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ORIGINAL CONTRIBUTIONS

Predictive Performance of the STOP-Bang Score for Identifying Obstructive Sleep Apnea in Obese Patients

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Abstract

Background The loud *S*noring, *T*iredness, *O*bserved apnea, high blood *P*ressure (STOP)-*B*ody mass index (BMI), *A*ge, *N*eck circumference, and *g*ender (Bang) questionnaire is a validated screening tool for identifying obstructive sleep apnea in surgical patients. However, the predictive performance of the STOP-Bang score in obese and morbidly obese patients remains unknown.

Methods Preoperative patients were approached for consent and were screened for obstructive sleep apnea (OSA) by the STOP questionnaire. Information concerning Bang was collected. Laboratory or portable polysomnography were performed in 667 patients. Patients with BMI of ≥30 kg/m^2 were defined as obese patients and ≥35 kg/m^2 as morbidly obese. The predictive parameters (sensitivity, specificity, and positive and negative predictive values) for the STOP-Bang score in obese and morbidly obese patients were analyzed.

Results In 310 obese patients, a STOP-Bang score of 3 has high sensitivity of 90 % and high positive predictive value of 85 % for identifying obese patient with OSA. A STOP-Bang score of 4 had high sensitivity (87.5 %) and high negative predictive value (90.5 %) for identifying severe OSA, whereas a STOP-Bang score of 6 had high specificity (85.2 %) to identify severe OSA. The diagnostic odds ratio of a STOP-Bang score of 4 was 4.9 for identifying severe OSA. In 140 morbidly obese patients, a STOP-Bang score of 4 had high sensitivity (89.5 %) for identifying severe OSA.

Conclusions The STOP-Bang score was validated in the obese and morbidly obese surgical patients. For identifying severe OSA, a STOP-Bang score of 4 has high sensitivity of 88 %. For confirming severe OSA, a score of 6 is more specific.

Keywords STOP-Bang questionnaires · Obstructive sleep apnea · Morbid obesity · Surgery · Sleep apnea screening · Anesthesia

Abbreviation

OSA	Obstructive sleep apnea
AHI	Apnea–Hypopnea Index
PSG	Polysomnography
BMI	Body mass index
PPV	Positive predictive value
NPV	Negative predictive value

Introduction

Obstructive sleep apnea (OSA) is a common sleep disorder characterized by repetitive episodes of apnea and hypopnea during sleep [1–3]. As patients with OSA were shown to have an increase in postoperative adverse events [4–6], it is essential to have an early diagnosis of OSA [7]. The gold standard for the diagnosis of OSA is by overnight polysomnography, but it is costly and has limited availability. The use of preoperative screening tools will help to identify patients with undiagnosed OSA [8, 9].

According to the World Health Organization in 2008, over 200 million men and nearly 300 million women were obese [10]. In the Wisconsin Sleep Cohort Study, a 1 SD difference in body mass index (BMI) was accompanied with a fourfold increase in the prevalence of OSA [11]. Seventy percent of patients with OSA are estimated to be obese and conversely the prevalence of OSA in obese men and women is about 40–70 % [12–15].

The loud *S*noring, *T*iredness, *O*bserved apnea, high blood *P*ressure (STOP)-*B*ody mass index (BMI), *A*ge, *N*eck circumference, and *g*ender (Bang) questionnaire has been validated to screen obstructive sleep apnea in surgical patients.

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A score of ≥3 has been shown to have a high sensitivity for detecting OSA [16] and a score of 5–8 identified patients with high probability of moderate/severe OSA [17]. It is a commonly used tool to screen surgical patients with OSA [18–21]. The predictive performance of the STOP-Bang questionnaire in the obese or morbidly obese patients remains unknown. The objective of the study was to evaluate the predictive performance of the STOP-Bang questionnaire for identifying the obese or morbidly obese patients with OSA.

Materials and Methods

Study Subjects

The study was conducted from 2006 to 2009 in the preoperative clinics of Toronto Western Hospital and Mount Sinai Hospital, Toronto, ON, Canada. Institutional Review Board approvals were obtained from both institutions (MSH, 06-0143-E and 07-0183-E; UHN, 06-0135-AE and 07-0515-AE). The methods of the study have been previously described [16, 17]. Patients aged 18 years or older, who were ASA I–IV undergoing elective procedures in general surgery, gynecology, orthopedics, urology, plastic surgery, ophthalmology, or spinal surgery were included in the screening process and approached for consent by the research assistants for the preoperative polysomnograpy. Patients who were unwilling or unable to give informed consent or patients who were expected to have abnormal electroencephalic findings (e.g., brain tumor, deep brain stimulator, and epilepsy surgery) were excluded. Patients with diagnosed OSA and not on continuous positive airway pressure were also included in the study. All patients were asked to complete the STOP questionnaire [16]. Information concerning Bang was collected by a research assistant.

Sleep Studies

In the initial 2-year period of the study, the recruited patients were invited to undergo an overnight polysomnography study in the sleep laboratory. During the subsequent 2 years of the study, the patients underwent a portable polysomnography study with a 10-channel portable device (Embletta X100) at home. The results of the polysomnography were used to evaluate the various scores of the STOP-Bang questionnaire.

The laboratory polysomnograpy was performed overnight in the sleep laboratory. The polysomnograpy recordings were scored by a certified polysomnograpy technologist who was blinded to the results of the STOP-Bang questionnaire and other clinical information about the patients. The sleep stages and Apnea–Hypopnea Index (AHI) were scored according to the American Academy of Sleep Medicine Task Force recommendations [22]. The portable polysomnography was performed at home with a level 2 diagnostic tool (Embletta X100), which has been validated against laboratory polysomnography [23, 24]. The polysomnograpy recordings were analyzed by certified polysomnograpy technologists. The manual scoring was performed using Somnologia Studio 5.0 as the scoring platform according to the Manual of the American Academy of Sleep Medicine [25].

The diagnosis of OSA was based on an AHI >5 with fragmented sleep and daytime sleepiness. The severity of OSA with both laboratory and portable polysomnograpy was classified based on the AHI values: >5–15 as mild OSA, >15–30 as moderate OSA, and >30 as severe OSA [22, 25].

Data Analysis and Statistics

Based on the World Health Organization definition which defined obesity as BMI ≥30 kg/m^2 [10], obese patients with successful polysomnograhy and complete document of the STOP-Bang questionnaire were included in the data analyses. The calculation of the sample size was performed according to the method reported by Obuchowski [26]. Briefly, two separate calculations of sample size were performed based on either estimated sensitivity using the precision (potential error) of sensitivity, expected power, a type 1 error, and estimated prevalence; or specificity, the precision of specificity, expected power, type 1 error, and prevalence. The larger number of the two was chosen as the sample size. Based on the previous publication by Chung [16], the following parameters were used to calculate the sample size: a sensitivity of 0.88, a precision of 0.09, a prevalence rate estimated to be 25 % for severe OSA in obese patients [27], a type I error of 0.05, and a power of 0.8. The result was 200 for obese patients. The number calculated based on a specificity of 0.8 was 101 for obese patients. Therefore, 200 obese patients were initially chosen as the sample size.

Statistical analyses were performed by using SAS 9.2 (SAS Institute Inc., Cary, NC, USA). The patient characteristic data are presented with descriptive statistics as mean±SD or median (interquartile ranges) for non-normally distributed variable or frequency (percentage) for categorical variables. Comparison of means was performed using unpaired Student's *t* test, comparison of two medians was performed using the Mann–Whitney test, and comparison of proportions was performed using chi-square test or Fisher's exact test. The relationship between AHI and BMI was assessed with Pearson correlation analysis. $P<0.05$ was defined as significant.

Area under the receiver operating characteristic curve of STOP-Bang score, diagnostic odds ratios, predicted probabilities, and 95 % confidence interval (95 % CI) for each score of STOP-Bang questionnaire were calculated by a logistic regression. To assess the predictive performance of the STOP-Bang score, multiple 2×2 contingency tables were used to calculate sensitivity, specificity, positive predictive values (PPVs), and negative predictive values (NPVs) for each score.

Results

As shown in the patient flowchart (Fig. 1), 7,013 patients were approached for consent and were screened for OSA by the STOP-Bang questionnaire. Six hundred sixty-seven patients with successful polysomnography answered all of the items in the STOP questionnaire and had complete documentation of BMI, age, gender, and neck circumference. In this study, the data of 310 obese patients with BMI of ≥30 kg/m^2 which were part of the dataset in the previous publications was utilized [16, 17]. Of the patients, 140 (45 %) were morbidly obese with BMI of ≥35 kg/m^2. In 667 patients, there is a statistically significant correlation between AHI and BMI (coefficient=0.237, P<0.0001). No significant correlation between AHI and BMI was found in 310 obese patients (coefficient=0.092, P>0.05) and 140 morbidly obese patients (coefficient=0.133, P>0.05). The characteristic of obese and morbidly obese patients were shown in Table 1.

Of the 310 obese patients, there were 253 (81.6 %) with OSA (AHI >5), 149 (48.1 %) with moderate/severe OSA (AHI >15) and 80 (25.8 %) with severe OSA (AHI >30), respectively. The prevalence of OSA is higher in the male obese patients than the female, especially for moderate/severe OSA (60 vs. 39 %, P<0.0001) and severe OSA (40 vs. 16 %, P<0.0001; Fig. 2). The distribution of the STOP-Bang scores

Table 1 Demographic data of the obese patients and the morbidly obese patients

	Obese patients	Morbidly obese patients
N	310	140
Gender, F/M	184/126 (59/41)	104/36 (74/26)
Age, years	57.4±11	56.4±11
BMI, k/m^2	35.7±5	40.1±5
Neck, cm	39.8±4	40.7±4
AHI median (25–75th)	13.9 (7–31)	13.7 (7–33)
Severity of OSA, *N* (%)		
No OSA	57 (18.4)	22 (15.7)
Mild OSA	104(33.5)	52 (37.1)
Moderate OSA	69 (22.3)	28(20.0)
Severe OSA	80 (25.8)	38 (27.2)
AHI >5	253 (81.6)	118 (84.3)
AHI >15	149 (48.1)	66 (47.1)
AHI >30	80 (25.8)	38 (27.1)
Positive response of STOP, *N* (%)		
Q1 (Snoring)	182 (58.7)	83 (59.3)
Q2 (Tired or sleepy)	210 (67.7)	99 (70.7)
Q3 (Observed apnea)	174 (56.1)	82 (58.6)
Q4 (high blood pressure)	91 (29.4)	38 (27.1)
Score BMI (B) (>35 kg/m^2)	140 (45.2)	140 (100)
Score Age (A) (>50 years)	228 (73.6)	100 (71.4)
Score Neck (N) (>40 cm)	138 (44.5)	71 (50.7)
Score Gender (G)	126 (40.8)	36 (25.7)

Data are depicted as number (percentage), mean±SD, or median (interquartile range)

OSA obstructive sleep apnea, *AHI* Apnea–Hypopnea Index, *BMI* body mass index

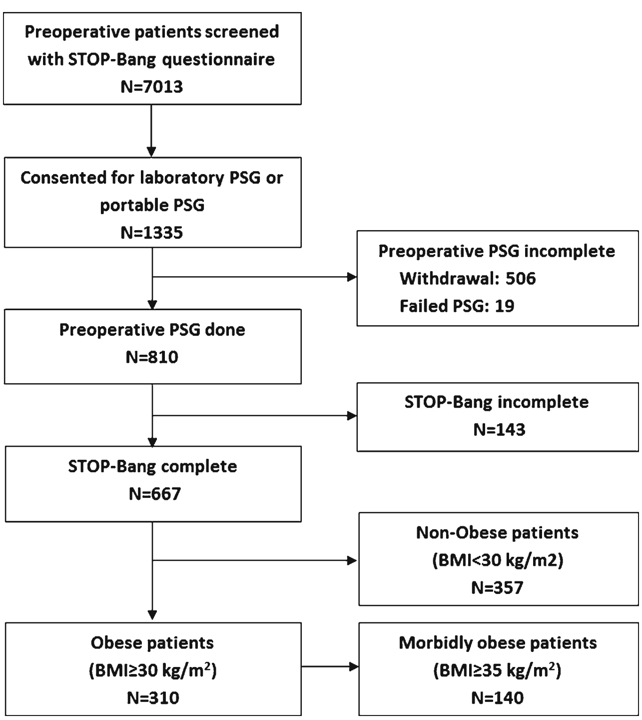

Fig. 1 The flowchart of study patients

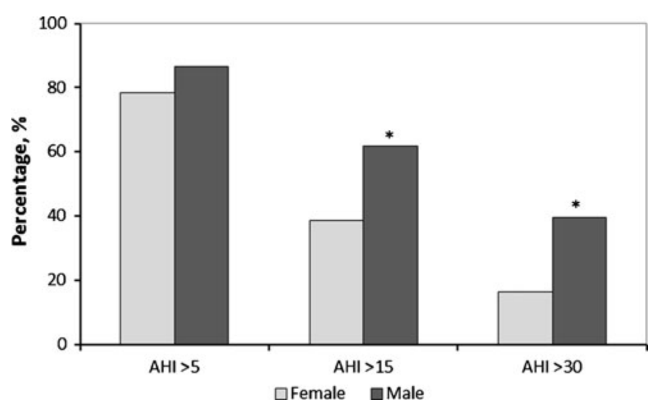

Fig. 2 The prevalence of OSA defined by different AHI levels in male and female obese patients

showed most obese patients had a score of 3 (21.0 %), 4 (25.2 %), or 5 (20.3 %) and similarly most morbidly obese patients had a score of 3 (16.4 %), 4 (29.3 %), or 5 (22.1 %; Fig. 3).

The sensitivity, specificity, PPVs, and NPVs of STOP-Bang score for all OSA (AHI >5), moderate/severe OSA (AHI >15) and severe OSA (AHI >30) in the obese patients were summarized in Table 2. For predicting obese patient with OSA (AHI >5), a STOP-Bang score of 3 had a high sensitivity [90.5 % (86.2–93.8)], a low specificity [28.1 % (16.4–39.7)] and a high PPV [84.8 % (80.0–88.9)]. For identifying obese patient with severe OSA, a STOP-Bang score of 4 had a high sensitivity [87.5 % (78.2–93.8)] and a reasonable specificity [41.3 % (34.9–48.0)], whereas a STOP-Bang score of 6 had a high specificity [85.2 % (80.0–89.5)] and a low sensitivity [37.5 % (26.9–49.0)]. A STOP-Bang score of 5 has a sensitivity of 68 % and a specificity of 69 %.

Since bariatric surgery is targeted to morbidly obese patient with BMI ≥35 kg/m^2, we further evaluated the predictive performance of STOP-Bang score for predicting OSA in the morbidly obese patients. Predictive parameter of STOP-Bang score for all OSA (AHI >5), moderate/severe OSA (AHI >15), and severe OSA (AHI >30) in the morbidly obese patients were summarized in Table 3. Comparing its predictive performance in the morbidly obese patients vs. obese patient, a STOP-Bang score of 4 has higher sensitivity for predicting all OSA (78.8 vs. 68.8 %) and moderate/severe OSA (86.4 vs. 77.9 %) but a similar sensitivity for severe OSA (87.5 vs. 89.5 %).

Using the STOP-Bang score to predict obese patients with all OSA (AHI >5), moderate/severe OSA (AHI >15), and severe OSA (AHI >30), the area under the receiver operating characteristic curve was 0.63 (95 % CI, 0.55–0.71), 0.66 (95 % CI, 0.61–0.72), and 0.73 (95 % CI, 0.67–0.79), respectively. Based on an equipoise decision which privilege neither sensitivity nor specificity, the best discrimination score of STOP-Bang for moderate/severe (AHI >15) or severe OSA (AHI >30) in the obese patients was 5, while it was 3 for all OSA (AHI >5).

Using the STOP-Bang score to predict morbidly obese patients with all OSA (AHI >5), moderate/severe OSA (AHI >15), and severe OSA (AHI >30), the area under the receiver operating characteristic curve was 0.59 (95 % CI, 0.47–0.71), 0.69 (95 % CI, 0.60–0.77), and 0.71 (95 % CI: 0.62–0.81), respectively. Based on an equipoise decision which privilege neither sensitivity nor specificity, the best discrimination score of STOP-Bang for moderate/severe (AHI >15) or severe OSA (AHI >30) in the morbidly obese patients also was 5.

The diagnostic odds ratio of the STOP-Bang scores 3, 4, and 5 for all OSA (AHI >5), moderate/severe OSA (AHI >15), and severe OSA (AHI >30) in obese patient and morbidly obese patients were summarized in Table 4. A STOP-Bang score of 4 has a higher diagnostic odds ratio for severe OSA in the obese patients than a score of 5. However, a STOP-Bang score of 5 has a higher diagnostic odds ratio for severe OSA in the morbidly obese patients than a score of 4.

The predicted probability of OSA, moderate/severe OSA, or severe OSA was greater as the STOP-Bang score increased in the obese patients. The same trends occur across the groups of all OSA, moderate/severe OSA, and severe OSA (Fig. 4). As the STOP-Bang score increased from score ≥1 to score ≥7, the probability of OSA, moderate/severe OSA, and severe OSA increased from 82 % (95 % CI, 77–85 %) to 95 % (95 % CI, 72–99 %), 48 % (95 % CI, 42–53 %) to 70 % (95 % CI, 47–86 %), and 26 % (95 % CI, 21–31 %) to 50 % (95 % CI, 29–71 %), respectively.

The predicted probability of OSA by the STOP-Bang scores 3, 4, or 5 as cutoffs in the obese patients were compared in Fig. 5a. For identifying severe OSA, both scores 4 or 5 show a strong discrimination, which is verified by a triple increase of predicted probability of STOP-Bang scores of ≥4 or 5 versus a STOP-Bang scores of <4 or 5. For morbidly obese patients, scores 4 or 5 also show similar discrimination for identifying severe obstructive sleep apnea (Fig. 5b).

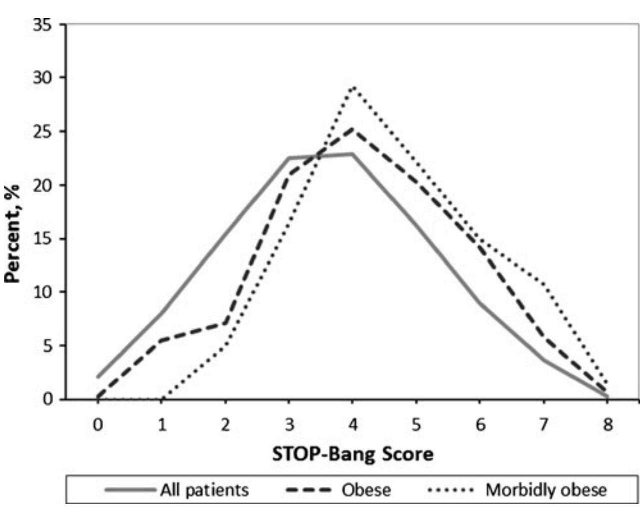

Fig. 3 The distribution of the STOP-Bang score in the obese patients and the morbidly obese patients

Discussion

Our study shows that for obese and morbidly obese patients, a STOP-Bang score of 5 has the best discrimination for predicting moderate/severe OSA (AHI >15) or severe OSA (AHI >30) when either sensitivity or specificity is not privileged [28]. For identifying obese patients with AHI >15 and AHI >30, the sensitivity of score of 4 was 78 and

Table 2 Predictive parameter of STOP-Bang score for identifying OSA in the obese patients

STOP-Bang	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
AHI >5 (all OSA)				
≥3	90.5 (86.2–93.8)	28.1 (16.4–39.7)	84.8 (80.0–88.9)	40.0 (24.9–56.7)
≥4	68.8 (62.7–72.4)	45.6 (32.4–59.3)	84.9 (79.2–89.5)	24.8 (16.9–34.1)
≥5	44.3 (38.1–50.6)	73.7 (60.3–86.5)	88.2 (81.3–93.2)	23.0 (17.1–29.7)
≥6	22.5 (17.5–28.2)	87.7 (76.3–94.9)	89.1 (78.8–95.5)	20.3 (15.5–25.9)
AHI >15 (moderate/severe OSA)				
≥3	94.6 (89.7–97.7)	19.9 (14.0–26.9)	52.2 (46.1–58.3)	80.0 (64.4–91.0)
≥4	77.9 (70.3–84.2)	44.7 (36.9–52.8)	56.6 (49.5–63.5)	68.6 (58.8–77.3)
≥5	53.0 (44.7–61.2)	70.2 (62.5–77.1)	62.2 (53.2–70.7)	61.7 (54.3–68.8)
≥6	29.5 (22.4–37.6)	87.6 (81.5–92.2)	68.8 (55.9–79.8)	57.3 (50.9–63.6)
AHI >30 (severe OSA)				
≥3	100 (95.5–100)	17.4 (12.7–22.9)	29.6 (24.3–35.5)	100 (91.2–100)
≥4	87.5 (78.2–93.8)	41.3 (34.9–48.0)	34.1 (27.7–41.1)	90.5 (83.2–95.3)
≥5	68.8 (57.4–78.7)	68.7 (62.3–74.6)	43.3 (34.6–52.4)	86.3 (80.5–91.0)
≥6	37.5 (26.9–49.0)	85.2 (80.0–89.5)	46.9 (34.3–59.8)	79.7 (74.1–84.5)

Data are depicted as average (95 % confidence interval)

AHI Apnea–Hypopnea Index, *PPV* positive predictive value, *NPV* negative predictive value

88 % respectively; the specificity of score 6 was 88 and 85 %, respectively. For identifying morbidly obese patients with AHI >15 and AHI >30, the sensitivity of score 4 was 86 and 90 %, respectively; the specificity of score 6 was 87 and 81 %, respectively. The obese patients were shown to have an increased predicted probability of OSA, especially severe OSA with a higher STOP-Bang score. Previously, the STOP-Bang score was validated as a screening tool for the preoperative clinics and sleep clinic patients [16, 29]. The findings of this study validated the prediction of moderate and severe OSA in the obese and morbidly obese patients with the STOP-Bang score.

Our data indicate that a STOP-Bang score of 4 as the cut-off gives a good discrimination in the obese and morbidly obese patients for identifying OSA, especially severe OSA since the predicted probability for severe OSA was twofold higher in the obese patients with a score of ≥4 than a score of <4. The predictive performance of a STOP-Bang score of 4 is better for predicting severe OSA than moderate/severe OSA since its negative predictive value for severe OSA is higher (90.5 vs. 68.6 %).

Although a STOP-Bang score of 5 had the best discrimination for predicting moderate/severe OSA and severe OSA in the obese patients based on an equipoise decision, its

Table 3 Predictive parameter of STOP-Bang score for identifying OSA in the morbidly obese patients

STOP-Bang	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
AHI >5 (all OSA)				
≥3	95.8 (90.4–98.6)	9.1 (1.1–29.2)	85.0 (77.7–90.6)	28.6 (3.7–71.0)
≥4	78.8 (70.3–85.8)	22.7 (7.8–45.4)	84.5 (76.4–90.7)	16.7 (5.6–34.7)
≥5	51.7 (42.3–61.0)	63.6 (40.7–82.8)	88.4 (78.4–94.9)	19.7 (11.2–30.9)
≥6	29.7 (21.6–38.8)	86.4 (65.1–97.1)	92.1 (78.6–98.3)	18.6 (11.6–27.6)
AHI >15 (moderate/severe OSA)				
≥3	97.0 (89.5–99.6)	6.8 (2.2–15.1)	48.1 (39.4–57.0)	71.4 (29.0–96.3)
≥4	86.4 (75.7–93.6)	28.4 (18.5–40.1)	51.8 (42.1–61.5)	70.0 (50.6–85.3)
≥5	65.2 (52.4–76.5)	64.9 (52.9–75.6)	62.3 (49.8–73.7)	67.6 (55.5–78.2)
≥6	42.4 (30.3–55.2)	86.5 (76.6–93.3)	73.7 (56.9–86.6)	62.7 (52.6–72.1)
AHI >30 (severe OSA)				
≥3	100 (90.8–100)	6.9 (2.8–13.6)	28.6 (21.1–37.1)	100 (59.0–100)
≥4	89.5 (75.2–97.1)	25.5 (17.4–35.1)	30.9 (22.5–40.4)	86.7 (69.3–96.2)
≥5	76.3 (59.8–88.6)	60.8 (50.6–70.3)	42.0 (30.2–54.5)	87.3 (77.3–94.0)
≥6	50.0 (33.4–66.6)	81.4 (72.5–88.4)	50.0 (33.3–66.6)	81.4 (72.5–88.4)

Data are depicted as average (95 % confidence interval)

AHI Apnea–Hypopnea Index, *PPV* positive predictive value, *NPV* negative predictive value

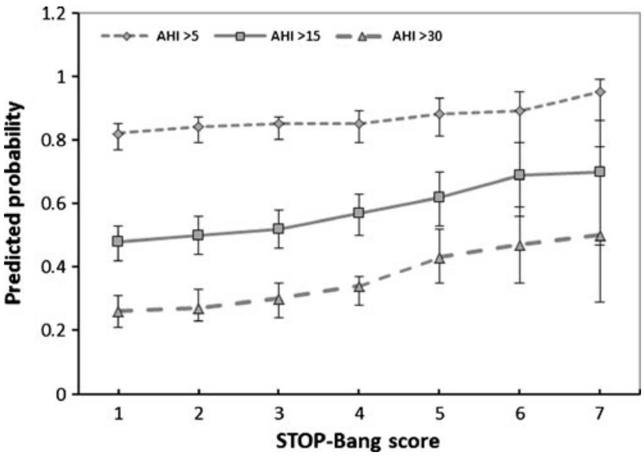

Fig. 4 The predicted probability of STOP-Bang score for identifying severe OSA (AHI >30) in the obese patients

sensitivity of 53 and 69 % are lower than score of 4 correspondingly and its specificity of 70 and 69 % are lower than score 6 correspondingly. A STOP-Bang score of 4 put the emphasis on identifying the OSA diagnosis with near-certainty (privilege sensitivity) and a STOP-Bang score of 6 excluded the diagnosis with near-certainty (privilege specificity). For the obese and morbidly obese patients, a STOP-Bang score of 0–3 indicates a low risk of OSA. A STOP-Bang score of 4–5 indicates an intermediate risk of OSA and a STOP-Bang score of 6–8 indicates a high risk of OSA (Fig. 6).

The association between obesity and OSA has been recognized by a number of epidemiological studies [12, 30]. Our data confirmed the findings that the obese patients had a significantly high incidence of OSA. BMI is not a good predictor of OSA in the obese patients, which was also reported by other investigators [31]. Excessive fat deposition may play a mechanistic role in the severity of OSA. The severity of central obesity, which is characterized by a high waist–hip ratio or increased neck circumference, is correlated with OSA even in those with a normal BMI [30]. Upper airway obstruction may be caused both by adipose deposition around upper airway structures and by decrease in the resting lung volume due to excessive fat in the chest [32–34].

Our findings for morbidly obese patients will be helpful for OSA screening before bariatric surgery. Studies published in the past decade indicate that the prevalence of OSA in patients undergoing bariatric surgery was 64–94 %, 44–58 % presented with moderate/severe OSA (AHI >15), and 15–36 % with severe OSA (AHI >30) [13, 27, 35, 36]. Our study was in obese patients with different types of surgery but we have similar findings: 84 % of the morbidly obese patients were diagnosed with OSA (AHI >5), 47 % with AHI >15, and 27 % with AHI >30. Evaluation of predictive performance of STOP-Bang questionnaire in the morbidly obese patients shows that STOP-Bang score of 4 also give a reasonable sensitivity, especially for predicting severe OSA. Our findings will provide clinicians with information how to use STOP-Bang score in the preoperative evaluation of OSA in the morbidly obese patient.

Limitation of the Study

There are a few limitations with our study. The study could be criticized because polysomnography were performed with two methods, either laboratory or portable polysomnography. Secondly, the study populations are surgical patients referred to the preoperative clinics. These results may not be applicable to other patient population and further validation in different patient population needs to be done. Also, there may be a self-selection bias involved in the patient recruiting process. The subjects having OSA-related symptoms might be more motivated to give consent to this study resulting in a high prevalence of OSA in this study. Also, due to the different surgical population, the obese patients in our study may not be completely consistent with the group of morbidly obese patients undergoing bariatric surgery.

Table 4 Diagnostic odds ratio of STOP-Bang scores 3, 4, and 5 for predicting OSA in the obese patients and morbidly obese patients

STOP-Bang	AHI >5	AHI >15	AHI >30
Obese patients			
≥3 vs. <3	3.72 (1.82–7.61)	4.37 (1.94–9.84)	n/a
≥4 vs. <4	1.85 (1.03–3.32)	2.84 (1.73–4.67)	4.93 (2.42–10.05)
≥5 vs. <5	2.22 (1.17–4.22)	2.66 (1.67–4.24)	4.83 (2.79–8.36)
Morbidly obese patients			
≥3 vs. <3	2.26 (0.41–12.46)	2.32 (0.43–12.37)	n/a
≥4 vs. <4	1.09 (0.37–3.26)	2.51 (1.06–5.97)	2.91 (0.94–8.98)
≥5 vs. <5	1.87 (0.73–4.80)	3.45 (1.72–6.92)	4.99 (2.14–11.65)

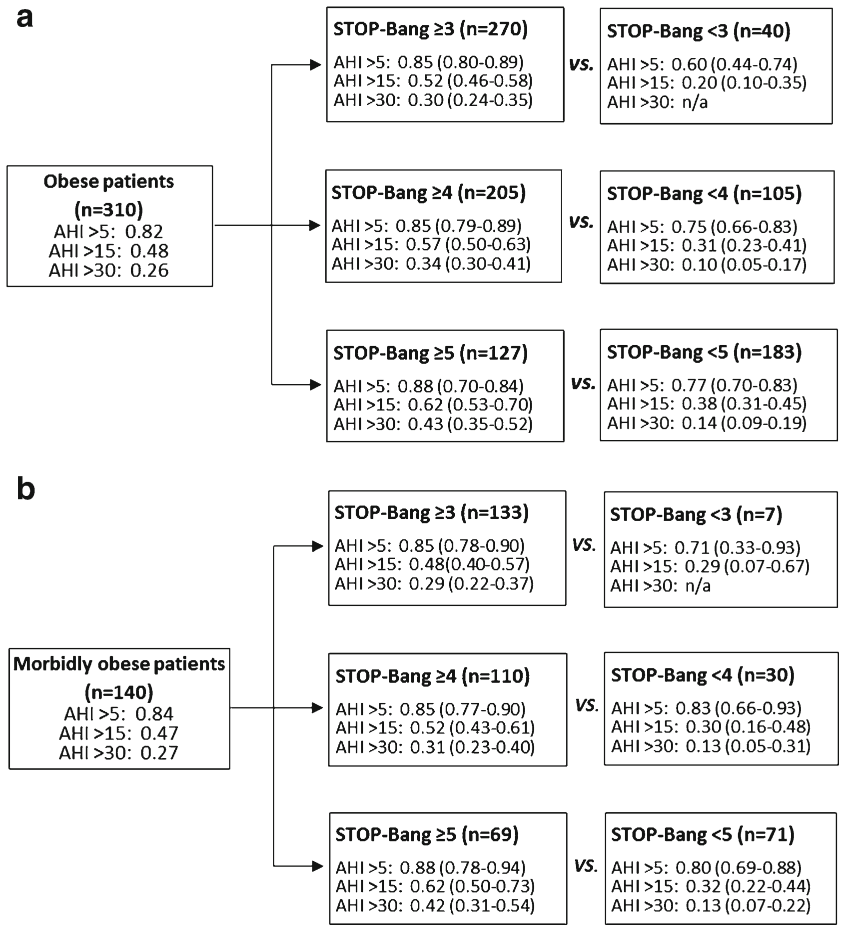

Fig. 5 The predicted probability of STOP-Bang scores 3, 4, and 5 for predicting OSA at different AHI levels in the obese (**a**) and the morbidly obese patients (**b**)

Conclusion

The STOP-Bang score was validated in the obese and morbidly obese surgical patients. In the obese surgical patients, a STOP-Bang score of 3 has a high sensitivity of 90 % and a high positive predictive value of 85 % to identify OSA. For identifying moderate/severe OSA, a STOP-Bang score of 4 has a sensitivity of 78 % and a STOP-Bang score of 6 has a specificity of 88 %. For identifying severe OSA, a STOP-Bang score of 4 has a high sensitivity of 88 %. For identifying severe OSA, a STOP-Bang score of 6 is more specific. In the morbidly obese patients, a STOP-Bang score of 4 has high sensitivity across the entire spectrum of OSA severity with a sensitivity of 90 % for severe OSA.

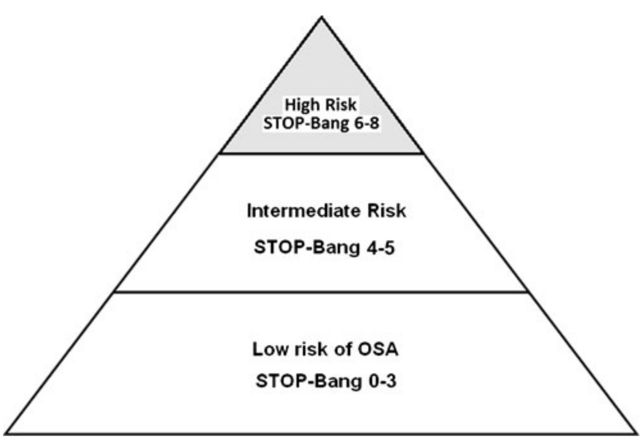

Fig. 6 STOP-Bang score and the risk of OSA in obese patients

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