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SCIENTIFIC INVESTIGATIONS

The STOP-Bang Questionnaire as a Screening Tool for Obstructive Sleep Apnea in Pregnancy

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Study Objectives: We examined the validity of the STOP-Bang questionnaire and a modified STOP-Bang questionnaire to screen for obstructive sleep apnea (OSA) in women with obesity during the second trimester of pregnancy.

Methods: Ninety-nine pregnant women age 18 years or older with body mass index ≥ 40 kg/m^2 completed the STOP-Bang questionnaire during their second trimester. The number of oxygen desaturation events (≥ 4% from baseline) was measured using overnight pulse oximetry, with OSA defined as ≥ 5 events/h. A Modified STOP-Bang score was derived by replacing the "Tired" item with Epworth Sleepiness Scale score ≥ 10. Seven candidate models were compared using information theoretic criteria: STOP-Bang, Modified STOP-Bang, and individual STOP-Bang items (Snore, Tired, Observed to stop breathing, high blood Pressure and Neck circumference). We used penalized logistic regression and negative binomial regression to derive predicted probabilities of having OSA and the predicted total event counts.

Results: The predicted probability of meeting oximetry criteria for OSA increased with higher STOP-Bang scores, from < 10% for a score < 3 to 68% with a score of 6. The total number of disordered breathing events was 1.26 (95% confidence interval 1.06 to 1.50) times greater for a 1-unit increase in STOP-Bang. Of the candidate models, the best relative fit was the Snore item followed by STOP-Bang score (essentially equivalent). The predicted probability of having OSA was 5.0% for no snoring and 26.4% for snoring.

Conclusions: STOP-Bang has been shown to be a useful screening tool for OSA in pregnant women with obesity; however, the snoring question alone might be a simpler, effective predictor.

Clinical Trial Registration: Registry: ClinicalTrials.gov; Title: STOPBANG As A Screening Tool for Obstructive Sleep Apnoea in Pregnancy; URL: https://clinicaltrials.gov/ct2/show/NCT02542488; Identifier: NCT02542488

Keywords: obesity, OSA, pregnancy, sleep apnea, snoring, STOP-Bang

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BRIEF SUMMARY

Current Knowledge/Study Rationale: Undiagnosed obstructive sleep apnea in pregnancy can result in maternal and neonatal complications. In this study we evaluated the use of the STOP-Bang questionnaire to predict OSA in women with class III obesity during their second trimester of pregnancy. We also examined whether any individual components of the STOP-Bang questionnaire could be used as an alternative screening tool.

Study Impact: This study suggests that the STOP-Bang questionnaire can be used as a screening tool for OSA in pregnant women with class III obesity during the second trimester of pregnancy. Loud and frequent snoring alone is also a good predictor of OSA in this population.

INTRODUCTION

Obstructive sleep apnea (OSA) is a sleep-related breathing disorder characterized by repeated episodes of upper airway collapse during sleep, resulting in episodes of hypoxemia. The prevalence of symptomatic OSA in the general female population is 2% to 6%.[1,2] The relationship between obesity and OSA has been well documented.[3,4] Bixler et al. reported that the presence of sleep apnea in premenopausal women was associated exclusively with obesity.[5] Physiological changes of pregnancy and gestational weight gain also predispose to OSA.[6–8] There are few studies that have looked at the risk of OSA exclusively among pregnant women with obesity, and therefore the prevalence in this population is unclear.[9]

There is a growing body of evidence that untreated OSA in pregnancy increases the risk of complications such as pregnancy-induced hypertension, preeclampsia, and gestational diabetes mellitus.[9–11] Maternal sleep-disordered breathing has also been associated with perinatal complications including intrauterine growth restriction, preterm birth, and neonatal intensive care unit admission.[12–14] Testing all pregnant women for OSA would be costly and inefficient; and therefore a method of identifying women at higher risk of OSA antenatally is required. Several screening tools have been validated for use in identifying patients at risk of OSA in the nonpregnant population. Because daytime somnolence and poor sleep quality are relatively common complaints of pregnancy, it is unsurprising that questionnaires which explore tiredness such as the

Figure 1—STOP and modified STOP questions.

STOP Questions

S—Do you **S**nore loudly? (louder than talking or loud enough to be heard through closed doors)
T—Do you often feel **T**ired or sleepy?
O—Has anyone **O**bserved you stop breathing?
P—Do you have or are you being treated for high blood **P**ressure?
Score 1 for each "Yes" answer

Modified STOP Questions

S—Do you **S**nore loudly? (louder than talking or loud enough to be heard through closed doors)
T—Is your Epworth Sleepiness Scale score (a measure of **T**iredness) ≥ 10
O—Has anyone **O**bserved you stop breathing?
P—Do you have or are you being treated for high blood **P**ressure?
Score 1 for each "Yes" answer

Epworth Sleepiness Scale (ESS) and Berlin questionnaire are poor predictors of sleep-disordered breathing in pregnancy.[15–17]

The STOP-Bang questionnaire is an eight-question screening tool that has a high sensitivity to detect moderate to severe OSA in surgical and sleep clinic patients.[18] The probability of having OSA in these populations increases with an increasing STOP-Bang score. Age older than 50 years and male sex are not relevant in pregnant women making the maximum STOP-Bang score in this population six. Two studies examining the use of STOP-Bang in the first and third trimesters of pregnancy concluded that it had a good negative predictive value but was not useful for detecting OSA.[16,19] Tantrakul et al. examined the utility of STOP-Bang in 72 women across trimesters and found it to have the best predictive value during the second trimester.[20] However none of these studies looked specifically at patients with class III obesity.[21]

The purpose of our study was to determine whether the STOP-Bang questionnaire could be used to screen for OSA in pregnant women with class III obesity. We hypothesized that women with higher STOP-Bang scores would be more likely to meet oximetry criteria for OSA. We also proposed that modifying the STOP-Bang questionnaire by replacing the binary "tiredness" question with an elevated ESS score might strengthen this association. We sought to compare the relative fit of seven models: STOP-Bang, modified STOP-Bang, and five individual binary questions in the STOP-Bang questionnaire.

METHODS

This prospective observational study was approved by the Tyne and Wear South Research & Ethics Committee and registered on Clinicaltrials.gov: NCT02542488. After obtaining written informed consent, 117 patients were enrolled at Sunderland Royal Hospital between February 2016 and August 2017. Eligible women were age 18 years or older and had a BMI ≥ 40 kg/m^2 at their initial midwife appointment. We selected women with a high BMI with the goal of finding a greater number of participants who had OSA on which to base our analysis. BMI ≥ 40 kg/m^2 was specifically chosen because women in this BMI category are referred to our hospital's obstetric clinic antenatally. Any women with preexisting sleep apnea or respiratory disease were excluded.

Data were collected between weeks 17 to 28 of pregnancy as we were aiming to use the screening tool to predict OSA when women are seen at their anomaly scan or glucose tolerance test. Although the prevalence of OSA increases with each trimester,[20] screening for OSA during these routine second-trimester appointments avoided the need for additional hospital visits and enabled time to refer women for potential OSA treatment before delivery. Participants were asked the following questions: Do you snore loudly (loud enough to be heard through closed doors)? Do you often feel tired or sleepy? Has anyone observed you stop breathing? Do you have or are you being treated for high blood pressure? They were then given the ESS questionnaire to complete and a research midwife recorded their age and measured their BMI, noninvasive blood pressure and neck circumference. STOP-Bang scores were calculated for all participants. The ESS was calculated and a score of ≥ 10 was included as a "point" in the Modified STOP-Bang score (**Figure 1**).

After this appointment all participants were given a Masimo Rad-8 pulse oximeter (part number 9019, Masimo Corporation, Irvine, California, United States) to use at home for one night and return the following day. This device, which records oxygen saturations and pulse rate, is used routinely by our institution's respiratory department to help diagnose OSA. The oximetry data was analyzed using the Stowood Visi-Download software (Stowood Scientific Instruments Ltd, Oxford, United Kingdom). A desaturation was defined as a drop in the oxygen saturations of ≥ 4% from the baseline. These desaturations can result in the development of significant complications due to sympathetic activation and oxidative stress.[22] The oxygen desaturation index (ODI) was calculated from the average number of oxygen desaturations per hour.[23] All of the oximetry recordings were reviewed by a pulmonary physiologist to ensure that they were adequate. A minimum of 4 hours of continuous oximetry measurements were required for the sleep study to be deemed acceptable for inclusion.

We defined suspected OSA as ≥ 5 oxygen desaturation events per hour in accordance with the American Academy of Sleep Medicine guideline.[24] All patients with an ODI ≥ 5 were contacted to inform them of the result and offered referral to a sleep physician for further assessment.

Statistical Analysis

All analyses were performed using Stata software (Release 14, StataCorp, College Station, Texas, United States). A formal sample size estimation was not conducted a priori, due to the lack of a robust and sufficiently precise estimate of the prevalence of OSA in pregnant women with class III obesity at this gestation. Poststudy, using the derived log odds ratio and its standard error, we calculate that our study had ~90% power to detect a small odds ratio of 2.5 for a 1-unit increment in STOP-Bang score (with one-sided P = .05). Given the small absolute number of events (n = 15), the odds ratio and predicted probabilities of having OSA were derived using logistic regression with penalized maximum likelihood[25] using the Stata

Table 1—Sample characteristics.

Variable	Summary Statistic
Age (years)	28.1 (5.4)
BMI at booking (kg/m^2)	44.4 (4.5)
Gestation (STOP-Bang data collection) in weeks	20.1 (2.6)
Gestation (oximetry) in weeks	20.9 (2.0)
Snoring (%)	50.5
Tired (%)	83.8
Observed to stop breathing (%)	8.1
Systolic blood pressure (mmHg)	117 (10)
Diastolic blood pressure (mmHg)	71 (8)
Neck circumference (cm)	40.1 (2.8)
STOP-Bang total	2.7 (0.9)
Epworth Sleepiness Scale score	6.3 (4.0)
Presumed OSA from oximetry result (%)	15.2
ODI, median (interquartile range) (range)	2.2 (0.9 to 3.7) (0 to 11.9)
Oximetry duration (hours)	8.2 (1.7)
Total number of disordered breathing events, median (interquartile range) (range)	17 (8 to 32) (0 to 76)

Data are mean (standard deviation) unless otherwise stated. (n = 99). BMI = body mass index, ODI = oxygen desaturation index, OSA = obstructive sleep apnea.

"firthlogit"[26] and "margins" commands. Point estimates are presented together with 95% confidence intervals.

We compared seven candidate models: STOP-Bang total and modified STOP-Bang total, plus five individual STOP-Bang items (Snore, Tired, Observed to stop breathing, high blood Pressure, and Neck circumference). BMI > 35 kg/m^2, age older than 50 years, and sex were not included because there is no variance in the dataset for these binary outcomes. Models were compared using an information theoretic approach (Akaike Information Criterion; AIC) with the lowest AIC value indicating the best relative fit. The difference in AIC from the "best" model (ie, the model with the lowest AIC value; AIC difference = 0) was evaluated according to the following scale: 0–2, essentially equivalent model; 2–7, plausible alternative; 7–14, weak support; greater than 14, no empirical support.[27] Results are presented for the model with the best relative fit from the candidate models compared, as well as for any model found to be "essentially equivalent."

As it has been reported that the number of disordered breathing events is a better measure than the rate at which these events occur (ODI or respiratory event index)[28] we also derived the predicted total desaturation events. These predicted frequencies were calculated following a negative binomial regression model, providing the incidence rate ratio (ratio of counts) for a 1-unit increment in the predictor (STOP-Bang or modified STOP-Bang, or a "yes" versus a "no" for a binary question).

RESULTS

A total of 132 eligible women were approached to participate in the study. Of the 117 recruited, 18 were excluded for the following reasons: miscarried (n = 1), withdrew from the study (n = 4), no neck circumference recorded (n = 1), pulse oximeter not used (n = 3), inadequate oximetry recording (n = 2), not seen before end of second trimester (n = 7).

Sample characteristics for the 99 women that completed the study are displayed in **Table 1**. Fifteen participants had an ODI ≥ 5, all having results within the range for mild OSA (5–15).[29] Total STOP-Bang and Modified STOP-Bang scores ranged from 1–5. A total of 41 women (41%) had a neck circumference > 40 cm, 84% (n = 84) answered yes to the "tired" question, and 3% (n = 3) had high blood pressure. Among those women with ODI ≥ 5, the incidence of snoring was 87% (n = 13) and 20% (n = 3) reported that they had been observed to stop breathing while asleep.

The odds ratio for the logistic regression of OSA on STOP-Bang was 2.20 (95% confidence interval, 1.19 to 4.1). This finding indicates that a 1-unit increase in STOP-Bang increases the odds of having the ODI criterion for OSA by a factor of 2.2. **Table 2** presents the predicted probabilities of having suspected OSA by STOP-Bang score. Fewer than 1 in 10 pregnant women in the second trimester would be predicted to have OSA with STOP-Bang scores < 3. The predicted probability of having OSA increases to around one in two pregnant women for a STOP-Bang score of 5, and over two-thirds with a score of 6 (the maximum for pregnant women). The negative binomial regression of total disordered breathing events on STOP-Bang revealed an incidence rate ratio of 1.26 (1.06 to 1.50); for a 1-unit increase in STOP-Bang the total number of events increases by a factor of 1.26. The predicted number of events for STOP-Bang scores ranging from 0–6 is shown in **Table 3**.

Table 4 shows the AIC values for the comparison of the candidate models. The single Snore item is the best overall model, with the standard STOP-Bang total score "essentially equivalent."

The odds ratio for the logistic regression of OSA on snoring (yes/no) was 6.8 (1.7 to 28.2). The predicted probability of having OSA was 5.0% (1.5 to 15.8%) for answering "no"

Table 2—Predicted probability of obstructive sleep apnea by STOP-Bang score.

STOP-Bang Score	Predicted Probability (%)
0	1.8 (0.2 to 12.2)
1	4.0 (1.0 to 14.6)
2	8.3 (3.6 to 18.1)
3	16.7 (10.3 to 26.1)
4	30.7 (16.9 to 49.2)
5	49.5 (21.2 to 78.1)
6	68.4 (25.0 to 93.4)

Values are predicted probability (95% confidence interval).

Table 3—Predicted number of total disordered breathing events by STOP-Bang score.

STOP-Bang Score	No. Events
0	11 (6 to 17)
1	14 (9 to 19)
2	18 (14 to 22)
3	23 (19 to 27)
4	29 (21 to 37)
5	36 (20 to 52)
6	46 (18 to 73)

Values are predicted number of total disordered breathing events (95% confidence interval).

Table 4—Comparison of the seven candidate models for the prediction of OSA.

Variable	AIC	AIC Difference Versus Best Model	Inference
STOP-Bang total	76.4	1.4	Essentially equivalent
Modified STOP-Bang total	80.1	5.1	Plausible alternative
Snore	75.0	0.0	Best model
Tired	85.1	10.1	Weak support
Observed to stop breathing	82.6	7.6	Weak support
High blood **P**ressure	85.5	10.5	Weak support
Neck circumference	84.1	9.1	Weak support

AIC difference was evaluated according to the following scale: 0–2, essentially equivalent model; 2–7, plausible alternative; 7–14, weak support; greater than 14, no empirical support. AIC = Akaike Information Criterion (lowest value = best relative fit), OSA = obstructive sleep apnea.

to the snoring question and 26.4% (16.2 to 40.1%) for "yes". The negative binomial regression of total disordered breathing events on snoring revealed an incidence rate ratio of 1.69 (1.23 to 2.34). The predicted total number of events was 16 (12 to 20) for "no snoring" and 27 (21 to 33) for "snoring."

DISCUSSION

We found that women with class III obesity who had higher STOP-Bang scores midpregnancy were more likely to meet the ODI criterion for OSA. Substituting the "tiredness" question with an elevated ESS score to form a Modified STOP-Bang did not improve its predictive ability. Of the individual components of STOP-Bang, snoring was the best predictor of OSA. The prevalence of OSA in this population diagnosed by overnight pulse oximetry was 15.2%. This is in keeping with other studies that have quoted the prevalence of OSA to be 11% to 20% depending on gestation of pregnancy.[30,31]

Based on the results in our study, fewer than 10% of women would be predicted to have OSA with a STOP-Bang score < 3. This probability increased to 31% and 50% for STOP-Bang scores of 4 and 5, respectively. This is the first study to look at the use of the STOP-Bang questionnaire to screen for OSA, specifically in women with class III obesity during the second trimester. Tantrakul et al. also observed STOP-Bang to be predictive of OSA in pregnancy, reporting a score of ≥ 3 to have a sensitivity of 63% and specificity of 94% in the second trimester.[20] Medical staff working in antenatal clinics need a quick and simple way to identify those women who should be investigated for sleep-disordered breathing. A recent survey of members of the Society for Obstetric Anesthesia and Perinatology found that approximately half of the respondents screen for OSA and of these more than three-fourths use the STOP-Bang questionnaire.[32] Our findings suggest that the STOP-Bang questionnaire is a suitable screening tool for OSA during the second trimester in pregnant women with obesity.

A large proportion of our study population reported feeling tired, yet only 18% had an ESS score above the common cutoff for excessive daytime sleepiness (> 10). It has been well documented in the literature that tiredness and the ESS are not good discriminators of OSA in pregnancy.[1] This could explain why we did not find the Modified STOP-Bang score to be a superior screening tool to the original STOP-Bang questionnaire.

Just over half of our participants reported snoring on the STOP questionnaire. Other authors have described snoring rates of 17% to 34% but did not specifically look at women with obesity in the second trimester.[33,34] Another reason we may have observed a higher snoring rate is that studies focusing on snoring conducted detailed interviews with precise criteria for snoring, whereas our study used simple self-reporting on the STOP instrument. Another pertinent finding was that women who answered yes to the snoring question were more likely to have OSA. This is in keeping with previous studies that have identified a positive association with snoring and sleep-disordered breathing in pregnancy.[16,35] Smith et al. suggested that habitual snoring (snoring at least 3 nights per week) could be

used as a triage tool for OSA in pregnancy, especially among those with a BMI ≥ 40.[36]

We found a low prevalence of hypertension in our study population (3%). The prevalence of hypertension reported by other authors ranges from 8% to 50%.[16,30,35] The wide variation in rates of hypertension between studies is likely to be due to the gestation at blood pressure was recorded. Gestational hypertension begins after the 20th week of pregnancy[37]; hence, studies of women at greater gestations are likely to find a higher rate of hypertension. As the mean gestation of completing the STOP-Bang questionnaire in our study was 20 weeks, gestational hypertension would not have developed yet. The prevalence of hypertension amongst our participants is consistent with that reported by Louis et al. who studied over 2,512 women midpregnancy and found that 2.3% had hypertension.[38]

Our study has some limitations. Our sample size was small and only 15 patients had an ODI ≥ 5, and none had moderate or severe OSA. Most participants had STOP-Bang data and oximetry recorded at their anomaly scan at approximately 20 weeks gestation, as we were aiming to set up a screening process for OSA during routine antenatal visits. It is possible that including third-trimester patients would have given us a larger number of OSA-positive results for our analysis and perhaps higher ODI values. However, other studies have found that OSA, even in pregnant women with obesity, is often mild.[10,30,39]

Another limitation is the use of portable oximetry to diagnose OSA. Overnight polysomnography (PSG) remains the gold standard for diagnosis of OSA. However, PSG is expensive and involves patients having to stay in a sleep laboratory overnight. The ODI has been shown to be a sensitive and specific tool to detect OSA.[23,40,41] In a study of 123 patients with class III obesity, the investigators discussed the possibility that overnight pulse oximetry may underestimate OSA due to the decreased basal nocturnal saturation in patients with obesity. They reported that, despite this, there was a strong correlation between ODI and apnea-hypopnea index.[42] However, the validity of portable oximetry in a pregnant population has not been studied specifically. The WatchPAT 200 device (Itamar Medical, Caesarea, Israel) is a portable level 3 device that has been validated for use in pregnancy[43] but is also costly and not commonly available in the National Health Service. Because we were conducting a small study we chose to use the investigative tool that our institution's pulmonary physiology department use routinely to diagnose OSA. In any case, our prevalence and range of ODIs is similar to studies using PSG.

In conclusion, this study has demonstrated that the STOP-Bang questionnaire can help to screen for OSA in women with class III obesity during their second trimester of pregnancy. However, we are mindful that the STOP-Bang questionnaire takes time to complete and requires additional measurements not normally conducted in an antenatal clinic. As snoring also helped to identify those with OSA, we would suggest a simpler screening method: pregnant women with class III obesity who report loud and frequent snoring should be referred for investigation of sleep disordered breathing. A larger scale study should be conducted using PSG or WatchPAT in women during the second and third trimester with the goal of developing a pregnancy-specific screening tool for OSA.

ABBREVIATIONS

AIC, Akaike Information Criterion
BMI, body mass index
ESS, Epworth Sleepiness Scale
ODI, oximetry desaturation index
OSA, obstructive sleep apnea
PSG, polysomnography

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