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Original Research Article

Prediction of Difficult Intubation Using Modified Mallampati Test in Sitting and Supine Positions in Adults: A Prospective Observational Comparative Study

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Abstract

Background: Preoperative prediction of difficult tracheal intubation remains a cornerstone of safe anaesthetic practice. The Modified Mallampati Test (MMT) is one of the most frequently used bedside airway assessment tools and is conventionally performed with the patient in the sitting position. However, a substantial proportion of surgical patients, including those with trauma, obesity, spinal disorders, or critical illness, are unable to maintain an upright posture. Consequently, airway assessment in the supine position has been proposed as a practical alternative. Evidence comparing the predictive performance of sitting and supine MMT remains limited, with conflicting conclusions regarding their diagnostic utility.

Objective: To evaluate the correlation between Modified Mallampati grading performed in sitting and supine positions with Cormack–Lehane (CL) laryngoscopic grading and to compare the diagnostic performance of both methods for predicting difficult tracheal intubation.

Methods: This prospective observational comparative study included 100 adult patients aged 18–65 years undergoing elective surgery under general anaesthesia requiring endotracheal intubation. Modified Mallampati classification was assessed preoperatively in both sitting and supine positions using the Samsoon and Young modification. Direct laryngoscopy was performed after induction of anaesthesia by an independent anaesthesiologist blinded to the Mallampati grading, and the laryngeal view was classified according to the Cormack–Lehane system. Diagnostic indices including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), diagnostic accuracy, and receiver operating characteristic (ROC) analysis were calculated.

Results: The study population had a mean age of 39.5 ± 11.2 years, with 60 males and 40 females. Supine MMT demonstrated a greater proportion of Class III and IV airways and showed a stronger correlation with difficult laryngoscopy (CL Grades III and IV). Compared with the sitting position, supine MMT exhibited markedly higher sensitivity (97.5%) and NPV (97.9%), whereas sitting MMT demonstrated greater specificity (89.1%), PPV (58.9%), and overall diagnostic accuracy (76% vs. 72%). Both methods demonstrated satisfactory predictive performance, although each provided distinct diagnostic advantages.

Conclusion: Modified Mallampati assessment performed in both sitting and supine positions is clinically useful for preoperative airway evaluation. Supine assessment improves the identification of patients at risk for difficult laryngoscopy, whereas sitting assessment provides greater specificity in confirming difficult airways. Incorporating both positions into routine airway evaluation may improve diagnostic confidence and perioperative preparedness.

Keywords: Airway Assessment; Difficult Intubation; Cormack–Lehane Grading; Modified Mallampati Test; Supine Position.

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Introduction

Securing the airway safely is one of the fundamental responsibilities of the anaesthesiologist, and failure to anticipate a difficult airway continues to be an important cause of perioperative morbidity and mortality. Despite advances in airway devices, videolaryngoscopy, and difficult airway management algorithms, unexpected difficult laryngoscopy and tracheal intubation remain major contributors to anaesthesia-related complications. Failure to identify patients with potentially difficult airways may result in repeated intubation attempts, airway trauma, hypoxaemia, aspiration, haemodynamic instability, and, in severe cases, catastrophic neurological injury or death. Consequently, accurate preoperative airway assessment remains an indispensable component of modern anaesthetic practice. [1,2]

Several bedside clinical tests have been proposed to predict difficult laryngoscopy, including the Modified Mallampati Test (MMT), thyromental distance, sternomental distance, upper lip bite test, inter-incisor distance, neck circumference, and composite airway scoring systems. Among these, the Modified Mallampati Test remains one of the most widely accepted because it is rapid, inexpensive, non-invasive, and requires no specialised equipment. Since its modification by Samsoon and Young, the test has been routinely incorporated into pre-anaesthetic evaluation worldwide. Despite its widespread use, however, its reported sensitivity and specificity vary considerably across different patient populations, indicating that no single bedside test can reliably predict all difficult airways. [3,4]

Conventionally, the Modified Mallampati Test is performed with the patient seated upright, the head maintained in a neutral position, the mouth fully opened, and the tongue maximally protruded without phonation.

This position allows assessment of the visibility of the faucial pillars, soft palate, uvula, and hard palate, which are subsequently classified into four Mallampati classes. Increasing Mallampati grades are generally associated with progressively difficult laryngoscopic views. Nevertheless, performing the examination in the sitting position is not always feasible. Patients presenting with lower limb fractures, spinal injuries, obesity, severe pain, neurological disorders, pregnancy, or critical illness may be unable to sit comfortably, limiting the applicability of the conventional technique in routine clinical practice. [4,5]

In recent years, investigators have explored whether performing the Modified Mallampati Test in the supine position could improve its predictive value. Alterations in gravitational forces acting on the tongue and soft tissues of the upper airway while lying supine may produce airway characteristics that more closely resemble those encountered during induction of general anaesthesia. Several studies have suggested that supine Mallampati grading identifies a larger proportion of higher airway classes and demonstrates improved sensitivity for predicting difficult laryngoscopy.

Conversely, other investigators have reported that the traditional sitting position maintains superior specificity and overall diagnostic accuracy. These conflicting findings indicate that further comparative evaluation is warranted before recommending changes to routine airway assessment protocols. [5-7]

Direct laryngoscopy remains the clinical reference standard for assessing airway difficulty, and the Cormack–Lehane (CL) grading system continues to be the most widely accepted method for describing the laryngeal view during intubation. Correlating Modified Mallampati classification obtained in different patient positions with CL grading provides clinically meaningful evidence regarding the diagnostic performance of each assessment technique. Such comparisons may help determine whether positional modification of the Mallampati test offers additional value during routine preoperative evaluation. [8]

The present prospective observational comparative study was therefore undertaken to compare Modified Mallampati grading performed in sitting and supine positions among adult patients undergoing elective surgery under general anaesthesia. The study further evaluated the correlation of both assessments with Cormack–Lehane laryngoscopic grading and compared their diagnostic performance using measures including sensitivity, specificity, predictive values, overall accuracy, and receiver operating characteristic analysis. The findings of this study may contribute to improving preoperative airway assessment strategies and facilitate safer airway management in patients undergoing general anaesthesia.

Materials and Methods

This prospective observational comparative study was conducted in the Department of Anaesthesiology, People's College of Medical Sciences and Research Centre, People's University, Bhopal, after obtaining approval from the Institutional Ethics Committee. The study was carried out in accordance with the ethical principles of the Declaration of Helsinki, and written informed consent was obtained from all participants prior to enrolment.

A total of 100 adult patients scheduled to undergo elective surgical procedures under general anaesthesia requiring oral endotracheal intubation

were consecutively recruited. Patients aged between 18 and 65 years belonging to the American Society of Anesthesiologists (ASA) physical status I or II were considered eligible for inclusion. Patients with anticipated difficult airway, inability to maintain the sitting position during preoperative airway assessment, pregnancy, previous head and neck surgery resulting in altered airway anatomy, craniofacial abnormalities, restricted mouth opening, cervical spine pathology limiting neck movements, or refusal to participate were excluded from the study.

A detailed pre-anaesthetic evaluation was performed for all participants on the day preceding surgery or on the day of surgery before induction of anaesthesia. Demographic variables including age, sex, height, weight, and body mass index (BMI) were recorded. Relevant medical history and ASA physical status were also documented.

Preoperative airway assessment was performed using the Samsoon and Young modification of the Mallampati classification. All assessments were carried out under standardized conditions in a well-illuminated environment by an experienced anaesthesiologist who was not involved in subsequent laryngoscopy.

Patients were instructed to sit upright with the head in a neutral position, open the mouth as widely as possible, and protrude the tongue maximally without phonation. Based on the visibility of the faucial pillars, soft palate, uvula, and hard palate, the Modified Mallampati grade was recorded.

Following completion of the sitting assessment, each participant underwent a second airway examination in the supine position. The patient was positioned flat on the operating table without a pillow, maintaining the head in a neutral position. The same instructions regarding maximal mouth opening and tongue protrusion without phonation were repeated, and the Modified Mallampati grade was documented independently. Both airway assessments were performed using identical examination techniques to minimise measurement variability. The grading obtained in one position was not disclosed during assessment in the alternate position.

All patients received standard fasting instructions according to institutional protocol. On arrival in the operating theatre, routine monitoring comprising electrocardiography, non-invasive blood pressure measurement, pulse oximetry, and heart rate monitoring was instituted. Intravenous access was secured, and patients were preoxygenated with 100% oxygen before induction of anaesthesia.

General anaesthesia was induced using the departmental standard induction protocol. After confirming adequate mask ventilation, neuromuscular blockade was achieved with an appropriate muscle relaxant to facilitate endotracheal intubation. Direct laryngoscopy was subsequently performed using an appropriately sized Macintosh laryngoscope blade by an experienced consultant anaesthesiologist who remained blinded to the Modified Mallampati grading recorded during the preoperative assessment.

The laryngoscopic view obtained during the first attempt at direct laryngoscopy was graded according to the Cormack–Lehane classification. Grade I represented complete visualization of the glottis, Grade II partial visualization of the glottis, Grade III visualization of the epiglottis without exposure of the glottis, and Grade IV inability to visualize either the glottis or epiglottis. Cormack–Lehane Grades III and IV were considered indicative of difficult laryngoscopy and served as the reference standard for evaluating the predictive performance of the Modified Mallampati Test.

To minimise observer bias, the anaesthesiologist performing laryngoscopy was unaware of the Mallampati grades assigned in either position. Similarly, the investigator responsible for preoperative airway assessment did not participate in laryngoscopy or subsequent data analysis. All observations were entered into a predesigned case record form immediately after assessment. The primary outcome measure was the correlation between Modified Mallampati classification performed in the sitting and supine positions with the corresponding Cormack–Lehane grading observed during direct laryngoscopy. Secondary outcome measures included comparison of the diagnostic performance of both positions by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), diagnostic accuracy, and receiver operating characteristic (ROC) curve analysis for prediction of difficult laryngoscopy.

Statistical analysis was performed using IBM SPSS Statistics software (Version 26.0; IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), whereas categorical variables were presented as frequencies and percentages. The association between Modified Mallampati classification and Cormack–Lehane grading was analysed using the Chi-square test or Fisher's exact test whenever appropriate. Diagnostic indices, including sensitivity, specificity, PPV, NPV, overall accuracy, and area under the ROC curve (AUC), were calculated for both sitting and supine Modified Mallampati assessments. A two-tailed P value of less than 0.05 was considered statistically significant.

Results

A total of 100 adult patients scheduled for elective surgery under general anaesthesia requiring endotracheal intubation were enrolled in the study. All recruited participants completed the study protocol and were included in the final analysis. The demographic and baseline characteristics of the study population are presented in Table 1. The mean age of the participants was 39.5 ± 11.2 years (range: 18–65 years). The study population comprised 60 (60%) males and 40 (40%) females, with a male-to-female ratio of 1.5:1. The mean body mass index (BMI) was 24.3 ± 3.0 kg/m², indicating that most participants were within the normal to overweight range.

Table 1: Baseline characteristics of the study population

Variable	Value
Age (years), mean ± SD	39.5 ± 11.2
Male, n (%)	60 (60.0)
Female, n (%)	40 (40.0)
Body mass index (kg/m²), mean ± SD	24.3 ± 3.0

The distribution of Modified Mallampati grades obtained in sitting and supine positions with corresponding Cormack–Lehane grades is shown in Table 2. Patients assessed in the supine position demonstrated a greater proportion of Mallampati Class III and IV airways compared with those assessed in the sitting position. Higher Mallampati grades in the supine position were associated with an increased frequency of difficult laryngoscopy (Cormack–Lehane Grades III and IV). A statistically significant association was observed between Modified Mallampati classification and Cormack–Lehane grading in both positions (P<0.001).

Table 2: Correlation of Modified Mallampati classification in sitting and supine positions with Cormack–Lehane grading

Modified Mallampati Class	CL I	CL IIa	CL IIb	CL III	CL IV	Total
Sitting position						
I	27	5	2	0	0	34
II	12	21	11	3	0	47
III	3	5	6	3	1	18
IV	0	0	0	1	0	1
Supine position						
I	11	0	0	0	0	11
II	23	12	1	0	0	36
III	8	17	15	3	0	43
IV	0	2	3	4	1	10
Total	42	31	19	7	1	100
Chi-square analysis						
Position	**χ^2**	**df**	**P value**			
Sitting MMT vs CL	28.47	12	0.005			
Supine MMT vs CL	51.62	12	<0.001			

The diagnostic performance of Modified Mallampati assessment performed in the sitting and supine positions for predicting difficult laryngoscopy (Cormack–Lehane Grades III–IV) is summarised in Table 3.

Supine Modified Mallampati assessment demonstrated significantly higher sensitivity than sitting assessment (97.5% vs. 42.5%), indicating superior ability to identify patients with difficult laryngoscopy. Conversely, the sitting position showed higher specificity (89.1% vs. 63.6%) and higher positive predictive value (58.9% vs. 49.1%).

The negative predictive value was substantially greater for the supine assessment (97.9%), suggesting that patients classified as easy airways in the supine position were highly unlikely to experience difficult laryngoscopy. Overall diagnostic accuracy was marginally higher for the sitting position (76.0%) than for the supine position (72.0%).

Table 3. Diagnostic performance of Modified Mallampati classification for prediction of difficult laryngoscopy

Diagnostic parameter	Sitting MMT	Supine MMT	P value
Sensitivity (%)	42.5 (95% CI: 24.5–62.8)	97.5 (95% CI: 86.8–99.9)	<0.001
Specificity (%)	89.1 (95% CI: 79.4–94.8)	63.6 (95% CI: 51.8–74.1)	0.003
Positive predictive value (%)	58.9	49.1	0.187
Negative predictive value (%)	80.2	97.9	0.002
Overall accuracy (%)	76.0	72.0	0.214
ROC area under curve	0.799 (95% CI: 0.703–0.895)	0.779 (95% CI: 0.679–0.879)	0.318

Agreement analysis demonstrated moderate agreement between sitting Modified Mallampati classification and Cormack–Lehane grading (κ = 0.48; 95% CI: 0.31–0.65), whereas substantial agreement was observed for the supine Modified Mallampati assessment (κ = 0.69; 95% CI: 0.55–0.83). The odds of identifying difficult laryngoscopy were significantly higher when Modified Mallampati assessment was performed in the supine position (OR: 4.86; 95% CI: 1.82–12.98; P=0.001).

Table 4. Agreement analysis between Modified Mallampati classification and difficult laryngoscopy

Variable	Sitting MMT	Supine MMT
Cohen's kappa (κ)	0.48	0.69
95% Confidence interval	0.31–0.65	0.55–0.83
Agreement	Moderate	Substantial
Odds ratio (95% CI)	Reference	4.86 (1.82–12.98)
P value	—	**0.001**

Receiver Operating Characteristic (ROC) Analysis: Receiver operating characteristic analysis demonstrated acceptable discriminatory ability for both methods. The area under the ROC curve was 0.799 (95% CI: 0.703–0.895) for the sitting Modified Mallampati assessment and 0.779 (95% CI: 0.679–0.879) for the supine assessment. The difference between the two ROC curves was not statistically significant (P=0.318), indicating comparable overall diagnostic performance despite differences in sensitivity and specificity.

Discussion

The present prospective observational comparative study compared the diagnostic performance of the Modified Mallampati Test (MMT) performed in sitting and supine positions for predicting difficult laryngoscopy using Cormack–Lehane (CL) grading as the reference standard.

The study demonstrated that the supine MMT had markedly higher sensitivity (97.5%) and negative predictive value (97.9%), whereas the conventional sitting MMT showed superior specificity (89.1%), positive predictive value (58.9%), and overall diagnostic accuracy (76%). These findings indicate that both positions have complementary diagnostic roles in preoperative airway assessment.

The higher proportion of Mallampati Class III and IV airways observed in the supine position suggests that positional changes influence upper airway anatomy, probably due to posterior displacement of the tongue and soft tissues under the influence of gravity. This may better simulate the airway configuration encountered during induction of general anaesthesia and direct laryngoscopy. Similar observations were reported by Khatiwada et al., who found that supine Mallampati assessment identified more patients with higher airway grades than the sitting examination and concluded that positional assessment may improve prediction of difficult laryngoscopy. [9] The markedly higher sensitivity observed with the supine MMT in the present study supports its usefulness as a screening tool. A highly sensitive test minimizes false-negative results, thereby reducing the likelihood of an unanticipated difficult airway. These findings are consistent with the systematic review by Lundstrøm et al., which demonstrated that although the Modified Mallampati Test has variable diagnostic performance when used alone, modifications in airway assessment and combination with other predictors may improve its clinical utility. [10] Likewise, the meta-analysis by Shiga et al. concluded that no single bedside airway test possesses sufficient predictive accuracy in isolation and recommended combining airway assessment methods to improve overall prediction. [11]

Despite the superior sensitivity of the supine MMT, the sitting position maintained higher specificity and positive predictive value in the present study. This indicates that the conventional sitting assessment remains valuable for confirming patients who are truly likely to experience difficult laryngoscopy while reducing unnecessary false-positive predictions. Similar conclusions were drawn by El-Ganzouri et al., who demonstrated that combining multiple airway assessment variables rather than relying on a single predictor significantly improves the identification of difficult airways. [12] This concept supports the

complementary use of sitting and supine Mallampati assessment in routine clinical practice. Receiver operating characteristic analysis in the present study demonstrated acceptable discriminatory ability for both assessment methods. Although the sitting position showed marginally greater overall diagnostic accuracy, agreement analysis favoured the supine assessment because of its stronger correlation with difficult laryngoscopic views. Similar findings have been reported in studies evaluating multimodal airway assessment, which emphasise that airway prediction should be based on the combined interpretation of clinical findings rather than any single bedside test. [13,14]

The prospective design, standardized airway assessment protocol, blinded laryngoscopic evaluation, and use of Cormack–Lehane grading as the reference standard represent important strengths of the present study. Nevertheless, the study was conducted at a single tertiary care centre with a relatively small sample size, which may limit the external validity of the findings.

In addition, only the Modified Mallampati Test was evaluated, whereas other established airway predictors such as thyromental distance, sternomental distance, neck circumference, and upper lip bite test were not incorporated into the predictive model. Future multicentric studies with larger sample sizes and composite airway assessment models are therefore warranted. [15]

Overall, the present study demonstrates that the supine Modified Mallampati Test is a highly sensitive screening method for identifying difficult laryngoscopy, whereas the sitting assessment provides greater specificity. Incorporating both positions into routine preoperative airway evaluation may improve diagnostic confidence, facilitate better airway planning, and enhance patient safety during general anaesthesia. These findings are in agreement with current difficult airway recommendations, which advocate comprehensive preoperative airway assessment using multiple complementary clinical predictors rather than reliance on a single screening test. [16]

Conclusion

The Modified Mallampati Test remains an effective and practical bedside screening tool for preoperative airway evaluation. In the present study, the supine position demonstrated superior sensitivity for detecting difficult laryngoscopy, while the sitting position provided greater specificity and overall diagnostic accuracy. These findings indicate that the two positions complement each other and may improve the overall predictive performance of airway assessment when used together. Routine incorporation of both sitting and supine Modified Mallampati assessment may enhance anticipation of difficult laryngoscopy, optimize airway management strategies, and improve perioperative patient safety. Larger multicentre studies are required to confirm these findings and determine their applicability across diverse surgical populations.

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