity in subgroup A in group I was 92.3% while the sensitivity in the subgroup A in group II was 84.6% .There was no statistically significant relation between the two groups.

Rekha et al. (2020) concluded that USG‑derived measurement can predict the correct size of ETT in 70.7% of children. *Rekha et al. (2020)* also stated that the rate of agreement with age based formula was 65.8%.

In the subgroup B in group I, the sensitivity was 93.3%, while in the subgroup B in Group II, the sensitivity was 72.2%. There was no statistically significant relation between the two groups.

Singh, et al. (2019) found that, the sensitivity of USG was more than 98 % and the sensitivity of age based formula was 95%.

In the subgroup C in group I, the sensitivity was 75%, while in the subgroup C in group II, the sensitivity was 46.2%. There was no statistically significant relation between the two groups.

All the children with negative leak test in subgroup C in group I showed high leak test, while in subgroup C in group II 42.9 % of children showed low leak test and 57.1% showed high leak test. There was no statistically significant relation between the two groups.

CONCLUSION

Using USG of the airway was a very useful, easy and reliable tool for prediction of ETT size in pediatric population. The sensitivity of USG in prediction of endotracheal tube size was superior to age based formula. The sensitivity of USG in prediction of ETT size was higher in younger than older children.

REFERENCES

1. **Demet A, Mukadder O, Achmet A, Emre S, Tülayzkan S and Emre A (2016):** Ultrasonographic Measurement of Subglottic Diameter for Paediatric Cuffed Endotracheal

Tube Size Selection.Turk J Anaesthesiol Reanim , 44: 301-5.

2. **Essam M and Suzan A (2019):** Routine use of ultrasonography in prediction of uncuffed endotracheal tube size in pediatric patients. Ain-Shams Journal of Anesthesiology, 11:9-14.
3. **Jagadish G, Sutag A, Ranjana R and Madhuri S (2017):** Ultrasonographic Estimation of Endotracheal Tube Size in Paediatric Patients and its Comparison with Physical Indices Based Formulae. Journal of Clinical and Diagnostic Research. 11(5): UC05-UC08.
4. **Jagadish G and Madhuri S (2017):** Upper airway imaging and its role in preoperative airway evaluation. Medical Journal of Dr. D.Y. Patil University,May 24.P.300-306.
5. **Raphael P.O, Thasim E, Simon B. P and Rajagopal P (2016):** Comparative study on prediction of pediatric ETT size byUSG and by age based formulas International Journal of Research in Medical Sciences, 4 (7): 25-32.
6. **Rahul P, Suresh K, Jeyaseelan L, Sajan P and Raj S (2018):** Usefulness of Ultrasound‐guided Measurement of Minimal Transverse Diameter of Subglottic Airway in Determining the Endotracheal Tube Size in Children with Congenital Heart Disease: Annals of Cardiac Anaesthesia, [4] .p.382-387.
7. **Rekha M, Anusha C, Lenin B, Prasanna U and Pankaj K (2020):** Correlation between correctly sized uncuffed endotracheal tube and ultrasonographically determined subglottic diameter in paediatric population .Indian Journal of Anaesthesia, 64.[2]. P.16-21.
8. **Schramm C, Knop J, Jensen K and Plaschke N (2012):** Role of ultrasound compared to age‐related formulas for uncuffed endotracheal intubation in a pediatric population. Paediatr Anaesth, 22:781‐6.
9. **Singh S, Jindal P, Ramakrishnan P and Raghuvanshi S (2019):** Prediction of endotracheal tube size in children by predicting subglottic diameter using ultrasonographic measurement versus traditional formulas.Saudi J Anaesth. , 13:93-9.

دراسه مقارنه بين قياس قطر تحت المزمار المستعرض باستخدام الموجات فوق الصوتيه والمعادلة التي تعتمد علي العمر للتنبؤ بحجم الأنبوبه الحنجريه فى الأطفال الخاضعين للتخدير الكلي

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خلفيــة البحــث: أهميــة اختيــار الحجــم المناســب للأنبوبــة الحنجريــة فــى الاطفــال لتجنــب حدوث المضاعفات عند تركيب أنبوبة ذات حجم أكبر أو أصغر من اللازم.

الهــدف مــن البحــث: تحديــد دقــة الموجــات فــوق الصــوتية فــي إختيــار الحجــم المناســب مــن الأنابيــب الحنجريــه ومقارنــة ذلــك بالمعــادلات التــي تعتمــد علــي العمربنــاءً علــى اختبار تسرب الهواء.

المرضــي وطــرق البحــث: بعــد موافقــة اللجــان العلميــة والأخلاقيــة لجامعــة الأزهــر تــم إختيــار88 مــن الأطفــال تتــراوح أعمــارهم بــين 2 و 12 عامًــا وقــد تــم إجــراء هــذه الدراســة فــي مستشــفيات جامعــة الأزهــر فــي الفتــرة مــن مــايو 2019 الــي مــايو 2021 وتم تقسيمهم الي مجموعتين:

المجموعــة الأولــى (العــدد = 44): تــم اخضــاع هــؤلاء الأطفــال لكــي يــتم التنبــؤبحجم الأنبوبــة الحنجريــة عديمــة البــالون عــن طريــق قيــاس قطرتحــت المزمــار المســتعرض باستخدام الموجات فوق الصوتيه.

المجموعــة الثانيــة (العــدد = 44): تــم اخضــاع هــؤلاء الأطفــال لكــي يــتم حســاب الحجــم المناســب للأنبوبــة الحنجريــة عديمــة البــالون باســتخدام المعادلــة التــي تعتمــد علــي العمرطبقــا لمعادلــة كــولي : حجــم (القطــر الــداخلي بــالمليمتر = 25. 0 (العمــر بالسنوات + 4).

فـــي المجموعـــة الأولـــي: تـــم قيـــاس القطر المســـتعرض لعمـــود الهـــواء داخـــل القصـــب الهوائيـــه باســـتخدام الموجـــات فـــوق الصـــوتية وتـــم تركيـــب أنبوبـــة حنجريـــة عديمـــة البـــالون طبقـــا للمقـــاس الـــذي تـــم قياســـه بالموجـــات فـــوق الصـــوتية بعـــدها تـــم اســـتخدام اختبـــار تســـرب الهـــواء للحكـــم علـــي الانبوبـــه الحنجريـــة التـــي تـــم تركيبهـــا إذا مـــا كانـــت مناسبه , كبيره أو صغيرة الحجم.

فـــي المجموعـــة الثانيـــة: تـــم تركيـــب انبوبـــة حنجريـــة وتـــم اختيـــار الحجـــم طبقـــا لمعادلـــة كـــولي بعـــدها تـــم اســـتخدام اختبـــار تســـرب الهـــواء للحكـــم علـــي الانبوبـــه الحنجريـــة التـــي تـــم تركيبها إذا ما كانت مناسبه، كبيرة أو صغيرة الحجم.

وكانت نتائج الدراسة على النحو التالى:

كانـــت دقـــة الموجـــات فـــوق الصـــوتية 86.4% بينمـــا كانـــت دقـــة المعادلـــة التـــي تعتمد علي العمر 68.2%.

تم تقسيم الاطفال في كل مجموعة حسب اعمارهم إلي ثلاث مجموعات فرعية:

مجموعـــة (أ) ويتـــراوح عمـــر الاطفـــال فيهـــا مـــن 2 – 4 ســـنوات. مجموعـــة (ب) ويتـــراوح عمـــر الاطفـــال فيهـــا مـــن 5 – 8 ســـنوات. مجموعـــة (ج) ويتـــراوح عمـــر الاطفال فيها من 9 – 12سنوات.

فـــى المجموعـــة الفرعيـــة (أ) فـــى المجموعـــة الأولـــي كانـــت دقـــة الموجـــات فـــوق الصـــوتية 92.3% أمـــا فـــي المجموعـــة الفرعيـــة المقابلـــه فـــي المجموعـــة الثانيـــة وصـــلت دقة المعادلة التي تعتمد على العمر الي 84.6%.

فـــى المجموعـــة الفرعيـــة (ب) فـــي المجموعـــة الأولـــي كانـــت دقـــة الموجـــات فـــوق الصـــوتية93.3% أمـــافي المجموعـــة الفرعيـــة المقابلـــه فـــي المجموعـــة الثانيـــة كانـــت دقـــة المعادلة التي تعتمد علي العمر 72.2%.

فـــى المجموعـــة الفرعيـــة (ج) فـــى المجموعـــة الأولـــي كانـــت دقـــة الموجـــات فـــوق الصـــوتية 75% أمـــا ف المجموعـــة الفرعيـــة المقابلـــه فـــي المجموعـــة الثانيـــة كانـــت دقـــة المعادلة التي تعتمد علي العمر46.2%.

الاستنتاج:

- إستخدام الموجات فوق الصوتية في اختيار الحجم المناسب للأنبوبة الحنجرية في الاطفال سهل ومفيد ويعتمد علية.

- دقة الموجات فوق الصوتيه فى إختيار الحجم المناسب للانبوبه الحنجرية في الاطفال أعلي من دقة المعادلة التي تعتمد علي العمر.

- دقة الموجات فوق الصوتيه فى التنبؤ بحجم الأنبوبة الحنجرية في الاطفال الأصغر سنا اعلي من الأطفال الأكبرسنا.

- دقة المعادلة التي تعتمد علي العمر فى حساب حجم الأنبوبة الحنجرية في الأطفال تقل بتقدم العمر.

وأوصينا بالأتي:

- إستخدام الموجات فوق الصوتيه فى التنبؤ بحجم الانبوبة الحنجرية في الاطفال وخصوصا من هم دون ال 8 سنوات.

- الإعتماد علي المعادلة التي تعتمد علي العمر ف حساب حجم الأنبوبه الحنجرية فى الأطفال صغيري السن دون الأطفال كبيرى السن.

- الجمع بين إستخدام الموجات فوق الصوتيه والمعادلة التي تعتمد علي العمرلحساب حجم الأنبوبه الحنجريه في الأطفال قد يؤدي إلي نتائج تتقارب ال 100.%

- إذا ما تم تكرارهده الدراسة علي عينة أكبرمن الأطفال فإن ذلك قد يؤدي إلى نتائج أكثر دقة.

الكلمات الدالة: قطرالقصبة الهوائية المستعرض، المعادلة التى تعتمد على العمر، حجم ألأنبوبة الحنجرية، الأطفال، التخدير الكلى.

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