



An Educational Module on Ultrasound Guided Endotracheal Tube Sizing and Placement Verification in the Pediatric Surgical Patient



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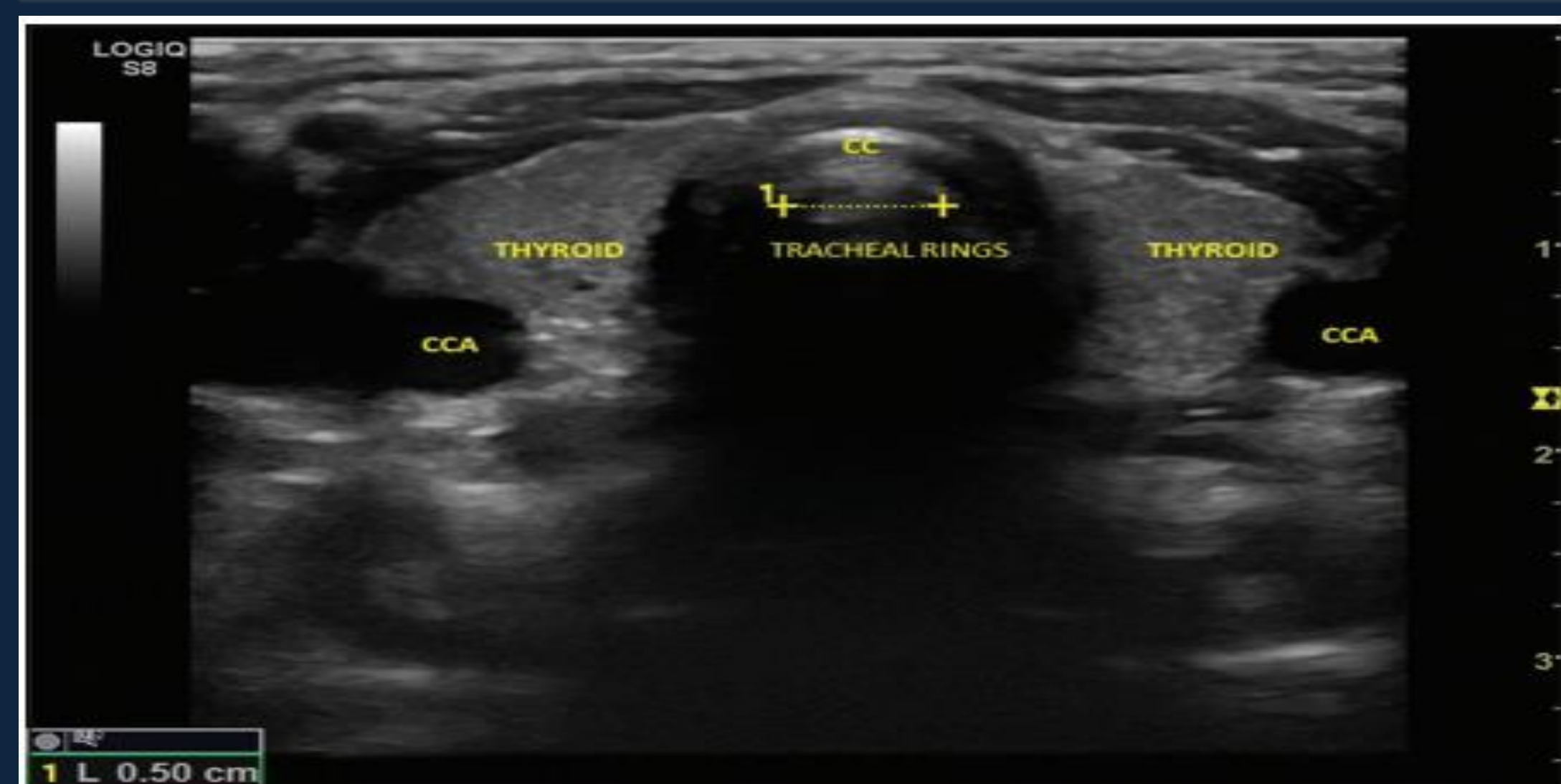
Introduction

Characteristic variances alter the management of the pediatric airway. A narrowing larynx contributes to mucosal damage and recurrent laryngeal nerve damage with placement of the endotracheal tube (ETT) cuff.

- Traditional methods, such as Cole's age-based formula, provide inaccurate indicators of ETT size.
- Patients with lumbar and thoracic congenital scoliosis, down syndrome, congenital heart disease, and those undergoing orofacial cleft repair present additional complexity in accurately sizing ETTs.

Purpose

To improve anesthesia provider knowledge and attitude on utilizing ultrasound to measure subglottic diameter as a tool to approximate best-fit ETT size compared to traditional formulas for calculating ETT size in pediatric patients.



Clinical Significance

- Too large of an ETT = trauma to the airway increases the risk of complications such as laryngeal edema, stridor, and stenosis.
- Too small of an ETT = increased risk of aspiration, pressure within the tube, pollution of anesthetic gases into the operating room suite, and inaccurate measurements of tidal volumes.
- 90% of subglottic stenosis results from tracheal intubation.
 - Subglottic stenosis leads to ischemia, swelling, and necrosis of the surrounding walls. Development of infection and irreversible loss of connective tissue result.
- Postintubation croup is associated with intubation using an ETT that is too large in OD, repeated intubations, traumatic intubation, and patients aged 1 to 4 years old.

Methodology

- An expansive analysis was conducted as facilitated by The Cumulative Index to Nursing and Allied Health Literature (CINAHL), Embase, and PubMed.
- Boolean operators include variations of the following terms: "age-based formula", "pediatric", "ultrasound", and "endotracheal tube."

Inclusion criteria:

- Literature published within the past 13 years
- Full text articles
- Written in English
- Research that focused on research from studies involving subjects aged 1 day to 17 years.
- Literature studies focused on the efficacy of utilizing ultrasound for ETT sizing and placement in pediatric patients to decrease associated risks and complications.

Exclusion criteria:

- Systematic reviews, literature reviews, and meta-analyses
- N = 15

The Florida International University Institutional Review Board (IRB) has deemed this project Exempt. Documentation available upon request.



PICO Question

(P) In pediatric surgical patients (I) does the utilization of ultrasound for endotracheal tube sizing and placement (C) compared to traditional age-based formulas for sizing and placement verification (O) decrease re-intubation frequency and post-extubation stridor?

Literature Review

Author	Design and Objectives	Conclusion
Nandhini et al., 2022	An observational study aimed to determine the diagnostic accuracy of ultrasonography in predicting endotracheal tube size in pediatric patients compared to age-based formulas. Patients scheduled for surgery requiring general anesthesia were intubated with ETTs-sized using ultrasound-guided (USG) measurement of the tracheal diameter. USG-based ETT size was compared against actual tube size. Age-based ETT size was also compared against actual tube size. A sample size of 201 children between the ages of 2-14 years were included.	ETT sizes assessed using USG measurement matched tubes successfully used in 189 out of the 201 patients. Compared to age-based formulas for ETT sizing, only 152 out of the 201 tubes sizes matched the tubes successfully used. In 94% of the patients included in the sample size, USG measurement accurately predicted the size of the ETT. Ultrasound is the preferred method against age-based formulas for sizing ETT in the pediatric population.
Shibasaki et al., 2010	A nonrandomized trial assessed whether the subglottic diameter measured by ultrasonography offers improved prediction of appropriate ETT size than current age-based formulas. Participants were grouped by weight. In the development phase, tube size was selected via Cole, Motoyama, and Khine formulas. In the validation phase, linear regression was used to predict the correct ETT size. A sample of 192 patients between the ages of 1 month to 6 years receiving surgery with general anesthesia requiring endotracheal intubation were included.	Predicted ETT size using age-based and weight-based formulas correlated with clinically appropriate tube size 35% of the time for cuffed tubes and 60% for uncuffed tubes. Predicted ETT size based on ultrasound correlated with appropriate clinical tube size 98% of the time for cuffed tubes and 96% for uncuffed tubes. ETT size predicted with ultrasound is statistically correlated with the optimal ETT size more frequently than age-based formulas
Gooty et al., 2023	A double-blind randomized control study assessed whether ultrasonography-based measurement of subglottic diameter was good for predicting ETT size in pediatric patients compared to age-based formulas. Subjects were divided into two groups. Group U utilized ultrasonography to determine the ETT size. Group A used age-based formula to determine ETT size. The study was conducted using 68 patients undergoing elective surgery requiring general anesthesia with a micro cuff tube.	Statistical significance was observed in group U. No significance was seen in group A. A strong positive correlation (R=0.960) was concluded between ultrasonography-based ETT measurement and actual ETT size used clinically. The difference in reintubations and post-op complications in group U were statistically significant (P < 0.002). The percentage of reintubations were reduced to 17.65% with ultrasonography compared to the age-based group (29.4%).
Ekor et al., 2022	A prospective observational study aimed to assess whether tracheal diameter measured via ultrasound provided a better approximation for appropriate ETT size compared to Cole's age-based formula. 106 patients were split into two groups equally. One group used values from the ultrasound of the subglottic region to determine appropriate ETT size. The other 53 patients used Cole's age-based formula to calculate the appropriate ETT size.	In the ultrasound-predicted ETT group, 52 of their 53 patients matched the clinically used ETT. In the formula predicted ETT group, 35 of their 53 members matched the clinically used ETT size. The ultrasound-predicted ETT group predicted accurate ETT size significantly more times than Cole's age-based formula group.
Gollu et al., 2018	A prospective study aimed to determine the tracheal diameter in children using ultrasonographic techniques and compare it with commonly used age-based formulas for appropriately sizing an ETT. Following induction of anesthesia, the subglottic tracheal region was measured. ETT size according to age-based formulas by Cole, Motoyama, and Khine were calculated for analysis. A total of 61 patients aged between 2 and 17 years were included.	Ultrasonographically determined transverse diameter and the tube diameter determined by the anesthesiologist were compared, and an agreement coefficient of 0.273 was found with an F value of 3.537. Agreement of the transverse diameters determined by the Cole formula and ultrasonography was 0.273 (F value 2.10). Ultrasonographical determination of transverse tracheal diameter is a suitable method for determining the correct endotracheal tube size when compared with age-based formulas.
Elshazly et al., 2020	A randomized controlled trial assessed the re-intubation frequency and required intubation time in pediatric surgical patients. Participants were randomly assigned into either the age-based group (ABG) or the ultrasound-based group (UBG). The sample size included 50 children scheduled for elective surgery between the ages of 1 and 6 years old.	The UBG results showed increased time of 2.0 to 3.0 minutes longer for intubation time. In the ABG there was a higher re-intubation frequency due to an ETT which was too large in size than in UBG (= 0.047. The secondary outcomes of post-extubation in both groups were not found to be statistically significant. There was a significant correlation between ETT OD and the transverse diameter of the subglottic airway in the USB (r = 0.988, P < 0.001).

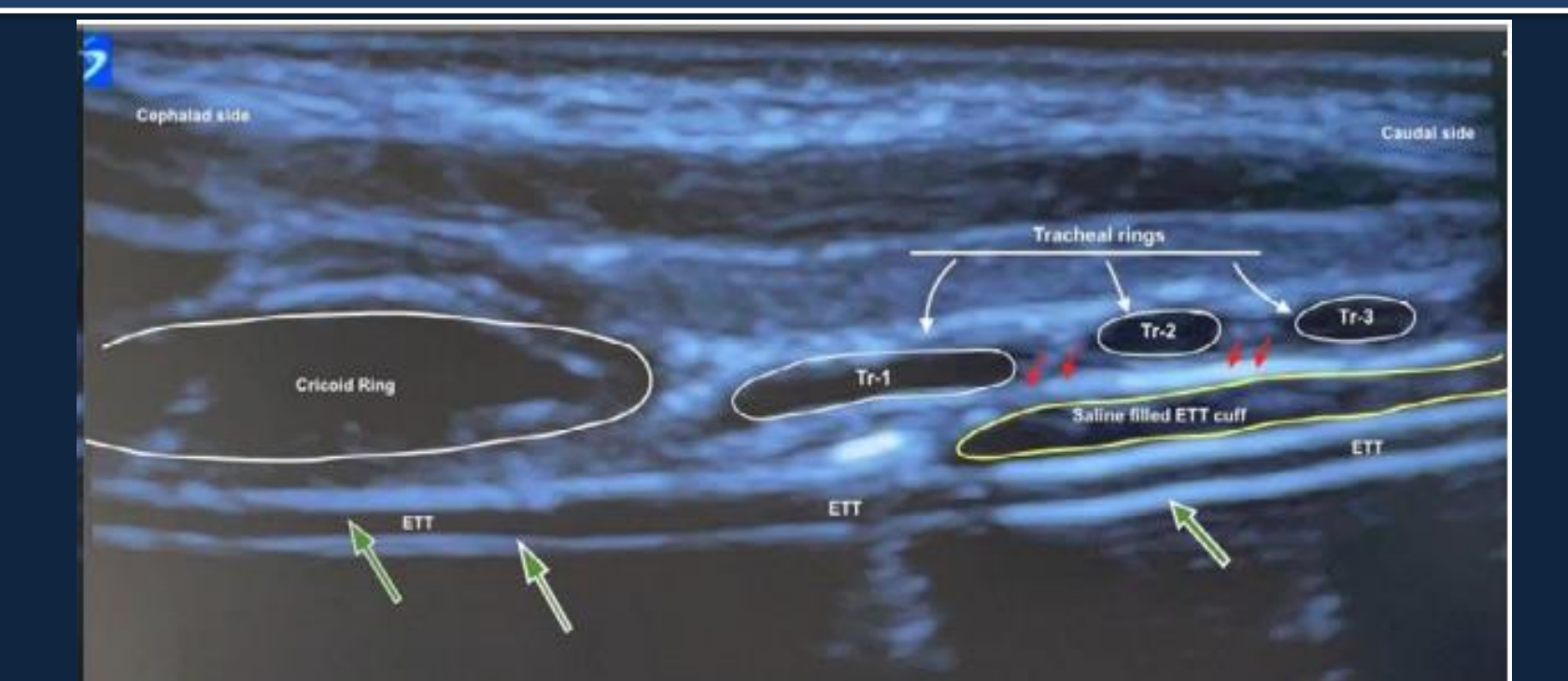
Results

- USG measurement was preferred for ETT sizing compared to demographic-based formulas.
- Eight studies concluded that using ultrasound to measure the subglottic diameter provided an appropriate ETT size.
- Ultrasonographic ETT sizing was found to insignificantly alter the occurrence of post-extubation complications. However, the occurrence of post-extubation complications (stridor, laryngospasm, cough, and sore throat) were found to be reduced with the use of USG measurement of the ETT.
- Ultrasound for ETT sizing reduced re-intubation frequency.
- USG measurement of the subglottic diameter was the most effective method for determining appropriate ETT fit in special pediatric populations.

Clinical Recommendations

- Ultrasonography appropriately predicts ETT size and is an effective tool compared to traditional age-based formulas used to calculate tube size.
- Ultrasound is portable, cost-effective, and eliminates unnecessary radiation exposure to the patient.
- The time is NOW: POCUS is a valuable tool that should be used to assess endotracheal tube placement in combination with outstanding ETT verification methods.
- The potential for practice change transition is indicated.

Point-of-care-ultrasound (POCUS) is an effective tool that should be utilized to locate the ETT cuff position rapidly in the pediatric population.



Conclusion

- Ultrasound is the preferred method against age-based formulas for sizing ETT in the pediatric population.
- The use of ultrasound to assess subglottic diameter shows strong feasibility.
- ETT size predicted with ultrasound is statistically correlated with the optimal ETT size more frequently than age-based formulas.
- The subglottic diameter measured by ultrasonography offers a good predictor.
- Ultrasonography was the most sensitive, 100%, method of prediction.
- Ultrasonography is a reliable method of estimation of subglottic diameter and for prediction of endotracheal tube size in children.
- Findings conclude that ultrasound is superior to age-based formulas for reducing re-intubation frequency
- Age-based formulas used to approximate ETT size in pediatric surgical patients vary largely in accuracy; ultrasonography is the preferred method of choice
- The literature presented in this QI project highlights the use of ultrasonography to approximate the ETT in the pediatric population and its benefits in special pediatric demographics.

References

References available upon request

Contact Information

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