CHEST

STOP-Bang Questionnaire

A Practical Approach to Screen for Obstructive Sleep Apnea

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There exists a high prevalence of OSA in the general population, a great proportion of which remains undiagnosed. The snoring, tiredness, observed apnea, high BP, BMI, age, neck circumference, and male gender (STOP-Bang) questionnaire was specifically developed to meet the need for a reliable, concise, and easy-to-use screening tool. It consists of eight dichotomous (yes/no) items related to the clinical features of sleep apnea. The total score ranges from 0 to 8. Patients can be classified for OSA risk based on their respective scores. The sensitivity of STOP-Bang score ≥ 3 to detect moderate to severe OSA (apnea-hypopnea index [AHI] > 15) and severe OSA (AHI > 30) is 93% and 100%, respectively. Corresponding negative predictive values are 90% and 100%. As the STOP-Bang score increases from 0 to 2 up to 7 to 8, the probability of moderate to severe OSA increases from 18% to 60%, and the probability of severe OSA rises from 4% to 38%. Patients with a STOP-Bang score of 0 to 2 can be classified as low risk for moderate to severe OSA whereas those with a score of 5 to 8 can be classified as high risk for moderate to severe OSA. In patients whose STOP-Bang scores are in the midrange (3 or 4), further criteria are required for classification. For example, a STOP-Bang score of ≥ 2 plus a BMI > 35 kg/m^2 would classify that patient as having a high risk for moderate to severe OSA. In this way, patients can be stratified for OSA risk according to their STOP-Bang scores.

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OSA is the most common type of sleep-disordered breathing. In OSA, repetitive episodes of partial and complete pharyngeal collapse cause a reduction or total cessation of airflow during sleep. The condition is associated with hypertension, cerebrovascular disease, myocardial infarction, diabetes, long-term cognitive impairment, and increased all-cause mortality.[1-3] This chronic sleep disturbance results in daytime sleepiness and fatigue that impedes a patient's ability to function, thereby negatively affecting his or her quality of life. The current prevalence rate of moderate to severe OSA (apnea-hypopnea index [AHI] ≥ 15 events/h) is about 10% to 20%.[4] This estimated prevalence rate represents a substantial increase over the past 2 decades.[4] Since these apnea and

ABBREVIATIONS: AHI = apnea-hypopnea index; NPV = negative predictive value; PPV = positive predictive value; PSG = polysomnogram; STOP-Bang = snoring, tiredness, observed apnea, high BP, BMI, age, neck circumference, and male gender

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hypopnea events occur during sleep, most patients with OSA may not be aware that they have the condition. It has been estimated that up to 80% of individuals with moderate to severe OSA may remain undiagnosed and, more alarmingly, untreated.[5]

The prevalence of OSA specifically found in surgical patients differs among various populations. The prevalence rate is approximately 70% in patients undergoing bariatric surgery[6] and 8.4% of orthopedic patients,[7] and 7.2% among patients undergoing a variety of surgeries.[8] Since 60% of surgical patients with moderate to severe OSA were not recognized or diagnosed preoperatively,[9,10] the point estimates from these studies may actually be an underestimation.

Because of the potentially serious adverse consequences associated with untreated OSA in the general and surgical population, prompt diagnosis and treatment of unrecognized OSA is critical. The reference standard for diagnosis of OSA is an overnight polysomnogram (PSG). However, the procedure is time-consuming, labor-intensive, and costly. Growing awareness of sleep apnea has extended the already long waiting lists in many sleep laboratories.[11] As a result, patients with OSA are currently left waiting a mean of 11.6 months before being able to initiate medical therapy (CPAP) and 16.2 months before being able to initiate surgical therapy in Ontario, Canada.[12] Moreover, PSG requires the expertise of sleep medicine specialists, who may not be readily available at many hospitals and medical centers. All of these factors exacerbate delays that can prevent prompt diagnosis and treatment of OSA, which further emphasizes the vital need for a simple, practical, and reliable method of identifying and triaging patients at high risk of OSA. In an effort to deal with this issue, a number of screening tests were developed to identify high-risk patients.[8,13-19] Many are lengthy and complicated, and require upper airway assessment, which makes them inconvenient to use and vulnerable to variability among clinicians performing the upper airway assessment.

The STOP and STOP-Bang Questionnaire

The snoring, tiredness, observed apnea, high BP (STOP) and snoring, tiredness, observed apnea, high BP-BMI, age, neck circumference and gender (STOP-Bang) questionnaires (e-Appendix 1) were developed in response to the need for a concise, user-friendly OSA screening tool in preoperative clinics.[20] The STOP questionnaire includes four questions related to snoring, tiredness, observed apnea and high blood pressure, and shows a moderately high level of sensitivity (65.6%) and specificity (60%) in detecting OSA (AHI > 5) in surgical patients.[20] For moderate to severe OSA (AHI > 15), the sensitivity and specificity of the STOP questionnaire are 74% and 53%, respectively. For severe OSA (AHI > 30), sensitivity is 80% and specificity is 49%.[20]

The STOP-Bang questionnaire includes the four questions used in the STOP questionnaire plus four additional demographic queries,[20] for a total of eight dichotomous (yes/no) questions related to the clinical features of sleep apnea (snoring, tiredness, observed apnea, high blood pressure, BMI, age, neck circumference and male gender). For each question, answering “yes” scores 1, a “no” response scores 0, and the total score ranges from 0 to 8. The components of STOP questionnaire were selected based on the factor analysis of 14 candidate questions designed to reflect snoring, daytime tiredness, observed breathing cessation, and high BP.[20] The “Bang” items were chosen based on univariate analysis of item predictive performance. The diagnostic OR to detect OSA (AHI > 5 events/h) was 1.949 (95% CI, 0.792-4.798) for BMI > 35 kg/m^2; 4.024 (95% CI, 2.023-8.003) for age > 50 years; 4.943 (95% CI, 1.963-12.446) for neck circumference > 40 cm, and 2.767 (95% CI, 1.419-5.396) for male gender (F. C., unpublished data, February 2014).

The questionnaire can be completed quickly and easily (usually within 1-2 min), and overall response rates are typically high (90%-100%).[20] The questionnaire has demonstrated a high sensitivity using a cutoff score of ≥ 3: 84% in detecting any sleep apnea (AHI > 5 events/h), 93% in detecting moderate to severe sleep apnea (AHI > 15 events/h), and 100% in detecting severe sleep apnea (AHI > 30 events/h).[20] Corresponding specificities were 56.4%, 43%, and 37%.[20] If patients score 0 to 2 on the STOP-Bang questionnaire, they are considered to be at low risk of OSA, and the possibility of those patients having moderate to severe sleep apnea can be confidently ruled out.

Because of its ease of use, efficiency, and high sensitivity, the STOP-Bang questionnaire has been widely adopted and validated in various populations and among patients with assorted medical conditions. It has been applied in sleep[21-30] and medical clinics,[31] surgical patients,[32,33] the general population,[34,35] pregnant patients,[36] individuals with mental illness,[37] highway bus drivers,[38-40] and patients with renal failure.[41]

Association Between STOP-Bang Scores and Predictive Probability of OSA

Although the high sensitivity of the STOP-Bang questionnaire makes it useful as an OSA screening tool, it is possible that the modest specificity (43% to detect moderate to severe sleep apnea) will yield a high false-positive rate.[20] This, in turn, could result in unnecessary referral to sleep clinics for polysomnography, as well as increase the cost of care for surgical patients owing to additional perioperative monitoring. To address these issues effectively and help curb unnecessary treatment or expenses, we further investigated the relationship between STOP-Bang scores and the predicted probability of OSA specifically in surgical patients.[33] We discovered that as the STOP-Bang scores increased from 0 to 2 up to 7 to 8, the probability of moderate to severe OSA increased from 18% to 60% and the probability of severe OSA rose from 4% to 38% (Table 1).[33]

In total, the relationship between the various STOP-Bang scores and the predicted probability of OSA has been investigated through four studies: two conducted with patients referred to sleep clinics[21,42] and two with surgical patients.[32,33] Figure 1 features the results of pooled data from these studies. In both sleep clinic (Fig 1A, 1B) (N = 1,852) and surgical patients (Fig 1C, 1D) (N = 957), the probability of moderate OSA (AHI, 15-30) (Fig 1A, 1C) stayed almost the same in patients with STOP-Bang scores of 3, 4, and 5, and then gradually decreased at STOP-Bang scores of 6 and 7/8. In contrast, the probability of severe OSA (AHI > 30) (Fig 1B, 1D) steadily increased as the STOP-Bang score increased from 3 to 7 or 8. The data indicate that as the STOP-Bang score increases, the probability of severe OSA increases but the probability of moderate OSA does not.

Alternative Models for Scoring the STOP-Bang Questionnaire

For ease of use, all items on the STOP-Bang questionnaire are treated equally for scoring purposes, using a count of 0 or 1. The items on the questionnaire do not share an equal predictive weight for OSA.[14,20] In the "Bang" components, BMI > 35 kg/m^2, neck circumference > 40 cm, and male gender are more predictive than being of aged > 50 years.[43] Whereas previous studies showed that the prevalence of sleep apnea tends to increase with age, the severity of sleep apnea—as indicated by both the number of events and the minimum oxygen saturation—actually decreases with age.[44]

The predictive performance of specific combinations of items has also been explored.[43] Compared with the specificity of 31% for detecting moderate to severe OSA using a combination of any three positive items on the STOP-Bang questionnaire, the following three combinations significantly improve the specificity to detect any OSA (AHI > 5), moderate to severe OSA (AHI > 15), and severe OSA (AHI > 30) at the expense of sensitivity: (1) STOP score ≥ 2 plus BMI > 35 kg/m^2; (2) STOP score ≥ 2 plus neck circumference > 40 cm (16 in); and (3) STOP score ≥ 2 plus male gender.[43] The specificity to detect moderate to severe OSA increases as follows based on those different combinations: to 85% for the combination of a STOP score ≥ 2 plus BMI > 35 kg/m^2; to 79% for the combination of a STOP score ≥ 2 plus neck circumference > 40 cm (16 in); and to 77% for the combination of a STOP score ≥ 2 plus male. These valuable data can assist in accurately identifying more patients with moderate to severe OSA (Table 2).

The STOP-Bang Questionnaire and Serum Bicarbonate

Chronic daytime hypercapnia ($PaCO_2$ ≥ 45 mm Hg) is found in 10% to 38% of patients with OSA,[45] and as the severity of OSA increases, the risk of chronic daytime hypercapnia may also increase.[46] Serum bicarbonate (HCO_3^-) may increase in moderate to severe

TABLE 1] STOP-Bang Scores and Predicted Probabilities for Any OSA, Moderate-to-Severe OSA, and Severe OSA in a Surgical Population

STOP-Bang Score	Any OSA (AHI > 5)	Moderate/Severe OSA (AHI > 15)	Severe OSA (AHI > 30)
0-2	0.46 (0.39-0.53)	0.18 (0.13-0.24)	0.04 (0.02-0.08)
3	0.72 (0.65-0.78)	0.36 (0.29-0.43)	0.13 (0.09-0.19)
4	0.73 (0.66-0.79)	0.42 (0.34-0.49)	0.18 (0.13-0.25)
5	0.77 (0.69-0.84)	0.50 (0.42-0.59)	0.30 (0.23-0.39)
6	0.79 (0.68-0.87)	0.57 (0.45-0.69)	0.32 (0.22-0.44)
7 and 8	0.86 (0.72-0.93)	0.60 (0.44-0.73)	0.38 (0.29-0.53)

Data are given as probability (95% CI). AHI = apnea-hypopnea index; STOP-Bang = snoring, tiredness, observed apnea, high BP, BMI, age, neck circumference, and male gender. (Adapted with permission Chung et al.[33])

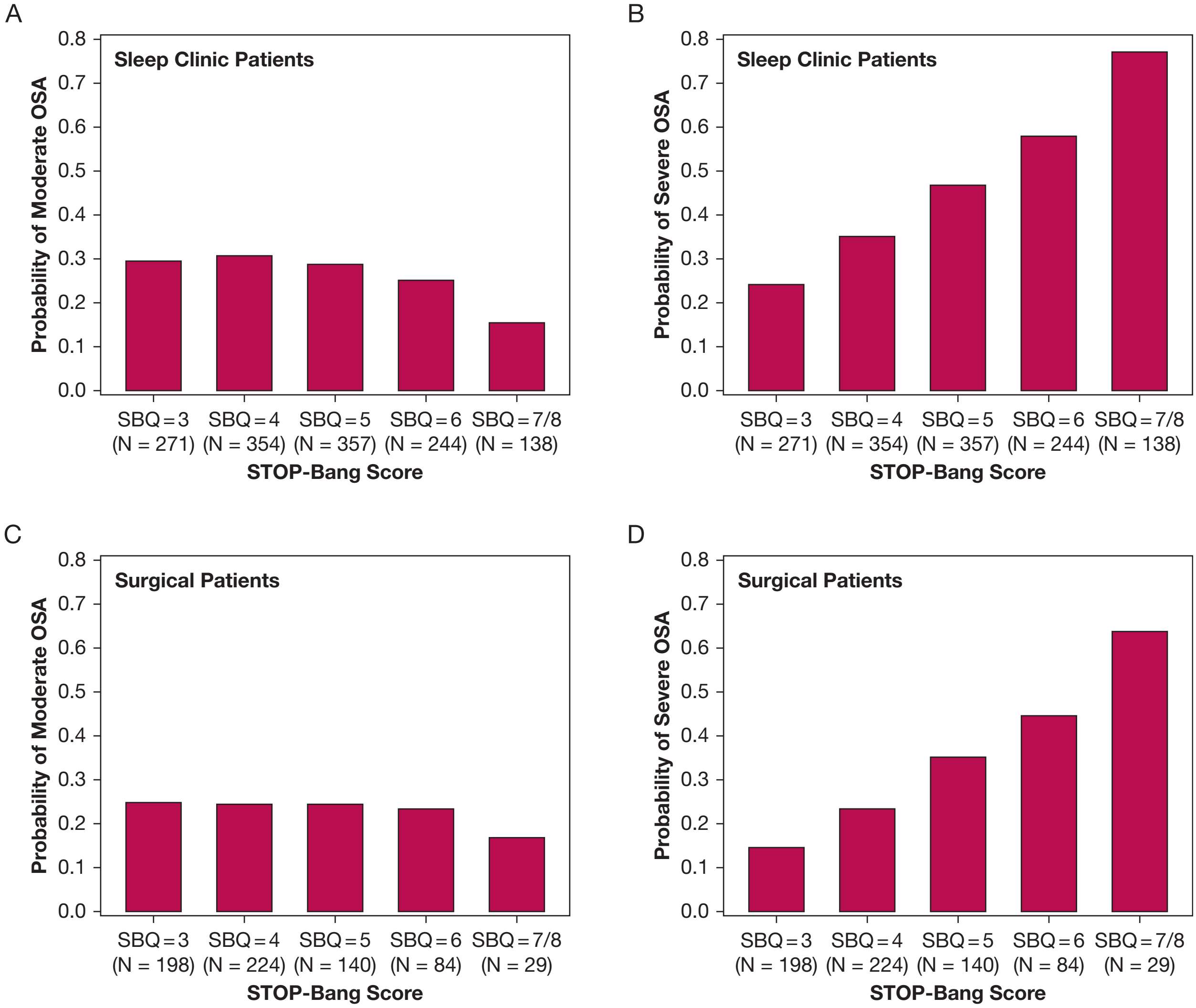

Figure 1 – *Relationship between SBQ score and the probability of OSA. A, SBQ score and probability of moderate OSA (apnea-hypopnea index [AHI] > 15-30) in sleep clinic patients. B, SBQ score and probability of severe OSA (AHI > 30) in sleep clinic patients. C, SBQ score and probability of moderate OSA (AHI > 15-30) in surgical patients. D, SBQ score and probability of severe OSA (AHI > 30) in surgical patients. (A) and (B) are based on the meta-analysis of two studies in sleep clinics.[21,43] (C) and (D) are based on the meta-analysis of two studies in surgical patients.[32,33] SBQ = STOP-Bang questionnaire; STOP-Bang = snoring, tiredness, observed apnea, high BP, BMI, age, neck circumference, and male gender.*

TABLE 2] Predictive Performance of Combination of Two Items From STOP and One From Bang for Identifying Patients With Moderate to Severe Obstructive Sleep Apnea (Apnea-Hypopnea Index > 15)

Cutoff	Sensitivity	Specificity	PPV	NPV
STOP-Bang ≥ 3	87.3 (81.8-91.6)	30.7 (25.7-36.1)	43.8 (38.8-48.8)	79.7 (71.5-86.4)
STOP ≥ 2 + Bang ≥ 1	71.6 (64.7-77.8)	46.1 (40.5-51.7)	45.0 (39.5-50.7)	72.4 (65.7-78.4)
STOP ≥ 2 + BMI > 35 kg/m^2	20.8 (15.4-27.2)	85.0 (80.6-88.7)	46.1 (35.4-57.0)	63.5 (58.7-68.0)
STOP ≥ 2 + Neck > 40 cm	33.5 (27.0-40.6)	79.0 (74.1-83.3)	49.6 (40.8-58.4)	65.8 (60.8-70.5)
STOP ≥ 2 + male gender	40.1 (33.2-47.3)	76.8 (71.8-81.3)	51.6 (43.4-59.8)	67.5 (62.4-72.3)
STOP ≥ 2 + age > 50 y	59.4 (52.2-66.3)	56.1 (50.5-61.6)	45.5 (39.3-51.8)	69.1 (63.1-74.7)

Data are presented as average (95% CI). Bang = BMI, age, neck circumference, and male gender; NPV = negative predictive value; PPV = positive predictive value; STOP = snoring, tiredness, observed apnea, and high BP. (Adapted with permission Chung et al.[43])

OSA without meeting criteria of overt chronic daytime hypercapnia, as documented in obesity hypoventilation syndrome.[46] Obesity hypoventilation syndrome is defined by daytime hypercapnia and hypoxemia ($PaCO_2$ > 45 mm Hg and PaO_2 < 70 mm Hg) in an obese patient (BMI > 30 kg/m^2) who has sleep-disordered breathing and which occurs in the absence of any other cause of hypoventilation.[45]

Since nocturnal intermittent hypercapnia resulting from to obstructive apnea or hypopnea may lead to renal HCO_3^- retention to compensate for acute respiratory acidosis,[47] it may subsequently result in elevated serum HCO_3^-. Our findings indicate that serum HCO_3^- is significantly correlated to AHI,[48] and the addition of serum HCO_3^- ≥ 28 mmol/L to a STOP-Bang score ≥ 3 improves the specificity to predict moderate to severe OSA but decreases its sensitivity.[48] Under that condition (a STOP-Bang score of ≥ 3 plus HCO_3^- ≥ 28 mmol/L), the specificity for detecting moderate to severe OSA increases from 30% to 82%, and from 28% to 80% for detecting severe OSA.[48]

Two-Step Strategy for Using STOP-Bang Questionnaire

Based on these data,[33,43,48] we propose a two-step algorithm (Fig 2) to use the STOP-Bang questionnaire to identify patients effectively with a high probability of moderate to severe sleep apnea. As shown in Figure 2, the first step is to check the STOP-Bang score. If a patient scores 0 to 2 on the STOP-Bang questionnaire, he or she is unlikely to have moderate to severe OSA.

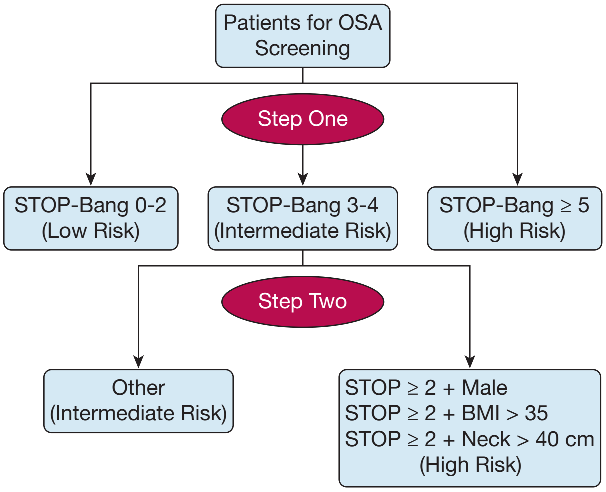

Figure 2 – *STOP-Bang algorithm with a two-step scoring strategy. See Figure 1 legend for expansion of abbreviation.*

Conversely, a patient with a STOP-Bang score of 5 to 8 has a high probability of having moderate to severe OSA (Table 1).[33] The second step is for patients falling in the middle: those with STOP-Bang scores of 3 or 4. These patients can be further classified as having a higher risk for moderate to severe OSA if one of the following conditions is met: (1) the combination of a STOP score of ≥ 2 plus BMI > 35 kg/m^2; (2) a STOP score of ≥ 2 plus male gender; (3) a STOP score of ≥ 2 plus neck circumference > 40 cm (16 in); or (4) a STOP-Bang score of ≥ 3 plus serum HCO_3^- ≥ 28 mmol/L. This two-step algorithm needs to be further validated prospectively.

STOP-Bang Questionnaire in the General Population and in Bus Drivers

Studies in primary care patients demonstrate that the STOP-Bang questionnaire has predictive performance similar to that seen in surgical and sleep clinic patients.[34,35] Silva et al[35] evaluated the STOP-Bang questionnaire in 4,770 participants in the Sleep Heart Health Study. The prevalence of moderate to severe OSA (respiratory disturbance index [RDI] ≥ 15 events/h) and severe OSA (RDI ≥ 30 events/h) in this population was 13% and 7%, respectively. The sensitivity of a STOP-Bang score ≥ 3 was 89% to detect moderate to severe OSA (RDI ≥ 15 events/h) and 93% to detect severe OSA (RDI ≥ 30 events/h). Specificities were 30% and 29%, respectively. Positive predictive values (PPV) were lower: 16% and 9%, respectively. Negative predictive values (NPV) were higher: 95% and 98%, respectively.[35] The relatively low PPV and high NPV were probably related to the relatively low OSA prevalence in the study population. In another study of 178 patients with 60% with OSA (AHI ≥ 5 events/h), the sensitivity of the STOP-Bang questionnaire to detect OSA (AHI ≥ 5 events/h) was 96% whereas the specificity was 24%, PPV was 66%, and NPV was 81%.[34] Further research is needed to investigate the association between STOP-Bang scores and OSA probability in the general population.

The STOP-Bang questionnaire has also been evaluated for its ability to detect moderate to severe OSA in highway bus drivers.[38] The prevalence of moderate to severe OSA among the highway bus drivers was 54%. Compared with other questionnaires (Berlin, STOP, and OSA50), the STOP-Bang questionnaire had the highest sensitivity and NPV and was more helpful as a screening test to identify drivers at risk for OSA.[38] The sensitivity and specificity of a STOP-Bang score

≥ 3 to detect moderate to severe OSA were 87% and 49%, respectively. The PPV and NPV was 66% and 76%, respectively.[38]

STOP-Bang Questionnaire in Obese Patients

The prevalence of OSA is high in the obese population. In morbidly obese surgical patients (BMI ≥ 35 kg/m^2), 84% had OSA (AHI > 5 events/h), 47% had moderate to severe OSA (AHI > 15 events/h), and 27% had severe OSA (AHI > 30 events/h).[49] We evaluated the predictive performance of the STOP-Bang questionnaire for OSA in obese (BMI ≥ 30 kg/m^2) and morbidly obese (BMI ≥ 35 kg/m^2) surgical patients.[49] Although STOP-Bang ≥ 3 is very sensitive (sensitivity range, 91%-100%) to detect OSA in obese and morbidly obese patients, the specificity is low (from 7%-28%), yielding high false-positive rates. A STOP-Bang score cutoff of 4 provides a better balance of sensitivity and specificity in the obese population. In morbidly obese patients, a STOP-Bang score ≥ 4 retained high sensitivity across the entire spectrum of OSA severity, with a sensitivity of 90% for detecting severe OSA,[49] whereas a STOP-Bang score ≥ 6 demonstrated a specificity of 81% for detecting severe OSA.[49]

OSA Screening: Benefits and Challenges

The high prevalence of undiagnosed OSA requires a reliable, efficient, and easily used screening tool. The STOP-Bang questionnaire has been widely adopted to fulfill this need. As the STOP-Bang score increases, the probability of severe OSA rises. Using the STOP-Bang questionnaire, sleep clinicians can quickly and reliably identify those at risk of severe OSA and prioritize patients for polysomnography or out-of-center sleep testing. Similarly, surgical patients can be stratified for OSA severity according to their STOP-Bang scores.

Several studies show that screening OSA with STOP-Bang questionnaire identifies patients with an increased incidence of postoperative complications.[50-52] Data from a prospective study of 3,452 patients show that patients identified as being at high risk of OSA by the STOP-Bang questionnaire had a higher rate of postoperative complications (9% vs 2% in patients with a low risk of OSA), difficult intubation (20% vs 9%), and difficult mask ventilation (23% vs 7%).[51] The STOP-Bang score was positively associated with postoperative critical care admission.[52] A prospective cohort study showed that untreated OSA was independently associated with more cardiopulmonary complications, particularly unplanned reintubations and myocardial infarction.[53] In another retrospective study,[54] a diagnosis of OSA and prescription of CPAP therapy were associated with a reduction in postoperative cardiovascular complications. In a randomized controlled trial, perioperative auto-titrating positive airway pressure has been shown to prevent postoperative worsening of OSA and desaturation in patients newly diagnosed with OSA.[55] However, the randomized controlled trials did not show that the incidence of postoperative complications was reduced by perioperative auto-titrating positive airway pressure treatment,[55,56] probably because of the small sample size (177 in the study of Liao et al[55] and 86 in the study of O'Gorman et al[56]) and poor compliance with CPAP in these studies.[32,55-57] Further research is needed to identify barriers to CPAP compliance in the perioperative setting.

Currently no data are available to evaluate the impact of preoperative OSA screening and corresponding perioperative care measures on perioperative outcomes. We need to investigate prospectively whether a perioperative pathway incorporating preoperative OSA screening, perioperative OSA precautions, and postoperative treatment of OSA improves perioperative outcomes in patients with OSA.

OSA is independently associated with a higher rate of long-term cardiovascular events after coronary artery bypass.[58] Effective OSA screening in a preoperative clinic, followed by the initiation of CPAP treatment, may yield long-term health benefits.[59]

Limitations

When using the STOP-Bang questionnaire, several key points should be taken into account. Although the STOP-Bang questionnaire has been validated in different populations, a selection bias might be present in some of the validation studies. For example, most patients in sleep clinics were referred because they were already suspected of having sleep-related issues. In studies targeting surgical patients, a self-selection bias from patients themselves may have occurred in that patients with preexisting sleep symptoms might be more willing to consent to an overnight PSG. Generally speaking, younger patients were more likely to decline the studies.[20] As a result of these potential selection biases, the high prevalence of OSA in the study populations may affect interpretation of the predictive parameters by presenting a seemingly inflated PPV. Although the STOP-Bang questionnaire is validated in multiple populations, it was less useful in identifying OSA patients in two distinct groups: the veteran population[60] and patients with renal failure.[41] To ensure effective screening, validation of the STOP-Bang questionnaire in the specific target population is recommended. Since measurement tapes may not be consistently available in the physician's office, and because of potential issues with measurement variability in neck circumference, these challenges may affect accuracy of the STOP-Bang score.

Conclusions

Studies have demonstrated that the STOP-Bang questionnaire is a concise, effective, and reliable OSA screening tool. It can facilitate efficient allocation of resources in both diagnosing and treating previously unrecognized OSA. The probability of moderate to severe OSA increases in direct proportion to the STOP-Bang score, which makes the questionnaire an easily used tool for identifying patients at high risk for OSA. Patients with a STOP-Bang score of 0 to 2 can be classified as being at low risk for moderate to severe OSA. Those with a STOP-Bang score of 5 to 8 can be classified as being at high risk for moderate to severe OSA. In patients with a STOP-Bang score of 3 or 4, the specific combinations of positive items should be examined further to ensure proper classification. If a combination of a STOP score ≥ 2 plus (BMI > 35 kg/m^2 or male gender or neck circumference > 40 cm) or a STOP-Bang score ≥ 3 plus serum $HCO_3^- \geq 28$ mmol/L is found, these patients can be further classified as being at high risk of moderate to severe OSA.

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Additional information: The e-Appendix can be found in the Supplemental Materials section of the online article.

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