

A COMPARISON OF PREOPERATIVE AIRWAY ASSESSMENT TECHNIQUES: THE MODIFIED MALLAMPATI AND THE UPPER LIP BITE TEST

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The purpose of this study was to compare the preoperative anesthetic airway evaluation methods of the modified Mallampati test (MMT) and upper lip bite test (ULBT) with the direct laryngoscopic views obtained during tracheal intubation. Positive relationships were predicted for the MMT and ULBT with direct laryngoscopic view and between the MMT and ULBT. We assessed 50 patients' airways preoperatively by MMT and ULBT. Intraoperatively, laryngoscopic views were graded on the Cormack and Lehane scale. Descriptive statistics and correlations were computed.

There was no relationship between the MMT and the ULBT and the Cormack and Lehane scale. There was a sig-

nificant relationship between the ULBT and the Cormack and Lehane scale ($r = 0.512$; $P < .001$). The ULBT was superior to the MMT in every measure in this study: sensitivity (55% vs 11%), specificity (97% vs 75%), positive predictive value (83% vs 9%), and accuracy (90% vs 64%).

The findings of this study support those of a previous study of the ULBT. Because of the ease of the ULBT and the promising results of this small study, we recommend further research with a larger, more diverse sample.

Key words: Airway assessment, modified Mallampati test, upper lip bite test.

Of all anesthetic deaths, 30% to 40% are attributed to the inability to manage a difficult airway.¹ Of the overall claims against anesthesiologists in the Closed Claims Project, 17% involved difficult or impossible intubation in which no preoperative airway assessment was documented.² In light of this, it is not surprising that the American Association of Nurse Anesthetists has established the preanesthetic assessment of the patient and the airway as the first standard of practice.³

Prediction of potentially difficult airway management during the preoperative period is determined by the anatomy of the oropharyngeal structures, architecture, and range of movement of the oropharynx and neck. Clinical evaluation of these anatomical structures occurs by noting the atlanto-occipital joint extension, thyromental distance, and the modified Mallampati classification.⁴ The "sniffing" position or atlanto-occipital joint extension was first described in 1913 by Jackson and is believed to align the oral, pharyngeal, and laryngeal axes for a direct view of the glottic opening. Although the sniffing position is

widely used, aligning the axes is based on observation alone and not on actual measurement of the angles of flexion and extension achieved. In fact, no scientific validation has been found demonstrating that this maneuver had any more significant effect on the laryngoscopic view over simple neck extension.⁵

The *thyromental distance*, or area between chin and thyroid cartilage, is defined as the distance from the thyroid cartilage to the tip of chin or mentum.⁴ The determination of the thyromental distance can be difficult in overweight patients, patients who are immobilized, and patients with goiters or other neck disease. Karkouti et al⁶ found the interobserver reliability was moderate relating to the thyromental distance assessment technique; moreover, thyromental distance was of little value in predicting a difficult intubation in adults.⁷

Another preoperative method to assess the presence of a difficult airway is the modified Mallampati test (MMT). This assessment determines the size of the tongue in relation to the oropharynx and the ability to open the mouth.⁸ Its classifications are based on obser-

vation of the pharyngeal structures with the mouth fully open and tongue maximally protruded. Mallampati et al⁸ found significant correlation between the ability to visualize pharyngeal structures and ease of laryngoscopy and intubation ($P < .001$). The literature indicates that the modified Mallampati classification has relatively high specificity but low sensitivity and a high number of false-positive results.⁹⁻¹¹

The MMT has shown poor reliability in assessing oropharyngeal views.⁶ The lack of reliability could be due to discrepancies in administering, evaluating, and interpreting the test. Because the assessment of the oropharyngeal anatomy requires an open mouth with tongue protrusion, patients with small mouth openings or altered levels of consciousness could be misclassified. The MMT, the sniffing position, and the thyromental distance do not consider the patient's dentition or variations in the degree of mandibular range of motion that may be present¹²; thus, the validity of each assessment is influenced by the experience and skill level of the anesthesia provider.⁶

Recently, a new technique to evaluate for difficult airway intubation was reported. The upper lip bite test (ULBT) was developed by Khan et al¹² in an effort to produce a simple, single test that could be used preoperatively to evaluate for a difficult airway. The test is classified according to the ability to bite the upper lip with the lower teeth. The researchers state the anatomical distinction between the ULBT and the other preoperative airway evaluation methods lies in the range and freedom of movement of the mandible and the architecture of the teeth.¹² In a sample of 300, the ULBT was found to have an accuracy of 88%, compared with 67.7% for the MMT, and the specificity of the ULBT for predicting easy intubation was 88.7% compared with 66.8% for the MMT.¹²

The ULBT takes into account some of the limitations associated with traditional airway evaluation methods. Interobserver reliability in distinguishing the oropharyngeal anatomy is negligible due to the simplicity in observation and performance of the test¹²; thus, its use is not dependent on skill or experience level. Although this technique shows much promise, limited data exist to support its widespread adoption as the method of choice for preoperative airway assessment.

Purpose

The purpose of this study was to compare the preoperative anesthetic airway evaluation methods of MMT and ULBT with the direct laryngoscopic views obtained during tracheal intubation.

• Hypotheses

1. There will be a significant direct relationship

between the MMT and Cormack and Lehane scale.

2. There will be a significant direct relationship between the ULBT and Cormack and Lehane scale.

3. There will be a significant direct relationship between results of the ULBT and the MMT.

Methods

• **Design.** This was a prospective, comparative study evaluating the relationship between the 2 preoperative airway assessment techniques and glottic exposure obtained during orotracheal intubation. The interrater reliability was single blinded, that is, the anesthesiologist assessing glottic exposure was blinded to the preoperative airway, but the other investigators were not.

• **Sample and setting.** A power analysis was conducted assuming a moderate effect, a power of .80, and an α of .05. A sample size of 50 was determined to be appropriate for this study. A convenience sample of 50 participants scheduled for elective surgery under general anesthesia were selected from the surgical schedule of a large metropolitan level I trauma center located in the southeastern United States. Criteria for inclusion were: age 18 years or older and scheduled for an elective surgical procedure under general anesthesia requiring intubation.

To achieve more consistent physiological effects and scoring, we limited paralytic agents to one (vecuronium). Exclusion criteria included the following: (1) rapid-sequence induction of anesthesia (different muscle relaxants used); (2) inability to open the mouth due to existing trauma or medical condition, preexisting neck or facial disease causing distortion of the airway, edentulous, and/or a history of difficult intubation; (3) altered level of consciousness, confusion, or inability to follow commands; and/or (4) preexisting limitation or pain with cervical spine movement. Patients requiring rapid-sequence induction are already at high risk for aspiration; the airway should be rapidly secured with an endotracheal tube and not subjected to repeated or delayed assessment as might occur in the study.

• **Protection of human rights.** Permission to conduct the study was obtained from the university and the medical center. Written consent was obtained from participants in the preoperative holding area. Because all study procedures included usual and customary care, there were no additional risks to participants.

• Operational definitions.

MMT: A scale indicating the amount of posterior pharynx that can be visualized with the mouth open⁸: class I, visualization of soft palate, fauces, uvula, and

Table 1. Definitions of outcome terms

Term	Definition*	
	Actual	Predicted
True-positive	Difficult	Difficult
False-positive	Easy	Difficult
True-negative	Easy	Easy
False-negative	Difficult	Easy
Sensitivity	Percentage of correctly predicted difficult intubations as a proportion of all intubations that were difficult	
Specificity	Percentage of correctly predicted easy intubations as a proportion of all intubations that were easy	
Positive predictive value	Percentage of correctly predicted difficult intubations as a proportion of all predicted difficult intubations	
Negative predictive value	Percentage of correctly predicted easy intubations as a proportion of all predicted easy intubations	
Accuracy	Percentage of correctly predicted easy or difficult intubations as a proportion of all intubations	

* Actual indicates grade on the Cormack and Lehane Scale (C&L); difficult, class or grade III and IV on the modified Mallampati test and the C&L and class III on the upper lip bite test; and easy, class or grade I and II on all 3 airway assessment techniques.

pillars; class II, visualization of soft palate, fauces, and uvula; class III, visualization of soft palate and base of the uvula; and class IV, soft palate not visible. Classifications of III or IV were considered potentially difficult intubations. Assessments were conducted with the participant in sitting position at eye level to investigator with the mouth maximally open and tongue maximally protruded. The airway was examined twice with a flashlight and then graded.

ULBT: A scale indicating the range of motion and bite of the lower teeth onto the upper lip¹²: class I, lower incisors can bite the upper lip above the vermilion line, class II, lower incisors can bite the upper lip below the vermilion line, and class III, lower incisors cannot bite the upper lip. A classification of III was considered a potentially difficult intubation. This was assessed by having the participant in the sitting position at eye level to investigator. The ULBT was demonstrated by the investigator, performed by the participants twice, and graded.

Cormack and Lehane scale: A scale indicating the glottic view obtained with direct laryngoscopy¹³: grade I, full view of the glottis; grade II, glottis partially exposed, anterior commissure not seen; grade III, only epiglottis seen; and grade IV, epiglottis not seen. Grades III and IV were considered difficult intubations.

Outcome terms (Table 1): *true-positive*, a difficult intubation that was predicted to be difficult; *false-positive*, an easy intubation that was predicted to be diffi-

cult; *true-negative*, an easy intubation that was predicted to be easy; *false-negative*, a difficult intubation that was predicted to be easy; *sensitivity*, the percentage of correctly predicted difficult intubations as a proportion of all intubations that were truly difficult, ie, true-positives/(true-positives + false-negatives); *specificity*, the percentage of correctly predicted easy intubations as a proportion of all intubations that were truly easy, ie, true-negatives/(true-negatives + false-positives); *positive predictive value*, the percentage of correctly predicted difficult intubations as a proportion of all predicted difficult intubations, ie, true-positives/(true-positives + false-positives); *negative predictive value*, the percentage of correctly predicted easy intubations as a proportion of all predicted easy intubations, ie, true-negatives/(true-negatives + false-negatives); and *accuracy*, the percentage of correctly predicted easy or difficult intubations as a proportion of all intubations, ie (true-positives + true-negatives)/(true-positives + true-negatives + false-positives + false-negatives).

• **Procedure.** After written consent was obtained, participants were assessed in the preoperative holding area using the MMT and the ULBT. Two researchers collected all data (S.A.D. and S.W.W.). Participants received a standard induction sequence (vecuronium, 0.1 mg/kg; propofol, 1.5-2.5 mg/kg; fentanyl, 1-2 µg/kg; lidocaine, 1 mg/kg; isoflurane, 0.6% inspired concentration; and 100% oxygen). A laryngoscopy

Table 2. Frequencies of airway assessment classifications (n = 50)*

Class	MMT		ULBT		Cormack and Lehane	
	No.	%	No.	%	No.	%
I	14	28	21	42	25	50
II	25	50	23	46	16	32
III	11	22	6	12	8	16
IV	0	0	NA	NA	1	2

MMT indicates modified Mallampati test; ULBT, upper lip bite test; and NA, not applicable.

was then performed with a No. 3 or No. 4 MacIntosh blade after loss of train of four by using a nerve stimulator to stimulate the facial nerve. The laryngeal view was graded using the Cormack and Lehane scale. Interobserver reliability was assessed for the first 20 participants (10 subjects per investigator). An anesthesiologist with extensive experience in difficult airway classification and management was blinded to the 2 investigators' (senior nurse anesthesia student) classification of the airway. Strong reliability was established ($\kappa = 1.0$).

Findings

The 50 participants included 19 men (38%) and 31 women (62%) with ages ranging from 18 to 85 years (mean, 44.3 years; SD, 13.149 years). African Americans represented 16% (n = 8), and 42% (n = 21) were white. Participant height ranged from 60 to 77 in (mean, 66.5 in; SD, 4.16 in), weight ranged from 54 to 139 kg (mean, 82.58 kg; SD, 18.41 kg), with body mass index (BMI) between 19.29 and 48.65 (mean, 29.1; SD, 6.8).

Table 2 shows the frequencies of classifications on the 3 airway assessments. There were 11 participants (22%) with an MMT grade of III and none with a grade of IV; 6 (12%) demonstrated a ULBT of III. A total of 17 participants were predicted to have a Cormack and Lehane graded scale of III and IV. A grade III or IV on the Cormack and Lehane scale was exhibited by 9 (18%); all were successfully intubated. The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy are given in Table 3.

As participant height decreased, the MMT predicted intubation to be more difficult ($r = -0.377$; $P < .01$), but there was no relationship between the MMT and weight ($r = 0.191$; $P > .05$). There was a positive relationship between MMT and BMI ($r = 0.339$; $P < .05$). No relationships were found between the ULBT and height ($r = -0.009$; $P > .05$), weight ($r = 0.046$; P

Table 3. Outcomes of upper lip bite test (ULBT) and modified Mallampati test (MMT) as compared with the Cormack and Lehane scale

Outcome calculations	ULBT (n = 50)	MMT (n = 50)
True-positive	5	1
False-positive	1	10
True-negative	40	31
False-negative	4	8
Sensitivity (%)	55	11
Specificity (%)	97	75
Positive predictive value (%)	83	9
Negative predictive value (%)	90	79
Accuracy (%)	90	64

Table 4. Spearman rho correlations among the Cormack and Lehane (C&L) scale, the modified Mallampati test (MMT), and the upper lip bite test (ULBT)

	MMT	ULBT
C&L (P, 1-tailed)	0.172 (.116)	0.512* (.000)
MMT (P, 1-tailed)	–	0.223 (.059)

* < .05

> .05), or BMI ($r = 0.051$; $P > .05$). There was a significant relationship between weight and the Cormack and Lehane scale ($r = 0.283$; $P < .05$) but not between the scale and height ($r = 0.011$; $P > .05$) or BMI ($r = 0.26$; $P > .05$).

The hypotheses were tested by using the Spearman rho (Table 4). No significant relationships were found between the MMT and Cormack and Lehane scale ($r = 0.172$; $P > .05$) or between the MMT and the ULBT ($r = 0.223$; $P > .05$). A significant direct relationship between the ULBT and Cormack and Lehane scale was demonstrated ($r = 0.512$; $P < .001$).

Discussion

• **Limitations.** There were several limitations to the study. Data were collected from a single level I trauma center in the southeastern United States using a convenience sample. Thus, caution should be used when generalizing to other settings. Interrater reliability for the Cormack and Lehane scale was assessed only at the beginning of the study rather than episodically

throughout. Nevertheless, the investigators were senior nurse anesthesia students who had been independently intubating for more than a year, and the Cormack and Lehane scale has limited subjectivity. Interobserver reliability was not assessed for the MMT. All participants were scheduled for elective surgery, and there were no participants with an ASA status of more than III. In addition, and importantly, the ULBT requires the patients' cooperation, ability to move the mouth, and the presence of teeth; only participants meeting those criteria participated.

• **Findings.** This study supported the findings of Khan et al,¹² that the ULBT was superior to the MMT in specificity and accuracy of predicting difficult intubation. In addition, although Khan et al¹² found no differences between the 2 assessments in sensitivity, positive predictive value, and negative predictive value, the present study found the ULBT to be superior to the MMT in all measures (see Table 3). Some of the differences between the 2 studies lie in the strength of the findings.

Proportionally, more patients in the present study (11 [22%]) demonstrated an MMT of III (predicted difficult intubation) compared with the previous study in which 4.6% were reported having classifications of III or IV. This may be because of the setting for this study—a level I trauma center that also provides most of the city's indigent care. A smaller difference in the percentage exhibiting a ULBT of III was found—12% (n = 6) for the present study vs 4.6% for the previous study. In the present study, 18% of the participants (9/50) had airways that were difficult to intubate during laryngoscopy, as measured by the Cormack and Lehane scale. In contrast, Khan et al¹² reported finding only 5.7% (17/300) of participants having a difficult intubation. In both studies, all intubation attempts were successful. This proportionally high level of difficult intubations may be accounted for by the nature of the agency in which the present study was conducted. The hospital is a tertiary center that serves a large region in the southeastern United States. Many of its patients are indigent and/or referred.

No relationship between MMT and the Cormack and Lehane scale was found. This was a surprising finding because the MMT has been recognized as the "gold standard"¹⁴ for many years and has been described as the primary airway assessment tool technique used in modern anesthesia practice.³ Mallampati et al⁸ reported using a convenient sample of 210 participants and 22 data collectors and finding a significant relationship between the ability to visualize pharyngeal structures and ease of laryngoscopy and intubation ($P < .001$). Interrater reliability was not reported; the large number

of data collectors could have affected the reliability. In the present study, interobserver reliability was strong for the Cormack and Lehane assessments but was not conducted with the MMT.

The MMT requires anesthesia providers to recognize and identify the complex oropharyngeal anatomy to determine the appropriate level of classification. Discrepancies in administering, evaluating, and interpreting the MMT have been suggested by others when they found the MMT was not reliable in predicting a difficult airway.⁶ Oates et al⁹ found the MMT to be a subjective instrument in predicting a difficult airway, with interobserver variations significantly altering the results. One factor cited as "critical" in achieving a reliable Mallampati score is the maximal extrusion of the tongue and opening of the mouth. The authors further state, "failure to apply this rigorously is a major pitfall when performing the assessment."^{9(p308)} They also concluded that the MMT score could be significantly altered with phonation and accessory muscle use, and the impact of the interobserver variation was significant in explaining the results. Other studies evaluating the Mallampati classification have shown this technique too insensitive when used alone. Savva¹¹ found the MMT too insensitive and insufficiently specific for routine use (sensitivity, 64.7%; specificity, 66.1%; and positive predictive value, 8.9%). Savva¹¹ found that other assessment tools, such as the sternomental distance, were more sensitive and specific than the Mallampati classification. Frerk¹⁰ concluded that the MMT used as the sole preoperative assessment tool is sensitive but not very specific, finding that the high numbers of false-positive results prohibits it from being an accurate sole preoperative assessment tool. In the current study, 10 participants (20%) had false-positive findings for the MMT; Kahn et al¹² found 33.2%.

In the present study, a strong correlation between the ULBT and Cormack and Lehane scale ($r = 0.512$; $P < .001$) was found; no significant relationship was found between the ULBT and the MMT. The ULBT showed a significantly higher specificity than the MMT (97% vs 75%, respectively) and accuracy (90% vs 64%, respectively), similar to results found by Khan et al.¹² In comparing the positive predictive value, the ULBT predicted difficult intubations correctly 83% of the time, whereas the MMT predicted a difficult intubation only 9% of the time. In contrast, Khan et al¹² reported positive predictive values for the ULBT and MMT as 28.9% and 13%, respectively. Demographic variables of the participants were not reported in the original study, and significant differences in weight and/or height between participants in the 2 studies may have existed.

In the present study, as height decreased, the MMT predicted intubation to be more difficult ($r = -0.377$; $P < .01$). No relationship existed between the MMT and weight ($r = 0.191$; $P > .05$). There was also a direct relationship between the MMT and BMI ($r = 0.339$; $P < .05$). Although there were no relationships between the Cormack and Lehane scale and BMI or height, increasing weight was weakly but significantly associated with a higher classification on that scale ($r = 0.283$; $P < .05$). There were no relationships between the ULBT and height, weight, or BMI. The ULBT is examining external structures that are not impacted by weight or height; the MMT and Cormack and Lehane scale address internal structures, which may be influenced by height or weight. The relationship of height to the MMT may be a factor in the reliability and validity of the MMT.

In the original study, only 3 false-negatives were found for the MMT (1.0%) and 4 false-negatives for the ULBT (1.3%).¹² In contrast, the present study found 8 false-negatives for the MMT (16%) and 4 false-negatives for the ULBT (8%). In addition, the percentage of false-positives was high for the MMT in the original study (33.2%) and the present study (20%). This could represent interobserver differences in laryngoscopy techniques, MMT, and/or differences in sample characteristics.

True-positive, false-positive, true-negative, and false-negative results along with sensitivity, specificity, positive predictive value, negative predictive value, and accuracy for the MMT and ULBT are shown in Table 4. The ULBT had more false-negatives in the original study and, thus, a lower sensitivity compared with the present study. Overall, however, the ULBT was a better predictor of difficult intubation; predicting difficult intubation is, after all, the goal of a preoperative assessment.

Summary

Although tracheal intubation for most patients can be accomplished with ease, there are patients for whom intubation presents a higher risk. The ability to predict difficult intubations allows anesthesia providers the opportunity to plan accordingly, thus providing safer care. The ULBT provides a simple, easily interpreted assessment that has now been demonstrated in 2 studies to be a reasonable predictor of intubation difficulty. The ULBT is limited to patients who are able to follow commands, have teeth, and are able to move the mandible. The MMT, heretofore considered the gold standard, has been demonstrated in 2 studies to lack validity. Further research is needed on the ULBT that includes more patients with higher ASA classifications and different ethnicities. In addition,

more study is needed with participants whose BMI falls in the obese range. Future studies would be strengthened if interrater reliability involved blinding of all investigators to the preoperative assessment when conducting the Cormack and Lehane assessment. Finally, a multisite study would better enable generalizability of the findings.

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