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Assessment of the Subglottic Region for Estimation of Appropriate Size Endotracheal Tube in Pediatric Patient: Ultrasonography Versus Age Based Formula

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Abstract

Introduction: Pediatric patients, because of their anatomical differences in airway compared to adult pose many challenges during endotracheal intubation during general anesthesia. One such challenge is selecting the proper size of endotracheal tube for intubation. *Objective:* To assess the subglottic diameter by ultrasonography and compare with age based formula for selection of the appropriate size endotracheal tube in pediatric patients. *Materials and Methods:* 60 pediatric patients aged 5 to 15 *years* of both gender with normal airway, scheduled for surgery under general anesthesia and intubation, were included for this prospective clinical randomised study. Patients were divided randomly into Two groups of 30 each. In Group A (n = 30) estimation of endotracheal tube size was done by ultrasonography and patients were intubated by that size of tube. In Group B (n = 30) estimation of endotracheal tube size was done by age based Motoyama formula and patients were intubated by that size of tube. Time required for intubation, leak test for appropriate size endotracheal tube, hemodynamic parameters and peri-operative complications were studied. *Results:* In our study, in Group A 26 of 30 (86.66%) patients and in Group B 19 of 30 (63.33%) patients had appropriate size of tube as checked with the leak test, the *P* value (< 0.05) was significant. *Conclusion:* Ultrasound guided assessment of subglottic region is more reliable method to estimate appropriate size of endotracheal tube in pediatric patients.

Keywords: Ultrasonography; Age based formula; Subglottic diameter; Endotracheal intubation; Pediatric patients.

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Introduction

The most important part in anesthesia practise is airway management and endotracheal intubation. We can provide adequate ventilation during surgery through endotracheal tube only. Children have some difference in airway anatomy compare to adults like their larynx have high position, funnel shape larynx, large epiglottis, and narrowest part of airway is subglottic region compared to adult.[1–3]

The important part during endotracheal intubation in children is selecting adequate size ET tube. In children the level at cricoid cartilage is narrowest part of upper airway. So, if we measure the diameter at this level using ultrasonography we can decide proper size of endotracheal tube.[4]

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ET tube size can also be predicted using different methods like X-ray neck, formula based on age of the patient, patient's little finger diameter, CT scan, and MRI. CT scan and MRI are expensive and time consuming. In our routine practise we predict the size of ET tube on age based formulas. Now-a-days Ultrasound can also be used to predict the ET tube size in children. The advantages of ultrasonography are that it is easy technique, without any complications, non-invasive and painless method for predicting ET tube size in pediatric patients. So, our aim of study was use ultrasonography to predict the ET tube size in children and then compare with MOTOYOMA formula (Age based formula). Our objectives of study were to note the intubation time, no. of attempts for intubation and to note the hemodynamic changes during intubation.

Materials and Methods

After institutional ethical committee approval and written informed consent, we carried out this study in department of Anesthesiology, tertiary care hospital from *October 2016* to *October 2017*.

Inclusion Criteria

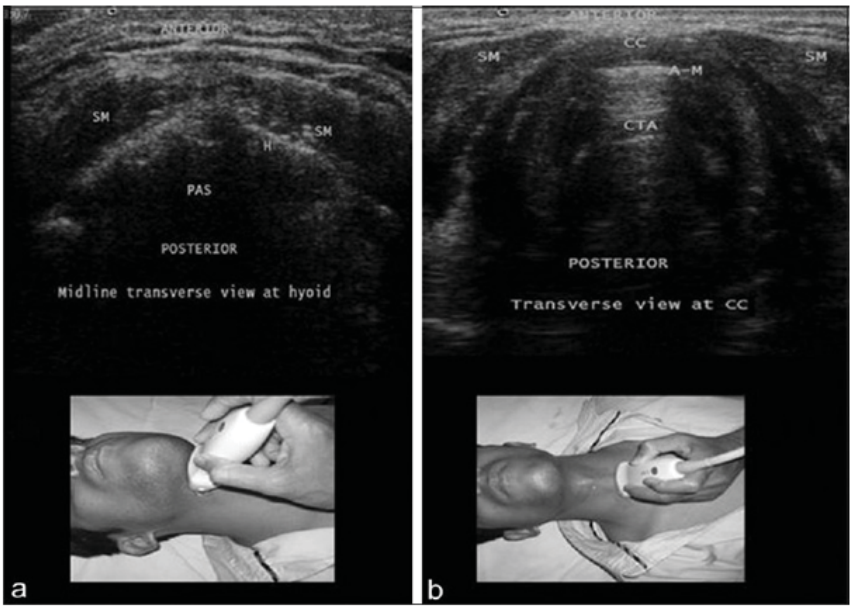
Age

5–15 years, either sex, ASA Grade I and II and Mallampati Grading I/II (MPG), posted for planned surgical procedures. While patients with Throat pain, upper airway infection, the patient suffering from any respiratory disease, pre-existing any laryngeal or tracheal anomaly, difficult airway were excluded from our study. We divided patients into two groups using envelope method. In Group A (n = 30), Ultrasonography was used and in Group B age based formula was used, and patients were intubated by that size of tube.

Technique of Ultrasonography for Group A Patients

In our study, I have used a linear probe of smaller size with *8–15 MHz* frequency. The patients were kept in morning sniffing position that is extension of head and flexion of neck. The probe was placed transversely in the midline. (**Fig. 1A**) displays midline transverse view at hyoid bone.

We started scanning from cephalic to caudal direction. During Ultrasonography initially patient was asked to do swallowing movement, at this time true vocal cords can be seen as paired hyper echoic linear structures, then probe was moved caudally. At this time, patients were asked to take slow respiration. Here hyper echoic arch can be seen that is cricoid cartilage, now press the fridge button in ultrasonography and then maximum diameter was measured. This is the outer diameter of the ET tube to be inserted. From this outer diameter we found out corresponding internal diameter that is usually written on endotracheal tube,[1,5,6] displays as in (**Fig. 1B**).



Figs. 1A & 1B:

Age Based Formula for Group B Patients

Age based formula (For more than *2 years*) used was MOTOYAMA.[1]

Internal Diameter in *mm* = 0.25 (age in *years*) + 3.5.

All the patients underwent a thorough pre-anesthetic check-up on pre-operative day and were investigated for routine investigations like hemoglobin, random blood sugar, urine–routine and microscopy. Patients were kept nil by mouth for *6 hours*, consent was taken and patients were taken to operation theatre. In Operation Theatre, Ringer lactate drip was started. Multipara monitor was attached which include, pulse , SpO_2, ECG, non-invasive blood pressure, and $etco_2$. All the patients were premedicated with inj. glycopyrrolate *5–10 mcq/kg* I.V., inj. Ondansatron 0.08 *mg/kg* I.V., inj. ranitidine *0.25–1 mg/kg* I.V. and inj. Paracetamol *15 mg/kg* I.V. *5 min* before induction.

After *3 minutes* of pre-oxygenation, patients were given inj. propofol *2 mg/kg* and Inj. suxamethonium chloride *1.5 mg/kg* intravenously. Once fasciculation disappeared oral cuffed endotracheal tube was inserted as determined by the ultrasonography in Group A and age based formula in Group B. Endotracheal tube placement was confirmed with bilateral equal air entry and capnography. inj. vecuronium bromide *0.1 mg/kg* loading dose was given. After that leak test was performed for appropriate size endotracheal tube.

Leak Test

Leak test was done after *5 min* of established airway after closing expiratory valve of breathing system at a fixed gas flow of O_2 at *2–3 lit/min* noting the airway pressure at equilibrium.[7] If the leak was found at an inflation pressure of *10–20 cm* H_2O. The tube size was considered optimal, if no audible leak found when the lungs were inflated to a pressure of *20–30 cm* H_2O, tube size was considered bigger and exchanged with 0.5 smaller size. and if leak was present at inflation pressure less than *10 cm* of H_2O, *0.5 cm* bigger size tube was inserted.[1–3] Endotracheal cuff was inflated after completion of leak test. All the patients were maintained with O_2, N_2O, inhalation agent Sevoflurane and non-depolarising muscle relaxant. At the end of surgery patients were extubated by conventional method.

Monitoring

We monitored following parameter:

1. Ease of Intubation (endotracheal tube inserted without any force or resistance);
2. Time required for intubation in sec–(Intubation time–Starting from direct laryngoscopy till disappearance of cuff of the particular size of endotracheal tube for particular age group.);
3. No. of attempt of insertion (*maximum* 2);
4. Requirement of change of endotracheal tube.
5. The patient's hemodynamic and cardiovascular indicators such as heart rate, systolic blood pressure, diastolic blood pressure, oxygen saturation (SpO_2) and End tidal CO_2 were recorded at baseline, at the time of induction, at the time of intubation, *1 min* after intubation, *2 min* after intubation, *3 min* after intubation, *4 min* after intubation, *5 min* after intubation, *10 min*, *15 min*, *30 min*, *60 min*, *90 min*, *120 min*, immediate post-operative period.

Patients were monitored for complications like bronchospasm and hypoxia intra-operatively and sore throat, coughing, hoarseness of voice, dysphagia post-operatively for *24 hours* in post-operative recovery unit.

Results

Table 1 shows Demographic data, which were comparable in both groups.

Table 1: Demographic Data

Parameter	Group A Mean ± SD	Group B Mean ± SD	*p* value
Age (*years*)	9.8 ± 2.6961	10.867 ± 2.701	> 0.05
Sex (M:F)	21:9	22:8	> 0.05
Weight (*kg*)	22.7333 ± 7.0610	27.1 ± 6.5197	> 0.05
ASA Grading ASA I:II	21:9	23:7	> 0.05

Table 2 shows the other parameters like the mean time required for intubation in Group A was 13.6 ± 1.4288 *sec* as compared to 16.2 ± 1.7889 *sec* in Group B and *p* value was < 0.01 which was statistically highly significant. In Group A, the endotracheal tube was inserted with first attempt in 30/30 patients whereas in Group B, the insertion of endotracheal tube with first attempt was in 28/30 patients.

In Group A 26 of 30 patients had appropriate size of tube, while in 3 patients endotracheal tube size was larger as confirmed by leak test and in 1 patient endotracheal tube size was smaller as confirmed by leak test.

In Group B 19 of 30 patients had appropriate size of tube, while in 10 patients endotracheal tube size was larger as confirmed by leak test and in 1 patient endotracheal tube size was smaller as confirmed by leak test.

We did not observe any intra-operative complications like hypoxia and bronchospasm in both the groups. In post-operative period in Group A, 3 patients had coughing and 2 patients had sore throat while in Group B, 9 patients had coughing and 8 patients had sore throat. The pulse rate, systolic and diastolic blood pressure, SpO_2 and $Etco_2$ values were comparable in both groups with respect to intragroup and intergroup.

Table 2: Other Parameters

Parameter	Group A	Group B	*p* value
Time required for intubation in sec	13.6 ± 1.4288	16.2 ± 1.7889	< 0.01
Ease of insertion of endotracheal tube	Easy = 30/30 Not easy = 0/30	Easy = 29/30 Not easy = 1/30	> 0.05
Attempt of intubation	1st attempt = 30/30 2nd attempt = 0/30	1st attempt = 28/30 2nd attempt = 2/30	> 0.05
Parameter	**Group A**	**Group B**	***p* value**
Leak test			
-b/w *10-20 cm* H_2O	26/30	19/30	< 0.05
-> *20 cm* H_2O	3/30	10/30	< 0.05
-< *10 cm* H_2O	1/30	1/30	> 0.05
Appropriate size endotracheal tube	26/30	19/30	< 0.05
Requirement of change of endotracheal tube	4/30	11/30	< 0.05

Discussion

In pediatric patients it is difficult to predict the proper size of endotracheal tube. In routine practise age based formula Motoyoma is used to select the endotracheal tube size, which may not be reliable.[1,8] Other methods like Cole formula, Broselow tape can also be used, but they have again limitations as there can be variation in the growth of various internal organs[9] (**Table 3)**. The future is all about advancement and one such advancement is use of Ultrasonography. As we know the narrowest part of airway in children is subglottic region, so we measure at this level through ultrasonography. The result which we get with ultrasonography are comparable to that of MRI, and ultrasound is non-invasive and relatively easy to learn as compared to MRI or CT scan.

Table 3: Outer diameter and corresponding internal diameter of the Endotracheal Tube

Tube OD size (*mm*)	Tube ID size (*mm*)
4.3	3.0
5.0	3.5
5.6	4.0
6.3	4.5
6.7	5.0
7.3	5.5
8.0	6.0
8.7	6.5
9.3	7.0

In our study, we have compared age based formula with that of ultrasound for assessment of endotracheal tube size in pediatric patients in regards to time required for intubation in sec, ease and attempts of intubation, leak test, requirement of change of endotracheal tube, intra-operative hemodynamic changes as well as intra-operative complications, post-operative complication.

The mean time required for intubation in Group A was 13.6 ± 1.4288 *sec* as compared to 16.2 ± 1.7889 *sec* in Group B and *p* value was < 0.01 which was statistically highly significant, this is because pre-determined endotracheal tube size by ultrasonography decreases time required for intubation during laryngoscopy. Ease of insertion of Group A and Group B were comparable. In Group A, the endotracheal tube was inserted with first attempt in 30/30 (100%) patients whereas in Group B, the insertion of endotracheal tube with first attempt was in 28/30 (96.66%) patients. This is because measuring minimal transverse diameter of the subglottic airway by ultrasound reduces the number of reintubations[10] our results are similar to results of Schramm, Christoph, *et al.* Pediatric Anesthesia. 22.8 (2012).

In our study in Group A we found 26 of 30 patients had proper size of tube, in 3 patients larger size of endotracheal tube was inserted, In 1 of 30 patient small size of endotracheal tube was inserted. While in Group B we found 19 of 30 patients had proper size of tube, in 10 patients endotracheal tube was larger, while only in one patient tube size was smaller. This is because pre-determined tube size by USG decreases the chances of exchange of endotracheal tube.[1] We did not observe any intra-operative complications like hypoxia and bronchospasm in both the Groups. In Group A we observed coughing in post-operative period in 3 patients and sore throat in 2 patients, while in Group B 9 patients developed coughing in post-operative period and 8 patients developed sore throat. Thus Optimally fitted tracheal tubes decrease the probability of post-extubation adverse events in children undergoing general anesthesia.[11]

Conclusion

From our study, we can conclude that Ultrasound is a better way to assess proper size of endotracheal tube in pediatric patients as compared to age based formula, and thus reduces chances of intra-operative and post-operative complications related to endotracheal intubation.

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