Research Article

A COMPARISON OF THE RATIO OF PATIENT'S HEIGHT TO THYROMENTAL DISTANCE WITH THE MODIFIED MALLAMPATI TEST AND THE UPPER LIP BITE TEST IN PREDICTING DIFFICULT LARYNGOSCOPY

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ABSTRACT

Background. In an attempt to determine a more comprehensive and accurate as well as simple and clinically applicable day to day basis parameter for predicting difficult laryngoscopy, individual test like upper lip bite tests and mallampati classification have been compared. In this study we compared patients height to thyromental ratio (RHTMD) with upper lip bite test (ULBT) and mallampati test (MMT). We also investigated whether the combination of these tests can improve the ability to predict difficult laryngoscopy.

Methods. In this prospective study 300 patients who were scheduled for elective surgery were selected. Before induction of anesthesia, the airway was assessed for ULBT, RHTMD and MP class. Cormack Lehan(CL) grading system was used to define difficult intubation after inducing anesthesia . Finally sensitivity, specificity, positive and negative predictive values of these tests individually and in combination were calculated.

Results. The ratio of height to thyromental distance had the highest sensitivity(89.62%), specificity(94.32%) and positive predictive value(97.44%) as compared to the modified Mallampati test[having sensitivity, specificity and positive predictive value of 63.68%,52.05%, 95.07% respectively and the upper lip bite test[having sensitivity, specificity and positive predictive value of 53.3%, 77.2%, 84.96% respectively, thus making it a good predictive test for preoperative airway assessment and evaluation of laryngoscopy among the three tests used. When the three tests i.e. the modified Mallampati test (MMT), the ratio of height to thyromental distance (RHTMD) and the upper lip bite test(ULBT) were combined sensitivity was 98.55%, specificity was 2.45%, positive predictive value(PPV) was 94.3%, negative predictive value(NPV) was 32.05%

Conclusion: We conclude that the accuracy of RHTMD is significantly higher than the other two tests, and in combination these tests more reliably predict difficult intubation.

INTRODUCTION

Endotracheal intubation is considered in every patient receiving general anesthesia. The ability to place an unobstructed conduit into a patient's airway to assist with ventilation and to protect the airway is potentially a lifesaving skill. Problems with airway management are among the most frequent causes of anesthetic mishaps (dental damage, aspiration of gastric contents, airway trauma, unanticipated surgical airway, anoxic brain injury, cardiopulmonary arrest) and fatality. [1,2] Difficult intubation occur in about 0.8-7% of patients in operating room settings [3,4] Failed intubation of the trachea occurs in about 1 in 2000 patients in an elective setting[5,6.] Because of potentially serious consequences of failed tracheal intubation, considerable attention has been focused on attempts to predict patients in whom laryngoscopy and intubation might be difficult[6,7] and in this regard combination of different test scores have been developed but none of them have proven to be totally reliable[7,8,9] Research is ongoing to devise a simple bedside test to anticipate difficult tracheal intubation, which has high sensitivity, specificity, Positive predictive value (PPV), Negative predictive value (NPV), Likelihood ratio (LR) with minimal False positive (FP) and False negative (FN) values.

In this context we conducted a study to evaluate sensitivity, specificity, Positive predictive value(PPV),Negative predictive value(NPV), Relative risk (RR), Odds ratio (OR) and Likelihood ratio(LR) for various screening tests like the ratio of patients height to thyromental distance(RHTMD), modified Mallampati (MMT) and upper lip bite test(ULBT) in isolation and in various combinations, with an attempt to determine a more comprehensive and accurate as well as simple and clinically applicable day to day basis parameter for predicting difficult laryngoscopy.

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MATERIALS AND METHODS

In this prospective observational study a total of 300 adult patients were enrolled with American society of Anesthesiologist (ASA) physical status I-III undergoing elective urologic, abdominal and gynecological surgeries under general anesthesia. Patients with history of previous surgery, trauma, tumours and burns to the airways or to the cranial, cervical and facial regions, Patients who were unable to sit, edentulous, or needed awake intubation were excluded from the study. The following three predictive test measurements were carried out on all patients by a single anesthetist having minimum 6 years of experience.

1. Modified Mallampati Test (MMT): Samsoon and young`s modification of the Mallampati test records oropharyngeal structures visible upon maximal mouth opening. When seated, each patient was asked to open his or her mouth maximally and to protrude the tongue without phonation. The view thus obtained, was classified as:
   I. Good visualization of the soft palate, fauces, uvula, and tonsillar pillars
   II. Pillars obscured by the base of the tongue but the soft palate, fauces and uvula visible
   III. Soft palate and base of the uvula visible
   IV. Soft palate not visible.
2. Ratio of height to thyromental distance (RHTMD): Thyromental distance (in meters) was measured from the bony point of the mentum while the head was fully extended and the mouth closed. The height of the patient was measured in meters and then the ratio of height to thyromental distance was calculated.
3. Upper lip bite test (ULBT): The upper lip bite test was classified as:

Class 1: If the lower incisors could bite the upper lip above the vermilion line
Class 2: If the lower incisors could bite the upper lip below the vermilion line
Class 3: If the lower incisors could not bite the upper lip

On arrival in the operating room, routine monitoring, including ECG, non-invasive arterial blood pressure and oxygen saturation were recorded. Induction of anesthesia was done with injection lignocaine 2% 1-1.5mg/kg IV, injection propofol 2-2.5mg/kg IV, injection fentanyl 1-2mcg/kg IV. Muscle relaxant (Rocuronium 0.5 to 0.8 mg/kg) was given to facilitate endotracheal intubation.

A single anesthesiologist with 6 years experience in anesthesia, who was not informed of the preoperative airway evaluation, performed laryngoscopy and evaluated difficulty of laryngoscopy at intubation. The head of the patient was placed in the "sniffing position" and laryngoscopy was done to visualize the larynx and the view was classified using the Cormack and Lehane's (CL) classification without external laryngeal manipulation:

CL I=Vocal cords visible
CL II= Only posterior commissure or arytenoids visible
CL III: Only epiglottis visible;
CL IV: Neither glottis nor epiglottis visible

Difficult visualization of the larynx (DLV) was described as Cormack and Lehane's III or IV views on direct laryngoscopy while the easy visualization of the larynx(ELV) was defined as

Cormack and Lehane's I or II view on laryngoscopy.[1] Confirmation of successful intubation was done by bilateral auscultation over the lung fields and capnography.

Statistical Analysis of Data

All the continuous variables of the study were represented by descriptive statistics (Frequency, Percentage, Mean ± SD) and all the categorical variables were analyzed by applying various parametric and non-parametric tests after confirming the normal distribution of data. In addition to this, all the results were discussed at 5% level of significance i.e. p-value <0.05 was considered statistically significant. Appropriate statistical charts were used to represent the analyzed data. All the data was analyzed with the help of Statistical Software Package: SPSS-V-23.0

RESULTS

The demographic characters of study patients are shown in table 1.

Table 1 Showing various demographic parameters of study patients.

	AGE(years)	WEIGHT(kg)	HEIGHT(m)	BMI(kg/m^2)
Mean	37.6	66.8	1.6	26.1
Median	35	68	1.59	26.365
Mode	34	69	1.55	27.94
Std. Deviation	12.13	7.71	0.07	3
Minimum	18	46	1.43	17.47
Maximum	70	84	1.78	37.33

Mean value of RHTMD in our study was 27.191. Easy visualization of larynx (ELV) was seen in mean ratio of height to thyromental distance(RHTMD) of 27.04 and difficult visualization of larynx(DLV) was seen in mean RHTMD of 27.56(Table 3). The difference in mean RHTMD with easy visualization of larynx versus difficult visualization of larynx was statistically significant(p value<0.05). The variation of demographic characters with visualization of larynx is shown in Table 3.

Table 2 Showing MMT,ULBT, RHTMD, CL distribution among study subjects.

ULBT	MMT	RHTMD	CL grading
Grade, frequency (%)	Grade, frequency (%)	Grade, frequency (%)	Grade, Frequency (%)
I ,119 (39.7)	I , 84 (28)	≤ 25.0, 27 (9)	I , 96 (32)
II , 120 (40)	II, 109(36.3)	25.1 - 29.0 , 221 (73.7)	II, 116 (38.7)
III, 61 (20.3)	III ,99 (33)	29.1+, 52, (17.3)	III, 84 (28)
	IV, 8 (2.7)		IV, 4 (1.3)

Table 3 Showing variation of demographic parameters with visualization of larynx.

Variable	Value	ELV(n=212)	DLV(n=88)	P Value
Male n(%)	156 (52%)	112 (52.8%)	44(50%)	0.65
Female n(%)	144(48%)	100(47.2%)	44(50%)	
Age(years)	37.61 ±12.135	36.72 ± 11.76	39.75 ± 12.81	0.049*
Weight (Kg)	66.81± 7.706	65.92 ± 7.71	68.97 ± 7.29	0.002*
Height(m)	1.60287±0.074207	1.61 ± 0.07	1.59 ± 0.07	0.021*
BMI(kg/m^2)	26.067 ± 3.0006	25.58 ± 2.76	27.25 ± 3.24	0.001*
RHTMD	27.191± 1.8600	27.04+-1.82	27.56+-1.92	0.027*

Table 4 Showing sensitivity, specificity, 95% Confidence interval(CI),positive Likelihood ratio(LR+),negative likelihood ratio(LR-),Positive predictive value(PPV), Negative predictive value(NPV), Area under curve(AUC) and p-value of modified Mallampati test(MMT), upper lip bite test (ULBT), ratio of height to thyromental distance(RHTMD) in various combinations in study patients

| TEST	Sensitivity (%)	95% CI	Specificity (%)	95% CI	LR+	LR-	PPV (%)	NPV (%)	AUC	P-VALUE
MMT	63.68	57.02-69.89	52.05	84.48-96.09	1.005	0.3946	95.07	51.27	0.73	0.106
ULBT	53.3	46.59-59.9	77.27	67.49-84.78	1.345	0.6043	84.96	40.72	0.82	0.024
RHTMD	89.62	84.79-93.05	94.32	87.38-97.55	1.77	0.11	97.44	79.05	0.85	0.015
MMT+ULBT	95.3	95.25-95.48	5.42	1.7-20.9	1.05	0.12	94.7	30.05	0.433	0.741
MMT+RHTMD	30.21	22.4-30.4	75.21	65.4-92.55	1.37	0.14	95.8	20.05	0.451	0.821
ULBT+RHTMD	96.34	96.25-96.55	5.88	0.90-17.5	1.09	0.19	97.5	25.05	0.461	0.641
MMT+ULBT+RHTMD	98.55	97.45-98.65	2.45	0.20-14.9	1.05	0.1	94.3	32.05	0.4	0.811
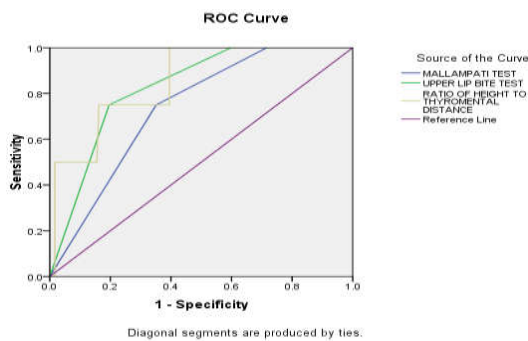
Figure 1 Showing Receiver operating characteristic curve of Sensitivity and specificity of modified Mallampati test (MMT), upper lip bite test (ULBT) and the ratio of height to thyromental distance (RHTMD)

DISCUSSION

The management of the airway is the primary and unique responsibility of an anesthetist. Failure to be prepared for difficult airway is the major cause of severe morbidity and mortality related to anesthesia[10]. According to World Health Organization (WHO), about 600 people die every year due to the consequences of difficult intubation. Accordingly, the search for a predictive test that has ease of applicability and accuracy of prediction persists. Various preoperative airway assessment tests were introduced and used from time to time to predict difficult intubation and laryngoscopy but no single test is accepted as an ideal bedside test to predict difficult laryngoscopy.

Preoperative tests used for airway assessment and evaluation of difficult laryngoscopy and intubation should be highly sensitive, specific and should have a high positive predictive value (PPV) with few negative predictions with an attempt to determine a more comprehensive and accurate as well as simple and clinically applicable day to day basis parameter for predicting difficult laryngoscopy.

In our study, as a stand-alone test, the ratio of height to thyromental distance had the highest sensitivity(89.62%), specificity(94.32%) and positive predictive value(97.44%) as compared to the modified Mallampati test[having sensitivity, specificity and positive predictive value of 63.68%,52.05%, 95.07% respectively and the upper lip bite test[having sensitivity, specificity and positive predictive value of 53.3%, 77.2%, 84.96% respectively, thus making it a good predictive test for preoperative airway assessment and evaluation of laryngoscopy among the three tests used. Our observations are in concordance with Krobbuaban *et al*[11] who conducted a study and found that the odds ratio of RHTMD was highest and thus has proved a useful screening test for difficult laryngoscopy.

Our observations also correlate with the observations of Safavi *et al*[12] who in their study compared the ability to predict difficult visualization of the larynx from the following preoperative airway predictive indices, in isolation and combination: modified Mallampati test (MMT), the ratio of height to thyromental distance (RHTMD) and the Upper-Lip-Bite test (ULBT). They concluded that the RHTMD is comparable with ULBT for prediction of difficult laryngoscopy in general population**.**

Analysis of our study revealed that the area under curve(AUC) of the ratio of height to thyromental distance(RHTMD) was 0.85 and that of upper lip bite test(ULBT) was 0.82 whereas for the modified Mallampati score was 0.73(Figure I) The area under curve was highest for the ratio of height to thyromental distance among the three tests used. The area under curve(AUC) of ratio of height to thyromental distance (RHTMD) for predicting difficult laryngoscopies is not significantly different from the upper lip bite test(ULBT).

Thus, the ratio of height to thyromental distance and the upper lip bite test were comparable as regards to area under curve(AUC) as a predictor of difficult laryngoscopy.Our observations correlate with the observations of Safavi *et al* [12] who in their study compared the ability to predict difficult visualization of the larynx from the following preoperative airway predictive indices, in isolation and combination: modified Mallampati test (MMT), the ratio of height to thyromental distance (RHTMD) and the Upper-Lip-Bite test (ULBT). They concluded that the RHTMD is comparable with ULBT for prediction of difficult laryngoscopy in general population as regards to area under curve of these two tests.

On comparing upper lip bite test(ULBT) and the modified Mallampati test (MMT), we found that the upper lip bite test (ULBT) was less sensitive as compared to the modified Mallampati test (MMT) [53.3% versus 63.68%] but more specific than the modified Mallampati test(MMT) [77.27% versus 52.05%].Our observations are in concordance with the observations of Khan   *et al*[13] who in their study found that the upper lip bite test showed significantly higher specificity and accuracy than the modified Mallampati test (P < 0.001). Comparisons of sensitivity, positive and negative predictive values, between the two tests, however, did not reveal any significant differences (P > 0.05).   Our observations also correlate well with the observations of Chohedri *et al*[14] and of Hester *et al*[15] who in their studies concluded that the ULBT has high level of accuracy and specificity compared to other tests.

When modified Mallampati test (MMT) was combined with upper lip bite test (MMT+ULBT), the sensitivity was 95.3%, specificity was 5.42%, positive predictive value (PPV) was 94.7%, negative predictive value (NPV) was 30.05%.

However, when modified Mallampati test (MMT) was combined with the ratio of height to thyromental distance (MMT+RHTMD), the sensitivity was 30.21%, specificity was 75.21%, positive predictive value was 95.8% and negative predictive value was 20.05%.The combination of the upper lip bite test and the ratio of height to thyromental distance (ULBT+RHTMD) had sensitivity of 96.34%, specificity of 5.88%, positive predictive value of 97.5%and negative predictive value of 25.05.This showed that the upper lip bite test (ULBT) and the ratio of height to thyromental distance(RHTMD) in combination(ULBT+RHTMD) had better sensitivity than the modified Mallampati test(MMT) and the ratio of height to thyromental distance(RHTMD)in combination(MMT+RHTMD) or the modified Mallampati test (MMT) and the upper lip bite test(ULBT) in combination (MMT+ULBT). However, the modified Mallampati test (MMT) and the ratio of height to thyromental distance(RHTMD) had greater specificity in combination(MMT+RHTMD) than the modified Mallampati test(MMT) and the upper lip bite test(ULBT) in combination(MMT+ULBT) or the upper lip bite test(ULBT) and the ratio of the height to thyromental distance(RHTMD) in combination(ULBT+RHTMD). Thus, the combination(of tests) with best sensitivity was the upper lip bite test and the ratio of height to thyromental distance(ULBT+RHTMD) having sensitivity of 96.34% with p value of 0.641 followed by the modified Mallampati test and the upper lip bite test in combination (MMT+ULBT) having sensitivity of 95.3%with p value of 0.741 and the modified Mallampati test and ratio of height to thyromental distance test in combination (MMT+RHTMD) having sensitivity of 30.21% with p value of 0.821 and the combination(of tests) with best specificity was the modified Mallampati test and the ratio of height to thyromental distance (MMT+RHTMD) having specificity of 75.21% with p value of 0.821 followed by the upper lip bite test and the ratio of height to thyromental distance in combination(ULBT+RHTMD) having specificity of 5.88% with p value of 0.641 and the modified Mallampati test and the upper lip bite test(MMT+ULBT) having specificity of 5.42% with p value of 0.741.Our observations correlate with the study of Safavi *et al*[11] who compared the ability to predict difficult visualization of the larynx from the following preoperative airway predictive indices, in isolation and combination: modified Mallampati test (MMT), the ratio of height to thyromental distance (RHTMD) and the Upper-Lip-Bite test (ULBT). They found that when upper lip bite test(ULBT) and the ratio of height to thyromental distance(RHTMD) were combined, the sensitivity increased to 99.11% whereas when modified Mallampati test(MMT) and the ratio of height to thyromental distance(RHTMD) were combined, the sensitivity decreased to 26.52%.

When the three tests i.e. the modified Mallampati test (MMT), the ratio of height to thyromental distance (RHTMD) and the upper lip bite test (ULBT) were combined (MMT+RHTMD+ULBT), sensitivity was 98.55%, specificity was 2.45%, positive predictive value (PPV) was 94.3%, negative predictive value (NPV) was 32.05%. These three tests in combination had the highest sensitivity as compared to the sensitivity obtained when these three tests were used alone or in various combinations. This statistical analysis suggests that combination of tests are more reliable and has better predictive values as compared to individual tests used alone which correlate with the study of Shiga *et al*[3] who concluded that

currently available screening test for difficult intubation have only poor to moderate discriminative power when used alone. Combinations of individual tests or risk factors add some incremental diagnostic value in comparison to the value of each test alone.

Our observations also correlate with the observations of Khan *et al*[16] who investigated whether the combination of preoperative airway assessment tests or a composite score can improve the ability to predict easy laryngoscopy and intubation compared with each test alone.

Safavi *et al*[12] in their study compared the ability to predict difficult visualization of the larynx from the following preoperative airway predictive indices, in isolation and combination: modified Mallampati test (MMT), the ratio of height to thyromental distance (RHTMD) and the Upper-Lip-Bite test (ULBT). They found that when modified Mallampati test, the ratio of height to thyromental distance and the upper lip bite test were combined, the sensitivity was maximum (99.64%).

CONCLUSION

In conclusion, as a stand-alone test, the ratio of height to thyromental distance(RHTMD) is superior among the three tests used for predicting difficulty laryngoscopy and intubation as it showed highest sensitivity, specificity, positive and negative predictive values. Combination of the tests i.e. modified Mallampati test (MMT), upper lip bite test(ULBT) and the ratio of height to thyromental distance (RHTMD) are better predictors of difficult laryngoscopy and intubation as compare to either test used alone.

Limitations of our study

1. Significant interobserver variations are found with the modified Mallampati test (MMT). Many patients involuntarily phonate during assessment of the MMT score which may considerably alter the modified Mallampati classification. This might be the reason for poor predictability of MMT.
2. The ratio of height to thyromental distance (RHTMD) depends upon accurate measurement of patient's thyromental distance and height that lessens the simplicity of this method. Also, the cutoff point of the ratio of height to thyromental distance (RHTMD) for predicting difficult laryngoscopy is race dependent. One should calculate the cutoff point for each population separately.
3. The upper lip bite test (ULBT) for predicting difficult laryngoscopy has some limitations. There is ethnic variation in craniofacial configuration of populations. Moreover, review of dental literature shows that there are significant racial variations in morphology and morphometry of human mandible and maxillary bones. So, the upper lip bite test (ULBT) may not be applicable for some populations.

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