e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2024; 16(5); 469-476

Original Research Article

To Assess the Ratio of Height to Thyromental Distance as a Predictor of Difficult Laryngoscopy

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Received: 25-02-2024 / Revised: 23-03-2024 / Accepted: 26-04-2024
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Conflict of interest: Nil

Abstract:

Background and Aim: Unanticipated difficult airway and its associated morbidity can be avoided by using airway assessment tests preoperatively, in isolation or in combination. The aim of this present study was to assess the Ratio of height to thyromental distance (RHTMD) as a predictor of difficult laryngoscopy and to compare it with other indices like Modified Mallampati Test (MMT), Thyromental distance (TMD) and Upper lip bite test (ULBT).

Material and Methods: This study was conducted on 215 patients scheduled for elective surgery under general anaesthesia needing endotracheal intubation. Airway was assessed preoperatively using MMT, ULBT, TMD and RHTMD. Intraoperatively, Cormack and Lehane's classification was used to assess and grade difficult laryngoscopy. Data was analysed using SPSS version 26.0.

Results: The incidence of difficult laryngoscopy in our study was 11.16%. RHTMD emerged as the best predictor with the maximum area under curve (AUC = 0.83). Of the four indices, RHTMD was found to have the highest sensitivity (91.67%), positive predictive value (30.99%) and negative predictive value(98.61%) compared to other indices.

Conclusion: RHTMD emerged as the single best predictor of difficult laryngoscopy with maximum area under curve (AUC = 0.83). Predictability of difficult airway can be enhanced by combining it with other tests.

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

Introduction

Difficult airway prediction and management is a major reason of concern for anaesthesiologists.[1] Failure to secure and maintain a patent airway can result in significant morbidity, mortality and litigations.[2] Airway or oesophageal injury, aspiration and severe hypoxemia associated with difficult airway can result in brain damage or death.[3] The incidence of difficult laryngoscopy and intubation is 1.5%-13%.[4]

Cormack and Lehane grade II and III requiring multiple attempts or blades or both, has an incidence as high as 1-18% whereas failed endotracheal intubation has an incidence of 0.05-0.35% while cannot ventilate, cannot intubate falls in the incidence of 0.0001-0.02%.[5] Race or ethnicity can lead to differences in patient characteristics thus ultimately affecting the incidence of difficult laryngoscopy and intubation.[6] Difficult laryngoscopy and intubation can result due to problems in dentition, jaw protrusion, prominent maxillary teeth, restricted neck movements (cervical flexion and atlanto-occipital extension) or mouth opening. Pathological conditions leading to difficulty in examination include cervical spondylosis, post radiation fibrosis of mouth leading to tissue changes, trismus, contractures of neck due to burns, infections of neck, temporo- mandibular joint arthritis and neoplasms of oropharynx. [7]

To overcome and avoid the problems associated with difficult airway and subsequent difficult intubation, several preoperative bedside airway assessment tests are available. These include Modified Mallampati test (MMT), Thyromental distance (TMD), Upper lip bite test (ULBT) and the recently introduced parameter–Ratio of height to thyromental distance (RHTMD). Modified Mallampati test is used to assess the oropharynx where the patient is asked to open the mouth maximally and protrude the tongue without phonation while seated. The observer sits opposite at eye level and with a pen torch inspects the pharyngeal structures. This test however may not give precise results owing to inter-observer variations and involuntary phonation by patients during the test. [5]

The Upper lip bite test is better than modified Mallampati test in predicting difficult airway. This is because the upper lip bite test can assess a combination of jaw subluxation and the presence of buck teeth simultaneously. The upper lip bite test is however not useful for edentulous patients. Also, ethnic and racial variations in craniofacial configurations can result in problems with this test. [8]

Another test is the thyromental distance which is measured in cm from bony point of mentum to thyroid notch while head is fully extended and mouth closed using a rigid ruler. Distance is rounded to nearest 0.5 cm [5]. Since the thyromental distance varies with patient's height; it poses difficulty in correctly anticipating the laryngeal view [8].

According to Schmitt et al,[9] Ratio of height to thyromental distance takes into consideration the patient's body proportions and hence is a better predictor of difficult laryngoscopy than thyromental distance alone. Patient's height is measured in cm from vertex to heel with the patient standing and is rounded to nearest cm [5]. This test however is race dependent and lacks simplicity as it requires accurate measurement of patient's thyromental distance and height [8].

These preoperative non-invasive clinical tests are compared intraoperatively with the modified Cormack and Lehane Classification assessed by performing laryngoscopy with the patient's head in sniffing position with a Mcintosh laryngoscopic blade by an anaesthesiologist. Observer bias can be possibly seen in Cormack and Lehane's grading as laryngoscopy is done by different anaesthesiologists with varying experience and skill [8]. Since it is not clear which test or parameter is better than others for predicting difficult airway, so we thought it was worthwhile to conduct a study on preoperative assessment of difficult airway using ratio of height to thyromental distance (RHTMD).

Material and Methods

This was a prospective, single blinded comparative study conducted on two hundred and fifteen patients scheduled for elective surgery under general anaesthesia needing endotracheal intubation. The study was approved by Institutional research and ethics committee and informed written consent was obtained from all patients after preoperative evaluation. The airway was assessed preoperatively using MMT, ULBT, TMD and RHTMD by the principal investigator and correlated intraoperatively with the ease of exposure of the glottis at direct laryngoscopy using the Cormack and Lehane classification. The height, weight, ASA status and body mass index were noted for all patients. Patients with ASA Class I and II between 15 and 60 years scheduled for elective surgery under general anaesthesia were included in this study. Patients who had obvious distorted anatomy of head and neck, cervical spine pathology, those unable to sit/stand, those with midline neck swellings, edentulous patients or patients with trismus were excluded.

The Modified Mallampati Test (MMT) was assessed with patients in sitting position, mouth wide open and tongue maximally protruding without phonation. The view was classified into –

- Class I - Good visualization of soft palate, fauces, uvula and tonsillar pillars.
- Class II - Pillars obscured by base of tongue but soft palate, fauces and uvula visible.
- Class III - Soft palate and base of uvula visible.
- Class IV - Soft palate not visible.

The ULBT was assessed by asking the patient to bite his/her upper lip with lower incisors. The test is classified as follows:

- Class I - Lower incisors can bite the upper lip above the vermilion line.
- Class II - Lower incisors can bite the upper lip below the vermilion line.
- Class III - Lower incisors cannot bite the upper lip.

The TMD was measured with a rigid ruler from lower border of thyroid notch to bony point of mentum with patient's head extended and mouth closed and graded as:

- Class I >6.5cm
- Class II >6-6.5 cm
- Class III <6 cm

The RHTMD was calculated by the formula: RHTMD= Height in cm/TMD in cm and graded as:

- Grade I <23.5.
- Grade II > 23.5.

MMT class 3 and class 4, ULBT class 3, TMD <6 cm and RHTMD >23.5 were considered as predictors of difficult laryngoscopy.

On the day of surgery, patients were kept nil per oral (NPO) for 6 hours for solids and for 2 hours for clear fluids. All the patients were premedicated with tablet alprazolam 0.25mg orally 1 hour prior to induction of anaesthesia. An emergency difficult airway cart was kept ready in the operation theatre. A standard general anaesthesia protocol was followed for all cases. After starting an intravenous line, patients were attached to monitors-ECG, NIBP, SPO_2. After preoxygenation with 100 percent oxygen in each patient, anaesthesia was induced with 5mg/kg of thiopentone sodium and 1.5 mg/kg of succinylcholine was given intravenously to facilitate tracheal intubation after ensuring mask ventilation. Injection fentanyl 1-2 µg/kg was given for analgesia. 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. An anaesthesiologist (with a minimum of 3 year experience in anaesthesia) who documented the Cormack and Lehane's Grading was blinded to the preoperative airway indices to minimise the observer bias. The Cormack and Lehane's grade 3 and 4 were considered as difficult laryngoscopy. Tracheal intubation was done with an appropriately sized endotracheal tube and standard anaesthetic management was continued till the end of surgery.

The observations made were compiled and analysed using appropriate statistical tests.

Sensitivity, Specificity, Positive Predictive Values (PPV) and Negative Predictive Values (NPV) were calculated for each test.

Sample size estimation: The sample size of n=215 was calculated by using the formula **n =Z2α/2* V(AUC) / d2 ,** where V(AUC)=(0.0099*e-a/2)*(6*a2+16),a=ɸ-1(AUC)*1.414, Zα/2=1.96, was standard normal deviate at type 1 error α =0.05, AUC= 0.87 was area under curve, ɸ-1= 1.13, the inverse of standard cumulative normal distribution at AUC 0.87 and d= 5% margin of error. The Area under curve (AUC) for predicting the difficult laryngoscopy using ratio of height to thyromental distance was 0.87.[5]

Statistical Analysis: Data was entered into Microsoft excel sheet and summarized using frequency distribution and descriptive analysis. Chi square test was used to find the association of categorical variables. Binary logistic regression model was used to find the predictors of outcome. Receiver operative Characteristics Curve was used to compute the area under curve for significant predictors. Sensitivity, Specificity, Negative Predictive value and Positive Predictive Value was calculated using appropriate formulas. The P value <0.05 was considered significant. All statistical analysis were performed using SPSS version 26.0.

Results and Analysis

Demographic data of patients is presented in Table 1. Out of a total number of 215 patients, 111(51.63%) patients were females and 104(48.37%) patients were males with age ranging from 15 to 60 years, 139 patients (64.65%) belonged to ASA Class 1 and 76 patients (35.35%) belonged to ASA Class 2. The mean age, mean weight, mean height and mean BMI were 37.25 ± 11.8, 67.8 ± 11, 166.59 ± 7.92 and 24.49 ± 3.68 respectively. When demographic data was compared in the easy (CL I&II) and difficult (CL III&IV) laryngoscopy groups, significant differences were found in the mean age and BMI between difficult and easy laryngoscopy groups ($p<0.05$), while gender, weight and height were not significant ($p>0.05$).

Table 1: Demographic Data of Patients in Easy & Difficult Laryngoscopy Groups.

Variable	Mean ± SD		P value
	CL I and II (Easy Laryngoscopy)	CL III and IV (Difficult Laryngoscopy)	
Age (years)	36.29 ± 11.68	44.88 ± 9.55	0.035
Gender, M/F	92/99	12/12	0.866
Weight (kg)	67.36 ± 11.28	71.29 ± 7.79	0.099
Height (cm)	166.49 ± 8.05	167.4 ± 6.95	0.596
BMI (kg/m^2)	24.35 ± 3.77	25.59 ± 2.62	0.007

Our preoperative airway assessment using the different predictors are documented as follows in (Tables 2-4, Figure 1-2).

Table 2: Distribution of MMT, ULBT, TMD and RHTMD

Variable	No. of patients	Percentage
MMT		
Class I	38	17.67%
Class II	113	52.56%
Class III	60	27.91%
Class IV	4	1.86%
ULBT		
Class I	147	68.37%
Class II	55	25.58%
Class III	13	6.05%

TMD		
Class I {>6.5 cm}	156	72.56%
Class II {6-6.5 cm}	44	20.47%
Class III {<6 cm}	15	6.98%
RHTMD		
Grade I {<23.5}	144	66.98%
Grade II {≥23.5}	71	33.02%

Table 3: Association of predictive tests with Cormack-Lehane grading

Predictive tests	CL I and II(n=191)	CL III and IV(n=24)	Total	P value
MMT				
Easy(I and II)	142 (74.35%)	9 (37.50%)	151 (70.23%)	0.0002†
Difficult(III and IV)	49 (25.65%)	15 (62.50%)	64 (29.77%)	
ULBT				
Easy (Class I&II)	181 (94.76%)	21 (87.50%)	202 (93.95%)	0.165*
Difficult(Class III)	10 (5.24%)	3 (12.50%)	13 (6.05%)	
TMD				
Easy(≥6 cm)	180 (94.24%)	20 (83.33%)	200 (93.02%)	0.07*
Difficult(<6 cm)	11 (5.76%)	4 (16.67%)	15 (6.98%)	
RHTMD				
Easy{<23.5}	142 (74.35%)	2 (8.33%)	144 (66.98%)	<.0001*
Difficult{≥23.5}	49 (25.65%)	22 (91.67%)	71 (33.02%)	

* Fisher's exact test, † Chi square test

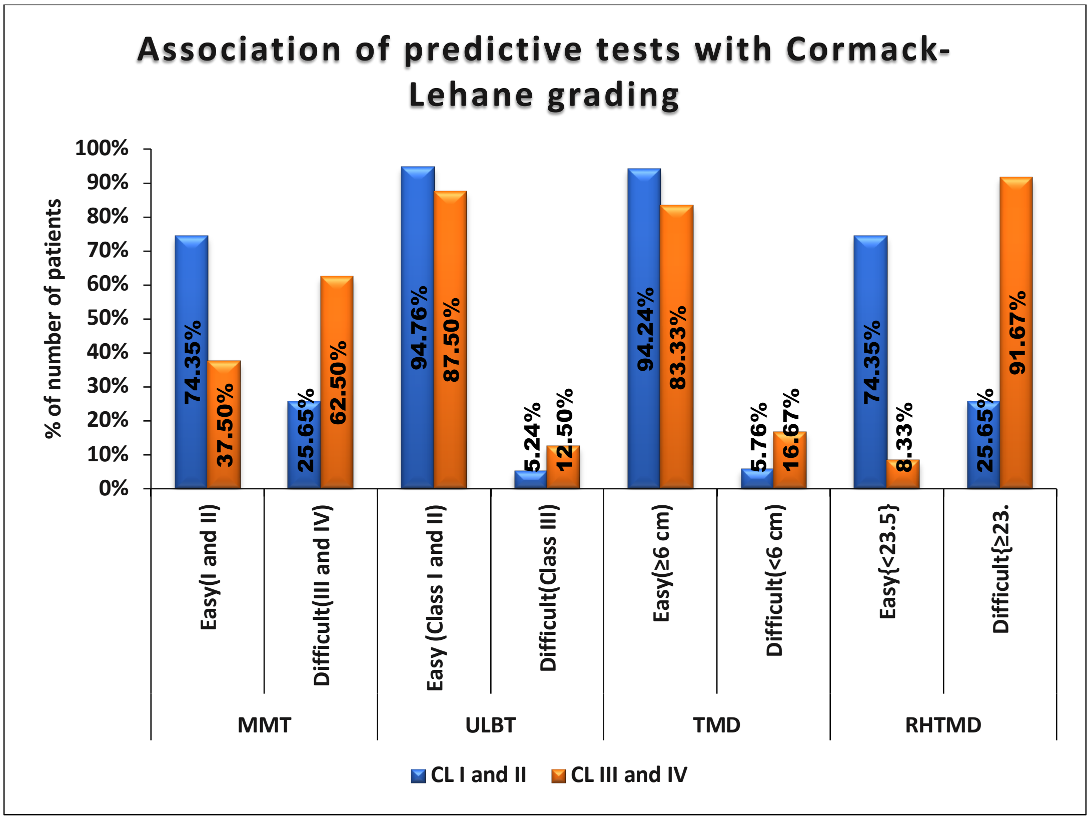

Figure 1: Association of predictive tests with Cormack-Lehane grading

Table 4.1: Comparison of Various Predictive Tests

Variables	MMT	ULBT	TMD	RHTMD
Sensitivity (95% CI)	62.5%	12.5%	16.67%	91.67%
Specificity (95% CI)	74.35%	94.76%	94.24%	74.35%
AUC (95% CI)	0.68	0.54	0.55	0.83
Positive Predictive Value (95% CI)	23.44%	23.08%	26.67%	30.99%

Negative Predictive Value (95% CI)	94.04%	89.6%	90%	98.61%
Diagnostic accuracy	73.02%	85.58%	85.58%	76.28%

Table 4.1 shows sensitivity, specificity, AUC, positive predictive value, negative predictive value and accuracy of MMT, ULBT, TMD and RHTMD for predicting difficult laryngoscopy.

Study results showed that RHTMD had the highest sensitivity of 91.67% followed by MMT (62.50%), TMD (16.67%) and ULBT (12.50%) in prediction of difficult laryngoscopy while ULBT had the lowest sensitivity of 12.50%. On the other hand, ULBT had the highest specificity of 94.76% followed by TMD (94.24%), RHTMD (74.35%) and MMT (74.35%) in prediction of difficult laryngoscopy while MMT had the lowest specificity of 74.35%.

Highest positive predictive value (30.99%) and highest negative predictive value (98.61%) were found in RHTMD. The maximum area under curve was found for RHTMD (AUC = 0.83).

Table 4.2: Comparison of sensitivity, specificity, AUC between MMT, ULBT, TMD and RHTMD

Variables	P value of sensitivity[‡]	P value of specificity[‡]	Comparison of AUC[§]
MMT vs ULBT	<0.0001	<0.0001	0.007
MMT vs TMD	0.007	<0.0001	0.061
MMT vs RHTMD	0.039	1	0.014
ULBT vs TMD	1	1	0.75
ULBT vs RHTMD	<0.0001	<0.0001	<0.0001
TMD vs RHTMD	<0.0001	<0.0001	<0.0001

[‡]McNemar test, [§] DeLong et al test

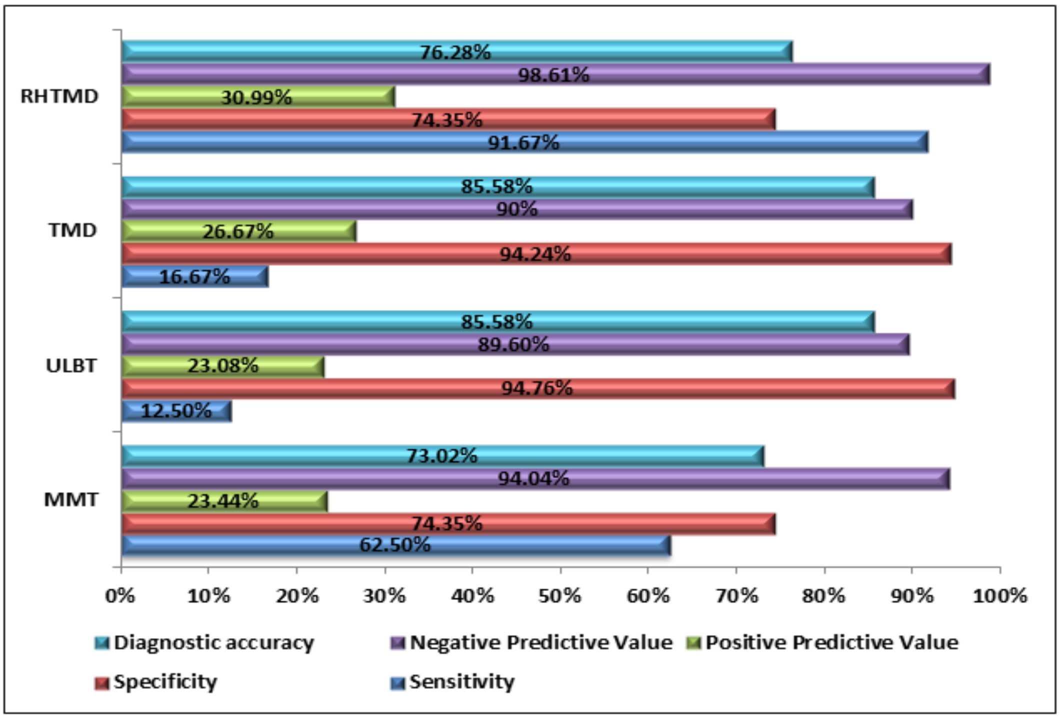

Figure 2: Sensitivity, specificity, accuracy, positive predictive value and negative predictive value of MMT, ULBT, TMD and RHTMD for predicting difficult laryngoscopy

Tables 4.1 & 4.2 and Figure 2 show comparison of various predictive tests.

On comparison, sensitivity of MMT was significantly higher than ULBT (p value<.0001), TMD (p value=0.007) and was significantly lower than RHTMD (p value=0.039). Sensitivity of RHTMD was significantly higher than ULBT (p value<.0001), TMD (p value<.0001).

Specificity of ULBT, TMD was significantly higher than MMT and RHTMD. (p value<.0001) Area under curve of RHTMD was significantly higher than ULBT (p value<.0001), TMD (p value<.0001) and MMT (p value=0.014). Area under curve of MMT was significantly higher than ULBT (p value=0.007).

Discussion

Prediction of difficult laryngoscopy and tracheal intubation continues to be a challenge for anaesthesiologists.[10] Thus, it is important to identify bedside clinical tests to plan alternative methods of securing the airway and arrange experienced help in cases of suspected difficult intubation.[11]

In our study, MMT as described by Mallampati, was found to have a sensitivity of 62.5%, a specificity of 74.35%, a positive predictive value of 23.44% and a negative predictive value of 94.04%. The p-value for MMT was 0.0002, indicating the presence of a statistically significant association between MMT and CL grade. So, MMT emerged as a good predictor of difficult laryngoscopy. Our results were comparable to those of Eberhart et al,[12] in which MMT had a similar sensitivity and specificity while positive predictive value was lower and negative predictive value of 93.8% was higher. The higher positive predictive value in our study may be attributed to the presence of only one observer since interobserver variations can influence the results as seen in the study by Tham et al where phonation markedly improved the laryngoscopic view and shifted the assessment towards the better classes while lack of patient cooperation resulted in interobserver variations.[13]

The ULBT introduced by Khan ZH et al[14] was found to have a sensitivity of 12.5%, specificity of 94.76%, positive predictive value of 23.08% and negative predictive value of 89.6%. The p-value for ULBT was 0.165, which indicated the lack of significant association between ULBT and CL grade. So, ULBT was not found to be a good predictor of difficult laryngoscopy. Our results were similar to those of Eberhart et al but different from the original study by Khan et al[14] where ULBT had higher specificity (88.7%) and accuracy (88%) as compared to MMT but the sensitivity, positive predictive value and negative predictive value of both tests were comparable. These variations could be due to the inability of patients to completely understand and comprehend the instructions, even after the anaesthesiologist demonstrated the test. [15] Also, there is difficulty in assessing the ULBT in edentulous patients as suggested by Eberhart et al.[12]

Similarly, Thyromental Distance (TMD) or Patil's test was found to have a sensitivity of 16.67%, specificity of 94.24%, positive predictive value of 26.67% and negative predictive value of 90%. The p-value for TMD was 0.07, which indicated the lack of significant association between TMD and CL grade. So, we did not find TMD to be a reliable predictor of difficult laryngoscopy. Thus, TMD showed high specificity at the cost of low sensitivity similar to the study by Shah et al.[5] However, these findings were not comparable with the study done by Frerk[16] where sensitivity (90.9%), specificity (81.5%) and negative predictive value (99.47%) were higher than our study while positive predictive value (18.86%) was lower than our study. These differences can be attributed to the wide range of cut off values (5.5-7cm) for TMD in literature. Interobserver variations also contribute to these differences as it has not been defined clearly whether to measure the TMD from the thyroid notch to the inner or outer aspect of the mentum.[4]

Another test introduced by Schmitt et al[9] known as RHTMD emerged as a very good predictor of difficult laryngoscopy in our study with high sensitivity (91.67%), specificity (74.35%), positive predictive value (30.99%) and negative predictive value (98.61%). This could be attributed to less need for patient cooperation and that, both, soft tissue and bone variables that contribute to a difficult airway are addressed in RHTMD. These findings were comparable to those observed by Schmitt et al[9] (sensitivity 81%, specificity 91%) and Vaswani JP et al[17] (sensitivity 95.2%, specificity 66.7%, positive predictive value 60.6%, negative predictive value 96.3%). The small differences in findings among different studies could be due to the use of different cut off values for RHTMD such as ≥23.5 by Krobbuaban et al[2], ≥25 by Schmitt et al[9], ≥22.7 by Honarmand et al[1] in people of different races and ethnicities. The p-value for RHTMD was <0.0001, indicating the presence of a statistically significant association between RHTMD and CL grade. So, RHTMD emerged as a good predictor of difficult laryngoscopy.

On comparison, RHTMD was found to have the highest sensitivity (91.67%) positive predictive value (30.99%) and negative predictive value (98.61%) while ULBT had the highest specificity (94.76%). Since there is always a trade-off between sensitivity and specificity (any increase in sensitivity will be accompanied by a decrease in specificity), so we choose that variable as best in which combination of sensitivity and specificity gives the maximum predictive value i.e. maximum area under curve. So, overall, RHTMD emerged as the best predictor of difficult laryngoscopy (AUC= 0.83).

In a study by Safavi et al[8] RHTMD was compared with MMT and ULBT in predicting difficult laryngoscopy and it was concluded that RHTMD and ULBT were comparable and better predictors than MMT. Ali ST et al[18] found that RHTMD (89.3%) and ULBT (88.3%) had more accuracy than MMT (79.9%). Thus, RHTMD can be used as a reliable bedside screening test for predicting difficult airway. Racial and ethnic variations as well as observer bias in Cormack and

Lehane's grading, since laryngoscopy was done by different anaesthesiologists, may have resulted in differences in the results of various studies.[4] In our study, the incidence of difficult laryngoscopy was observed to be 11.16%, which is comparable with the reported incidence of 1.5-13% in previous studies.[2,3,4] The huge variation in the incidence reported in the studies could be due to the use of different definitions and the inclusion of different grades of the Cormack-Lehane grading for the laryngoscopic view.[19] or due to the lack of uniformity in practicing laryngoscopy such as in positioning the head and neck, external laryngeal manipulation, application of Sellick maneuver, multiple attempts, type of blade used and varying skill of anaesthesiologists.[4] Since multiple factors can lead to difficult airway, using a combination of tests will produce better results than single test alone as suggested by Kaniyil et al when sensitivity could be increased remarkably by using all four tests (MMT, ULBT, TMD, RHTMD) in their study, thus, allowing maximum cases of difficult laryngoscopy to be correctly predicted.[4]

There were several limitations of this study. This study was carried out in elective surgical patients while emergency patients were excluded, anthropometric variations in different population groups might have resulted in differences in the assessment of predictive tests and that ULBT was difficult to assess in many patients since they could not completely understand and comprehend the instructions, even after the anaesthesiologist demonstrated the test.

Conclusion

From our study, we concluded that RHTMD is a good predictor of difficult airway compared to MMT, ULBT and TMD. It can further enhance the predictability if it is combined with other predictive tests. Therefore, RHTMD can be used in airway assessment routinely.

Ethical approval: The study was approved by the Institutional Ethics Committee.

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