**Original Article**



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TANAFFOS

# Use of STOP-BANG Questionnaire to Predict Postoperative Respiratory Complications after Bariatric Surgery

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**Background:** Obstructive sleep apnea (OSA) is the most common sleep-related breathing disorder associated with multisystem organ involvement. The STOP-BANG questionnaire is a short and valid questionnaire used to screen OSA. This study aimed to investigate the ability of the STOP-BANG questionnaire to predict postoperative OSA-related respiratory complications in patients undergoing bariatric surgery.

**Materials and Methods:** In this cross-sectional study, all the eligible patients were evaluated in preoperative visits using a predetermined checklist including demographic and clinical information related to OSA and the STOP-BANG questionnaire. After bariatric surgery, patients were assessed for postoperative OSA-related complications. The receiver operating characteristic (ROC) curve was used to determine the cut-off point of the STOP-BANG checklist score based on the patient's postoperative outcomes.

**Results:** In total, 115 subjects were included in the study. There were significant associations in terms of gender, age, body mass index (BMI), patient's neck circumference, diabetes, heart diseases, and the mask ventilation grade variables between the two groups of patients with high risk and low risk according to the STOP-BANG questionnaire ($P < 0.05$ for all comparisons). In addition, airway obstruction and hypoxia (mild and moderate) were more prevalent in the high-risk group than in the low-risk one ($P < 0.05$ for all comparisons). A significant difference was reported with a cut-off score of 2 in the STOP-BANG questionnaire for those with and without airway obstruction. Moreover, the cut-off point of 4 in the STOP-BANG questionnaire was determined as a predictor for both airway obstruction and mild-to-moderate hypoxia.

**Conclusion:** STOP-BANG scores may be used as a preoperative risk stratification tool to predict the risk of intraoperative adverse events and postoperative complications in bariatric surgery.

**Keywords:** Airway obstruction; Bariatric surgery; Obstructive sleep apnea; STOP-BANG

## INTRODUCTION

Obstructive sleep apnea (OSA) is one of the primary sleep disorders that causes breathing to stop or slow down for a short time (but repeatedly) during sleep (1). Although in many cases of apnea, the affected person may not notice the tightness or cessation of their breathing during the night, these periods often lead to a significant decline in their sleep quality. According to a study, those with untreated sleep apnea have a seven-fold higher risk of being involved in motor vehicle accidents than people

without the condition (2). It has also been noted that due to the importance of sleep for one's health and the sympathetic activation caused by frequent awakenings as a result of a feeling of suffocation during the night, untreated sleep apnea can lead to serious complications such as cardiac arrest, type 2 diabetes, high blood pressure, obesity, memory loss, and depression (3). Therefore, some measures must be taken to diagnose sleep apnea.

To screen for sleep apnea, accessible tools such as the STOP-BANG questionnaire are used. STOP-BANG is an 8-item questionnaire used to help diagnose OSA. This tool determines the risk of OSA by evaluating several factors (4, 5). Numerous studies have indicated that the possibility of unwanted complications during or shortly after surgery is significantly higher in individuals with an increased risk of OSA than in those who are at low risk of this condition. In a systematic review and meta-analysis conducted by Nagappa et al., which included 10 studies, it was found that the complications after head and neck, thoracic, abdominal, vascular, and orthopedic surgeries in high-risk individuals are significantly higher than in low-risk patients (6).

Conventional weight loss methods, such as diet, exercise, and medication, typically reduce body weight by 5 to 15 percent (7). In addition, the majority of obese individuals who lose weight will return to their original weight or gain more weight after follow-up (8). As a result, bariatric surgical procedures that reduce the size of the stomach or change nutrient absorption are becoming more widespread. These methods often lead to significant and sustainable weight loss (9). However, bariatric surgery also has considerable short-term and long-term risks that must be taken into consideration. Since this surgery is performed to reduce the weight of obese individuals who have several risk factors in terms of OSA and also considering that these patients are known to be at risk for postoperative and postanesthetic respiratory complications, the present study aimed to investigate the capability of the STOP-BANG questionnaire in predicting the occurrence of complications after bariatric surgery regardless of prior history of diagnosed obstructive sleep apnea.

## MATERIALS AND METHODS

Patients who were eligible for bariatric surgery in Loghman Hakim Hospital were consecutively included in this cross-sectional study (March 2021–March 2022). The inclusion criteria were being a candidate for bariatric surgery, willingness to participate in the study, and having no neck anomalies, diagnosed sleep disorders, or a history of upper airway surgery; while the exclusion criteria were the death of the patient during surgery, changing the surgical plan for any reason, and the occurrence of unexpected complications during the surgery. The approval to conduct the study was obtained from the Ethics Committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran (IR.SBMU.RETECH.REC.1400.1042), and the necessary arrangements were made with the research assistant of Loghman Hakim Hospital. This study conforms to the Declaration of Helsinki regarding research involving human subjects. All participants signed the written informed consent form.

The required information (demographic and clinical data) was collected before the surgery using the pre-op checklist and the STOP-BANG questionnaire. After the surgery, the necessary information was also obtained through the post-op checklist (assessing the complications). The pre-op checklist includes the variables of age, gender, height, body mass index (BMI), weight, neck circumference, the Mallampati score (assessment of upper airway based on visualization of the uvula and soft plate in hopes of predicting the difficult airway), type of surgery, cardiovascular diseases (history of hypertension, heart failure, and ischemic heart disease), history of diabetes mellitus and insulin-dependent diabetes, lung diseases (history of asthma and chronic obstructive pulmonary disease), history of smoking, history of drug use, history of alcohol use, OSA, mask ventilation grade (Grade1: Ventilated by mask, Grade2: ventilated by mask with oral airway or other adjuvant, Grade3: difficult mask ventilation requiring two practitioners), number of attempts at intubation, and the Cormack and Lehane score (describes the best view of glottis during laryngoscopy). After bariatric surgery, patients were examined by an anesthesiologist for unexpected complications, and all of the observed complications were recorded in the post-op

checklist. These complications included airway obstruction requiring intervention, hypoxia (Hypoxia: arterial saturation of oxygen by pulse oximetry of less than 93%; mild-to-moderate hypoxia: arterial saturation of oxygen by pulse oximetry of 90-93% by 3 liters of oxygen through the nasal cannula; severe hypoxia: arterial saturation of oxygen by pulse oximetry of less than 90despite of 3 liters of oxygen through a nasal cannula), respiratory distress (tachypnea more than 20 breaths per minute), complaints of difficulty in breathing and swallowing, occurrence of systemic hypotension (systolic blood pressure less than 90 mmHg or diastolic blood pressure of less than 60 mmHg), myocardial infarction, atrial fibrillation, length of hospital stay during recovery, length of hospital stay in the ICU, and duration of anesthesia. The information evaluated in the STOP-BANG questionnaire includes gender, age, BMI, loud snoring, fatigue or drowsiness during the day, sleep apnea, and high blood pressure, and each question can be answered with positive or negative options. Obtaining a score higher than or equal to 3 is considered high risk, whereas a score below 3 is defined as low risk.

### Statistical analysis

This study assesses the capability of the STOP-BANG questionnaire to predict cardiorespiratory complications after bariatric surgery. The required data were gathered via two checklists, i.e., post-op and STOP-BANG, and were then input into SPSS software version 23 for data analysis. Data analysis includes descriptive and inferential analyses. Descriptive statistics examines the characteristics of the data, while inferential statistics evaluates the research hypotheses. The descriptive analysis included the presentation of the mean, standard deviation, frequency, and percentage. However, in the inferential part, the Chi-square test or its non-parametric counterpart, Fisher's exact test, was used to investigate the relationship between the two categorical parameters. A comparison of the mean of quantitative parameters was conducted between the two groups using an independent t-test. The receiver operating characteristic (ROC) curve was used to determine the STOP-BANG score's cut-off point based on postoperative outcomes in patients. The significance level in all the tests was considered to be 0.05.

## RESULTS

All the participants in this study (n=155) had undergone sleeve gastrectomy surgery and were divided into two groups of low-risk and high-risk based on the score of the STOP-BANG questionnaire. The results of examining the relationship between demographic and clinical data in high-risk and low-risk patients based on the STOP-BANG checklist score are presented in Table 1. In this study, the number of men in the high-risk group was significantly higher (P<0.001). Moreover, in the high-risk group, the number of participants over the age of 50 years was significantly higher than that of those under 50 years old (P=0.003). A considerable number of individuals in the high-risk group had a BMI over 35 kg/m$^2$ and a neck circumference of more than 40 cm (P<0.001 for both comparisons). The different grades of Mallampati and Cormack were divided into two categories III or IV and I or II which did not show a significant difference between the low-risk and high-risk groups (P=0.31 and P=0.29, respectively). On the other hand, grade 3 mask ventilation was significantly more prevalent in the high-risk group than in the low-risk group (P=0.04), while grade 1 was significantly more common in the low-risk group (P=0.02), and grade 2 did not show a significant difference (P=0.47).

The number of patients with diabetes and cardiovascular diseases was significantly higher in the high-risk group than in the low-risk group (P=0.01 and P=0.001, respectively); however, no significant difference was observed in hypothyroidism between the two groups (P=1.0). Furthermore, no significant differences were observed between the two study groups in terms of the need for intubation, suffering from OSA, the number of smokers, alcohol use, and drug use (P<0.05 for all comparisons) (Table 1).

The postoperative outcomes were compared between the two groups of patients (low-risk and high-risk) according to the STOP-BANG score (Table 2). The number of individuals with airway obstruction was significantly higher in the high-risk group compared with the low-risk group (P<0.001). Participants were classified into three groups based on whether they needed a jaw thrust, a nasal/oral airway, or both, and these characteristics were compared between the two study groups (low-risk and

high-risk). It was found that only the number of participants who required a jaw thrust was significantly higher in the high-risk group (P<0.001).

Moreover, the number of hypoxic events in the first 2 hours after extubation in the postanesthetic care unit was significantly higher in the high-risk group than in the low-risk group (P<0.001). However, the number of participants with mild-to-moderate hypoxia was significantly higher in the high-risk group than in the low-risk group (P<0.001), while the number of individuals with severe hypoxia was not significantly different between the two groups (P=1.0). Although none of the participants with distress, difficulty in swallowing, and systemic hypotension were in the low-risk group, no significant difference was found between the two groups in this regard (P=1.0, P=0.56, and P=1.0, respectively). New-onset atrial fibrillation or myocardial infarction during recovery stay was not observed. The mean length of hospital stay during recovery and the duration of anesthesia did not show a significant difference between the two groups (P=0.06 and P=0.51, respectively). Furthermore, the number of patients hospitalized in the ICU was 10 and 0 in the high-risk and low-risk groups, respectively, but the difference between the two groups was not statistically significant (P=0.06) (Table 2).

It is worth mentioning that the mean score of the STOP-BANG questionnaire for the two groups of low-risk (>3) and high-risk (≤3) individuals was 1.56±0.55 and 4.51±1.19, respectively (data not shown).

Table 3 presents the cut-off points of the STOP-BANG questionnaire score based on the consequences following bariatric surgery. According to the results, the cut-off points were 2, 2, 5, 4, and 4, for the outcomes, including airway obstruction, jaw thrust, jaw thrust and nasal/oral airway, hypoxia, and mild/moderate hypoxia. In addition, sensitivity, specificity, 95% confidence interval, and the area under the curve (AUC) of each outcome are given in Table 3.

**Table 1.** Comparison of demographic and clinical findings of patients based on STOP-BANG status

| Variables | | Total (n=155) | Low risk (n=43) | High risk (n= 112) | p-value |
|---|---|---|---|---|---|
| **Gender** | Female | 106 (68.4%) | 42(97.7%) | 64(57.1%) | **< 0.001** |
| | Male | 49 (31.6%) | 1 (2.3%) | 48 (42.9%) | |
| **Age(years)** | < 50 | 135 (87.1) | 43 (100%) | 92 (82.1%) | **0.003** |
| | ≥ 50 | 20 (12.9) | 0 (0%) | 20 (17.9%) | |
| **BMI (kg/m²)** | < 35 | 31 (20%) | 21 (48.8%) | 10 (8.9%) | **< 0.001** |
| | ≥35 | 124 (80) | 22 (51.2%) | 102 (91.1%) | |
| **Neck circumference (cm)** | <40 | 66 (42.6%) | 39 (90.7%) | 27 (24.1%) | **< 0.001** |
| | ≥40 | 89 (57.4) | 4 (9.3%) | 85 (75.9%) | |
| **Mallampati score** | I or II | 130 (83.9%) | 34 (79.1%) | 96 (85.7%) | 0.314 |
| | III or IV | 25 (16.1) | 9 (20.9%) | 16 (14.3%) | |
| **Cormack grade** | I or II | 117 (75.5%) | 35 (81.4%) | 82 (73.2%) | 0.29 |
| | III or IV | 38 (24.5%) | 8 (18.6%) | 30 (26.8%) | |
| **Lung diseases (yes)** | | 4 (2.6%) | 0 (0%) | 4 (3.6%) | 0.576 |
| **Diabetes (yes)** | | 26 (16.8%) | 2 (4.7%) | 24 (21.4%) | **0.012** |
| **Cigarette smoker (yes)** | | 44 (28.4%) | 8 (18.6%) | 36 (32.1%) | 0.094 |
| **Alcohol user (yes)** | | 19 (12.3%) | 2 (4.7%) | 17 (15.2%) | 0.074 |
| **Opium addiction (yes)** | | 4 (2.6%) | 1 (4.7%) | 3 (2.7%) | 0.90 |
| **Coronary artery disease (yes)** | | 36 (23.2%) | 2 (4.7%) | 34 (30.4%) | **0.001** |
| **Hypothyroidism (yes)** | | 7 (4.5%) | 2 (4.7%) | 5 (4.5%) | 1 |
| **Mask ventilation grade** | I | 63 (40.6%) | 24 (55.8%) | 39 (34.8%) | **0.02** |
| | II | 69 (44.5%) | 17 (39.5%) | 52 (46.4%) | 0.47 |
| | III | 23 (14.8%) | 2 (4.7%) | 21 (18.8%) | **0.04** |
| **Number of attempts to intubate** | 1 | 146 (94.2%) | 39 (90.7%) | 107 (95.5%) | 0.264 |
| | 2 | 9 (5.8%) | 4 (9.3%) | 5 (4.5%) | |

BMI: body mass index; Mask Ventilation Grades. Grade1: Ventilated by mask, Grade2: ventilated by mask with oral airway or other adjuvant, Grade3: difficult mask ventilation requiring two practitioners. b: Fisher's exact test

**Table 2.** Comparison of postoperative outcomes in patients based on STOP-BANG status

| Variables | Total (n=155) | Low risk (n=43) | High risk (n= 112) | p-value |
|---|---|---|---|---|
| **Airway obstruction (yes)** | 92 (59.4%) | 7 (16.3%) | 85 (75.9%) | <0.001 |
| **Jaw thrust needed(yes)** | 71 (45.8) | 3 (7.0) | 68 (60.7) | <0.001 |
| **Nasal/oral airway needed (yes)** | 7 (4.5) | 3 (7.0) | 4 (3.6) | 0.39 |
| **Jaw thrust and nasal/oral airway needed(yes)** | 14 (9.0) | 1 (2.3) | 13 (11.6) | 0.11 |
| **Hypoxia (yes)** | 56 (36.1%) | 5 (11.6%) | 51 (45.5%) | <0.001 |
| **Hypoxia (mild-to-moderate)** | 44 (28.4%) | 2 (4.7%) | 42 (37.5%) | <0.001 |
| **Hypoxia (severe)** | 12 (7.7%) | 3 (7%) | 9 (8%) | 1 |
| **Tachypnea >20/min (yes)** | 2 (1.3%) | 0 (0%) | 2 (1.8%) | 1 |
| **Difficulty in swallowing (yes)** | 3 (1.9%) | 0 (0%) | 3 (2.7%) | 0.561 |
| **Systemic-hypotension(yes)** | 2 (1.3%) | 0 (0%) | 2 (1.8%) | 1 |
| **ICU stay(yes)** | 10 (6.5%) | 0 (0%) | 10 (8.9%) | 0.063 |
| **Recovery unit stay (min)** | 56.13±19.22 | 51.51±10.38 | 57.9±21.45 | 0.064 |
| **Anesthesia time (min)** | 65.77±19.75 | 67.44±22.45 | 65.13±18.69 | 0.517 |

Hypoxia: arterial saturation of oxygen by pulse oximetry of less than 93%; Mild-to-moderate hypoxia: arterial saturation of oxygen by pulse oximetry of 90-93% by 3liters of oxygen through the nasal cannula; Systemic hypotension: systolic blood pressure less than 90 mmHg or diastolic blood pressure of less than 60 mmHg. a: Pearson chi-square test; b: Fisher's exact test; c: Independent sample t-test

**Table 3.** Diagnostic accuracy of postoperative outcomes based on STOP-BANG scores

| Components of STOP-BANG | Cut-off | Sensitivity % (95% CI) | Specificity % (95% CI) | Significance level P (Area=0.5) | AUC |
|---|---|---|---|---|---|
| **Airway obstruction** | > 2 | 92.39 (84.9 - 96.9) | 57.14 (44.0 - 69.5) | <0.0001 | 0.813 |
| **Jaw thrust** | >2 | 95.8(88.1-99.1) | 47.6(36.6-58.8) | <0.0001 | 0.74 |
| **Nasal/oral airway needed** | <=4 | 85.7(42.2-97.6) | 38.5(30.6-46.9) | 0.155 | 0.645 |
| **Jaw thrust and nasal/oral airway needed** | >5 | 50(23.1-76.9) | 88.7(82.2-93.4) | 0.0001 | 0.771 |
| **Hypoxia** | > 4 | 62.50 (48.5 - 75.1) | 76.77 (67.2 - 84.7) | <0.0001 | 0.728 |
| **Mild/moderate hypoxia** | > 4 | 63.64 (47.8 - 77.6) | 72.97 (63.7 - 81.0) | <0.0001 | 0.717 |

## DISCUSSION

The present study aimed to determine the predictive ability of the STOP-BANG questionnaire in identifying complications after bariatric surgery. The analysis of postoperative outcomes in patients based on their STOP-BANG scores revealed that the high-risk group had significantly higher rates of complications such as airway obstruction, jaw thrust, nasal/oral airway hypoxia, and mild/moderate hypoxia, compared to the low-risk group. Moreover, the study identified cut-off points for the questionnaire based on these complications.

Upon examining the results of two groups with and without airway obstruction, a significant difference was observed in their cutoff score of the STOP-BANG questionnaire. Seet et al.'s study found that patients with a STOP-BANG score greater than 5 had a five-fold increased risk of unexpected intraoperative and postoperative side effects, whereas patients with a score greater than 3 had a one-quarter probability of side effects (10). Vasu et al.'s study further supported this, as higher STOP-BANG scores were associated with higher rates of postoperative respiratory and cardiac complications (11). Thus, the STOP-BANG scores accurately predict the classification of patients at risk of airway obstruction. Our study also found that patients who had STOP-BANG scores higher than 2 were at a higher risk of developing airway obstruction if the score was 3 or higher, as indicated by similar studies such as Bray and Knapp study (12). In fact, a STOP-BANG score greater than 5 can be considered as a predictor of airway obstruction in patients. In the present study, the classification of STOP-BANG scores also demonstrated that increased scores are associated with an increased risk of

unexpected side effects after surgery, making the STOP-BANG score an ideal tool for intraoperative and postoperative risk stratification. It is important to note that the variation in scores obtained from the STOP-BANG questionnaire in different studies can be attributed to the type of investigation and the demographic characteristics of the participants. Nevertheless, based on our findings, a cut point of 2 can be an ideal predictor for airway obstruction in patients.

According to our study's findings, a cut-off point of 4 was found to be a predictor of hypoxia in the categories of mild and moderate hypoxia. Proczko et al.'s study indicated that patients with at least three STOP-BANG criteria were more likely to have postoperative complications, such as decreased oxygen saturation and respiratory rate (13). However, Khanna et al.'s study contradicted these findings, as the STOP-BANG score did not show a significant relationship with postoperative hypoxia (14). Previous studies demonstrated that the STOP-BANG questionnaire has been widely accepted because of its ease of implementation, as well as its high sensitivity and moderate specificity (5, 15-18). Similar to our study, previous studies also evaluated the STOP-BANG tool's ability to identify patients at risk of postoperative complications. Vasu et al. in a retrospective study showed that patients who scored 8-3 compared to those who scored 0-2, reported a higher rate of postoperative respiratory complications, 19.6% versus 1-3%, respectively (11). Another retrospective study by Seet et al. in Singapore revealed that 25.4% of patients with a median STOP-BANG score of 3-4 experienced at least one postoperative adverse event. Moreover, individuals scoring as high-risk, STOP-BANG scores of 5 to 6 and 7 to 8, had higher incidence rates of adverse events with rates of 34.3% and 44.4%, respectively (10). Thus, overall, the STOP-BANG score can be used as a preoperative risk stratification tool to predict intraoperative and postoperative adverse events.

It is noteworthy that some demographic and clinical factors, including age and underlying cardiovascular diseases and diabetes, were significantly more prevalent in the high-risk group (identified by the STOP-BANG criteria). These factors may have contributed to the higher rates of complications such as airway obstruction, hypoxia, and mild/moderate hypoxia in this group, serving as interventionist factors. Also, the number of patients hospitalized in the ICU was 10 and 0 in the high-risk and low-risk groups, respectively, but the difference between the two groups was not statistically significant (P = 0.06). This difference might be related to the underlying cardiovascular and metabolic diseases rather than respiratory events. The decision of ICU admission was made by the surgeon and anesthesiologist based on the overall condition of the patient before the surgery.

Classification of patients into two groups, high-risk and low-risk, based on this test, can be a reliable predictor of complications. This scoring system can be used to identify patients, especially those who have undergone bariatric surgery, who are at risk of respiratory complications. Similar evaluation indices have been proposed for other surgeries. Although we started categorizing the patients based on the definition of OSA-related scores (STOP-BANG score of above or below 3), the cut-off points found for each specific adverse event were not exactly compatible to that definition. It is necessary to further define scoring based on this questionnaire to predict the probability of postoperative respiratory complications. In this study, patients in the high-risk group (score of 3 or more) had a longer duration of hospitalization in recovery and intensive care wards, although the difference was not statistically significant compared to the low-risk group. However, the extended duration of hospitalization in recovery and specialized wards may result from factors such as increased surgical complications, patient transfers, nurse shift changes, and other related issues. Specialized care was found to be effective in reducing complications, consistent with other studies. These serious complications, which burden the medical system with costs, also impose an unexpected psychological burden on the patient and their family.

The present study had several limitations. One of these limitations was the small sample size, which may have reduced the generalizability of our results. To draw a definite conclusion from the findings, a larger number of individuals with a wider range of disease records and demographic information should be evaluated. Moreover, this research was carried out in a single center, and it is recommended that further multi-center studies be conducted for more accurate results. In addition, due to the small sample size in some groups, the ROC curve could not be drawn for the determination of the cut-off point of the STOP-BANG checklist score based on the postoperative outcomes in patients. Conducting studies with a larger sample size will allow for the determination of higher and more accurate cut-off points for postoperative complications. Additionally, it should be remembered that the STOP-BANG questionnaire scoring system is designed to screen one specific disorder, i.e., OSA. The net result from this study about previous observations is that this questionnaire's elements are important contributors to postoperative respiratory adverse events. To design another specific tool for screening such events, a larger sample size and post-hoc analyses seem to be mandatory.

## CONCLUSION

Patients who underwent bariatric surgery were found to be more likely to have OSA if they scored higher on the STOP-BANG questionnaire. A STOP-BANG score of 2 to 8 and 4 to 8 can allow clinicians to identify patients with an increased likelihood of OSA due to airway obstruction and hypoxia, respectively. The STOP-BANG score can aid healthcare teams in stratifying patients undergoing bariatric surgery for undiagnosed OSA, administering postoperative precautions, and triaging patients for diagnosis and treatment. Additionally, this scoring system could guide the health care team to predict difficult mask ventilation and postoperative hypoxic events, regardless of OSA diagnosis. Conducting future studies with a larger sample size and in a multi-center manner may lead to better generalization of the results obtained.

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