Predicting Difficult Laryngoscopy and Intubation With Laryngoscopic Exam Test: A New Method

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Abstract- Airway assessment is fundamental skill for anesthesiologists and failure to maintain a patient's airway is the tremendous cause of anesthesia-related morbidity and mortality. None of the tests which have recommended for predicting difficult intubation stands out to be the best clinical test or have high diagnostic accuracy. Our study aimed to determine the utility of a new test as "laryngoscopic exam test (LET)" in predicting difficult intubation. Three hundred and eleven patients aged 16-60 years participated and completed the study. Airway assessment was carried out with modified Mallampati test, upper lip bit test and LET preoperatively, and Cormack and Lehane's grading of laryngoscopy were assessed during intubation as a gold standard, and difficult laryngoscopy was considered as Cormack and Lehane's grade III or IV of laryngoscopic view. The incidence of difficult intubation was 6.1%. The LET showed higher sensitivity, specificity, and accuracy (P<0.05), without revealing significant differences among three tests (P=0.375). The LET is a simple bedside test and an alternative method for predicting difficult intubation.

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Keywords: Difficult intubation; Airway management; Laryngoscopy; Mallampati

Introduction

Airway assessment and difficult airway management are fundamental skills for anesthesiologists. Failure to maintain a patient's airway or failed tracheal intubation is the tremendous cause of anesthesia-related morbidity and mortality (1-4). The incidence of difficult laryngoscopy and tracheal intubation has been reported from 1.5% to 18% in patients undergoing surgery (5-9).

Although during recent years, some studies have recommended new tests for predicting difficult laryngoscopy and intubation, none of them stands out to be simple or the best clinical test and do not have high diagnostic accuracy (6,7,10-13).

Because the activation of gag reflex contracts the pharyngeal wall and moves hypopharynx upward and may visualize the glottis (6,14-16), and thus the airway could be easily evaluated, we hypothesized that our new test "Laryngoscopic Exam Test (LET)" could be a reliable predictor for difficult laryngoscopy and tracheal intubation. Thus, we designed this observational study in patients undergoing general anesthesia.

Materials and Methods

Approval for the study was obtained from our institution's Ethics Committee (Reference No=90-3-3), and informed consent was obtained from all subjects. In this prospective observational study, 319 consecutive male and female ASA I and II patients aged 16-60 years required general anesthesia, were enrolled between January and September 2014. Exclusion criteria included patients who had facial, cervical, pharyngeal and head and neck surgery, ASA class higher than II, facial and airway anomalies, pregnancy, and limitation of cervical movement as well as patients undergoing general anesthesia without tracheal intubation and edentulous patients.

Preoperatively, three anesthesiologists not involved in intubation and airway management of the patients

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evaluated three tests for predicting difficulty in endotracheal intubation using modified Mallampati test (MMT), upper lip bite test (ULBT), and a new test named "laryngoscopic exam test (LET)", will be discussed later, remembering that each anesthesiologist who evaluated one of the mentioned tests was blinded to other two tests. The MMT was done according to the visibility of pharyngeal structures with the patient in an upright sitting position, head in neutral position, mouth open, and tongue protruding without phonation according to the following criteria: (17) Class I is visualization of the hard palate, soft palate, fauces, uvula, and pillars. Class II is visualization of the hard palate, soft palate, fauces, and base of uvula. Class III is visualization of the hard palate and soft palate. Class IV is visualization of only the hard palate. The ULBT was performed with the patient in an upright sitting position according to the following criteria: Class I is lower incisors can bite the upper lip above the vermilion line. Class II is lower incisors can bite the upper lip below the vermilion line, and class III is lower incisors cannot bite the upper lip (8). The new test (LET) introduced by the first principal author (Akhlaghi M.), was performed as follow: with the patient in sitting position and neutral head position while protruding his/her tongue without phonation, the examiner used a lighted Macintosh blade No. 3.0 and gently slide the blade towards the base of the tongue until the patient's gag reflex was activated and movement of the hypopharynx was performed. Just at the time of activation of the gag reflex, examiner's judgment of visualization of the pharyngeal structure was assessed and recorded according to the following criteria: Class 0; the ability to visualize any part of the epiglottis on gag reflex activation. Class I is visualization of the soft palate, fauces, uvula, and pillars seen on gag reflex activation. Class II is visualization of soft palate and base of the uvula seen on gag reflex activation. Class III is visualization of only soft palate seen on gag reflex activation (Figure 1). During all examinations, MMT classes I and II, ULBT classes I and II, and LET classes 0 and I were declared to be easy, and MMT classes III and IV, ULBT class III and LET classes II and III were declared to be difficult intubation.

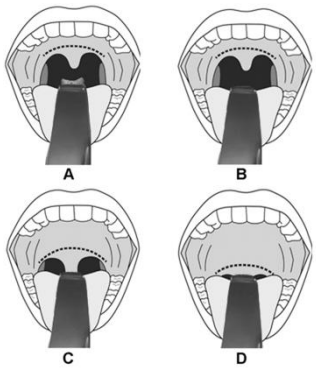

Figure 1. Schematic view of Laryngoscopic Exam Test (LET). A Class 0; the ability to visualize any part of the epiglottis on gag reflex activation. B, Class I; soft palate, fauces, uvula, and pillars are seen on gag reflex activation. C, Class II; soft palate and base of the uvula seen on gag reflex activation. D, Class III; only soft palate seen on gag reflex activation

After preoxygenation and inducing general anesthesia with midazolam 0.5 mg/kg, fentanyl 2 µg/kg, propofol 2-3 mg/kg and atracurium 0.5 mg/kg, endotracheal intubation was carried out by an anesthetist who was not informed or involved during examinations for predicting difficult laryngoscopy and intubation. After induction of anesthesia, patient's head was placed in a sniffing position, and a Macintosh blade No. 3.0 was used to view the larynx, and if no laryngeal view was achieved, a second attempt was made with a Macintosh blade No. 4.0, and up to three attempts were performed by the same anesthetist in all subjects. Classification of laryngoscopic view was based on the Cormack and Lehane (C-L) method, (18) and C-L grades I and II were classified as "easy intubation" and C-L grades III and IV were classified as "difficult intubation."

Quantitative data such as age, height, weight analyzed by t-test, and presented as mean±SD, and qualitative data like gender was compared by Chi-square test and presented as the number (percentage).

In order to obtain a power of 85% and a level of significance of 5% using accuracy (ACC) more than 85%, the one-tailed test revealed an actual significance level of 0.0499 and a total sample size of 275 patients. So we decided to use a sample size of more than 300

subjects.

The preoperative assessment data and the C-L's laryngoscopic view were used to determine the accuracy of the three mentioned tests in predicting difficult intubation. Sensitivity, specificity, accuracy, positive and negative predictive values as well as positive and negative likelihood ratios were calculated from MMT, ULBT and LET with 95% confidence interval (CI 95%), using the C-L laryngoscopic view as gold standard. Data were analyzed by Stata software (Stata Corp. 2011. Stata Statistical Software: Release 12. College Station, TX: Stata Corp LP), and *P* of less than 0.05 was considered as significant. The area under the curve (AUC) was also computed by receiver operating characteristic (ROC) using this software.

Results

Three hundred and nineteen patients have enrolled the study. Eight subjects excluded from the study due to the absence of the pharyngeal reflex, and 311 patients completed the study. There was a predominance of male participants (59.5% *vs.* 40.5%). The mean values of weight, height, and body mass index (BMI) of participants were within normal range. Demographic data and statistical parameters are shown in Table 1.

Table 1. Demographic data and airway characteristic of the patients

Variables		Statistical parameter	C-L Grade		*P*
			Easy (grade I and II) n=292 (94%)	Difficult (grade III and IV) n=19 (6%)	
Age (year)		36.72 ± 13.83	36.34 ± 13.90	42.36 ± 11.10	0.066
Weight (kg)		72.12 ± 13.97	71.80 ± 14.00	76.90 ± 11.80	0.120
Height (cm)		168.84 ± 8.85	168.80 ± 8.80	169.40 ± 8.70	0.768
BMI (kg/m^2)		25.20 ± 4.40	25.10 ± 4.50	26.80 ± 3.80	0.121
Gender	**Male**	185 (59.5%)	173 (55.63%)	12 (3.80%)	0.736
	Female	126 (40.5%)	119 (38.27%)	7 (2.20%)	

BMI=body mass index, C-L=Cormack, and Lehane
Data are presented as Mean±Standard Deviation and Percent

In this study, no failed intubation was found after up to three attempts of laryngoscopy. According to the C-L's grading scales, difficulty in laryngoscopy was found in 19 (6.1%) of the patients, and only 3 (1%) of the patients had grade IV C-L's grading view. Quantitative data of three predictive tests are shown in table 2.

Table 2. Relationship between the results of three predicting tests and laryngoscopic grades (n=311)

Predictors		C-L Grade		Total (%)
		Easy (grade I and II) n= 292 (94%)	Difficult (grade III and IV) n= 19 (6%)	
MMT	**Easy**	225	25	250 (80.39)
	Difficult	21	40	61 (19.61)
ULBT	**Easy**	234	30	264 (84.89)
	Difficult	7	40	47 (15.11)
LET	**Easy**	239	24	263 (84.57)
	Difficult	7	41	48 (15.43)

MMT=Modified Mallampati Test; ULBT = Upper Lip Bite Test; LET = Laryngoscopic Exam Test; C-L =Cormack-Leahane

Sensitivity, specificity, positive and negative predictive values, positive and negative likelihood ratios as well as the accuracy of the three prediction tests are shown in table 3. Although, there was no statistical difference among MMT and ULBT and LET (*P*=0.375), data showed that the best accuracy was related to the LET. Analysis of ROC for predicting difficult laryngoscopy revealed an AUC of 0.76 (CI=0.70-0.82), 0.74 (CI=0.68-0.80) and 0.80 (CI=0.74-0.86) for MMT, ULBT and LET respectively (Figure 2).

Table 3. Statistical terms for the three methods to predict difficult intubation

Test	TP	FP	TN	FN	Se % (95% CI)	Sp % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	PLR % (95% CI)	NLR % (95% CI)	ACC % (95% CI)	AUC (95% CI)	*P*
MMT	40	21	225	25	61.54 (48.62-73.09)	91.46 (87.07-94.51)	65.57 (52.20-77.07)	90.00 (85.02-93.00)	7.20 (4.59-11.33)	0.42 (0.31-0.57)	85.21 (80.31-88.00)	0.76 (0.70-0.82)	0.00
ULBT	35	12	234	30	53.85 (41.12-66.12)	95.12 (91.41-97.38)	74.47 (59.40-86.20)	88.64 (84.22-92.81)	11.04 (6.08-20.03)	0.49 (0.37-0.63)	86.50 (82.55-90.60)	0.74 (0.68-0.80)	0.00
LET	41	7	239	24	63.08 (50.20-74.45)	97.20 (93.98-98.75)	85.42 (72.65-93.40)	90.87 (86.22-94.30)	22.17 (10.43-47.09)	0.38 (0.28-0.52)	90.03 (86.70-93.30)	0.80 (0.74-0.86)	0.00

MMT = Modified Mallampati Test; ULBT = Upper Lip Bite Test; LET = Laryngoscopic Exam Test; TP = True Positive; FP = False Positive; TN = True Negative; FN = False Negative; Se = Sensitivity; Sp = Specificity;
PPV = Positive Predictive Value; NPV = Negative Predictive Value; PLR = Positive Likelihood Ratio; NLR = Negative Likelihood Ratio; ACC = Accuracy; AUC = Area Under the Curve

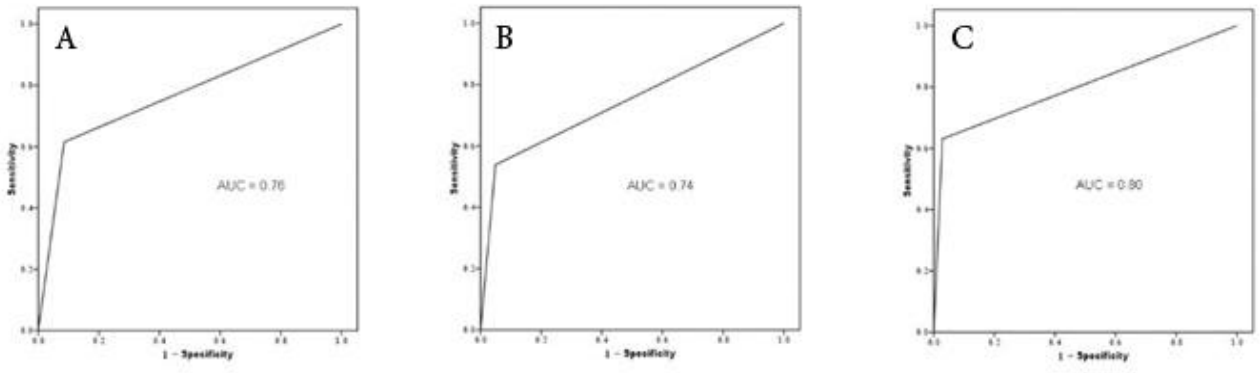

Figure 2. ROC curve analysis of three predicting tests for difficult intubation. AUC, area under the curve; A: MMT, Modified Mallampati Test; B: ULBT, Upper Lip Bite Test; C: LET, Laryngoscopic Exam Test

Discussion

Predicting difficult intubation is the major and one of the most important challenges for anesthesiologists so that they have to pay more attention to it to prevent its related complications (4). Unfortunately, despite developing new methods for predicting difficult intubation, limitations of the related studies have remained so far, and interobserver variability of these methods causes the problem to be unsolved, even some tests like MMT and ULBT are not totally reliable (19,20).

Our study compared the sensitivity, specificity and predicting values of MMT and ULBT with our new method in predicting difficult laryngoscopy and intubation using C-L's criteria of laryngoscopy as a gold standard (12,20).

The incidence of a difficult laryngoscopy and endotracheal intubation varies from 0.05% to 18% (5,7,8,21). Our study revealed that the incidence of difficult intubation was 6.1% (19 patients) which agrees with some studies (7-9,22). Although we used strict criteria for difficult intubation using grades III and IV of C-L's grading scale, avoidance of external pressure during intubation and involvement of an experienced anesthetist in laryngoscopy and intubation, we disagree in part with a few studies which presented the incidence of difficult intubation more than 20% (12,23).

Many methods have been described in the literature to assess the airway and predict difficult intubation. Mallampati test, thyromental distance, interincisor gap, the length of the mandibular rim, chin protrusion and upper lip bite test have been described earlier (24). Recently, some new tests or combination of those tests were presented for predicting difficult intubation, but all of them have limitations and no single test alone or combined tests are 100% sensitive and specific (7,24-27). The novelty of our study is that the test was performed directly with a laryngoscope which shows the pharyngeal view better than other two tests based on the upward movement of the hypopharynx and laryngeal structure and epiglottis during gag reflex. This helps the

pharyngeal structure to be visualized better by the examiner.

The sensitivity, specificity, positive and negative predictive value and accuracy of LET were higher than other two tests. Although, these differences were not statistically significant among three tests (P=0.375), however, the high values in our test is valuable and would consider LET as a reliable bedside method for predicting difficult intubation.

The sensitivity and specificity of LET were 63.08% (CI=50.15% to 74.44%) and 97.15% (CI=93.97% to 98.74%), respectively which were higher than MMT and ULBT, and with accompanying smaller false positive value (2.25%) in comparison with MMT (6.75%) and ULBT (3.85%) which is the merit of our study and could result in less time to overcome problems of anticipated difficult intubation.

Detection of as many patients as possible with a difficult airway is required to minimize the potentially serious consequences of unanticipated difficult tracheal intubation, and higher sensitivity and specificity along with high positive and negative predictive value is important for predicting difficult airway (11). Our study revealed that the LET had sensitivity, specificity, positive and negative predictive value and accuracy (63.08%, 97.15%, 90.03%, 90.98%, and 90.03%, respectively) higher than MMT and ULBT, which may result in better prediction for difficult laryngoscopy.

A more appropriate determination of validity is to conduct analysis using ROC. Hence, we plotted ROC of MMT, ULBT and LET. The curve showed that the AUC was larger for LET.

Some limitations of our study have to be addressed. Relative low sensitivity in our study may be due to the absence of inter-observer reliability. Another limitation is that some patients had the unlovely sensation to the LET which was due to their gag reflex and resulted to their unhappiness. Considering the pros and cons of the test, we could demonstrate that prophylaxis of life-threatening complications of unpredicted difficult airway could overcome these problems.

The study revealed that our new bedside clinical test has higher level of accuracy compared to the MMT and ULBT. Due to higher sensitivity, specificity as well as positive and negative predictive values, LET seems to be a better test for preoperative airway assessment and predicting difficult intubation.

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