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Research Paper

Ratios of Height-to-Thyromental Distance and Height-to-Sternomental Distance as Predictors of Difficult Airway in Patients Posted for General Anesthesia

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Background: Preoperative airway assessment and anticipation of a difficult airway is of utmost critical value in anesthesiology as failure to secure airway can lead to morbidity and mortality. The study evaluated ratio of height-to-thyromental distance (RHTMD) and ratio of height-to-sternomental distance (RHSMD) as predictors of a difficult airway.
Methods: The prospective observational study evaluated 131 adult participants scheduled for elective surgery under general anesthesia. In addition to the preoperative airway assessment, RHTMD and RHSMD were calculated. Correlation of these ratios with the Cormack–Lehane grading of glottis visualisation on direct laryngoscopic view following induction of anesthesia was analyzed. The optimal cut-off point for RHTMD and RHSMD were identified using receiver operating characteristic curve analysis.
Results: The incidence of difficult intubation was 14.50%. The cut-off values for RHTMD and RHSMD were < 21.50 (sensitivity 85.25%, specificity 100.00%) and < 10.50 (sensitivity 84.21%, specificity 96.42%) respectively for predicting difficult airway. The area under the curve with 95% confidence interval for RHTMD was 0.875 (0.730–1.000) and that for RHSMD was 0.890 (0.777–1.000).
Conclusion: RHTMD was found to be a better predictor of difficult intubation and restricted laryngoscopic view compared to RHSMD.

Keywords: *airway assessment, Cormack–Lehane's grading, difficult intubation, sternomental distance, thyromental distance*

Introduction

Anticipating and managing difficult intubation is a vital skill to the practice of anesthesiology. Difficult/failed intubation is one of the major causes of anesthesia related morbidity and mortality.[1] Closed claims analysis study for management of difficult airway found that the vast majority (85%) of airway related events involve brain damage, and one-third of mortality was attributable solely to anesthesia, which was due to inability to maintain a patent airway and oxygenation.[2] Task Force on Management of the Difficult Airway by the American Society of Anesthesiologists (ASA) recommends that a patient must be assessed preoperatively for airway difficulties.[3] Difficult laryngoscopy and intubation is described in 1.5 to 16.0% of patients.[4] Hence preoperative evaluation of the airway is one of the fundamental steps in anesthesia.

Difficult airway may manifest as difficulty in ventilation, difficult laryngoscopy, or difficult intuba-

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tion. Manipulation of the airway by multiple attempts during direct laryngoscopy often leads to airway trauma, bleeding, and oedema which ultimately interfere with vocal cord visualization.[5]

Many preoperative airway assessment tests like inter-incisor gap, mouth opening, Mallampati grading, head and neck movement, upper lip bite test, sternomental distance (SMD), and thyromental distance (TMD) are used to predict difficult intubation, but sensitivity and positive predictive values (PPVs) of these individual tests are low while false positive results are high.[6]

Ratio of height-to-thyromental distance (RHTMD) introduced by Schmitt et al.[7] and ratio of height-to-sternomental distance (RHSMD) are considered as useful screening tests for predicting difficult laryngoscopy; however, very few studies exist comparing these two predictive tests.[8]

The present study was carried out to evaluate the ability of RHTMD and RHSMD to predict difficult laryngoscopy.

Methods

This prospective analytical cross-sectional study was carried out in 131 patients in a tertiary care teaching hospital. Approval from the Institutional Ethics Committee was obtained before conducting the study. Written informed consent was obtained from the patients for participation in the study. Patients of either gender, from 18 to 60 years of age, belonging to ASA physical status 1 and 2 scheduled for elective surgery under general anesthesia and tracheal intubation were included in the study. Patients with restricted neck mobility, major airway abnormalities, tumours or mass in the neck or airway, post burn neck contractures, pregnancy, kyphoscoliosis, obesity (BMI [body mass index] > 30), and those requiring rapid sequence intubation were excluded from the study. Sample size was calculated with the anticipated sensitivity and specificity of RHTMD 93% and 62% respectively[4] and 95% confidence level. Consecutive patients fulfilling the inclusion and exclusion criteria were enrolled for the study. Anesthesiologists with > 5 years of experience were involved in the preoperative airway assessment and grading of glottis exposure on direct laryngoscopy. All the enrolled patients underwent a thorough preoperative evaluation including a detailed history and clinical examination and advised standard preoperative fasting guidelines. Laboratory investigations, chest X-ray, electrocardiography (ECG), and echocardiography were assessed relevant to the patient and surgical requirements. Airway assessment was done by a single anesthesiologist in all the cases who would not participate in the endotracheal intubation. Parameters included modified Mallampati classification (MMC), inter incisor gap, TMD, SMD, weight (kg), height (cm), BMI, and neck mobility. The Mallampati grading was done in the sitting position, with mouth open and tongue protruded without phonation. Patients were graded as class 1 if soft palate, faucial pillars, and uvula were visible; class 2 if soft palate or/and uvula were visible; class 3 if only soft palate and the base of uvula were visible; and class 4 if soft palate is not visible and only hard palate is visible.

TMD (in cm) was measured from bony point of mentum to thyroid notch with head in extension and mouth closed. SMD (in cm) was measured from bony point of mentum to manubrium sterni with head in extension and mouth closed. RHTMD was calculated from the ratio of height and TMD. RHSMD was calculated from the ratio of height and SMD. Mallampati class 3 and 4, TMD < 6.0 cm, SMD < 13.5 cm, RHTMD > 23.5,[7] and RHSMD > 12.5[8] were considered as predictors of difficult intubation. On arrival at the operation theatre, baseline vital parameters were recorded. Standard general anesthesia procedure was performed as per the institutional practice. Difficult airway carts with bougie, stillette, videolaryngoscopes, laryngeal mask airway, and fiberoptic bronchoscope of appropriate sizes were made available in the operating room. Intraoperative monitoring included pulse oximetry, non-invasive blood pressure, capnography, and ECG.

All patients were given intravenous premedication with ondansetron 0.10 mg/kg, midazolam 0.02 mg/kg, glycopyrrolate 0.02 mg/kg, and fentanyl 2.00 μg/kg. Following preoxygenation with 100% oxygen for 3 minutes induction was achieved with inj. propofol 1.0–2.0 mg/kg and muscle relaxation was achieved by vecuronium 0.1 mg/kg. An anesthesiologist with > 5 years of experience did a direct laryngoscopy with an appropriate sized macintosh blade and graded the glottis exposure. The best view obtained at the first attempt by the laryngoscopy without using any external manoeuvre was considered for the Cormack–Lehane classification.[9] Grade 1—visualization of the entire laryngeal aperture, grade 2—visualization of parts of the laryngeal aperture or the arytenoids, grade 3—visualization of only the epiglottis, and grade 4—visualization of only the soft palate.

Intubation was considered difficult if the view on laryngoscopy was Cormack–Lehane grade 3 or 4, more than 3 attempts at tracheal intubation, duration taken for intubation longer than 10 minutes, failure to intubate or if special manoeuvres or additional aids such as stylets/bougie/video laryngoscopy/fiberoptic bronchoscope were required to facilitate intubation. If difficulty was experienced in tracheal intubation external laryngeal manipulation and backward, upward and rightward pressure on thyroid cartilage was applied as it improved visualization of glottis on direct laryngoscopy.

After endotracheal intubation with appropriate size endotracheal tube anesthesia was maintained with O_2, N_2O, isoflurane and vecuronium with controlled ventilation and further anesthetic management continued.

The preoperative airway assessment data and the findings during intubation were assessed to establish the incidence of difficult intubation, and the ability of RHTMD and RHSMD to predict difficult airway was noted in each patient. Data were analyzed using SPSS software v.23 (IBM Statistics, Chicago, USA) and Microsoft office 2007 and were represented using mean ± standard deviation, sensitivity, specificity, percentages, diagrams, chi-square test, and receiver operating characteristic (ROC) curve analysis. $P < 0.05$ was considered statistically significant.

Results

All the enrolled 131 patients completed the study. The mean age of the patients was 40.340 ± 11.908 years. The mean height of patients was 160.780 ± 10.774 cm. The mean weight of patients was 62.270 ± 12.424 kg. The mean BMI (kg/m^2) was 24.210 ± 1.870 (Tables 1 and 2).

Difficult intubation was seen in 19 patients (incidence 14.5%) based on Cormack–Lehane grading (grade 3 and 4 was seen in 12 and 7 patients respectively) (Table 3). There was no failed intubation in our study. Of the 19 cases of difficult intubation, 16 were intubated in the first attempt with external laryngeal manipulation, and the remaining 3 patients were intubated using gum elastic bougie. On analysing RHTMD and RHSMD using chi-square test RHTMD is found to have more predictive value than RHSMD (Table 4). ROC curves were constructed for RHTMD (Figure 1) and RHSMD (Figure 2). The optimum cut-off value derived from the ROC curve for RHTMD and RHSMD was 21.50 and 10.50 respectively. RHTMD

Table 1. Demographic Data of Patients

Variable	No. of patients	Percentage
Age, y		
18–20	11	8.4
21–30	19	14.5
31–40	40	30.5
41–50	32	24.4
51–60	29	22.1
Total	131	100.0
Gender		
Female	68	52.0
Male	63	48.0
ASA grade		
1	74	56.5
2	57	43.5

Abbreviation: ASA, American Society of Anesthesiologists.

Table 2. Descriptive Statistics

Variable	Minimum	Maximum	Mean	SD
Age, y	18	60	40.340	11.908
Height, cm	140	181	160.780	10.774
Weight, kg	36	96	62.270	12.424
BMI, kg/m^2	18.36	29.62	24.210	1.870
TMD, cm	6	19	9.460	1.816
SMD, cm	8	24	17.850	2.802
RHTMD	9	27	17.490	3.391
RHSMD	7	20	9.210	1.690

Abbreviations: BMI, body mass index; RHSMD, ratio of height-to-sternomental distance; RHTMD, ratio of height-to-thyromental distance; SD, standard deviation; SMD, sternomental distance; TMD, thyromental distance.

was found to be more sensitive and specific compared to RHSMD, both RHTMD and RHSMD were comparable on ROC curve analysis without much difference in area under the curve (AUC). Using RHTMD in combination with RHSMD increases the chance of predicting difficult intubation, rather than using them alone, and both the predictive tests were found to be highly statistically significant.

Discussion

Various clinical trials have outlined the importance of preoperative airway assessment plans to aid the anesthesiologists in managing difficult airway. Several methods using both single and multiple tests have been employed to predict difficult airway.[9] A screening test employed for prediction of difficult intubation should have high specificity and sensitivity, resulting in minimal false positive and false negative values. The consequences of false negative results are deleterious and life threatening.

A test to predict difficult intubation should have high sensitivity so that it will identify most patients in whom intubation will be truly difficult. The incidence of difficult intubation in various studies range from 1–18%, and that of failed intubation is between 0.05–0.35%.[10] The incidence of difficult intubation and failed intubation in the present study was 14.5% and 0.0% respectively. This wide variation in the incidence of difficult laryngoscopy and intubation can be attributed to factors such as ethnic differences among populations, experience of the attending anesthesiologist, sniffing position, and use of external laryngeal manipulation. External laryngeal manipulation increases thyromental height and improves laryngoscopic view.[11]

The cut-off value for TMD ranges from 5.5–7.0 in different studies. According to previous studies, TMD ≤ 6 cm improved the prediction of difficult intubation.[12] In the present study among 19 patients who were found to have difficult intubation 14 patients had a TMD ≤ 6 cm. Ramadhani et al.[13] evaluated SMD as a sole predictor of difficult laryngoscopy in the obstetric population. SMD and laryngoscopic view were documented in parturient patients undergoing Caesarean section under general anesthesia, and the

Table 3. Distribution of Predictive Tests Based on CL Grading

Test	CL grade			Chi-square test	*P* value
	Easy (%)	Difficult (%)	Total (%)		
RHTMD					
Easy	112 (100.0) (TN)	6 (31.6) (FN)	118 (90.1)	$X^2 = 85.074$	$P = 0.0001$[a]
Difficult	0 (0.0) (FP)	13 (68.4) (TP)	13 (9.9)		
Total	112 (85.5)	19 (14.5)	131 (100.0)		
RHSMD					
Easy	111 (99.0) (TN)	13 (68.4) (FN)	124 (94.7)	$X^2 = 30.242$	$P = 0.0001$[a]
Difficult	1 (1.0) (FP)	6 (31.6) (TP)	7 (5.3)		
Total	112 (85.5)	19 (14.5)	131 (100.0)		

Abbreviations: CL, Cormack–Lehane; FN, false negative; FP, false positive; RHSMD, ratio of height-to-sternomental distance; RHTMD, ratio of height-to-thyromental distance; TN, true negative; TP, true positive.
[a]Highly significant.

Table 4. Analysis of RHTMD and RHSMD

RHTMD	RHSMD		Total (%)	Chi-square test	*P* value
	Easy < 12.50 (%)	Difficult > 12.50 (%)			
Easy < 23.50	116 (93.5)	2 (28.6)	118 (90.0)	$X^2 = 31.296$	$P = 0.0001$[a]
Difficult > 23.50	8 (6.5)	5 (71.4)	13 (10.0)		
Total	124 (100.0)	7 (100.0)	131		

Abbreviations: RHSMD, ratio of height-to-sternomental distance; RHTMD, ratio of height-to-thyromental distance.
[a]Highly significant.

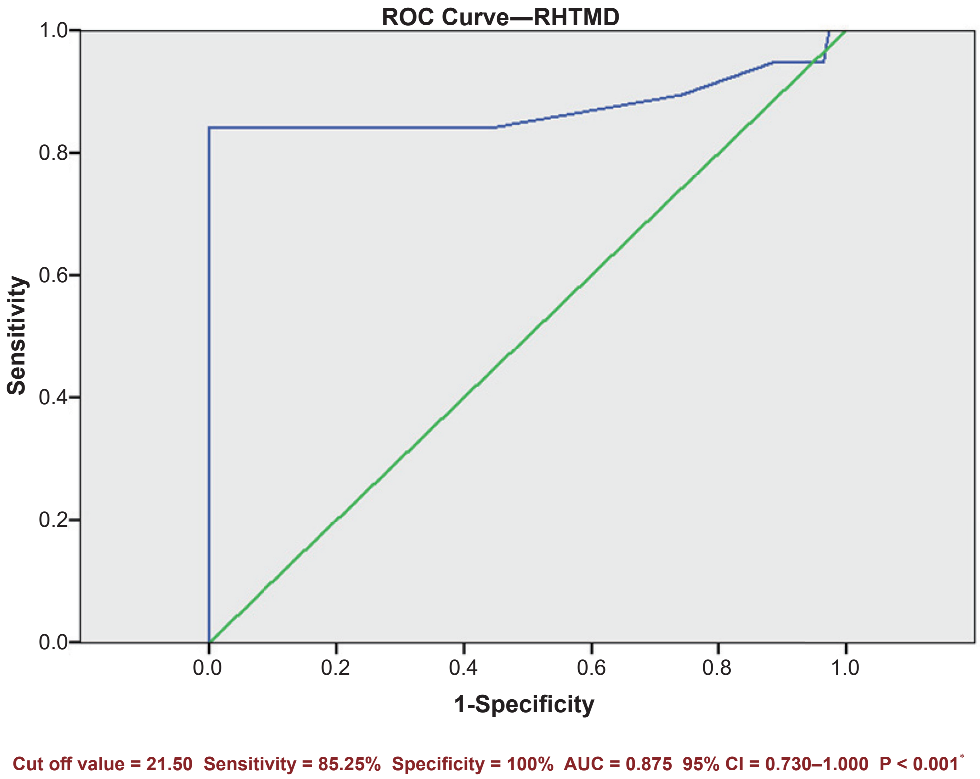

Figure 1. Receiver Operating Characteristic (ROC) Curve of Ratio of Height-to-Thyromental Distance (RHTMD)
Abbreviations: AUC, area under the curve; CI, confidence interval.

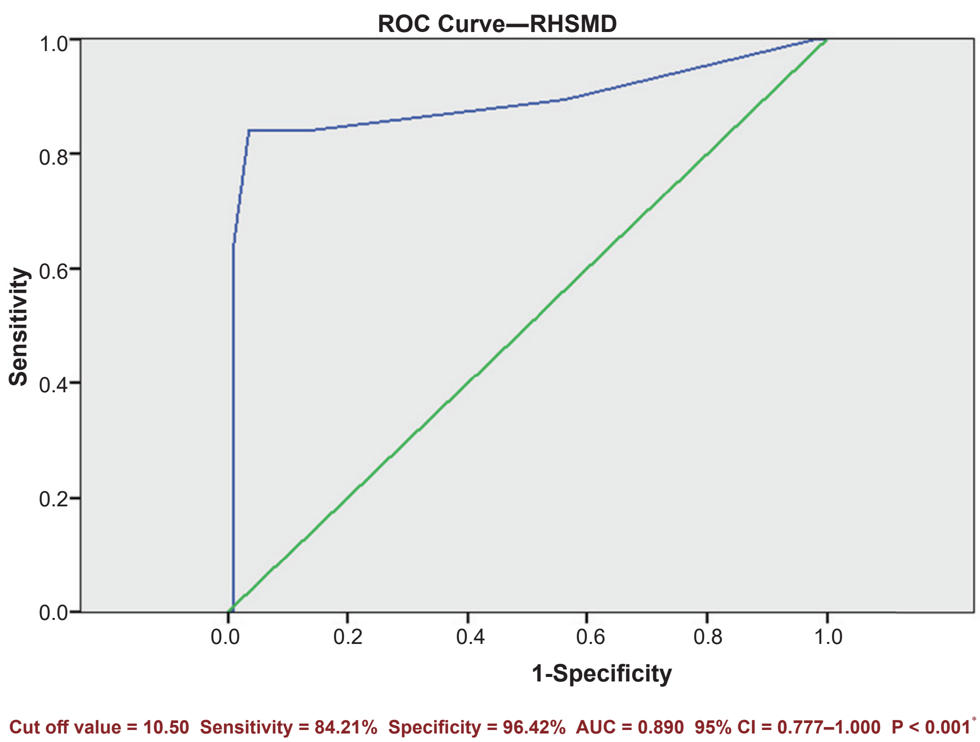

Figure 2. Receiver Operating Characteristic (ROC) Curve of Ratio of Height-to-Sternomental Distance (RHSMD)
Abbreviations: AUC, area under the curve; CI, confidence interval.

incidence of difficult laryngoscopy in the study was 3.5%. The study concluded that SMD of < 13.5 cm can predict difficult laryngoscopy. In the present study of the 19 patients who were found to have difficult intubation, 16 patients had SMD of ≤ 12.5 cm.

The primary aim of our study was to evaluate the efficacy of 2 predictive tests RHTMD and RHSMD. Schmitt et al. introduced RHTMD as a better predictor of difficult laryngoscopy than TMD.[7] RHTMD takes into consideration the body proportions of the patient, and hence it is a better predictor than TMD.

Kaniyil et al.[12] conducted a prospective observational study on adult patients to evaluate RHTMD as a predictor of difficult laryngoscopy. Airway indices like RHTMD, TMD, MMC, and the upper lip bite test were assessed and correlated with Cormack–Lehane laryngoscopic grading. The incidence of difficult laryngoscopy in the study was 5.33%. Among the 4 indices, RHTMD was found to be the single best test with sensitivity of 62.5% and specificity of 96.1% with a good PPV. A combination of all the indices resulted in 100% sensitivity and high specificity; the optimal cut-off value derived from the ROC curve for RHTMD was found to be 22.10. The optimal cut-off value derived from the ROC curve for RHTMD for our study population is 21.50 which is comparable with earlier studies, with AUC 0.875 which is a measure of discriminative power and accuracy. The cut-off value established by other studies in the past for RHTMD ranges from 23.5 to 25.0, which may be attributed to variations in the anthropometric measurements among the population. According to Safavi et al.[14], the cut-off value for RHTMD for prediction of difficult laryngoscopy is race dependent, and the cut-off value for each population has to be calculated separately. Farzi et al.[8] conducted a study on adult patients to compare airway tests RHTMD, RHSMD, and assessment of oropharyngeal view by MMC. The study demonstrated that RHSMD had the least false negative value, cut off point of RHSMD > 12.5 was not different between men and women, and RHSMD ≥ 12.5 had direct relationship with difficult laryngoscopy. In our study, RHSMD had good specificity and accuracy with a cut-off of 10.50. Ray et al.[4] conducted an observational study in 138 children aged between 1 and 12 years scheduled for elective surgery under general anesthesia. They compared RHTMD with RHSMD as predictors of difficult laryngoscopy; 2b restricted view (Cormack–Lehane view as per Cooks modification) was used for predicting difficult laryngoscopy as there were no 3a, 3b, or grade 4 view in the entire study population; the incidence of difficult laryngoscopy was found to be 10.1%. ROC curve analysis was done for predicting difficult laryngoscopy. RHTMD was found to be a better predictor of restricted laryngoscopic view with AUC of 0.792 compared to RHSMD (AUC = 0.463). The study concluded that in children aged 1 to 12 years, RHTMD is a better predictor of restricted laryngoscopic view compared to RHSMD.

In this study, we have compared RHTMD and RHSMD as predictors of difficult laryngoscopy. Grade 3 and 4 Cormack–Lehane view is considered as difficult laryngoscopic view. The incidence of difficult intubation in our study is 14.5%; RHTMD was found to have high sensitivity (85.25%) and specificity (100.00%) compared to RHSMD with sensitivity and specificity of 84.21% and 96.42% respectively, and the AUC of RHTMD is 0.875 compared to RHSMD with AUC = 0.890.

Conclusion

On analysing RHTMD and RHSMD, RHTMD is found to be a better predictor of difficult intubation and restricted laryngoscopic view than RHSMD. Using RHTMD in combination with RHSMD increases the chance of predicting difficult intubation, rather than using them alone.

Conflict of Interest

There are no conflicts of interest.

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