Original Article

Prediction of difficult laryngoscopy: Extended mallampati score versus the MMT, ULBT and RHTMD

Mohammadreza Safavi, Azim Honarmand, Mahsa Amoushahi

Department of Anesthesiology and Critical Care Research Center, Isfahan University of Medical Sciences, Isfahan, Iran

Abstract

Background: Preoperative using of anatomical landmarks detects potentially difficult laryngoscopies. The main object of the present study was to evaluate the predictive power of Extended Mallampati Score (EMS) in comparison with modified Mallampati test (MMT), the ratio of height to thyromental distance (RHTMD) and the Upper-Lip-Bite test (ULBT) in isolation and combination.

Materials and Methods: Four hundred seventy sixadult patients who candidate for elective surgery under general anesthesia requiring endotracheal intubation were included in this study and evaluated based of all four factors before surgery. This study was randomized prospective double - blind. After that, laryngoscopy was performed by an anesthesiologist who didn't involve in preoperative airway assessment and graded based on Cormack and Lehane's classification. We calculated sensitivity, specificity, and area under receiver-operating characteristic (ROC) (AUC) for each score.

Results: The AUCof the ROC was significantly more for the ULBT (AUC = 0.820, $P = 0.049$) and RHTMD score (AUC = 0.845, $P = 0.033$) than the EMS (AUC = 0.703). This variable was significantly higher for the EMS compared with MMT (0.703 vs. 0.569, $P = 0.046$ respectively). There was no significant difference between the AUC of the ROC for the ULBT and the RHTMD score ($P = 0.685$).The optimalcut-off point for the RHTMD for predicting difficult laryngoscopy was 29.3.

Conclusion: EMS predicted difficult laryngoscopy better than MMT while both ULBT and RHTMD had more power than EMS and MMT in this regard. ULBT and RHTMD had similar predictive value for prediction of difficult laryngoscopy in general population.

Key Words: Difficult laryngoscopy, extended mallampati score, modified mallampati, ratio of patient's height to thyromental distance, upper lip bite test

Address for correspondence:
Associate Prof. Azim Honarmand, Anesthesiology and Critical Care Research Center, Isfahan University of Medical Sciences, Isfahan, Iran.
E-mail: honarmand@med.mui.ac.ir

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INTRODUCTION

Failure in managing the airway is the most important cause of death in patients undergoing general anesthesia. About 75-50% of cardiac arrests during general anesthesia are because of difficult intubation that causes inadequate oxygenation and/or ventilation, which about 55-93% of them cause death or brain death.[1-5] Difficult laryngoscopy (characterized by poor glottic visualization) is equal to difficult intubation

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in the most patients. The reported data for difficult intubation varies from 1.5-13% in the patients who are undergoing surgery.[6] Preoperative evaluation is very important but the fact that which of these anatomical landmarks and clinical factors are the best is unknown yet.[7,8] Several investigation explained prediction schemes by using a single risk factor or a multifactorial index.[9-11] A standard method for evaluation of difficult laryngoscopy is using the modified Mallampati (MMP) examination.[9,10] For performing the MMT examination, the patient must be sit upright while his or her head is neutral position; tongue maximally protruded and has no phonation.[10] It was shown that the predictive value of the examination is dependent on the position of the cervical spine. Lewise and colleagues suggested that the MMP be performed with patient in sitting position while extended the craniocervical junction.[12] In a study which performed by Mashour and Sandberg,[13] it was shown that the MMP with extension (Extended Mallampati Score, or EMS) was associated with improved specificity and positive predictive value. In another study, Mashour *et al*.[14] showed that the EMS predicted difficult laryngoscopy better than the MMT in the morbidly obese populations. Khan *et al*.[11] showed that the upper lip bite test (ULBT) had more accuracy for prediction of difficult laryngoscopy compared with the MMT. Also, Krobbuaban and colleagues[15]showed that the ratio of height to thyromental distance (RHTMD) was a powerful bedsidescreening test for prediction of difficult laryngoscopy during preoperative period. To the best of our knowledge, there was no study to compare the EMS with the ULBT or RHTMD for prediction of difficult laryngoscopy. So, we designed this prospective blind study to compare predictive value of the three methods of airway assessment (EMS, ULBT and RHTMD) for difficult laryngoscopy.

MATERIALS AND METHODS

After obtaining institutional approval from Ethic Committee of our university and taking written informed consent from the patients, this prospective observational study was performed on 467 consecutive ASA I-III adult patients. These patientswere scheduled for elective surgery under general anesthesia requiring endotracheal intubation. They gave to participate in this randomized prospective double-blind study. The other inclusion criteria were patients who had no previous history of burn or trauma to the airway, had no tumors or mass in the laryngeal, facial and cervical region, had no restricted mobility of the neck and mandible (e.g. rheumatoid arthritis or cervical diskdisorders), had ability to sit and open their mouth.Patient data which included sex, age, weight, height andbody mass index (BMI) were collected. The following four predictive test measurements were performed on all patients:

- MMT: Samsoon and Young's modification of the Mallampati test[10,16] recorded oral cavity structures visible upon maximal mouth opening (as measured by interdental distance). While patient seated and the head was in natural position, each patient was asked to open his/her mouth as much as possible and to protrude the tongue without phonation. The view was classified as:
    - Good visualization of the soft palate, fauces, uvula and pillars
    - Pillars obscured by the base of the tongue but the soft palate, fauces and uvula visible
    - Soft palate and base of the uvula visible and
    - Soft palate not visible.
- RHTMD: The thyromental distance (TMD) was measured from the bony point of the mentum while the head was fullyextended and the mouth closed[17,18]
- ULBT: The ULBT was rated as class I if the lower incisors could bite the upper lip above the vermilion line; class II if the lower incisors could bite the upper lip below the ver milion line and class III if the lower incisors could not bite the upper lip[11]
- EMS: The EMS was performed with the patient sitting, craniocervical junction extended, mouth open fully, tongue protruded maximally, no phonation, and the examiner eye-to-eye.[13] EMS was classified as:
    - Entire uvula clearly visible
    - Upper half of uvula visible
    - Soft and hard palate clearly visible
    - Only hard palate visible.

After generation of a randomization list, an anesthesiologist who was blinded to the study prepared identical patients and recorded all data. Another anesthesiologist blinded to the group allocation administered grade of laryngoscope patients.Then, after patient arrival to the operating room, routine monitoring including non-invasive arterial blood pressure, an electrocardiogram and oxygen saturation wasmeasured. Induction of anaesthesia was performed with 5 mg/kg of sodium thiopental intravenously (IV) and fentanyl 3 μg/kg IV. For facilitation of endotracheal intubation, atracurium 0.6 mg/kg IV was administered. The patients' lungs were ventilated by mask with 100% oxygen. After that, laryngoscopy and evaluation of its difficulty was performed by a single anesthesiologist who was not informed from the preoperative class of airway. While the patient's head was placed in the sniffing position, the laryngoscopy was done by using a Macintosh #4 blade to visualize the larynx.

The laryngoscopic view was classified by using the Cormack and Lehane (CL) classification[19] without external laryngeal manipulation as following:

- Vocal cords visible;
- Only posterior commissure or arytenoids visible;
- Only epiglottis visible;
- None of the foregoing visible.

During direct laryngoscopy, if the patient had CL III or IV view, it was considered difficult visualization of the larynx (DVL) and if it was CL I or II, it was considered Easy visualization of the larynx (EVL). By using MedCalc statistical software 9.3.6.0, power analysis showed that if the incidence of difficult laryngoscopy was considered 5%, 467 patients must be enrolled to the study for providing 80% power in detection of an improvement in discriminating power (measured by the area under curve of the appropriate receiver-operating characteristic curve) of an absolute value of 7% (e.g. from 60% to 67%) with a type I error of 5% and using a two-sided alternative hypothesis. The sensitivity, specificity, positive likelihood ratio (+LR) and negative likelihood ratio (- LR), positive predictive value (PPV), and negative predictive value (NPV) of each test was calculated. Also, combinations of the predictors were formulated and the sensitivity, specificity, + LR, - LR, PPV and NPV were calculated and compared between the combinations. For determining clinical value of each score, the area under a receiver-operating characteristic (ROC) curve (AUC)[20]and 95% confidence interval (CI) was calculated as the main end-point of the study. 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. Also, 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 to the ideal point (sensitivity = 100%; false positive = 0%). Patient data are presented as mean ± SD or numbers (%). BMI was calculated 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 EMS, MMT or ULBT. Differences between the AUC values of four predictive tests were analyzed using MedCalc statistical software 9.3.6.0, and a $P < 0.05$ was defined as statistically significant. All other calculations were performed using the SPSS version 16.0.

RESULTS

Four hundred seventy six patients were included in the present study. Out of which four patients were excluded from the study on account morbid obesity (3 patients), trauma to the airway (1 patient).Then, four patients were unable to cooperate and were therefore excluded from the study [Figure 1 Flow chart] Demographic characteristics; BMI and the mean for the RHTMD are showed in Table 1.DVL was observed in 33 (6.9%) patients. No patient excluded from the study due to failed intubation. As Table 1 show, the patients' weight, BMI and RHTMD was significantly different between the DVL and EVL groups. The distributions for MMT, EMS, ULBT, the Cormack and Lehane grades are presented in Table 2. The measures used to explain the predictive properties of the four models are shown in Table 3. The AUC of the ROC for the EMS (AUC 0.703; 95% CI, 0.660-0.744) was significantly higher than MMT (AUC 0.569;95% CI, 0.523-0.614, $P = 0.0001$) but it was significantly lower when compared with the ULBT (AUC 0.820;95% CI, 0.783-0.854, $P = 0.0001$) and the RHTMD score (AUC 0.845; 95% CI, 0.810–0.877, $P = 0.0001$) [Table 3]. The AUC of the ROC for the

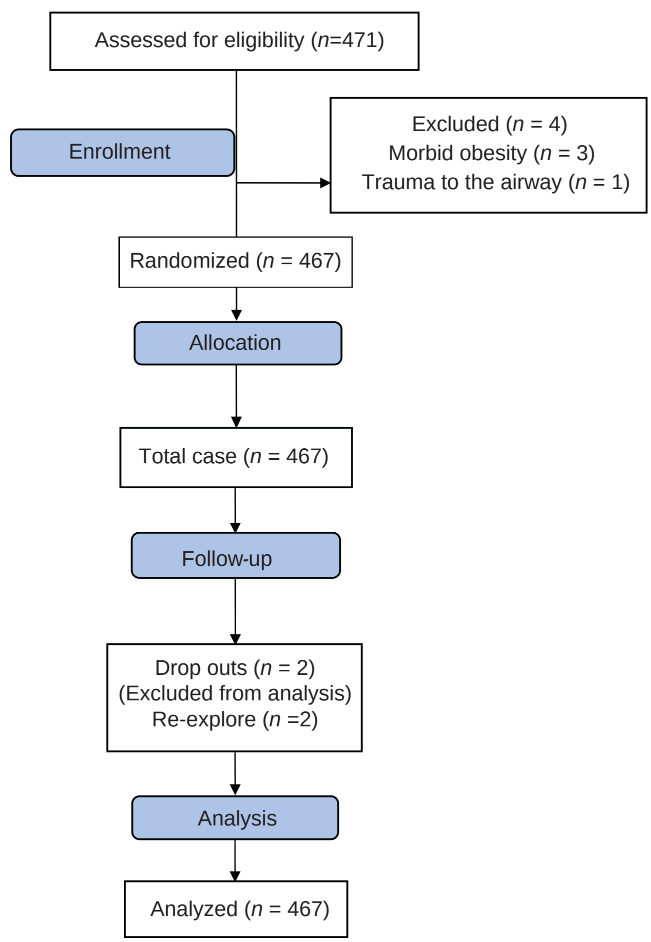

Figure 1: Flow chart

Table 1:Demographic data, BMI and mean for RHTMD of all patients

Variable	Value	ELV (*n*=443)	DLV (*n*=33)	*P* value
Sex				0.132
Men	326 (68.5)	309 (94.8)	17 (5.2)	
Female	150 (31.5)	134 (89.3)	16 (10.7)	
Age (yr)	36.3± 15.5	36.1± 15.5	39.4± 16.0	0.742
Weight (kg)	70.4±8.9	69.7±7.9	80.5± 14.4	0.000
Height (cm)	168.7±5.9	169.8±5.9	164.2±5.6	0.696
BMI (Kg.m^{-2})	24.8±3.2	24.2±2.4	30.1±6.5	0.000
ASA class				0.917
I	357 (75.0)	332 (74.9)	25 (75.8)	
II	119 (25.0)	111 (25.1)	8 (24.2)	
RHTMD	25.4±5.6	24.6±3.9	36.40±11.4	0.000

DVL: Difficult visualization of the larynx, EVL: Easy visualization of the larynx, BMI: Body mass index, RHTMD: Ratio of height to thyromental distance. Data are presented as mean±SD or number (%)

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

Variable	Number of patients (%)
Mallampati class	
I	286 (60.1)
II	135 (28.4)
III	21 (4.4)
IV	1 (2)
Extended mallampati score	
I	332 (70.0)
II	102 (21.4)
III	8 (1.70)
IV	0 (0.00)
ULBT	
I	356 (74.8)
II	80 (16.8)
III	7 (1.5)
Laryngoscopic view	
I	350 (73.5)
II	93 (19.5)
III	25 (5.3)
IV	8 (1.7)

MMT: Samsoon and Young's modification of the Mallampati test, ULBT: Upper-lip-bite test, EMS: Extended mallampati score

ULBT and the RHTMD score was not significantly different ($P > 0.05$) [Table 3].Predictive values for the foursingle or combined predictors are presented in Table 3. The cut-off points for predicting difficult intubation was Grade 3 for ULBT, MMT and EMS. The most sensitive of the single tests was the ULBT with a sensitivity of 75.8% while for the MMT, it was the least sensitivity equal to 63.6%. The sensitivity for EMS (66.7) was higher than MMT and lower than ULBT [Table 3]. The RHTMD had highest specificity equal to 90.52% and highest positive predictive value equal to 36.4% compared with the other three tests. The positive predictive value for EMS was higher than MMT and lower than RHTMD. The highest negative predictive value and the AUC of ROC curve amongst single predictors were with the RHTMD. The negative predictive value for EMS was higher than MMT and lower than RHTMD [Table 3]. His combination of the EMS with RHTMD, ULBT or MMT increased the AUC of ROC curve compared with the EMS as single predictors but that was not statistically significant. The combination with the best results wasthe EMS–RHTMD with specificity, the positive likelihood ratio, the PPV, the AUC of ROC curve of 99.3%, 93.97, 87.5%, and 0.815 respectively. The optimal cut-off point for the RHTMD for predicting difficult laryngoscopy was 29.3 (sensitivity, 72.73%; specificity, 90.52%). The multivariate analysis oddsratios (95% CI) of the RHTMD, Mallampati class, EMS and ULBT were 0.062 (0.030-0.129), 0.069 (0.038-0.128), 0.015 (0.006-0.036) and 0.050 (0.029-0.086), respectively. The multivariate analysis relative risk (95% CI) of the RHTMD, Mallampati class, EMS and ULBT were 1.511 (1.267-1.802), 1.804 (1.356-2.398), 4.449 (2.414-8.198) and 3.307 (1.772-6.171), respectively.

DISCUSSION

A major factor that has been considered to be related

Table 3: Predictive values for MMT, EMS, ULBT 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	63.64	45.1-79.6	46.95	42.2-51.7	1.2	0.77	8.2	94.5	0.569	0.1636
ULBT	75.76	57.7-88.9	80.81	76.8-84.4	3.95	0.30	22.7	97.8	0.820*	0.0001
RHTMD	72.73	54.5-86.7	90.52	87.4-93.1	6.67	0.30	36.4	97.8	0.845*	0.0001
EMS	66.67	48.2-82.0	68.62	64.1-72.9	2.12	0.49	13.7	96.5	0.703*	0.0001
M+U	39.39	22.9-57.9	99.32	98-99.9	58.17	0.61	81.2	95.7	0.694	0.0002
M+R	38.24	21.8-56.3	98.13	98-99.3	57.16	0.59	79.1	94.5	0.691	0.0003
U+R	39.39	22.9-57.9	99.55	98.4-99.9	87.26	0.61	86.7	95.7	0.695	0.0002
E+M	48.48	30.8-66.4	99.10	97.7-99.7	53.70	0.52	80.0	96.3	0.738	0.0001
E+U	48.47	30.7-66.3	99.55	98.4-99.9	107.39	0.51	88.9	96.1	0.740	0.0001
E+R	63.64	45.1-79.6	99.32	98-99.9	93.97	0.37	87.5	97.3	0.815	0.0001
E+M+U+R	30.30	15.6-48.7	100.0	99.2-100	-	1.0	-	93.1	0.652	0.0046

M, MMT, MMT: Modified mallampati test, U, ULBT, ULBT: Upper-lip-bite test, R, RHTMD, RHTMD: Ratio of height to thyromental distance (TMD), E, EMS: Extended mallampati score, CI: Confidence interval, AUC: Area under a receiver-operating characteristic curve. *P<0.05 vs. MMT. No significant difference was noted in the AUC of the ROC for the ULBT and the RHTMD score to the morbidity and mortality following anesthesia is unexpected difficult intubation.[16] 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.[1-4,20-22] The incidence of DVL was 6.9% in our study and it was comparable with the some previous studies.[20-22]The difference in incidence of DVL can be due to various factors such as different anthropometric features that exists among populations, unavailability of uniform grading in description of laryngeal views, application of cricoids pressure, position of head, the degree of muscle relaxation and the type or size of laryngoscope blade. Our data showed that the AUC of ROC for RHTMD and ULBT was 0.845 and 0.820 respectively, whereas the AUC for the corresponding EMSand MMT was 0.703 and 0.569 respectively. These data documented that the EMS was better than MMT for prediction of difficult laryngoscopy while the RHTMD and ULBT had more power than EMS in this regard. Also, we foundthat the AUC of ROC curve for RHTMD to predict difficult intubations was notsignificantly different from the ULBT.Another important finding in our study was that combination of EMS with RHTMD, ULBT, and MMT didn't increase its accuracy for predicting of difficult intubation. The combination of EMS with RHTMD or ULBT increased its accuracy compared with using EMS alone but not in comparison with using RHTMD or ULBT alone. In our study, the sensitivity, specificity, positiveand negative predictive values ofthe ULBT were 75.76%, 80.81%, 22.7%, and 97.8% respectively. These values were76.5%, 88.7%, 28.9%, and 98.4% respectively, in the original study by Khan *et al*.[11] in 2003. Khan *et al*.[11] study showed that the ULBT wasbetter than MMT in prediction of difficult airway. Their conclusion is in agreement with the results of our study. Our study showed that the RHTMD was the useful predictor with a sensitivity and specificity 72.73% and 90.52% respectively. Also, it was shown that ULBT and RHTMD had less amount of detection failure for prediction of difficult laryngoscopy than the MMT test.In addition, one of useful index for evaluation of efficacy of a predictive test is the likelihood ratio (LR1) fora positive test. This index is equal to the number of timesmore likely that a patient with a positive test resultwill present with a difficult intubation. In our study, the LR1was 6.67 and 3.95 for the RHTMD and ULBT respectively, whereas it was 1.2 and 2.12 for the MMT and EMS.As Schmitt and colleagues[18] study showed, the RHTMD >25 can be used to predict difficult laryngoscopy but they emphasized that it might be dependable to the race and population that study was performed in them. In our study, a RHTMD more than 29.3 was a cutoff point for predicting difficult visualization of larynx. This difference between our study with Schmitt *et al*. merit more studies to determine the importance of ethnicity. In calculation of RHTMD, it is necessary to measure patient's TMD and height precisely. Therefore inter-observer variations are highly unlikely in contrast to significant inter-observer variations that found with the MMT. Also, many patients phonate involuntary during evaluation of the MMT score which may alter significantly the classification of Mallampati score.[23] Mashour *et al*.[14] showed that the EMS was superior to MMT for prediction of difficult laryngoscopy in the morbidly obese population. Their findings were in agreement with our study. It was the only study performed on the specific of EMS, and there is no other texture to accept or deny this. It was shown that predictive value of the MMT is dependent on the position of patient. Lewis and colleagues[12] showed that best position for evaluation by MMT was the patient sitting, head extended and tongue maximally protruded. We designed our study in elective surgical patients while emergency cases were not included in the study. Also, our conclusion is not applicable to all subgroups of the general population such as elderly, obese or patient candidate for cesarean delivery.

CONCLUSION

Our study showed that the EMS was better predictor of difficult laryngoscopy than MMT in general population. The RHTMD and ULBT were superior to the EMS in this concern. Combination of EMS with the other scores didn't significantly increase accuracy of it in predicting difficult airway. This is the first study that compared the predictive value of EMS with RHTMD, MMT, and ULBT. It is necessary to do more studies with larger sample size in different populations before final conclusion can be elucidated.

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