ORIGINAL ARTICLE

Obstructive Sleep Apnea Syndrome and Postoperative Complications

Clinical Use of the STOP-BANG Questionnaire

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Objective: To determine whether high risk scores on preoperative STOP-BANG (Snoring, Tiredness during daytime, Observed apnea, high blood Pressure, Body mass index, Age, Neck circumference, Gender) questionnaires during preoperative evaluation correlated with a higher rate of complications of obstructive sleep apnea syndrome (OSAS).

Design: Historical cohort study.

Setting: Thomas Jefferson University Hospital, Philadelphia, Pennsylvania.

Patients: Adult patients undergoing elective surgery at a tertiary care center who were administered the STOP-BANG questionnaire for 3 consecutive days in May 2008.

Main Outcome Measures: Number and types of complications.

Results: A total of 135 patients were included in the study, of whom 56 (41.5%) had high risk scores for OSAS. The mean (SD) age of patients was 57.9 (14.4) years; 60 (44.4%) were men. Patients at high risk of OSAS had a higher rate of postoperative complications compared with patients at low risk (19.6% vs 1.3%; $P < .001$). Age, American Society of Anesthesiologists class of 3 or higher, and obesity were associated with an increased risk of postoperative complications. On multivariate analysis, high risk of OSAS and American Society of Anesthesiologists class 3 or higher were associated with higher odds of complications.

Conclusion: The STOP-BANG questionnaire is useful for preoperative identification of patients at higher than normal risk for surgical complications, probably because it identifies patients with occult OSAS.

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OBSTRUCTIVE SLEEP APNEA syndrome (OSAS) is a common disorder of breathing during sleep that may have serious perioperative consequences. In the general population, its prevalence is estimated to be 5% to 9%, and it most often affects obese males.[1] The prevalence of OSAS is higher in the surgical population and varies with different surgical types.[2-4]

The cardiorespiratory consequences of OSAS may be exacerbated in the perioperative setting because of the adverse effects of anesthetics and analgesics on ventilatory control and upper airway muscle tone, predominantly during the early postoperative period.[5] Therefore, it is important to identify surgical patients who are at high risk for OSAS.[6]

Gupta et al[7] found an increased risk of postoperative complications in patients with OSAS compared with control subjects matched for age, sex, and body mass index. Similarly, Hwang et al[8] demonstrated that the rate of postoperative complications increases in proportion with episodes of overnight desaturation during home nocturnal oximetry.

Nocturnal polysomnography is the criterion standard for the diagnosis of OSAS.[9] Home sleep testing has also been gaining increasing acceptance and has the advantage of convenience and cost. Nevertheless, neither procedure has been used extensively in the preoperative assessment settings. Therefore, most preoperative patients with OSAS have not had their conditions diagnosed, raising the potential for a negative effect on postoperative outcome.[10,11] Recently, the STOP-BANG (Snoring, Tiredness during daytime, Observed apnea, high blood Pressure, Body mass index, Age, Neck circumference, Gender) questionnaire was validated as a screening modality for OSAS in the preoperative setting.[12] This instrument is a concise, self-administered, and easy-to-use questionnaire that consists of 8 yes-or-no questions.

In this historical cohort study, we hypothesized that OSAS may be an independent risk factor for postoperative pulmonary and cardiac complications. We

evaluated the clinical usefulness of the STOP-BANG questionnaire in the surgical setting.

METHODS

STUDY DESIGN

We conducted a historical cohort study regarding adult patients undergoing elective surgery at our tertiary care center. The STOP-BANG questionnaire was administered to all patients about to undergo elective surgery for 3 consecutive days in May 2008. The clinical records of these patients were reviewed to obtain information on types and numbers of complications. Patients with renal failure and low albumin levels (<3.5 g/dL; to convert to grams per liter, multiply by 10) were excluded. The study was approved by the local institutional review board.

OUTCOME MEASURES

Clinical records were reviewed to obtain demographic data, type of surgery, duration of surgery, use of neuromuscular blocking drugs during surgery, American Society of Anesthesiologists (ASA) class, comorbidities, length of stay in the hospital, serum albumin level, and creatinine level. The team reviewing the clinical records was masked to the results of the STOP-BANG questionnaire.

Data regarding pulmonary or cardiac complications were also collected. Pulmonary complications included hypoxemia, atelectasis, pulmonary embolism, or pneumonia. Atelectasis was noted if it was reported in the clinical or radiology record. *Hypoxemia* was defined as a decrease in the oxyhemoglobin saturation requiring more aggressive care, including an increase in the flow rate of supplemental oxygen or transfer to the intensive care unit. Pneumonia was reported if the patient received treatment for a clinical diagnosis of pneumonia. Cardiac complications included new-onset atrial fibrillation, systemic hypotension, or myocardial infarction. Systemic hypotension was described as a decrease in systolic blood pressure to less than 90 mm Hg that required more aggressive care, including volume resuscitation or vasopressors.

Patients were classified as being at high risk for OSAS if their STOP-BANG score was 3 or more and were classified as being at low risk if their score was less than 3. In this study, *obesity* was defined as a body mass index (calculated as weight in kilograms divided by height in meters squared) of greater than 30. The relative risk of elective surgical procedures was classified on the basis of the location of the surgery. The thoracic, head and neck, vascular, and upper abdominal operations were labeled as high-risk procedures. All other procedures were classified as low risk.

The outcomes of the study were the presence or absence of postoperative pulmonary or cardiac complications and the length of stay in the hospital. We evaluated the following variables as predictors of postoperative complications: age older than 60 years, obesity, ASA class of 3 or higher, comorbidities, use of neuromuscular blocking drugs, duration of surgery, and type of surgery (high risk vs low risk).

STATISTICAL ANALYSIS

Data were analyzed using STATA 10 statistical software (StataCorp LP, College Station, Texas). Continuous variables are reported as mean (SD). Categorical variables are listed as percentages. Continuous and categorical variables were compared using the Wilcoxon rank sum and Fisher exact tests, respectively, to determine which risk factors were associated with postoperative complications. Multiple logistic regression analysis was performed to assess the effect of individual risk factors on postoperative complications after adjustment for other factors. Odds ratios and corresponding 95% confidence intervals (CIs) are reported, and $P < .05$ is considered statistically significant. The accuracy of the STOP-BANG questionnaire is also reported. To calculate sample size, we estimated that one-third of the population has a high risk score for OSAS and that the incidence of complication is 30.0% in those with high risk scores and 5.0% in those with low risk scores for OSAS. With a power of 90.0% and an α of .05, we estimated that the sample size necessary to show a statistically significant difference in proportions is 134 patients.

STOP-BANG Questionnaire

1. Snoring
   Do you snore loudly (louder than talking or loud enough to be heard through closed doors)?
   Yes No
2. Tired
   Do you often feel tired, fatigued, or sleepy during daytime?
   Yes No
3. Observed
   Has anyone observed you stop breathing during your sleep?
   Yes No
4. Blood pressure
   Are you now being or have you been treated for high blood pressure?
   Yes No
5. BMI
   BMI more than 35 kg/m^2?
   Yes No
6. Age
   Age over 50 years old?
   Yes No
7. Neck circumference
   Neck circumference greater than 40 cm?
   Yes No
8. Gender
   Gender male?
   Yes No

Figure 1. The STOP-BANG (Snoring, Tiredness during daytime, Observed apnea, high blood Pressure, Body mass index, Age, Neck circumference, Gender) questionnaire. A high risk of sleep apnea is defined as a score of 3 or more; low risk of sleep apnea, a score of less than 3.

RESULTS

DEMOGRAPHICS

The STOP-BANG questionnaire (**Figure 1**) was administered to 180 patients before elective surgery. After excluding patients with renal failure and a low serum albumin level, 135 patients were included in the study. The mean patient age was 57.9 (14.4) years, and 60 patients (44.4%) were men. **Table 1** lists the baseline characteristics of all patients. There were 56 patients (41.5%) at high risk for OSAS as defined by a STOP-BANG score of 3 or higher. Thirty-four patients (25.2%) were obese.

TYPES OF OPERATIONS

Table 2 lists the types of operations performed on the study participants. Most of the surgical procedures were performed with the patient under general anesthesia. Nineteen patients (14.1%) did not undergo surgery while under general anesthesia. High-risk surgical procedures were

Table 1. Baseline Characteristics of Study Patients

Characteristic	No. (%) of Patients[a]		
	Low Risk for OSAS (n=79)	High Risk for OSAS (n=56)	Total (N=135)
Age, mean (SD), y	53 (15.1)	64.7 (10.1)	57.9 (14.4)
Age group, y			
>60	22 (27.8)	42 (75.0)	64 (47.4)
≤60	57 (72.1)	14 (25.0)	71 (52.6)
Sex			
Male	22 (27.8)	38 (67.9)	60 (44.4)
Female	57 (72.1)	18 (32.1)	75 (55.6)
Obese (BMI >30)	10 (12.6)	24 (42.8)	34 (25.2)
Current smoker	8 (10.1)	5 (8.9)	13 (9.6)
ASA class			
1	12 (15.2)	1 (1.8)	13 (9.6)
2	37 (46.8)	19 (33.9)	56 (41.5)
3	30 (38.0)	36 (64.3)	66 (48.9)
Mallampati class			
1	38 (48.1)	15 (26.8)	53 (39.3)
2	29 (36.7)	15 (26.8)	44 (32.6)
3	11 (13.9)	21 (37.5)	32 (23.7)
4	1 (1.3)	5 (8.9)	6 (4.4)
Comorbidities			
COPD	1 (1.3)	2 (3.6)	3 (2.2)
Hypertension	22 (27.8)	37 (66.1)	59 (43.7)
Diabetes mellitus	5 (6.3)	9 (16.1)	14 (10.4)
CAD	3 (3.8)	5 (8.9)	8 (5.9)
Asthma	5 (6.3)	4 (7.1)	9 (6.7)
Duration of surgery, mean (SD), h	2.1 (1.4)	2.3 (1.2)	2.2 (1.3)
Use of neuromuscular blocking drugs[b]	44/75 (58.7)	33/55 (60)	77/130 (59.2)

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; OSAS, obstructive sleep apnea syndrome.

[a] Age and duration of surgery are presented as mean (SD). All other variables are expressed as number (percentage). Percentages may not equal 100 because of rounding.

[b] The use of neuromuscular blocking drugs could not be obtained for 5 patients.

Table 2. Types of Operations[a]

Operation	No. (%) of Patients		
	Low Risk for OSAS (n=79)	High Risk for OSAS (n=56)	Total (N=135)
Orthopedic	28 (35.4)	23 (41.1)	**51** (37.8)
Head and neck	12 (15.2)	11 (19.6)	**23** (17.0)
Abdominal	10 (12.6)	9 (16.1)	**19** (14.1)
Gynecologic	10 (12.6)	2 (3.6)	**12** (8.9)
Genitourinary	5 (6.3)	4 (7.1)	**9** (6.7)
Otorhinolaryngologic	4 (5.1)	1 (1.8)	**5** (3.7)
Cardiothoracic	1 (1.3)	2 (3.6)	**3** (2.2)
Vascular	1 (1.3)	2 (3.6)	**3** (2.2)
Others	8 (10.1)	2 (3.6)	**10** (7.4)

Abbreviation: OSAS, obstructive sleep apnea syndrome.

[a] Percentages may not total 100 because of rounding.

performed in 48 patients (35.5%). Information on the use of neuromuscular blocking drugs could not be obtained in 5 patients. Of the remaining 130 patients, 77 (59.2%) underwent surgery with neuromuscular blocking drugs.

COMPLICATIONS

There were 12 occurences of postoperative pulmonary or cardiac complications (8.9%) (**Table 3**). Patients at high risk for OSAS had a higher rate of postoperative complications compared with patients at low risk (19.6% vs 1.3%; $P<.001$). Patients older than 60 years had a higher rate of postoperative complications compared with patients 60 years or younger (14.1% vs 4.2%; $P=.04$). Obese patients also had a higher rate of postoperative complications (17.6% vs 5.9%; $P=.04$). Similarly, an ASA class of 3 or higher was associated with a higher rate of postoperative complications (16.7% vs 1.4%; $P=.001$).

The use of neuromuscular blocking drugs, type of surgery, comorbidities, and duration of surgery were not associated with a higher rate of postoperative complications. The mean length of stay in the hospital was 2.7 (2.6) days and was significantly longer for patients at high risk for OSAS compared with patients at low risk (3.6 [3.6] days vs 2.1 [1.4] days; $P=.003$). In a multiple logistic regression model (**Table 4**) that included age older than 60 years, obesity, high risk of OSAS, and ASA class of 3 or higher as independent variables, high risk of OSAS and ASA class of 3 or higher were associated with significantly higher odds of postoperative complications.

We also evaluated the accuracy of the STOP-BANG questionnaire for predicting postoperative complications by calculating the area under the receiver operating characteristic curve. The area under the curve was 0.82 (**Figure 2**). The threshold of 3 or higher, chosen based on the prior literature,[12] had a sensitivity of 91.7% (95% CI, 61.5%-99.8%), a specificity of 63.4% (95% CI, 54.3%-71.9%), a positive predictive value of 19.6%, (95% CI, 10.2%-32.4%), and a negative predictive value of 98.7% (95% CI, 93.1%-100.0%) for predicting postoperative complications.

COMMENT

This is the first study, to our knowledge, to document that STOP-BANG scores indicative of high risk of OSAS confer a heightened (approximately 10-fold) risk of postoperative complications in patients undergoing elective surgery. Obstructive sleep apnea syndrome is highly prevalent among surgical patients.[2-4] In our study using the STOP-BANG questionnaire, we estimate the prevalence of OSAS to be 41.5% of our elective surgical population, although we did not confirm the diagnosis with polysomnography.

The high rate of postoperative complications in patients with OSAS may be owing to a variety of reasons.[7,8] Central nervous system suppression owing to anesthesia, sedation, and analgesia can foment sleep-disordered breathing and further asphyxia-related complications. In addition, rapid eye movement (REM) sleep is diminished to absent on the first postoperative night, and this typically is followed by REM rebound on subsequent nights.[13] Because of this rebound, REM-

Table 3. Characteristics of Patients With Postoperative Complications

Sex/Age, y	BMI	ASA Class	STOP-BANG Score	Type of Surgery	Complication
				Low Risk for OSAS	
F/74	26	3	2	Orthopedic	Pneumonia
				High Risk for OSAS	
M/89	22	3	3	Head and neck	Pneumonia and respiratory failure on ventilator with ICU transfer
F/58	21	3	3	Cardiothoracic	Hypoxemia and atelectasis
F/62	29	3	6	Abdominal	Hypoxemia and atelectasis with ICU transfer
M/73	20	3	4	Head and neck	Hypoxemia and atelectasis with ICU transfer
F/59	31	3	3	Cardiothoracic	Hypoxemia and atelectasis
F/67	36	3	4	Abdominal	Hypoxemia and atelectasis with ICU transfer
M/73	33	3	5	Orthopedic	Atrial fibrillation
M/65	37	3	4	Orthopedic	Hypoxemia and pulmonary embolism
M/70	37	3	6	Orthopedic	Hypotension
M/71	36	3	4	Orthopedic	Hypotension
F/48	27	2	4	Abdominal	Pneumonia

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); ICU, intensive care unit; OSAS, obstructive sleep apnea syndrome; STOP-BANG, Snoring, Tiredness during daytime, Observed apnea, high blood Pressure, Body mass index, Age, Neck circumference, Gender.

Table 4. Risk Estimate of Factors for Postoperative Complications on Multiple Logistic Regression

Variables	OR (95% CI)	Adjusted *P* Value
Age >60 years	1.01 (0.21-5.02)	.98
ASA class ≥3	8.9 (1.04-75.71)	.04
High risk for OSAS	11.40 (1.18-110.47)	.03
Obesity	1.64 (0.42-6.41)	.47

Abbreviations: ASA, American Society of Anesthesiologists; CI, confidence interval; OR, odds ratio; OSAS, obstructive sleep apnea syndrome.

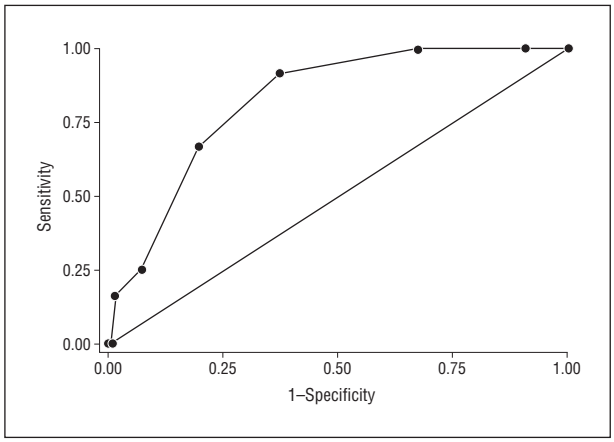

Figure 2. Receiver operating characteristic (ROC) curve of the STOP-BANG (Snoring, Tiredness during daytime, Observed apnea, high blood Pressure, Body mass index, Age, Neck circumference, Gender) questionnaire for the diagnosis of postoperative complications. The area under the ROC curve is 0.8235.

associated hypoxemic episodes may increase 3-fold on the second and third postoperative nights, leading to an increased risk of complications.[14,15]

Other studies[16-19] have described a variety of risk factors for the development of postoperative complications. We found age older than 60 years, obesity, ASA class of 3 or higher, and high risk of OSAS to be associated with an increased risk of postoperative complications. On multivariate analysis, high risk of OSAS and an ASA class of 3 or higher were associated with a higher risk of complications. In addition, patients at high risk of OSAS had a higher risk of pulmonary or cardiac complications and had an increased length of stay in the hospital.

These considerations highlight the importance of identifying OSAS in presurgical patients so that appropriate intervention can be administered. Hwang et al[8] used home nocturnal oximetry to identify patients at risk for OSAS, which may be another, although possibly less practical, method of screening for individuals at high risk for the condition.

The STOP-BANG questionnaire is concise and easy to administer in a preoperative setting. It has been validated in surgical patients and has a high sensitivity to identify most patients with OSAS, especially moderate and severe OSAS.[12] We used this questionnaire in the preoperative area to identify patients at risk for postoperative complications. By using a cutoff of 3 or higher, we found this questionnaire to have a sensitivity of 91.7% and a specificity of 63.4% in identifying patients at high risk for postoperative complications. Interestingly, it also has a high negative predictive value. Therefore, this questionnaire is a good tool to identify patients at high risk of OSAS during preoperative evaluation.

Data regarding the perioperative management of patients with OSAS are limited. Theoretically, the use of nasal continuous positive airway pressure (CPAP) in a perioperative setting may be beneficial.[7,20] In a randomized control trial, nasal CPAP use has been shown to reduce the need for intubation, incidence of pneumonia, infection, and sepsis in patients who developed acute hypoxemia after elective major abdominal surgery.[21] In a randomized clinical trial, the prophylactic use of nasal CPAP was shown to significantly reduce pulmonary morbidity and length of stay in hospitalized patients after the surgical repair of thoracoabdominal aortic aneurysms.[22] Similarly, Zarbock et al[23] showed that prophylactic use of nasal CPAP prevents pulmonary complications, in-

cluding pneumonia, hypoxemia, and reintubation, after cardiac surgery.

This study has several strengths. It is the first study, to our knowledge, to identify the clinical usefulness of the STOP-BANG questionnaire in an elective surgical population and to demonstrate that a high risk score is associated with an increased incidence of postoperative complications. Its major limitation is that its conclusions are based on a retrospective review of clinical records, raising the potential for errors of omission and methodologic inconsistencies. We think it would be useful for other investigators to evaluate the STOP-BANG questionnaire for postoperative complications and to provide external validation of our study results.

In conclusion, this study demonstrated that a high risk score for OSAS on the STOP-BANG questionnaire is associated with an increased incidence of postoperative complications. Most patients with OSAS have undiagnosed conditions and are almost certainly at risk in the perioperative setting. The STOP-BANG questionnaire is a convenient and useful screening tool that appears to reliably identify patients who are at increased risk for postoperative complications.

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