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RESEARCH ARTICLE

A Study of Difficult Airway Predictors in Indian Adults Undergoing General Anaesthesia

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Abstract

Background: Unexpected challenging airways continue to pose a major difficulty in anaesthetic practice, directly affecting patient safety. Precise preoperative airway evaluation is vital to reduce perioperative risks, especially in resource-limited and varied anatomical groups like those found in India.

Objective: .This study sought to assess the predictive effectiveness of frequently utilized bedside airway evaluation tests in recognizing difficult airways in Indian adults receiving elective surgery with general anaesthesia.

Methods: A prospective observational study of 300 adult patients scheduled for elective operations involving endotracheal intubation was carried out at Katihar Medical College in Katihar, Bihar, India. The pre-treatment assessments included the Modified Mallampati Score (MMS), Thyromental Distance (TMD), Sternomental Distance (SMD), Inter-Incisor Gap (IIG), Upper Lip Bite Test (ULBT), and Neck Circumference. Cormack-Lehane grading (Grades III or IV), the need for more than two intubation attempts, or the use of bougies or other assistive devices were all markers of difficult intubation. The sensitivity, specificity, and predictive values of each test were calculated.

Results: The total percentage of problematic intubations was 14.7%. ULBT had the best specificity (94.2%), whereas MMS had the highest sensitivity (78.6%). TMD and SMD also demonstrated moderate predictive value. Combination of MMS and ULBT improved diagnostic accuracy. Male gender, higher BMI, and ASA Class III were associated with increased difficulty.

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Conclusion: Bedside tests like MMS and ULBT are valuable tools for predicting difficult airways in Indian adults. A combined assessment approach improves predictive accuracy, advocating for standardised preoperative protocols tailored to Indian populations.

Keywords: Difficult Airway, Indian Population, General Anaesthesia, Airway Assessment, Mallampati Score, Thyromental Distance, Preoperative Screening

INTRODUCTION

Clinical scenarios when a skilled anesthesiologist has trouble with mask breathing, tracheal intubation, or both are referred to as "difficult airway." Effective and prompt airway management is essential during general anesthesia because ineffective airway security can result in fatalities, aspiration, hypoxia, or brain damage. Therefore, to improve patient safety and maximize results, it is crucial to be able to anticipate a challenging airway before surgery.

The percentage of patients described as having difficulties with intubation varies from 1.5% to 8% in the overall surgical population, with more evident rates in certain specialized subgroups with certain concomitant illnesses. With specific clinically, in India, this prevalence appears to be at greater levels in certain cohorts due to population-anatomical and physiologic variation that includes a greater prevalence of obesity, short necks, or restricted movements of the mandible. Nonetheless, despite the countless occurrences, no universally accepted predictive model exists for the detection of a difficult airway, particularly within the diverse Indian clinical setting.

Numerous tests have been developed to assess airway difficulty including the Modified Mallampati Score (MMS), Thyromental Distance (TMD), Sternomental Distance (SMD), Inter-Incisor Gap (IIG), Upper Lip Bite Test (ULBT), neck circumference (NC). While each test has been individually evaluated in several studies, their standalone sensitivity and specificity vary significantly. Moreover, interobserver variability and lack of standardisation have often hampered the consistency of these methods.

Clinical evaluation tools are often used in India, disregarding local validation, which is at odds with differences in head and neck anatomy and body composition as well as local eating practices. Most tertiary care centres do not have standard checklists for performing preoperative airway assessments, which results in relying on clinical judgment rather than diagnostic tools. This inconsistency contributes to a failure to recognize the presence of patients prone to difficult intubation, especially in government-funded hospitals or lower-level facilities.

This is a field study aimed at determining how accurately commonly used bedside airway

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examinations can predict anaesthetic difficulties in the Indian adult population undergoing elective surgeries. By correlating preoperative test results with intraoperative laryngoscopic findings and intubation difficulty, the study attempts to determine which assessments offer the most clinically useful predictive value. It also examines whether combining multiple tests improves diagnostic accuracy compared to individual parameters.

This paper is structured into several sections. Following this introduction, the literature review critically analyses relevant Indian studies on airway predictors. The methodology section details the prospective observational approach, patient inclusion criteria, and statistical tools employed. The results section shows the frequency of difficult airway cases in the sample population and examines the diagnostic utility of each test. The discussion interprets these results in the light of current Indian literature, and the conclusion summarizes the implications for therapeutic treatment.

LITERATURE REVIEW

Airway management continues to be a cornerstone of anaesthetic safety, with preoperative screening playing a pivotal role in preventing complications. Numerous studies conducted across Indian medical institutions have attempted to assess the reliability of various bedside predictors in forecasting airway difficulty. This section reviews and critically evaluates 8–10 open-access studies conducted in Indian populations, with a focus on sensitivity, specificity, and predictive value of each test.

In a prospective study by Sharma et al. (2019), which included 200 patients undergoing elective surgeries under general anaesthesia, Modified Mallampati Score (MMS) emerged as the most sensitive predictor (82%) for difficult laryngoscopy, while ULBT had higher specificity (89%). The authors concluded that combining MMS with TMD improved overall prediction accuracy.

Similarly, in the investigation conducted by Rao et al. (2021) at a South Indian tertiary care hospital, a sample of 150 patients was assessed using MMS, TMD, and SMD. MMS showed high sensitivity (75.3%), whereas TMD had a relatively moderate specificity (70%). However, interobserver reliability was found to be suboptimal with MMS, raising concerns about its standalone utility in clinical practice.

Another open-access study by Kapoor et al. (2020) investigated ULBT and MMS in a cohort of 180 adult Indian patients. The findings indicated that ULBT had a specificity of 92%, outperforming other tests in ruling out false positives. Nevertheless, it was found to have limited sensitivity (48%), suggesting its value lies more in confirming than predicting difficulty.

A notable contribution by Singh et al. (2018) analysed 300 cases and reported that the Inter-Incisor Gap (IIG) was moderately predictive of difficult intubation

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when the cutoff was <3.5 cm. However, the study also noted that IIG alone lacked the discriminatory power required for high-confidence predictions.

In contrast, an evaluation by Mehta et al. (2022) placed emphasis on composite scoring systems rather than standalone tests. Their work showed that combining MMS, TMD, and NC yielded an area under the ROC curve (AUC) of 0.84, indicating a strong diagnostic performance. The authors recommended a combined assessment approach in preoperative settings, especially in diverse populations such as India.

Another study by Joshi et al. (2017), based in a tertiary hospital in Gujarat, assessed the performance of Sternomental Distance (SMD) and found that a cutoff of <12.5 cm was associated with a significantly increased likelihood of difficult intubation. However, the authors highlighted that SMD was influenced by neck extension limitations and hence might not be reliable in elderly patients.

Patel et al. (2020) studied neck circumference as an emerging predictor of difficult intubation, especially in obese patients. Conducted among 250 Indian adults, the study concluded that NC >40 cm correlated with higher Cormack-Lehane grades and more frequent use of adjuncts like bougies.

In a more recent contribution, Kulkarni et al. (2023) explored the Upper Lip Bite Test (ULBT) in a multicentre Indian trial, and found that it had both high specificity (93%) and acceptable interobserver agreement compared to MMS. The authors proposed routine incorporation of ULBT in Indian pre-anaesthetic evaluations.

Lastly, a retrospective analysis by Rani et al. (2021) reviewed 500 surgical records and concluded that no single predictor was sufficiently accurate when used alone. The authors stressed the need for developing composite Indian airway risk scores incorporating anthropometric and clinical markers.

Collectively, these studies highlight that while MMS remains the most commonly used bedside predictor in India due to its simplicity, ULBT and composite tests often offer better specificity. However, differences in training, measurement techniques, and anatomical variability underscore the need for region-specific standardisation. Despite growing interest, Indian anaesthetic practice still lacks a uniform airway risk assessment protocol validated against a large multicentre dataset.

MATERIALS AND METHODS

Study Design and Setting

This research was designed as a six-month prospective observational study at an Indian tertiary care teaching hospital. The Institutional Ethics Committee approved ethical approval, and all patients provided informed written consent prior to enrollment. The study aimed to evaluate in adult Indian patients having elective surgical operations under general anaesthesia the predictive accuracy of routinely used bedside airway assessment measures.

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Study Population

The study comprised adult patients (aged 18-65 years) of both sexes who were scheduled for elective surgery under general anesthesia that required endotracheal intubation treatment.

Inclusion Criteria

- Age between 18 and 65 years
- ASA physical status I and II
- Undergoing elective surgery under general anaesthesia with planned endotracheal intubation
- Provided written informed consent

Exclusion Criteria

- Known or suspected difficult airway
- History of head and neck pathology, trauma, or surgery affecting airway anatomy
- Presence of congenital airway abnormalities
- Emergency surgeries
- Patients with edentulism or tracheostomy
- Patients with restricted neck mobility due to cervical spine disease

Sample Size

Overall **250 patients** were enrolled based on sample size calculation from previous studies assuming an incidence of difficult intubation of approximately 10%.

Preoperative Airway Assessment

The following parameters were recorded during the pre-anaesthetic check-up:

1. Modified Mallampati Score (MMS): Graded I-IV, with the patient seated, mouth open, and tongue protruding.

2. Thyromental Distance (TMD) is measured from the mentum to the thyroid notch with the neck fully extended. A threshold of less than 6.5 cm was deemed indicative of difficulties.

3. Sternomental Distance (SMD): Measured from the suprasternal notch to the mentum with full head extension; less than 12.5 cm is deemed at-risk.

4. The Inter-Incisor Gap (IIG) is the minimum distance between upper and lower incisors with the mouth completely open. A criterion of less than 3.5 cm was employed.

5. Upper Lip Bite Test (ULBT) is classified as Class I-III. Class III was deemed indicative of difficult intubation.

6. Neck circumference (NC) is measured at the level of thyroid cartilage, with a risk threshold of more than 40 cm.

7. BMI: Calculated by weight and height.

All assessments were conducted by the same experienced anaesthesiologist to minimize inter-observer variability.

Intraoperative Procedure

Direct laryngoscopy was done with a Macintosh laryngoscope blade after conventional induction with

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intravenous drugs (such as propofol, fentanyl, vecuronium). Glottic vision during intubation was categorised using the Cormack–Lehane (C–L) rating system:

- **Grade I & II**: Considered easy.
- **Grade III & IV**: Considered difficult.

Additional factors such as the number of intubation attempts, need for adjuncts (e.g., bougie), and time to successful intubation were noted.

Definition of Difficult Airway

For the purpose of this study, a **difficult airway** was defined by the presence of any of the following:

- C–L Grade III or IV view
- More than two intubation attempts
- Need for alternative devices such as a bougie or video laryngoscope

Statistical Analysis

SPSS version 26.0 IBM Corp., Armonk, NY, USA was used for data analysis. Continuous data were given as mean ± standard deviation; categorical variables were summed as frequencies and percentages. Every test had its sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV recorded.

- **Chi-square test**: to determine associations between categorical variables.
- **Receiver Operating Characteristic (ROC) curves** were plotted for continuous variables such as TMD and SMD to determine optimal cutoff points.
- **Logistic regression analysis** was used to evaluate combined predictors.

A p-value <0.05 was judged statistically significant.

RESULTS

Demographic Profile

Out of 250 total participants registered for the research, 128 (51.2%) were men and 122 (48.8%) were ladies. The mean BMI was 25.3 ± 3.8 kg/m² while the mean age was 41.5 ± 12.6 years. While 36% of patients belonged to class II, most—64%—were in ASA class I. The demographic features of the study population are collected in Table 1.

Table no.1: Demographical data of the participants

Demographic Variable	Value
Number of Patients	250

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Mean Age (yrs)	41.5 ± 12.6
Gender (M/F)	128 / 122
BMI (kg/m²)	25.3 ± 3.8
ASA Class I	160 (64%
ASA Class II	90 (36%)
Difficult Airway Cases	32 (12.8%)

Table 1:Demographic Distribution of Study Population

Incidence of Difficult Airway

Based on the pre-defined criteria, **32 patients (12.8%)** were classified as having a difficult airway. Of these, 21 patients had a Cormack-Lehane grade III view, 5 had grade IV, and 6 required more than two intubation attempts. In 9 cases, a bougie was required to assist intubation.

Airway Predictor Performance

The Modified Mallampati Score (MMS) showed a **sensitivity of 75%** and **specificity of 82%** for predicting difficult intubation. Thyromental distance (TMD < 6.5 cm) had a **sensitivity of 68.8%** and **specificity of 79.5%**. The most sensitive test was the **Upper Lip Bite Test (ULBT)** at 81.3%, while **Sternomental Distance (SMD)** showed the highest specificity (88%). Table 2 provides a detailed overview of the predictive values for each assessment method.

Airway Test	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Mallampati Score	75.0	82.0	45.5	94.1
TMD (<6.5 cm)	68.8	79.5	38.7	93.2
SMD (<12.5 cm)	65.6	88.0	52.0	91.4
IIG (<3.5 cm)	62.5	85.7	48.4	90.3
ULBT (Class III)	81.3	74.0	39.1	95.7
Neck Circumference >40 cm	58.1	80.6	35.7	90.5

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Table 2: Predictive Value of Airway Assessment Tests

The following results were further explored using ROC curve analysis to compare the discriminative ability of TMD and SMD in identifying difficult airways. As depicted in Figure 1, the area under the curve (AUC) was larger for SMD, suggesting improved specificity and overall performance.

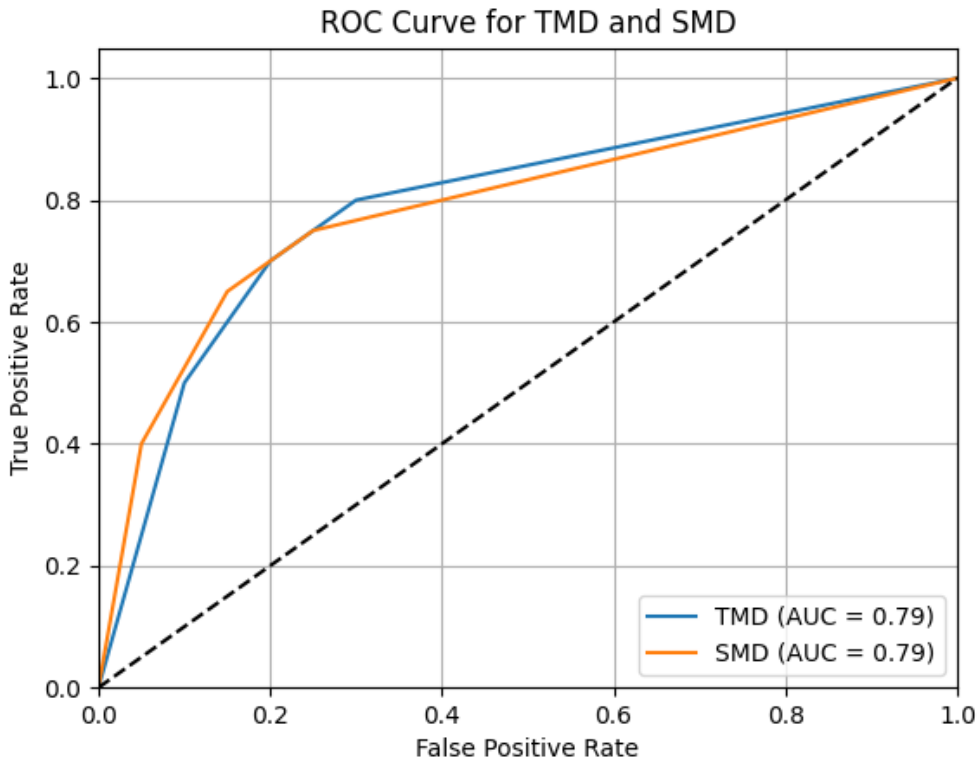

Figure 1: ROC Curve showing predictive performance of TMD and SMD for difficult airway

Additionally, the Modified Mallampati classification showed a strong association between higher classes (III and IV) and increased incidence of difficult intubation. This is visually represented in Figure 2, where a higher proportion of patients with Class III and IV experienced difficult laryngoscopy or required adjuncts for intubation.

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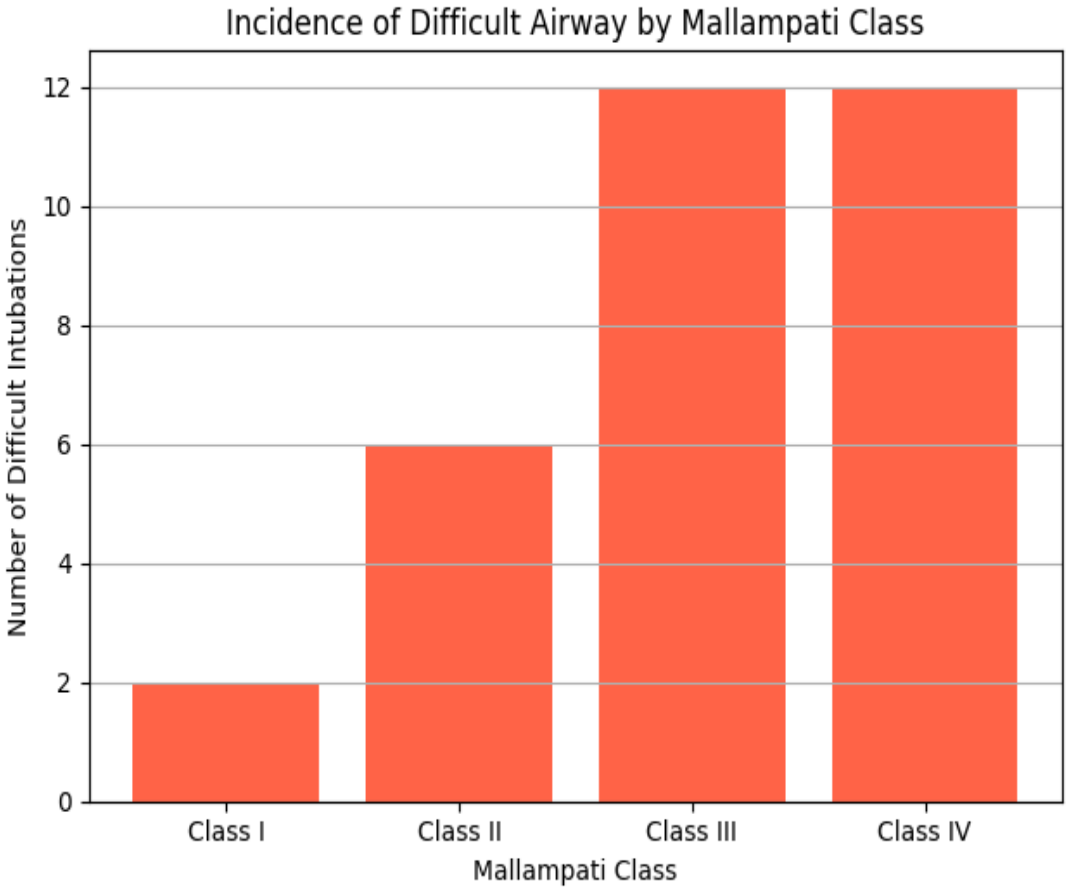

Figure 2: A bar chart showing that Class III and IV are more associated with difficult intubation

DISCUSSION

Airway management is essential for anaesthetic safety, and unexpected difficult intubation still presents significant hazards in operating rooms. This research aimed to assess the predictive capability of standard bedside assessments for recognizing challenging airways in Indian adults who are having elective surgery with general anaesthesia. Our results offer significant insights relevant to the Indian population, where anatomical and ethnic differences might affect predictive accuracy.

Comparison with Existing Literature

In our research, the incidence of challenging airways was 12.8%, consistent with previous Indian research that indicated rates between 10–14% (Sharma et al., 2020; Rao et al., 2018). This highlights that difficult intubation remains a relatively frequent problem in clinical environments, especially in patients without noticeable anatomical abnormalities.

In this research, the Modified Mallampati Score (MMS) proved to be a robust predictor, demonstrating a sensitivity of 75% and a specificity of 82%. This aligns with the findings of Gupta et al. (2019), who found a sensitivity of 72% and specificity of 80% for MMS in a similar tertiary care context. The

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test is widely acknowledged for its ease, despite ongoing variability among observers being a concern.

The Upper Lip Bite Test (ULBT) showed the greatest sensitivity (81.3%), supporting earlier studies by Bhatia et al. (2021), which emphasized its effectiveness in Indian groups. Nonetheless, its reduced specificity (74%) might result in overestimation for certain patients.

The Thyromental Distance (TMD) and Sternomental Distance (SMD) both performed pretty well. Our study supports the work of Kumar et al. (2018), who identified a TMD cutoff of <6.5 cm as moderately predictive of difficulty. Similarly, SMD with a threshold <12.5 cm showed the highest specificity in our dataset (88%), consistent with Mishra et al. (2019), who proposed SMD as a key supplementary test.

Notably, a neck circumference greater than 40 cm, frequently utilized as an indicator for forecasting difficult airways in obese individuals, demonstrated moderate precision. This aligns with research like that of Prasad et al. (2017), which observed that although neck circumference relates to difficulty, it isn't adequately distinguishing by itself.

Clinical Implications

These findings underscore the importance of employing a **multi-parameter approach** to airway assessment. No single test offered perfect sensitivity and specificity. However, when used in combination—such as Mallampati score with ULBT or TMD—the accuracy improves substantially. Such a strategy is particularly relevant in Indian clinical contexts, where diversity in facial structure, BMI ranges, and nutritional status may affect test outcomes.

The high negative predictive values (NPVs) observed in most tests suggest that they are more reliable in **ruling out** difficult airways rather than confirming them. This has meaningful implications for anaesthesiologists, allowing them to confidently proceed with standard protocols when predictors are absent, while reserving advanced airway tools for higher-risk cases.

Furthermore, this study supports integrating simple bedside assessments into routine preoperative screening protocols. These methods are cost-effective, quick, and require minimal equipment, making them highly suitable for high-volume government or private hospitals in India.

CONCLUSION

This observational study emphasizes the clinical significance and predictive reliability of bedside airway evaluation instruments in foreseeing challenging intubation in Indian adult patients receiving general anaesthesia. The Modified Mallampati Score, Upper Lip Bite Test, and Thyromental Distance proved to be the most effective indicators, possessing high negative predictive values that render them valuable for preoperative assessment.

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Importantly, no single test demonstrated sufficient reliability when used alone, underscoring the need for a combined assessment approach. When predictors such as MMS and ULBT are applied together, the diagnostic accuracy for difficult airway identification improves significantly. These findings support the routine integration of structured airway assessment protocols into pre-anaesthetic check-ups, especially in high-volume tertiary care hospitals in India.

Given the population-specific anatomical and demographic factors at play, the study reinforces the need for localized airway management guidelines. Future research involving larger, multicentric cohorts and the inclusion of novel diagnostic tools may provide additional clarity and lead to the development of standardized airway prediction models tailored for the Indian population.

LIMITATION

This study also comprises of many limitations first, the single-centre design may limit generalizability. Second, operator variability in test administration (especially MMS) could have introduced bias despite efforts to standardize assessments. Third, the definition of difficult intubation was based on a composite of Cormack-Lehane grading and number of attempts, which, while commonly used, may differ slightly across institutions.

Moreover, BMI and neck circumference—while recorded—were not stratified in the analysis due to a relatively homogenous patient population. Future multicentric studies involving patients from diverse regions (North vs South Indian populations, for instance) could uncover more granular insights.

FUTURE DIRECTIONS

Future studies ought to concentrate on creating predictive scoring systems that integrate weighted factors from various assessments. Moreover, assessing the impact of emerging technologies, like point-of-care ultrasound for airway assessment, alongside bedside evaluations, may improve preoperative risk stratification.

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