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Stop-Bang Combined with Flexible Laryngoscopy Predicts Difficult Intubation in Patients With Obstructive Sleep Apnea

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ABSTRACT

Background: Patients with ear-nose-and-throat (ENT) pathology often suffer from obstructive sleep apnea (OSA). This syndrome has been associated with both laryngeal pathology and difficult intubation (DI). The aim of our research was to prove that the STOP-BANG score for the detection of OSA can be used as a prediction score for DI and to define the most specific way to use it preoperatively.

Methods: We included 100 patients who were being prepared for microscopic laryngeal surgery. Flexible laryngoscopy and anesthesiologic exams were performed preoperatively. The STOP-BANG score, modified Mallampati score, and demographic data were provided during the interview. The difficulty of intubation was determined according to the intubation difficulty scale (IDS).

Results: According to IDS, there were 33% of DIs in our study. Age, weight, height, and body mass index (BMI) did not show statistical significance when it comes to DI. The Modified Mallampati score showed a statistical connection to intubation; however, there was an absence of its connection to OSA. Independently, the STOP-BANG score showed statistical significance when it comes to DI with an AUC of 0.660, while when combined with flexible laryngoscopy, its AUC improves to 0.824. We have provided the cut-off value for the STOP-BANG score of 3.50, which is specific for laryngology.

Conclusion: The STOP-BANG score can be used for the prediction of a difficult airway in laryngology if used in combination with flexible laryngoscopy.

Keywords: Sleep apnea, obstructive, laryngoscopy, intubation, intratracheal, risk factors

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Introduction

Obstructive sleep apnea (OSA) represents a breathing disorder during sleep which, if not timely and adequately treated, can lead to serious cardiovascular, cerebrovascular, and neuropsychological diseases.[1,2] Difficulties during sleep arise due to the collapse or occlusion of the upper airway, which results in systemic inflammation, endothelial dysfunction, and oxidative stress.[1]

Possible non-surgical treatment options for OSA include diet and lifestyle changes, continuous positive airway pressure (CPAP) ventilation during sleep, and various dental appliances. However, a large number of patients presenting to an otorhinolaryngologist suffer from OSA, and usually all other treatment methods have been exhausted, and surgical intervention is necessary.[1,2] Otorhinolaryngological causes of OSA include septal deviation, nasal valve collapse, larger turbinates, allergic and non-allergic rhinitis, nasal polyposis, chronic rhinosinusitis, tonsillitis, epiglottis deviations, pharynx abnormalities, long soft palate or uvula, etc.[3] Surgical interventions performed in order to treat severe OSA include nasal procedures, tonsillectomy, hypopharyngeal procedures, uvulopalatopharyngoplasty, etc.[1,4] Tracheostomy is considered a last resort option of treatment.

According to the definition, OSA is a consequence of airway instability during sleep, and for many years it was associated with disorders at the nasal and/or pharyngeal level. Later research proved that OSA can be caused by narrowing of the larynx and neuromuscular changes at this level. Also, it has been proved that OSA can occur postoperatively due to anatomical changes at the laryngeal level and after radiation and chemotherapy.[5-7]

The association between OSA and difficult airway during endotracheal intubation has already been proven, as well as the fact that the incidence of complications during anesthesia is higher in these patients compared to the general population. The cause can be found in anatomical and physiological changes at the upper respiratory tract level. The anesthetic parameter most often associated with OSA is the Mallampati score.[8,9] Recognizing the existence and risk for the development of OSA in asymptomatic patients is extremely important in the preoperative preparation of patients for general anesthesia and intubation.[10,11] Endotracheal intubation represents a special challenge for the ENT anesthesiologist.[12] In the case of other surgical specialties, difficult intubation (DI) occurs in 2.8-6.8%, while in ENT it occurs in as much as 15.8% of cases.[13] Research considering parameters and scores which would make preoperative prediction of a DI possible in ENT surgery are scant.

The STOP-BANG questionnaire was developed in 2008 by Chung et al[14] and serves for the more accurate detection of patients who are at risk for developing OSA as well as for assessing the degree of OSA. Given the fact that narrowing of the glottic space and OSA have been previously connected,[15,16] the aim of our research was to prove the frequency of OSA with the help of the STOP-BANG questionnaire in patients with laryngeal pathology, as well as the influence of existing OSA on the difficulty of intubation in these patients. Also, we wanted to find the most accurate way to use the STOP-BANG score in the preoperative prediction of a DI in patients with laryngeal pathology.

Materials and Methods

Our prospective pilot study included a total of 100 patients who were being prepared for microscopic laryngeal surgery at the Otorhinolaryngology Clinic, University Clinical Center, Niš, Serbia from June to November 2023. Criteria for inclusion were age over 18 years, diagnosis of a lesion of the vocal folds, general endotracheal anesthesia, and the absence of a tracheostomy. Exclusion criteria were patients younger than 18 years, urgent surgical interventions, presence of a tracheostomy cannula, more than 50% of lumen stenosis according to the Cotton-Myer grade, vocal cord motion below half range, refusal of the patient to participate in our research, and inability to understand and/or sign an informed consent about participation. The study was approved by the Ethical Committee of the Medical School, University in Niš, Niš, Serbia on 08.06.2023 with the decision number 12-6600/2-2.

Each patient was examined by a surgeon, and flexible laryngoscopy was performed soon after hospital admission. The surgeon would identify the airway as normal or difficult during the flexible laryngoscopy, according to his previous clinical experience. The following ENT clinical data considering pathology were analyzed: Cotton-Myer grade of stenosis, vocal cord mobility, and site of stenosis.[17-19]

In addition to the surgeon's examination, every patient was examined preoperatively by an anesthesiologist. During the routine preoperative anesthesiologic examination, the patient would be asked about parameters needed to calculate the STOP-BANG score (Table 1) and the modified Mallampati score would be performed by asking the patient to sit up straight and open the mouth as wide as possible with a maximally protruded tongue. The classification of the patients was done according to general recommendations.[20] After the STOP-BANG score was calculated by an anesthesiologist, patients were classified into 3 groups according to the risk for developing moderate-to-severe OSA (Table 2). Body mass index (BMI) was calculated and classified according to World Health Organization (WHO) recommendation.[21] Patients were asked during the interview if they had ever experienced apneic episodes during sleep, as it was important to see how many patients were symptomatic.

Every patient had uniform premedication with midazolam 0.1 mg/kg and atropine 0.5 mg. After an adequate response to premedication was achieved, the patients were transferred to the operating room where standard monitoring was connected, e.g., electrocardiography, blood pressure monitoring, capnography, and pulse oximetry. Medications used during induction of general anesthesia were uniform, including midazolam 0.15-0.2 mg/kg, fentanyl 100 mcg, propofol 1-1.5 mg/kg, and succinylcholine 1 mg/kg. Endotracheal intubation was performed using a standard Macintosh laryngoscope blade, and IDS was calculated. Details about calculating the IDS are provided in Table 3. In order to exclude bias, anesthesiologist who

Table 1. Parameters Needed for Calculation and Classification of STOP-BANG Score

Parameter	Result	Calculation
Questions to be asked during the interview		
Do you snore loudly?	No	0
	Yes	1
Do you often feel tired, fatigued, or sleepy during the daytime?	No	0
	Yes	1
Has anyone observed you stop breathing during sleep?	No	0
	Yes	1
Do you have (or are you being treated for) high blood pressure?	No	0
	Yes	1
Objective measures		
BMI*	≤35 kg/m^2	0
	>35 kg/m^2	1
Age	≤50 years	0
	>50 years	1
Neck circumference	≤40 cm	0
	>40 cm	1
Gender	Female	0
	Male	1
Results		
0-2	Low risk for moderate-to-severe OSA	
3-4	Intermediate risk for moderate-to-severe OSA	
5-8	High risk for moderate-to-severe OSA	

*BMI, body mass index.

Table 2. Interpretation of the STOP-BANG Score Results

STOP-BANG Result	Risk
0-2	Low risk for moderate-to-severe OSA
3-4	Intermediate risk for moderate-to-severe OSA
5-8	High risk for moderate-to-severe OSA

Table 3. Calculation of Intubation Difficulty Scale

Parameters	Score
Number of attempts >1	Each 1 point
Number of operators >1	Each 1 point
Number of alternative techniques	Each 1 point
Cormack-Lehane grade	Grade1 = 0 point
	Grade 2 = 1 point
	Grade 3 = 2 point
	Grade 4 = 3 point
Lifting force	Normal = 0 point
	Increased = 1 point
Laryngeal pressure	Normal = 0 point
	Increased = 1 point
Vocal cord mobility	Abduction = 0 point
	Adduction = 1 point
Sum of scores	IDS > 5 = difficult intubation

performed the intubation was not the same anesthesiologist who performed the preoperative evaluation of the difficult airway.

Patients were divided into 2 groups according to the calculated difficulty of intubation: normal intubation (NI) group and DI group.

Mean and SD were used to present continuous variables. Statistical significance was calculated using independent samples *t*-test, Mann–Whitney U-test, Kruskal-Wallis H test, and Chi-square test. Binary logistic regression was used to predict the outcome and combine different parameters. The area under the curve (AUC) was used to determine the test performance and define the cut-off values. A *P*-value below .05 was considered a statistically significant result. All results were statistically processed in the program SPSS 10.0 (SPSS Inc.; Chicago, IL, USA) for Windows. The power of the study was calculated using the program G*Power. For a study power of 80% and a probability of error of 0.05, the required number of patients is 80.

Results

The mean age of the included patients was 60.31 ± 31 years, and there was no statistical significance between the DI and NI groups when it comes to age. Of all the included patients, a total of 33% was defined as difficult to intubate, according to the IDS. When clinically analyzed, there was the need to attempt intubation more than once in 45.4% of DI cases, and intubation was performed by more than one anesthesiologist in 27.3% of DI cases. Clinical details of intubations are presented in Table 4. When it comes to demographic characteristics of included patients, there was no statistical significance between the DI and NI groups when it comes to age, height, and weight. The BMI of all the included patients was 26.75 ± 5.29 kg/m^2, which belongs to the overweight group according to official classification. There was no statistical difference between the 2 groups when it comes to BMI. There were a total of 22 patients who could be classified as obese, e.g., BMI >30 kg/m^2, but only 7 of them were difficult to intubate according to IDS. The demographic data of the included patients are represented in Table 5. The structure of the patients, according to ENT clinical parameters and classifications, is presented in Table 6.

We have calculated the STOP-BANG score for every patient and classified them into 3 groups, as recommended, with a total of 22 patients in the low-risk group, 44 patients in the intermediate-risk group, and 34 patients in the high-risk group for developing OSA. It was previously mentioned that patients were asked about having apneic episodes during sleep that they were aware of. As much as 20% of the included patients declared being aware of these apneic episodes. Patients who were aware of apneic episodes were then classified into STOP-BANG score groups, according to previously mentioned recommendations, and the results are presented in Figure 1. Our results showed that the patients who were aware of apneic episodes during sleep were classified into higher classes of STOP-BANG scores, with statistical significance of $P = .001$.

Modified Mallampati score showed a statistical significance when it comes to the prediction of a DI with $P < .0001$; however, it lacked statistical significance when it comes to the STOP-BANG score and its classification.

Patients in higher classes of STOP-BANG score were more difficult to intubate, with statistical significance of $P = .008$. After the patients were classified in groups, the statistical significance maintained but lost its power, with $P = .05$. The details concerning STOP-BANG classification and intubation difficulty are provided in Figure 2.

After running the C statistics, the ROC curve for the STOP-BANG score showed AUC = 0.660. This result excluded the possibility of using this score as as an independent prediction parameter for difficult intubation in laryngology. Flexible laryngoscopy, as the surgical score, showed $\chi^2 = 31.027$; $P < .0001$ and AUC = 0.766 (95% CI = 0.657-0.875, $P < .0001$). This indicated that flexible laryngoscopy is an extremely valuable parameter but still dependent on the prediction of a difficult intubation. Therefore, we combined these 2 parameters and the

Table 4. Clinical Details of Difficult Intubations

	All the Included Cases, n* (%)	Normal Intubation (NI**), n (%)	Difficult Intubation (DI***), n (%)	*P* (DI vs NI cases), n (%)
Cases where the intubation was attempted more than once	15 (15%)	0 (0%)	15 (45.45%)	**.0001**
Cases where intubation was attempted by more than one anesthesiologist	10 (10%)	1 (1.30%)	9 (27.27%)	**.0001**
Cases where one or more alternative intubation techniques were necessary	30 (30%)	4 (5.19%)	26 (78.79%)	**.0001**

*n, number of patients.
**NI, normal intubation.
***DI, difficult intubation.

Table 5. Demographic Data of the Included Patients

	All Patients	Difficult Intubation (DI)	Normal Intubation (NI)	*P* (DI vs NI)
n[a] (%)	100 (100%)	33 (33%)	33 (66%)	
Female gender n (%) Male gender n (%)	37 (37%) 63 (63%)	5 (5%) 28 (28%)	32 (32%) 35 (35%)	**.002**
Age (mean ± SD)	60.31 ± 11.70	62 ± 9.87	59.48 ± 12.48	.220
BMI[b] (median ± SD[c]) in kg/m^2	26.75 ± 5.29	26.90 ± 5.18	26.69 ± 5.38	.579
Weight (median ± SD) in kg	77.81 ± 18.22	79.61 ± 18.80	73.92 ± 18.00	.712
Height (median ± SD) in cm	170.75 ± 9.61	173.18 ± 8.91	169.54 ± 9.78	.437

P < .05 are marked in bold.
[a]n = number.
[b]BMI = body mass index.
[c]SD = standard deviation.

results showed an AUC of 0.824 with the statistical model: $\chi^2 = 35.455$; $P < .0001$; Nagelkerke $R^2 = 41.5$; percent of correct classification of cases = 82%. All 3 AUC curves are represented in Figure 3.

After classification, the AUC of STOP-BANG score was 0.613 (95% CI = 0.499-0.726, $P = .058$) and when combined with flexible laryngoscopy, the AUC was 0.796 (95% CI = 0.694-0.897, $P = .0001$).

STOP-BANG score was not designed to predict DI and, therefore, there is no official cut-off value considering this prediction in laryngology. We have analyzed the AUC curve and provided a cut-off value of 3.50 with a specificity of 49.3% and a sensitivity of 75.8%. When classified according to this cut-off value, the statistical significance was $\chi^2 = 5.718$; P = .017 when it comes to the prediction of a DI. The AUC after this classification was 0.625 and this result improved to 0.827 after combining with flexible laryngoscopy, with the statistical model: $\chi^2 = 36.692$; $P < .0001$; Nagelkerke $R^2 = 42.7$; percent of correct classification of cases = 81%. Area under curve are provided in Figure 4.

Discussion

Higher incidence of difficult endotracheal intubation is normally expected in laryngology, as previously mentioned. However, in our research, according to the calculated IDS score, there was a total of 33% of DIs. Other research indicates the incidence of difficult airway is 15.8% in the general ENT pathology.[13] This discrepancy can be explained by the fact that our study included only patients with laryngeal masses, which could compromise airway patency. Also, some of the available research determines DI only by analyzing Cormack-Lehane gradation and not the more sensitive IDS. When the details of intubations are analyzed, it can be seen that clinical difficulties with intubations were confronted in fewer cases than the IDS previously identified.

The incidence of OSA is predominantly higher in ENT pathology than in other pathologies.[2] It is important to note that we specifically chose laryngeal pathology with the aim of proving the importance of a compromised airway at the laryngeal level in the incidence of OSA. Our results showed that no demographic characteristic, indicating the possible existence of OSA, had statistical significance considering intubation difficulty. Also, mean BMI was specific for the overweight class of patients and still did not show statistical significance in the prediction of a DI. These data are more than enough to show that laryngeal pathology alone can cause a severe grade of OSA and symptomatic OSA in many cases. This conclusion is supported by systematic reviews and research which concluded that head and neck cancer, particularly laryngeal tumors, can present a significant risk for the development of OSA.[22,5] Novakovic et al stated that airway obstruction at the laryngeal level should be considered

Table 6. Structure of Patients According to Ear Nose Throat Clinical Characteristics

	Class	Difficult Intubation (DI)	Normal Intubation (NI)	Σ*
Site of stenosis	Glottis	27	55	82
	Supraglottis	5	8	13
	Hypopharynx	0	4	4
	Trachea	1	0	1
Laryngeal stenosis grading	Grade I: 0-50%	25	64	89
	Grade II: 51-70%	8	3	11
Vocal cord paralysis	Grade 2: Half the range of motion	1	0	1
	Grade 3: Almost full motion	4	0	4
	Grade 4: Full range of motion	28	67	95

Σ* = sum.

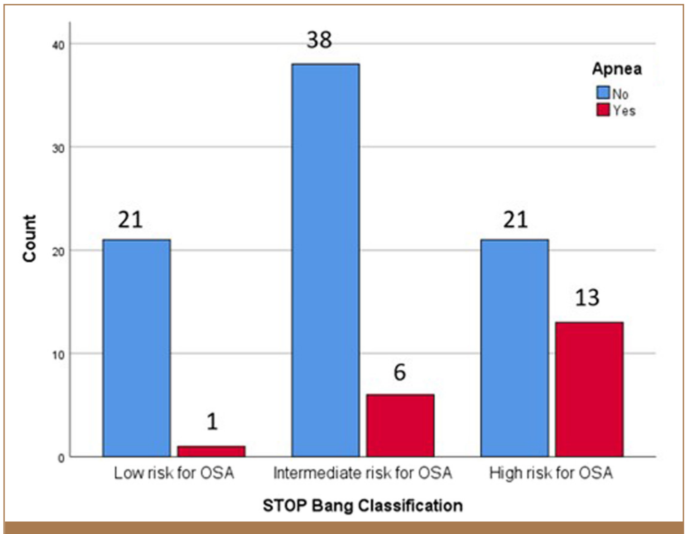

Figure 1. Clustered bar chart depicting the incidence of patients with symptomatic obstructive sleep apnea in every class of STOP-BANG score.

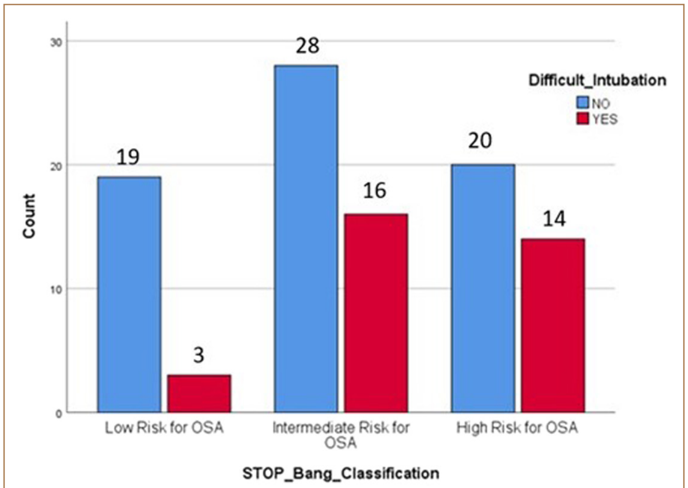

Figure 2. Clustered bar chart depicting the incidence of difficult intubation in every class of STOP-BANG score.

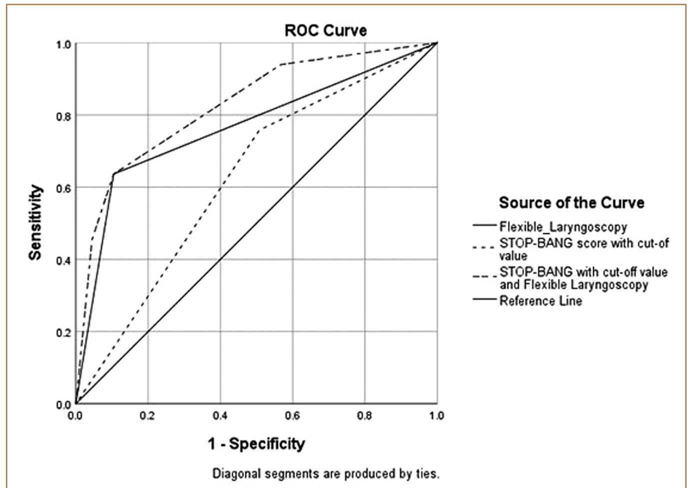

Figure 4. Area under curves of independent and combined parameters: STOP-BANG score with cut-off value: AUC = 0.625 (95% CI = 0.511-0.739, *P* = .043). Flexible laryngoscopy: AUC = 0.766 (95% CI = 0.657-0.875, *P* < .0001). STOP-BANG score with cut-off value and flexible laryngoscopy: AUC = 0.827 (95% CI = 0.739-0.916, *P* < .0001). AUC, area under curve.

whenever OSA is resistant to standard therapies. Our research did not include higher grades of laryngeal stenosis than 70% since these patients had a severe level of stridor and, in these patients, urgent tracheotomy is provided before any attempt at intubation. However, it was evident that patients in the DI group were more likely to be in higher groups of laryngeal stenosis grading and had a limited range of vocal cord motion. Novakovic et al[16] also indicated that people with OSA have a greater incidence of laryngopharyngeal reflux, chronic cough and laryngeal inflammation. Our study also shows that as much as 20% of included patients with laryngeal pathology had symptomatic OSA to the level of being aware of apneic episodes during sleep.

Previous research indicated that Mallampati score can be an independent predictor of both presence and severity of OSA.[9,23] Considering this, we wanted to exclude bias in our study and checked if this parameter had an influence on the existence of OSA in our patients. We have proved that there was statistical significance for the prediction of a DI but not for OSA prediction.

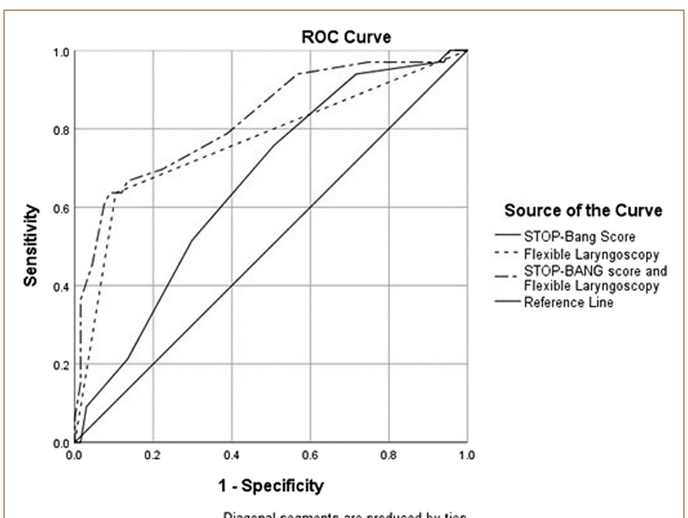

Figure 3. Area under curves of independent and combined parameters: STOP-BANG score: AUC = 0.660 (95% CI = 0.551-0.769, *P* = .009). flexible laryngoscopy: AUC = 0.766 (95% CI = 0.657-0.875, *P* < .0001). STOP-BANG score and flexible laryngoscopy: AUC = 0.824 (95% CI = 0.733-0.915, *P* < .0001).

Previous research showed the possible use of the STOP-BANG score in the prediction of a difficult airway.[24-26] Thammaiah et al[10] showed the importance of this score after classification of patients in the prediction of a difficult airway in gynecological surgery with an AUC as high as 93.1%. Our results did not show the independence of this score, and this can be explained by the pathology itself and by the fact that this AUC was obtained after classification of patients into 2 groups instead of 3. The cut-off value was not obtained by the authors.[10,26] The importance of this score in airway difficulty prediction was also proven in other surgical fields; however, only a few studies proposed cut-off values.[11] Acar et al,[24] Toshniwal et al,[25] and Singh et al[27] proposed a cut-off value of 3 for the prediction of a DI in general surgery. Our results indicated that the more suitable cut-off value in laryngology is 3.50. This can be explained by the fact that there is a higher incidence of DI in ENT surgery, specifically in laryngology.

Other studies proposed a combination of the STOP-BANG score with different parameters; however, no study combined this score with flexible laryngoscopy.[28,29] Our study indicated that these 2 parameters cannot be used independently but when used together, they can represent a useful tool for the prediction of a DI in laryngeal pathology. It is important to note the significance of the surgical parameter in the improvement of the sensitivity and specificity of this statistical model. However, the subjectivity of surgeons' assessment during flexible laryngoscopy and the lack of a standardized score can be considered limitations of this model. Our future research should aim to provide more objectivity by designing a new, standardized score for flexible laryngoscopy.

Symptomatic OSA can be a consequence of isolated laryngeal pathology, and its existence can indicate a possible difficulty during intubation. The STOP-BANG score cannot be used independently in the prediction of a difficult intubation; however, when combined with flexible laryngoscopy, it can be considered a useful parameter. We provide a new cut-off value of 3.50 for the prediction of a DI in laryngology.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics Committee Approval: The study was approved by the Ethical Committee of the Medical Faculty, University Clinical Center of Niš, Niš, Serbia (date: 08.06.2023 approval number: 12-6600/2-2).

Informed Consent: Informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer reviewed.

Author Contributions: Concept – M.D., M.S.; Design – M.D., M.S.; Supervision – M.D., M.S.; Materials – D.M., N.M., T.K., N.N.; Data Collection and/or Processing – M.D., N.N., N.Dj, T.K., N.M.; Analysis and/or Interpretation – M.D., M.S.; Literature Search – M.D., N.N., N.Dj., T.K., N.M.; Writing Manuscript – M.D.; Critical Review – M.D., M.S.

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