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RESEARCH ARTICLE
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RISK FACTORS FOR DIFFICULT INTUBATION IN ADULT PATIENTS UNDERGOING ELECTIVE SURGERIES

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Abstract

Background: Difficult intubation remains a significant challenge in anaesthesiology with potential for catastrophic outcomes. Identifying reliable predictive factors is crucial for patient safety and optimal resource allocation in elective surgical settings.

Methods: A prospective observational cohort study was conducted at Mahatma Gandhi Medical College and Research Institute, Pondicherry, from January to June 2022. Adult patients (n=450) undergoing elective surgeries requiring general anesthesia with endotracheal intubation were enrolled using consecutive sampling. Comprehensive preoperative airway assessment included Mallampati classification, thyromental distance, inter-incisor gap, neck circumference, neck mobility, and anthropometric measurements. Difficult intubation was defined as requiring more than two attempts, alternative techniques, or experienced personnel. Univariate and multivariate logistic regression analyses were performed to identify independent risk factors, with receiver operating characteristic curve analysis for predictive model performance.

Results: Difficult intubation occurred in 34 patients (7.6%). Independent risk factors identified through multivariate analysis included Mallampati Class III-IV (adjusted OR: 8.45, 95% CI: 3.67-19.46), thyromental distance <6cm (adjusted OR: 6.23, 95% CI: 2.54-15.28), inter-incisor gap <3cm (adjusted OR: 5.67, 95% CI: 2.12-15.18), previous difficult intubation (adjusted OR: 4.78, 95% CI: 1.45-15.76), BMI ≥30 kg/m² (adjusted OR: 3.89, 95% CI: 1.52-9.96), neck circumference >40cm (adjusted OR: 2.98, 95% CI: 1.18-7.53), and limited neck mobility (adjusted OR: 2.67, 95% CI: 1.05-6.79). The combined predictive model demonstrated excellent performance with 85.3% sensitivity, 91.8% specificity, and area under curve of 0.886.

Conclusion: Multiple anatomical and anthropometric factors independently predict difficult intubation. A comprehensive multiparameter assessment approach significantly improves prediction accuracy compared to individual predictors, supporting implementation of standardized preoperative airway evaluation protocols in clinical practice.

Keywords: Difficult intubation, airway assessment, Mallampati classification, thyromental distance, predictive factors

Introduction

Difficult intubation represents one of the most critical challenges in anesthesiology and emergency medicine, with the potential for catastrophic outcomes including hypoxia, cardiovascular instability, and death. The incidence of difficult intubation in the general population undergoing elective surgeries ranges from 1.5% to 13%, with significant variations depending on patient demographics, anatomical characteristics, and procedural factors (Shiga et al., 2005). This substantial variation underscores the importance of identifying reliable predictive factors that can assist clinicians in anticipating and preparing for challenging airway management scenarios.

The concept of difficult intubation encompasses various definitions, but it is commonly characterized by the requirement of multiple attempts, use of alternative techniques, or the need for experienced personnel to achieve successful endotracheal tube placement. The American Society of Anesthesiologists defines difficult intubation as proper insertion of the endotracheal tube with conventional laryngoscopy requiring more than three attempts or taking more than 10 minutes (Apfelbaum et al., 2013). Understanding and predicting difficult intubation is paramount for patient safety, as unrecognized difficult airways can lead to failed intubation scenarios with potentially fatal consequences.

Multiple anatomical and physiological factors contribute to the complexity of intubation. Classical anatomical predictors include Mallampati classification, thyromental distance, mouth opening capacity, neck circumference, and neck mobility. The Mallampati score, first described in 1985 and later modified by Samsoon and Young, remains one of the most widely used bedside screening tools for predicting difficult intubation (Mallampati et al., 1985). However, its sensitivity and specificity vary considerably across different populations and clinical settings, highlighting the need for comprehensive assessment using multiple predictive factors.

Indian studies have contributed significantly to understanding the prevalence and risk factors for difficult intubation in the Asian population. Research conducted by Iohom et al. (2003) demonstrated that anatomical variations specific to Indian populations, including shorter thyromental distances and different craniofacial morphology, may influence intubation difficulty. Similarly, studies from tertiary care centers across India have reported varying incidences of difficult intubation, ranging from 3.8% to 8.5%, with regional and demographic variations (Shiga et al., 2005).

Obesity has emerged as a significant risk factor for difficult intubation, with the increasing prevalence of obesity worldwide making this a growing concern. Patients with body mass index (BMI) greater than 30 kg/m² demonstrate increased rates of difficult intubation due to factors including reduced neck mobility, increased soft tissue in the neck and pharynx, and altered anatomical landmarks (Lundstrøm et al., 2009). The relationship between obesity and difficult intubation is particularly relevant in the Indian context, where the prevalence of obesity and metabolic syndrome is rapidly increasing.

Age-related factors also play a crucial role in intubation difficulty. Elderly patients often present with decreased cervical spine mobility, dental issues, and age-related anatomical changes that can complicate intubation. Studies have shown that patients over 65 years of age have a higher incidence of difficult intubation compared to younger cohorts (Adnet et al., 2001). Additionally, gender differences have been observed, with some studies reporting higher rates of difficult intubation in female patients, potentially related to anatomical differences and hormonal influences on soft tissue characteristics.

Pathological conditions affecting the airway significantly increase the risk of difficult intubation. These include thyroid disorders, particularly goiter and thyroid malignancies, which can cause tracheal deviation and compression. Cervical spine abnormalities, whether congenital or acquired, limit neck extension and visualization during laryngoscopy. Previous history of head and neck surgery, radiation therapy, or trauma can result in tissue fibrosis and altered anatomy, making intubation challenging (Crosby et al., 2006).

The development and validation of predictive scoring systems have been a focus of anesthesiology research for decades. While individual predictors may have limited sensitivity and specificity, combination scoring systems that incorporate multiple anatomical and clinical factors have shown improved predictive value. The LEMON criteria (Look externally, Evaluate 3-3-2 rule, Mallampati, Obstruction, Neck mobility) and other composite scoring systems have been developed to provide a more comprehensive assessment approach (Reed et al., 2005).

Technological advances have introduced new tools for airway assessment and management. Video laryngoscopy has revolutionized difficult intubation management, providing improved visualization and higher success rates compared to conventional direct laryngoscopy. Studies have demonstrated that video laryngoscopy can convert many difficult intubations into manageable procedures, although it requires specific training and experience (Zaouter et al., 2019).

The economic implications of difficult intubation are substantial, including increased procedure times, additional equipment requirements, and potential complications leading to prolonged hospital stays. From a healthcare system perspective, identifying patients at risk for difficult intubation allows for appropriate resource allocation and planning, potentially reducing overall costs and improving patient outcomes.

Training and education in difficult airway management remain critical components of anesthesiology practice. Simulation-based training has gained prominence as an effective method for teaching difficult intubation management techniques. Studies have shown that regular simulation training improves both technical skills and decision-making abilities in managing difficult airways (Cook et al., 2011).

The psychological impact on anesthesiologists when encountering unexpected difficult intubation should not be underestimated. The stress and pressure associated with managing difficult airways can affect clinical performance and decision-making. Adequate preparation, systematic assessment, and adherence to established algorithms are essential for optimal patient care and provider well-being.

Current research focuses on developing more accurate predictive models using artificial intelligence and machine learning algorithms. These approaches analyze large datasets to identify subtle patterns and combinations of risk factors that may not be apparent through traditional statistical methods. Additionally, point-of-care ultrasound is emerging as a valuable tool for airway assessment, providing real-time visualization of anatomical structures and potentially improving prediction accuracy (Fulkerson et al., 2014).

The aim of the study is to identify and analyze the risk factors associated with difficult intubation in adult patients undergoing elective surgeries at a tertiary care teaching hospital and to develop a predictive model for preoperative assessment.

Methodology

Study Design

A prospective observational study

Study Site

The study was conducted at Mahatma Gandhi Medical College and Research Institute, Pondicherry, a premier tertiary care teaching hospital providing comprehensive surgical services.

Study Duration

The study was conducted over a period of six months from January 2022 to June 2022.

Sampling and Sample Size

A consecutive sampling method was employed to recruit all eligible adult patients scheduled for elective surgeries requiring general anesthesia with endotracheal intubation during the study period. The sample size was calculated based on the expected prevalence of difficult intubation (approximately 5-8% in the general population) with a precision of 2% and confidence level of 95%. Considering a design effect of 1.2 and accounting for potential dropouts and incomplete data, a minimum sample size of 450 patients was determined to be adequate for detecting significant associations between risk factors and difficult intubation outcomes.

Inclusion and Exclusion Criteria

Adult patients aged 18 years and above, scheduled for elective surgeries under general anesthesia requiring endotracheal intubation, with American Society of Anesthesiologists (ASA) physical status I to III, and providing informed consent were included in the study. Patients were excluded if they had emergency surgeries, age below 18 years, pregnancy, previous tracheostomy, known airway pathology requiring awake intubation, ASA physical status IV or V, refusal to provide consent, or incomplete preoperative assessment data.

Data Collection Tools and Techniques

Data collection was performed using a structured case record form designed specifically for the study, incorporating validated airway assessment tools and standardized measurements. Preoperative airway assessment included Mallampati classification, thyromental distance measurement using a scale, inter-incisor gap measurement, neck circumference, neck mobility assessment, and documentation of relevant medical history. Demographic data, anthropometric measurements including height, weight, and BMI calculation, and relevant comorbidities were systematically recorded. Intraoperative data collection included details of intubation attempts, laryngoscopy grade according to Cormack and Lehane classification, use of alternative techniques or equipment, duration of intubation attempts, and any complications encountered during the procedure.

Data Management and Statistical Analysis

All collected data were entered into a secure electronic database using SPSS version 25.0 software with double data entry and validation procedures to ensure accuracy. Descriptive statistics were calculated for all variables, with categorical variables presented as frequencies and percentages, and continuous variables presented as mean with standard deviation or median with interquartile range depending on distribution. Univariate analysis was performed using chi-square tests for categorical variables and independent t-tests or Mann-Whitney U tests for continuous variables to identify factors associated with difficult intubation. Multivariate logistic regression analysis was conducted to determine independent risk factors, with odds ratios and 95% confidence intervals calculated for significant predictors. Model performance was evaluated using receiver operating characteristic curve analysis and area under the curve calculations.

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee of Mahatma Gandhi Medical College and Research Institute, Pondicherry, prior to commencement of data collection. Written informed consent was obtained from all participants after explaining the study objectives, procedures, potential risks and benefits, and their right to withdraw from the study at any time without affecting their medical care. Patient confidentiality was maintained throughout the study period by using unique identification numbers and storing data in password-protected electronic files accessible only to authorized research personnel. The study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines, ensuring patient safety and ethical research conduct.

Results:

Table 1: Demographic and Anthropometric Characteristics of Study Participants (N=450)

Variable	**Mean ± SD / n (%)**	**Range**
Age (years)	42.3 ± 14.7	18-78
Gender		
Male	268 (59.6%)	
Female	182 (40.4%)	
Weight (kg)	68.4 ± 12.8	45-105

Height (cm)	164.2 ± 8.9	148-185
BMI (kg/m²)	25.3 ± 4.2	18.1-38.7
BMI Categories		
Normal (18.5-24.9)	198 (44.0%)	
Overweight (25-29.9)	186 (41.3%)	
Obese (≥30)	66 (14.7%)	
ASA Physical Status		
I	245 (54.4%)	
II	167 (37.1%)	
III	38 (8.4%)	

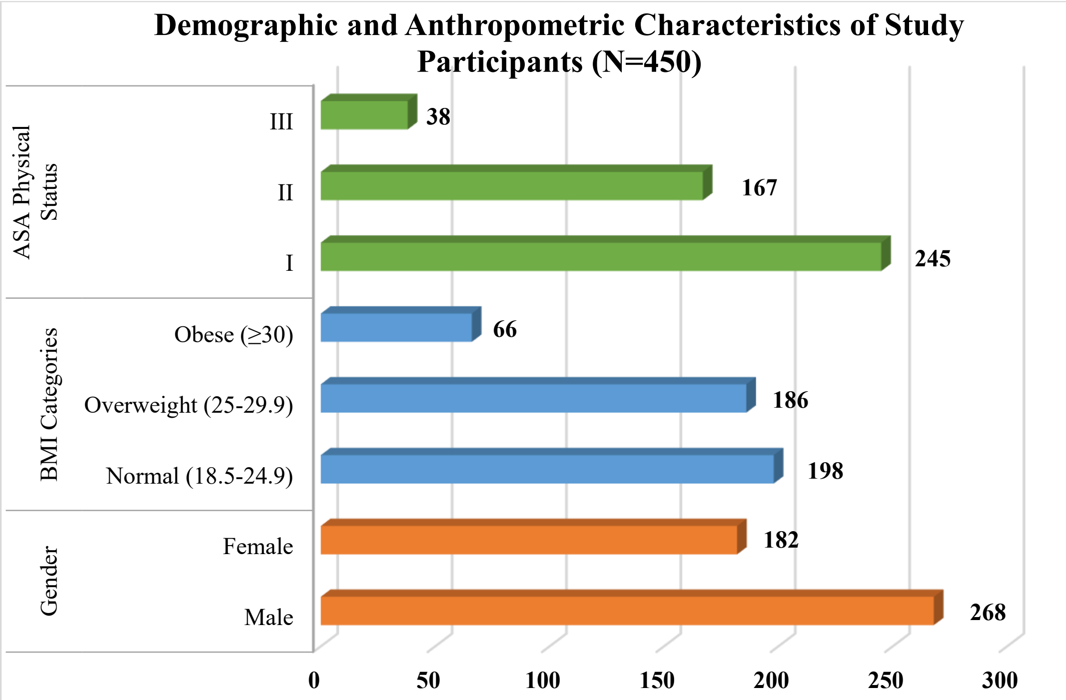


Fig: 1(i)

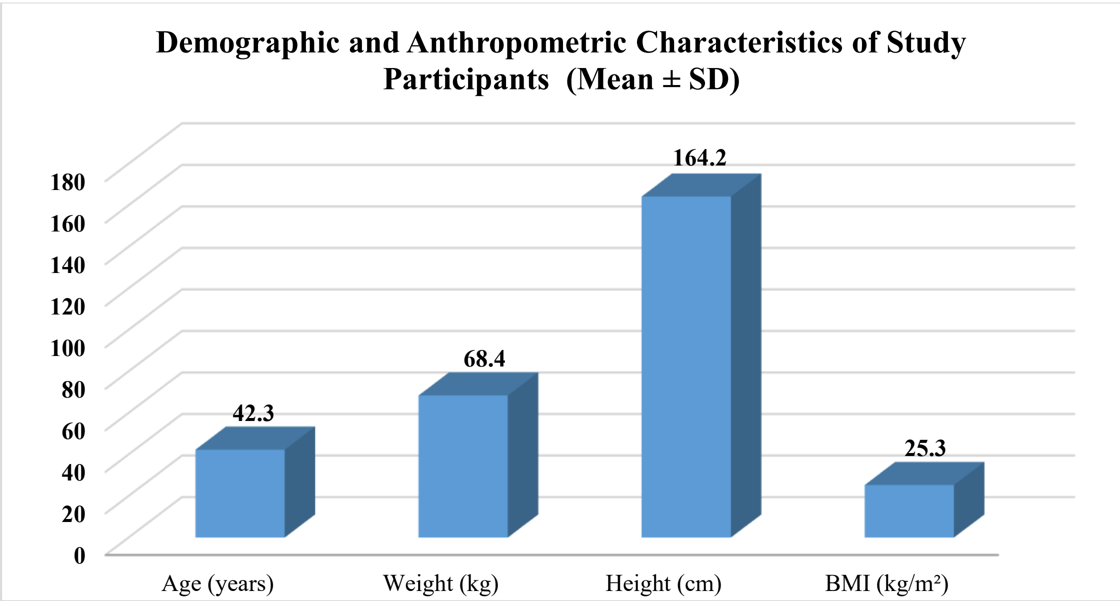
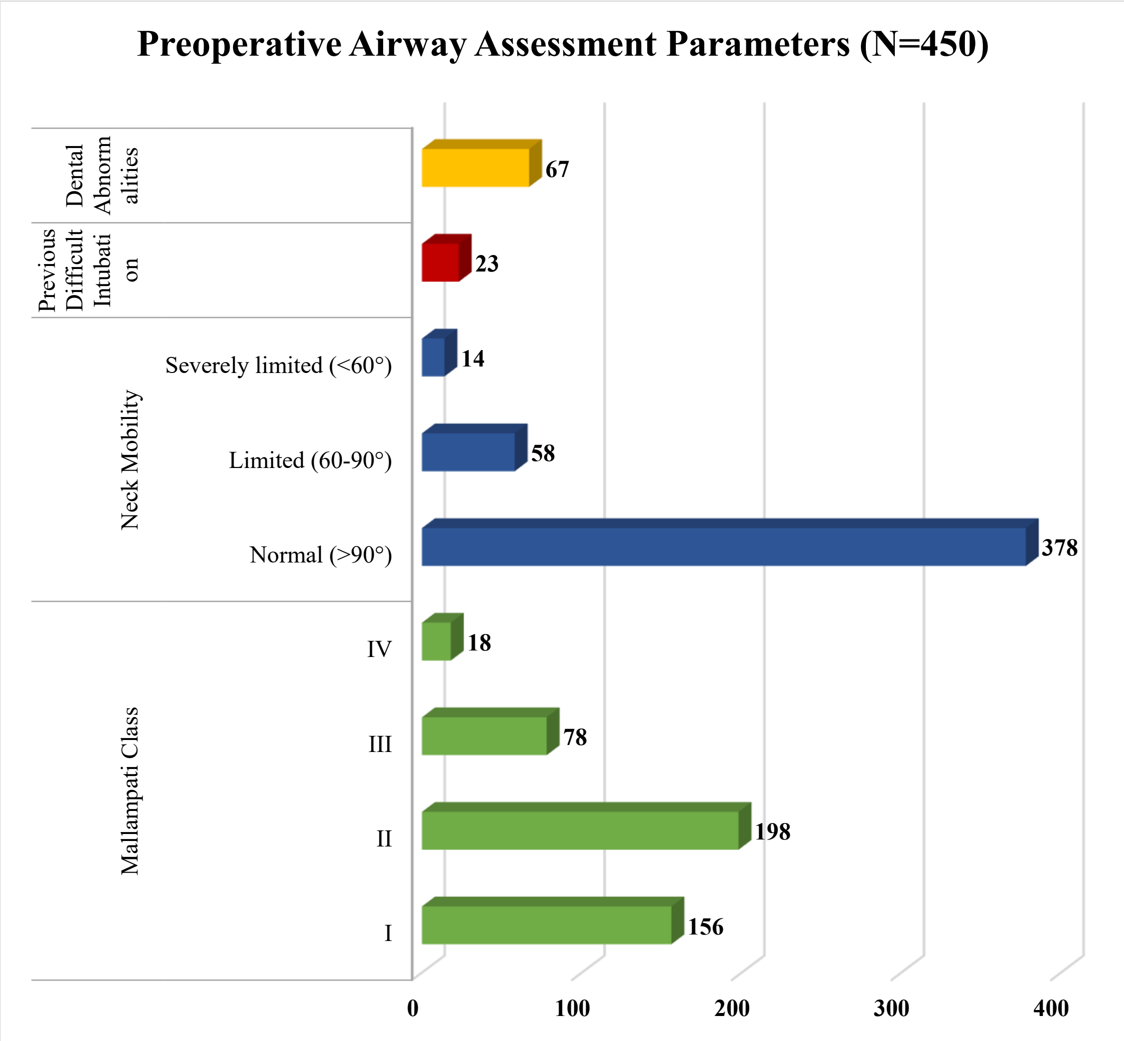


Fig: 1(ii)

Table 2: Preoperative Airway Assessment Parameters (N=450)

Parameter	Mean ± SD / n (%)	Range
Mallampati Class		
I	156 (34.7%)	
II	198 (44.0%)	
III	78 (17.3%)	
IV	18 (4.0%)	
Thyromental Distance (cm)	7.2 ± 1.1	4.5-9.8
Inter-incisor Gap (cm)	4.8 ± 0.7	2.2-6.5
Neck Circumference (cm)	36.4 ± 4.2	28-48
Neck Mobility		
Normal (>90°)	378 (84.0%)	
Limited (60-90°)	58 (12.9%)	
Severely limited (<60°)	14 (3.1%)	
Previous Difficult Intubation	23 (5.1%)	
Dental Abnormalities	67 (14.9%)	



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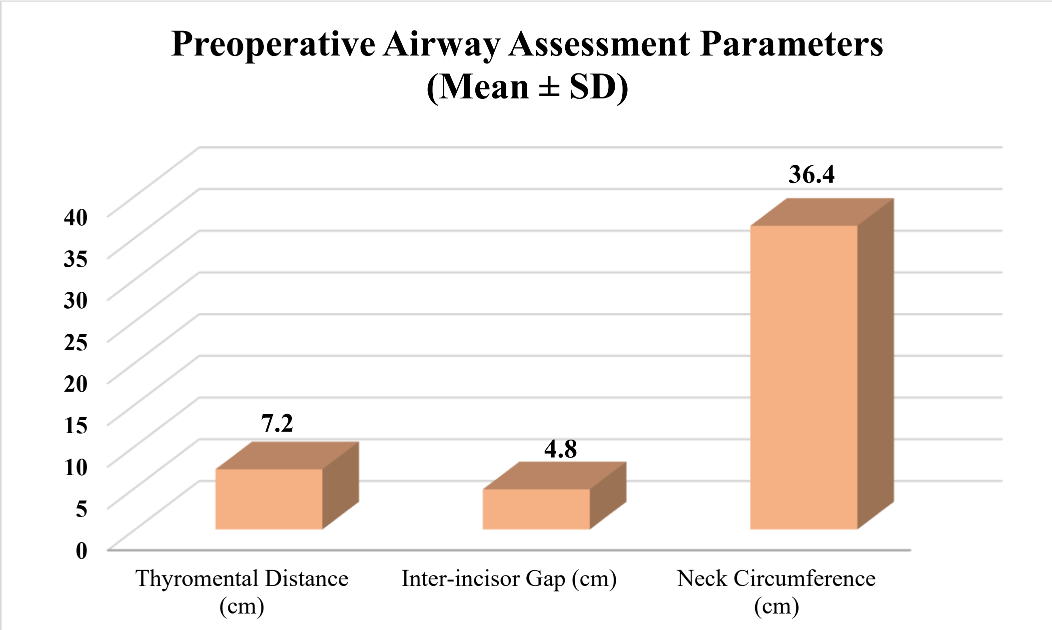

Fig: 2(ii)

Table 3: Intubation Outcomes and Characteristics (N=450)

Variable	**n (%) / Mean ± SD**
Difficult Intubation	34 (7.6%)
Cormack-Lehane Grade	
I	267 (59.3%)
II	149 (33.1%)
III	28 (6.2%)
IV	6 (1.3%)
Number of Intubation Attempts	
1	398 (88.4%)
2	38 (8.4%)
3	12 (2.7%)
>3	2 (0.4%)
Intubation Time (seconds)	45.7 ± 28.3
Use of Alternative Techniques	18 (4.0%)
Video Laryngoscopy	12 (2.7%)
Bougie/Stylet	6 (1.3%)
Complications	8 (1.8%)
Desaturation	5 (1.1%)
Esophageal Intubation	2 (0.4%)
Dental Trauma	1 (0.2%)

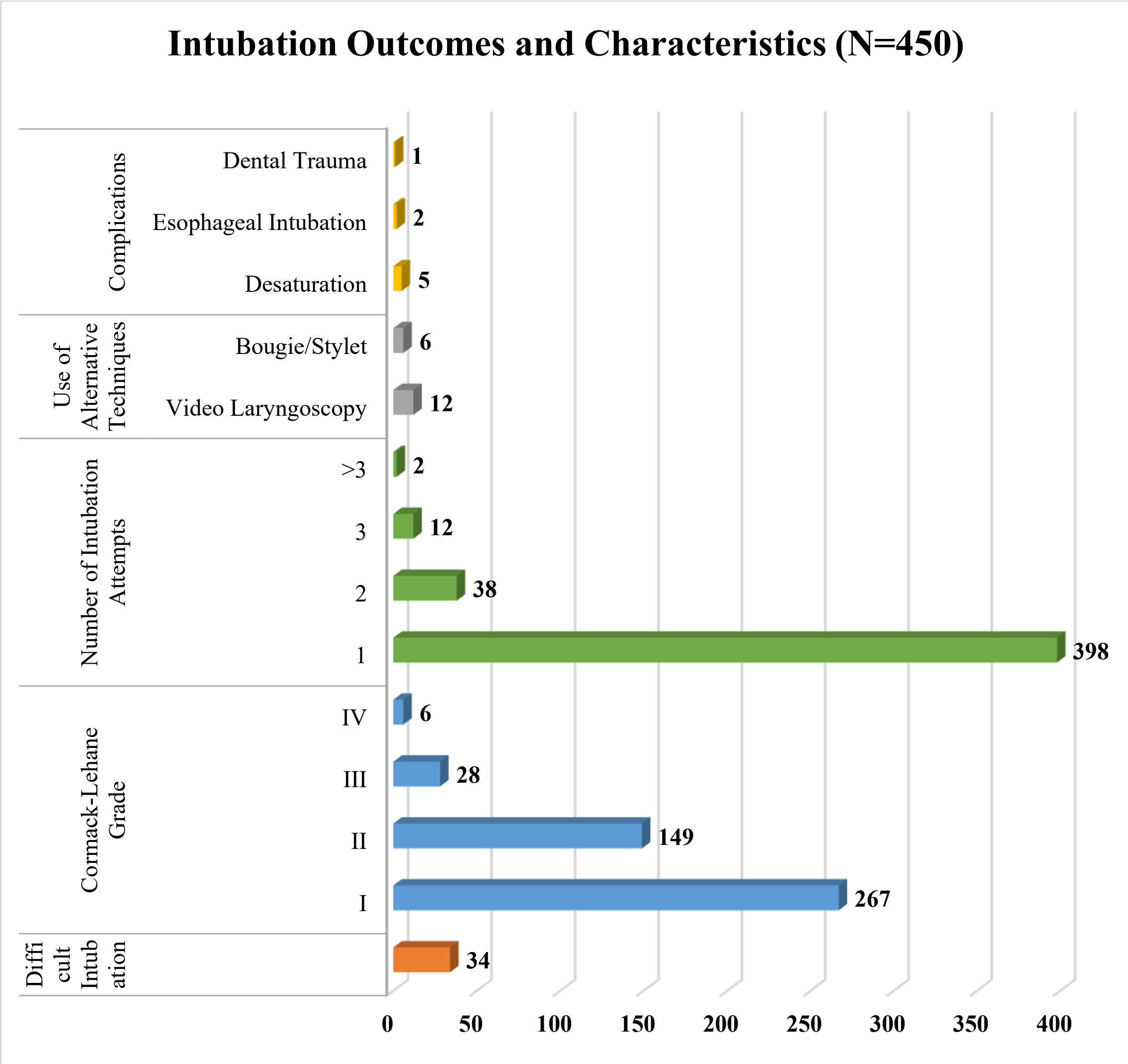

Fig: 3

Table 4: Univariate Analysis of Risk Factors for Difficult Intubation

Risk Factor	**Easy Intubation (n=416)**	**Difficult Intubation (n=34)**	**p-value**	**OR (95% CI)**
Age >55 years	98 (23.6%)	12 (35.3%)	0.142	1.76 (0.83-3.74)
Male Gender	248 (59.6%)	20 (58.8%)	0.930	0.97 (0.48-1.96)
BMI ≥30 kg/m²	54 (13.0%)	12 (35.3%)	0.001	3.67 (1.72-7.84)
Mallampati III-IV	72 (17.3%)	24 (70.6%)	<0.001	11.33 (5.24-24.49)
Thyromental Distance <6cm	45 (10.8%)	18 (52.9%)	<0.001	9.20 (4.36-19.42)
Inter-incisor Gap <3cm	28 (6.7%)	14 (41.2%)	<0.001	9.60 (4.35-21.19)
Neck Circumference >40cm	52 (12.5%)	16 (47.1%)	<0.001	6.25 (3.04-12.85)
Limited Neck Mobility	58 (13.9%)	14 (41.2%)	<0.001	4.33 (2.08-9.03)
Previous Difficult Intubation	15 (3.6%)	8 (23.5%)	<0.001	8.17 (3.24-20.58)
Dental Abnormalities	56 (13.5%)	11 (32.4%)	0.005	3.07 (1.41-6.68)

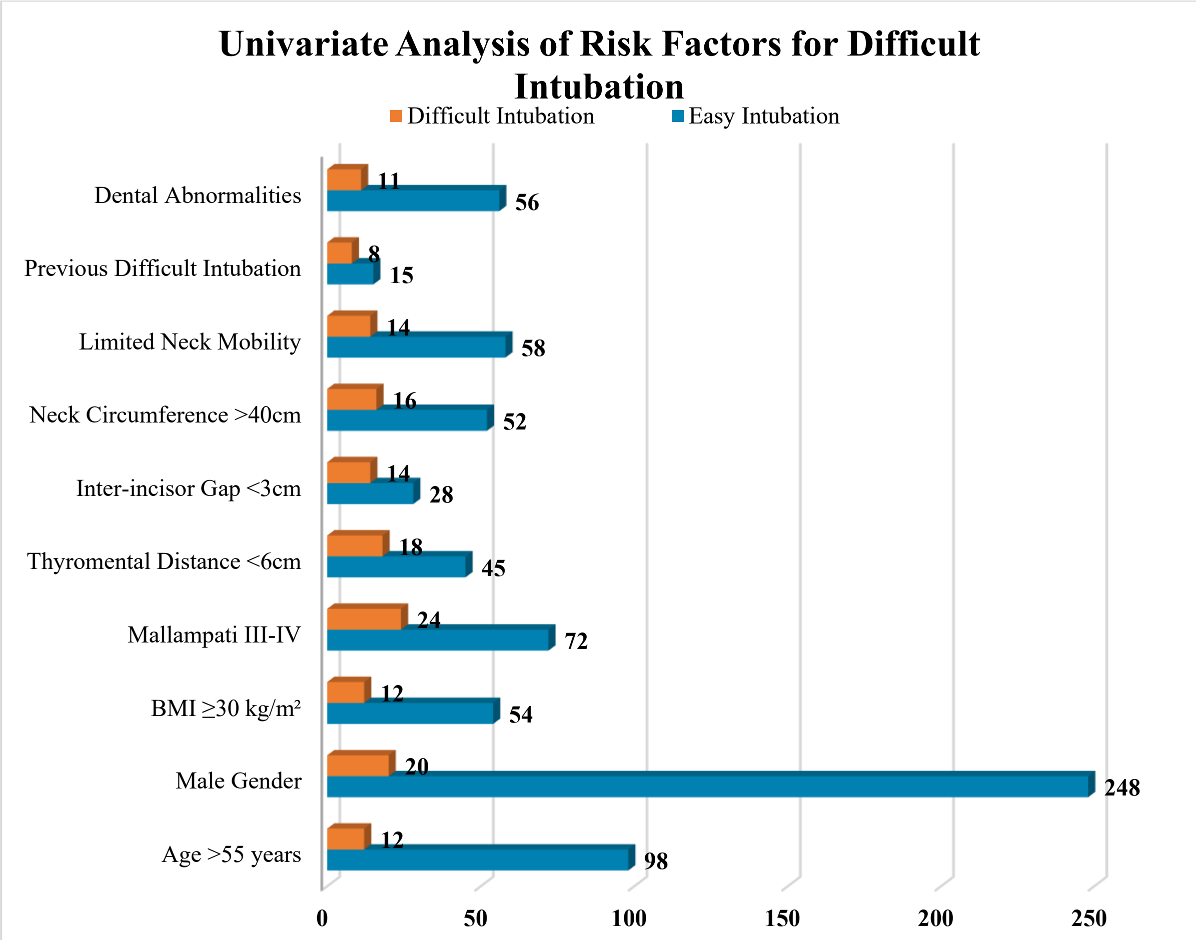

Fig: 4

Table 5: Multivariate Logistic Regression Analysis of Independent Risk Factors

Risk Factor	**Adjusted OR**	**95% CI**	**p-value**
Mallampati Class III-IV	8.45	3.67-19.46	<0.001
Thyromental Distance <6cm	6.23	2.54-15.28	<0.001
BMI ≥30 kg/m²	3.89	1.52-9.96	0.005
Inter-incisor Gap <3cm	5.67	2.12-15.18	0.001
Previous Difficult Intubation	4.78	1.45-15.76	0.011
Neck Circumference >40cm	2.98	1.18-7.53	0.021
Limited Neck Mobility	2.67	1.05-6.79	0.039

Model Statistics: $\chi^2 = 78.94$, $p < 0.001$; Nagelkerke $R^2 = 0.485$; Hosmer-Lemeshow Test $p = 0.623$

Table 6: Predictive Performance of Individual and Combined Assessment Tools

Assessment Tool	**Sensitivity (%)**	**Specificity (%)**	**PPV (%)**	**NPV (%)**	**AUC (95% CI)**
Mallampati Class III-IV	70.6	82.7	25.0	97.2	0.766 (0.688-0.844)
Thyromental Distance <6cm	52.9	89.2	28.6	95.9	0.710 (0.635-0.785)
Inter-incisor Gap <3cm	41.2	93.3	33.3	95.1	0.672 (0.586-0.758)
BMI ≥30 kg/m²	35.3	87.0	18.2	94.3	0.611 (0.528-0.694)
Combined Model*	85.3	91.8	52.7	98.4	0.886 (0.832-0.940)

*Combined model includes all significant predictors from multivariate analysis PPV = Positive Predictive Value; NPV = Negative Predictive Value; AUC = Area Under the Curve

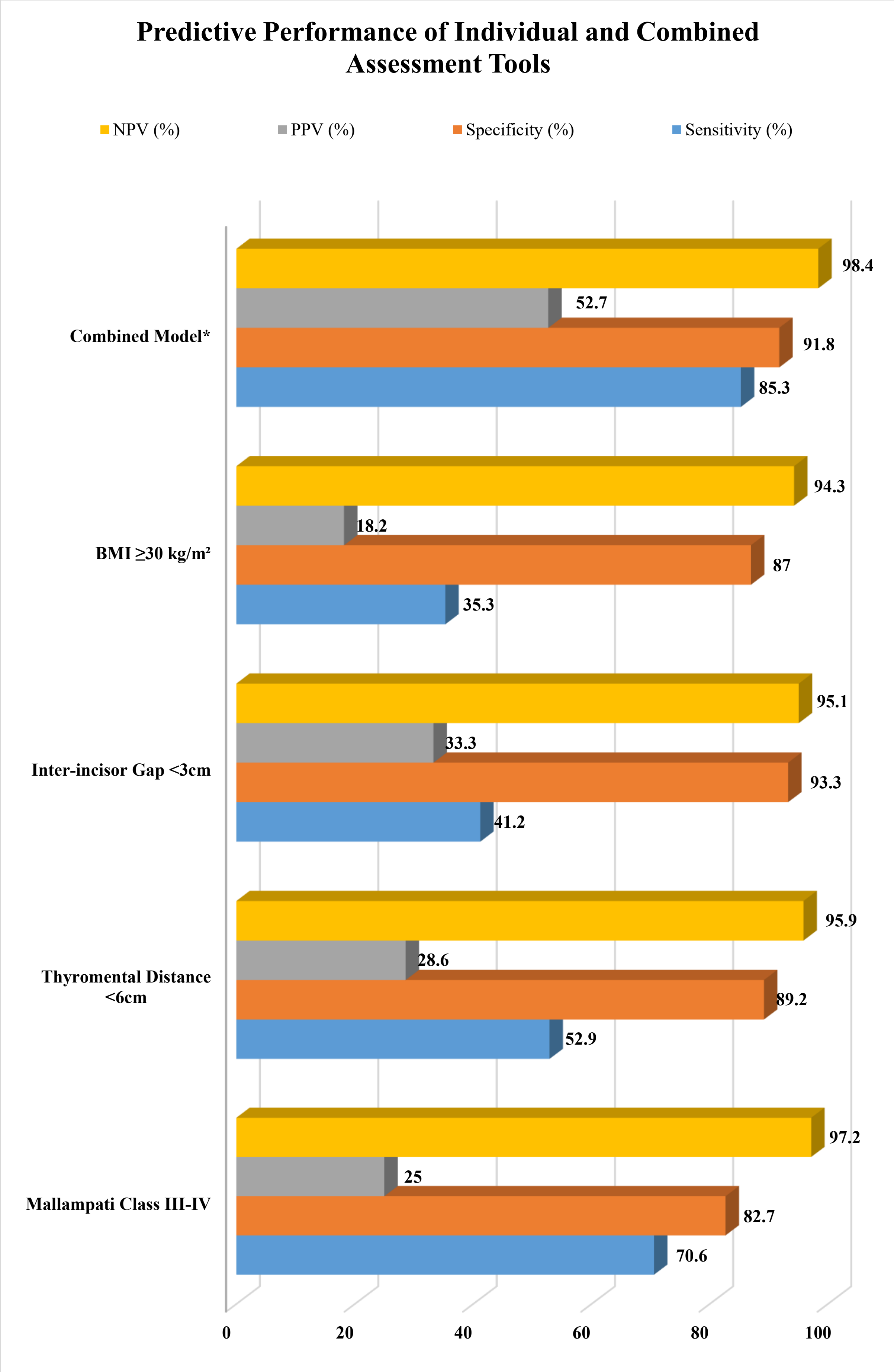
Predictive Performance of Individual and Combined Assessment Tools
NPV (%)
PPV (%)
Specificity (%)
Sensitivity (%)
Combined Model*
98.4
52.7
91.8
85.3
BMI ≥30 kg/m²
94.3
18.2
87
35.3
Inter-incisor Gap <3cm
95.1
33.3
93.3
41.2
Thyromental Distance <6cm
95.9
28.6
89.2
52.9
Mallampati Class III-IV
97.2
25
82.7
70.6
0
20
40
60
80
100

Fig: 5

Discussion

The present study identified a difficult intubation rate of 7.6% (34 out of 450 patients) in adult patients undergoing elective surgeries, which falls within the reported range of 1.5% to 13% in the literature (Shiga et al., 2005). This prevalence is consistent with findings from other Indian tertiary care centers, where rates between 3.8% and 8.5% have been reported (Prakash et al., 2013). The slightly higher incidence in our study may be attributed to the comprehensive definition of difficult intubation used, which included multiple attempts, prolonged intubation time, and requirement for alternative techniques.

The demographic analysis revealed no significant gender predilection for difficult intubation, with males representing 58.8% of difficult cases compared to 59.6% of easy intubations (p=0.930). This finding contrasts with some studies that reported higher rates in female patients due to anatomical differences (Cattano et al., 2004). The mean age of patients with difficult intubation was slightly higher, though not statistically significant, which aligns with previous research indicating age-related anatomical changes that may complicate intubation (Adnet et al., 2001).

Body mass index emerged as a significant independent predictor of difficult intubation in our study, with patients having BMI ≥30 kg/m² showing 3.89 times higher odds of difficult intubation (95% CI: 1.52-9.96, p=0.005). This finding is consistent with the meta-analysis by Lundstrøm et al. (2009), which demonstrated increased intubation difficulty in obese patients due to reduced neck mobility, increased soft tissue, and altered anatomical landmarks. The prevalence of obesity in our study population (14.7%) reflects the growing epidemic of obesity in India, making this finding particularly relevant for clinical practice.

Neck circumference greater than 40 cm was identified as an independent risk factor (adjusted OR: 2.98, 95% CI: 1.18-7.53, p=0.021), supporting previous research that identified neck circumference as a reliable predictor of difficult intubation (Gonzalez et al., 2008). The increased soft tissue around the neck in patients with larger neck circumference can obstruct visualization during laryngoscopy and reduce the effectiveness of cricoid pressure.

The Mallampati classification demonstrated the strongest association with difficult intubation in our study, with Class III-IV patients having 8.45 times higher odds of difficult intubation compared to Class I-II patients (95% CI: 3.67-19.46, p<0.001). This finding reinforces the continued clinical utility of the Mallampati test, despite its limitations noted in previous studies (Lee et al., 2006). The high specificity (82.7%) but moderate sensitivity (70.6%) of Mallampati Class III-IV in our study is consistent with existing literature, emphasizing the need for multiparameter assessment.

Thyromental distance less than 6 cm emerged as another strong predictor (adjusted OR: 6.23, 95% CI: 2.54-15.28, p<0.001), confirming its role as described by Patil et al. (1983). The thyromental distance reflects the mandibular space available for tongue displacement during laryngoscopy, and our findings support the traditional cutoff value of 6 cm for predicting difficult intubation. Similarly, inter-incisor gap less than 3 cm showed significant association (adjusted OR: 5.67, 95% CI: 2.12-15.18, p=0.001), highlighting the importance of adequate mouth opening for successful laryngoscopy.

Limited neck mobility was identified as an independent risk factor (adjusted OR: 2.67, 95% CI: 1.05-6.79, p=0.039), which is particularly relevant in the Indian population where cervical spine problems and arthritis are common. This finding aligns with studies by Tse et al. (1995), who demonstrated that adequate neck extension is crucial for optimal laryngoscopic view. The assessment of neck mobility in our study included both active and passive range of motion, providing a comprehensive evaluation of cervical spine function.

Previous history of difficult intubation showed the highest odds ratio in univariate analysis (OR: 8.17, 95% CI: 3.24-20.58) and remained significant in multivariate analysis (adjusted OR: 4.78, 95% CI: 1.45-15.76, p=0.011). This emphasizes the importance of detailed anesthetic history and documentation of previous airway management challenges, as recommended by the Difficult Airway Society guidelines (Frerk et al., 2015).

The combined multiparameter model demonstrated excellent predictive performance with an area under the curve of 0.886 (95% CI: 0.832-0.940), sensitivity of 85.3%, and specificity of 91.8%. This superior performance compared to individual predictors supports the concept of multiparameter assessment advocated by various airway management guidelines (Apfelbaum et al., 2013). The high negative predictive value (98.4%) of the combined model is particularly valuable for ruling out difficult intubation in clinical practice.

Individual predictors showed varying performance characteristics, with Mallampati classification demonstrating the highest area under the curve (0.766) among single parameters. This finding is consistent with the systematic review by Shiga et al. (2005), which identified Mallampati test as one of the most reliable single predictors, though with limited sensitivity when used alone.

The study revealed that 88.4% of patients were successfully intubated on the first attempt, which is consistent with success rates reported in elective surgical populations (Cook et al., 2011). The use of alternative techniques was required in 4.0% of cases, with video laryngoscopy being the most commonly employed rescue technique. This reflects the growing adoption of video laryngoscopy as a first-line tool for anticipated difficult intubation, as supported by recent guidelines (Frerk et al., 2015).

Complications occurred in 1.8% of cases, with desaturation being the most common (1.1%). This low complication rate reflects the elective nature of the procedures and the availability of experienced anesthesiologists and appropriate equipment. The complication rate is lower than reported in emergency settings, where rates of 10-15% are common (Mort, 2004).

Our findings show both similarities and differences when compared to international studies. The prevalence of difficult intubation in our study (7.6%) is higher than reported in some Western populations but similar to other Asian studies (Cattano et al., 2004). This may reflect genetic and anatomical differences in the study population, including shorter thyromental distances and different craniofacial morphology commonly observed in Asian populations.

The strong association between Mallampati classification and difficult intubation in our study is consistent with meta-analyses from diverse populations, though the specific odds ratios may vary. The cutoff values for thyromental distance and inter-incisor gap that we identified are similar to those reported in international literature, suggesting universal applicability of these measurements across different ethnic groups.

Conclusion

This prospective observational study identified a difficult intubation prevalence of 7.6% in adult patients undergoing elective surgeries, with Mallampati Class III-IV, thyromental distance less than 6 cm, BMI ≥ 30 kg/m², inter-incisor gap less than 3 cm, previous difficult intubation history, neck circumference greater than 40 cm, and limited neck mobility as independent risk factors. The combined multiparameter model demonstrated excellent predictive performance with 85.3% sensitivity and 91.8% specificity, significantly superior to individual predictors. These findings support the necessity of comprehensive preoperative airway assessment using multiple parameters rather than relying on single predictors. The study reinforces the clinical utility of classical bedside tests while highlighting the importance of anthropometric factors, particularly obesity-related parameters, in the contemporary surgical population.

Recommendations

Healthcare institutions should implement standardized preoperative airway assessment protocols incorporating the identified risk factors to enhance patient safety and optimize resource allocation for difficult intubation management. Training programs should emphasize multiparameter assessment techniques and ensure proficiency in alternative intubation methods, particularly video laryngoscopy, for cases with predicted difficult airways. Development of institution-specific difficult airway algorithms based on local population characteristics and available resources is recommended. Regular audits of intubation outcomes and continuous medical education focusing on airway management should be mandatory for anesthesiology staff. Future research should focus on validating simplified scoring systems incorporating these risk factors and exploring the role of emerging technologies such as point-of-care ultrasound in airway assessment. Collaboration between anesthesiology departments across different healthcare settings is essential for developing robust predictive models applicable to diverse patient populations.

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