

Comparative Evaluation of Height-to-Thyromental Distance Ratio, Modified Mallampati Score, and Upper Lip Bite Test as Predictors of Difficult Laryngoscopy

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ABSTRACT

Introduction: Predicting difficult laryngoscopy is essential to prevent serious anaesthesia-related complications. Conventional tests like the Modified Mallampati score (MMS) and upper lip bite test (ULBT) have limitations, while the ratio of height to thyromental distance (RHTMD) offers a more objective, anthropometric approach. The aim of the study is to compare the predictive accuracy of RHTMD, MMS, and ULBT in identifying difficult laryngoscopy in patients undergoing elective surgery.

Material and Methods: This prospective observational study included 80 ASA I–III adult patients scheduled for elective surgeries under general anaesthesia. Preoperative airway assessments included MMS, ULBT, and RHTMD, with a cut-off value of ≥ 26 for RHTMD. After induction, direct laryngoscopy was performed, and the view was graded using the Cormack-Lehane (CL) system. Grades III and IV were classified as difficult laryngoscopy. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, and area under the curve (AUC) were calculated for each parameter using SPSS v28.

Results: The incidence of difficult laryngoscopy was 8.75%. MMS and ULBT both demonstrated 57.14% sensitivity, 97.26% specificity, 66.67% PPV, 95.95% NPV, and 93.75% accuracy. RHTMD ≥ 26 showed 71.43% sensitivity, 69.86% specificity, 18.52% PPV, 96.23% NPV, and 70% accuracy. The ROC-AUC for the composite predictive model was 0.737 ($p = 0.039$). CL grading achieved 100% diagnostic accuracy.

Conclusion: While MMS and ULBT offer high specificity, RHTMD provides better sensitivity. A combined approach improves preoperative prediction of difficult laryngoscopy and enhances airway safety.

Keywords: Difficult laryngoscopy, Mallampati score, Upper lip bite test, RHTMD, Airway management.

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INTRODUCTION

Airway management remains a cornerstone of anaesthesia practice, where failure to predict or manage a difficult laryngoscopy can lead to life-threatening complications such as hypoxia, brain injury, or cardiac arrest.¹ Reports suggest that 1.5 to 13% of patients undergoing general anaesthesia encounter difficult laryngoscopy, with up to 75% of anaesthesia-related cardiac arrests being airway-related, underscoring the need for reliable prediction tools in preoperative evaluation.¹⁻³ Traditionally, the modified Mallampati score (MMS) has served as a standard bedside test to assess airway difficulty by evaluating oropharyngeal structures.⁴ However, its predictive accuracy is hampered by significant interobserver variability and patient non-cooperation, especially in obese or elderly individuals.^{4,5} Another commonly used clinical tool, the upper lip bite test (ULBT), assesses mandibular mobility and dentition alignment. ULBT has shown better specificity and positive predictive value in several studies, yet its universal applicability remains limited.⁶⁻⁸ To overcome such limitations, researchers have introduced the height-to-thyromental distance ratio (RHTMD), a more objective tool that accounts for individual anthropometric variation by normalizing thyromental distance to patient height. This ratio reduces variability due to body size and neck extension, offering a population-adjusted predictive approach for difficult laryngoscopy.⁹⁻¹¹ RHTMD is particularly promising in ethnically diverse populations such as India, where facial dimensions and neck mobility vary widely.¹² Despite the widespread use of these tests, none of them has emerged as a universally superior predictor when used independently. Consequently, there is a growing consensus that combining predictors may improve diagnostic accuracy. However, few prospective studies have simultaneously compared RHTMD, MMS, and ULBT in a single population cohort.¹³⁻¹⁵ The aim of the study is to compare the predictive performance of MMS, ULBT, and RHTMD in patients undergoing elective surgery under general anaesthesia.

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MATERIAL AND METHODS

This prospective observational study was conducted over 18 months (May 1, 2023, to October 31, 2024) in the “Department of Anaesthesiology, Shri Ram Murti Smarak Institute of Medical Sciences, Bareilly”, following ethical clearance from the Institutional Ethics Committee. Written informed consent was obtained from all participants.

Patient Selection

Eighty adult patients (18–60 years) of either sex, belonging to the American Society of Anesthesiologists (ASA) physical status I–III, scheduled for elective surgery under general anaesthesia requiring endotracheal intubation, were enrolled. Patients were excluded if they had prior surgery, trauma, burns, or tumors involving the airway or craniofacial region; cervical spine disorders; restricted neck or jaw mobility; were edentulous; unable to sit upright; or required awake intubation.

Sample Size Calculation

Based on a previous study estimating the AUC of ULBT at 0.69, and aiming to detect a difference of 0.20 with 80% power and $\alpha = 0.05$, the calculated minimum sample size was 62. However, 80 patients were included to account for attrition and improve statistical power. The standard ROC-based formula was used for this estimation.

Study Procedure

Demographic details including age, sex, weight, height, and BMI were recorded. Airway assessment was performed preoperatively using three bedside tests:

Modified Mallampati Score (MMS)

Patients were asked to open their mouth fully and protrude the tongue without phonation. Oropharyngeal view was graded from class I to IV.

Height-to-Thyromental Distance Ratio (RHTMD)

With the head fully extended and mouth closed, thyromental distance was measured from the mentum to thyroid notch. RHTMD was calculated as height (cm) divided by TMD (cm). A ratio >23.5 was considered predictive of difficult laryngoscopy.

Upper Lip Bite Test (ULBT)

Patients were asked to bite their upper lip with lower incisors. The test was graded as:

- Class I: Upper lip mucosa completely covered
- Class II: Mucosa partially visible
- Class III: Unable to bite upper lip

Anaesthetic Technique and Laryngoscopy

Following standard monitoring, anaesthesia was induced

with thiopental sodium (4 mg/kg) and atracurium (0.6 mg/kg). Laryngoscopy was performed in the sniffing position using a Macintosh #4 blade without external pressure. Cormack–Lehane Grades I–II were considered easy, and Grades III–IV as difficult laryngoscopy.

Data Analysis

Data were analysed using SPSS v28. Continuous variables were expressed as mean $\pm$ SD or median (IQR), and categorical data as frequencies and percentages. Unpaired t-tests and chi-square/Fisher's tests compared groups. ROC analysis assessed AUC, sensitivity, specificity, PPV, and NPV. Significance was set at $p < 0.05$.

RESULTS

In our study, difficult laryngoscopy was more prevalent among patients aged 50 to 65 years (71.43%), whereas easy laryngoscopy was more common in the younger 20 to 35 years group (45.21%). However, the age-wise difference was not statistically significant ($p = 0.163$). Similarly, sex distribution and ASA class did not show any significant association with laryngoscopy difficulty, indicating that these demographic and preoperative variables are not reliable predictors of difficult laryngoscopy in this study population (See Table 1).

Mallampati class, ULBT, and laryngoscopic view showed a strong association with difficult laryngoscopy (all $p < 0.001$). Higher Mallampati grades (III and IV) and ULBT grade III were predominantly seen in difficult cases, whereas lower grades were more common in easy laryngoscopies. Notably, none of the difficult laryngoscopies had favorable laryngoscopic views (Grades I or II), while all had grades III or IV, underscoring the diagnostic utility of these airway assessment tools (Table 2).

A significant association ($p = 0.040$) was found between RHTMD ≥ 26 and difficult laryngoscopy, with 71.43% of difficult cases falling in this category. In contrast, most easy cases (69.86%) had an RHTMD < 26 , indicating that this metric can be a useful predictor for identifying potentially difficult airways (Table 3a).

RHTMD ≥ 26 demonstrated a sensitivity of 71.43% and specificity of 69.86% in predicting difficult laryngoscopy, with a notably high negative predictive value of 96.23%. This suggests that a low RHTMD is effective in ruling out difficult laryngoscopy, although its low positive predictive value (18.52%) limits its ability to definitively predict difficulty (Table 3b).

Among all parameters, laryngoscopic view had the highest diagnostic performance with 100% sensitivity, specificity, and accuracy. Mallampati and ULBT also showed high specificity (97.26%) and accuracy (93.75%) but

Table 1: Age group distribution and laryngoscopy difficulty

Variable	Category	Difficult (n = 7)		Easy (n = 73)		p-value
		Frequency	Percent	Frequency	Percent	
Age group	20–35 Years	1	14.29%	33	45.21%	0.163
	35–50 Years	1	14.29%	14	19.18%	
	50–65 Years	5	71.43%	26	35.62%	
	Total	7	100.00%	73	100.00%	
Sex	Female (F)	4	57.14%	40	54.79%	0.905
	Male (M)	3	42.86%	33	45.21%	
	Total	7	100.00%	73	100.00%	
ASA Class	I	3	42.86%	37	50.68%	0.692
	II	4	57.14%	36	49.32%	
	Total	7	100.00%	73	100.00%	

Test used: Chi-square test

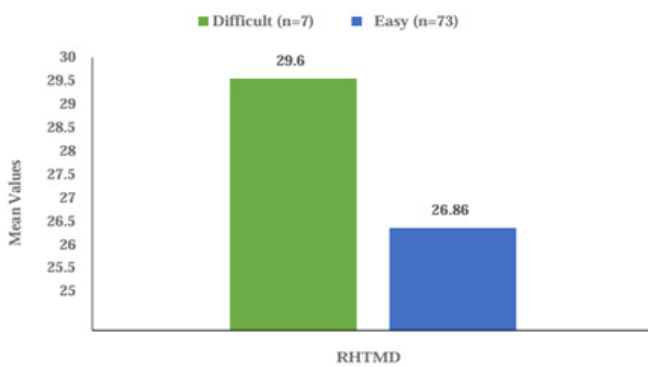


Figure 1: Compares the ratio of height to thyromental distance (RHTMD) between the difficult and easy laryngoscopy groups.

had moderate sensitivity (57.14%). RHTMD ≥ 26 had lower overall accuracy (70%) but a high NPV, making it more suitable for excluding rather than confirming difficult laryngoscopy. These findings support the combined use of multiple predictors for optimal preoperative airway assessment (Table 4).

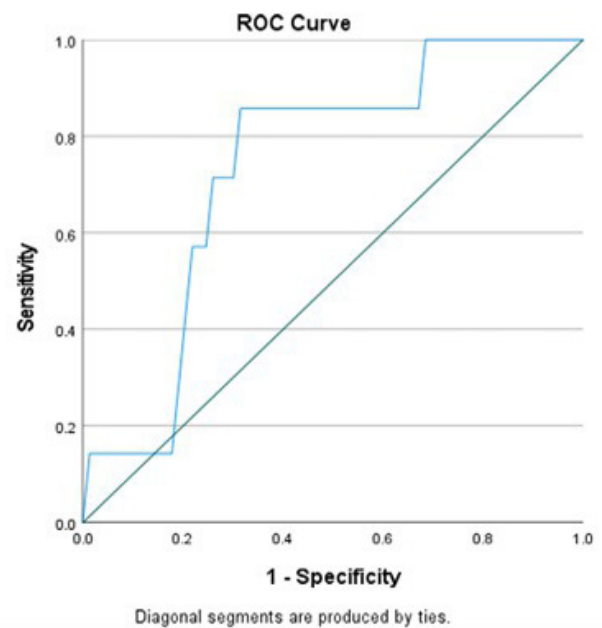


Figure 2: Area under the curve (AUC) for the predictive model evaluating laryngoscopy difficulty.

Table 2: Mallampati class, ULBT, and laryngoscopic view in relation to laryngoscopy difficulty

Variable	Category	Difficult (n=7)		Easy (n=73)		p-value
		Frequency	Percent	Frequency	Percent	
Mallampati class	I	1	14.29%	21	28.77%	<0.001*
	II	2	28.57%	50	68.49%	
	III	2	28.57%	2	2.74%	
	IV	2	28.57%	0	0.00%	
ULBT	I	1	14.29%	8	10.96%	<0.001*
	II	2	28.57%	63	86.30%	
	III	4	57.14%	2	2.74%	
Laryngoscopic view	I	0	0.00%	24	32.88%	<0.001*
	II	0	0.00%	49	67.12%	
	III	3	42.86%	0	0.00%	
	IV	4	57.14%	0	0.00%	

Test used: Chi-square test, * Statistically significant

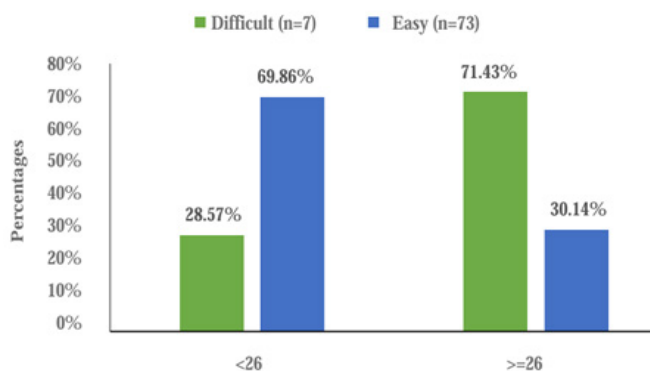
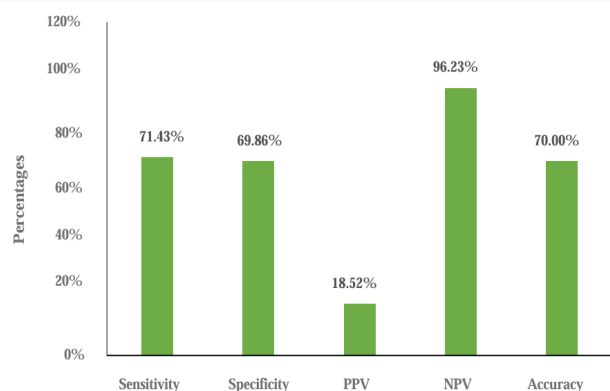
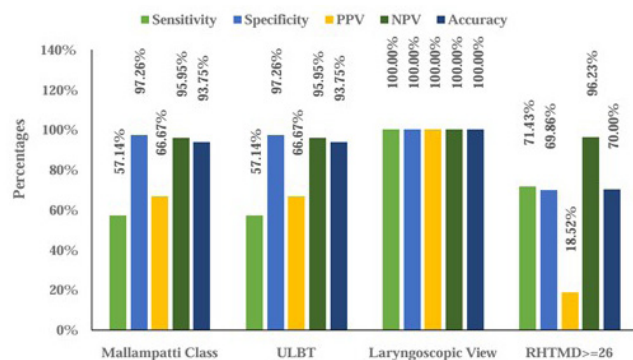
Table 3 (a): RHTMD and its predictive value for laryngoscopy difficulty

RHTMD	Difficult (n = 7)		Easy (n = 73)		p-value
	Frequency	Percent	Frequency	Percent	
<26	2	28.57%	51	69.86%	0.040*
≥26	5	71.43%	22	30.14%	
Total	7	100.00%	73	100.00%	

Test used: Chi-square test, * signifies significant p -value < 0.05

Table 3 (b): Diagnostic metrics for RHTMD ≥ 26

Metric	Value
Sensitivity	71.43%
Specificity	69.86%
Positive predictive value (PPV)	18.52%
Negative predictive value (NPV)	96.23%
Accuracy	70.00%

**Figure 3:** Comparison of the ratio of height to thyromental distance (RHTMD) between participants with difficult and easy laryngoscopy using a cutoff value of 26.**Figure 4:** Shows that the sensitivity of RHTMD ≥26 for predicting difficult laryngoscopy was 71.43%, with a specificity of 69.86%.**Figure 5:** Evaluates the diagnostic performance of the parameters for predicting difficult laryngoscopy

DISCUSSION

In this study, difficult laryngoscopy occurred predominantly in patients aged 50 to 65 years (71.43%), while easy laryngoscopy was more common among younger patients (20–35 years; 45.21%). Though notable, the association was not statistically significant ($p = 0.163$). This finding aligns with Kaniyil *et al.*¹⁶ and Safavi *et al.*¹⁷, who also observed higher age-related incidence without statistical significance. In contrast, Wang *et al.*¹⁸ reported a significant age-related increase in laryngoscopy difficulty, particularly in patients with reduced cervical mobility, suggesting that age-related anatomical changes may influence prediction.

Gender and ASA class also lacked significant association with difficult laryngoscopy ($p = 0.905$ and 0.692 , respectively), consistent with Safavi *et al.*¹⁷ and Bindra *et al.*¹⁹, who found sex and ASA status unrelated to airway difficulty. In contrast, Adnet *et al.*²⁰ noted that higher ASA class might correlate with increased intubation difficulty in emergency settings, indicating possible context-dependent relevance.

Modified Mallampati score (MMS) showed a statistically significant association ($p < 0.001$), with 57.14%

Table 4: Sensitivity, Specificity, and Accuracy of Predictive Parameters

Predictive parameter	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Mallampati class	57.14	97.26	66.67	95.95	93.75
ULBT	57.14	97.26	66.67	95.95	93.75
Laryngoscopic view	100.00	100.00	100.00	100.00	100.00
RHTMD ≥ 26	71.43	69.86	18.52	96.23	70.00

of difficult cases in Class III/IV. This mirrors findings by Shah *et al.*²¹ and Sinharay *et al.*,²² who highlighted MMS's moderate predictive value. In contrast, Bindra *et al.*¹⁹ found that MMS and EMS were unreliable in acromegalic patients due to altered anatomy, indicating population-specific limitations.

Upper lip bite test (ULBT) emerged as a strong predictor: 57.14% of difficult laryngoscopies were Class III, and 86.30% of easy cases were Class II ($p < 0.001$). This agrees with Safavi *et al.*¹⁷ (AUC 0.820) and Shah *et al.*²¹ (specificity 91.53%). In contrast, Tang *et al.*²³ found ULBT to be less predictive, reporting an AUC of 0.69 and Class III sensitivity of only 28%, suggesting diminished utility in broader surgical populations.

Cormack-Lehane (CL) grading perfectly aligned with laryngoscopy difficulty—100% of difficult cases were in Grades III/IV, and all easy cases in I/II. This supports its use as the gold standard, as noted by Safavi *et al.*¹⁷ and Kaniyil *et al.*¹⁶. In contrast, Koh *et al.*²⁴ reported a low incidence of CL Grades III–IV (1.8%) and emphasized the limited utility of anthropometric predictors over direct laryngoscopic view.

RHTMD ≥ 26 had significant correlation with difficult laryngoscopy ($p = 0.040$), showing sensitivity of 71.43% and NPV of 96.23%. Similar findings were reported by Shah *et al.*²¹ and Safavi *et al.*¹⁷ (AUC 0.845). In contrast, Koh *et al.*²⁴ found no significant predictive power in TMD or RHTMD, favoring CL grading instead. Tang *et al.*²³ also reported ULBT and mouth opening as more effective than RHTMD, indicating variability in predictive strength across populations.

The ROC curve in our study showed an AUC of 0.737 for RHTMD, indicating moderate discriminative power. This mirrors the values reported by Shah *et al.*²¹ and Safavi *et al.*¹⁷. In contrast, Carvalho *et al.*⁵ concluded that no single predictor offered sufficient accuracy alone, suggesting improved outcomes with multimodal approaches.

CONCLUSION

Modified Mallampati score and upper lip bite test are highly specific and reliable in predicting difficult laryngoscopy. While RHTMD showed good sensitivity, its predictive accuracy improved when combined with other assessments. Direct laryngoscopic grading (Cormack-Lehane) remains the gold standard. Implementing multiple assessment tools preoperatively enhances airway prediction and safety in anaesthesia. This approach can help minimize unforeseen intubation challenges during elective procedures.

ETHICAL APPROVAL

Obtained.

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