Balık et al. BMC Anesthesiology (2025) 25:46
https://doi.org/10.1186/s12871-025-02926-1

BMC Anesthesiology

RESEARCH

Open Access

# Comparison of NoSAS score with STOP-Bang and Berlin scores in predicting difficult airway

Onurcan Balık[1], Eyyüp Sabri Özden[1*], Mustafa Soner Özcan[1], Filiz Alkaya Solmaz[1] and Pakize Kırdemir[1]

## Abstract

**Background** This study aimed to compare the effectiveness of the NoSAS, STOP-Bang, and Berlin scoring systems, which are utilized to predict obstructive sleep apnea syndrome (OSAS), in forecasting difficult airway management. Additionally, the study sought to determine which of these scoring systems is the most practical and effective for this purpose.

**Methods** Following the ethics committee approval, preoperative NoSAS, STOP-Bang, and Berlin scores were calculated for 420 patients aged 18 years and older who were scheduled for tracheal intubation. Mask ventilation and intubation were performed by research assistant with a minimum of two years of experience. Detailed examinations and recordings were conducted, including demographic data, neck circumference, OSAS diagnosis, history of difficult intubation, comorbidities, ASA classification, Mallampati classification, and Cormack-Lehane grade. Subsequently, the predictive efficacy of these three scoring systems for difficult mask ventilation and difficult intubation was compared.

**Results** In our study, 83 patients (19.8%) were classified as having difficult mask ventilation, and 101 patients (24.0%) were classified as having difficult intubation. The NoSAS score demonstrated a higher predictive power compared to the other scoring systems for difficult mask ventilation and difficult intubation. The cut-off value for the NoSAS score was determined to be 6.5 for predicting difficult mask ventilation and 7.5 for predicting difficult intubation.

**Conclusion** The routine implementation of the NoSAS score, an easy-to-use, rapid and objective tool primarily developed for OSAS screening, is likely to be effective in preoperatively identifying difficult airways in patients undergoing general anesthesia.

**Keywords** Berlin score, Difficult airway, NoSAS score, STOP-Bang score

## Background

The preoperative evaluation of a patient's airway is crucial, as difficult airway management is a leading cause of anesthesia-related morbidity and mortality. Difficult airway is supported by several studies measuring the prevalence and effects of difficult airways in anesthesia practice. The incidence of difficult face mask ventilation is % 1.4–5.0 and the incidence of difficulty intubating with a conventional laryngoscope is % 5–8. For every patient requiring tracheal intubation, an airway assessment must be performed to determine whether intubation can be safely achieved after the induction of general anesthesia or if it needs to be performed while the patient is awake. A comprehensive airway assessment should evaluate the difficulty of tracheal intubation and the efficacy of oxygenation methods, such as face mask ventilation and the use of supraglottic airway devices. Ensuring

*Correspondence:
Eyyüp Sabri Özden
dreyupsabri@gmail.com; eyyupozden@sdu.edu.tr
[1] Department of Anesthesiology and Reanimation, Faculty of Medicine, Suleyman Demirel University, Operating Room, Floor:1, Cunur, Isparta 32260, Turkey

optimal oxygenation and ventilation in an anesthetized patient is a primary responsibility of anesthesiologists, and any difficulty in airway management is a significant concern [1–4].

Various tests have been developed to predict the likelihood of a difficult airway preoperatively. Tests such as the modified mallampati test, Cormack-Lehane classification, upper lip bite test, thyromental height, thyromental distance, sternomental distance and neck circumference measurement are tests that predict preoperative difficult airway. An effective test should alert clinicians to potential airway difficulties, allowing them to make appropriate preparations. Difficulties in mask ventilation and intubation pose risks of prolonged apnea, which can lead to hypoxia and potentially fatal outcomes [5, 6].

Research indicates that a obstructive sleep apnea syndrome (OSAS) may be associated with difficulties in airway management during anesthesia. The American Society of Anesthesiologists (ASA) recommends managing patients with known or suspected OSAS according to difficult airway guidelines due to potential challenges with ventilation, laryngoscopy, and intubation [7–9]. 80–90% of patients with OSAS remain undiagnosed. To address this, simple and quick bedside screening tests like the NoSAS, STOP-Bang, and Berlin scores have been developed [10]. The NoSAS score is a new screening tool that was defined in 2016 as an easy-to-use, short time-consuming and objective scale. Although there are many studies describing the relationship between STOP-Bang and Berlin scores and difficult airway, there is no study in the literature addressing the relationship between the NoSAS score and difficult airway [11].

The objective of this study is to evaluate the predictive efficacy of the NoSAS, STOP-Bang and Berlin scores in identifying patients at risk of a difficult airway during general anesthesia. Furthermore, the objective is to ascertain which of these scores is more applicable in routine preoperative evaluation.

## Methods

This prospective observational study received approval from the Clinical Research Ethics Committee of Süleyman Demirel University (decision number 41, dated March 6, 2023).

A power analysis was conducted using GPower v.3.1.9.2 (University of Kiel, Kiel, Germany). Given that three different OSAS scales were applied to the same group, repeated measures ANOVA was used to determine the required sample size. For a single group with three repeated measurements, an effect size of $d=0.09$ was used, resulting in a total sample size of $n=320$ for 95% power and a 0.05 error rate.

The NoSAS, STOP-Bang, and Berlin scores were calculated for 420 patients aged 18 years and older who were scheduled for elective surgery requiring tracheal intubation between April and July 2023. Mask ventilation and intubation were performed by research assistant with a minimum of two years of experience in anesthesiology and reanimation, and the results were recorded in the patient follow-up forms.

Patients with a history of head and neck surgery, burns, trauma, radiotherapy, or head and neck anomalies, those scheduled for head and neck surgery, obstetric patients, those undergoing awake fiber optic intubation, those for whom the primary choice for ventilation under general anesthesia was a laryngeal mask, patients under 18 years of age, those requiring rapid sequence intubation, and those needing emergency surgery were excluded from the study.

Demographic information, neck circumference, diagnosis of OSAS, use of continuous positive airway pressure (CPAP) or bilevel positive airway pressure (BIPAP), history of difficult intubation, comorbidities, presence of snoring, smoking status, ASA classification, type of surgery, Mallampati classification, and Cormack-Lehane grade were recorded in detail.

The STOP-Bang score consists of four yes/no questions related to snoring, fatigue, apnea, and hypertension, as well as four additional demographic questions concerning body mass index (BMI) ($\geq 35$ kg/m$^2$), age ($>50$ years), neck circumference ($>40$ cm), and gender (male). Each question is scored 1 point, yielding a total score range of 0–8 [12]. The Berlin score is self-administered and consists of 10 questions categorized into three groups: presence and severity of snoring, frequency of daytime sleepiness, and presence of obesity or hypertension [13]. The NoSAS score includes parameters such as neck circumference, BMI, gender, age, and snoring, with a total score ranging from 0 to 17 [11].

The NoSAS, STOP-Bang, and Berlin scores were calculated for patients either one day before or during the preoperative period in the recovery unit. Neck circumference measurements for the NoSAS and STOP-Bang scores were taken at the level of the thyroid cartilage with the patient in a neutral head position. For the STOP-Bang score, patients with at least three positive responses were classified as high risk, and those with fewer than three positive responses were classified as low risk [12]. In the Berlin score, a high-risk classification was assigned if two or more categories were positive, while one positive category indicated low risk [13]. For the NoSAS score, a score of 8 or above indicated high risk, and a score below 8 indicated low risk [11].

The mask ventilation difficulty scale developed by Han et al. was used to determine the difficulty of mask ventilation. According to this scale, V1 indicates easy mask ventilation by one person, V2 indicates mask ventilation with airway assistance by one person, V3 indicates adequate ventilation with two persons, and V4 indicates patients who cannot be ventilated at all. V3 and V4 were considered difficult mask ventilation [14]. Adnet et al. developed the intubation difficulty scale (IDS) to provide a reproducible and quantitative method for assessing the complexity of intubation. This scale aims to objectively evaluate intubation difficulty based on seven different parameters. Patients with an IDS score above 5 were classified as having difficult intubation [15] (Table 1).

For the induction of anesthesia, 0.05 mg/kg midazolam, 2 mg/kg propofol (or 2–5 mg/kg sodium thiopental), 1 mg/kg lidocaine, and 1 μg/kg fentanyl were administered following routine monitoring (ECG, non-invasive blood pressure, and oxygen saturation). To facilitate tracheal intubation, 0.6 mg/kg rocuronium was administered. Laryngoscopy and intubation were performed 120 s after the administration of rocuronium in the standard sniffing position. Following general anesthesia induction, mask ventilation and intubation were evaluated using the mask ventilation difficulty scale and IDS. The adequacy of mask ventilation was assessed using capnography, chest movement, and pulse oximetry. The first attempt at laryngoscopy was performed using a Macintosh laryngoscope, and the Cormack-Lehane grade was recorded. Patients with a Cormack-Lehane Grade 3 or 4 underwent external laryngeal pressure. If external laryngeal pressure did not improve the grade, intubation was performed using video laryngoscopy.

### Statistical analysis

The data were analyzed using IBM SPSS Statistics 23 (IBM Inc., Chicago, IL, USA). Descriptive statistics for continuous variables are presented as mean ± standard deviation, while categorical variables are described using frequencies (n) and percentages (%). The chi-square test was employed for comparisons between categorical variables. The normal distribution of continuous variables was assessed using the Kolmogorov–Smirnov test, and the homogeneity of variances was verified with Levene's test. Comparisons between groups for non-normally distributed data were conducted using the Kruskal–Wallis test and the Mann–Whitney U test. A significance level of $p < 0.05$ was applied to all analyses.

To determine the agreement between the NoSAS, STOP-Bang, and Berlin scores with the mask ventilation difficulty scale and IDS, sensitivity and specificity were calculated as part of diagnostic testing. For a more effective comparison of the three tests' abilities to predict difficult intubation and difficult mask ventilation, receiver operating characteristic (ROC) curves were generated, and the areas under the curves (AUC) along with optimal cut-off values were determined and compared.

## Results

Of the 420 patients who underwent elective surgery under general anesthesia and participated in this study, 245 (58.3%) were female and 175 (41.7%) were male. The demographic data, preoperative characteristics, and airway features of the patients are detailed in Table 2.

No patients were classified as V4. Among the participants, 83 patients (19.8%) were classified as V3, and 101 patients (24.0%) were classified as having difficult intubation (IDS > 5). Video laryngoscopy was performed for intubation in 19 patients (4.5%). The Mallampati class III was observed in 95 patients (22.6%), while class IV was observed in 18 patients (4.3%). Cormack-Lehane grades 3 were observed in 57 patients (13.6%), while grades 4 were observed in nine patients (2.1%). Intubation was performed by two operators for 43 patients (10.2%) and by three operators for two patients (0.5%). Two intubation attempts were made for 50 patients (11.9%), three for 10 patients (2.4%), and four for one patient (0.2%). Only one patient (0.2%) required the use of an adjunct airway device (Table 2).

**Table 1** Intubation difficulty scale (15)

| Intubation Difficulty Scale | | | | | |
|---|---|---|---|---|---|
| Number of Intubation Attempts > 1 (N1) | Each attempt = 1 point | | | | …. points |
| Number of Operators > 1 (N2) | Each operator = 1 point | | | | …. points |
| Alternative Intubation Techniques (N3) | Each alternative technique (e.g., blade/laryngoscope change, bougie guide, Fastrach, video laryngoscope, fiber-optic intubation, or other adjunct airway devices) = 1 point | | | | ….. points |
| Cormack-Lehane Grade (N4) | Grade 1 = 0 points | Grade 2 = 1 point | Grade 3 = 2 points | Grade 4 = 3 points | …. points |
| Need for Mandibular Elevation (N5) | Normal = 0 points | | Elevated = 1 point | | …. points |
| External Laryngeal Pressure (N6) | Not applied = 0 points | | Applied = 1 point | | …. points |
| Vocal Cord Movement (N7) | Abduction = 0 points | Adduction = 1 point | | Vocal cords not visible = 0 points | …. points |

**Table 2** Demographic data, preoperative characteristics and airway features

| | | |
|---|---|---|
| **Demographic Data** | | **Mean ± SD** |
| **BMI (kg/m$^2$)** | | 27.32 ± 5.22 |
| **Neck Circumference (cm)** | | 39.25 ± 5.32 |
| **Age (years)** | | 50.85 ± 15.35 |
| **Preoperative Characteristics** | | **n (%)** |
| **OSAS Diagnosis** | | 11 (2.6) |
| **CPAP/BIPAP Use** | | 6 (1.4) |
| **History of Difficult Intubation** | | 12 (2.9) |
| **Smoking** | | 147 (35.0) |
| **Snoring** | | 208 (49.5) |
| **Hypertension** | | 125 (29.8) |
| **ASA Classification** | **I** | 62 (14.8) |
| | **II** | 266 (63.3) |
| | **III** | 90 (21.4) |
| | **IV** | 2 (0.5) |
| **Airway Features** | | **n (%)** |
| **Difficult Mask Ventilation** | **V1** | 226 (53.8) |
| | **V2** | 111 (26.4) |
| | **V3** | 83 (19.8) |
| **Intubation Difficulty Scale** | **Easy (≤ 5)** | 319 (76.0) |
| | **Difficult (> 5)** | 101 (24.0) |
| **Intubation Method** | **Macintosh laryngoscopy** | 401(95.5) |
| | **Video laryngoscopy** | 19 (4.5) |
| **Mallampati Classification** | **I** | 82 (19.5) |
| | **II** | 225 (53.6) |
| | **III** | 95 (22.6) |
| | **IV** | 18 (4.3) |
| **Cormack-Lehane Grade** | **1** | 244 (58.1) |
| | **2** | 110 (26.2) |
| | **3** | 57 (13.6) |
| | **4** | 9 (2.1) |
| **Number of Operators** | **1** | 375 (89.3) |
| | **2** | 43 (10.2) |
| | **3** | 2 (0.5) |
| **Number of Attempts** | **1** | 359 (85.5) |
| **Airway Features** | | **n (%)** |
| **Number of Attempts** | **2** | 50 (11.9) |
| | **3** | 10 (2.4) |
| | **4** | 1 (0.2) |
| **Use of Adjunct Airway Device** | | 1 (0.2) |
| **Trauma** | | 4 (1.0) |

*ASA* American Society of Anesthesiologists, *BIPAP* bi-level positive airway pressure, *BMI* body mass index, *CPAP* continuous positive airway pressure, *OSAS* obstructive sleep apnea syndrome, *SD* standard deviation, *V1* mask ventilation easily performed by one person, *V2* mask ventilation with airway assistance by one person, *V3* adequate ventilation with two persons. Data are shown as mean ± SD and n (%)

A statistically significant difference was observed in methods of mask ventilation based on gender ($p < 0.001$). Among patients with a mask ventilation difficulty score of V3, 31 (37.3%) also experienced difficult intubation. A significant correlation was found between the mask ventilation difficulty scale and the IDS ($p < 0.001$). Additionally, statistically significant associations were identified between the mask ventilation difficulty scale and various factors, including intubation method, OSAS diagnosis, ASA classification, Mallampati classification, Cormack-Lehane grade, number of intubation operators, number of attempts, BMI, age, and intubation time (Table 3).

A statistically significant difference was found between ASA score, Mallampati classification and intubation difficulty scale ($p < 0.05$). In patients with difficult intubation (IDS > 5), the number of patients with OSAS diagnosis and CPAP/BIPAP users was higher and statistically significant ($p < 0.001$). In patients with difficult intubation, smoking and snoring complaints were found to be higher and statistically significant ($p < 0.05$). The intubation difficulty scale rate of men was found to be higher and statistically significant compared to women ($p = 0.001$) (Table 4).

The average NoSAS score was 7.78, the STOP-Bang score was 2.56 and the Berlin score was 1.02. Based on these scores, 209 patients (49.8%) were classified as high risk using the NoSAS score, 214 patients (51.0%) using the STOP-Bang score and 204 patients (48.6%) using the Berlin score (Table 5).

Significant differences in mask ventilation methods were observed based on the NoSAS, STOP-Bang, and Berlin scores ($p < 0.001$) (Table 6). Following this, ROC analysis was conducted, revealing AUC values of 0.723 for the NoSAS score, 0.704 for the STOP-Bang score, and 0.679 for the Berlin score (Table 7). The NoSAS score emerged as the most reliable index for differentiating levels of mask ventilation difficulty. The cut-off value for the NoSAS score was established at 6.5, with reference values identified for different groups (Fig. 1).

Significant differences were also found in the IDSs based on the NoSAS, STOP-Bang, and Berlin scores ($p < 0.001$) (Table 6). ROC analysis yielded AUC values of 0.721 for the NoSAS score, 0.703 for the STOP-Bang score, and 0.666 for the Berlin score (Table 8). Consequently, the NoSAS score was determined to be the most reliable measure for differentiating levels of intubation difficulty. The cut-off value for the NoSAS score was established at 7.5, with reference values for different groups detailed (Fig. 2).

**Table 3** Relationship between categorical variables and the mask ventilation difficulty scale

| | | Mask Ventilation Difficulty Scale | | | |
|---|---|---|---|---|---|
| | | (V1) | (V2) | (V3) | p |
| **Gender** | **Female** | 172 (76.1) | 44 (39.6) | 29 (34.9) | < 0.001* |
| | **Male** | 54 (23.9) | 67 (60.4) | 54 (65.1) | |
| **Intubation Difficulty Scale** | **Easy (≤ 5)** | 196 (86.7) | 71 (64.0) | 52 (62.7) | < 0.001* |
| | **Difficult (> 5)** | 30 (13.3) | 40 (36.0) | 31 (37.3) | |
| **Intubation Method** | **Macintosh laryngoscopy** | 222 (98.2) | 101 (91.0) | 78 (94.0) | 0.006* |
| | **Video laryngoscopy** | 4 (1.8) | 10 (9.0) | 5 (6.0) | |
| **OSAS Diagnosis** | **Absent** | 224 (99.1) | 106 (95.5) | 79 (95.2) | 0.035* |
| | **Present** | 2 (0.9) | 5 (4.5) | 4 (4.8) | |
| **ASA Classification** | **I** | 49 (21.7) | 6 (5.4) | 7 (8.4) | < 0.001* |
| | **II** | 142 (62.8) | 70 (63.1) | 54 (65.1) | |
| | **III** | 35 (15.5) | 34 (30.6) | 21 (25.3) | |
| | **IV** | 0 (0.0) | 1 (0.9) | 1 (1.2) | |
| **Mallampati Classification** | **I** | 58 (25.7) | 14 (12.6) | 10 (12.0) | < 0.001* |
| | **II** | 126 (55.8) | 60 (54.1) | 39 (47.0) | |
| | **III** | 38 (16.8) | 32 (28.8) | 25 (30.1) | |
| | **IV** | 4 (1.8) | 5 (4.5) | 9 (10.8) | |
| **Cormack-Lehane Grade** | **1** | 178 (78.8) | 33 (29.7) | 33 (39.8) | < 0.001* |
| | **2** | 41 (18.1) | 49 (44.1) | 20 (24.1) | |
| | **3** | 7 (3.1) | 24 (21.6) | 26 (31.3) | |
| | **4** | 0 (0.0) | 5 (4.5) | 4 (4.8) | |
| **Number of Operators** | **1** | 212 (93.8) | 89 (80.2) | 74 (89.2) | 0.001* |
| | **2** | 14 (6.2) | 20 (18.0) | 9 (10.8) | |
| | **3** | 0 (0.0) | 2 (1.8) | 0 (0.0) | |
| **Number of Attempts** | **1** | 207 (91.6) | 84 (75.7) | 68 (81.9) | < 0.001* |
| | **2** | 18 (8.0) | 19 (17.1) | 13 (15.7) | |
| | **3** | 1 (0.4) | 7 (6.3) | 2 (2.4) | |
| | **4** | 0 (0.0) | 1 (0.9) | 0 (0.0) | |
| **BMI (kg/m$^2$)** | | 26.00 ± 4.69 | 28.50 ± 5.33 | 29.35 ± 5.47 | < 0.001* |
| **Age (years)** | | 46.83 ± 15.14 | 55.33 ± 14.63 | 55.81 ± 13.81 | < 0.001* |
| **Intubation Duration (sec)** | | 10.69 ± 7.13 | 16.41 ± 17.78 | 16.28 ± 15.15 | 0.001* |

*ASA* American Society of Anesthesiologists, *BMI* body mass index, *OSAS* obstructive sleep apnea syndrome. *$p < 0.05$, chi-square test/Kruskal–Wallis H test. Data are shown as n (%) and mean ± SD

## Discussion

The current study evaluated the effectiveness of the NoSAS, STOP-Bang, and Berlin scores in predicting difficult airways in patients undergoing general anesthesia. Our results show that while all three scores were effective in predicting difficult mask ventilation and intubation, the Berlin score was less reliable and more time-consuming to calculate compared to the NoSAS and STOP-Bang scores. Given its quicker computation, ease of application, and objectivity, we propose that the NoSAS score be routinely used in preoperative assessments.

Currently, scales such as NoSAS, STOP-Bang, and Berlin are commonly employed in the clinical screening of OSAS. While the STOP-Bang and Berlin scores incorporate subjective factors such as snoring, fatigue, and daytime sleepiness, the NoSAS score, developed in 2016 with initial testing in the HypnoLaus cohort from Lausanne, Switzerland and later validation in the EPISONO cohort undergoing polysomnography, relies on more objective criteria, including age, gender, neck circumference, and BMI. Snoring is the sole subjective factor. The NoSAS score is noted for its objectivity and user-friendliness and has demonstrated comparable or superior effectiveness in detecting OSAS relative to the STOP-Bang and Berlin scores [10, 11, 16–22].

In a retrospective study the use of the STOP-Bang score for predicting difficult airways was evaluated in 200 patients who received general anesthesia in 2022.

**Table 4** Relationship between categorical variables and intubation difficulty scale

| | | Intubation Difficulty Scale | | |
|---|---|---|---|---|
| | | Easy (≤ 5) | Difficult (> 5) | p |
| **ASA** | **I** | 54 (16.9) | 8 (7.9) | 0.015* |
| | **II** | 204 ( 63.9) | 62 (61.4) | |
| | **III** | 59 (18.5) | 31 (30.7) | |
| | **IV** | 2 (0.6) | 0 (0.0) | |
| **Mallampati Classification** | **I** | 76 (23.8) | 6 (5.9) | < 0.001* |
| | **II** | 180 (56.4) | 45 (44.6) | |
| | **III** | 57 (17.9) | 38 (37.6) | |
| | **IV** | 6 (1.9) | 12 (11.9) | |
| **Cigarette** | **Absent** | 216 (67.7) | 57 (56.4) | 0.038* |
| | **Present** | 103 (32.3) | 44 (43.6) | |
| **OSAS Diagnosis** | **Absent** | 316 (99.1) | 93 (92.1) | < 0.001* |
| | **Present** | 3 (0.9) | 8 (7.9) | |
| **CPAP/BIPAP use** | **Absent** | 319 (100.0) | 95 (94.1) | < 0.001* |
| | **Present** | 0 (0.0) | 6 (5.9) | |
| **Snoring** | **Absent** | 186 (58.3) | 26 (25.7) | < 0.001* |
| | **Present** | 133 (41.7) | 75 (74.3) | |
| **Gender** | **Female** | 201 (63.0) | 44 (43.6) | 0.001* |
| | **Male** | 118 (37.0) | 57 (56.4) | |

*ASA* American Society of Anesthesiologists, *BIPAP* bi-level positive airway pressure, *CPAP* continuous positive airway pressure, *OSAS* obstructive sleep apnea syndrome. *$p < 0.05$, chi-square test/Kruskal–Wallis H test. Data are shown as n (%)

Among these patients, 45 experienced difficulty with intubation, and 73 encountered difficulty with mask ventilation. The study found a moderate positive correlation between a high STOP-Bang score and difficult airway management. The authors concluded that the STOP-Bang score, particularly a score of 5 or above, could serve as an independent predictor of a difficult airway, comparable to other established airway assessment parameters [23]. There is no existing study specifically evaluating the NoSAS score in this context.

In a meta-analysis which reviewed 16 studies including 335,846 patients, males were found to be approximately twice as likely to be associated with difficult mask ventilation [24]. The definition of difficult mask ventilation is subjective and observer-dependent, which may result in varying frequencies across studies and populations. Srivilaithon et al. found the incidence of difficult intubation to be 12.95% in their retrospective study of 1641 patients in the emergency department. It was found that 74.5% of these patients were male [25]. Consistent with many previous studies, our findings revealed a significant association between male gender and difficult mask ventilation and difficult intubation.

It is important to remember that the ultimate goal of airway management is successful oxygenation rather than tracheal intubation. Failure of tracheal intubation does not directly lead to negative outcomes such as death or

**Table 5** NoSAS, STOP-Bang and Berlin scores

| | mean ± SD | | n (%) |
|---|---|---|---|
| **NoSAS Score** | 7.78 ± 5.05 | **Low** (< 8 points) | 211 (50.2) |
| | | **High** (≥ 8 points) | 209 (49.8) |
| **STOP-Bang score** | 2.56 ± 1.90 | **Low** (< 3 question positive) | 206 (49.0) |
| | | **High** (≥ 3 question positive) | 214 (51.0) |
| **Berlin score** | 1.02 ± 0.97 | **Low** (Number of positive categories 0/1) | 216 (51.4) |
| | | **High** (Number of positive categories 2/3) | 204 (48.6) |

Data are shown as mean ± SD and n (%)

**Table 6** Relationship between scoring systems and the mask ventilation difficulty scale and intubation difficulty scale

| | | Mask Ventilation Difficulty Scale | | | | Intubation Difficulty Scale | | |
|---|---|---|---|---|---|---|---|---|
| | | V1 | V2 | V3 | p | Easy | Difficult | p |
| **NoSAS score** | **Low** | 157 (69.5) | 31 (27.9) | 23 (27.7) | < 0.001* | 189 (59.2) | 22 (21.8) | < 0.001* |
| | **High** | 69 (30.5) | 80 (72.1) | 60 (72.3) | | 130 (40.8) | 79 (78.2) | |
| **STOP-Bang score** | **Low** | 154 (68.1) | 32 (28.8) | 20 (24.1) | < 0.001* | 180 (56.4) | 26 (25.7) | < 0.001* |
| | **High** | 72 (31.9) | 79 (71.2) | 63 (75.9) | | 139 (43.6) | 75 (74.3) | |
| **Berlin score** | **Low** | 152 (67.3) | 37 (33.3) | 27 (32.5) | < 0.001* | 180 (56.4) | 36 (35.6) | < 0.001* |
| | **High** | 74 (32.7) | 74 (66.7) | 56 (67.5) | | 139 (43.6) | 65 (64.4) | |

*V1* mask ventilation easily performed by one person, *V2* mask ventilation with airway assistance by one person, *V3* adequate ventilation with two persons. *$p < 0.05$, chi-square test. Data are shown as n (%)

**Table 7** Areas Under the Curve (AUC) of NoSAS, STOP-Bang and Berlin scoring systems in predicting difficult mask ventilation

| | AUC | Standard error | p | Cut-off | Sensitivity | Specificity | Lower limit | Upper limit |
|---|---|---|---|---|---|---|---|---|
| NoSAS score | 0.723 | 0.028 | < 0.001* | 6.5 | 0.819 | 0.499 | 0.669 | 0.778 |
| STOP-Bang score | 0.704 | 0.029 | < 0.001* | 2.5 | 0.759 | 0.552 | 0.648 | 0.76 |
| Berlin score | 0.679 | 0.033 | < 0.001* | 1.5 | 0.518 | 0.724 | 0.615 | 0.743 |

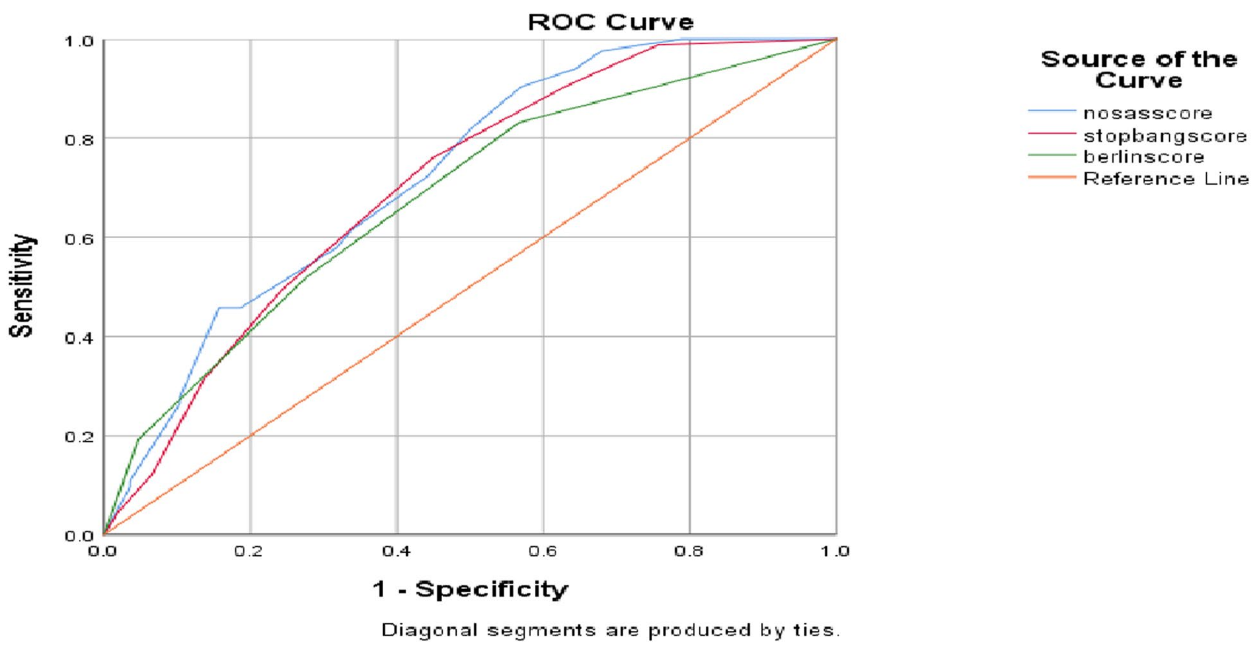


**Fig. 1** ROC curve comparing the effectiveness of NoSAS, STOP-Bang, and Berlin scoring systems in predicting difficult mask ventilation

**Table 8** Areas Under the Curve (AUC) of NoSAS, STOP-Bang and Berlin scoring systems in predicting difficult intubation

| | AUC | Standard error | p | Cut-off | Sensitivity | Specificity | Lower limit | Upper limit |
|---|---|---|---|---|---|---|---|---|
| NoSAS score | 0.721 | 0.028 | < 0.001* | 7.5 | 0.782 | 0.592 | 0.666 | 0.776 |
| STOP-Bang score | 0.703 | 0.030 | < 0.001* | 3.5 | 0.535 | 0.784 | 0.644 | 0.762 |
| Berlin score | 0.666 | 0.031 | < 0.001* | 1.5 | 0.505 | 0.734 | 0.606 | 0.726 |

brain damage when mask ventilation is adequate. Xue et al. emphasized that difficult mask ventilation often accompanies difficult or impossible tracheal intubation in about one-third of cases [5]. Therefore, difficult mask ventilation should be addressed as a more critical issue than tracheal intubation failure in anesthetized patients [26]. In a study evaluating 294 patients, 31.6% of patients had difficult mask ventilation and 3% had difficult intubation [27]. The classic scenario where anesthesiologists face difficulties in mask ventilation and intubation is one of the most feared and challenging situations. The ability to predict such situations allows anesthesiologists to prepare using alternative airway management techniques, such as laryngeal masks, fiber optics, and video laryngoscopy. We also found a significant relationship between the IDS and difficult mask ventilation ($p < 0.001$). Thus, considering the proportional difficulty of intubation with mask ventilation, appropriate measures should be taken.

Khan et al. performed a prospective study on 530 patients and identified difficult mask ventilation in 84 patients (15.8%) and found the STOP-Bang score as 3 or higher in 139 patients. A STOP-Bang score of 3 or higher was found to predict difficult mask ventilation with a sensitivity of 65.48% and specificity of 81.17%, the researchers suggested that the preoperative STOP-Bang score could be useful in predicting difficult mask

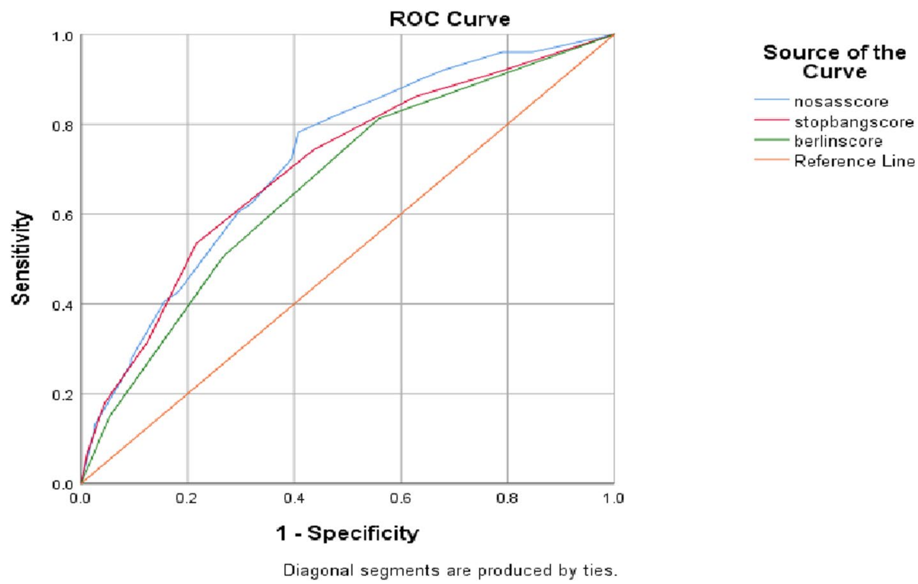


**Fig. 2** ROC curve comparing the effectiveness of NoSAS, STOP-Bang, and Berlin scoring systems in predicting difficult intubation

ventilation [28]. Their findings are similar to our results. A prospective observational study involving 250 patients, the authors evaluated the difficulty of mask ventilation and the IDS after anesthesia induction, using a STOP-Bang score cut-off value of 3. The study identified 102 patients with a STOP-Bang score $\geq 3$ (Group H) and 148 patients with a score $< 3$ (Group L). The incidence of difficult mask ventilation during induction was significantly higher in Group H (59.8%) compared to Group L (4.05%) ($p < 0.001$). Additionally, Group H had a higher incidence of difficult intubation ($p < 0.001$) [29]. In our study, among patients with a mask ventilation difficulty score of V3, 72.3% had a high NoSAS score, 75.9% had a high STOP-Bang score, and 67.5% had a high Berlin score. ROC analysis of the mask ventilation methods and the three scoring systems showed that the NoSAS score was the most reliable index for predicting mask ventilation difficulty, with a cut-off value of 6.5. The cut-off values for the STOP-Bang and Berlin scores were 2.5 and 1.5, respectively. Thus, we find the NoSAS score to be preferable compared to other scoring systems due to its ease of application and higher reliability in predicting difficult mask ventilation.

Our study highlights that high NoSAS, Berlin, and STOP-Bang scores are all associated with high IDS values and are linked to difficult intubation scenarios. Among difficult intubation patients, 78.2% had a high NoSAS score, 74.3% had a high STOP-Bang score, and 64.4% had a high Berlin score. The AUC values for the NoSAS, STOP-Bang, and Berlin tests were 0.721, 0.703, and 0.666, respectively. Thus, the NoSAS score was found to be the most reliable index for distinguishing degrees of intubation difficulty, with a cut-off value of 7.5. Similar to our findings, Mahmoud et al. identified high STOP-Bang scores as a risk factor for difficult intubation [30]. In a single-center study 200 patients undergoing elective surgery were evaluated using the STOP-Bang score. The difficult intubation rate was 78.6% in the high-risk group and 38.7% in the low-risk group [31]. However, Neligan et al. reported unexpectedly that obstructive sleep apnea was not associated with difficult intubation, possibly due to their study's limited scope of only six difficult intubation cases among 180 patients [32]. Results of this and similar previous studies suggest that some difficult intubation cases may have been missed, potentially due to preoperative OSAS being overlooked. Gokay et al. discovered that the STOP-Bang score was more effective than the Berlin score in predicting difficult intubation for patients at high risk for OSAS. The authors recommended the regular use of these scores and the creation of clinical protocols for anesthesia and postoperative care, highlighting the STOP-Bang score's superior effectiveness in detecting complications and its quicker application [33]. On the other hand, given its high success rate in predicting difficult intubation, ease of use, and lower subjectivity, we recommend using the NoSAS score for routine preoperative assessments.

Our study's limitations include the lack of analysis of other difficult airway indicators such as thyromental distance, mouth opening, and jaw movement. Evaluating these criteria alongside the NoSAS score during preoperative assessment could further enhance the value of the

NoSAS score in predicting airway management difficulties. Another limitation was that the procedures were not performed by a single individual, which could have affected consistency.

## Conclusions

Preoperative assessment of all surgical patients using quick and easily applicable bedside screening tests is essential for identifying difficult airways and preparing anesthesiologists for potential perioperative complications.

A ROC analysis was conducted due to the statistically significant correlation observed between the mask ventilation difficulty scale, the intubation difficulty scale and all three scoring systems. The results demonstrated that the NoSAS score exhibited a superior predictive capacity in comparison to the other scoring systems with regard to predicting difficult mask ventilation and difficult intubation. The optimal cut-off value for the NoSAS score in predicting difficult mask ventilation was determined to be 6.5, while the optimal cut-off value for predicting difficult intubation was 7.5.

Although there are many studies explaining the relationship between STOP-Bang and Berlin scores and difficult airway, there is no study in the literature that addresses the relationship between NoSAS score and difficult airway. We believe that preoperative use of the NoSAS score, which is an easy-to-use, rapid and objective scale and was first developed as a simple but effective tool for OSAS screening, will be successful in the detection of difficult airway in all patients receiving general anesthesia. Future research should include larger studies with different populations, validation of the findings in different clinical settings and further investigation of the relationship between the NoSAS score and other airway determinants in predicting difficult airway.

### Abbreviations

| | |
|---|---|
| OSAS | Obstructive sleep apnea syndrome |
| ASA | American Society of Anesthesiologists |
| CPAP | Continuous positive airway pressure |
| BIPAP | Bilevel positive airway pressure |
| BMI | Body mass index |
| IDS | Intubation difficulty scale |
| ROC | Receiver operating characteristic |
| AUC | Areas under the curves |

### Acknowledgements

We would like to express our gratitude to Tony Karakas, one of the editors whose native language is English, for his meticulous editing of our work, ensuring its accuracy and adherence to the highest standards of English language, grammar, punctuation, spelling, and general style.

### Authors' contributions

OB and ESO: Conceptualization, Methodology, Formal analysis, Writing – original draft and editing. MSO and FAS: Conceptualization, Writing—original draft and editing, Methodology and Investigation. FAS and PK: Methodology and editing.

### Funding

The authors received no financial support for this study.

### Data availability

The data for this study are not publicly available due to sensitivity and are available from the corresponding author upon reasonable request.

## Declarations

### Ethics approval and consent to participate

This study was approved by the Süleyman Demirel University Clinical Research Ethics Committee (decision number 41, dated March 6, 2023). An informed consent to participate was obtained from all of the participants in the study.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

Received: 1 September 2024 Accepted: 23 January 2025
Published online: 29 January 2025

### References

1. Apfelbaum JL, Hagberg CA, Connis RT, Abdelmalak BB, Agarkar M, Dutton RP, Fiadjoe JE, Greif R, Klock PA, Mercier D, Myatra SN, O'Sullivan EP, Rosenblatt WH, Sorbello M, Tung A. 2022 American Society of Anesthesiologists practice guidelines for management of the difficult airway. Anesthesiology. 2022;136:31–81.
2. Jung H. A comprehensive review of difficult airway management strategies for patient safety. Anesth Pain Med. 2023;18:331–9. https://doi.org/10.17085/apm.23123.
3. Toshniwal G, McKelvey GM, Wang H. STOP-Bang and prediction of difficult airway in obese patients. J Clin Anesth. 2014;26:360–7.
4. Law JA, Duggan LV, Asselin M, Baker P, Crosby E, Downey A, Hung OR, Kovacs G, Lemay F, Noppens R, Parotto M, Preston R, Sowers N, Turkstra TP, Wong DT, Jones PM, Canadian airway focus group. Canadian Airway Focus Group updated consensus based recommendations for management of the difficult airway: part 2. Planning and implementing safe management of the patient with an anticipated difficult airway. Can J Anaesth. 2021;68:1405–36.
5. Xue F-S, Liu Q-J. Tracheal intubation awake or under anesthesia for potential difficult airway: look before you leap. Chin Med J. 2018;131:753–66.
6. Roth D, Pace NL, Lee A, Hovhannisyan K, Warenits AM, Arrich J, Herkner H. Aiway physical examination tests for detection of difficult airway management in apparently normal adult patients. Cochrane Database Syst Rev. 2018;5:CD008874.
7. Carron M, Ieppariello G, SafaeeFakhr B, Foletto M. Perioperative care of the obese patient: a successful approach. Br J Surg. 2020;107:772–3.
8. Nagappa M, Wong DT, Cozowicz C, Ramachandran SK, Memtsoudis SG, Chung F. Is obstructive sleep apnea associated with difficult airway? Evidence from a systematic review and meta-analysis of prospective and retrospective cohort studies. PLoS ONE. 2018;13:204–8.
9. Mathangi K, Mathews J, Mathangi CD. Assessment of perioperative difficult airway among undiagnosed obstructive sleep apnoea patients undergoing elective surgery: A prospective cohort study. Indian J Anaesth. 2018;62:538–44.
10. Hong C, Chen R, Qing S, Kuang A, Yang HJ, Su X, Zhao D, Wu K, Zhang N. Validation of the NoSAS score for the screening of sleep-disordered breathing: a hospital-based retrospective study in China. J Clin Sleep Med. 2018;14:191–7.
11. Marti-Soler H, Hirotsu C, Marques-Vidal P, Vollenwider P, Waeber G, Preisig M, Tafti M, Tufik SB, Bittencourt L, Tufik S, Haba-Rubio J, Heinzer R. The NoSAS score for screening of sleep-disordered breathing: a derivation and validation study. Lancet Respir Med. 2016;4:742–8.

12. Tan A, Yin JD, Tan LW, van Dam RM, Cheung YY, Lee C-H. Using the Berlin questionnaire to predict obstructive sleep apnea in the general population. J Clin Sleep Med. 2017;13:427–32.
13. Martins EF, Martinez D, Cortes AL, Nascimento N, Brendler J. Exploring the STOP-BANG questionnaire for obstructive sleep apnea screening in seniors. J Clin Sleep Med. 2020;16:199–206.
14. Han R, Tremper KK, Kheterpal S, O'Reilly M. Grading scale for mask ventilation. Anesthesiology. 2004;101:267–75.
15. Adnet F, Borron SW, Racine SX, Clemessy JL, Fournier JL, Plaisance P, Lapandry C. The intubation difficulty scale (IDS) proposal and evaluation of a new score characterizing the complexity of endotracheal intubation. Anesthesiology. 1997;87:1290–7.
16. Tan A, Hong Y, Tan LWL, van Dam RM, Cheung YY, Lee CH. Validation of NoSAS score for screening of sleep-disordered breathing in a multiethnic Asian population. Sleep Breath. 2017;21:1033–8.
17. Peng M, Chen R, Cheng J, Li J, Liu W, Hong C. Application value of the NoSAS score for screening sleep-disordered breathing. J Thorac Dis. 2018;10:4774–81.
18. Arslan BO, Ucar ZZ, Batum Ö, Orman MN. Validation of the NoSAS score for screening sleep-disordered breathing: A sleep clinicbasedstudy in Turkey. Turk J Med Sci. 2021;51:319–27.
19. Georgakopoulou VE, Pantazis N, Tsiafaki X, Nena E, Amfilochiou A, Steiropoulos P. Validation of NoSAS score for the screening of obstructive sleep apnea. Med Int (Lond). 2023;3:14–8.
20. Costa JC, Rebelo-Marques A, Machado JN, Gama JMR, Santos C, Teixeira F, Moita J. Validation of NoSAS (Neck, Obesity, Snoring, Age, Sex) score as a screening tool for obstructive sleep apnea: analysis in a sleep clinic. Pulmonology. 2019;25:263–70.
21. Herschmann S, Berger M, Haba-Rubio J, Heinzer R. Comparison of NoSAS score with Berlin and STOP-BANG scores for sleep apnea detection in a clinical sample. Sleep Med. 2021;79:113–6.
22. Chen H, Zheng Z, Chen R, Zeng Y, Li N, Zhu J, Zhong Y, Liu H, Lu J, Zhang N, Hong C. A meta-analysis of the diagnostic value of NoSAS in patients with sleep apnea syndrome. Sleep Breath. 2022;26:519–31.
23. Bilge A, Erol A, Arican S, Tuncer US. The use of STOP-BANG questionnaire and other difficult airway determinants in difficult airway prediction and correlation. Ulus Travma Acil Cerrahi Derg. 2022;28:1277–84.
24. Hung KC, Chuang MH, Kang FC, Chang YJ, Lin CM, Yu CH, Chen IW, Sun CK. Prevalence and risk factors of difficult mask ventilation: A systematic review and meta-analysis. J Clin Anesth. 2023;90:111–97.
25. Srivilaithon W, Muengtaweepongsa S, Sittichanbuncha Y, Patumanond J. Predicting difficult intubation in emergency department by intubation assessment score. J Clin Med Res. 2018;10(3):247–53.
26. Myatra SN, Kalkundre RS, Divatia JV. Optimizing education in difficult airway management: meeting the challenge. Curr Opin Anaesthesiol. 2017;30:748–54.
27. Khan M, Siddiqui AS, Raza SA, Samad K. Incidence and predictors of difficult mask ventilation in high-risk adult population scheduled for elective surgery: a prospective observational study. Cureus. 2022;14:22–32.
28. Khan MN, Ahmed A. Accuracy of STOP-Bang questionnaire in predicting difficult mask ventilation: an observational study. Cureus. 2021;13:159–65.
29. Thammaiah SH, Sreenath RH, Kumararadhya GB, Babu N, Archana KN. Preoperative STOP-BANG questionnaire to predict difficult airway in undiagnosed obstructive sleep apnea patients undergoing elective gynecological surgeries under general endotracheal anesthesia: A prospective observational study. Ann Afr Med. 2023;22:520–5.
30. Mahmoud M, Hasanin AM, Mostafa M, Alhamade F, Abdelhamid B, Elsherbeeny M. Evaluation of super-obesity and super-super-obesity as risk factors for difficult intubation in patients undergoing bariatric surgery. Surg Obes Relat Dis. 2021;17:1279–85.
31. Acar H, Uysal HY, Kaya A, Ceyhan A, Dikmen B. Does the STOP-Bang, an obstructive sleep apnea screening tool, predict difficult intubation? Eur Rev Med Pharmacol Sci. 2014;18:1869–74.
32. Neligan PJ, Porter S, Max B, Malhotra G, Greenblatt EP, Ochroch EA. Obstructive sleep apnea is not a risk factor for difficult intubation in morbidly obese patients. Anesth Analg. 2009;109:1182–6.
33. Gokay P, Tastan S, Orhan ME. Is there a difference between the STOP-BANG and the Berlin Obstructive Sleep Apnoea Syndrome questionnaires for determining respiratory complications during the perioperative period? J Clin Nurs. 2016;25:1238–52.

## Publisher's Note