Ratio of height to thyromental distance as a predictor of difficult laryngoscopy: A prospective observational study

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Abstract
Background and Aim: Various airway indices are used either singly or in combination to predict difficult laryngoscopy. Recently introduced ratio of height to thyromental distance (RHTMD) is reported to have better predictability. We aimed to assess the prediction of difficult laryngoscopy by RHTMD and compared it with other indices.

Material and Methods: In this prospective, single-blinded comparative observational study, 300 adult patients of either gender scheduled to receive general anesthesia were assessed. Airway indices, like RHTMD, thyromental distance, modified Mallampati test, and upper lip bite test, were assessed and correlated with Cormack and Lehane's laryngoscopic grading. The validity parameters like specificity, sensitivity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated for each test. Effect of combining all the indices was also analyzed. Receiver operating characteristic curves were constructed and optimal cutoff value for the quantitative indices was calculated.

Results: The incidence of difficult laryngoscopy in our study was 5.33%. Of the four indices, the single best test was RHTMD, with better sensitivity, high specificity, NPV, and accuracy and with good PPV. A combination of all the indices resulted in 100% sensitivity and higher specificity.

Conclusions: RHTMD is a single best preoperative test for predicting difficult laryngoscopy. A combination of tests has higher sensitivity and specificity with better discriminative power. Therefore indices should be used in combination in the preoperative airway assessment of adult patients.

Keywords: Airway assessment test, difficult airway, difficult laryngoscopy, ratio of height to thyromental distance

Introduction
The foremost responsibility of every anesthesiologist is to keep the airway patent because failure to do so and oxygenate will result in a catastrophe. Airway-related incidents are a major cause of anesthesia-related morbidity, mortality, and litigations.[1] The reported incidence of difficult laryngoscopy and intubation is 1.5%–13%[2,4] and cannot intubate and cannot ventilate is 0.001%–0.02%.[3,7] Unanticipated difficult airway and associated morbidity can be reduced if difficult airway could be predicted correctly during the preoperative assessment. The fundamental initial step in planning airway management is evaluation of airway. Although several preoperative bed side airway assessment tests are there, which anatomical landmark or indices is the best predictor is debatable. The recently introduced ratio of height to thyromental distance (RHTMD) is reported to have better predictability but not many published studies have compared it with other indices for predicting difficult laryngoscopy. We aimed to assess the role of RHTMD in predicting difficult laryngoscopy compared with modified Mallampati test (MMT), thyromental distance (TMD), and upper lip bite test (ULBT).

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Material and Methods

This prospective, single-blinded observational comparative study was conducted in a tertiary care teaching hospital after getting institutional research and ethics committee approval. Three hundred adult patients of either gender in 15- to 60-year age group of American society of anaesthesiologists (ASA) physical status I and II, scheduled for elective surgery under general anesthesia with endotracheal intubation, were enrolled in the study. Patients with obvious distorted anatomy of head and neck, cervical spine pathology, inability to sit/stand, need for rapid sequence induction, and midline neck swellings, and edentulous patients were excluded from the study.

Informed written consent was obtained from all patients after preoperative evaluation. The airway was assessed in the preoperative holding area using MMT, TMD, ULBT, and RHTMD by the principal investigator. The height, weight, ASA status, and body mass index were also noted for all patients.

The MMT was assessed with patients in sitting position, mouth wide open, and tongue maximally protruding without phonation.\[7] The ULBT was assessed by asking the patient to bite his/her upper lip with lower incisors.\[8] TMD was measured with a rigid ruler from lower border of thyroid notch to bony point of mentum with patients head extended and mouth closed.\[9] The RHTMD was calculated by the formula: RHTMD = Height in cm/TMD in cm. MMT Class 3 and Class 4, ULBT Class 3, TMD < 6 cm, and RHTMD > 23.5 were considered as predictors of difficult laryngoscopy.\[10]

An emergency difficult airway cart was kept ready in the operation theater. A standard general anesthesia protocol was followed for all cases. All patients received premedication, inj midazolam 0.02 mg/kg and inj fentanyl 2 μg/kg intravenously, after attaching standard monitors. After preoxygenation with 100% O\(_2\) in each patient, anesthesia was induced with 5 mg/kg of thiopentone sodium and 1.5 mg/kg of succinyl choline was given intravenously to facilitate tracheal intubation after ensuring mask ventilation. Direct laryngoscopy was performed using a Macintosh size 3 or 4 laryngoscope with the patient in sniffing position, and the glottic view was graded using the Cormack and Lehane’s classification.\[11]

The anesthesiologist (with a minimum of 2-year experience in anesthesia) who documented the Cormack and Lehane’s grading was blinded to the preoperative airway indices to minimize the observer bias. The Cormack and Lehane’s Grades 3 and 4 were considered as difficult laryngoscopy. Tracheal intubation was done with an appropriately sized endotracheal tube and standard anesthetic management was continued.

Sample size was calculated (\(n = \frac{4pq}{d^2 \times \text{proportion}}\)) expecting a sensitivity of 80% for RHTMD for detecting the difficult airway based on a prior study.\[10] To detect a sensitivity of 80% with a precision of 15% and expecting 10% of the patients to have difficult airway, the sample size was calculated to be 285 subjects. We selected 300 as sample size for the study. Statistical analysis of data was done to evaluate the predictive value of each test for difficult laryngoscopy. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of each test was calculated. Statistical significance of each test was calculated and compared using OpenEpi version 3.03. Receiver operating characteristic (ROC) curve was plotted for the indices with sensitivity against 1-specificity using Statistical Package for Social Sciences software version 18 (SPSS Inc., Chicago, IL, USA). The area under the curve (AUC) was calculated, which is a measure of the prognostic accuracy of the test. An optimal cutoff value for each quantitative variable was also obtained. Demographic data were presented as mean ± standard deviation or as number.

Results

All the enrolled 300 patients completed the study. The demographic data of patients are summarized in Table 1. The incidence of difficult laryngoscopy was 5.33% (Cormack–Lehane’s Grades 3 and 4 in 15 and 1 patient, respectively). The distribution of predictive tests based on Cormack–Lehane’s laryngoscopic grading is given in Table 2. There was no failed intubation in our study. Of the 16 cases of difficult laryngoscopy, 14 were intubated in first attempt with optimum external laryngeal manipulation. The remaining two patients were intubated with the help of gum elastic bougie; one in second attempt and other in third attempt with a change of laryngoscope blade size.

The sensitivity, specificity, PPV, NPV, and accuracy of the studied tests are presented in Table 3. MMT had the highest
sensitivity of followed by RHTMD and TMD, and ULBT had the least sensitivity. Specificity was good for all the tests. PPV was highest for ULBT and worst for MMT. NPVs were high for MMT, TMD, and RHTMD and moderate for ULBT. Accuracy of all tests except MMT was very high.

ROC curves were constructed [Figure 1] and AUC for each index was calculated, which was highest for RHTMD (0.873) [Table 3]. The optimum cutoff value derived from ROC curve for RHTMD was 22.1 and for thyromental distance was 6.55 cm.

When all the four tests were considered together and any one test was positive, the sensitivity was 100%, and specificity of predicting difficult laryngoscopy was 73%.

Discussion

A thorough preoperative airway assessment is the cornerstone of successful airway management as unanticipated difficult airway often leads to worse outcome. Although there are several predictors and clinical tests, no single test could correctly predict all cases of difficult laryngoscopy. Of all the difficult airways we encountered, only 50% are correctly predicted preoperatively.[12] An ideal airway predictor should have a high sensitivity, specificity, and PPV. A false negative prediction can be life threatening; therefore, low false negative prediction is more important. A false positive result is also important, because predicted difficult airway necessitates alternate approaches for airway management, which often require more time and resources often at the cost of patient discomfort.

In our study of 300 adult patients, we compared the airway indices RHTMD, TMD, MMT, and ULBT with respect to sensitivity, specificity, PPV, NPV, and accuracy. The incidence of difficult laryngoscopy in our study was 5.33%, which is comparable with the reported incidence of 1.5%–13%.[3‑6] The wide range of incidence reported in studies could be due to several reasons such as lack of uniformity in the practice of laryngoscopy and intubation as in head and neck positioning, application of Sellick manoeuvre, external laryngeal manipulation, multiple attempts, type of blade used, and varying skill of anesthesiologists.[6]

The RHTMD was introduced by Schmitt et al. as a better predictor of difficult laryngoscopy than TMD.[10] RHTMD addresses the body proportions of the patient and hence should be a better index than TMD. A cutoff value of 23.5 was reported as a risk factor for difficult laryngoscopy.[3,13,14] In our study, RHTMD has higher sensitivity and accuracy, better specificity, and highest NPV. The sensitivity of RHTMD in our study was 62.5%, which was comparable with earlier studies,[14‑17] but lower compared with some other

| Test    | Grade          | Number of cases | CL I and II Number of cases | CL III and IV Number of cases |
|---------|----------------|-----------------|-----------------------------|-------------------------------|
| MMT     | Easy (I and II)| 215             | 210                         | 5                             |
|         | Difficult (III and IV) | 85             | 74                          | 11                            |
| TMD     | Easy (>6 cm)   | 285             | 277                         | 8                             |
|         | Difficult (≤6 cm) | 15             | 7                           | 8                             |
| ULBT    | Easy (1 and 2) | 294             | 282                         | 12                            |
|         | Difficult (3)  | 6               | 2                           | 4                             |
| RHTMD   | Easy (<23.5)   | 279             | 273                         | 6                             |
|         | Difficult (≥23.5) | 21             | 11                          | 10                            |

Table 2: Distribution of predictive tests studied with respect to Cormack-Lehane’s grading

| Variable | 95% CI | Sensitivity | Specificity | PPV | NPV | Accuracy | Area under ROC curve |
|----------|--------|-------------|-------------|-----|-----|----------|----------------------|
| MMT      | 68.8 (44.4‑85.8) | 73.9 (68.5‑78.7) | 12.9 (7.4‑21.7) | 97.7 (94.7‑99) | 73.7 (68.4‑78.3) | 0.724 |
| TMD      | 50 (28‑72) | 97.5 (95‑98.8) | 53.3 (30‑1.75.2) | 97.2 (94.6‑98.6) | 95 (91.9‑97.0) | 0.786 |
| ULBT     | 25 (10.2‑49.5) | 99.3 (97.5‑99.8) | 95.9 (93‑97.7) | 66.7 (30.90.3) | 95.3 (92.3‑97.2) | 0.669 |
| RHTMD    | 62.5 (38.6‑81.5) | 96.1 (93.2‑97.8) | 47.6 (28.3‑67.6) | 97.9 (95.4‑99) | 94.3 (91.1‑96.4) | 0.873 |

Table 3: Comparison of various predictive tests

Values as percentage. MMT = Modified Mallampati test, TMD = Thyromental distance, ULBT = Upper lip bite test, RHTMD = Ratio of height to thyromental distance, PPV = Positive predictive value, NPV = Negative predictive value, ROC = Receiver operating characteristic
The specificity of RHTMD was comparable with earlier reports. The area under the ROC curve, which is a measure of accuracy and discriminative power, was also higher for RHTMD (0.873). Higher AUC denotes more reliability and discriminative power. The optimal cutoff value for the study population obtained was 22.1 with a sensitivity of 81.3% and specificity of 84.9%. The cutoff value for RHTMD in other studies were different (23.5 and 25) and the calculated statistical values also differ which could be due to racial differences. A recent study in south Indian population, attempted to find out the optimum airway measurements to predict difficult intubation, has reported a cutoff value of 17.1. This is probably due to the higher mean TMD (9.03 cm) reported in the study. Though their sample size was good, the study could not provide optimum measurements for the predictive tests, as their best outcome being an area under ROC curve of 0.64 for RHTMD and all other indices giving a value <0.50. AUC is used as a measure of accuracy and discriminative power of a diagnostic test and is accepted to be of clinical relevance if the value is ≥0.7. Further investigations are needed to establish any significance of ethnicity on difficult airway prediction. A recent systematic review has pointed out the limited and inconsistent capacity of bedside predictors to discriminate between difficult and easy airways with few studies having AUC values in clinically relevant ranges.

The TMD or Patil’s test is found to have a wide range of cut off value (5.5–7cm) in literature. TMD can have a high inter-observer variability as the definition is not clear whether to measure the distance from thyroid notch to the inner or outer aspect of mentum. Arguably, the inner measurement should be taken as TMD is an indication of “mandibular space.” In a meta-analysis, it was found that a thyromental distance of ≤6.0 cm slightly improved the prediction of difficult intubation. We found a high specificity but a low sensitivity for TMD similar to other reports. The optimal cutoff value for our population obtained was 6.45 cm. Mean value of TMD in the study population was 7.5 cm. Other Indian studies have reported mean TMD values as 7.48, 9.03, 5.95, and 6.5 cm; the latter two studies adopted the inner measurement. Area under the ROC curve for TMD (0.786) was slightly lower than that of RHTMD (0.873).

Samsoon and Young’s modification of the Mallampati test as an airway predictor has been in use for many years, but it has got some major limitations. The high interobserver variability and poor demarcation between various classes make it a less reliable tool. Prevention of phonation and maximal protrusion of tongue has to be ensured for a reliable score with MMT. We observed a low or moderate sensitivity, specificity, and a poor PPV and accuracy similar to other reports. The ULBT which depends on jaw subluxation and presence of buck teeth was introduced as a simple and reliable predictor of difficult laryngoscopy. ULBT was reported to have a high interobserver reliability because of its precise and easy demarcation between classes. In our study, ULBT had the highest specificity, PPV, and accuracy but fails as a diagnostic test with its lowest sensitivity. High specificity of ULBT in our study was comparable with or higher than other previous reports. The low sensitivity of ULBT in our study compared with other reports could be due to population differences. Apart from this racial difference, another limitation of ULBT is that it cannot be applied to edentulous patients.

When we compared the four tests, the single best test was RHTMD having high specificity and accuracy, moderate sensitivity, PPV, and good NPV. Also it does not require patient cooperation unlike MMT or ULBT. Predictive value of any single clinical test is limited. If we do all four tests in parallel, we can increase the sensitivity to 100% so that all cases of difficult laryngoscopy can be correctly predicted. Since difficult airway is multifactorial in origin, using combination of tests is more sensible and will definitely yield better results than single test alone.

One of the limitations of our study is that observer bias in Cormack and Lehane’s grading could be possible as laryngoscopy was done by different anaesthesiologists, their skill and experience may vary, though all were experienced anesthesiologists. Our result may not be applicable to other racial groups. Anthropometric variations in different populations make it impossible to get an optimum cutoff value, for many indices predicting difficult intubation, which can be applied to other population groups. We need further studies to validate our findings with a strict definition of TMD so as to reach an optimum cut off value for a population. The inconvenience of carrying a pocket scale, which hindered the popularity of RHTMD in routine pre anesthetic assessment, could only be overcome if it would have a reliable discriminating capacity among airway indices.

As the diagnostic value or discriminative power of airway predictors vary with population groups or situations, it continues to be a challenge to the anesthesia provider to decide which technique or device will benefit that individual patient. A thorough preoperative airway assessment and close adherence to difficult airway algorithms are mandatory to prevent airway-related catastrophes.
Conclusions

Our study results suggest that RHTMD is a better bed side screening test for predicting difficult laryngoscopy in adult patients. Multiple tests should be used in combination for better prediction of difficult laryngoscopy.

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Conflicts of interest

There are no conflicts of interest.

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