Comparison of thyromental height test with ratio of height to thyromental distance, thyromental distance, and modified Mallampati test in predicting difficult laryngoscopy: A prospective study

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Abstract

Background and Aims: Preoperative airway assessment to predict patients with difficult laryngoscopy is always crucial for anesthesiologists. Several predictive tests have been studied by various authors in quest of finding the best airway predictor. Recently, a new airway predictor, thyromental height test (TMHT) has been reported to have good predictive value in assessing difficult airway. We conducted this study with primary aim to evaluate the diagnostic accuracy of TMHT and to compare it with other established airway predictors, such as ratio of height to thyromental distance (RHTMD), thyromental distance (TMD), and modified Mallampati test (MMT) for predicting difficult laryngoscopy.

Material and Methods: This prospective, observational study was conducted in 550 patients of either sex aged >18 years scheduled for elective surgery under general anesthesia. The patients' airway was assessed preoperatively by two anesthetists. Standard anesthetic protocol was followed in all the patients. The laryngoscopic view was graded according to Cormack–Lehane scale. The receiver operating characteristic (ROC) curve was used to calculate the ideal cut off values for TMHT and RHTMD. Standard formulae were used to calculate validity indexes.

Results: The incidence of difficult laryngoscopy was 10%. The cut-off value for TMHT and RHTMD were 5.1 cm and 19.5, respectively. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of TMHT were 78.18%, 93.94%, 58.90%, and 97.48%, respectively. The highest sensitivity, PPV, and NPV were observed with TMHT as compared with RHTMD, TMD, and MMT ($P < 0.0001$).

Conclusions: TMHT is the best predictive test with highest accuracy and odds ratio for predicting difficult airway out of all predictive tests evaluated.

Keywords: Airway, difficult laryngoscopy, RHTMD, thyromental height test

Introduction

The knowledge and related skills pertaining to airway management are of paramount importance to anesthesiologists. The incidence of difficult laryngoscopy and tracheal intubation is recorded in 1.5%–20% of patients.[1-3] Failure in managing the airway may result in significant morbidity and mortality. It is reported that of all the anesthetic deaths, 30%–40%, are attributed to inability to manage difficult airway.[4] Therefore, preoperative assessment of patients' airway to predict difficult laryngoscopy and intubation accurately is very crucial.

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Several preoperative airway assessment tests, such as modified Mallampati test (MMT), thyromental distance (TMD), sternomental distance (SMD), and ratio of height to thyromental Distance (RHTMD) have been used singly or in various combinations for predicting difficult airway.[5,6] However, no single test or combination of tests has been validated as the best predictor of difficult airway.

Recently, Etezadi *et al.* showed that the new airway predictor thyromental height test (TMHT) had a better predictive value than MMT, TMD, and SMD.[7] RHTMD has variably been shown to be a better predictor of difficult airway as compared with MMT, TMD, and SMD.[8,9] However, no published study has quantified sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of TMHT versus RHTMD for evaluating patients' airway for difficult laryngoscopy.

So, we conducted this prospective study with primary aim to evaluate validity indexes (sensitivity, specificity, PPV, and NPV), relative risk, accuracy, odds ratio, and likelihood ratio of TMHT to predict occurrence of difficult laryngoscopy. The secondary aim of the study was to compare validity indexes of TMHT, RHTMD, TMD, and MMT to determine an airway predictor with the highest diagnostic accuracy for predicting difficult laryngoscopy.

Material and Methods

This prospective, single blinded, observational study was conducted at a university hospital and has been registered with Clinical Trials Registry of India. After obtaining institutional ethical committee approval and written informed consent, 550 patients of either sex, between 18 and 70 years of age belonging to American Society of Anaesthesiologists (ASA) physical status I and II, scheduled for elective surgery under general anesthesia requiring endotracheal intubation were recruited for this study. Patients with airway malformation, neck burns contracture, midline neck swelling, and edentulous, and those who require awake intubation were excluded from the study.

During preanesthesia check-up, the patient's age, sex, weight, height, ASA physical status, and body mass index were recorded. The airway assessments were done by two anesthesiologists, involved in the study to avoid interobserver variability. The following airway predictors were assessed:

TMHT: Height between the anterior border of the thyroid cartilage and the anterior border of the mentum, with head in neutral position keeping his/her mouth closed. The height will be measured with the help of depth gauze (Kristeel, 1503 DG 1) as shown in Figure 1.

Figure 1: Thyromental height measurement using depth gauze

TMD: It is the distance from the bony point of the mentum to the thyroid notch, with head in full extension and mouth closed, measured with the help of a rigid ruler and classified as Class I if distance is >6.5 cm, Class II if distance is between 6 and 6.5 cm, and Class III if distance is <6 cm. TMD ≤6.5 cm was considered a difficult laryngoscopy.[10,11]

RHTMD: It was calculated as Height (in cm)/TMD.

MMT: Assessed by asking the patient to sit and open his or her mouth maximally and to protrude the tongue without phonation and classified as Class I if soft palate, fauces, uvula, anterior, and posterior tonsil pillars were visible; Class II in case soft palate, fauces, and uvula were visible; Class III if soft palate and base of uvula were visible; and Class IV when only hard palate was visible. MMT classes 3 and 4 were considered as predictors of difficult laryngoscopy.[12]

All the patients were fasted for 8 h before surgery. In the operating room, after taking baseline vitals, general anesthesia was induced with fentanyl 2 μg/kg, propofol 2–3 mg/kg, and muscle relaxation was achieved by vecuronium 0.1 mg/kg. After 3 min, laryngoscopy was performed in sniffing position by an experienced anaesthesiologists (>5 year experience), not involved in airway assessment, using Macintosh #3, 4 blade. Sniffing position for intubation was achieved by placing a pillow (height: 8 cm) under the head.[13] The patient trachea was then intubated and confirmed by bilateral auscultation over the lung fields and capnography. The laryngeal view was assessed by using modified Cormack and Lehane (C-L) grading system as follows: Class I: full glottic exposure, Class II: only posterior commissure of glottis, Class III: only epiglottis visible, and Class IV: epiglottis not visible.[14] The C-L grades I and II was considered as easy laryngoscopy and C-L grades III and IV as difficult laryngoscopy.

Statistical analysis

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 22 (SPSS Inc., Chicago, IL, USA). A prospective power analysis showed that assuming an incidence of difficult laryngoscopy of 8%, 327 patients provide a power of >90% to detect the agreement between the C-L test and the predictors with a type I error of 3%. Considering power attenuation (as huge variation was expected in the number of patients with and without outcome), we increased sample size of about twofold (550).[7] Patient data were presented as mean ± standard deviation or numbers (%). Area under the receiver operating characteristic (ROC) curve and area under the curve (AUC) were used to calculate the optimal predictive cut-off point for TMHT and RHTMD. The preoperative airway assessment data and the findings during intubation were used to calculate the validity indexes. Fischer exact test was used for statistical comparison; 95% confidence interval (CI) was calculated; and a P value of 0.05 (two-tailed) was defined as statistically significant.

Results

Five hundred and fifty patients were enrolled in the study. The demographic profiles of all patients are shown in Table 1. Fifty-five patients (10%) had C-L grading III or IV, which were managed either by using external laryngeal manoeuvre or with the help of bougie. There were no failed intubations.

According to the ROC curve, the cut-off values for TMHT and RHTMD were 5.1 cm and 19.5, respectively, as shown in Figures 2 and 3. The mean TMHT was 5.5 cm.

Comparison between C-L grades and preoperative predictors (TMHT, RHTMD, TMD, and MMT) are shown in Table 2.

The sensitivity, specificity, PPV, and NPV for TMHT were 78.18%, 93.94%, 58.90%, and 97.48%, respectively. Validity Indexes for TMHT, RHTMD, TMD, and MMT to predict the occurrence of difficult laryngoscopy, i.e., grade 3 or 4 according to the modified C-L classification are shown in Table 3. The highest sensitivity, PPV, NPV, accuracy, and odds ratio were observed with TMHT as compared with RHTMD, TMD, and MMT. The RHTMD was the least specific test (77.37%) as compared with other tests but had higher sensitivity (63.64%) and NPV (95.04%) compared with TMD and MMT.

Discussion

Preoperative airway assessment is a routine anesthetic practice to predict difficult airway so that adequate planning could be made to secure airway. Difficulty in managing airway could be catastrophic and may result in significant morbidity and mortality. The incidence of difficult laryngoscopy and intubation reported by numerous studies were varies from 1.3% to 13% in patients undergoing general anesthesia.[15-18] This wide variation in incidence of difficult laryngoscopy and intubation can be attributed to various factors, such as ethnic differences among populations, head position (sniffing position), inclusion of external laryngeal manoeuvre, and the different criteria used to define difficult laryngoscopy and intubation.[19] In our study, the incidence of difficult laryngoscopy was 10%, which is within the range as reported by previous studies and comparable to results obtained by Smita *et al.* (9.7%).[20]

Table 1: Demographic data of the patients

Variables	Range	Mean	SD
Age (years)	17-72	37.19	12.4
Weight (kg)	33-98	61.07	12.94
Height (cm)	135-184	158.4	9.04
BMI (kg/m^2)	14.5-35	24.52	4.80
Gender	Male (43.63%); female (56.36%)		

BMI=Body mass index

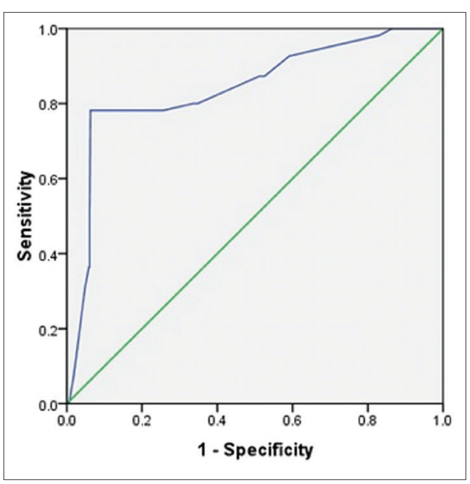

Figure 2: Receiver operating characteristic curve for TMHT

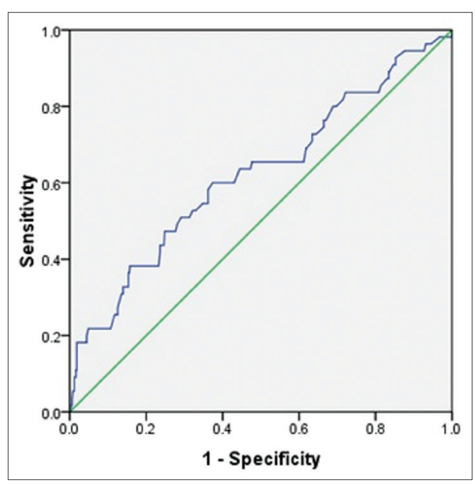

Figure 3: Receiver operating characteristic curve for RHTMD

Table 2: Comparison between C-L grades and four preoperative predictors (TMHT, RHTMD, TMD, and MMT)

Test	C-L grades		Total	K (95% CI)	Significance Fisher exact test
	Easy (*n*=495)	Difficult (*n*=55)			
TMHT					
Easy	465	12	477	0.630 (0.53-0.73)	0.0001
Difficult	30	43	73		
RHTMD					
Easy	383	20	403	0.235 (0.153-0.32)	<0.0001
Difficult	112	35	147		
TMD					
Easy	468	44	512	0.169 (0.100-0.36)	0.0005
Difficult	27	11	38		
MMT					
Easy	468	37	505	0.169 (0.05-0.28)	<0.0001
Difficult	27	18	45		

TMHT=Thyromental height test; RHTMD=Ratio of height to thyromental distance; TMD=thyromental distance; MMT=modified Mallampati test; C-L=Cormack-Lehane; CI=confidence interval

Table 3: Validity indexes for TMHT, RHTMD, TMD, and MMT to predict the occurrence of difficult laryngoscopy

Test	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	OR	Accuracy	LR	RR
TMHT	78.18	93.94	58.90	97.48	55.54	92.36	12.90	12.90
RHTMD	63.64	77.37	23.81	95.04	5.98	76	2.81	2.8
TMD	20	94.55	28.95	91.41	4.3	87.09	3.67	3.66
MMT	32.73	94.55	40	92.67	7.49	88.36	6	5.07

PPV=positive predictive value; NPV=negative predictive value; or=odds ratio; LR=likelihood ratio; RR=relative risk; TMHT=thyromental height test; RHTMD=ratio of height to thyromental distance; TMD=thyromental distance; MMT=modified Mallampati test

Recently, a new airway predictor TMHT was proposed by Etezadi *et al.*[7] According to the study, shorter thyromental height is associated with difficult laryngoscopy. This can be related to the fact that in patients with anterior larynx, backward, upward, rightward pressure is used, which increases the thyromental height, to improve the laryngoscopic view.[21] The area under the ROC curve was used to calculate the ideal cut-off point for TMHT (5.1 cm), with an AUC of 0.841 (95% CI, 0.780–0.903) for predicting difficult laryngoscopy. The cut-off value for TMHT in our study was very close to the value proposed by Etezadi *et al.* (5 cm). So, for the ease of calculation, we also performed the statistical analysis of TMHT by taking cut-off value (5 cm) as suggested by Etezadi *et al.* In this study, the sensitivity, specificity, PPV and NPV for TMHT were found to be 78.18%, 93.94%, 58.90%, and 97.48%, respectively. These values were 82.6%, 99.31%, 90.47%, and 98.63%, respectively, in original study. Although the statistical values are different in our study from that of the original study, however, the conclusion that TMHT is the most accurate predictor as compared with other studied airway predictors was comparable.

Selvi *et al.* reassessed the TMHT in their study. According to the study, the suggested cut-off value for TMHT was 43.5 mm. This may be attributed to the racial differences among population. The study compared TMHT with ULBT, TMD, and MMT.[22] Recently, the TMHT was studied in an Indian population. Validity indexes for TMHT found in our study were nearly comparable to other two studies performed on Indian population except PPV which was lower in our study.[23,24] However, the low PPV has also been reported earlier in the study conducted by Selvi *et al.* (PPV 20.87% at TMH <43.52 mm, PPV 14.66% at TMH <50 mm). The low value of PPV can be explained by the fact that males have more prominent (few millimetre) thyroid cartilage,[25] resulting in shorter TMH and thereby more false positives.

Safavi *et al.* concluded that the cut-off point for RHTMD for prediction of direct laryngoscopy is race dependent and recommend calculating cut-off point for each population separately.[26] Hence, we used ROC curve to set the cut off for RHTMD. In our study, the cut-off point for RHTMD was 19.5, with an AUC of 0.622 (95% CI, 0.537–0.707) in contrast to 25 as reported by Schmitt *et al.* who introduced this test.[8] This may be attributed to anthropometric differences among population. The sensitivity (63.64%) and NPV (95.04%) of RHTMD was higher in our study as compared with TMD and MMT. However, the PPV (23.81%) of RHTMD was lowest as compared with other tests, which correlates with the result obtained by previous studies.[9,26,27]

In this study, the TMD showed poor sensitivity (20%) and PPV (29.95), which correlates well with the findings of previous studies.[28-30] However, the specificity (94.55%) of TMD was comparable to TMHT (93.94%).

MMT is considered as the gold standard test for the prediction of difficult airway. But this test also has its own limitations. First, this test has a higher interobserver variability and a large number of false positive.[31] Second, statistical heterogeneity has been seen, which could be attributed to the inconsistent way of performing this test. MMT may have been conducted with or without phonation and/or with different head or tongue positions.[32] Meta-analysis done by Lundstrom *et al.* demonstrated that the MMT, as a standalone test, was an inadequate predictor of a difficult airway.[33] The sensitivity, specificity, and NPV for MMT in our study were comparable to the reported values in earlier studies. However, the PPV for MMT in our study was found to be higher as compared with results found by Krobbuaban *et al.*[10] The specificity (94.55%) and NPV (92.67%) for MMT were comparable to TMHT.

The limitations of our study were restricted demographic profile and exclusion of emergency patients and AUC for RHTMD was 0.622 (AUC of < 0.7 is considered poor). Also, we had not compared the TMHT with combinations of predictive test.

To conclude, our study demonstrates that TMHT is the best predictive test for difficult laryngoscopy with highest sensitivity, PPV, NPV, and odds ratio out of all predictive tests evaluated. Moreover, TMHT is a simple, bedside test that does not depend on head extension of the patient. TMHT also has small interobserver variability and larger level of accuracy (92.36%) as compared with other predictive test.

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Conflicts of interest

There are no conflicts of interest.

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