Ratio of height-to-thyromental distance and ratio of height-to-sternomental distance as predictors of laryngoscopic grade in children

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Abstract

Background and Aims: Failure to secure the airway is an important cause of morbidity and mortality in children. Children are often uncooperative for routine examination and pose problems for obtaining external measurements. We aimed to evaluate ratio of height-to-thyromental distance (RHTMD) and ratio of height-to-sternomental distance (RHSMD) as predictors of laryngoscopic grade in children aged 1–12 years.

Material and Methods: This study was an observational study conducted in children aged between 1 and 12 years scheduled for elective surgery under general anesthesia. Children unable to stand, having limited mouth opening/neck mobility, cleft palate or with midline neck masses were excluded. Weight, height, and thyromental and sternomental distances were measured preoperatively. Following induction of anesthesia and full-muscle relaxation, laryngoscopy was performed and Cormack–Lehane view with Cook’s modification was noted. Receiver operating characteristic (ROC) curve analysis using RHTMD and RHSMD was performed for predicting poor laryngoscopic view.

Results: A total of 138 children with mean age of 6.6 ± 3.4, RHTMD of 17.7 ± 2.1, and RHSMD of 10.0 ± 1.0 were included. No Grade 3 or 4 laryngoscopic views were obtained. ROC curve analysis was done for predicting 2b view (restricted), incidence of which was 10.1%. RHTMD was a better predictor of 2b laryngoscopic view with an area under curve (AUC) of 0.792 compared to RHSMD (AUC = 0.463).

Conclusions: In children aged 1–12 years, RHTMD is a better predictor of restricted view compared to RHSMD.

Keywords: Laryngoscopic grade, pediatric patients, ratio of height-to-thyromental distance

Introduction

Ability to predict a difficult airway aids in safe conduct of anesthesia by allowing for availability of appropriate equipment and experienced staff. Difficulties with airway management in pediatric patients are a major reason for cardiac arrest, brain injury, and death.[1-4] Several predictors for recognizing a difficult airway exist for adult population but have not been found to be reliably applicable in children. This may be in part due to lack of cooperation and comprehension in performing these tests by children. Use of external measurements may help circumvent these problems. Correlation of external measurements with laryngoscopic grade may help predict intubation difficulty.[5]

Two such parameters are ratio of height-to-thyromental distance (RHTMD) introduced by Schmitt et al. and ratio of height-to-sternomental distance (RHSMD) which have been found to have improved predictive value in adults.[6-8]
Knowledge of the application of these airway parameters in children is limited, and our study aimed to investigate the relation between them and the laryngoscopic grade.

**Material and Methods**

This observational study commenced after obtaining clearance from the Departmental Dissertation Committee and Institutional Ethics Committee for 18 months from October 8, 2013 (IEC 483/2013). Children aged between 1 and 12 years scheduled for elective surgery under general anesthesia requiring oral endotracheal intubation were included in this study. Children were excluded if they were unable to stand for height measurement, required rapid sequence induction, or had limited mouth opening, an unstable cervical spine/limited neck mobility, reactive airway, cleft palate, or midline neck mass.

Two investigators were involved in the study. Observer 1 was responsible for obtaining written informed consent, for the preoperative and intraoperative evaluation and measurements and compilation of study data. Observer 2 was a consultant anesthesiologist in charge of particular case who performed laryngoscopy and assessed Cormack–Lehane grade, and was blinded to measurements taken. Written informed consent was taken from parents/guardians of children fulfilling inclusion criteria by Observer 1 the day before surgery. Wherever possible, assent from children participating in study was also obtained.

The following measurements were taken: weight in kilograms (kg), height, thyromental distance (TMD) and sternomental distance (SMD), all in centimeters (cm). Height was measured with subject standing straight on a flat surface, head, shoulders, buttocks, and heels touching the wall with the head so that the Frankfurt Plane was parallel to the floor. Frankfurt Plane is an imaginary line joining the inferior margin of the orbit and the upper margin of external auditory meatus.[9]

TMD was measured as straight distance between thyroid notch and lower border of mental prominence. SMD was measured from sternal notch to lower border of mental prominence. Both measurements were made with head fully extended and mouth closed.

Premedication, nil per oral duration, and induction of anesthesia were ordered by Observer 2. Routine monitoring of electrocardiogram, pulse oximetry, end-tidal carbon dioxide, and noninvasive blood pressure was instituted in all cases. Following induction of anesthesia and confirmation of ability to bag and mask ventilate, muscle relaxant was administered as decided by Observer 2. Laryngoscopy was performed using an appropriately sized Macintosh laryngoscope by Observer 2 who also assessed Cormack–Lehane view as per the Cook’s modification.

From data, the following ratios were then computed:

a. RHTMD obtained by dividing height by TMD
b. RHSMD obtained by dividing height by SMD.

**Results**

A total of 138 children aged between 1 and 12 years were included in this study. The study population was further divided into two age groups, with 61 children in age group 1–5 years and 77 children in age group 6–12 years. The RHTMD ranged between 13.1 and 23.3 with mean and standard deviation of 17.7 ± 2.1. The RHSMD ranged between 7.9 and 13.6 with mean and standard deviation of 10.0 ± 1.0.

There were no Grade 3a and b or 4 laryngoscopic views in the entire study population. A Grade 2b view being considered a restricted view was used for analytical purpose. The incidence of restricted view was 10.1%. Age group 1–5 years had an incidence of 13.1% (8 out of 61) restricted views, while age group 6–12 years had an incidence of 7.8% (6 out of 77).

A receiver operating characteristic (ROC) curve analysis for each of the study parameters (RHTMD and RHSMD) for predicting a restricted view was computed [Figures 1-4 and Table 1].

The ROC curve for RHTMD for predicting a restricted view between 1 and 12 years of age is shown in Figure 1. The area under the curve (AUC) was 0.792 with a 95% confidence interval (CI) between 0.679 and 0.905. An optimal cutoff point of RHTMD >17.95 had a sensitivity of 93% and specificity of 62%.

![Figure 1: Receiver operating characteristic curve for ratio of height-to-thyromental distance in age group 1–12 years for predicting Grade 2b Cormack–Lehane View](image-url)
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The ROC curve for RHSMD for predicting a restricted view between 1 and 12 years of age is shown in Figure 2. The AUC was 0.463 with a 95% CI of 0.305–0.620, showing it to be a poor predictor of Grade 2b views. An optimal cutoff point of RHSMD > 9.6 with a sensitivity of 71% and specificity of 35% was deduced although little value is there in computing these data in light of poor performance of this test.

The AUC for RHTMD (0.792) was significantly greater than that of RHSMD (AUC = 0.463), showing it to be a better discriminator of a restricted view compared to easy views (1 and 2a) in children between 1 and 12 years of age.

The ROC curve for RHTMD for predicting a restricted view between 1 and 5 years of age is shown in Figure 3. The AUC was 0.732 with a 95% CI of 0.571–0.893. An optimal cutoff point of RHTMD > 17.9 with a sensitivity of 88% and specificity of 64% was deduced as revealed by ROC curve.

The ROC curve for RHTMD for predicting a restricted view between 6 and 12 years of age is shown in Figure 4. The AUC was 0.903 with a 95% CI of 0.804–1.00. An optimal cut off point of RHTMD > 18.6 with a sensitivity of 100% and specificity of 70% was deduced from the ROC curve.

From the ROC curve, RHTMD in age group 6–12 years was seen to have a greater AUC (0.903) than children aged 1–5 years (AUC = 0.732) and therefore a better predictor of a restricted view.

Discussion

Few studies exist in pediatric population and to detect a difficult airway. This may be a result of low incidence of a difficult airway, lack of cooperation for routine airway assessment, and difficulty in standardization based on anatomical and physical variations within the pediatric population.

Our study aimed to see if RHTMD and RHSMD could predict poor laryngoscopic views in children aged between 1 and 12 years. We assumed a poor laryngoscopic view to correlate with a difficult intubation and used Cook’s modification of the Cormack–Lehane Grading System.[10] This system considers the use of three discriminators of laryngoscopic difficulty, easy (Cormack–Lehane Grade 1 and 2a), restricted (Cormack–Lehane Grade 2b and 3a), and difficult (Cormack–Lehane Grade 3b and 4). In our study population of 138 children aged between 1 and 12 years, there were

Table 1: Prediction of Grade 2b Cormack-Lehane laryngoscopic view by RHTMD and RHSMD

| Cut off   | Sensitivity (%) | Specificity (%) | AUC   | 95% CI       | PPV (%) | NPV (%) | P     |
|----------|----------------|-----------------|-------|--------------|---------|---------|-------|
| RHTMD    |                |                 |       |              |         |         |       |
| 1-12 years | 18.0           | 93              | 62    | 0.792        | 0.679-0.905 | 21       | 99     | <0.001|
| RHSMD    |                |                 |       |              |         |         |       |
| 1-12 years | 9.6            | 71              | 35    | 0.463        | 0.305-0.620 | 11       | 91     | 0.649 |
| RHTMD    |                |                 |       |              |         |         |       |
| 1-5 years | 17.9           | 88              | 64    | 0.732        | 0.571-0.893 | 27       | 97     | 0.035 |
| RHTMD    |                |                 |       |              |         |         |       |
| 6-12 years | 18.6           | 100             | 70    | 0.903        | 0.804-1.00 | 22       | 100    | 0.001 |

RHTMD=Ratio of height-to-thyromental distance, RHSMD=Ratio of height-to-sternomental distance, AUC=Area under curve, CI=Confidence interval, PPV=Positive predictive value, NPV=Negative predictive value
no difficult (Grade 3 or 4) laryngoscopic views, and only 14 (10.1%) children had restricted (Grade 2b) views. Our findings are similar to Rafique and Khan who in 196 children between 1 month and 8 years of age observed only two difficult (Grade 3) laryngoscopic views, both of which were < 1 year of age. As we obtained no difficult views, we analyzed RHTMD and RHSMD as predictors of a restricted view. The absence of difficult laryngoscopic views in our study may be explained by findings of Heinrich et al. They observed in a large retrospective study that overall incidence of difficult laryngoscopy was 1.6%, of which incidence was 4.7% in children below 1 year compared to 0.7% children above 1 year of age. Most of difficult laryngoscopies were in the oro-maxillo-facial surgery and pediatric cardiac surgery department, with a possible explanation being high proportion of cleft palate interventions in oral surgery as well as syndromic children in pediatric cardiac surgery department. This may account for the absence of difficult views in our study which excluded children with known airway difficulties.

RHTMD has variably been shown to be a good individual predictor of difficult laryngoscopic grade in adults. RHTMD, introduced by Schmitt et al., has better predictive value for predicting difficult laryngoscopy than TMD as it accounts for individual’s body proportions unlike TMD. This may be useful in pediatric population who present a range of dimensions wherein use of a ratio would better account for these differences. Furthermore, ease of obtaining such measurements may be useful with younger children who may be noncompliant to other routine airway tests. The possible role of RHSMD as an airway predictor was also investigated which Farzi et al. found to be a useful and valuable clinical screening test in adults.

We found RHTMD to be a better predictor than RHSMD of a restricted view in children between 1 and 12 years. It had a higher AUC and a superior sensitivity and specificity. An optimal cutoff of ≥ 17.95 for RHTMD had a sensitivity of 93% and specificity of 62%.

One of the limitations of our study is that the age group of 1–12 years is a large range being nonhomogenous and with varying anatomical, physical, and developmental characteristics. A child aged in the lower end of group may have a completely different upper airway anatomy and body proportions compared to a prepubertal child in upper end of the study group. In view of this, we divided study population further into two groups to look for any difference within study population, with toddlers and preschool children in one group (1–5 years) and middle-aged children (6–12 years) in another, though this does not entirely circumvent the problem. We analyzed only RHTMD in these two groups as our analysis revealed it to be a fairly good predictor while RHSMD was poorly predictive.

Within the two age groups, there was no significant difference in mean RHTMD (P = 0.11). The incidence of a restricted view was 13.1% in children between 1 and 5 years while age group 6–12 years had an incidence of 7.8%. RHTMD was a better predictor of a restricted laryngoscopic view in age group 6–12 years with a higher AUC of 0.903 compared to younger children between 1 and 5 years (AUC = 0.732). This difference may be explained by the fact that younger children exhibit a greater difference in airway anatomy from adults. These differences are most important under 2 years of age and decrease as child matures, with most differences disappearing around 6–8 years of age. Thus, we can conclude that RHTMD is a good predictor of a restricted laryngoscopic view in children aged 1–12 years being a stronger predictor in older children between 6 and 12 years.

The biggest limitation of our study was that there were no difficult laryngoscopic grades. Thus, even though RHTMD seems to discriminate restricted laryngoscopic views from easy ones, whether or not it could predict difficult views remains uncertain. Similarly, RHSMD cannot be ruled out as a predictor of a difficult laryngoscopic view based on our study findings. However, we feel that it is worthwhile to explore this possibility in a much larger sample, especially in older children. We also recommend breaking up children into smaller age groups as we observed that there was a disproportionate increase in height in relation to TMD as child grows.

Another limitation of our study is that we did not standardize the Macintosh blade size and left it up to the laryngoscopist’s preference with assumption that he/she was experienced enough in pediatric intubation to make the best decision. Tripathi and Pandey observed
a difference in laryngoscopic views when the blade size was varied according to the patients TMD, thus implying that an inappropriately chosen blade may affect the final laryngoscopic view.\textsuperscript{[14]}

Interobserver variability in Cormack–Lehane view may exist especially with Cook’s modification in which several subgrades exist. Ochroch et al. found that Cormack–Lehane Grading System had excellent intraphysician concordance, but the interphysician reliability was poor.\textsuperscript{[15]} In addition, assumption that a poor laryngoscopic view correlates with a difficult intubation may not be entirely valid, with some Grade 1 views being difficult to intubate and some Grade 3 views being easy to intubate.\textsuperscript{[16]} All intubations in our study were performed in the first attempt without any additional equipment or other assistance, regardless of grade of laryngoscopy.

The measurements of TMD and SMD themselves though landmark-based were dependent on degree of extension at neck requiring some degree of cooperation and comprehension by a child. This leads to possibility of some children extending less which may have gone undetected on visual inspection.

Finally, though RHTMD was found to be a good predictive test, we feel that our small-study population coupled with low incidence of restricted laryngoscopic views prevents us from recommending any of the cutoff values.

**Conclusions**

RHTMD is a better predictor of restricted laryngoscopic view compared to RHSMD. RHTMD in children aged 1-12 years has a greater predictive value of a restricted laryngoscopic view in children between 6 and 12 years of age when compared to children between 1 and 5 years.

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**Conflicts of interest**

There are no conflicts of interest.

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