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Original Research Article

Evaluation of Different Airway Assessment Tests to Determine Difficult Intubation in Apparently Normal Adult Patients: A Prospective Observational Study

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Conflict of interest: Nil

Abstract:

Background: Difficult intubation remains a significant contributor to anaesthesia-related morbidity and mortality. Preoperative identification using bedside airway tests is essential for patient safety, yet no single test achieves perfect predictive accuracy.

Aim: To evaluate and compare six bedside airway assessment tests for predicting difficult intubation in apparently normal adult patients.

Materials and Methods: Prospective observational study at SMS Medical College, Jaipur. 83 ASA I–II adult patients undergoing elective surgery under GA were assessed using: Modified Mallampati Test with tongue protrusion (MMT-TP), MMT without tongue protrusion (MMT-NTP), Thyromental Distance (TMD), Sternomental Distance (SMD), Inter-Incisor Gap (IIG), and Modified Patil's Test/Upper Lip Bite Test (MPT/ULBT). Cormack-Lehane grading served as the gold standard.

Results: Mean age 38.63±13.62 years; M:F=3.15:1. Difficult intubation (CL Grade III/IV) occurred in 11/83 (13.25%). MPT/ULBT demonstrated the best overall performance: sensitivity 81.82%, highest specificity 95.83%, highest PPV 75.00%, NPV 97.18%, accuracy 93.98%, and AUC 88.83%. MMT-TP, MMT-NTP, and SMD showed comparable sensitivity (81.82%) and specificity (91.67%), with accuracy of 90.36% each. IIG showed 72.73% sensitivity and 93.06% specificity. TMD had the lowest sensitivity (63.64%) and AUC (77.65%). All tests had NPV >94%.

Conclusion: MPT/ULBT is the most reliable single predictor of difficult intubation with the highest accuracy (93.98%) and AUC (88.83%). However, no single test achieved perfect accuracy; a multimodal approach combining multiple tests is recommended for comprehensive preoperative airway evaluation.

Keywords: Difficult intubation; Airway assessment; Mallampati; Thyromental distance; Upper lip bite test; Cormack-Lehane; ROC curve; Sensitivity; Specificity.

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Introduction

Difficult airway management remains one of the most challenging and critical aspects of anaesthesiology practice. Failed intubation and "cannot intubate, cannot oxygenate" (CICO) scenarios are significant contributors to anaesthesia-related morbidity and mortality, accounting for approximately 25–30% of anaesthesia-related deaths and severe brain injuries. [1–3] The Fourth National Audit Project (NAP4) of the Royal College of Anaesthetists reported that inadequate preoperative airway assessment was a contributing factor in 40% of major airway complications. [4]

The reported incidence of difficult intubation in the general surgical population varies from 1.5–18% depending on the definition used, the population studied, and the experience of the operator. [5,6] The Cormack-Lehane classification system, which grades the laryngoscopic view during direct laryngoscopy, remains the most widely accepted gold standard for defining difficult intubation, with Grades III and IV considered difficult. [7,8]

Numerous bedside airway assessment tests have been developed to predict difficult intubation preoperatively. The Modified Mallampati Test

(MMT), initially described by Mallampati et al. [3] and modified by Samsoon and Young, [9] assesses the visibility of oropharyngeal structures. The thyromental distance (TMD) and sternomental distance (SMD) measure mandibular and neck anatomy. [10,11] The inter-incisor gap (IIG) evaluates mouth opening capacity. [12] The Upper Lip Bite Test (ULBT) or Modified Patil's Test (MPT) assesses mandibular protrusion and temporomandibular joint mobility. [13,14]

While individual tests have been extensively studied, comparative evaluation of multiple tests in the same population provides more meaningful clinical guidance. Manabe et al. [15] demonstrated that MMT without tongue protrusion may outperform the traditional version. El-Radaideh et al. [16] found MPT to have the highest diagnostic accuracy. Bhanushali et al. [17] introduced the Thyromental Height Test (TMHT) with 97.24% accuracy. However, head-to-head comparisons of six commonly used tests with ROC curve analysis from the Indian population remain limited. The present study was designed to evaluate and compare six bedside airway assessment tests for predicting difficult intubation in apparently normal adult patients undergoing elective surgeries at SMS Medical College, Jaipur.

Aim and Objectives

Aim: To evaluate different airway assessment tests to determine difficult intubation in apparently normal adult patients.

Objectives:

1. To assess the incidence of difficult intubation using Cormack-Lehane grading.
2. To evaluate the sensitivity, specificity, PPV, NPV, and diagnostic accuracy of six bedside airway tests.
3. To compare the diagnostic performance of all tests using ROC curve analysis.

Materials and Methods

Study Design: Prospective observational study at the Department of Anaesthesiology, SMS Medical College and Attached Group of Hospitals, Jaipur, Rajasthan, from January 2024 to December 2025. Approved by IEC, SMS Medical College. Consent obtained. Conducted per Declaration of Helsinki.

Participants: 83 consecutive ASA I–II adult patients (17–59 years) undergoing elective surgery under general anaesthesia with direct laryngoscopy. Exclusion: known difficult airway, cervical spine pathology, facial/airway anomalies, morbid obesity (BMI >40), emergency surgery.

Assessment: Six bedside airway tests performed preoperatively by a single trained observer blinded to subsequent laryngoscopy findings: (1) MMT-TP: Modified Mallampati with tongue protrusion (Class 1–4). (2) MMT-NTP: Modified Mallampati without tongue protrusion (Class 1–3). (3) TMD: Thyromental distance (Grade 1: >6.5 cm, Grade 2: 6.0–6.5 cm, Grade 3: <6.0 cm). (4) SMD: Sternomental distance (Grade 1: >13.5 cm, Grade 2: 12.5–13.5 cm, Grade 3: <12.5 cm). (5) IIG: Inter-incisor gap (Class A: ≥3 fingers, Class B: 2–3 fingers, Class C: <2 fingers). (6) MPT/ULBT: Upper Lip Bite Test (Class A/B/C).

Gold Standard: Cormack-Lehane grading during direct laryngoscopy (Macintosh blade). Grade I–II = Easy, Grade III–IV = Difficult intubation. Assessed by an anaesthesiologist blinded to preoperative test results.

Statistical Analysis: SPSS v26.0. Sensitivity, specificity, PPV, NPV, diagnostic accuracy from 2×2 contingency tables. ROC curve analysis with AUC comparison. Chi-square test for association. $p<0.05$ significant.

Results

Table 1: Baseline Demographics and Clinical Profile (N=83)

Parameter	Value	Range / %
Age (Mean ± SD)	38.63 ± 13.62 years	17–59 years
Male / Female	63 (75.90%) / 20 (24.10%)	M:F = 3.15:1
Weight (Mean ± SD)	70.18 ± 13.63 kg	45–103 kg
Height (Mean ± SD)	166.58 ± 7.15 cm	151–180 cm
BMI (Mean ± SD)	25.31 ± 4.88 kg/m²	17.60–37.90
ASA I / ASA II	44 (53.01%) / 39 (46.99%)	

Mean age 38.63 years, male predominance (75.90%), mean BMI 25.31 (normal-overweight range). Majority ASA I (53.01%).

Table 2: Cormack-Lehane Grade Distribution and Incidence of Difficult Intubation (N=83)

C-L Grade	n (%)	Classification
Grade I	44 (53.01%)	Easy
Grade II	28 (33.73%)	Easy
Grade III	07 (08.43%)	Difficult
Grade IV	04 (04.82%)	Difficult
Easy (I + II)	72 (86.75%)	
Difficult (III + IV)	11 (13.25%)	

Difficult intubation occurred in 11/83 patients (13.25%), consistent with reported incidence of 10–18% in general population. CL Grade I was most common (53.01%).

Figure 1: Cormack-Lehane Grade Distribution

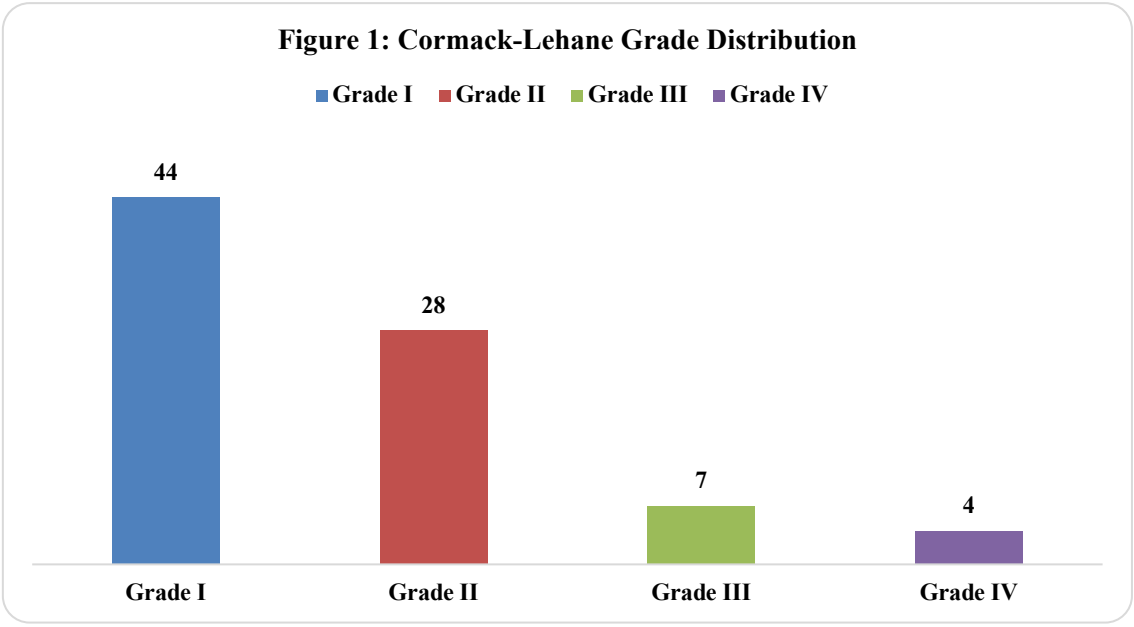


Table 3: Distribution of Airway Assessment Test Findings (N=83)

Test	Category	n (%)	Positive for Difficult
MMT-TP	Class 1	42 (50.60%)	
	Class 2	26 (31.33%)	
	Class 3–4	15 (18.07%)	Positive
MMT-NTP	Class 1	51 (61.45%)	
	Class 2	17 (20.48%)	
	Class 3	15 (18.07%)	Positive
TMD	Grade 1 (>6.5 cm)	36 (43.37%)	
	Grade 2 (6.0–6.5)	34 (40.96%)	
	Grade 3 (<6.0)	13 (15.66%)	Positive
SMD	Grade 1 (>13.5 cm)	44 (53.01%)	
	Grade 2 (12.5–13.5)	24 (28.92%)	
	Grade 3 (<12.5)	15 (18.07%)	Positive
IIG	Class A (≥3 fingers)	44 (53.01%)	
	Class B (2–3 fingers)	26 (31.33%)	
	Class C (<2 fingers)	13 (15.66%)	Positive
MPT/ULBT	Class A	46 (55.42%)	
	Class B	25 (30.12%)	
	Class C	12 (14.46%)	Positive

Test-positive rates ranged from 14.46% (MPT/ULBT) to 18.07% (MMT-TP, MMT-NTP, SMD), approximating the true difficult intubation rate of 13.25%.

Table 4: True Positive, True Negative, False Positive, and False Negative Values (N=83)

Test	TP	TN	FP	FN
MMT-TP	09	66	06	02
MMT-NTP	09	66	06	02
TMD	07	66	06	04
SMD	09	66	06	02
IIG	08	67	05	03
MPT/ULBT	09	69	03	02

MPT/ULBT had the lowest false positive rate (FP=3), indicating superior specificity. TMD had the highest false negative rate (FN=4), reflecting its lower sensitivity.

Table 5: Comparative Diagnostic Accuracy of All Airway Assessment Tests (N=83)

Test	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	AUC (%)
MMT-TP	81.82	91.67	60.00	97.06	90.36	86.74
MMT-NTP	81.82	91.67	60.00	97.06	90.36	86.74
TMD	63.64	91.67	53.85	94.29	87.95	77.65
SMD	81.82	91.67	60.00	97.06	90.36	86.74
IIG	72.73	93.06	61.54	95.71	90.36	82.89
MPT/ULBT	81.82	95.83	75.00	97.18	93.98	88.83

MPT/ULBT demonstrated the best overall diagnostic performance with the highest specificity (95.83%), PPV (75.00%), diagnostic accuracy (93.98%), and AUC (88.83%). TMD showed the lowest sensitivity (63.64%) and AUC (77.65%). All tests had NPV >94%, indicating excellent ability to rule out difficult intubation.

Figure 2: Sensitivity & Specificity

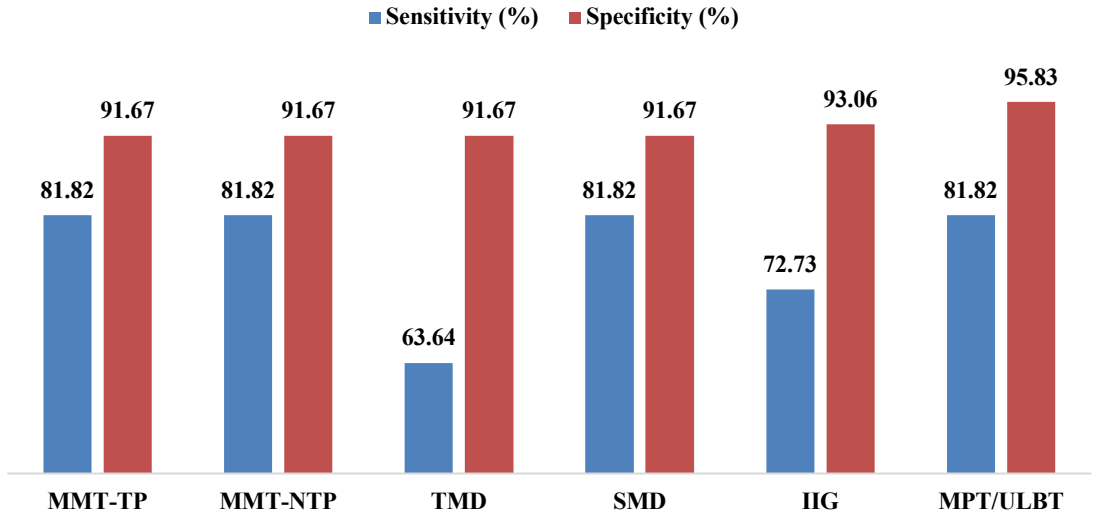


Table 6: ROC Curve Analysis — Area Under the Curve (N=83)

Test	AUC (%)	95% CI	p-value	Interpretation
MMT-TP	86.74	72.74–100.00	<0.01*	Good
MMT-NTP	86.74	72.74–100.00	<0.01*	Good
TMD	77.65	60.77–94.53	<0.01*	Fair
SMD	86.74	72.74–100.00	<0.01*	Good
IIG	82.89	67.46–98.33	<0.01*	Good
MPT/ULBT	88.83	75.77–100.00	<0.01*	Good

All tests demonstrated statistically significant discriminative ability (all p<0.01). MPT/ULBT had the highest AUC (88.83%), indicating best overall discrimination. TMD had the lowest AUC (77.65%, rated Fair). AUC interpretation: 0.9–1.0 = Excellent, 0.8–0.9 = Good, 0.7–0.8 = Fair.

Figure 3: AUC Comparison

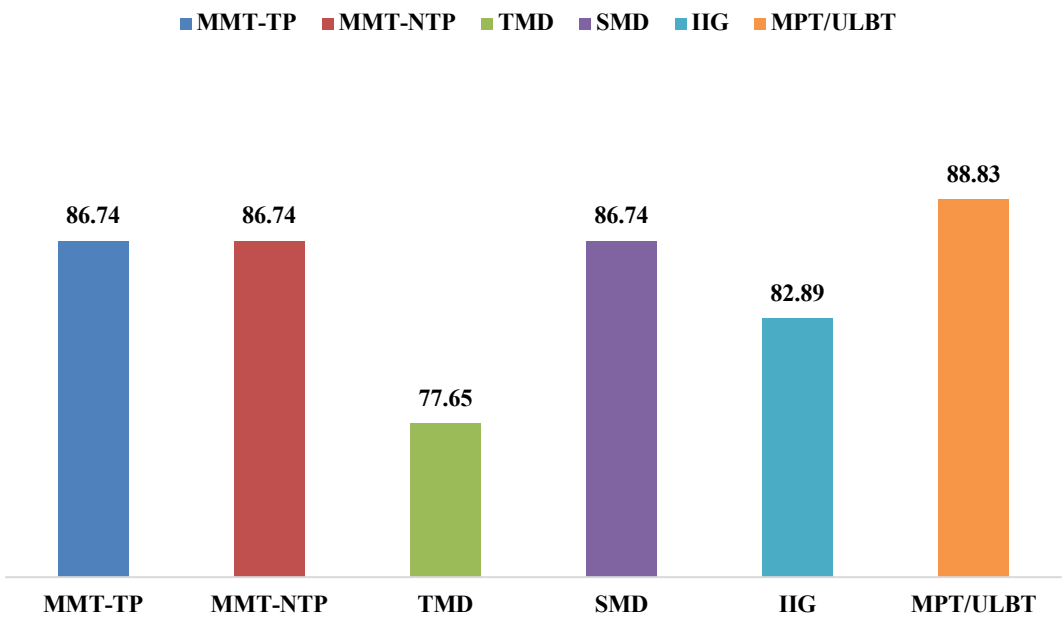
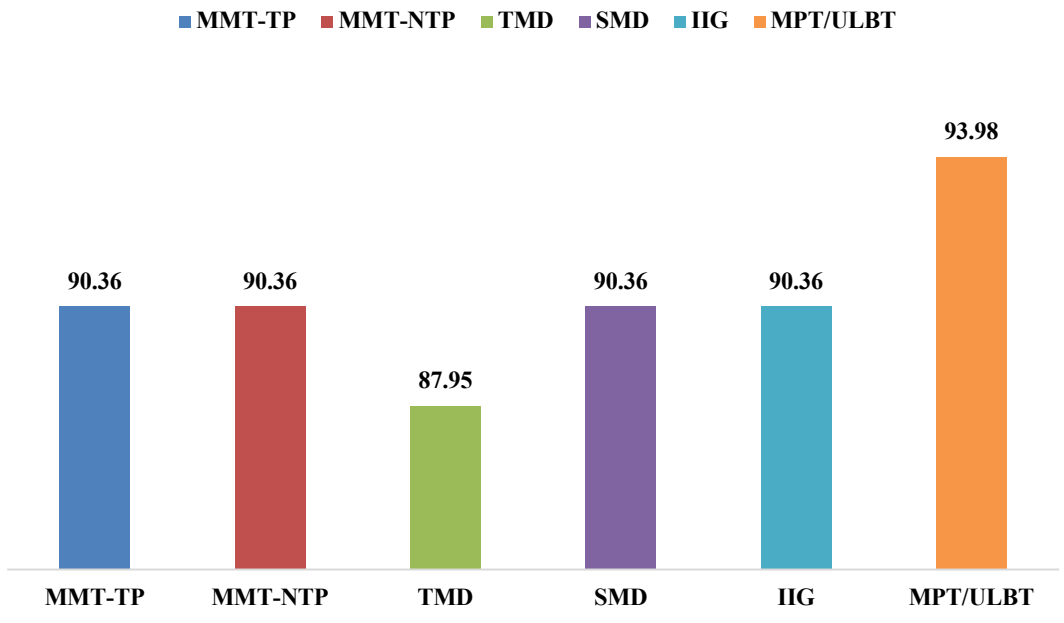


Figure 4: Diagnostic Accuracy



Discussion

The present prospective observational study evaluated six bedside airway assessment tests in 83 adult patients undergoing elective surgery under general anaesthesia at SMS Medical College, Jaipur. The incidence of difficult intubation was 13.25% (11/83), and the MPT/ULBT emerged as the most reliable single predictor with the highest accuracy (93.98%) and AUC (88.83%). All tests demonstrated high NPV (>94%), confirming their clinical utility in ruling out difficult intubation. These findings are discussed below.

Incidence of Difficult Intubation: The 13.25% incidence of difficult intubation in our study is concordant with Tamire et al. [18] (13.6% in Ethiopian patients) and Ashebir et al. [19] (13.4%). Dawood et al. [20] reported 12% in Iraqi patients. However, Savva [11] found only 4.9% and Khatiwada et al. [21] reported 3.8%, likely reflecting narrower definitions and different populations.

Modified Mallampati Test: MMT-TP sensitivity of 81.82% and specificity of 91.67% in our study is concordant with Khatiwada et al. [21] (83% sensitivity) and higher than Savva [11] (64.7% sensitivity, 66.1% specificity) and El-Radaideh et al. [16] (40% sensitivity). Dawood et al. [20] reported 66.67% sensitivity. The comparable performance of MMT-TP and MMT-NTP (identical values) contrasts with Manabe et al. [15] who found MMT-NTP superior. Our standardised assessment technique may explain this equivalence.

Thyromental and Sternomental Distance: TMD showed the lowest sensitivity (63.64%) among all tests, concordant with Savva [11] (64.7%) and Pathak et al. [22] (36.4% sensitivity, 100% specificity). Dawood et al. [20] reported 55.56% sensitivity for TMD. SMD demonstrated excellent performance (81.82% sensitivity, 91.67% specificity) concordant with Savva's landmark finding [11] (82.4% sensitivity, 88.6% specificity) that SMD ≤12.5 cm is the most reliable single screening tool. Prakash et al. [23] proposed sternomental displacement (SMDD) as an improved dynamic parameter (AUC 0.687 vs 0.66 for SMD).

Inter-Incisor Gap and MPT/ULBT: IIG sensitivity of 72.73% and specificity 93.06% contrasts with Savva [11] who found no significant association, but is concordant with Okiya [24] (IIG <3.5 cm significantly correlated with difficulty) and Tamire et al. [18] who recommended IIG in combination with other tests. MPT/ULBT emerged as the best single predictor in our study (accuracy 93.98%, AUC 88.83%), strongly concordant with El-Radaideh et al. [16] (highest accuracy 90.63%, specificity 95.17%, AUC 0.781). Ul Haq et al. [13] found LJP maneuver to have 95.9% sensitivity and 90.1% accuracy. Dawood et al. [20] found combining ULBT with MMT yielded the best results (88.89% sensitivity, 93.18% specificity).

Multimodal Assessment: No single test in our study achieved perfect accuracy, supporting the recommendation for multimodal assessment. Nelamangala et al. [25] demonstrated that combining MMT and TMD improved discriminative ability. Tamire et al. [18] found the combination of MMC, TMD, and IIG more effective than individual tests. Prakash et al. [23] achieved AUC 0.82 with multivariate models, higher than any single test. Bhanushali et al. [17] reported TMHT accuracy of 97.24%, outperforming both ULBT (86.23%) and MMT (81.65%), suggesting newer tests may further improve prediction.

Conclusion

Among six bedside airway assessment tests evaluated in 83 apparently normal adult patients, the MPT/ULBT demonstrated the best overall diagnostic performance with the highest specificity (95.83%), positive predictive value (75.00%), diagnostic accuracy (93.98%), and area under the ROC curve (88.83%). MMT-TP, MMT-NTP, and SMD showed comparable diagnostic accuracy (90.36% each) with good sensitivity (81.82%) and specificity (91.67%). IIG demonstrated 72.73% sensitivity with 93.06% specificity. TMD showed the lowest sensitivity (63.64%) and AUC (77.65%), suggesting limited standalone value. All tests exhibited high negative predictive values (>94%), confirming their utility in ruling out difficult intubation. No single test achieved perfect accuracy; therefore, a multimodal approach combining multiple bedside airway assessment tests—with MPT/ULBT as the cornerstone—is recommended for comprehensive preoperative airway evaluation to enhance patient safety.

Limitations

1. Sample size of 83 patients; larger studies needed for robust estimates.
2. Single-centre, single-observer design.
3. Newer parameters (TMHT, SMDD) not evaluated.
4. Combination of tests not systematically analysed.

Declarations

Ethics: Approved by IEC, SMS Medical College, Jaipur. Consent obtained. Helsinki guidelines followed.

Conflict of Interest: None.

Funding: None.

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