PREDICTION OF DIFFICULT INTUBATION DEPENDING ON TWO DIFFERENT METHODS OF AIRWAY ASSESSMENT: A PROSPECTIVE STUDY

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Abstract

Objectives: The original as well as the modified Mallampati test (MMT) are the most commonly performed bedside tests for predicting difficult intubation, but there is controversy regarding the accuracy of these tests. This prospective study compared the MMT with and without tongue protrusion to the lower jaw protrusion maneuver (LJP), in correlation with the modified Cormack-Lehane grading of laryngeal view with backward, upward, rightward pressure (BURP).

Methods: This prospective study was designed in patients requiring endotracheal intubation. In sitting position and before induction of general anesthesia, we assessed the airway for ease of intubation using the MMT with and without tongue protrusion, while the patient was asked to bring the lower jaw as much a possible beyond the upper jaw.

Data were collect for 64 adult patients (age range: 18 to 64; mean: 38.5 years). After a standardized induction of anesthesia, the laryngeal view was graded in accordance with the modified Cormack-Lehane classification of laryngoscopy with BURP.

The overall incidence of difficulty of intubation was determined. The preoperative data and laryngoscopic findings were used to evaluate the accuracy, sensitivity, specificity, and the predictive values (positive, PPV, and negative, NPV) for each test.

Results: The overall incidence of difficult intubation was 14.0%. The accuracy, sensitivity, specificity, PPV, and NPV of the MMT with tongue protrusion compared to the MMT without tongue protrusion were found to be 57.8% vs. 29.7%, 13.3% vs. 60%, 71.4% vs. 20.4%, 12.5% vs. 18.8%, and 72.9% vs. 62.5%, respectively. In comparison, the LJP maneuver had higher accuracy (65.6%), PPV (33.3%), and NPV (81.4), while its specificity (71.4%) was as high as that of the MMT with tongue protrusion.

Conclusion: MMT is the most commonly performed bedside test for predicting difficult intubation with easy preoperative performance, but with limited accuracy and has only poor to moderate discriminative power when used alone. LJP maneuver comes out to be a better predictor of difficult laryngoscopy and tracheal intubation.it is easy to perform and can be used in anticipating difficulty in laryngoscopy and endotracheal intubation. We therefore suggest adding it to the routine preoperative assessment of airway.

Keywords: Cormack-Lehane, difficult intubation, laryngoscopy, lower jaw, Mallampati.

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Introduction

Difficult laryngoscopy and difficult tracheal intubation occur in 1.5% to 8% of general anesthetic procedures[1]. Unanticipated difficult intubation is a risk to the patient's life and a challenge for the anesthesiologist[2]. Recently, several different predictive tests of potential difficulty in intubation in adults as well as in pediatric patients were commonly used in clinical settings[3].

Identifying situations and patients at risk for airway management problems is key to optimal care and has been the focus of numerous publications[4,5]. Different bed side tests are used to predict a difficult airway. These include the modified Mallampati test (MMT), mouth opening, the lower jaw protrusion maneuver, the thyromental distance, and the sternomental distance[4-6]. Methods requiring x-ray assessments of the head and neck are impractical for population screening[7].

The objective of this study is to systematically determine the diagnostic accuracy of bedside tests for predicting difficult intubation in patients with no airway pathology. We thus undertook this prospective study to compare the modified Mallampati test with tongue protrusion (MMT-WP) and without tongue protrusion (MMT-NT) and the lower jaw protrusion maneuver (LJP) relative to the modified Cormack-Lehane grading (CLG) of difficulty in intubation during anesthesia, to determine which method is more accurate for predicting the difficulty of intubation in patients aged 18 years and older.

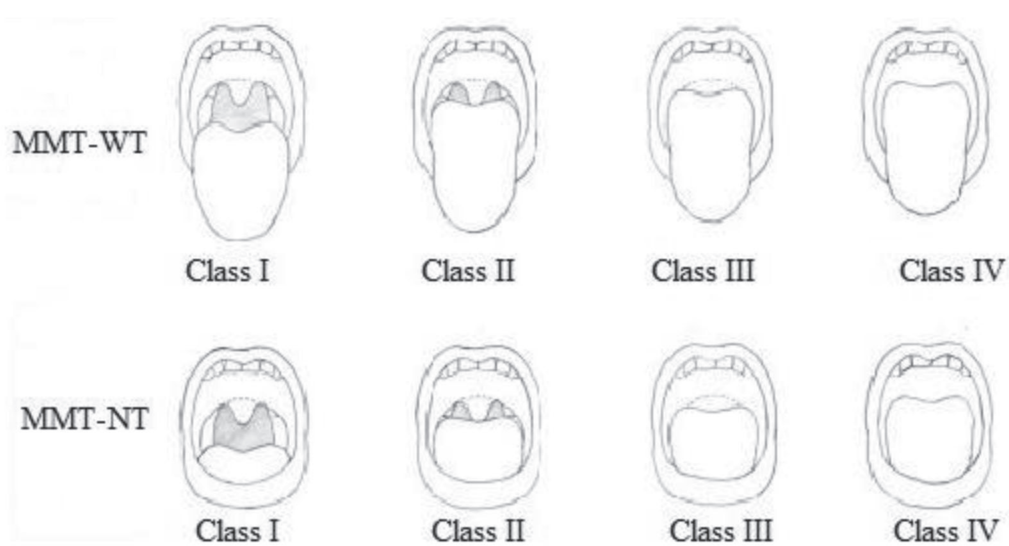
Materials and Methods

Population and study design

After obtaining formal approval from our institutional ethics committee (approval number: 20170208), we conducted this prospective study involving 64 adults of physical status I-III according to the American Society of Anesthesiologists (ASA) classification that were scheduled for various surgical procedures under general anesthesia with orotracheal intubation at the Jordan University of Science and Technology between May 15 and July 15, 2017. Written informed consent for participation in the study was obtained from all patients.

We applied the following inclusion criteria: (1) age of 18 years or older, and (2) the patient is a candidate for an elective intervention under general anesthesia. Exclusion criteria were: (1) the patient

Fig. 1
Modified Mallampati classification[8] for difficult laryngoscopy an intubation



Class I and II: No difficulty, Class III: Moderate difficulty, Class IV: Severe difficulty.
MMT-WT: Modified Mallampati test with tongue protrusion, MMT-NT: Modified Mallampati test without tongue protrusion.

is unconscious and cannot cooperate, (2) presence of upper airway pathology, cervical mass, cervical spine pathology, or limited neck movement that may complicate intubation and airway management, (3) presence of increased risk of pulmonary aspiration, and (4) pregnancy.

Measurements

Before induction of general anesthesia, the modififed mallampati test and the lower jaw protrusion maneuver were performed. The Modified Mallampati test was obtained while the patient was sitting, with maximum mouth opening, a neutral head position, without phonation, and with the examiner at the level of the patient. Two readings were recorded, one with tongue protrusion and the other without tongue protrusion (Figure 1). The classification was made according to the MMT introduced by Samsoon et al.[8] in the following manner: Grade 1: visibility of the soft palate, the fauces, the uvula, the anterior and posterior pillars; Grade 2: visibility of the soft palate, the fauces, and the uvula; Grade 3: visibility of the soft palate and the base of the uvula; Grade 4: only the hard palate is visible, while the soft palate is not visible at all[9,10]. Difficult intubation was defined as Grade 3 or Grade 4 with or without tongue protrusion. For the lower jaw protrusion maneuver (LJP), the patient was asked to protrude his/her lower jaw as far as possible; the final position was assessed with respect to the upper teeth in the following manner: Grade A: the lower incisors can be protruded anterior to the upper incisors; Grade B: the lower incisors can be brought edge to edge with the upper incisors; Grade C: The lower incisors cannot be brought edge to edge with the upper incisors[11]. Grade A was considered a predictor of “Easy” and Grade B and C predictors of “Difficult” laryngoscopy and tracheal intubation[11].

No study subject was premedicated. The same anesthetic technique was employed for all patients. On arrival in the operating theatre, the patient was placed in the supine position with the head placed on a jelly donut head ring, and an intravenous access was established that was maintained with lactated Ringer’s solution. Routine monitors (Electrocardiography (ECG), non-invasive blood pressure (NIBP), pulse oximetry, (SpO_2)) were applied. After the patient breathed oxygen for 3 minutes via a face mask, anesthesia was induced with 2-2.5 mg/kg propofol and 2 µg/kg fentanyl. Neuromuscular blockade was achieved with 0.5 mg/kg atracurium to facilitate tracheal intubation. Patients were intubated with an appropriate-sized endotracheal tube. Anesthesia was maintained with 1.5-2% sevoflurane in 50% oxygen and air.

After the induction of general anesthesia, the laryngeal view was assessed using a Macintosh blade size 3 and was graded according to the modified five-grade Cormack-Lehane classification[12,13] in the following manner: Grade 1: full view of the glottis; Grade 2a: partial view of the glottis; Grade 2b: the arytenoids or the posterior part of the vocal cords are only just visible. Grade 3: only the epiglottis was visible; Grade 4: neither the glottis nor the epiglottis were visible. All measurements were recorded with BURP. Difficult intubation was defined as Grade 2b, Grade 3, or Grade 4 with BURP.

The majority of intubations and laryngeal view grading were done by second-, third-, and fourth-year anesthesiology residents. The remaining assessments were done by a consultant of anesthesiology, who is not involved in this study.

The data used before induction and the data obtained after laryngoscopy were used as a method to assess each measurement and its relation to the difficulty of intubation.

Statistical analyses

Sample size calculations were based on effect size of approximately of 0.19 and an alpha error of 0.05, and a power of 80%. Assumed Confidence level is 95% and Standard normal deviate for $\alpha = Z\alpha = 1.96$, the sample size of 61 subjects were needed. A total of 64 subjects were enrolled to allow for potential subject dropout.

Statistical analyses were performed using SPSS for Windows version 18.0 (SPSS Inc., Chicago IL, USA).

The generalized estimating equation (GEE) with Bonferroni’s correction was used to detect differences in laryngeal view (Cormack-Lehane grade) among the three airway maneuvers.

For quantitative variables like age, height, weight, and sex, mean and standard deviation were computed and compared using *t*-tests.

In all analyses, a value of $p < 0.05$ was defined as statistically significant.

We defined a "true positive" (TP) as a difficult intubation that had been predicted to be difficult, a "false positive" (FP) as an easy intubation that had been predicted to be difficult, a "true negative" (TN) as an easy intubation that had been predicted to be easy, and a "false negative" (FN) as a difficult intubation that had been predicted to be easy. Sensitivity was defined as the percentage of correctly predicted difficult intubations as a proportion of all intubations that were truly difficult [TP / (TP + FN)]. Specificity was defined as the percentage of correctly predicted easy intubations as a proportion of all predicted difficult intubations [TN/ (TN + FP)]. Accuracy was calculated as the percentage of correctly predicted easy or difficult intubations as a proportion of all intubations [TP + TN/(TP + TN + FP + FN)]. The positive predictive value (PPV) was calculated as the percentage of correctly predicted difficult intubations as a proportion of all predicted difficult intubations [TP/TP + FP)], and the negative predictive value (NPV) as the percentage of correctly predicted easy intubations as a proportion of all predicted easy intubations [TN/TN + FN)].

The Receiver Operating Characteristic (ROC) curve was plotted to associate the sensitivity and the specificity of the three tests (Figure 2) and the area under ROC curve (AUC) was compared to obtain the most discriminative test (Table 6).

Table 1

Lower jaw protrusion maneuver[11]

Grade A	The lower incisors can be brought anterior to the upper incisors
Grade B	The lower incisors can be brought edge to edge with the upper incisors
Grade C	The lower incisors cannot be brought edge to edge with the upper incisors

Table 2

Demographic data

	n = 64
Age (years)	37.7 ± 12.3
Height (cm)	167.3 ± 8.9
Weight (kg)	80.2 ± 19.2
Body Mass Index (BMI)	29.0 ± 7.2
Sex: Male/Female	26/38
ASA I/II/III	32/31/1

Values are the mean (± SD) or real numbers.

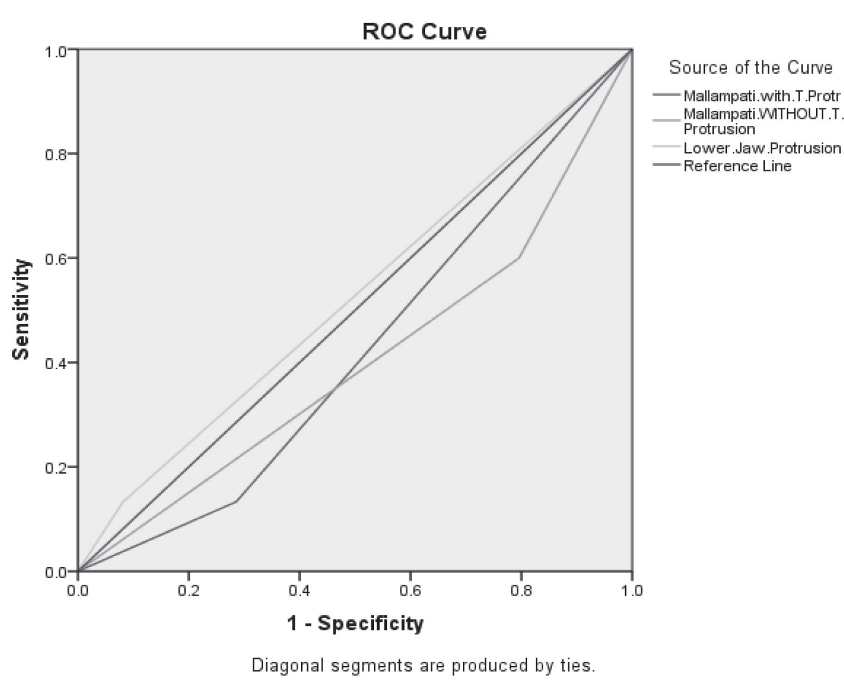


Fig. 2
Receiver operating characteristic curve analysis of Mallampati test with and without Tongue Protrusion and the lower Jaw Protrusion

Table 3
Relationship between the modified Mallampati test with and without tongue protrusion and laryngoscopic view with BURP

	Cormack-Lehane with BURP		Total
	Grade 1 and 2A	Grade 2B and 3	
Mallampati classes with tongue protrusion			
Mallampati I and II	35	13	48
Mallampati III and IV	14	2	16
Mallampati classes without tongue protrusion			
Mallampati I and II	10	6	16
Mallampati III and IV	39	9	48

BURP: backward, upward, rightward pressure. Data are given as real numbers.

Table 4
Relationship between the lower jaw protrusion maneuver and laryngoscopic view (Cormack-Lehane grading with BURP)

	Cormack-Lehane with BURP		Total
	Grade 1 and 2A	Grade 2B and 3	
Lower jaw protrusion maneuver			
Grade A	35	8	43
Grade B and C	14	7	21

BURP: backward, upward, rightward pressure. Values are given as real numbers.

Table 5
Comparison between the three tests

Statistical terms	Mallampati with tongue protrusion	Mallampati without tongue protrusion	Lower jaw protrusion maneuver
TP	2	9	7
FP	14	39	14
TN	35	10	35
FN	13	6	8
Accuracy (%)	57.8	29.7	65.6
Sensitivity (%)	13.3	60.0	46.7
Specificity (%)	71.4	20.4	71.4
PPV (%)	12.5	18.8	33.3
NPV (%)	72.9	62.5	81.4

TP: true positive; FP: false positive; TN: true negative; FN: false negative; PPV: positive predictive value; NPV: negative predictive value.
Values are given as real numbers or percentages.

Anesthetic management

Results

Complete data were available for all 64 patients who were enrolled in this study.

Patient age ranged from 18 to 64 years. Weight ranged from 46 to 133 kg; 16 patients weighed 90 kg or more and four patients weighed more than 110 kg. Demographic data and airway characteristics,

Table 6
Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Mallampati.with.T.Protr	.424	.081	.375	.266	.582
Mallampati.WITHOUT.T.Protrusion	.402	.088	.254	.230	.574
Lower.Jaw.Protrusion	.526	.088	.763	.354	.697

The test result variable(s): Mallampati with Tongue Protrusion, Mallampati WITHOUT Tongue Protrusion and the lower Jaw Protrusion, has at least one tie between the positive actual state group and the negative actual state group.
a. Under the nonparametric assumption
b. Null hypothesis: true area = 0.5

including age, gender, height, weight, body mass index, mouth opening, and thyromental distance, are listed in Table 2. Forty-eight and 16 patients had modified Mallampati Class I or II with or without tongue protrusion respectively, whereas 16 and 48 patients had Class III or IV with or without tongue protrusion respectively. Of all participants, 87.5% had an "Easy" Mallampati grade, while 12.5% had a "Difficult" grade (Table 3). Similarly, 61% of all patients enrolled in the study had an "Easy" LJP grade, while 39% of patients had a "Difficult" grade (Table 4).

Of all 64 patients, a total of nine patients (14%) had a difficult intubation; all of these patients were intubated using a gum elastic bougie.

The MMT with tongue protrusion has high specificity, accuracy, and NPV, whereas the MMT without tongue protrusion has the highest sensitivity of all tests assessed here. We found the highest accuracy, PPV, and NPV in the LJP maneuver, compared to other two tests. The specificity of the LJP maneuver is as high as that of the MMT with tongue protrusion.

True positive (TP), false positive (FP), true negative (TN), and false negative (FN) results together with sensitivity, specificity, positive predictive value, negative predictive value, and accuracy for the MMT with and without tongue protrusion and the LJP maneuver are shown in Table 5.

Discussion

Difficult or failed endotracheal intubations are one of the most common causes of anesthesia-related morbidity and mortality[14], and preoperative screening to identify patients in whom tracheal intubation may be difficult or impossible may thus save lives[15]. Several different methods of predicting possible difficulty in intubation have been devised in adult as well as in pediatric patients, such as the modified Mallampati test and the Wilson test, the upper lip bite test, and the thyromental and sternomental distance[3,16,17]. Khan et al.[10] reported a variation of the incidence of difficult intubation between 1.3 and 13%. In our study we found an incidence of difficult intubation of 14%, which is comparable to the finding of Honarmand et al. who conduct a prospective observational study of 600 cases and reported an overall difficult intubation of 14.7%[18]. A higher incidence (22.4%) was found by Haq et al.[11] and by Ayuso et al. (30%)[19]. This large variation might be due to the inconsistent criteria that are used to define difficult intubation as well as its dependency on the operator's experience and differences in anthropometric features among populations and in clinical setting[1,2,20].

Our aim was to assess the value of the MMT-WT and the MMT-NT and of the LJP for difficult laryngoscopy and tracheal intubation in association with the modified Cormack-Lehane criteria of intubation as a gold standard with BURB in adults. We used the BURB maneuver because it has been shown to provide better glottic exposure when using direct laryngoscopy in previous studies[21]. In contrast to our study, Lee et al.[6] found that the BURP maneuver worsened the laryngeal view compared with the conventional maneuver. In the present study, the sensitivity, specificity, and PPV of the MMT-NT were found to be 60%, 20.4%, and 18.8%, respectively. Similar sensitivity results were found by Prakash et al. (60%)[2], comparable to the study conducted by Jain et al. who found that the MMT had a sensitivity and PPV of 53% and 22%, respectively[17]. Many studies showed that the MMT has good specificity but low sensitivity and a poor predictive value[16,22,23]. The varying results might be due to the considerable interobserver variations found for the MMT, as well as to discrepancies in the evaluation and the interpretation of the observations[10,16]. Lee et al. performed a systemic review on 34513 patients in 42 studies and found poor to good accuracy of the Mallampati test[1].

In the current study, the LJP had better accuracy (65.6%), NPV (81.4%), and PPV (33.3%) than the MMT, but the specificity of the LJP (71.4%) was similar to that of the MMT, while the sensitivity of the MMT-NT was higher. The sensitivity of the LJP in our study was 46.4%, which is below the value that Haq et al.[11] found (95.6%), but higher than the value reported by Savva (29.4%)[15].The difference between the reported sensitivity results can presumably be attributed to interobserver variability.

Our study has some limitations. The majority of intubations were done by second-, third-, and fourth-year anesthesiology residents, who could not be blinded to the airway manipulations. To eliminate the element of instrumentation of the airway, we used a Macintosh blade size 3 for all subjects of our study and did not conduct an additional Macintosh laryngoscopy to establish the modified Cormack-Lehane grading of laryngeal view. We excluded morbidly obese patients and emergency cases from our study, while we did include obstetric patients, who have a rather high incidence of unanticipated difficult intubation compared to the general population. Since our study population was limited to patients scheduled for elective surgeries under general anesthesia with endotracheal intubation, our results are only applicable to this specific group of patients.

In conclusion, there is no test that can be considered foolproof for predicting difficult intubation. The MMT is the most commonly performed bedside test for predicting difficult intubation with easy preoperative performance, but it has limited accuracy and only poor to moderate discriminative power when used alone. The LJP maneuver has been shown here to be a better predictor of difficult laryngoscopy and tracheal intubation, is easy to perform, and can be used for anticipating difficulty in laryngoscopy and endotracheal intubation. Because the combination of both individual tests provides better diagnostic value in comparison to the value of each test alone, we suggest adding this simple bedside screening test to the routine preoperative airway assessment for difficult laryngoscopy.

Acknowledgments

The authors would like to thank all patients who agreed to participate in this research and also all the physician and nursing staffs in the operating rooms at King Abdullah University Hospital, who supported this research. We wish to thank Professor Y. Sawalmeh for his support and advice on statistical analyses.

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