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Bedside tests to predict laryngoscopic difficulty in pediatric patients

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ABSTRACT

Background and Objectives: Pediatric airway management is a priority during anesthesia, critical care and emergency medicine. The purpose of this study is to validate bedside tests that predict airway management difficulty in anesthetized children.

Methods: Children under 12 years of age were recruited in a cross-sectional study to assess the value of some anthropometric measures as predictors of laryngoscopic difficulty. The patients were divided into three groups by age. Weight, height, neck circumference, BMI (body mass index), inter incisors distance thyromental distance, sternomental distance, frontal plane to chin distance (FPCD) and the Mallampati index were determined and were correlated with the CML (Cormack & Lehane classification).

Results: The incidence of difficult laryngoscopy (CML 3 or 4) was 3.58%. Factors that were significantly associated with laryngoscopic difficulty included short inter incisors distance, high FPCD, thyromental distance, sternomental distance and the Mallampati index. The FPCD/weight index exhibited a higher area under the ROC curve than any other variable considered.

Conclusions: This study confirms that the FPCD and the FPCD/weight ratio are the most consistent predictors of laryngoscopic difficulty in pediatric patients. For patients over 6 months of age, the IID also correlated with laryngoscopic difficulty. For children who were capable of obeying simple orders, the Mallampati test correlated better with laryngoscopic difficulty than did the Mallampati test with phonation.

Our results strongly suggest that skilled professionals should perform airway management in children, especially in patients with a high FPCD or a high FPCD/weight ratio.

1. Introduction

Pediatric airway management is of primary importance during anesthesia, critical care and emergency medicine. However, difficulty in performing laryngoscopy and tracheal intubation occurs in 1.5–8% of patients under general anesthesia [1], and this problem is even worse in pediatric patients [2–4] because of the differences in anatomical and physiological structure when compared to adults [5–8]. Difficulty in airway management in pediatric patients is especially hazardous when considering the additional stress presented by pediatric patients in critical care or emergency settings.

Bedside tests for predicting laryngoscopic difficulty are useful for preemptively deciding whether tracheal intubation should be attempted under respiratory distress. The Mallampati [9,10] and the modified Mallampati [11] tests are widely used in clinical practice; however, their accuracy as individual tests has not been confirmed in a large meta-analysis study [12]. Other tests have been validated for adult patients, such as the hyomental distance [13], the upper lip bite test [14], the thyromental distance and the interincisor gap [15]. However, there is a lack of data for predictive factors for laryngoscopic difficulty in pediatric patients [16].

The purpose of this study is to create and validate bedside tests that can predict laryngoscopic difficulty in pediatric patients.

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2. Methods

After gaining approval by the Ethics on Research Committee of the Botucatu Medical School, São Paulo State University, 446 patients (59.5% males and 41.5% females) classified as stages 1 and 2 by the guidelines of the American Society of Anesthesiologists (ASA) and those who were under 12 years old and scheduled for surgical procedures under general anesthesia were included in this cross-sectional study. Exclusion criteria included patients with craniofacial abnormalities and those whose parents did not provide consent.

An objective assessment was performed in all patients one day prior to surgery, which included the patient age, height, weight, body mass index (BMI), neck circumference, thyromental distance, sternomental distance, interincisor distance (IID, or inter alveolar distance in edentulous patients), the frontal plane-to-chin distance (FPCD, the shortest distance between the chin and the bridge of the nose—see Fig. 1) and the Mallampati index for children who were able to obey simple orders. All measurements were performed with the patient in the supine position except for the Mallampati index, which was assessed with the child in the seated position. The patients were divided by age into three groups: group (1) consisted of children aged zero to 6 months, after which children start sitting and teething; group (2) consisted of children aged 6 months to 4 years and group (3) consisted of children aged 4 years to 12 years, after which all patients were able to obey simple instructions to evaluate Mallampati index. Patients were anesthetized with inhalatory sevoflurane, and after an intravenous (IV) line had been established, IV propofol (2 mg/kg), IV fentanyl (5 μg/kg) and IV rocuronium (0.6 mg/kg) were administered. Another anesthesiologist performed the laryngoscopy and tracheal intubation. The distances of each factor measured were divided by age (in years) to create an index that was plotted as an ROC curve. Data were analyzed using Stata Intercooler version 9.0. Ordinary variables are expressed as the mean and standard deviation. Variables were assessed for significance using analysis of variance followed by Tukey's test. The Mallampati index was assessed for significance using the Mann–Whitney test. Significance was assumed for all results with p-values less than 0.05.

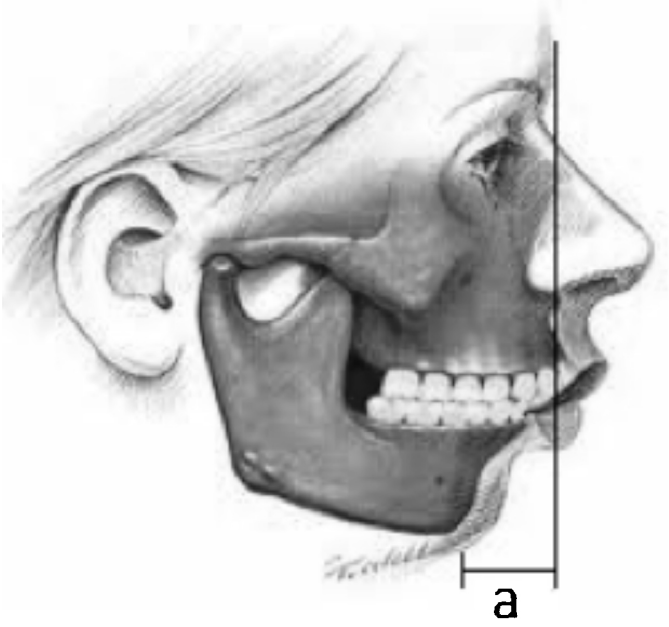


Fig. 1. (a) Frontal plane-to-chin distance (FPCD).

Table 1
Demographic Anthropometric Characteristics Of The Patients.

Variable	Mean ± SD		
	Group 1	Group 2	Group 3
n	28	148	270
Age (yrs)	0.23 ± 0.15	2.80 ± 1.28	8.76 ± 2.14
Height (m)	0.66 ± 0.27	0.92 ± 0.18	1.31 ± 0.19
Weight (kg)	8.95 ± 11.90	14.44 ± 5.14	33.78 ± 15.27
BMI	16.5 ± 3.61	17.11 ± 5.07	18.92 ± 4.78
Neck circumference (cm)	25.01 ± 3.23	26.75 ± 2.78	30.53 ± 3.98
Interincisor distance (cm)	2.49 ± 0.96	3.15 ± 0.72	4.07 ± 0.79
Frontal plane-chin distance (cm)	1.17 ± 0.91	1.26 ± 0.91	1.19 ± 0.94
Thyromental distance (cm)	3.53 ± 1.33	4.76 ± 1.33	6.54 ± 1.55
Sternomental distance (cm)	6.24 ± 2.74	8.50 ± 1.02	1.84 ± 1.01

Data are expressed as the mean ± SD.

3. Results

Demographic anthropometric characteristics of the patients are described in table 1.

The incidence of laryngoscopic difficulty (CML 3 or 4) was 3.58%; the incidence was higher in patients younger than 6 months (10.7% × 3.1%).

There were no statistically significant differences in the CML when the BMI and the neck circumference were analyzed. Shorter interincisors (Graphic 1), thyromental (Graphic 2), and sternomental distances (Graphic 3) and a longer FPCD (Graphic 4) correlated with a higher incidence of laryngoscopic difficulty.

Of the patients in group 1, only the FPCD correlated with laryngoscopic difficulty when the variables were divided by the patient's weight. An FPCD/weight ratio higher than 0.2 reflects a sensitivity of 88.89% and a specificity of 73.68%, suggesting that retrognathism is an important and reliable risk factor for laryngoscopic difficulty in very young patients (Graphic 5).

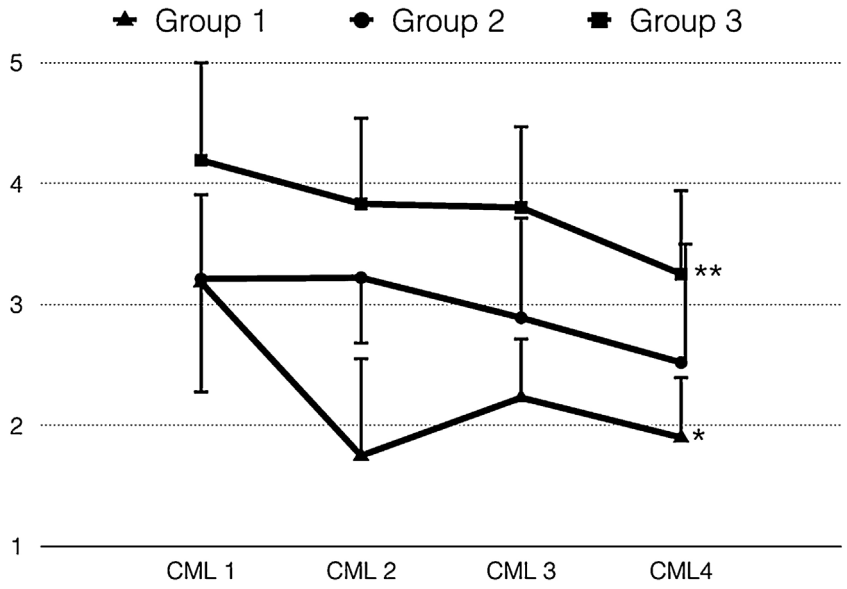
Of the patients in group 2, FPCD and IID significantly correlated with laryngoscopic difficulty. When higher than 0.1, the FPCD/weight index has a sensitivity of 75% and a specificity of 68.75%, whereas an IID/weight index below 0.30 has a sensitivity of 70% but a specificity of 13.79%, as plotted in the ROC curve (Graphic 6).

Of the patients in group 3, FPCD was the best predictor of laryngoscopic difficulty. When higher than 0.03, the FPCD/weight index had a sensitivity of 76.19% and a specificity of 50.2%. An IID/weight index below 0.2 also correlated with laryngoscopic difficulty, with a sensitivity of 85.71% and a specificity of 12.05%.

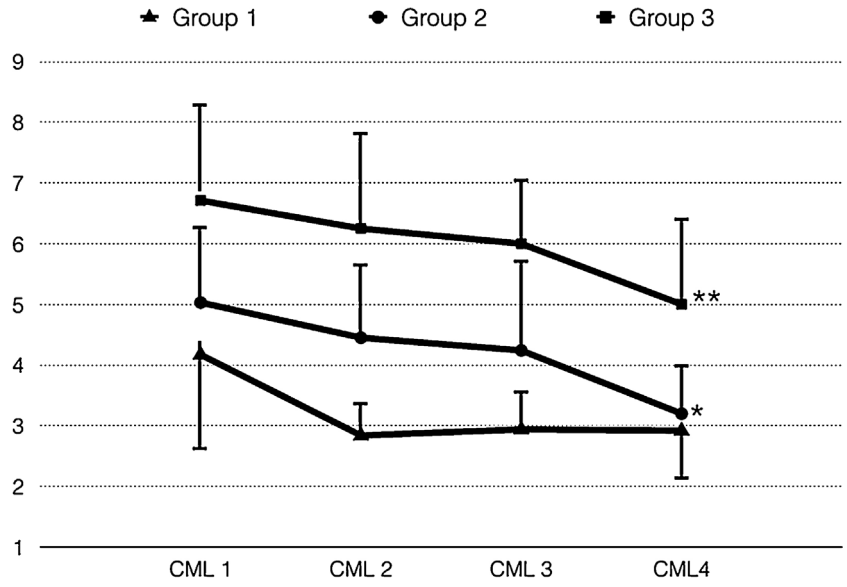
Forty-three patients (29.3%) under 4 years of age were capable of obeying simple orders; thus, the Mallampati index was applied to these patients. A Mallampati index greater than 2 had a sensitivity of 61.9% and a specificity of 52.4% with an area under the ROC curve of 0.6158. When the patient was required to produce an open vowel sound, the sensitivity decreased to 23.81% (Graphic 7).

4. Discussion

Unfortunately, few studies have assessed the clinical predictors of laryngoscopic difficulty in children [17], despite the high incidence of airway management complications in pediatric patients [2,18,19]. Except in children with certain craniofacial or mandibular abnormalities, such as Treacher Collins, Pierre Robin or Crouzon syndromes, predicting which pediatric patients could



Graphic 1. Interincisors distance association with Cormack & Lehane classification. * $p = 0.0310$ ** $p = 0.0012$. Data are expressed as the mean (lines)±standard deviation (bars).



Graphic 2. Thyromental distance association with Cormack & Lehane classification. Data are expressed as the mean (lines)±standard deviation (bars). * $p = 0.0015$ ** $p = 0.0146$.

present with airway management difficulties is not easily accomplished. The lack of guidelines for assessing airway management risk could increase the possibility of unanticipated difficult or failed airways.

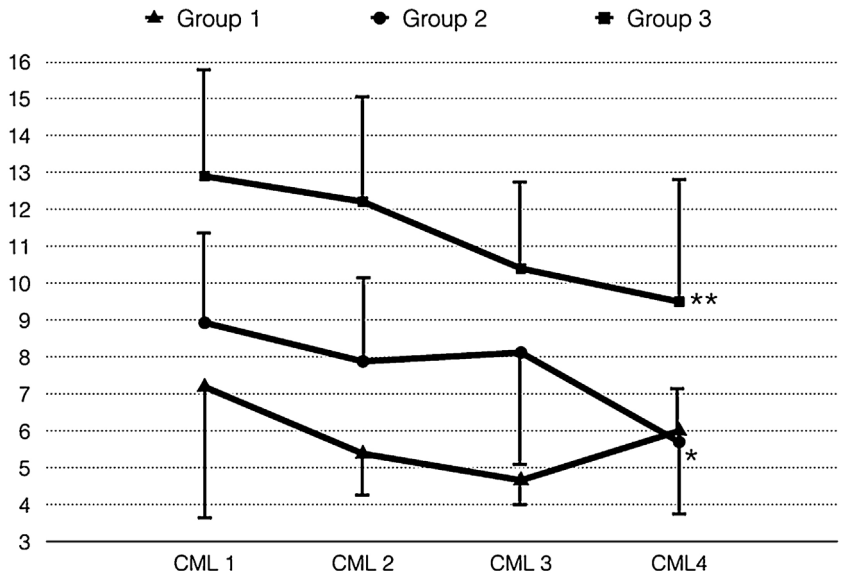
Recently, Mirghassemi et al. proposed an equation as a predictor of laryngoscopic difficulty [17]. The equation was expressed as $Y=(0.015 \times L)+(0.007 \times T)-(0.015 \times E)+0.179$, where L is the distance from the lower lip border to the mentum, T is the distance from ear tragus to the corner of the mouth, and E is the distance from ear lobe to the corner of the mouth. This study used multivariate regression analysis and determined that the probability of laryngoscopic difficulty is greater if the Y value tends towards 1. Our intention was to identify and validate simple measures that predict laryngoscopic difficulty in pediatric patients that can be easily implemented in clinical practice.

The incidence of laryngoscopic difficulty in our study was higher than the incidence identified in a large retrospective study (1.35%) [16]; this is likely due to a high measurement bias, which is typical of retrospective studies.

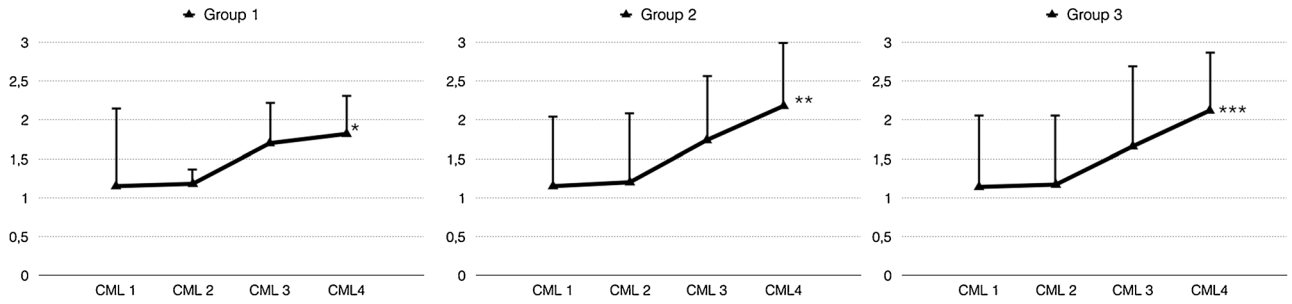
Our results suggest that a high BMI and large neck circumference do not correlate with laryngoscopic difficulty, which is consistent with a previous report on adult populations that analyzed BMI [20], but not with another study that assessed patient neck circumference [21].

We found a positive correlation between laryngoscopic difficulty and interincisors, thyromental distance and sternomental distance. We also found a positive correlation between FPCD and laryngoscopic difficulty. There are no previous studies in pediatric patients that assess these factors.

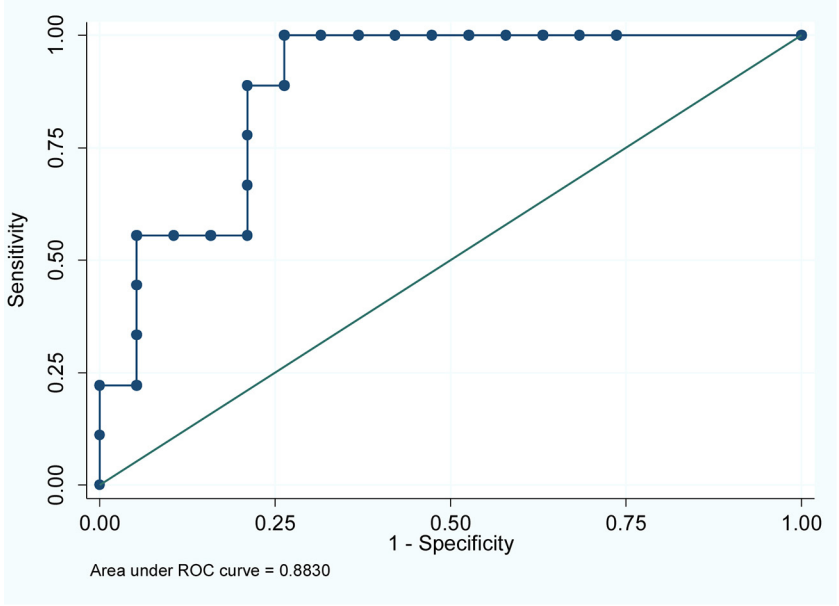
The Mallampati index, the most commonly used predictor in clinical practice, has been evaluated in adult patients in several



Graphic 3. Sternomental distance association with Cormack & Lehane classification. Data are expressed as the mean (lines)±standard deviation (bars). * $p = 0.0107$ ** $p = 0.0011$.

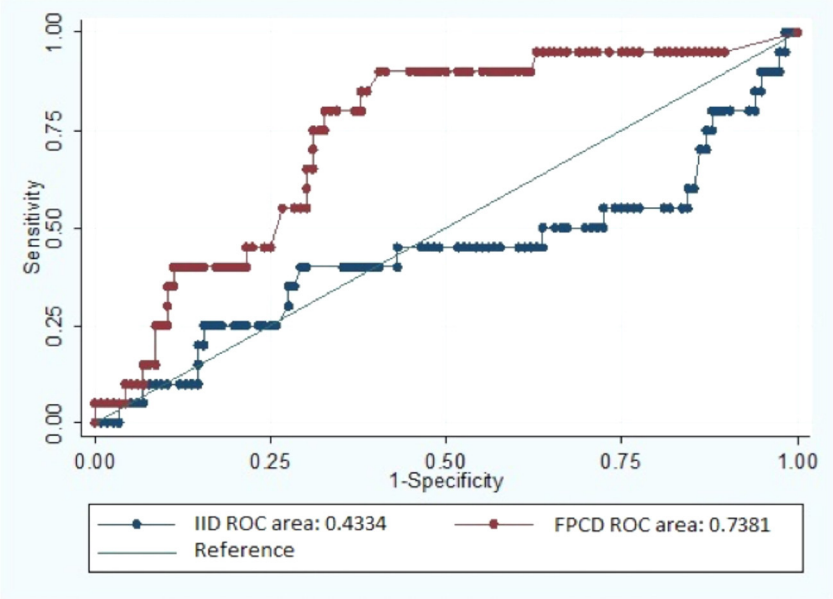


Graphic 4. FPCD association with Cormack & Lehane classification. Data are expressed as the mean (lines)±standard deviation (bars). * $p = 0.0125$ ** $p = 0.0137$ *** $p = 0.0321$.

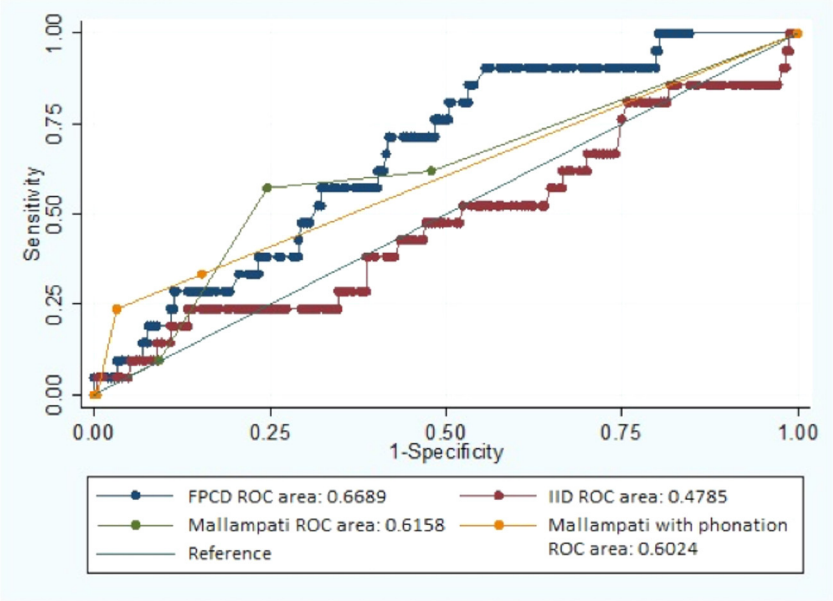


Graphic 5. ROC Curve: Distance between the frontal plane and the chin by weight of patients in group 1.

studies; however, investigators have questioned the accuracy of this test [12,22,23]. The Mallampati index is rarely used for pediatric patients partially because it demands that the patient obey simple orders. In our study, relatively few patients under 4 years of age (29,3%) were capable of following simple orders, which precluded the majority of our patients under 4 years of age



Graphic 6. ROC Curve: FPCD/weight and IID/weight of patients in group 2.



Graphic 7. ROC Curve: FPCD/weight, IID/weight, Mallampati index and Mallampati index with phonation of patients in group 3.

from qualifying for assessment by the Mallampati index. In the patients for whom the Mallampati index was applied, the sensitivity was low. The area under the ROC curve was 0.6158 (Graphic 3), which was lower than the area under the ROC curve identified in a meta-analysis involving 177,088 adults (area under the curve equal to 0.75) [23].

The major limitation of this study is the low number of patients of group I which can be explained by the lower rate of surgery requiring tracheal intubation in this age group when compared with older patients.

5. Conclusions

Our study supports the use of FPCD and the FPCD/weight ratio as the best predictors of laryngoscopic difficulty in pediatric patients. For patients over 6 months of age, the IID also correlates well with laryngoscopic difficulty. For children who were able to obey simple orders, the Mallampati test had a greater correlation with laryngoscopic difficulty than did the Mallampati test with phonation.

We strongly recommend that a skilled professional perform airway management in children and infants, especially in patients with one or more of the risk factors described. For higher-risk patients, alternative airway devices should be made readily available.

This study reveals the paucity of data involving pediatric patients and offers some easily implemented bedside tests that can predict airway management difficulty. Other efforts and studies are needed to develop safety guidelines in pediatric anesthesia or critical care medicine.

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