

Original article

The Prediction of Difficult Intubation in Elective Surgical Patients by Using Preoperative Bedside Airway Assessment Tools

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ABSTRACT

Background: Unexpected difficult tracheal intubation can delay oxygenation and increase perioperative harm. Bedside airway tests are widely used, but individual tests have inconsistent predictive performance. **Objective:** To evaluate commonly used preoperative bedside airway assessment tools for predicting difficult intubation in adults undergoing elective surgery. **Methods:** This cross-sectional diagnostic-accuracy study included 133 patients aged 18–65 years undergoing elective surgery under general anaesthesia at Social Security Hospital Lahore between December 2025 and April 2026. Modified Mallampati test (MMT), thyromental distance (TMD), inter-incisor gap (IIG), upper lip bite test (ULBT), LEMON score and atlanto-occipital extension (AOE) were assessed. Categorical data and reported diagnostic-performance measures were summarized using IBM SPSS Statistics version 27.0. **Results:** Nineteen patients (14.3%) screened positive by MMT, 15 (11.3%) by TMD, 31 (23.3%) by IIG, four (3.0%) by ULBT, 35 (26.3%) by LEMON and 13 (9.8%) by AOE. MMT had the highest reported sensitivity (66%), whereas LEMON had the highest reported specificity (77%). TMD showed the lowest sensitivity (10%); IIG, ULBT and AOE each had sensitivity of 20%. **Conclusion:** The tests showed heterogeneous performance, and no single bedside assessment provided consistently strong discrimination. MMT was the most sensitive and LEMON the most specific within the reported analysis; multimodal assessment should be considered clinically, while locally validated combination rules require further study. **Keywords:** Airway management, Difficult airway, Difficult intubation, Laryngoscopy, Mallampati test, Diagnostic accuracy

EDITORIAL INFORMATION

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INTRODUCTION

Airway assessment is a fundamental component of safe anaesthetic practice, as induction of general anaesthesia reduces upper-airway muscle tone and protective reflexes, while unsuccessful or repeated tracheal-intubation attempts may result in hypoxaemia, airway trauma, aspiration, haemodynamic instability and cardiac arrest (1–4). Failure to anticipate a difficult airway can lead to serious complications, emphasizing the importance of comprehensive preoperative evaluation. Contemporary difficult-airway guidelines recommend systematic assessment, advance planning, maintenance of oxygenation and timely availability of alternative airway devices and experienced assistance (1,3,4). Although difficult airway, difficult laryngoscopy and difficult tracheal intubation are closely related, they represent distinct clinical outcomes that should be clearly defined when evaluating diagnostic tests (1,5).

Several bedside airway assessment methods are routinely employed because they are simple, inexpensive, non-invasive and readily available. Commonly used tests include the modified Mallampati test (MMT), thyromental distance (TMD), inter-incisor gap (IIG), upper lip bite test (ULBT) and cervical-spine mobility assessment (5–12). The Mallampati classification evaluates oropharyngeal visibility, TMD reflects the available mandibular space, IIG measures mouth opening, and ULBT assesses mandibular

protrusion. Atlanto-occipital extension (AOE) evaluates neck mobility, which contributes to appropriate positioning during direct laryngoscopy (8–14). Anatomical limitations identified through these assessments may increase the likelihood of difficult airway management.

Despite their widespread use, individual bedside tests demonstrate variable diagnostic accuracy. Sensitivity indicates the ability of a test to identify patients with difficult airways, whereas specificity reflects its ability to correctly identify patients without airway difficulty. Systematic reviews have demonstrated that individual predictors generally have limited sensitivity and variable specificity, influenced by patient characteristics, examiner experience, measurement techniques and diagnostic thresholds (5–7,18). Consequently, negative findings on a poorly sensitive test cannot reliably exclude difficult intubation. These limitations emphasize the importance of interpreting bedside findings collectively rather than relying on a single predictor.

Composite assessment tools, including the EI-Ganzouri risk index and LEMON assessment, have been developed to improve prediction by combining multiple anatomical and clinical characteristics (15–17). The LEMON approach evaluates external anatomical features, the 3-3-2 assessment, Mallampati classification, airway obstruction and neck mobility. Although combining complementary predictors may improve clinical risk assessment, diagnostic performance varies across populations, and composite tools require appropriate validation before their superiority can be established (5–7,15).

Previous studies involving elective surgical patients have identified associations between difficult laryngoscopy or intubation and higher Mallampati grades, reduced thyromental distance, limited mouth opening and restricted neck extension (18–24). However, differences in patient demographics, anatomical characteristics, airway equipment and operator experience contribute to variations in reported sensitivity and specificity. No single bedside assessment has consistently demonstrated sufficient accuracy to independently predict difficult airway outcomes. Therefore, locally generated evidence is important, particularly in healthcare settings where resources and airway-management practices may differ.

The present study was conducted at Social Security Hospital Lahore to evaluate and compare the diagnostic performance of six bedside airway assessment methods among adult patients undergoing elective surgery. Specifically, it assessed the sensitivity and specificity of MMT, TMD, IIG, ULBT, LEMON and AOE in predicting airway difficulty. The findings aim to identify the relative strengths and limitations of these tests and support more effective preoperative airway assessment, appropriate clinical preparation and improved patient safety.

MATERIALS AND METHODS

A cross-sectional diagnostic-accuracy study was conducted at Social Security Hospital Lahore between December 2025 and April 2026. A convenience sample of 133 adults aged 18–65 years scheduled for elective surgery under general anaesthesia with tracheal intubation was included. Patients with an airway or neck mass, restricted neck or jaw movement, inability to sit for assessment, or facial trauma were excluded. The target sample was based on an anticipated difficult-airway prevalence of 10%, 95% confidence level and 5% absolute precision. Before anaesthesia, participants underwent MMT, TMD, IIG, ULBT, LEMON and AOE assessment using the study data-collection form. Test categories were dichotomized according to the study protocol for comparison with the documented intubation outcome. Data were analysed using IBM SPSS Statistics version 27.0. Categorical variables were summarized as frequency and percentage; sensitivity, specificity and reported overall test performance were calculated for each bedside assessment. Because participant-level contingency data were unavailable for secondary verification, only internally interpretable sensitivity and specificity estimates were retained in the comparative analysis. The study was conducted in accordance with the ethical requirements of Institutional Review Board of the University of Lahore (Ref. No.: DRC/DHPT024/12/25) and permission was obtained from the participating hospitals before data collection. Participation was voluntary, written informed consent was obtained from all participants, and confidentiality of participant information was maintained throughout data collection and analysis.

RESULTS

All 133 enrolled participants were included in the descriptive analysis. Most were aged 31–40 years (56, 42.1%), followed by 18–30 years (33, 24.8%), 41–50 years (25, 18.8%) and 51–65 years (19, 14.3%). Men comprised 80 (60.2%) participants and women 53 (39.8%). ASA physical status was Grade I in 51 (38.3%), Grade II in 48 (36.1%) and Grade III in 34 (25.6%) participants (Table 1).

Across the bedside assessments, the proportion screening positive for anticipated airway difficulty varied from 3.0% with ULBT to 26.3% with LEMON. Positive findings were recorded in 19 (14.3%) participants by MMT, 15 (11.3%) by TMD, 31 (23.3%) by IIG, 35 (26.3%) by LEMON and 13 (9.8%) by AOE (Table 2). These figures represent screening classifications rather than the confirmed prevalence of difficult intubation.

MMT had the highest reported sensitivity (66%), followed by LEMON (33%); TMD had the lowest sensitivity (10%). Reported specificity ranged from 67% for IIG to 77% for LEMON. Thus, MMT identified the greatest proportion of difficult cases in the reported analysis, whereas LEMON produced the highest proportion of negative results among cases without the outcome. No single test combined high sensitivity with high specificity (Table 3 and Figure 1).

Table 1. Demographic and clinical characteristics of participants

Characteristic	Category	n (%)
Age, years	18–30	33 (24.8)
	31–40	56 (42.1)
	41–50	25 (18.8)
	51–65	19 (14.3)
Sex	Male	80 (60.2)
	Female	53 (39.8)
ASA physical status	I	51 (38.3)
	II	48 (36.1)
	III	34 (25.6)

ASA, American Society of Anesthesiologists; SD, standard deviation.

Table 2. Distribution of bedside airway assessment findings

Assessment	Category	n (%)
Modified Mallampati test	Class I	99 (74.4)
	Class II	15 (11.3)
	Class III	16 (12.0)
	Class IV	3 (2.3)
Thyromental distance	Class I	118 (88.7)
	Class II	11 (8.3)
	Class III	4 (3.0)
Inter-incisor gap	Class I	102 (76.7)
	Class II	31 (23.3)
Upper lip bite test	Class I	91 (68.4)
	Class II	38 (28.6)
	Class III	4 (3.0)
LEMON assessment	0/10	98 (73.7)
	>0/10	35 (26.3)
Atlanto-occipital extension	Grades I–II	120 (90.2)
	Grades III–IV	13 (9.8)

Among the 133 patients assessed, the majority demonstrated favorable bedside airway assessment findings. Modified Mallampati Class I was observed in 74.4% of patients, while 14.3% were classified as Class III or IV. Similarly, 88.7% had Class I thyromental distance, 76.7% had Class I inter-incisor gap, and 68.4% had Class I upper lip bite test findings. The LEMON assessment showed a score of 0/10 in 73.7% of patients, whereas 26.3% had a score greater than zero, indicating the presence of at least one potential difficult airway predictor. Furthermore, 90.2% exhibited Grades I–II atlanto-occipital

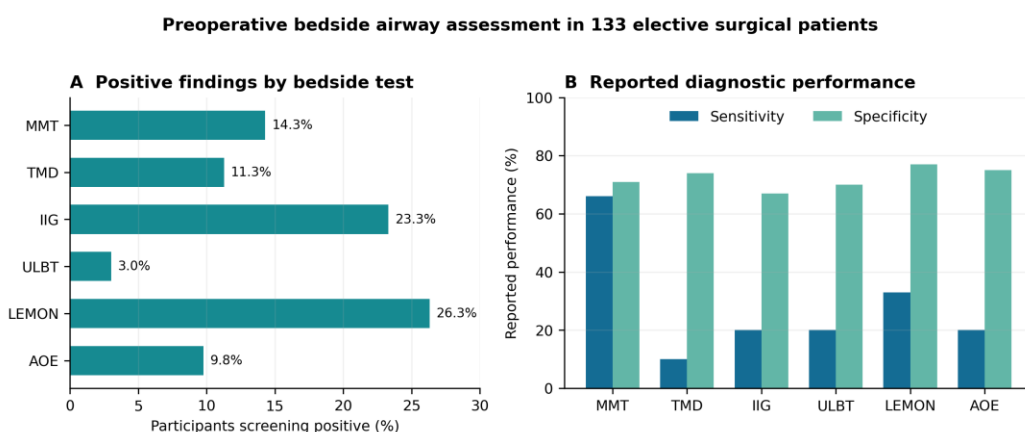
extension, while 9.8% had Grades III–IV. Overall, these findings suggest that most patients had favorable anatomical airway characteristics, although a smaller proportion demonstrated features potentially associated with difficult airway management.

Table 3. Reported performance of bedside tests for predicting difficult intubation

Test	Sensitivity (%)	Specificity (%)
MMT	66	71
TMD	10	74
IIG	20	67
ULBT	20	70
LEMON	33	77
AOE	20	75

Among the six bedside airway assessment tests, the Modified Mallampati Test (MMT) demonstrated the highest sensitivity (66%) with a specificity of 71%, indicating comparatively better ability to identify patients with difficult airways. The LEMON assessment showed the highest specificity (77%), followed by atlanto-occipital extension (AOE) at 75% and thyromental distance (TMD) at 74%. However, TMD demonstrated the lowest sensitivity (10%), while inter-incisor gap (IIG), upper lip bite test (ULBT), and AOE each exhibited a sensitivity of 20%. Overall, MMT showed the best sensitivity among the evaluated tests, whereas LEMON demonstrated the highest specificity. These findings suggest that no single bedside assessment test provided both high sensitivity and specificity, highlighting the importance of a comprehensive airway assessment rather than reliance on an individual test.

Figure 1. Distribution and reported diagnostic performance of preoperative bedside airway assessments.



Positive screening findings ranged from 3.0% for ULBT to 26.3% for LEMON. MMT provided the highest reported sensitivity (66%), while LEMON provided the highest specificity (77%). The wide separation between sensitivity and specificity across tests demonstrates that a positive screening prevalence does not itself establish diagnostic performance and that none of the evaluated tools was an adequate standalone screen.

DISCUSSION

This study compared six bedside airway assessments in 133 adults undergoing elective surgery. The principal finding was heterogeneous diagnostic performance: MMT had the highest reported sensitivity, whereas LEMON had the highest specificity. TMD, IIG, ULBT and AOE had low reported sensitivity, indicating that their use in isolation could miss a substantial proportion of difficult cases. Conversely, the modest specificity of all tests implies that positive findings require clinical interpretation rather than automatic classification as difficult intubation.

The relative performance of MMT is consistent with its widespread use, but systematic reviews show that Mallampati classification alone has limited ability to exclude difficult laryngoscopy or intubation (5–7). Its performance may vary with phonation, patient posture, head position and examiner interpretation (8,9). Higher Mallampati classes indicate reduced visibility of oropharyngeal structures, yet the

anatomical relationship with glottic exposure is indirect. These factors may explain why MMT was more sensitive than the other tests in this sample while retaining only moderate specificity.

TMD and IIG showed low sensitivity in the present analysis. Both tests capture a single anatomical dimension and may fail to represent the combined effects of mandibular space, tissue compliance, cervical movement and laryngoscope positioning (7,10,11,18). Previous observational studies and multivariable models have similarly shown that single measurements are less reliable than integrated clinical assessment (15,18–22). In addition, dichotomization at different thresholds across studies contributes to variation in reported accuracy.

LEMON had the highest reported specificity and the largest proportion of positive screening results. As a composite examination it incorporates several potential determinants of airway difficulty, but its original emphasis on rapid airway evaluation and variation in scoring limit direct comparison with elective-surgery studies (16,17). The threshold of any score above zero used in this dataset is particularly inclusive and should be validated before routine adoption. ULBT evaluates mandibular protrusion and dentition and has shown useful specificity in some studies, but its low sensitivity here reinforces the need to interpret it alongside other findings (12,13,23).

These results support a structured, multimodal preoperative assessment rather than reliance on one bedside test. Such assessment should inform preparation, availability of alternative airway devices and timely involvement of experienced clinicians, consistent with contemporary airway-management guidance (1,3,4). However, this study did not validate a prespecified combined score, so superiority of a particular combination cannot be concluded.

The study assessed several inexpensive tests in a consistent elective clinical setting and included a complete descriptive sample. Limitations include its single-center convenience sample, exclusion of some patients with obvious anatomical risk, limited sample size, potentially small number of difficult cases, and absence of participant-level contingency data for independent verification of diagnostic estimates. Confidence intervals and predictive values could not be reconstructed from the available aggregate results. Examiner variability, operator experience and the precise reference-outcome definition may also affect performance and limit generalizability. Future prospective studies should use blinded assessment, prespecified thresholds, complete 2×2 reporting and external validation in larger multicenter cohorts (25–28).

CONCLUSION

Preoperative bedside airway tests showed variable ability to predict difficult intubation in elective surgical patients. MMT had the highest reported sensitivity and LEMON the highest reported specificity, whereas the remaining tests performed poorly as standalone screening tools. These findings favor structured interpretation of multiple clinical features, but a specific combined prediction rule requires prospective validation before clinical implementation.

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