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AN OBSERVATIONAL PROSPECTIVE STUDY COMPARING RATIO OF PATIENTS' HEIGHT TO THYROMENTAL DISTANCE WITH OTHER AIRWAY ASSESSMENT TESTS FOR PREDICTING DIFFICULT ENDOTRACHEAL INTUBATION.

Anupriya Saxena[*1], Nazia Nazir [2], Savita Gupta[3] , Abhishek Bharti[4], Ruchi Singh[5]

[1*]Associate Professor , Department of Anesthesia, Government Institute of Medical Science, India.
[2]Professor , Department of Anesthesia, Government Institute of Medical Science, India.
[3]Associate Professor , Department of Anesthesia, Government Institute of Medical Science, India.
[4]Assistant Professor , Department of Community Medicine , Government Institute of Medical Science, India.
[5]Assistant Professor , Department of Anesthesia, Government Institute of Medical Science, India

***Corresponding Author:** Dr.Anupriya Saxena
[*]Associate Professor , Department of Anesthesia, Government Institute of Medical Science, India.
Address: Flat-9, Type:5 Block F Gautam Budha University Greater Noida: Uttar Pradesh
Mobile No:9953090044, anupriya.pmch@gmail.com

ABSTRACT

OBJECTIVE : Preoperatively done airway assessment reduces the airway complications and hence decreases the patients morbidity and mortality under general anesthesia. So it is very important to find out a single good and efficient preoperative airway assessment test. Our primary objective was to determine the efficiency of the ratio of height to thyromental distance test(RHTMD) as compared to multiple other airway assessment test for prediction of difficult airway.

DESIGN : A prospective, observational, and single-center study.

SETTING: Preoperative room and Operation theatre

PARTICIPANT: The study included 250 consecutive patients, both male and female, aged between 18 and 75 years, who were scheduled to undergo elective surgery requiring general anesthesia and endotracheal intubation.

INTERVENTION: An airway assessment was conducted in the preoperative room, and the anesthesiologist performing the intubation was unaware of the results of the preoperative airway assessment. The Cormack-Lehane grade(CL Grade) was later recorded during the intubation procedure. The airway difficulty level of the CL Grade was then compared with the preoperatively done airway assessment.

RESULTS: RHTMD exhibited the highest sensitivity(98%) ,specificity (93.22), positive and negative predictive value(95.52%,92%)) ,accuracy(96.98%) and the highest AUC value of 0.905, signifying excellent discriminative ability as compared to other studied airway predictors. The incidence of difficult airway predicted by RHTMD was 13% which was close to the actual incidence of difficult airway as shown by CL grading.(14%) Moreover all the difficult airway predicted by RHTMD were true positives.

CONCLUSION: RHTMD appears to be a promising test even if done alone for predicting difficult airway.

Keywords: Difficult Airway, Airway Assessment , Predictive Test.

Introduction

A difficult airway during anaesthesia can be a potentially life-threatening situation that may lead to increased morbidity and mortality. Approximately 30-40% of anaesthesia-related deaths are attributed to inadequate management of airway crises.[1] The incidence of difficult airways ranges from 1.5% to 20%[2,3.] Difficult intubation is said to occur when a experienced anesthesiologist has difficulty to insert a endotracheal tube into patients trachea.It may manifest as challenges with mask ventilation, problematic laryngoscopy, or difficult intubation.

It is mostly the unexpected difficult airway that leads to catastrophic consequences and airway crises. These occurrences have prompted the development of diagnostic screening tests, which are vital components of our preoperative assessments .By utilizing the results of these bedside evaluations, healthcare professionals can better plan for various alternative airway management strategies, ultimately helping to safeguard patients from potential complications.[4]

A variety of preoperative airway assessment tests are utilized to predict difficult airways, including the height-to-thyromental distance ratio(RHTMD), Mallampati grading(MPG), thyromental distance(TMD), sternomental distance (SMD), upper lip bite test(ULBT), interincisor gap(IIG) and thyromental height(TMHT).However, the sensitivity and positive predictive values (PPVs) of these individual tests differ significantly, making it challenging to rely on any single test with certainty.A cochrane database systemic review conducted in 2018 concluded that most of the existing airway assessment test have low sensitivities and high variability.[5]Hence futher research in this area is warranted. There are studies which individually compare few of these test but very few studies in literature have been found which are comparing all of these test in a single set of indian population. Hence in this study we hypothesized that the height-to-thyromental distance ratio could serve as the single most reliable predictor of difficult laryngoscopy when compared to TMD,SMD,MPG,ULBT,IIG,TMHT.

METHODS

Study Design

A prospective, observational, and single-center study was conducted between January 2023 to january 2024. It adheres to declaration of Helsinki(2013) and good clinical practice guidelines.

Permission of the Ethics Committee

Ethics Committee approval was obtained from the institutional ethical committee , before the commencement of the study and it was registered on Central Trial Registry-India(CTRI). Written informed consent obtained from all of the participants before inclusion in the study. The study was also registered on CTRI. (CTRI/2021/10/037057)

Patient Population

We recruited 250 patients between the age group of 18 to 75 years belonging to the American Society of Anesthesiologists physical status grade 1–3 who required general anesthesia and intubation. Pregnant patients, patients with body mass index(BMI)>35, patients at risk of pulmonary aspiration, patients scheduled for emergency surgery and patients with a history of difficult intubation or having obvious signs of abnormal airway anatomy were excluded from the study.[Figure 1]

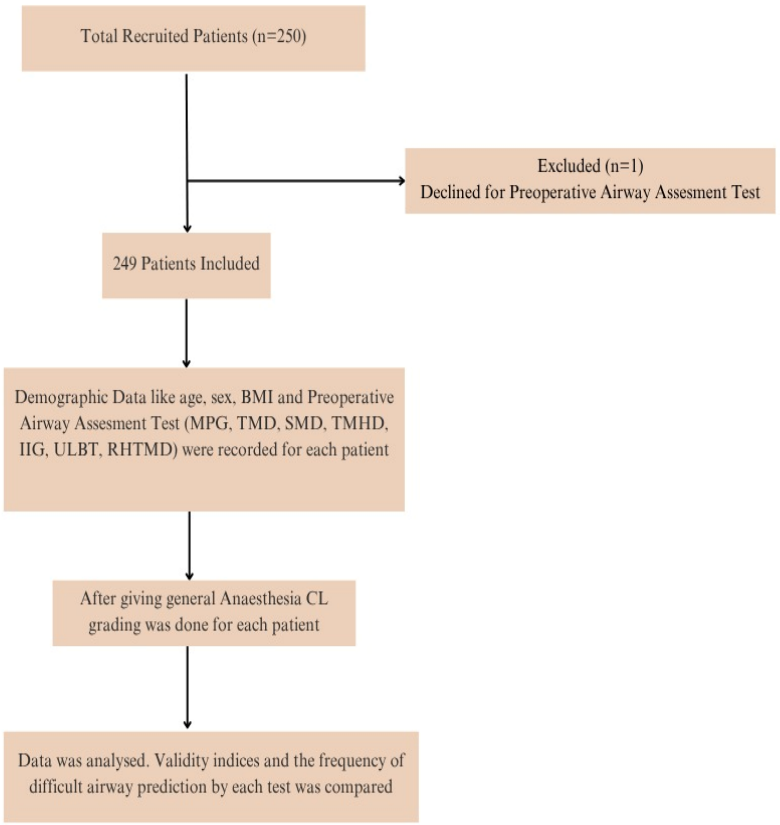

Figure 1:Patient Flow.

Induction of Anesthesia

In the operating room, ASA standard monitoring was applied , baseline vitals were recorded and a difficult airway cart was prepared.. Intravenous cannula was secured and ringer lactate was started. Thereafter general anaesthesia was induced with fentanyl 2 µg/kg and propofol 2 mg/kg. After ensuring adequate bag and mask ventilation neuromuscular blockade was achieved by giving injection atracurium besilate 0.5 mg/kg. The patient was then ventilated for 3 minutes with a mixture of oxygen and a 2% end-tidal concentration of sevoflurane. Adequacy of neuromuscular blockade was analysed before laryngoscopy by using the train of four ratio. Laryngoscopy was performed by an anesthetist who had at least 3 years of experience. The anesthetists who were intubating the patient were blinded to the preoperatively done airway assessment. Intubation was done after obtaining the best possible glottic view, which was graded as per the standard Cromack Lehane's grading(CL Grade).

Grade 1: Complete glottis view.
Grade 2A: Partial view of glottis
Grade 2B: Only the posterior part of the glottis seen or only arytenoid cartilages
Grade 3A: Only epiglottis seen but mobile.
Grade 3B: Only epiglottis seen but fixed.
Grade 4: No glottis structure seen

Grade 1 and 2a were classified as “easy airway” whereas CL grades 2b, 3a,3b, and 4 were designated as “difficult airway.” Following successful intubation, tube placement was confirmed through bilateral air entry, and the endotracheal tube was secured. Further anaesthetic management was done as per the standard protocol.

Description of various preoperatively done airway assessment Testing Methods
The airway assessment was done in the preoperative room by an anesthesiologist who was not involved in the study. In the preoperative assessment, the patient's age, sex, weight, BMI, and ASA status were recorded. The tests utilized in this study and relevant criteria are detailed below
Thyromental Distance(TMD): Patients were asked to lie in the supine position with the head in full extension and the mouth closed. The distance between the upper border of the thyroid cartilage and the mentum was measured with a ruler. A value of less than 6.5cm was considered to be a predictor of the difficult airway.[6][Figure 2]

Sternomental distance (SMD): The patient was asked to lie supine with the head in extension and mouth closed. The distance between the bony point of the mentum to the manubrium sterni was measured with the help of a ruler. An SMD ≤13.5 cm was considered predictive of a difficult airway. [6] [Figure 2]

Interincisior Gap(IIG): The patient was asked to open the mouth to its maximum capacity thereafter the space between the incisors was measured with help of a ruler. A value of less than 3 cm is considered to be difficult airway. [7]

Mallampati Grade(MPG): This measurement was performed with the patient in a sitting position with a neutral head and the tongue maximally protruding from the mouth without phonation. Patients were divided into the following classes as per the structures visible. [7]
· Class 0: Any part of the epiglottis is visible
· Class I: soft palate, uvula, and pillars are visible
· Class II: soft palate and uvula are visible
· Class III: only the soft palate and base of the uvula are visible
· Class IV: only the hard palate is visible
MPG grades of class III and IV are considered to be predictors of difficult airway.

Upper lip bite test(ULBT): The patient was sitting and was instructed to bite their upper lip with their lower incisors as much as possible. ULBT was graded as follows. [8] [Figure 2]
· Grade 1: If the skin of the upper lip is bitten;
· grade 2: if the mucosa of the upper lip is bitten;
· grade 3: if the upper lip cannot be bitten.
· Grades 2 and 3 were considered to be predictors of difficult airway.

Thyromental Height Test(TMHT): For measuring thyromental height the patient was asked to lie in a supine position with the mouth closed and the height between the anterior border of the thyroid cartilage and the anterior border of the mentum was measured with the help of a ruler. A value of less than 50mm is considered to be a predictor of a difficult airway. [3] [Figure 2]

Ratio of height to thyromental distance: The height of the patient was measured using the standard stadiometer having a straight vertical rod with markings and a sliding horizontal headpiece that can be fixed above the head to measure height. RHTMD was derived using the formula of the ratio of patient height in cm to TMD in cm. RHTMD > 25.0 was considered as a predictor of difficult airway. [9]

Figure 2: Various airway predictive test.

Statistical Analysis

The sample size calculated was 243 patients with 95% confidence interval and 80% power and alpha level of 0.05, assuming the incidence of difficult airway to be 8% based on previous study. [7] Taking into consideration the attrition of few patients we included a total 250 patients.

We conducted a statistical analysis with SPSS 28.0 .For continuous demographic variables (age, weight, height, and BMI), independent samples t-tests were used to compare the means in the easy airway group versus difficult airway group. Gender distribution compared using the chi-square test. Chi-square test was also used to test for distribution of predictive test outcomes relating with airway grading to ensure group level significant differences. To estimate the validity of each predictive test, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated.

Additionally, sensitivity and specificity were assessed using receiver operating characteristic (ROC) curve analyses, with the area under the curve (AUC) serving as an indicator of a test's discriminative ability. AUC values were estimated along with their standard error and 95% confidence interval to evaluate the overall performance of the predictive tests. Statistical significance was determined at a threshold of $p < 0.05$. These statistical methods collectively provided a comprehensive evaluation of the predictive tests in distinguishing between easy and difficult airways.

Results

A total of 250 patients were enrolled. One patient had to be excluded as he denied preoperative airway assessment. The rest of the 249 patients (117 males and 132 females) completed the study. All the patients were comparable with regard to demographic characteristics. [Table 1]. Difficult intubation was seen in 36 patients (incidence 14.4%) based on Cormack–Lehane grading (CL grades 2b, 3a,3b, and 4 were seen in 12,14,10,0 patients respectively). There was no failed intubation in our study. Of the 36 cases of difficult intubation, 30 were intubated in the first attempt with external laryngeal manipulation, and the remaining 6 patients were intubated in the second attempt using a video laryngoscope.

To compare the prediction of difficult airway by various airway assessment test , we calculated the percentage of difficult airway as shown by each assessment test and then compared it to the percentage of difficult airway as shown by gold standard CL grade. [TABLE 2]We found that RHTMD, IIG, ULBT were showing the incidence of difficult airway to be 13%,17%,16.5% respectively which was close to the true incidence of difficult airway as shown by the gold standard CL grade(14%).In our study TMD,TMHT tend to underestimate the incidence of difficult airway(8% and 10% vs 14%) whereas SMD,MPG over estimate the incidence of difficult airway(21% & 20% vs 14%)

All examined airway predictors demonstrated a significant correlation ($P < 0.05$) with C-L grades.[TABLE 3].

The standard validity indices for predicting the likelihood of difficult intubation based on the C-L classification are detailed in Table 4. RHTMD exhibited the heighest sensitivity, specificity ,positive predictive value(PPV),negative predictive value(NPV) and accuracy.Apart from RHTMD , IIG and ULBT also depicted increased specificity,sensitivity,PPV ,NPV and accuracy when compared to other airway predictors.

Table 5 and Figure 3 present the results of the area under the receiver operating characteristic (ROC) curve analysis for various diagnostic tests. The test with higher AUC values indicate better discrimination between the two outcome groups .In this analysis, most of the tests exhibited AUC values significantly greater than 0.5 ($p < 0.05$), suggesting discriminative ability beyond chance. Notably, the "RHTMD" test demonstrated the highest AUC value of 0.905, signifying excellent discriminative ability.

Table 1: Demographic Profile

Variable	**CLG* - Easy Airway**		**CLG - Diff Airway**		**P value**
	Mean	**SD**	**Mean**	**SD**	
Age(years)	38.26	13.25	40.69	10.46	0.135
Weight(kg)	58.68	14.74	59.47	11.10	0.206
Height(cm)	155.46	9.24	152.24	11.83	0.615
BMI$(Kg/m2)	24.98	5.01	25.86	7.42	0.263
	No of male	**No of female**	**No of male**	**No of female**	
Gender	104	109	13	23	0.58

*CLG-cromacke lehnae grading, $ Body mass index

Table 2: Frequency of difficult airway with each prediction test.

Airway assessment Test	Outcome	Frequency	Percentage
TMD@	Difficult Airway	20	8%
	Easy Airway	229	92%
SMD#	Difficult Airway	52	21%
	Easy Airway	197	79%
TMHT$	Difficult Airway	26	10%

	Easy Airway	223	90%
IIG[&]	Difficult Airway	42	17%
	Easy Airway	207	83%
MPG[*]	Difficult Airway	50	20%
	Easy Airway	199	80%
ULBT[##]	Difficult Airway	41	16.5%
	Easy Airway	208	83.5%
RHTMD[**]	Difficult Airway	32	13%
	Easy Airway	216	87%
CL Grade[$$]	Difficult Airway	36	14%
	Easy Airway	213	86%

@Thyromental distance(TMD)
Sternomental Distance(SMD)
$Thyromental height test(TMHT)
*Mallampati Grade (MPG)
&Inter Insicior Gap(IIG)
##Upper Lip Bite Test(ULBT)
**Ratio of height to thyromental distance(RHTMD)

Table 3: Distribution of predictive test with respect to CL - grading

		CL - Grading			
Test	**Grade**	**Easy Airway**	**Diff Airway**	**Total**	**P value**
	Total	**213**	**36**	**249**	
TMD	Easy	207	22	229	<.001
	Difficult	6	14	20	
SMD	Easy	177	24	197	<.001
	Difficult	40	12	52	
TMHT	Easy	208	15	223	<.001
	Difficult	5	21	26	
IIG	Easy	202	5	207	<.001
	Difficult	11	31	42	
MPG	Easy	183	16	199	<.001
	Difficult	30	20	50	
ULBT	Easy	203	5	208	<.001
	Difficult	10	31	41	
RHTMD	Easy	212	4	216	<.001
	Difficult	0	32	32	

Table 4: Validity Indexes for TMD,SMD,TMT,IIG,MPG,ULBT,RHTMD.

Test	Sensitivity	Specificity	PPV	NPV	Accuracy
TMD	**92.00%**	**85.56%**	**93.01%**	**85.00%**	**87.57%**
SMD	**79.81%**	**82.22%**	**84.44%**	**77.68%**	**78.71%**
TMHT	**90.59%**	**87.22%**	**91.70%**	**85.00%**	**90.87%**

IIG	**95.18%**	**87.78%**	**95.18%**	**93.73%**	**94.70%**
MPG	**84.14%**	**80.56%**	**85.33%**	**79.29%**	**79.08%**
ULBT	**92.20%**	**88.78%**	**94.63%**	**90.00%**	**91.16%**
RHTMD	**98.00%**	**93.22%**	**95.52%**	**92.00%**	**96.98%**

Table 5: Area under ROC Curve

	Area	**Std. Error**	**Asymptotic Sig.**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
TMD	0.107	0.038	0.000	0.033	0.181
SMD	0.204	0.04	0.000	0.127	0.282
TMHT	0.641	0.055	0.000	0.533	0.75
IIG	0.643	0.042	0.000	0.63	0.713
MPG	0.787	0.045	0.000	0.7	0.875
ULBT	0.817	0.047	0.000	0.725	0.909
RHTMD	0.905	0.034	0.000	0.839	0.971

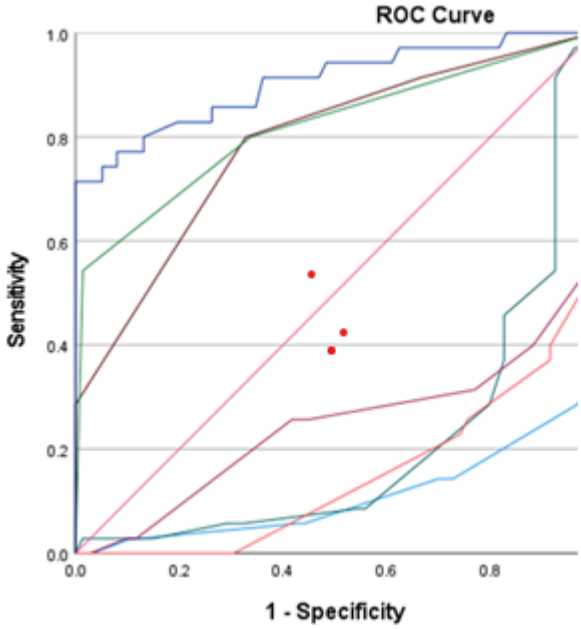

Figure 3:ROC Curve

Discussion

Airway assessment is an integral part of preoperative workup ,it becomes all the more important in settings of difficult airway because these patients need advance airway management which requires preparation to be done ahead of time to avoid complications. A number of tests have been suggested in literature which have attempted to predict the patients with difficult airway .But none of these can be relied upon with surety if tested alone , therefore many pairings have been suggested to increase the accuracy. [10,11,12]

In our study the incidence of difficult airway was 14.4% which correlates with the existing literature. (1.5% to 20%).The significant disparity in the reported incidence of difficult airways in

the literature may be attributed to ethnic ,racial differences within the study populations and the experience of the attending anesthesiologists. [13,14]

The best airway predictive test should be easy to perform,rapid and should provide reliable result. It should identify maximum patients who will have difficult airway (good sensitivity) and not falsely identify patients as difficult airway who actually are easy leading to resourse wastage. (low false positives).Hence the ideal test should have high sensitivity, specificity and possess a high positive predictive value with few false positive predictions.

Our study revealed RHTMD as the single best predictor of difficult airway in comparision to other parameters. The incidence of difficult airway predicted by RHTMD was 13% which was close to the actual incidence of difficult airway as shown by CL grading.(14%) Moreover all the difficult airway predicted by RHTMD were true positives that is all these patients had difficult laryngoscopy. RHTMD also depicted heighest sensitivity ,specificity,PPV,NPV and accuracy in predicting difficult airway. These findings are consistent with multiple other studies in literature. [15,16,17,18,19] However in a study conducted by Panjiar P et al comparing different airway predictive test in geriatric patients suggested that TMD and ULBT had better airway predictive value than RHTMD. The probable reason for this difference could be difference in the patient population studied. [20] .Another study by Panjiar P et al comparing TMHT ,RHTMD,TMD, and MMT for predicting difficult laryngoscopy reported a lower sensitivity (63.64%) and PPV (23.81%) of RHTMD as compared with other tests.This could be due to a lower cut off value of 19.5cm being taken by them as compared to 25.0cm as reported by Schmitt *et al*. [9,21]

The RHTMD was proposed by Schmitt et al. to address the variations in anatomical proportions among individual patients, such as height, which are often overlooked when measuring TMD/SMD in isolation. Patients of varying heights may exhibit the same TMD/SMD values; however, these measurements are likely to correlate with distinct jaw and mandibular anatomies in relation to adjacent structures. Additionally, the dimensions of the neck and mandible, along with the volume of the tongue and soft tissue, may differ according to the overall size and proportions of the body. [9]

The ULBT and the IIG are straightforward predictors of challenging laryngoscopy.These test focus on jaw subluxation and extent of mouth opening. Our study showed that, both ULBT and IIG were the other best predictor of difficult airway beside RHTMD. This is in accordance to a study done by Rao et al and a systemic review done by Faramarzi E et al .Since the performance of these test depend on the patients cooperation level they may become subjective for interpretation hence we favour using RTMD in which patient cooperation does not much alter the measurement. [7,8,19]

In our study the TMD,SMD,MPG showed lower sensitivity ,higher false positivies rate and lower accuracy for prediction of difficult airway. MPG has a subjective bias due to improper patient posture, inadequate mouth opening and involuntary phonation. There are various studies in literature both with good and poor validity indices for MPG.[3,23] TMD ,SMD also ignore the generalized body habitus of the patient hence using these test in combination indexes would be a clinically better step. These findings are consistent with other studies. [7,22,24]

TMHT is comparatively a newer test to predict difficult airway. We found TMHT to have moderately good sensitivity and specificity but the findings should be interpreted with caution as the results of this test may vary with race and age differences in the study population and variable cut-off values taken by different authors. The results obtained by Etezadi F et al, Jain et al, Panjar P, Bhiwal AK et al, Palczynski P et al revealed that TMHD is a good predictor of difficult airway especially in geriatric age group. [4,21,22,25] However, Yabuki et al. and Selvi et al concluded that TMHT shows a poor correlation with difficult airway when used alone. [26,27]

Our study had few limitations such as we did not attempt to define cut-off values for different airway difficulty predictor test in this study as the sample size was not large enough to determine the cut-off threshold values. Secondly we excluded the pregnant, obese, emergency cases and these cases could have added more light on the prediction of difficult airway. Thirdly we did not measure neck circumference which could have added more light on prediction of difficult airway

CONCLUSION

The RHTMD with its high accuracy ,sensitivity, specificity, positive and negative predictive value may be used as a routine single screening test for prediction of difficult airway.

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