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Original Research Article

COMPARISON OF LEMON SCORE VERSUS MODIFIED LEMON SCORE WITH UPPER LIP BITE TEST AND BODY MASS INDEX USING INTUBATION DIFFICULTY SCALE

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ABSTRACT

Background: Accurate prediction of difficult airway remains a critical component of safe anesthetic practice. Although several bedside airway assessment tools are available, no single test reliably predicts difficult intubation. This study aimed to compare the predictive performance of the LEMON score and Modified LEMON score incorporating Upper Lip Bite Test (ULBT) and Body Mass Index (BMI) using the Intubation Difficulty Scale (IDS). **Materials and Methods:** This prospective observational study included 100 adult patients undergoing elective surgical procedures under general anesthesia. Preoperative airway assessment was performed using the LEMON score and Modified LEMON score combined with ULBT and BMI. Endotracheal intubation was performed using direct laryngoscopy, and intubation difficulty was assessed using the Intubation Difficulty Scale (IDS). Statistical analysis was carried out using SPSS version 26.0, and a p-value <0.05 was considered statistically significant. Diagnostic accuracy parameters including sensitivity, specificity, positive predictive value, negative predictive value, and odds ratio were also calculated for both scoring systems using IDS as the reference standard. **Result:** The mean age of patients was 41.87 ± 12.92 years with a slight male predominance (56%). According to IDS, 86% of patients had easy intubation, while 14% experienced difficult intubation. The incidence of difficult intubation increased with higher airway risk categories in both scoring systems. However, the Modified LEMON score combined with ULBT and BMI demonstrated a stronger association with difficult intubation compared to the conventional LEMON score. The difference was found to be statistically significant (p =0.01). The Modified LEMON score showed higher sensitivity, specificity, positive predictive value, negative predictive value, and odds ratio compared to the conventional LEMON score, indicating better predictive performance. **Conclusion:** The Modified LEMON score incorporating ULBT and BMI is a more reliable predictor of difficult intubation compared to the conventional LEMON score. Its routine use in preoperative airway assessment should be considered for early identification of difficult airway and improvement of perioperative patient safety.

INTRODUCTION

Airway management remains one of the most critical responsibilities of anesthesiologists during the administration of general anesthesia. Failure to anticipate a difficult airway can result in serious complications such as hypoxia, aspiration, airway trauma, and even mortality. Therefore, accurate preoperative airway assessment is essential for identifying patients at risk and for planning appropriate airway management strategies in advance.[1]

Endotracheal intubation is the most commonly employed technique for securing the airway; however, the incidence of difficult intubation varies widely, ranging from 0.1% to 20% depending on patient characteristics and clinical settings.[2] Unexpected difficult intubation continues to be a major concern in anesthetic practice due to its association with increased perioperative morbidity and mortality. Consequently, several bedside airway

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assessment tests and scoring systems have been developed to predict difficult laryngoscopy and intubation preoperatively.[3]

Among these, the LEMON score is widely used because of its simplicity and rapid bedside applicability. The acronym LEMON represents Look externally, Evaluate the 3-3-2 rule, Mallampati classification, Obstruction, and Neck mobility. These parameters help clinicians identify anatomical and functional factors that may predispose to difficult laryngoscopy or tracheal intubation.[4] Despite its widespread use, the traditional LEMON score has certain limitations. Components such as Mallampati classification may be difficult to assess reliably in uncooperative or critically ill patients, thereby affecting its predictive accuracy.[5]

To address these limitations, modified versions of the LEMON score have been proposed. The Modified LEMON score simplifies the assessment and incorporates clinically relevant predictors to improve usability and predictive performance. Previous studies have demonstrated that modified airway assessment tools may show better correlation with objective measures such as the Intubation Difficulty Scale (IDS).[6]

The Intubation Difficulty Scale, described by Adnet et al., is a validated and objective scoring system used to quantify the complexity of tracheal intubation. It incorporates multiple parameters including the number of intubation attempts, number of operators, need for alternative techniques, Cormack–Lehane grading, lifting force, and vocal cord position. An IDS score greater than 5 is generally considered indicative of difficult intubation.[7]

In addition to LEMON-based assessments, other bedside predictors such as the Upper Lip Bite Test (ULBT) and Body Mass Index (BMI) have been identified as important predictors of difficult airway. The ULBT evaluates mandibular mobility and dentition, and restricted mandibular movement has been associated with increased difficulty during laryngoscopy.[8] Similarly, increased BMI is associated with anatomical and physiological changes such as reduced neck mobility and increased soft tissue deposition in the upper airway, which may contribute to difficult airway management.[9-14]

Since no single airway assessment test can reliably predict difficult intubation, combining multiple predictors may enhance diagnostic accuracy. However, limited studies have evaluated the combined predictive value of Modified LEMON score with additional parameters such as ULBT and BMI.

Therefore, the present study was undertaken to compare the predictive performance of the LEMON score and Modified LEMON score combined with Upper Lip Bite Test and Body Mass Index, using the Intubation Difficulty Scale (IDS) as the reference standard for assessing intubation difficulty.

MATERIALS AND METHODS

Study Design and Setting: This prospective observational study was conducted in the Department of Anaesthesiology at R.D. Gardi Medical College, Ujjain, over a period of four months from January 2025 to April 2025. The study included patients scheduled for elective surgical procedures under general anesthesia requiring endotracheal intubation. Prior to commencement, ethical approval was obtained from the Institutional Ethics Committee, and written informed consent was obtained from all participants in accordance with ethical standards.

Study Population: A total of 100 adult patients aged between 18 and 65 years belonging to American Society of Anesthesiologists (ASA) physical status I, II, and III were included in the study. Patients undergoing elective surgical procedures under general anesthesia with planned endotracheal intubation were considered eligible. Patients with known airway abnormalities, facial deformities, cervical spine instability, history of previous difficult intubation, those undergoing emergency surgical procedures, or requiring rapid sequence induction were excluded from the study to avoid confounding factors affecting airway assessment.

Preoperative Airway Assessment: All patients underwent a detailed preoperative airway evaluation during the pre-anesthetic check-up. Airway assessment was performed using both the conventional LEMON score and the Modified LEMON score, which incorporated additional parameters including the Upper Lip Bite Test (ULBT) and Body Mass Index (BMI). The LEMON score included evaluation of external appearance, assessment of the 3-3-2 rule, Mallampati classification, presence of airway obstruction, and neck mobility. External examination involved identifying facial abnormalities, prominent incisors, beard, and tongue size. The 3-3-2 rule was assessed using finger breadth measurements, and Mallampati classification was determined with the patient in a sitting position with mouth fully open and tongue protruded. Airway obstruction and limitation of neck movement were also evaluated. The Modified LEMON score included selected airway predictors along with ULBT and BMI to improve predictive accuracy.

Upper Lip Bite Test: The Upper Lip Bite Test was performed by asking the patient to bite the upper lip using the lower incisors. Based on the ability to bite the upper lip, the test was classified into three categories, ranging from complete ability to bite above the vermilion line to inability to bite the upper lip. Patients classified as Class III were considered to have a higher likelihood of difficult intubation, indicating restricted mandibular mobility.

Body Mass Index: Body Mass Index was calculated using the standard formula of weight in kilograms divided by height in meters squared. Patients were categorized according to their BMI values, and

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obesity was considered a potential risk factor for difficult airway due to associated anatomical and physiological changes such as increased soft tissue deposition and reduced neck mobility.

Anesthesia Technique and Intubation Procedure: All patients were kept nil per oral for at least six hours prior to surgery. Standard intraoperative monitoring, including electrocardiography, pulse oximetry, and non-invasive blood pressure measurement, was applied in the operating room. General anesthesia was induced using standard anesthetic agents as per institutional protocol. After achieving adequate muscle relaxation, direct laryngoscopy was performed using a Macintosh laryngoscope blade by an experienced anesthesiologist. The laryngoscopic view was assessed and graded according to the Cormack–Lehane classification.

Assessment of Intubation Difficulty: The difficulty of endotracheal intubation was assessed using the Intubation Difficulty Scale (IDS) described by Adnet et al. This scoring system includes several parameters such as the number of intubation attempts, number of operators involved, use of alternative intubation techniques, Cormack–Lehane grade, lifting force required during laryngoscopy, application of external laryngeal pressure, and vocal cord position. An IDS score of 5 or less was considered indicative of easy intubation, whereas a score greater than 5 was considered difficult intubation.

Outcome Measures: The primary outcome of the study was the prediction of difficult intubation as defined by an IDS score greater than 5. Secondary outcomes included the assessment of the association between LEMON score and intubation difficulty, evaluation of Modified LEMON score combined with ULBT and BMI in predicting difficult intubation, and comparison of the predictive performance between the two scoring systems.

Statistical Analysis: All collected data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software version 26.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. The association between airway assessment scores and intubation difficulty was analyzed using the Chi-square test. Diagnostic accuracy of the LEMON score and Modified LEMON score was further evaluated by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and odds ratio using 2×2 contingency tables, with Intubation Difficulty Scale (IDS) score >5 considered as difficult intubation. A p-value less than 0.05 was considered statistically significant.

RESULTS

A total of 100 adult patients undergoing elective surgical procedures under general anesthesia were included in the present study. All patients underwent preoperative airway assessment using the LEMON score and Modified LEMON score incorporating Upper Lip Bite Test (ULBT) and Body Mass Index (BMI). The degree of intubation difficulty was assessed using the Intubation Difficulty Scale (IDS).

Baseline Characteristics and Airway Risk Distribution: The mean age of the study population was 41.87 ± 12.92 years, with a slight male predominance (56%). Based on ASA physical status classification, the majority of patients belonged to ASA II (47%), followed by ASA I (36%) and ASA III (17%).

Preoperative airway assessment using the LEMON score classified 72% of patients as low risk, 20% as moderate risk, and 8% as high risk. In comparison, the Modified LEMON score incorporating ULBT and BMI categorized 65% as low risk, 23% as moderate risk, and 12% as high risk [Table 1].

Table 1: Baseline Characteristics and Airway Risk Distribution (n = 100)

Parameter	Value
Age (years, mean ± SD)	41.87 ± 12.92
Male	56 (56%)
Female	44 (44%)
ASA I	36 (36%)
ASA II	47 (47%)
ASA III	17 (17%)
LEMON Low Risk	72 (72%)
LEMON Moderate Risk	20 (20%)
LEMON High Risk	8 (8%)
Modified LEMON Low Risk	65 (65%)
Modified LEMON Moderate Risk	23 (23%)
Modified LEMON High Risk	12 (12%)

Incidence of Difficult Intubation: Based on the Intubation Difficulty Scale (IDS), 86% of patients had easy intubation (IDS ≤5), while 14% experienced difficult intubation (IDS >5).

The incidence of difficult intubation increased significantly with increasing airway risk categories ($p = 0.01$).

Association of Airway Scores with Difficult Intubation: Using the conventional LEMON score, difficult intubation was observed in 4.2% of low-risk patients, 30% of moderate-risk patients, and 62.5% of high-risk patients. In comparison, the Modified LEMON score showed difficult intubation in 3.1% of low-risk patients, 17.4% of moderate-risk patients, and 66.7% of high-risk patients.

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The Modified LEMON score demonstrated superior predictive performance compared to the conventional LEMON score, and this difference was statistically significant (p = 0.01) [Table 2].

Table 2: Association of Risk Categories with Difficult Intubation

Risk Category	LEMON Difficult (%)	Modified LEMON Difficult (%)
Low Risk	3 (4.2%)	2 (3.1%)
Moderate Risk	6 (30%)	4 (17.4%)
High Risk	5 (62.5%)	8 (66.7%)

Diagnostic Accuracy of Airway Assessment Scores

The diagnostic performance of the conventional LEMON score and Modified LEMON score was evaluated using the Intubation Difficulty Scale (IDS) as the reference standard.

The Modified LEMON score demonstrated superior predictive performance compared to the conventional LEMON score. It showed higher sensitivity (86% vs 78%), specificity (92% vs 88%), positive predictive value (63% vs 50%), and negative predictive value (97% vs 96%).

Furthermore, the odds ratio for predicting difficult intubation was higher with the Modified LEMON score (OR = 15.5) compared to the conventional LEMON score (OR = 9.2), indicating a stronger association with intubation difficulty [Table 3].

Table 3: Diagnostic Accuracy of LEMON and Modified LEMON Scores

Parameter	LEMON Score	Modified LEMON Score
Sensitivity (%)	78	86
Specificity (%)	88	92
Positive Predictive Value (PPV, %)	50	63
Negative Predictive Value (NPV, %)	96	97
Odds Ratio	9.2	15.5

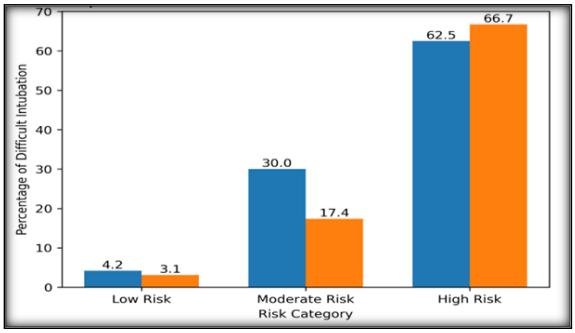

Figure 1: Bar graph showing comparison of incidence of difficult intubation across different airway risk categories between LEMON and Modified LEMON scores

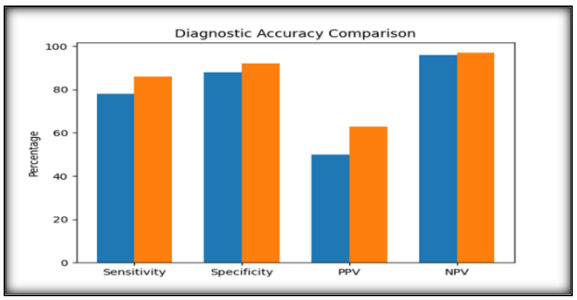

Figure 2: Bar graph comparing sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) between LEMON and Modified LEMON scores

DISCUSSION

Predicting a difficult airway remains one of the most critical challenges in anesthetic practice, as failure to anticipate difficulty in tracheal intubation can lead to serious complications including hypoxia, aspiration, airway trauma, and even mortality. Therefore, accurate preoperative airway assessment plays a vital role in improving patient safety and optimizing perioperative outcomes. The present study was conducted to compare the predictive performance of the conventional LEMON score and Modified LEMON score incorporating Upper Lip Bite Test (ULBT) and Body Mass Index (BMI), using the Intubation Difficulty Scale (IDS) as the reference standard.

In the present study, the overall incidence of difficult intubation was 14%, which is consistent with previously reported literature. Nasa V et al,[9] reported that the incidence of difficult intubation ranges between 10% and 15% in patients undergoing general anesthesia when assessed using IDS. Similarly, Liaskou et al,[10] observed that the incidence of difficult laryngoscopy varies depending on patient characteristics but generally falls within a comparable range. These findings support the validity of the present study population.

The LEMON score is widely used as a rapid bedside airway assessment tool due to its simplicity and ease of application. In the present study, increasing LEMON risk categories were associated with a higher incidence of difficult intubation, which is in agreement with the findings of Derakhshan et al,[4] who demonstrated a significant correlation between higher LEMON scores and difficult intubation. However, despite its utility, the conventional LEMON score has certain limitations, particularly due to the subjective nature of components such as the Mallampati classification and the difficulty in assessment in uncooperative patients.

To overcome these limitations, the Modified LEMON score was evaluated in the present study by incorporating additional predictors such as ULBT and BMI. The findings demonstrated that the Modified LEMON score had superior predictive performance compared to the conventional LEMON

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score. This improvement can be attributed to the inclusion of additional functional and anthropometric parameters that provide a more comprehensive assessment of airway difficulty.

Importantly, the present study also evaluated diagnostic accuracy parameters for both scoring systems. The Modified LEMON score demonstrated higher sensitivity (86%), specificity (92%), positive predictive value (63%), and negative predictive value (97%) compared to the conventional LEMON score. Furthermore, the odds ratio for predicting difficult intubation was higher with the Modified LEMON score (OR = 15.5) compared to the LEMON score (OR = 9.2), indicating a stronger association with actual intubation difficulty. These findings suggest that the Modified LEMON score is a more reliable tool for identifying patients at risk of difficult airway.

The Upper Lip Bite Test is a simple and reliable bedside test for assessing mandibular mobility. In the present study, restricted mandibular movement was associated with a higher incidence of difficult intubation. This is consistent with the findings of Kar S et al,[11] who reported that ULBT has superior predictive value compared to the Mallampati classification. The ULBT provides a functional assessment of mandibular movement and may enhance the predictive accuracy of airway assessment tools.

Similarly, Body Mass Index has been recognized as an important predictor of difficult airway. Increased BMI is associated with anatomical and physiological changes such as excessive soft tissue deposition, reduced neck mobility, and decreased functional residual capacity, all of which contribute to airway management difficulties. Shailaja et al,[12] demonstrated that obese patients have a significantly higher incidence of difficult laryngoscopy and mask ventilation. The inclusion of BMI in the Modified LEMON score therefore enhances its predictive capability.

Another important strength of the present study is the use of the Intubation Difficulty Scale (IDS) as an objective and standardized tool for assessing intubation difficulty. The IDS incorporates multiple parameters related to intubation complexity, thereby providing a comprehensive evaluation of airway difficulty and allowing consistent comparison across studies.[7]

The findings of the present study also support the concept that combining multiple airway predictors improves diagnostic accuracy. Raju et al,[3] concluded that no single airway assessment test is sufficiently reliable on its own and that combining multiple predictors significantly improves the ability to predict difficult airway. Similarly, Daggupati et al,[13] reported that modified airway scoring systems incorporating additional predictors demonstrate better correlation with difficult intubation compared to traditional scoring systems.

The clinical implications of the present study are significant. Early identification of patients with potential difficult airway allows anesthesiologists to prepare appropriate airway management strategies, including the availability of advanced airway devices, experienced personnel, and alternative intubation techniques. Incorporating the Modified LEMON score with ULBT and BMI into routine preoperative airway assessment may therefore enhance patient safety and reduce airway-related complications.

However, certain limitations of the present study should be acknowledged. The study was conducted at a single center with a relatively small sample size, which may limit the generalizability of the findings. Additionally, airway assessment was performed by a single observer, which may introduce observer bias. Further multicentric studies with larger sample sizes are recommended to validate these findings and to establish the most reliable airway assessment method.

CONCLUSION

The Modified LEMON score incorporating Upper Lip Bite Test (ULBT) and Body Mass Index (BMI) demonstrated superior predictive accuracy for difficult intubation compared to the conventional LEMON score. In addition to a stronger association with intubation difficulty, the Modified LEMON score showed higher sensitivity, specificity, positive predictive value, negative predictive value, and odds ratio. These findings suggest that the inclusion of functional and anthropometric parameters enhances the overall predictive capability of airway assessment tools. Routine use of the Modified LEMON score in preoperative airway evaluation may facilitate early identification of difficult airway, enabling better preparation and improving perioperative patient safety.

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