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Title: STOP-Bang Questionnaire: A practical approach to screen for obstructive sleep apnea

Short title: STOP-Bang Questionnaire to screen sleep apnea

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Disclosure of conflict of Interest

Authors declare no conflicts of interest. The STOP-Bang questionnaire is the property of University Health Network, Toronto, On, Canada.

Funding

Physician Services Incorporated Foundation, University Health Network Foundation, and Department of Anesthesia, University Health Network-Mount Sinai Hospital, University of Toronto, Toronto, Ontario, Canada

Abbreviation List

- AHI:** Apnea-hypopnea index
- APAP:** Autotitrating positive airway pressure
- BMI:** Body mass index
- CPAP:** Continuous positive airway pressure
- NPV:** Negative predictive value
- OSA:** Obstructive sleep apnea
- PPV:** Positive predictive value
- PSG:** Polysomnogram

1 **Summary**

2 Today, there exists a high prevalence of obstructive sleep apnea (OSA) in the general
 3 population, a great proportion of which remains undiagnosed. The STOP-Bang questionnaire
 4 has been specifically developed to meet the need for a reliable, concise and easy-to-use
 5 screening tool. It consists of eight dichotomous (yes/no) items related to the clinical features of
 6 sleep apnea (Snororing, Tiredness, Observed apnea, high blood Pressure, BMI, age, neck
 7 circumference and male gender). The total score ranges from 0 to 8. Patients can be classified
 8 for their OSA risk based on their respective scores.

9 The sensitivity of STOP-Bang score ≥ 3 to detect moderate-to-severe OSA (AHI > 15) and
 10 severe OSA (AHI > 30) is 93% and 100% respectively. The corresponding negative predictive
 11 values are 90% and 100%. As the STOP-Bang score increases from 0-2 to 7-8, the probability of
 12 moderate-to-severe OSA increases from 18% to 60%, and the probability of severe OSA rises
 13 from 4% to 38%. Patients with a STOP-Bang score of 0 to 2 can be classified as “low risk” for
 14 moderate-to-severe OSA, while those with a score of 5 to 8 can be classified as “high risk” for
 15 moderate-to-severe OSA. In patients whose STOP-Bang scores land in the mid-range (3 or 4),
 16 further criteria are required for classification. For example, a STOP score of ≥ 2 + BMI > 35
 17 kg/m² would classify that patient as having a high risk for moderate-to-severe OSA. In this way,
 18 patients can be stratified for their OSA risk according to their STOP-Bang scores.

Introduction

Obstructive sleep apnea (OSA) is the most common type of sleep disordered breathing (SDB). 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 10-20%.⁴ This estimated prevalence rate represents a substantial increase over the last two decades.⁴ Since these apnea and hypopnea events occur during sleep, the majority of 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 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.

Given 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 gold 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, OSA patients 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 these factors exacerbate delays that can prevent prompt diagnosis and treatment of OSA, further emphasizing 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, making these inconvenient to use and vulnerable to variability amongst clinicians performing the upper airway assessment.

The STOP and STOP-Bang questionnaire

The STOP and STOP-Bang questionnaires (Appendix) 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%. For severe OSA (AHI > 30), sensitivity is 80% and specificity is 49%.²⁰

1 The STOP-Bang questionnaire includes the four questions used in the STOP
 2 questionnaire, plus four additional demographic queries,²⁰ for a total of eight dichotomous
 3 (yes/no) questions related to the clinical features of sleep apnea (Snoring, Tiredness, Observed
 4 apnea, high blood Pressure, BMI, age, neck circumference and male gender). For each
 5 question, answering 'yes' scores 1, a 'no' response scores 0, and the total score ranges from 0
 6 to 8. The components of STOP questionnaire were selected based on the factor analysis of 14
 7 candidate questions designed to reflect snoring, daytime tiredness, observed breathing
 8 cessation and high blood pressure.²⁰ The 'Bang' items were chosen based on univariate
 9 analysis of item predictive performance. The diagnostic odds ratio to detect OSA (AHI>5
 10 events/h) was 1.949 (0.792-4.798) for BMI>35 kg/m²; 4.024 (2.023-8.003) for age >50 years
 11 old; 4.943 (1.963-12.446) for neck circumference > 40cm, and 2.767 (1.419-5.396) for male
 12 gender (unpublished data).

13 The questionnaire can be completed quickly and easily (usually within one to two
 14 minutes), and the overall response rates are typically high (90 to 100%).²⁰ The questionnaire
 15 has demonstrated a high sensitivity using a cut-off score of 3 or greater: 84% in detecting any
 16 sleep apnea (AHI >5 events/h); 93% in detecting moderate-to-severe sleep apnea (AHI >15
 17 events/h); and 100% in detecting severe sleep apnea (AHI >30 events/h).²⁰ The corresponding
 18 specificities were 56.4%, 43% and 37%.²⁰ If a patient scores 0 to 2 on the STOP-Bang
 19 questionnaire, he or she is considered to be at low risk of OSA, and the possibility of that
 20 patient having moderate-to-severe sleep apnea can be confidently ruled out.

Due to 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 sleep²¹⁻³⁰ and medical clinics,³¹ surgical patients,^{32,33} general population,^{34,35} pregnant patients,³⁶ individuals with mental illnesses,³⁷ highway bus drivers,³⁸⁻⁴⁰ and patients with renal failure.⁴¹

Association between the STOP-Bang scores and the predictive probability of OSA

Although the high sensitivity of the STOP-Bang questionnaire makes it very useful as an OSA screening tool, it's 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 increasing the cost of care for surgical patients due to additional perioperative monitoring. To effectively address these issues 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- 2 to 7- 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 the pooled data from these studies. In both sleep-clinic (Figure 1, Panels A & B, N=1,852) and surgical patients (Figure 1, Panels C & D, N=957), the probability of moderate OSA (AHI: 15-30,

1 Panels A & C) stayed almost the same in patients with STOP-Bang scores of 3, 4 and 5, and then
 2 gradually decreased at STOP-Bang scores of 6 and 7/8. In contrast, the probability of severe
 3 OSA (AHI > 30, Panels B & D) steadily increased as the STOP-Bang score increased from 3 to 7
 4 or 8. The data indicate that as the STOP-Bang score increases, the probability of severe OSA
 5 increases, but the probability of moderate OSA does not.

6 **Alternative models for scoring the STOP-Bang questionnaire**

7 For ease of use, all items on the STOP-Bang questionnaire are treated equally for
 8 scoring purposes, using a count of 0 or 1. It is important to note that the items on the
 9 questionnaire do not share an equal predictive weight for OSA.^{14,20} In the 'Bang' components,
 10 BMI > 35 kg/m², neck circumference > 40 cm and male gender are more predictive than being
 11 of an age > 50 years.⁴³ While previous studies have shown that the prevalence of sleep apnea
 12 tends to increase with age, the severity of sleep apnea – as indicated by both the number of
 13 events and the minimum oxygen saturation – actually decreases with age.⁴⁴

14 The predictive performance of specific combinations of items has also been explored.⁴³
 15 Compared with the specificity of 31% for detecting moderate-to-severe OSA using a
 16 combination of any three positive items in the STOP-Bang questionnaire, the following three
 17 combinations significantly improve the specificity to detect any OSA (AHI > 5), moderate-to-
 18 severe OSA (AHI > 15) and severe OSA (AHI > 30) at the expense of sensitivity: 1) STOP score ≥ 2
 19 + BMI > 35 kg/m²; 2) STOP score ≥ 2 + neck circumference > 40 cm (16 inches); and 3) STOP
 20 score ≥ 2 + male gender.⁴³ The specificity to detect moderate-to-severe OSA increases as
 21 follows based on those different combinations: to 85% for the combination of a STOP score ≥ 2

+ BMI > 35 kg/m²; to 79% for the combination of a STOP score ≥ 2 + neck circumference > 40 cm (16 inches); and to 77% for the combination of a STOP score ≥ 2 + male. This 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 (PaCO₂ ≥ 45 mmHg) 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 (HCO₃⁻) may increase in moderate-to-severe 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 (PaCO₂ > 45 mmHg and PaO₂ < 70 mmHg) in an obese patient (BMI > 30 kg/m²) who suffers from SDB and is in absence of any other cause of hypoventilation.⁴⁵

Since nocturnal intermittent hypercapnia due to obstructive apnea or hypopnea may lead to renal HCO₃⁻ retention to compensate for acute respiratory acidosis,⁴⁷ it may subsequently result in an elevated serum HCO₃⁻. Our findings indicate that serum HCO₃⁻ is significantly correlated to AHI,⁴⁸ and the addition of serum HCO₃⁻ ≥ 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 + HCO₃⁻ ≥ 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

1 **Two-step strategy for utilizing STOP-Bang questionnaire**

2 Based on these data,^{33,43,48} we propose a two-step algorithm (Figure 2) to utilize the
3 STOP-Bang questionnaire to effectively identify patients with a high probability of moderate-
4 to-severe sleep apnea. As shown in Figure 2, the first step is to check the STOP-Bang score. If a
5 patient scores 0 to 2 on the STOP-Bang questionnaire, he or she is unlikely to have moderate-
6 to-severe OSA. Conversely, a patient with a STOP-Bang score of 5 to 8 has a high probability of
7 having moderate-to-severe OSA (Table 1).³³ The second step is for the patients falling in the
8 middle – with STOP-Bang scores of 3 or 4. These patients can be further classified as having a
9 higher risk for moderate-to-severe OSA if one of the following conditions is met: 1) a
10 combination of a STOP score of ≥ 2 + BMI $> 35 \text{ kg/m}^2$; 2) a STOP score of ≥ 2 + male; 3) a STOP
11 score of ≥ 2 + neck circumference $> 40 \text{ cm}$ (16 inches); or 4) a STOP-Bang score of 3 or greater
12 + serum $\text{HCO}_3^- \geq 28 \text{ mmol/L}$. This two-step algorithm needs to be further validated
13 prospectively.

14 **The STOP-Bang questionnaire in the general population and bus drivers**

15 Studies in primary care patients demonstrate that the STOP-Bang questionnaire has
16 similar predictive performance as that seen in the surgical and sleep clinic patients.^{34,35} Silva et
17 al. evaluated the STOP-Bang questionnaire in 4770 participants in the Sleep Heart Health
18 Study.³⁵ The prevalence of moderate-to-severe OSA (RDI ≥ 15 events/h) and severe OSA (RDI
19 ≥ 30 events/h) in this population was 13% and 7% respectively. The sensitivity of a STOP-Bang
20 score ≥ 3 was 89% to detect moderate-to-severe OSA (RDI ≥ 15 events/h) and 93% to detect
21 severe OSA (RDI ≥ 30 events/h). The specificities were 30% and 29% respectively. The positive

predictive values were lower, 16% and 9% respectively. The negative predictive values were higher, 95% and 98% respectively.³⁵ The relatively low PPV and high NPV were probably related to relatively low OSA prevalence in study population. In another study of 178 patients with 60% having OSA (AHI ≥ 5 events/h), the sensitivity of the STOP-Bang questionnaire to detect OSA (AHI ≥ 5 events/h) was 96%, while the specificity was 24%, PPV was 66%, NPV was 81%.³⁴ Further research is needed to investigate the association between STOP-Bang scores and OSA probability in general population.

Also, the STOP-Bang questionnaire has 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 to other questionnaires (Berlin, STOP and OSA50), the STOP-BANG questionnaire was found to have the highest sensitivity and negative predictive value 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%. The positive and negative predictive values were 66% and 76% respectively.³⁸

The STOP-Bang questionnaire in obese patients

The prevalence of OSA is very high in the obese population. In morbidly obese surgical patients (BMI of ≥ 35 kg/m²), 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 of ≥ 30 kg/m²), and morbidly obese (BMI of ≥ 35 kg/m²) surgical patients.⁴⁹ Although a STOP-Bang ≥ 3 is very

sensitive (sensitivity ranged from 91 % to 100%) to detect OSA in the obese and morbidly obese, the specificity is low (from 7% to 28%), yielding high false-positive rates. A STOP-Bang score cut-off of 4 provides a better balance of sensitivity and specificity in the obese population. In morbidly obese patients, a STOP-Bang score ≥ 4 retained a high sensitivity across the entire spectrum of OSA severity, with a sensitivity of 90% for detecting severe OSA,⁴⁹ while 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 easy-to-use 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. By using the STOP-Bang questionnaire, sleep clinicians can quickly and reliably identify those at risk of severe OSA, and prioritize these 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 the patients with increased incidence of postoperative complications.⁵⁰⁻⁵² Data from a prospective study of 3452 patients shows that patients identified as high risk of OSA by STOP-Bang questionnaire had a higher rate of postoperative complications (9% vs. 2% in patients with low risk of OSA), difficult intubation (20% vs. 9%), and difficult mask ventilation (23% vs. 7%).⁵¹ The STOP-Bang score was found to be 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 re-intubations

and myocardial infarction.⁵³ In another retrospective study,⁵⁴ a diagnosis of OSA and prescription of continuous positive airway pressure (CPAP) therapy were associated with a reduction in postoperative cardiovascular complications. In a randomized controlled trial, perioperative autotitrating positive airway pressure (APAP) has been shown to prevent postoperative worsening of OSA and desaturation in newly diagnosed OSA patients.⁵⁵ However, the randomized controlled trials did not show that the incidence of postoperative complications was reduced by perioperative APAP treatment,^{55,56} probably due to the small sample size (177 in Liao's study,⁵⁵ 86 in O'Gorman's study⁵⁶) 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.

So far there is no data available to evaluate the impact of preoperative OSA screening and corresponding perioperative care measures on perioperative outcomes. We need to prospectively investigate if a perioperative pathway incorporating preoperative OSA screening, perioperative OSA precautions and postoperative treatment of OSA improve 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 utilizing the STOP-Bang questionnaire, several key points should be taken into account. Although the STOP-Bang questionnaire has been validated in different populations, a

1 selection bias might be present in some of the validation studies. For example, most patients in
2 sleep clinics were referred because they were already suspected of having sleep-related issues.
3 In studies targeting surgical patients, a self-selection bias from patients themselves may have
4 occurred in that patients with pre-existing sleep symptoms might be more willing to consent to
5 an overnight PSG. Generally speaking, younger patients were more likely to decline the
6 studies.²⁰ As a result of these potential selection biases, the high prevalence of OSA in the
7 study populations may affect the interpretation of the predictive parameters by presenting a
8 seemingly inflated positive predictive value. Despite the STOP-Bang questionnaire being
9 validated in multiple populations, it was found to be less useful for identifying OSA patients in
10 two distinct groups: the veteran population,⁶⁰ and patients with renal failure.⁴¹ To ensure
11 effective screening, validation of the STOP-Bang questionnaire in the specific target population
12 is recommended. Since measurement tapes may not be consistently available in the physician's
13 office and given potential issues with measurement variability of the neck circumference, these
14 challenges may affect the accuracy of the STOP-Bang score.

15 **Conclusion**

16 Studies have demonstrated that the STOP-Bang questionnaire is a concise, effective and
17 reliable OSA screening tool. It can help facilitate efficient allocation of resources in both
18 diagnosing and treating previously unrecognized OSA. The probability of moderate-to-severe
19 OSA increases in direct proportion to the STOP-Bang score, making the questionnaire an easy-
20 to-use tool for identifying patients at high risk for OSA. Patients with a STOP-Bang score of 0 to
21 2 can be classified as being at low risk for moderate-to-severe OSA. Those with a STOP-Bang

1 score of 5 to 8 can be classified as being at high risk for moderate-to-severe OSA. In patients
 2 with a STOP-Bang score of 3 or 4, the specific combinations of positive items should be
 3 examined further to ensure proper classification. If a combination of a STOP score ≥ 2 + (BMI >
 4 35 kg/m² or male or neck circumference > 40 cm) or a STOP-Bang score ≥ 3 + serum HCO₃⁻ ≥ 28
 5 mmol/L is found, these patients can be further classified as high risk of moderate-to-severe
 6 OSA.

7 **Acknowledgements**

8 **Author Contributions:** Dr. Frances Chung helped design the study, conduct the study and write
 9 the manuscript and had the overall responsibility for the study. Dr. Hairil R Abdullah helped
 10 design the study and write the manuscript. Dr. Pu Liao helped design the study, analyze the
 11 data and write the manuscript.

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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)	Mod/Sev OSA (AHI>15)	Severe OSA (AHI>30)
	Probability (95% CI)	Probability (95% CI)	Probability (95% CI)
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 & 8	0.86 (0.72, 0.93)	0.60 (0.44, 0.73)	0.38 (0.29, 0.53)

Note: AHI = apnea hypopnea index; CI = confidence interval; Mod/Sev OSA = moderate-to-severe OSA; n = number. * adapted from Chung's study with permission.³³

Table 2 Predictive performance of a combination of two items from STOP and one item from Bang for identifying patients with moderate-to-severe OSA (AHI >15)

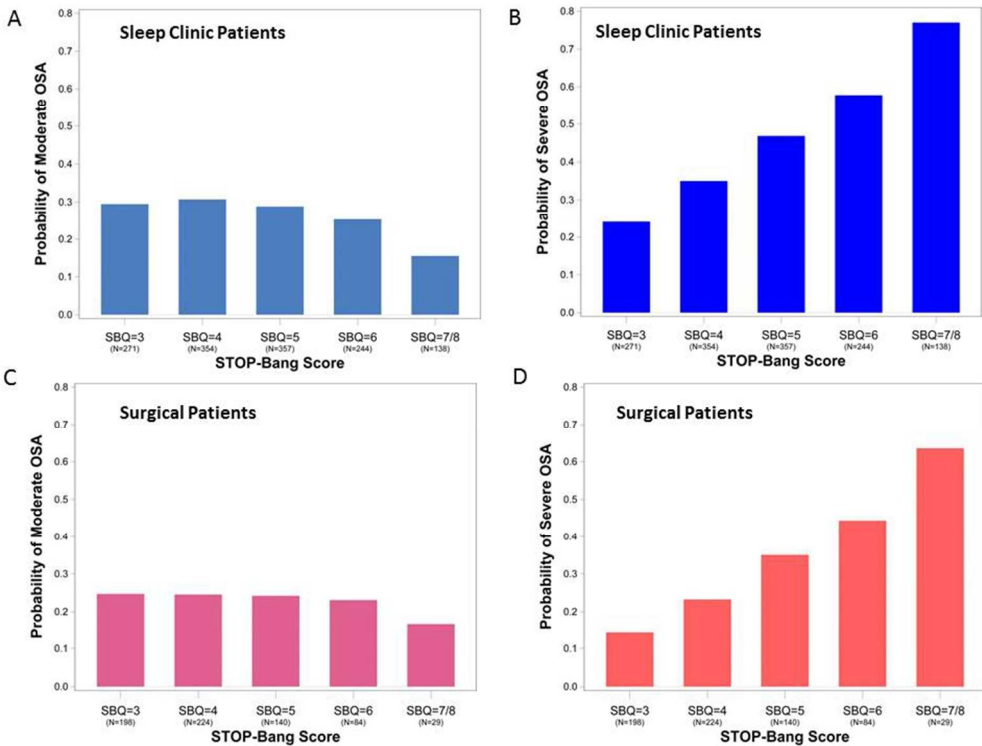
Cut-offs	Sensitivity	Specificity	PPV	NPV
STOP-Bang ≥ 3	87.3 (81.8-91.6)	30.7 (25.7-36.1)	43.8 (38.8-48.8)	79.7 (71.5-86.4)
STOP ≥ 2 + Bang ≥ 1	71.6 (64.7-77.8)	46.1 (40.5-51.7)	45.0 (39.5-50.7)	72.4 (65.7-78.4)
STOP ≥ 2 + BMI $>35 \text{ kg/m}^2$	20.8 (15.4-27.2)	85.0 (80.6-88.7)	46.1 (35.4-57.0)	63.5 (58.7-68.0)
STOP ≥ 2 + Neck $>40 \text{ cm}$	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	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 $>50 \text{ years}$	59.4 (52.2-66.3)	56.1 (50.5-61.6)	45.5 (39.3-51.8)	69.1 (63.1-74.7)

Note Data are presented as average (95% confidence interval). **AHI** = apnea hypopnea index; **PPV** = positive predictive value; **NPV** = negative predictive value. * adapted from Chung’s study with permission.⁴³

Figure Legend

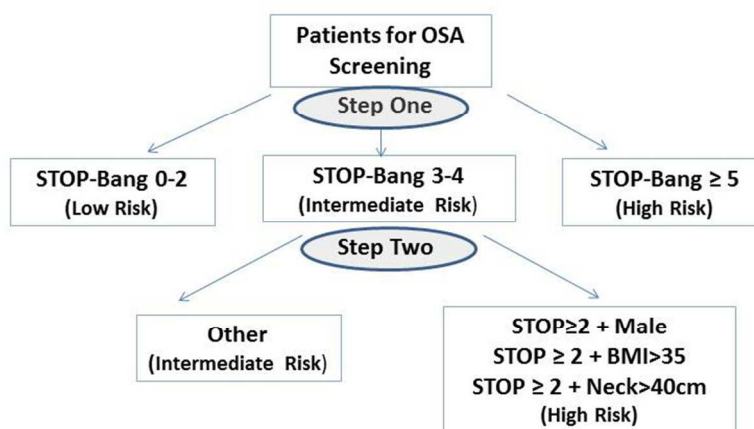
Figure 1 Relationship between STOP-Bang questionnaire score and the probability of obstructive sleep apnea (OSA). **Panel A:** The STOP-Bang questionnaire score and the probability of moderate OSA (AHI: >15 - 30) in sleep clinic patients. **Panel B:** The STOP-Bang questionnaire score and the probability of severe OSA (AHI >30) in sleep clinic patients. **Panel C:** The STOP-Bang questionnaire score and the probability of moderate OSA (AHI: >15 - 30) in surgical patients. **Panel D:** The STOP-Bang questionnaire score and the probability of severe OSA (AHI >30) in surgical patients.* Panels A & B are based on the meta-analysis of two studies in sleep clinic^{21,42} Panels C & D are based on the meta-analysis of two studies in surgical patients^{32,33}

Figure 2 STOP-Bang algorithm with a two-step scoring strategy



254x190mm (96 x 96 DPI)

Fig 2



254x190mm (96 x 96 DPI)

Appendix 1: STOP-Bang questionnaire

Snoring?

Yes No
☐ ☐ Do you **Snore Loudly** (loud enough to be heard through closed doors or your bed-partner elbows you for snoring at night)?

Tired?

Yes No
☐ ☐ Do you often feel **Tired, Fatigued, or Sleepy** during the daytime (such as falling asleep during driving)?

Observed?

Yes No
☐ ☐ Has anyone **Observed** you **Stop Breathing** or **Choking/Gasping** during your sleep?

Pressure?

Yes No
☐ ☐ Do you have or are being treated for **High Blood Pressure**?

Yes No
☐ ☐ **Body Mass Index more than 35 kg/m²?**

Yes No
☐ ☐ **Age older than 50 year old?**

Yes No
☐ ☐ **Neck size large? (Measured around Adams apple)**
circumference greater than 40cm or 16 inches?

Yes No
☐ ☐ **Gender = Male?**

Scoring Algorithm for general population

Low risk of OSA: Yes to 0-2 questions

Moderate risk: Yes to 3-4 questions

High risk: Yes to 5-8 questions

Yes to 2 or more of 4 STOP questions + male gender

Yes to 2 or more of 4 STOP questions + BMI > 35 kg/m²

Yes to 2 or more of 4 STOP questions + neck circumference >40cm or 16 inches.

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Modified from Chung F et al. studies.^{20,33,43}