

STOP-BANG Score as a Guide for Split-night Polysomnography

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Received: 04 Oct. 2016 Accepted: 10 Dec. 2016

Abstract

Background and Objective: STOP-BANG questionnaire is a well-known obstructive sleep apnea (OSA) screening tool. This study aimed to evaluate that patients with high probability of OSA in STOP-BANG questionnaire meet the criteria for assessment by split-night polysomnography (PSG).

Materials and Methods: Patients who were admitted to three sleep clinics and underwent full-night PSG entered into the study. The patients filled in the STOP questionnaire at their first clinic visit. Weight, height, and neck circumference were measured by technicians for computing STOP-BANG score. The apnea-hypopnea index (AHI) was used for diagnosis of OSA for which $5 \leq \text{AHI} < 15$, $15 \leq \text{AHI} < 30$, and $\text{AHI} \geq 30$ were considered as mild, moderate, and severe OSA, respectively. AHI cutoff levels of 20 and 40 were used to evaluate split-night PSG criteria. Sensitivity analysis was performed for identifying predictive parameters.

Results: In assessment of 990 patients, the sensitivity of the STOP-BANG ≥ 3 for OSA diagnosis at AHI thresholds of 5, 15 and 30 were 93, 96 and 97.8, and the specificity were 39, 24.5 and 20, respectively. The specificities of the STOP-BANG score ≥ 7 for OSA diagnosis at AHI thresholds of 20 and 40 were 99.2 and 97.9, and the positive predictive values were 90.5 and 64.3, respectively.

Conclusion: We found that the STOP-BANG could be considered not only as an OSA screening test, but also as a test to determine proper patients for split-night PSG, the benefit of which is a cost reduction in OSA management.

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Keywords: Snore, Tiredness, Observed apnea, Blood Pressure, Body mass index, Age, Neck circumference, and Gender (STOP-BANG); Obstructive sleep apnea; Split-night polysomnography; Screening

Citation: Alemohammad ZB, Khajeh-Mehrizi A, Sadeghniaat-Haghighi K, Rahimi-Golkhandan A. STOP-BANG Score as a Guide for Split-night Polysomnography. *J Sleep Sci* 2016; 1(4): 151-5.

Introduction

Obstructive sleep apnea (OSA) is a disorder characterized by recurrent episodes of apnea or hypopnea, resulting from complete or partial obstruction of upper airway during sleep (1). It is a common disorder affecting 2-26 percent of the general population according to sex, age, and disease definition (2, 3).

OSA results to significant morbidity and

mortality. It has serious consequences such as refractory hypertension, cardiovascular and neurovascular diseases, memory loss, daytime sleepiness, and impaired quality of life (4-6). Therefore, identifying OSA patients in early stages and treating them play an important role in the reduction of its complications.

Polysomnography (PSG) as a multiparametric evaluation remains as the gold standard test for diagnosis and staging of the OSA (7). An increased attention to OSA in recent years has led to increase of request for OSA diagnosis (8). However, the slow development of sleep laboratories and heavy expenses of the PSG have lim-

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ited its accessibility (9). To overcome these practical limitations, multiple screening tools were introduced.

One self-administrative easy to answer questionnaire is the Snore, Tiredness, Observed apnea, blood Pressure, Body mass index (BMI), Age, Neck circumference, and Gender (STOP-BANG) questionnaire which was developed in 2008 (10). This questionnaire was initially developed as a screening tool not as a proxy one. By considering the STOP-BANG as a proxy measure for the split-night PSG, OSA diagnosis could be available at no extra cost. In other words, the patients defined as high risk with the proxy test could undergo the split-night PSG rather than full-night PSG.

The purpose of this study was to evaluate the predictive parameters of the STOP-BANG questionnaires in screening of OSA. In addition, the predictive parameters of the STOP-BANG were analyzed in higher cutoffs as a proxy test to represent split-night PSG criteria in sleep clinics.

Materials and Methods

Study design and participants: We conducted this cross-sectional study in three sleep clinics between September 2008 and August 2014, with a convenience sampling method among patients who were admitted to the sleep clinics and underwent diagnostic PSG. Patients filled in the STOP questionnaire at their first clinic visit. Expert technicians measured height, weight, and neck circumference for calculating STOP-BANG score. Patients who were previously diagnosed by PSG, treated for sleep apnea, with technically unsatisfactory PSG or incomplete questionnaire were excluded. Informed consents were obtained from all patients. The ethics Committee of Tehran University of Medical Sciences approved this study.

Questionnaire: The STOP-BANG questionnaire includes STOP questionnaire plus BMI, age, neck circumference, and gender. STOP questionnaire consists of four yes/no questions evaluating snoring, tiredness, observed stop breathing during sleep, and high blood pressure. BMI more than 35 kg/m^2 , age more than 50 years, neck circumference more than 40 cm, and gender of male are considered as positive scores (10). Participants with the score of at least three in STOP-BANG were defined as being at high risk for OSA. We

used the Persian version of the STOP-BANG questionnaire in this study (11).

PSG: We performed one-night diagnostic polysomnogram using computerized polysomnographic system including the monitoring of electroencephalogram, electrocardiogram, electrooculogram, electromyogram (submental and bilateral anterior tibialis), snoring, arterial oxygen saturation, abdominal and thoracic respiratory efforts, or nasal pressure, body position, and video monitoring by infrared beams (12). A sleep specialist (certified by the board of registered polysomnographic technologists) scored the polysomnographic recordings manually in accordance with the American Academy of Sleep Medicine (AASM) Manual for the Scoring of Sleep and Associated Events. An apnea was defined as near total cessation of airflow, whereas a hypopnea was defined as the reduction of airflow for more than 30% with 4% reduction of arterial oxygen saturation. The duration of all events should last at least 10 seconds. Apnea-hypopnea index (AHI) was calculated as dividing the number of apnea and hypopnea by the total sleep time in hours. AHI equal or more than five was considered as the threshold for clinical diagnosis of OSA, while the severity of OSA was defined by cutoff levels of $5 \leq \text{AHI} < 15$, $15 \leq \text{AHI} < 30$ and $\text{AHI} \geq 30$ as mild, moderate, and severe OSA, respectively (13). AHI cutoff levels of 20 and 40 were considered to represent split-night PSG criteria (14).

Statistical analysis: Descriptive statistics were presented as frequency (percentage) and mean \pm standard deviation. We computed predictive parameters of the STOP-BANG including specificity, sensitivity, positive, and negative predictive values, likelihood ratio for a positive and negative test result (LR+ and LR-), odds ratio and area under the curve using the AHI thresholds of 5, 15, and 30. To evaluate the screening power, a cutoff score of 3 for the STOP-BANG was applied. To evaluate the proxy power, cutoffs at 6 and 7 for the STOP-BANG were applied. Based on the AASM practice parameters, AHI thresholds of 20 and 40 were applied to recommend the split-night PSG; therefore, we evaluated the proxy power of the STOP-BANG at these AHI thresholds. SPSS (version 18; SPSS Inc., Chicago, IL, USA) and MedCalc version 12.2.1.0 were used for statistical analysis. $P < 0.05$ was considered statistically significant.

Table 1. Characteristics of study participants

Characteristics	AHI < 5 (no OSA) n = 238	5 ≤ AHI < 15 (Mild OSA) n = 247	15 ≤ AHI < 30 (Moderate OSA) n = 173	AHI ≥ 30 (Severe OSA) n = 332	All patients n = 990	P-value
Female (%)	90 (37.8)	72 (29.1)	33 (19.1)	74 (22.3)	269 (27.2)	< 0.001
Age (years)	41.8 ± 13.1	46.4 ± 11.4	47.3 ± 13.0	48.1 ± 12.5	46.1 ± 12.7	< 0.001
Weight (kg)	76.0 ± 13.7	84.5 ± 15.9	89.2 ± 17.3	93.4 ± 18.0	86.3 ± 17.7	< 0.001
Height (cm)	168.5 ± 10.8	169.9 ± 10.4	171.4 ± 10.6	170.4 ± 10.1	170.0 ± 10.4	0.068
BMI (kg/m ²)	26.8 ± 4.8	29.2 ± 4.9	30.2 ± 4.7	32.1 ± 5.7	29.8 ± 5.5	< 0.001
Neck circumference (cm)	38.0 ± 3.6	40.1 ± 4.4	40.8 ± 4.3	42.1 ± 4.3	40.4 ± 4.4	< 0.001
Mean SaO ₂	94.0 ± 2.4	93.2 ± 2.0	92.2 ± 2.6	88.7 ± 7.9	91.7 ± 5.4	< 0.001
Lowest SaO ₂	87.3 ± 9.2	83.3 ± 8.2	79.1 ± 10.2	69.0 ± 14.1	78.9 ± 13.2	< 0.001

AHI: Apnea-hypopnea index; OSA: Obstructive sleep apnea; BMI: Body mass index; SaO₂: Oxygen saturation

Results

Characteristics of 990 study participants are shown in table 1. According to the PSG, 238 patients (24%) had AHI < 5, whereas the remaining patients had mild (n = 247, 24.9%), moderate (n = 173, 17.5%), and severe (n = 332, 33.6%) OSA.

The STOP-BANG classified 851 (86%) patients as being at high risk for OSA. Patients with mild to severe OSA significantly were categorized as being at high risk in STOP-BANG (Table 2).

Predictive parameters of the STOP-BANG for screening of the OSA in the AHI thresholds of 5, 15, and 30 are shown in table 3. The sensitivities of the STOP-BANG ≥ 3 for OSA diagnosis at AHI thresholds of 5, 15, and 30 were 93, 96, and 97.8, respectively; the specificities were 39, 24.5, and 20, respectively. The positive predictive values of the STOP-BANG ≥ 3 for OSA diagnosis at AHI threshold of 5, 15, and 30 were 83, 57 and 38.2, respectively; the negative predictive values were 66.9, 85.6, and 95, respectively.

Furthermore, predictive parameters of the STOP-BANG as a proxy test for OSA in AHI cut-off scores of 20 and 40 were calculated (Table 4). The specificities of the STOP-BANG ≥ 7 for OSA diagnosis at AHI threshold of 20 and 40 were 99.2, and 97.9, respectively; the positive predictive values were 90.5 and 64.3, respectively.

Discussion

We considered the STOP-BANG both as a screening test for OSA diagnosis and as a proxy test to replace split-night PSG criteria in sleep

clinics. A key factor in a screening test is its sensitivity, because the higher the sensitivity goes, the lower the false negative of the test will be. To calculate the predictive parameters of questionnaires for OSA screening, we used the cutoffs 2 for the STOP and 3 for the STOP-BANG similar to previous studies (10, 15). Current findings confirmed preceding studies in demonstrating the high ability of the STOP-BANG for OSA screening.

Full night PSG is the most expensive technology used for OSA management because it may require patients to undergo two overnight laboratory assessments: one for diagnosis and the other for titration (16). Combining the diagnostic and CPAP titration into a single night (split-night PSG) potentially can increase convenience of patients and cost of the sleep testing process (14). Moreover, split-night PSG could be applied when the immediate diagnosis and treatment of OSA is desired. For instance, in Iran, drivers suspected of having OSA that have high STOP-BANG score, should undergo PSG to confirm or rule out OSA. Drivers with high STOP-BANG score can undergo split-night PSG, thus the treatment can begin earlier and they can return to work soon.

During a split night study, the patient is evaluated for a minimum of 2 hours as a baseline polysomnogram and then CPAP titration is initiated for a minimum of 3 hours during the second part of the test. During the first part of the split-night study, an experienced night technician estimates the AHI. AASM recommends that split-night PSG when AHI is ≥ than 20-40 during first 2 hours of PSG (17).

Table 2. The classification of patients based on STOP-BANG versus OSA severity

STOP-BANG	AHI < 5 (no OSA)	5 ≤ AHI < 15 (Mild OSA)	15 ≤ AHI < 30 (Moderate OSA)	AHI ≥ 30 (Severe OSA)	All patients	P value
Low risk (%)	93 (39.1)	26 (10.5)	13 (7.5)	7 (2.1)	139 (14)	< 0.001
High risk (%)	145 (60.9)	221 (89.5)	160 (92.5)	325 (97.9)	851 (86)	

AHI: Apnea-hypopnea index; OSA: Obstructive sleep apnea; STOP-BANG: Snore, Tiredness, Observed apnea, blood Pressure, Body mass index, Age, Neck circumference, and Gender

Table 3. Predictive parameters of the STOP-BANG for OSA identification in AHI cutoffs of 5, 15 and 30

AHI cutoffs	STOP-BANG cutoff point ≥ 3						
	Sensitivity	Specificity	PPV	NPV	LR+	LR-	AUC
5	93 (91.9-95.5)	39 (32.8-45.6)	83 (80.3-85.4)	66.9 (58.4-74.6)	1.54 (1.3-1.8)	0.16 (0.1-0.2)	0.78 (0.75-0.8)
15	96 (93.9-97.6)	24.5 (20.8-28.6)	57 (53.6-60.3)	85.6 (78.7-91)	1.27 (1.1-1.5)	0.16 (0.1-0.2)	0.75 (0.73-0.78)
30	97.8 (95.7-99.1)	20 (17.1-23.3)	38.2 (34.9-41.5)	95 (89.9-98)	1.22 (1.1-1.4)	0.11 (0.05-0.2)	0.74 (0.71-0.77)

OSA: Obstructive sleep apnea; AHI: Apnea-hypopnea index; PPV: Positive predictive value; NPV: Negative predictive value; LR+: Likelihood ratio of a positive test result; LR-: Likelihood ratio of a negative test result; AUC: Area under the curve; STOP-BANG: Snore, Tiredness, Observed apnea, blood Pressure, Body mass index, Age, Neck circumference, and Gender

If the diagnostic part of the test was thought by the nurse to show an AHI of > 20 , manual CPAP titration could be undertaken. Formal scoring of the AHI cannot be performed during the night.

The technician must carefully monitor the patient's response in all sleep stages and positions to find an optimal pressure level. The ability to conduct CPAP titration will be found among experienced technicians who have a good understanding of respiratory physiology and anatomy, sleep and respiratory disorders, and equipment. However, when patients did not meet OSA criteria during the first part of the test, the cost incurred is that of a split-night PSG and a separate cost for the full-night titration performed later (16). Therefore, it could be cost-effective if we can determine which people can satisfy the criteria of the first part of the split-night test. Moreover, all patients should receive an educational intervention before a split-night test. It is explained to them that CPAP treatment is likely to be needed, and, if so, would be started during the sleep time. Sleep technicians spend a lot of their workload to explain, educate about CPAP, adapt the mask and, give the patient an adaptation period to positive pressure before the diagnostic part begins. Because of split-night study requirements such as a particular room with a PAP device, an experienced technician, time to education and mask fitting, a sleep specialist should consider standards on when "split night" protocols should be used.

Considering the STOP-BANG as a proxy test to represent split-night PSG criteria, could have a

positive impact on the economy of OSA diagnosis and treatment. In a proxy test, the specificity is a key factor. The higher the specificity is the lower the false positive of the test will be. To evaluate the proxy power, cutoffs 6 and 7 for the STOP-BANG were used. In the cutoff seven, the specificities were increased, and the sensitivities were decreased comparing to the cutoff six, the consequence of which was an appropriate positive LR. Based on present findings, there are high specificity and positive predictive value in cutoff 7 for both AHI levels of 20 and 40. Therefore, the patients with the score of equal or > 7 could be a good candidate for split night test because he or she may meet the criteria of split-night with high probability.

There are a few limitations with this study. This study was conducted on a convenient sample of sleep clinic patients. The prevalence rate of OSA in sleep clinic referrals could be higher than expected in the general population. Another limitation of this study was the use of retrospective data. Future research may benefit from further validation in the general population by prospective randomized controlled trials.

Conclusion

We found that the STOP-BANG questionnaire could be considered not only as an OSA screening test, but also as a test to determine proper patients for split-night PSG, the benefit of which is a cost reduction for OSA management.

Table 4. Predictive parameters of the STOP-BANG for OSA identification in AHI cutoffs of 20 and 40

AHI cutoffs	Sensitivity	Specificity	PPV	NPV	LR+	LR-	AUC
STOP-BANG cutoff point ≥ 6							
20	30.9 (26.6-35.5)	92.1 (89.7-94.3)	75 (67.9-81.2)	63.8 (60.4-67.1)	3.9 (3.4-4.6)	0.75 (0.6-1)	0.76 (0.73-0.78)
40	35.2 (29.3-41.5)	88.1 (85.6-90.4)	50 (42.4-57.6)	80.1 (77.2-82.8)	2.9 (2.5-3.5)	0.74 (0.6-0.9)	0.74 (0.72-0.77)
STOP-BANG cutoff point ≥ 7							
20	8.9 (6.4-12)	99.2 (98.2-99.8)	90.5 (77.2-97.4)	59 (55.8-62.1)	12.5 (9.2-17)	0.92 (0.3-2.4)	0.76 (0.73-0.78)
40	10.8 (7.2-15.3)	97.9 (96.7-98.9)	64.3 (48-78.4)	76.5 (73.6-79.1)	5.3 (3.7-7.6)	0.91 (0.6-1.5)	0.74 (0.72-0.77)

AHI: Apnea-hypopnea index; PPV: Positive predictive value; NPV: Negative predictive value; LR+: Likelihood ratio of a positive test result; LR-: Likelihood ratio of a negative test result; STOP-BANG: Snore, Tiredness, Observed apnea, blood Pressure, Body mass index, Age, Neck circumference, and Gender

Conflict of Interests

Authors have no conflict of interests.

Acknowledgments

The authors wish to thank the staff of sleep laboratories and Occupational Sleep Research Center for their support.

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