Original Article

A comparison of between hyomental distance ratios, ratio of height to thyromental, modified Mallamapati classification test and upper lip bite test in predicting difficult laryngoscopy of patients undergoing general anesthesia

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Abstract

Background: Failed intubation is imperative source of anesthetic interrelated patient's mortality. The aim of this present study was to compare the ability to predict difficult visualization of the larynx from the following pre-operative airway predictive indices, in isolation and combination: Modified Mallampati test (MMT), the ratio of height to thyromental distance (RHTMD), hyomental distance ratios (HMDR), and the upper-lip-bite test (ULBT).

Materials and Methods: We collected data on 525 consecutive patients scheduled for elective surgery under general anesthesia requiring endotracheal intubation and then evaluated all four factors before surgery. A skilled anesthesiologist, not imparted of the noted pre-operative airway assessment, did the laryngoscopy and rating (as per Cormack and Lehane's classification). Sensitivity, specificity, and positive predictive value for every airway predictor in isolation and in combination were established.

Results: The most sensitive of the single tests was ULBT with a sensitivity of 90.2%. The hyomental distance extreme of head extension was the least sensitive of the single tests with a sensitivity of 56.9. The HMDR had sensitivity 86.3%. The ULBT had the highest negative predictive value: And the area under a receiver-operating characteristic curve (AUC of ROC curve) among single predictors. The AUC of ROC curve for ULBT, HMDR and RHTMD was significantly more than for MMT ($P < 0.05$). No significant difference was noted in the AUC of ROC curve for ULBT, HMDR, and RHTMD ($P > 0.05$).

Conclusion: The HMDR is comparable with RHTMD and ULBT for prediction of difficult laryngoscopy in the general population, but was significantly more than for MMT.

Key Words: Failed intubation, hyomental distance ratios, laryngoscopy, modified Mallampati test, ratio of height to thyromental distance, upper-lip-bite test

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INTRODUCTION

The importance of pre-operative prediction of a difficult airway is obvious: 85% of all mistakes regarding airway management result in permanent cerebral damage,[1] and up to 30% of all anesthetic deaths can be attributed to the management of difficult airways.[2,3] For patients in whom a general anesthetic

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is desirable or needed, a variety of factors have been recognized that when present possibly will yield intubation difficult. These concomitant factors may be separated into patient characteristics, factors related with the general populations, and factors linked with anesthesia.[4] Difficult laryngoscopy (characterized by poor glottic visualization) is synonymous with difficult intubation in most patients.[5] Difficult intubation is described in 1.5-13% of patients.[6] Recognition of those patients in whom intubation might be difficult is the ideal that we attempt to attain. Unhappily, the techniques of evaluation we presently employ clinically do not precisely predict which patients will be difficult to intubate.[7] Several investigation explain prediction schemes by applying a single risk factor or a multifactorial index.[8,9] One test for difficult laryngoscopy is the upper-lip-bite test (ULBT), assesses the possibility of a patient to cover the mucosa of the upper lip with the lower incisors. Grade 1 (the lower incisors can completely cover the upper lip's mucosa) and Grade 2 (the lower incisors can touch the upper lip but cannot completely cover the mucosa) are considered to predict easy laryngoscopy and are compared with Grade 3 of the ULBT (the lower incisors fail to bite the upper lip), which was noticed to be associated with difficult laryngoscopy.[10] Another test for difficult laryngoscopy is the thyromental distance (TMD), which is different according with patient size.[11] Nevertheless, numerous studies question whether the TMD is either sensitive or specific enough to be used as the only predictor of difficult laryngoscopy.[12] Even though, Schmitt *et al*.[13] showed that the ratio of height to TMD (ratio of height to thyromental distance [RHTMD] height [cm]/TMD [cm]) had a better predictive value than the TMD, no published study has quantified its sensitivity, specificity and positive predictive value (PPV) versus the ULBT and the Mallampati classification,[4] revised by Samsoon and Young for evaluating patient's airway for difficult laryngoscopy. Recently, Takenaka *et al*.[14] defined the ratio of the HMD in the neutral position (HMDn) and at the extreme of head extension (HMDe) as the hyomental distance ratio (HMDR) and demonstrated that it was a good predictor of a reduced occipitoatlantoaxial complex extension capacity in patients with rheumatoid arthritis [Figure 1].

The ability to predict a difficult tracheal intubation permits anesthesiologists to take precautions to decrease the risk.[15] The predictive value of Mallampati classification, the HMDR, RHTMD and the ULBT methods of airway assessment for difficult laryngoscopy were investigated before in different separate studies. It was not clear, which method can be predicted difficult laryngoscopy better. No previous

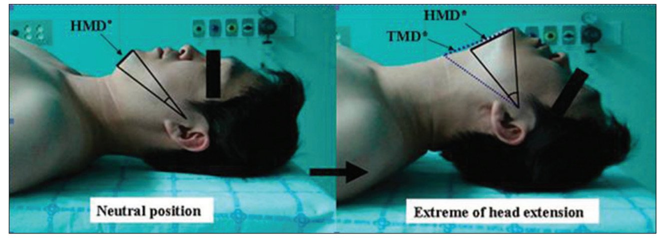

Figure 1: Method for measuring the hyomental distance ratio. The HMDR was defined as the ratio of the hyomental distance at the extreme of head extension (expressed as HMDe) to that in the neutral position (expressed as HMDn). Thyromental distance at the extreme of head extension was expressed as TMD

study on one sample population was performed to answer to this question. Hence, we performed a prospective, blind study of the predictive value of the Mallampati classification revised by Samsoon and Young versus the HMDR, RHTMD, and the ULBT methods of airway assessment for difficult laryngoscopy in patients required tracheal intubation for general anesthesia.

MATERIALS AND METHODS

This prospective observational study was approved by the Ethics Committee of our university, and all patients gave written, informed consent. We subsequently studied 525 successive ASA physical status I-III adult patients programmed to be given general anesthesia necessitate endotracheal intubation for elective surgery. Patients with a history of previous surgery, burns or trauma to the airways or to the cranial, cervical and facial regions, patients with tumors or a mass in the above-mentioned regions, patients with restricted motility of the neck and mandible (e.g., rheumatoid arthritis or cervical disk disorders), inability to sit, edentulous or need awake intubation were excluded from the study. Patients younger than 18 year of age, with apparent malformations of the airway, incapability to sit, recent operation of the head and neck, edentulous, or have need of awake intubation were kept out from the study to prevent the introduction of a variable that might separately influence predictability of difficult laryngoscopy. If it was necessary to attempt laryngoscopy for more than 1 time or it was needed to use a different technique for successful intubation or time to accomplish the intubation was more than 15 s, the patient was excluded from the study.

Patient data collected included sex, age, weight, height, and body mass index (BMI). The subsequent three predictive test measurements were carried out on all patients:

- Modified Mallampati test (MMT): Samsoon and Young's modification of the Mallampati test recorded oropharyngeal structures visible upon maximal mouth opening. While seated, each patient was asked to open his or her mouth maximally and to protrude the tongue without phonation. The view was classified as (1) good visualization of the soft palate, fauces, uvula and tonsillar pillars; (2) pillars obscured by the base of the tongue but the soft palate, fauces and uvula visible; (3) soft palate and base of the uvula visible; and (4) soft palate not visible.[4,16]
- RHTMD: TMD was measured from the bony point of the mentum while the head was fully extended and the mouth closed.[17] Then the ratio of height to TMD was calculated.
- ULBT: The ULBT was rated 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 and class 3 if the lower incisors could not bite the upper lip.[10]
- HMDR: The HMDR was calculated as the ratio of the HMDe to that in the neutral position. Patients were instructed to look straight ahead, keep the head in the neutral position, close the mouth and not swallow. A hard-plastic bond ruler was pressed on the skin surface just above the hyoid bone, and the distance from the tip to the anterior-most part of the mentum was measured and defined as the HMDn [Figure 1]. Patients were then instructed to extend the head maximally, taking care that the shoulders were not lifted while extending the head. The HMD was measured again in this position, and this variable was defined as the HMD at the extreme of head extension. On arrival in the operating room, routine monitoring, including non-invasive arterial blood pressure, an electrocardiogram and oxygen saturation, were introduced. Induction of anesthesia was with 4 mg/kg of sodium thiopental intravenous (i.v.). Atracurium 0.6 mg/kg i.v. was administered to facilitate endotracheal intubation. The patient's lungs were ventilated by mask with 100% oxygen. Another single anesthesiologist with 10 year experience in anesthesia, who was not informed of the pre-operative classes, performed laryngoscopy and evaluated difficulty of laryngoscopy at intubation. The head of the patient was placed in the "sniffing" position and laryngoscopy was done with using a Macintosh #4 blade to visualize the larynx and the view was classified using the Cormack and Lehane (CL) classification,[18] without external laryngeal manipulation: (1 = vocal cords visible; 2 = only posterior commissure or arytenoids visible; 3 = only epiglottis visible; 4 = none of the foregoing visible). If it was necessary to apply external laryngeal pressure, the case was excluded from the study. Difficult visualization of the larynx (DVL) was described as CL 3 or 4 views on direct laryngoscopy. Easy visualization of the larynx (EVL) was defined as CL 1 or 2 view on direct laryngoscopy. Confirmation of successful intubation was by bilateral auscultation over the lung fields and capnography. A prospective power analysis disclosed that presuming a frequency of difficult laryngoscopy of 5%, 400 patients offer a power of more than 80% to find out an improvement of discriminating power (measured by the area under a receiver-operating characteristic curve [AUC of the appropriate ROC curve]) of an absolute value of 15% (e.g. from 50% to 0.65%) with a type I error of 5% and using a two-sided alternative hypothesis. By means of these clinical data (Mallampati score, the RHTMD, ULBT, HMDR score, and the CL classification) noted for each patient, several measures were computed that have been commonly used to explain the predictive properties of a scoring system. Using these clinical data recorded for each patient and the sensitivity, specificity, positive likelihood ratio (+LR) and negative likelihood ratio (−LR), PPV, and negative predictive value (NPV) of each test were calculated. Secondly, combinations of predictors were formulated. Likewise, the sensitivity, specificity, +LR, −LR, PPV, and NPV were obtained and compared among the combinations. The AUC of ROC curve,[19] was used as the main end-point of the study to determine whether or not the score was clinically valuable. A ROC plot was achieved by calculating the sensitivity (true positive fraction) and specificity (true negative fraction) of every observed data value (cut-off value), and plotting sensitivity against 1-specificity (false positive fraction). A value of 0.5 under the ROC curve indicates that the variable performs no better than chance and a value of 1.0 implies perfect discrimination. A larger area under the ROC curve denotes more reliability,[20] and good discrimination of the scoring system. In addition, the ROC curves were used to recognize the optimal predictive cut-off points for each test. The most

favorable predictive cut-off point is the point on the ROC curve that is nearest (unweighted distance) to the ideal point (sensitivity = 100%; false positive = 0%). Patient data were presented as mean ± SD or numbers (%). BMI was determined from weight (kg)/height^2(m). Patient data and value of the airway predictors were compared using *t*-tests for continuous variables and U-test for MMT or ULBT. Differences between the AUC values of three predictive tests were analyzed using MedCalc statistical software 9.3.6.0, and a *P* value of 0.05 was defined as statistically significant. All other calculations were performed using the SPSS version 16.0.

RESULTS

A total of 538 patients were enrolled in the study. 13 patients were excluded (three patients due to previous surgery on the airway, two patients due to restricted motility of neck, three patients due to mass in the neck, four patients due to being edentulous, and one patients due to need to awake intubation). Finally, 525 patients were included in our study. No patient was excluded from the study due to any problem. We had two cases with Grade 4 CL. the tracheal intubation in these two patients was performed by using the GlideScope video laryngoscopes. Demographic characteristics, BMI and the mean for HMDe, HMDn in the neutral position, the HMDR and RHTMD are shown in Table 1. The incidence of DVL was 51 (9.7%). No case of failed intubation was noted. Our data showed that there were significant differences in weight, BMI, HMDe, the HMDR and RHTMD between the DVL and EVL patients [Table 1]. The distribution of MMT, ULBT, the CL grades are presented in Table 2. The predictive values of MMT, ULBT, HMDn, HMDe, HMDR and RHTMD are presented in Table 3. A ULBT Grade 2 and MMT Grade 3 were considered as the cut-off points for predicting difficulty by using the discrimination analysis. The most sensitive of the single tests was ULBT with a sensitivity of 90.2%. The HMDe was the least sensitive of the single tests with a sensitivity of 56.9. The HMDR had sensitivity 86.3%. The ULBT had the highest NPV (negative predictive value) and the AUC of ROC curve among single predictors. The AUC of ROC curve for ULBT, HMDR and RHTMD was significantly more than for MMT ($P < 0.05$) [Table 3]. No significant difference was noted in the AUC of ROC curve for ULBT, HMDR, and RHTMD ($P > 0.05$). The combination of the four tests decreased the AUC of ROC curve compared with the HMDR, RHTMD, MMT, and the ULBT as single predictors. The combination with the best results was the Mallampati test-RHTMD with specificity, the PPV, the AUC of ROC curve of 100.0%, 100.0%, and 0.843 respectively. The various other combinations resulted in decreased sensitivity and the AUC of ROC curve [Figure 2]. By using discrimination analysis, the optimal cut-off point for the HMDR and RHTMD for predicting difficult laryngoscopy was 1.10 (sensitivity, 86.3%; specificity, 69.7%) and 22.25 (sensitivity, 70.6%; specificity, 85.2%) respectively. The multivariate analysis odds ratios (95% CI) of the HMDR, RHTMD, Mallampati class and ULBT were 1.653 (0.616-4.433), 0.104 (0.059-0.183), 0.610 (0.321-1.161) and 0.097 (0.061-0.154), respectively. The multivariate analysis relative risk (95% CI) of the HMDR, RHTMD, Mallampati class and ULBT were 0.956 (0.891-1.026), 1.467 (1.276-1.687), 1.067 (0.963-1.183), and 2.067 (1.519-2.814), respectively.

Table 1: Demographic data, BMI and mean for HMD at two positions, HMDR and RHTMD of all patients

Variable	Value	ELV (*n*=562)	DLV (*n*=41)	*P* value
Sex *n* (%)				
Men	341 (65.0)	303 (88.9)	38 (11.1)	0.086
Female	184 (35.0)	171 (92.9)	13 (7.1)	
Age (year)	46.1±24.7	45.9±25.1	48.2±20.1	0.525
Weight (kg)	67.2±11.7	66.6±11.4	72.6±12.6	0.000
Height (cm)	166.2±9.1	165.9±9.0	168.6±9.2	0.050
BMI (kg.m^{-2})	24.3±4.0	24.2±3.9	26.7±4.4	0.025
ASA class *n* (%)				
I	348 (66.3)	320 (92)	28 (8)	0.080
II	177 (33.7)	154 (87)	23 (13)	
HMDn (cm)	4.5±0.9	4.4±0.8	4.3±1.0	0.500
HMDe (cm)	5.8±1.1	5.9±1.0	5.3±1.3	0.002
HMDR	1.3±0.2	1.3±0.18	1.2±0.2	0.000
RHTMD	21.3±1.9	21.1±1.7	23.3±2.6	0.000

Data are presented as mean±SD or number (%). DVL: Difficult visualization of the larynx, EVL: Easy visualization of the larynx, BMI: Body mass index, ASA: American Society of Anesthesiologists, HMDn: Hyomental distance in the neutral position (cm), HMDe: Hyomental distance in the extreme of head extension (cm), HMDR: Hyomental distance ratio, RHTMD: Ratio of height to thyromental distance, ELV: Easy larynxgoscopy view, DLV: Difficult larynxgoscopy view

Table 2: Distribution of MMT, ULBT and laryngoscopic view of all included patients

Variable	Number of patients (%)
Mallampati class	
I	267 (50.9)
II	190 (36.2)
III	66 (12.6)
IV	2 (0.4)
ULBT	
I	287 (54.7)
II	190 (36.2)
III	48 (9.1)
Laryngoscopic view	
I	251 (47.8)
II	223 (42.5)
III	49 (8.8)
IV	2 (0.4)

MMT: Samsoon and Young's modified mallampati test modification of the mallampati test, ULBT: Upper-lip-bite test

Table 3: Predictive values for MMT, ULBT, HMDn, HMDe, HMDR and RHTMD to predict the occurrence of a grade 3 or 4 intubation according to the modified cormack-lehane classification

Test	Sensitivity (%)	95% CI	Specificity (%)	95% CI	+LR	−LR	+PPV (%)	−NPV (%)	AUC of ROC-curve	*P* value
MMT	68.6	54.1-80.9	52.8	48.2-57.4	1.46	0.59	13.6	94.0	0.611	0.0110
ULBT	90.2	78.6-96.7	59.4	54.8-63.9	2.22	0.17	19.3	98.3	0.831*	0.0001
RHTMD	70.6	56.2-82.5	85.4	81.9-88.5	4.84	0.34	34.3	96.4	0.792*	0.0001
HMDn	74.5	60.4-85.7	41.4	37.0-46.0	1.27	0.62	12.1	93.8	0.513†	0.7570
HMDe	56.9	42.2-70.6	72.3	68.0-76.3	2.05	0.60	18.1	94.0	0.639†	0.0002
HMDR	86.3	73.7-94.3	69.7	65.3-73.8	2.85	0.20	23.5	97.9	0.752*	0.0001
M+U	07.8	02.2-18.9	99.4	98.2-99.9	12.4	0.93	57.1	90.9	0.536	0.4047
M+R	68.6	54.1-80.9	100.0	99.2-100.0	-	0.31	100.0	96.7	0.843	0.0001
M+HMDR	13.7	5.70-26.3	99.6	98.5-99.90	32.5	0.87	77.8	91.5	0.567	0.1272
U+R	43.1	29.4-57.8	99.2	97.9-99.8	51.1	0.57	84.6	94.2	0.711	0.0001
U+HMDR	15.7	07.0-28.6	99.6	98.5-99.9	37.2	0.85	80.0	91.7	0.576	0.0805
R+HMDR	25.5	14.3-39.6	98.7	97.3-99.5	20.1	0.75	68.4	92.5	0.621	0.0056
M+U+R	03.9	0.6-13.5	100.0	99.2-100.0	-	0.96	100.0	90.6	0.520	0.6483
M+U+R+H	13.7	5.7-26.3	99.8	98.8-100.0	64.9	0.86	87.5	91.5	0.568	0.1213

MMT: Modified mallampati test, ULBT: Upper-lip-bite test, HMDn: Hyomental distance in the neutral position (cm), HMDe: Hyomental distance in the extreme of head extension (cm), HMDR: Hyomental distance ratio, RHTMD: Ratio of height to thyromental distance, CI: Confidence interval, −LR: Negative likelihood ratio, +LR: Positive likelihood ratio, PPV: Positive predictive value, NPV: Negative predictive value, AUC of ROC: Area under a receiver-operating characteristic curve. *$P<0.05$ versus MMT. †$P<0.05$ versus HMDR. There was no significant difference between the AUC of the ROC for the ULBT, HMDR and the RHTMD scores

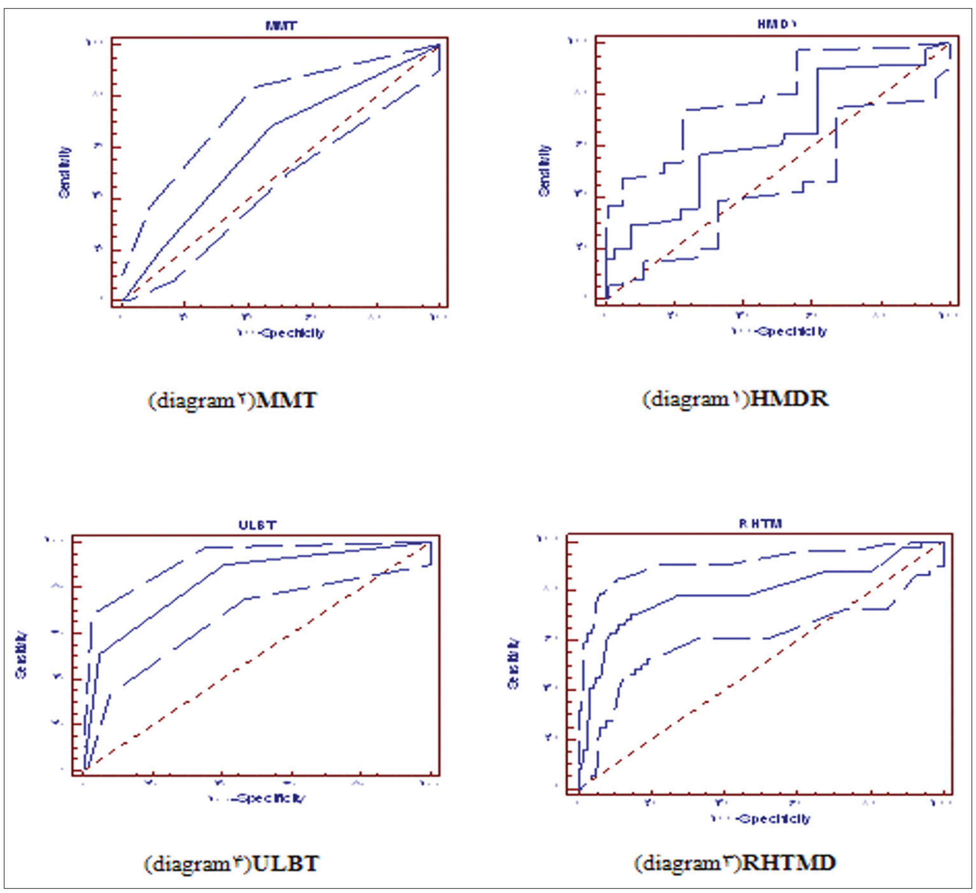

Figure 2: Receiver operating curves for hyomental distance ratio, modified Mallampati test, upper-Lip-Bite test and ratio of height to thyromental distance with selected optimum cut-off points and area under a ROC curve

DISCUSSION

A major factor that has been considered to be related to the morbidity and mortality following anesthesia is unexpected difficult intubation.[4] For this reason, it is necessary to investigate for a simple and accurate predictive test. The previous studies reported that the incidence of difficult intubation was 1.3-13%, which was depending to the criteria employed for its definition.[6,11,21-25] According to the obtained results of this study, the sensitivity of HMDR test is 56.86% and the specify of that is 72.3% and PPV (positive predictive value) is not in acceptable situation and is about 18.1% although the NPV (negative predictive value) is inacceptable situation about 94% according to the significant of determining. The difficult intubation in patients in operations room, this test is not reliable. In the same study that carried out by Huh *et al.*,[26] HDMR is a reliable test for evaluating the DLV and has the reliable prediction value about 2% in other test, which checked is MMT test. The sensitive of that is 68.63% and specify is 52.85% and the epidemiology view is not suitable examination for screening. And positive and NPV is 13.6% and 94%. The positive results are valuable. Another test that checked in this study is RHTMD test, which has sensitive and specificity about 70.59%, 85.41% and in proportion to other two tests has high valuation in predictive difficult visual of larynges. However, this test similar to other tests has suitable NPV about 96.4%. Finally, the ULBT test is the last test which has sensitivity and specify about 90.20% and 59.41%.And if want to use one test for screening the ULBT test is better because this test has the most sensitivity. Otherwise ULBT test has positive and NPV about 19.3% and 98.3% so that the negative results of ULBT test is valuable for determining the patient's situation. Khan *et al.*,[10] understood that ULBT is a reliable test for predicting difficult intubation. We designed our study in elective surgical patients while emergency cases were not included in the study. Furthermore, our conclusion is not applicable to all subgroups of the general population such as elderly, obese or patient candidate for cesarean delivery. In conclusion: By the way evaluating and comparing the above tests shows that each one has advantages and disadvantages according to result of this study validity and reliability of ULBT, RHTMD, HMD, and MMT are not possible for prediction of difficult laryngoscope and yet the Cormack lyhan test is the most suitable test in hard difficult intubation in patients under intubation.

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