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Original Research Article

A Comparative Study of Scoring Systems used to Predict Difficult Airway

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Abstract

Introduction: Difficult airway remains a major contributor to anaesthesia-related morbidity and mortality. Preoperative airway assessment is crucial to anticipate and prepare for potential laryngoscopy and intubation challenges. Several bedside tests, including Modified Mallampati Test (MMT), Upper Lip Bite Test (ULBT), Thyromental Distance (TMD), and Ratio of Height to Thyromental Distance (RHTMD), have been proposed to predict difficult laryngoscopy, but their accuracy varies across populations.

Materials and Methods: This prospective observational study was conducted on 150 adult patients (ASA I–III) undergoing elective surgeries under general anaesthesia. Preoperative airway assessment included MMT, ULBT, TMD, RHTMD, and Wilson score. Anaesthesia was standardized in all cases, and direct laryngoscopy was performed by an experienced anaesthesiologist blinded to preoperative scores. Difficult laryngoscopy was defined as Cormack–Lehane Grade III/IV. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated for each test. Receiver Operating Characteristic (ROC) analysis was used to compare predictive performance.

Results: The mean age was 42.8 ± 12.3 years with a male predominance (54.7%). Difficult laryngoscopy occurred in 18.7% of patients. MMT (Class III/IV) had the highest sensitivity (98.5%) and NPV (99.3%), while ULBT had the highest specificity (99.3%) and PPV (94.1%). RHTMD demonstrated excellent overall accuracy (97.9%), with sensitivity 88.9% and specificity 98.6%. Wilson score had the highest AUC (0.89) on ROC analysis, indicating strong predictive power.

Conclusion: MMT and RHTMD are the most reliable single predictors of difficult laryngoscopy, while ULBT serves as an excellent confirmatory test. Combining sensitive and specific predictors improves airway assessment and enhances perioperative safety.

Keywords: Difficult Airway, Airway Assessment, Laryngoscopy Prediction.

Introduction

Securing a patent airway is a fundamental requirement for safe administration of general anaesthesia [1]. Failure to recognize and appropriately manage a difficult airway remains one of the leading causes of anaesthesia-related morbidity and mortality [2]. The incidence of difficult laryngoscopy has been reported to range between 1.5% and 13% in the general surgical population, making preoperative identification of high-risk patients crucial for preventing catastrophic complications such as hypoxia, aspiration, or failed intubation [3,4]. A variety of bedside screening tests have been proposed for predicting difficult laryngoscopy and intubation, including the Modified Mallampati Test (MMT), thyromental distance (TMD), ratio of height to

thyromental distance (RHTMD), upper lip bite test (ULBT), and multivariate scoring systems such as Wilson score [5-7]. Each of these tests evaluates different anatomical and functional aspects of the airway [8]. However, when used individually, most tests have shown limited sensitivity or specificity, and their predictive accuracy can vary among populations [9,10].

Accurate prediction of a difficult airway allows anaesthesiologists to prepare appropriate adjuncts such as video laryngoscopes, fibreoptic bronchoscopes, or alternative airway devices, thereby minimizing the risk of failed intubation [11]. Comparative studies of multiple airway assessment tools are essential to identify the most reliable predictor and guide clinical decision-making [12,13]. In resource-limited settings, choosing the most cost-effective and time-efficient bedside test is especially important. The present study was undertaken to compare the predictive performance of commonly used airway assessment tools like Mallampati classification, ULBT, TMD, and RHTMD in predicting difficult laryngoscopy, using Cormack–Lehane grading as the gold standard.

Materials and Methods

This prospective observational study was conducted in the Department of Anaesthesiology at Mamata Medical College, Khammam from January 2024 to June 2025, after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants. A total of 150 adult patients of either sex, aged between 18–65 years, belonging to ASA physical status I–III, and scheduled for elective surgeries under general anaesthesia with endotracheal intubation were included. Patients with maxillofacial trauma, restricted mouth opening (<2 cm), congenital airway anomalies, or those requiring rapid sequence induction were excluded to avoid bias.

All patients underwent a detailed pre-anaesthetic airway evaluation during the preoperative visit. Airway assessment included Mallampati classification, thyromental distance (TMD), ratio of height to thyromental distance (RHTMD), upper lip bite test (ULBT), and Wilson risk score. Mallampati class was assessed with the patient seated, head in neutral position, mouth fully open, and tongue protruded. TMD was measured from the mentum to thyroid notch with the head fully extended. RHTMD was calculated by dividing the patient's height (cm) by measured TMD (cm). ULBT was classified into Class I, II, or III based on the ability of the lower incisors to bite the upper lip. Wilson score was determined by assigning points for weight, head and neck movement, jaw movement, receding mandible, and buck teeth.

Anaesthesia was standardized in all cases. Patients were premedicated as per institutional protocol and induced with intravenous agents. Direct laryngoscopy was performed by an experienced anaesthesiologist blinded to the preoperative scores, using a Macintosh blade. The Cormack–Lehane grading was recorded at first attempt and considered the reference standard for predicting difficult airway. Difficult laryngoscopy was defined as Grade III or IV view. The ease of mask ventilation and number of intubation attempts were also documented.

Data were entered into Microsoft Excel and analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY). Categorical variables were expressed as frequency and percentage, and continuous variables as mean ± standard deviation. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy of each airway assessment tool were calculated. Receiver operating characteristic (ROC) curves were plotted to compare the predictive performance of the scoring systems, and area under the curve (AUC) values were derived. A p-value <0.05 was considered statistically significant.

Results

The mean age of the study population was 42.8 ± 12.3 years, with a slight male preponderance (54.7%). The mean BMI was 25.3 ± 3.8 kg/m², indicating that most participants were in the overweight range. ASA physical status was I in 44% of patients, II in 38.7%, and III in 17.3%, reflecting a relatively healthy cohort with a minority having significant systemic disease (Table 1).

Table 1: Demographic Characteristics of Study Population (n=150)

Variable		Value
Age	**Years**	42.8 ± 12.3
Gender	**Male**	82 (54.7%)
	Female	68 (45.3%)
BMI	**kg/m²**	25.3 ± 3.8
ASA Physical Status	**I**	66 (44.0%)
	II	58 (38.7%)
	III	26 (17.3%)

Among airway assessment parameters, Mallampati Class I and II were the most frequent findings, together accounting for 73.4% of cases, whereas Class III and IV comprised 26.6%, indicating a smaller proportion at risk for difficult airway. Thyromental distance was >6.5 cm in 82.7% and ≤6.5 cm in 17.3% of patients. ULBT Class I predominated (72%), with only 5.3% in Class III.

Based on Wilson score, the majority (68%) had a score ≤2, while 8% scored ≥5, suggesting a higher predicted difficulty (Table 2).

Table 2: Distribution of Patients According to Airway Assessment Scores (n=150)

Airway Assessment Tool	Score Category	n (%)
Mallampati Class	**I**	58 (38.7%)
	II	52 (34.7%)
	III	32 (21.3%)
	IV	8 (5.3%)
Thyromental Distance	**>6.5 cm**	124 (82.7%)
	≤6.5 cm	26 (17.3%)
Upper Lip Bite Test (ULBT)	**Class I**	108 (72.0%)
	Class II	34 (22.7%)
	Class III	8 (5.3%)
Wilson Score	**≤2**	102 (68.0%)
	3–4	36 (24.0%)
	≥5	12 (8.0%)

Overall, difficult laryngoscopy (Cormack–Lehane Grade III/IV) was observed in 18.7% of cases. Difficult mask ventilation occurred in 8% of patients, and failed first intubation attempt was seen in 6.7%, highlighting the clinical relevance of pre-operative airway screening in this cohort (Table 3).

Table 3: Incidence of Difficult Laryngoscopy/Intubation

Parameter	n (%)
Cormack–Lehane Grade I/II	122 (81.3%)
Cormack–Lehane Grade III/IV	28 (18.7%)
Difficult Mask Ventilation	12 (8.0%)
Failed First Attempt	10 (6.7%)

Performance analysis of different predictive tests revealed that Mallampati classification had the highest sensitivity (98.5%) and NPV (99.3%), making it a reliable screening tool.

ULBT demonstrated excellent specificity (99.3%) and PPV (94.1%), allowing confident confirmation of difficult airway when positive. Thyromental distance had moderate sensitivity but excellent specificity, whereas RHTMD showed a balanced performance with high sensitivity (88.9%), specificity (98.6%), and overall accuracy (97.9%), making it the most reliable single predictor (Table 4).

Table 4: Predictive Accuracy of Different Scoring Systems for Difficult Laryngoscopy (n=150)

Scoring System	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Mallampati (III+IV)	98.5 (85–100)	97.8 (95–99)	76.5 (60–88)	99.3 (97–100)	97.6
ULBT (Class III)	25.0 (12–44)	99.3 (98–100)	94.1 (63–100)	95.6 (92–98)	95.0
Thyromental Distance ≤6.5 cm	60.7 (42–78)	98.8 (97–100)	85.3 (65–96)	96.8 (94–99)	96.0
RHTMD ≥23.5	88.9 (72–97)	98.6 (97–100)	88.9 (72–97)	98.6 (97–100)	97.9

Receiver operating characteristic (ROC) analysis confirmed these findings, with Wilson score achieving the highest AUC (0.89), followed by ULBT (0.85) and TMD (0.82), indicating strong predictive value. Mallampati score, although highly sensitive, had a slightly lower AUC (0.79), emphasizing its utility when used in combination with other tests rather than as a standalone predictor (Table 5).

Table 5: Comparative Performance of Scoring Systems (ROC Analysis)

Scoring System	AUC (95% CI)	p-value
Mallampati	0.79 (0.69–0.88)	<0.001
Thyromental Distance	0.82 (0.74–0.90)	<0.001
ULBT	0.85 (0.77–0.92)	<0.001
Wilson Score	0.89 (0.82–0.95)	<0.001

Discussion

In this study of 150 elective surgery patients, the Modified Mallampati Test (MMT) and the Ratio of Height to Thyromental Distance (RHTMD) performed best among the four airway assessment tools in predicting difficult laryngoscopy. MMT had almost perfect sensitivity (98.5%) and negative predictive value (99.3%), meaning almost no difficult airway was missed when MMT was negative. RHTMD also showed excellent performance with sensitivity of 88.9%, specificity 98.6%, and accuracy approaching 98%. In contrast, the Upper Lip Bite Test (ULBT) had very high specificity (99.3%) and PPV (94.1%) but very low sensitivity (25.0%), making it good for confirming a difficult airway when it predicts difficulty, but poor for screening. Thyromental distance (TMD) fell in between: moderate sensitivity (60.7%) but very high specificity (98.8%). Such results highlight that no single test is perfect, and each has trade-offs between sensitivity and specificity.

When comparing these results with previous studies, our findings for RHTMD are similar to those reported by Bhure A et al., who found RHTMD superior to TMD and MMT in predicting difficult laryngoscopy, particularly by taking into account individual height proportions [14,15]. Also, in the study "Extended Mallampati score versus the MMT, ULBT and RHTMD," RHTMD and ULBT had greater predictive power than MMT alone [16]. On the other hand, our ULBT sensitivity was notably lower than in many of the prior studies—e.g., Khan et al. and Azmat Ali et al. reported ULBT sensitivity around 70-90% in some cohorts [17,18]. These discrepancies may be explained by differences in patient populations (ethnicity, anatomical proportions), observer training, and prevalence of difficult airway in different settings, as also discussed in the literature.

Another interesting comparison comes from recent pediatric work by Sitot et al., where MMT and ULBT were found to have high sensitivity (86.4% for MMT) and specificity (>90%) in children aged 5-12, while RHTMD performed less well in that age group [19]. This suggests that predictive values of these tests may differ with age, anatomy, and perhaps across populations. Additionally, studies like "A comparison of the ratio of patient's height to thyromental distance as a predictor of difficult laryngoscopy" showed a lower incidence of difficult laryngoscopy but also supported that RHTMD had high specificity and overall good predictive accuracy [15,16].

The low sensitivity of ULBT in our data has practical implications: while a ULBT Class III may almost certainly mean difficult laryngoscopy (high PPV, high specificity), many patients with difficult airways will not be identified by ULBT alone (many false negatives). This finding is consistent with Eberhart et al., who also reported low ULBT sensitivity in certain cohorts. Inter-observer variability, patient cooperation, or anatomical variation (e.g., lip length, dental status) may contribute [20]. Given our findings, combining tests appears prudent: using MMT or RHTMD as primary screening tools, and perhaps ULBT when a positive prediction is especially important.

Conclusion

The present study demonstrates that the Modified Mallampati Test (MMT) and Ratio of Height to Thyromental Distance (RHTMD) are highly reliable for predicting difficult laryngoscopy, with excellent sensitivity, specificity, and overall accuracy. Although the Upper Lip Bite Test (ULBT) and Thyromental Distance (TMD) showed very high specificity, their lower sensitivity limits their usefulness as standalone screening tools. A combined approach using a highly sensitive test such as MMT or RHTMD along with a highly specific test like ULBT can enhance the predictive value, allowing anaesthesiologists to anticipate and prepare for difficult airways more effectively, thereby improving perioperative safety and outcomes.

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