Original Article

Comparison of five methods in predicting difficult laryngoscopy: Neck circumference, neck circumference to thyromental distance ratio, the ratio of height to thyromental distance, upper lip bite test and Mallampati test

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Abstract

Background: Preoperative airway assessment tests have been presented to help in anticipating a difficult airway. We conducted this study to compare five methods in prediction of difficult laryngoscopy: Neck circumference (NC), NC to thyromental distance ratio (NC/TMD), the ratio of height to thyromental distance (RHTMD), upper lip bite test (ULBT) and Mallampati test (MMT). These five methods are the most commonly used ones and have different powers for it. It was not clear which of these methods predicts difficult laryngoscopy better.

Materials and Methods: Six hundred consecutive patients participated in this study. NC, NC/TMD and RHTMD were measured, and ULBT and MMT were performed and recorded. The laryngoscopy view was graded according to Cormack and Lehane's scale (CLS) and difficult laryngoscopy was defined as CLS grades 3 and 4. Accuracy of tests in predicting difficult laryngoscopy was assessed using the area under a receiver-operating characteristic curve.

Results: The area under the curve in ULBT and RHTMD were significantly larger than that in TMD, NC and MMT. No statistically significant differences were noted between TMD, NC and MMT (all $P > 0.05$) (ULBT = RHTMD > NC/TMD > TMD = NC = MMT). RHTMD (>22.7 cm) exhibited the highest sensitivity (sensitivity = 64.77, 95% confidence interval [CI]: 53.9–74.7) and the most specific test was ULBT (specificity = 99.41%, 95% CI: 98.3–99.9).

Conclusion: RHTMD and ULBT as simple preoperative bedside tests have a higher level of accuracy compared to NC/TMD, TMD, NC, MMT in predicting a difficult airway.

Key Words: Airway management, intubation, laryngoscopy

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INTRODUCTION

Airway management is a major concern for the anesthesiologists.[1] Difficult tracheal intubation that can cause intubation delay or failure, significantly increases the morbidity and mortality of general anesthesia.[2] The incidence of difficult laryngoscopy and intubation in various settings has been reported

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in a wide range from 1% to 15% in patients undergoing general anesthesia.[3-8] A large number of studies have been conducted to develop reliable predictors for a difficult airway. Many studies have tried to develop some bedside tests that are easy to perform and don't take the time and need to special equipment, but all these tests have their limitations, and no single one is complete.[2] Therefore, comparison of these methods is inevitable to find the best one. We compared some tests that are among well-known tests or the tests that recently have taken attentions in studies.

There are hypotheses suggesting that intubation in obese patients with fatty shorter necks and patients with small thyromental distance (TMD) are more difficult. Neck circumference (NC), NC/TMD ratio and the ratio of height to thyromental distance (RHTMD) have been presented with regard to this concept and have been assessed in several studies.[9-11] The Mallampati classification or Mallampati test (MMT) is a simple test to predict difficult tracheal intubation from anatomy of the oropharynx. The upper lip bite test (ULBT) has recently been introduced as a predictor test for difficult laryngoscopy (Cormack-Lehane classification grade 3 and 4),[12] mask ventilation[13] and intubation. It has been claimed that ULBT enjoys a higher positive predictive value (PPV) and specificity in comparison to Mallampati classification.[14] All these parameters are relatively quick bedside tests, and there is no need to special equipment and skills.

It is not clear, which method is better than others for prediction of difficult laryngoscopy. Therefore, we conducted this study to compare the predictive value of NC, NC/TMD, RHTMD, ULBT and MT for difficult laryngoscopy.

MATERIALS AND METHODS

This prospective observational study was conducted between November 2011 and September 2012 in Ayatollah Kashani Hospital of Isfahan University of Medical sciences. After receiving approval from ethical committee of Isfahan University of Medical sciences, 600 American Society of Anesthesiologists physical status I–II adult patients, who were scheduled to undergo elective operations under general anesthesia with endotracheal intubation were recruited for this study. The patients were selected to the study as nonprobability sampling. All subjects provided informed consent in accordance with the ethical committee.

Patients younger than 18 years of age, with an upper airway or facial abnormality or pathology (maxillofacial fractures, tumors, etc.), requiring a rapid sequence induction or awake intubation, and pregnant and edentulous patients were excluded.

Demographic information (age, height, gender, weight, body mass index, sex), patients' characteristics and history of any medical condition were taken and recorded at first.

Neck circumference (cm) at the level of cricoid cartilage was measured. The TMD (distance from the thyroid notch to the mentum in cm) was measured with the neck extended. The height was measured in cm with the patient barefoot on a flat surface against a solid wall. Then, NC/TMD and RHTMD were calculated and recorded.

The oropharyngeal view was classified by modified Mallampati classification (the revised scoring system of Samsoon and Young). Patients in the sitting position were asked to open their mouth fully and to protrude the tongue without phonation. The cases were rated as Class I, where soft palate, fauces, uvula, and pillars were visible; Class II, where soft palate, fauces, and uvula were visible; Class III, where the soft palate and the base of uvula were visible; and Class IV where soft palate was not visible.[15]

The ULBT was classified (as described by Khan *et al.*) as Class I, where lower incisors can bite the upper lip above the vermilion line, Class II, where lower incisors can bite the upper lip below the vermilion line, and Class III, where lower incisors cannot bite the upper lip.[14]

Predictive test measurements were carried out and recorded on all patients by a same physician not otherwise involved in the study.

No premedication was allowed, and the anesthetic technique was the same for all patients. In the operating room, the patients were positioned with pillows under the head, and the neck extended. Heart rate, blood pressure, SpO_2 and end tidal carbon dioxide were continuously monitored. Anesthesia was induced with propofol 2 mg/kg and fentanyl 3 µg/kg. Atracurium 0.6 mg/kg was IV administered to neuromuscular relaxation after mask ventilation. The laryngoscopic view was evaluated and rated with the patient's head in the sniffing position without any external laryngeal manipulation. Laryngoscopy was done by a Macintosh number 4 laryngoscope blade. Endotracheal intubation and evaluation of difficulty of laryngoscopy was performed by the same experienced anesthesiologist.

The laryngoscopic view was graded according to Cormack and Lehane's scale: Grade 1 view where the vocal cords were completely visible; grade 2 where only the arytenoids were visible; grade 3 where only the epiglottis was visible; and grade 4 where the epiglottis was not visible. Cormack-Lehane classification grades 3 and 4 were considered as difficult laryngoscopic view.[16]

The main goal of the study was to find out which test has the most discriminating power to be clinically useful. Receiver-operating characteristic (ROC) analyses were performed using the software MedCalc 9.2.0.1 (MedCalc Software, Mariakerke, Belgium). The area under ROC curve (AUC) was compared to obtain the most discriminative test. 95% confidence interval (CI) was calculated and $P < 0.05$ was considered as statistically significant.

RESULTS

Six hundred subjects with a mean age of 44 (±17) years (range 18–75 years) participated in this study. Demographic data and characteristics of all patients are shown in Table 1. Laryngoscopy and intubation were possible for all of the patients.

Predictive values of 5 tests in predicting difficult laryngoscopy (The optimal cutoff point, positive likelihood ratio [PLR] negative likelihood ratio PPV negative predictive value [NPV] AUC) are presented in Table 2 and pairwise comparison of ROC curves are shown in Table 3.

Area under the curve rates for ULBT (0.789) and RHTMD (0.764) were more than those obtained using other tests and this difference was statistically significant ($P < 0.05$). This rate for ULBT was more than that obtained using RHTMD, but it was not significant. AUC in NC/TMD was significantly higher than that in TMD, NC and MMT and no differences were noted between TMD, NC and MMT (ULBT = RHTMD > NC/TMD > TMD = NC = MMT). Figure 1 shows the ROC curves for ULBT and RHTMD.

Ratio of height to thyromental distance (>22.7 cm) has the highest sensitivity (sensitivity = 64.77%, 95% CI: 53.9–74.7) and the most specific test was ULBT (specificity = 99.41%, 95% CI: 98.3–99.9). ULBT has the most PPV and RHTMD has the most NPV (respectively 93.5% and 93.2%).

DISCUSSION

Prediction of a difficult airway to prevent unanticipated difficult tracheal intubation and consequent events and develop a plan to convert a difficult intubation into an easy one is an important concern for anesthesiologists. In this study, the incidence of difficult laryngoscopy was 14.7% that is more than what has been reported by previous studies.[11,17]

Area under the curve of the ROC for RHTMD and ULBT was more than what had been observed in other tests that revealed that RHTMD and ULBT are highly predictive.

Short TMD has been introduced as a simple, clinically used criterion that could predict a difficult airway. Various cutoff points have been reported for this distance in previous studies. Patil *et al*.[18] suggested 6.5 cm as the cutoff point in adult patients; TMD >6.0–6.5 cm could predict the difficult, but usually possible laryngoscopy and intubation if there are no other anatomical abnormalities and laryngoscopy may be impossible in TMD <6 cm. However, the presence of anatomical difficulties may increase this cutoff point to 6.0–6.5. Frerk suggested 7 cm as the cutoff point for difficult intubation where the posterior pharyngeal wall could not be visualized during inspection of the oropharynx.[17] Short neck, decreased head extension, short mandible, deep mandible and high anterior larynx are factors that contribute to difficult laryngoscopy and may all influence TMD.[18]

Table 1: Demographic data of all patients and distribution of laryngoscopic view

Category	Value (%)
Men	281 (47)
Women	319 (53)
Age	44 (±17)
Weight	68 (±11)
ASA class	
I	373 (75)
II	127 (25)
NC	37 (±4)
NC/TMD	5 (±0.75)
RHTMD	21 (±2)
MMT	
I	299 (50)
II	247 (41)
III	48 (8)
IV	6 (1)
ULBT	
I	341 (57)
II	213 (35)
III	46 (8)
Cormack and Lehane	
I	308 (51)
II	204 (34)
III	79 (13)
IV	9 (1.5)

MMT: Mallampati test, ULBT: Upper-lip-bite test, RHTMD: Ratio of height to thyromental distance, NC: Neck circumference, NC/TMD: Neck circumference to thyromental distance, ASA: American Society of Anesthesiologists

Table 2: Predictive values of five methods in predicting difficult laryngoscopy (Grade 3 or 4 according to the modified Cormack‑Lehane classification)

Test	Criterion	Sensitivity	95% CI	Specificity	95% CI	+LR	−LR	+PV	−PV	AUC	SE	95% CI
MMT	>2	62.50	51.5-72.6	51.95	47.5-56.4	1.30	0.72	18.3	89.0	0.596	0.034	0.556-0.636
ULBT	>2	48.86	38.1-59.8	99.41	98.3-99.9	83.39	0.51	93.5	91.9	0.789	0.030	0.754-0.821
RHTMD	>22.7692	64.77	53.9-74.7	82.42	78.8-85.6	3.68	0.43	38.8	93.2	0.764	0.031	0.728-0.798
NC (cm)	>41	26.14	17.3-36.6	98.24	96.7-99.2	14.87	0.75	71.9	88.6	0.589	0.034	0.549-0.629
NC/TMD	>5.1333	57.95	47.0-68.4	76.37	72.4-80.0	2.45	0.55	29.7	91.4	0.691	0.033	0.653-0.728
TMD (cm)	≤7.1	37.50	27.4-48.5	82.62	79.1-85.8	2.16	0.76	27.0	88.5	0.613	0.031	0.572-0.652

+LR: Positive likelihood ratio, −LR: Negative likelihood ratio, +PV: Positive predictive value, −PV: Negative predictive value, SE: Standard error, 95% CI: 95% confidence interval, MMT: Mallampati test, ULBT: Upper-lip-bite test, RHTMD: Ratio of height to thyromental distance, NC: Neck circumference, NC/TMD: Neck circumference to thyromental distance, AUC: Area under the curve, TMD: Thyromental distance

Table 3: Pairwise comparison of the AUC ROC curves

Variable	TMD	NC/TMD	NC	RHTMD	ULBT
MMT					
DBE	0.016	0.095	0.007	0.168	0.193
SL	*P*=0.712	*P*=0.040	*P*=0.881	*P*<0.001	*P*<0.001
ULBT					
DBE	0.176	0.097	0.200	0.025	
SL	*P*<0.001	*P*=0.014	*P*<0.001	*P*=0.502	
RHTMD					
DBE	0.152	0.073	0.175		
SL	*P*<0.001	*P*=0.036	*P*<0.001		
NC					
DBE	0.023	0.102			
SL	*P*=0.607	*P*=0.002			
NC/TMD					
DBE	0.079				
SL	*P*=0.026				

DBE: Difference between areas, SL: Significance level, MMT: Mallampati test, ULBT: Upper-lip-bite test, RHTMD: Ratio of height to thyromental distance, NC: Neck circumference, TMD: Thyromental distance, NC/TMD: Neck circumference to thyromental distance, AUC: Area under the curve, ROC: Receiver operating characteristic. ULBT=RHTMD>NC/TMD>TMD=NC=MMT

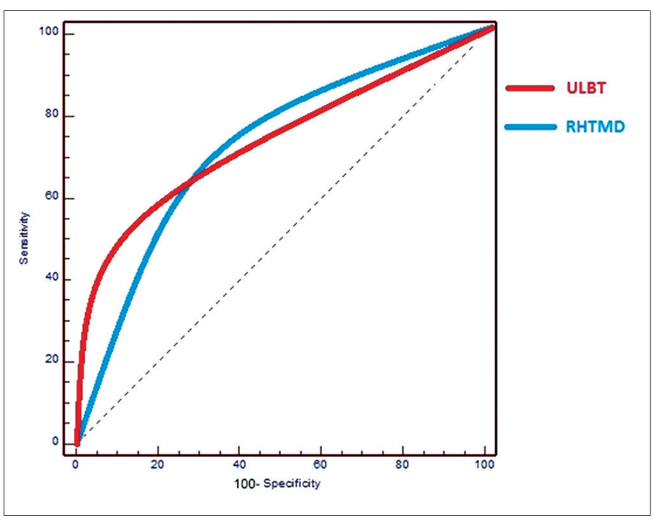

Figure 1: Receiver operating characteristic curve analysis of upper lip bite test and ratio of height to thyromental distance

Some studies have questioned small TMD in isolation, as a reliable predictive test for difficult laryngoscopy.[19,20] Benumof[21] in a study reported that both large and small TMDs have predicted difficult intubation.

Furthermore, studies have shown that the value of single screening tests for predicting difficult airway is limited[2] and combinations of these single tests or risk factors have been suggested to be more diagnostic than each test alone. Methods such as the El-Ganzouri score have combined risk factors,[22] as the multivariate risk index systems these scores, are more time-consuming and difficult to perform. Thus, combining two of the most valuable risk factors may increase the diagnostic value without increasing the burden of test significantly.

The RHTMD has been shown to be a more specific predictor for difficult intubation.[23] In this study, RHTMD exhibited 64.7% sensitivity, 82.4% specificity, 38.8% PPV, 93.2% NPV and 0.76 AUC. It has a higher sensitivity than other tests, thus provides minimum false-negative predictions. It means that RHTMD misses the least number of difficult laryngoscopies. The failure of a test to predict a difficult case (false-negative) could result in deleterious and life-threatening events. Therefore, decreasing false-negative prediction is crucially important. ULBT and RHTMD have equal AUC, but sensitivity of RHTMD (64.7%) is more than that of ULBT (48.7%), and it can be more useful as a bedside screening test.

Krobbuaban *et al*.[11] compared the predictive value of TMD, neck movement, RHTMD, MMT and interincisor gap (IIG) for predicting difficult laryngoscopy. The optimal cutoff point for the RHTMD, for predicting difficult laryngoscopy was 23.5 (sensitivity, 77%; specificity, 66%). RHTMD (sensitivity 77%, PPV 24%, NPV 95%, odds ratio 6.72 [95% CI: 3.29–13.72]) had a higher sensitivity, PPV, and fewer false-negatives compared to other tests.

Shah *et al*.[24] reported that ULBT and RHTMD exhibited the highest sensitivity, specificity, PPV, NPV that is 74.63%, 91.53%, 58.82%, 95.7%, and 71.64%, 92.01%, 59.26%, 95.24% respectively, compared to TMD, MMT, IIG and head and neck movement.

In our previous study,[25] we found that the RHTMD was a useful predictor compare to MMT and ULBT with a sensitivity, specificity, and PPV of 75.6%, 58.5%, and 96.2%, respectively.

Krobbuaban *et al*.[11] reported RHTMD ≥23.5 and Schmitt *et al*.[23] suggested that RHTMD ≥25 can be used to predict difficult laryngoscopies, and we found RHTMD ≥22.7 as a determining test for predicting difficult laryngoscopy. These small differences could be due to ethnicity, but further investigation is needed to determine such an effect.

Recent studies have introduced ULBT as a useful test to predict difficult intubation.[14] Our results showed that the specificity (99.4%), PPV (93.5%), NPV (91.9%), PLR (83.3%) and AUC (0.78) of ULBT were higher than what obtained using other four tests. It is applicable, reliable and easy to perform and does not need any equipment or special knowledge. ULBT is influenced by movement of mandible, shape and position of teeth, and thus it can be used in anticipating difficulty in laryngoscopy.

Ali *et al*.[26] compared ULBT with MMT in predicting difficult intubation. ULBT showed significantly higher accuracy (91.9%), PPV (71.6% and 95% CI: 59.1–81.7) and NPV (97.3% and 95% CI: 94.2–98.8) compared to the MMT. Comparison of specificity (93%), however, did not reveal any significant difference between the two tests. The sensitivity was 87.5% (95% CI: 74.9–94.3).

Eberhart *et al*.[12] made the same comparison but reported different results. Discriminating power for both tests was low and for the ULBT (0.60 [95% CI: 0.57–0.63]) it was lower than Mallampati score (0.66 [0.63–0.69]).

CONCLUSION

The study indicated that RHTMD and ULBT as simple preoperative bedside tests have a higher level of accuracy compared to NC/TMD, TMD, NC, MMT in predicting a difficult airway. From among them, RHTMD can be more predictive as a screening test. Further studies are needed to compare single or combined tests to find the most accurate tests with the best clinical properties.

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