The STOPBANG Questionnaire as a Screening Tool for Obstructive Sleep Apnoea in Pregnancy

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Clinical Trial Registration

The manuscript reports on a clinical trial:

STOPBANG As A Screening Tool for Obstructive Sleep Apnoea in Pregnancy

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Declarations

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Abstract

Study Objectives

We examined the validity of the STOPBANG questionnaire and a modified STOPBANG to screen for obstructive sleep apnea (OSA) in obese women during the second trimester of pregnancy.

Methods

Ninety-nine pregnant women aged ≥18 years with body mass index ≥40 kg/m^2 completed the STOPBANG 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/hour. A Modified STOPBANG score was derived by replacing the 'Tired' item with Epworth score ≥10. Seven candidate models were compared using information theoretic criteria: STOPBANG, Modified STOPBANG and individual STOPBANG items (Snore, Tired, Observed to stop breathing, high blood Pressure and Neck circumference). We used penalised 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 STOPBANG 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% CI 1.06 to 1.50) times greater for a 1-unit increase in STOPBANG. Of the candidate models, the best relative fit

was the Snore item followed by STOPBANG score (essentially equivalent). The predicted probability of having OSA was 5.0% for no snoring and 26.4% for snoring.

Conclusions

STOPBANG has been shown to be a useful screening tool for OSA in obese pregnant women; however the snoring question alone might be a simpler, effective predictor.

Key words:

OSA, Sleep Apnoea, Pregnancy, STOPBANG, Obesity, Snoring.

Brief Summary

Current Knowledge/Study Rationale:

Undiagnosed obstructive sleep apnoea in pregnancy can result in maternal and neonatal complications. In this study we evaluated the use of the STOPBANG questionnaire to predict OSA in class III obese women during their second trimester of pregnancy. We also examined whether any individual components of the STOPBANG questionnaire could be used as an alternative screening tool.

Study Impact:

This study suggests that the STOPBANG questionnaire can be used as a screening tool for OSA in class III obese pregnant women during the second trimester of pregnancy. Loud and frequent snoring alone is also a good predictor of OSA in this population.

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Introduction

Obstructive sleep apnoea (OSA) is a sleep-related breathing disorder characterized by repeated episodes of upper airway collapse during sleep, resulting in episodes of hypoxaemia. The prevalence of symptomatic OSA in the general female population is 2-6%.[1-2] The relationship between obesity and OSA has been well documented.[3-4] Bixler et al. reported that the presence of sleep apnoea in pre-menopausal 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 obese pregnant women 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, pre-eclampsia 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 non-pregnant population. Since daytime somnolence and poor sleep quality are relatively common complaints of pregnancy, it is unsurprising that questionnaires which explore tiredness such as the Epworth Sleepiness Scale (ESS) and Berlin questionnaire are poor predictors of sleep-disordered breathing in pregnancy.[15-17]

The STOPBANG 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 STOPBANG score. Age greater than 50 and male gender are not relevant in pregnant women making the maximum STOPBANG score in this population six. Two studies examining the use of STOPBANG in the first and third trimesters of pregnancy concluded that it had a good negative predictive value was not useful for detecting OSA.[16,19] Tantrakul et al. examined the utility of STOPBANG 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 STOPBANG questionnaire could be used to screen for OSA in class III obese pregnant women. We hypothesized that women with higher STOPBANG scores would be more likely to meet oximetry criteria for OSA. We also proposed that modifying the STOPBANG 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: STOPBANG, modified STOPBANG, and five individual binary questions in the STOPBANG 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 ≥18 years of age and had a BMI ≥40 kg/m^2 at their initial midwife appointment. We selected women with a high BMI with the aim 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 pre-existing sleep apnoea or respiratory disease were excluded.

Data was 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 Epworth Sleepiness Scale (ESS) questionnaire to complete and a research midwife recorded their age and measured their BMI, non-invasive blood pressure and neck circumference. STOPBANG scores were calculated for all participants. The ESS was calculated and a score of ≥ 10 was included as a 'point' in the Modified STOPBANG score (see Figure 1: STOP and Modified Stop Questions).

After this appointment all participants were given a Masimo Rad-8 pulse oximeter (part number 9019) 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 analysed using the Stowood Visi download software. 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 four hours 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 (StataCorp, 2015. Stata Statistical Software: Release 14, College Station, TX, USA: StataCorp LP). 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 class III obese pregnant women at this gestation. Post-study, 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 STOPBANG score (with one-sided P=0.05). Given the small absolute number of events (n=15), the odds ratio and predicted probabilities of having OSA were derived using logistic regression with penalised maximum likelihood[25] using the Stata 'firthlogit'[26] and 'margins' commands. Point estimates are presented together with 95% confidence intervals.

We compared seven candidate models: STOPBANG total and modified STOPBANG total, plus five individual STOPBANG items (Snore, Tired, Observed to stop breathing, high blood Pressure, and Neck circumference). BMI >35 kg/m^2, age >50 years, and gender were not included as there is no variance in the data set for these

binary outcomes. Models were compared using an information theoretic approach (Akaike's Information Criterion; AIC) with the lowest AIC value indicating the best relative fit. The difference in AIC from the 'best' model (i.e. 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 (STOPBANG or modified STOPBANG, or a 'yes' vs. 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 STOPBANG and Modified STOPBANG 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. Amongst 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 STOPBANG was 2.20 (95% confidence interval, 1.19 to 4.1). This finding indicates that a 1-unit increase in STOPBANG 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 STOPBANG score. Fewer than 1 in 10 pregnant women in the second trimester would be predicted to have OSA with STOPBANG scores <3. The predicted probability of having OSA increases to around 1 in 2 pregnant women for a STOPBANG 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 STOPBANG revealed an incidence rate ratio of 1.26 (1.06 to 1.50); for a 1-unit increase in STOPBANG the total number of events increases by a factor of 1.26. The predicted number of events for STOPBANG 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 STOPBANG 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' 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 STOPBANG scores mid-pregnancy were more likely to meet the ODI criterion for OSA. Substituting the "tiredness" question with an elevated ESS score to form a Modified STOPBANG did not improve its predictive ability. Of the individual components of STOPBANG, 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 11-20% 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 STOPBANG score < 3. This probability increased to 31% and 50% for STOPBANG scores of 4 and 5, respectively. This is the first study to look at the use of STOPBANG to screen for OSA specifically in women with class III obesity during the second trimester. Tantrakul et al. also observed STOPBANG 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 over three quarters use the STOPBANG questionnaire.[32] Our findings suggest that the STOPBANG questionnaire is a suitable screening tool for OSA during the second trimester in obese pregnant women.

A large proportion of our study population reported feeling tired, yet only 18% had an ESS score above the common cut-off 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 may explain why we did not find the Modified STOPBANG score to be a superior screening tool to the original STOPBANG questionnaire.

Just over half of our participants reported snoring on the STOP questionnaire. Other authors have described snoring rates of 17-34% but did not specifically look at obese women 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 8-50%.[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 STOPBANG 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 2512 women mid-pregnancy and found that 2.3% had hypertension.[38]

Our study has some limitations. Our study involved a small number of patients, only 15 had an ODI≥5, and none had moderate or severe OSA. Most participants had STOPBANG 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 obese pregnant women, 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 class iii obese patients, the investigators discussed the possibility that overnight pulse oximetry may underestimate OSA due to the decreased basal nocturnal saturation in obese patients. They reported that, despite this, there was a strong correlation between ODI and apnoea hypopnea index.[42] However the validity of portable oximetry in a pregnant population has not been studied specifically. The Watch-Pat 200 device (Itamar Medical Cesarea) 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. As 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 STOPBANG questionnaire can help to screen for OSA in women with class III obesity during their second trimester of pregnancy. However we are mindful that STOPBANG 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 aim of developing a pregnancy-specific screening tool for OSA.

Abbreviations

AIC Akaike's Information Criterion

BMI Body Mass Index

ESS Epworth sleepiness scale

ODI Oximetry desaturation index

OSA Obstructive sleep apnoea

PSG Polysomnography

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Disclosures

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The authors have no conflicts of interest to disclose.

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Table 1. Sample characteristics. Data are mean (SD) unless stated. (n=99).

Variable	Summary statistic
Age (years)	28.1 (5.4)
BMI at booking (kg/m^2)	44.4 (4.5)
Gestation (STOPBANG 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)

OSA, obstructive sleep apnoea; ODI, oxygen desaturation index; BMI, body mass index.

Table 2. Predicted probability of obstructive sleep apnoea by STOPBANG score.

STOPBANG score	Predicted Probability (%) (95% confidence interval)
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)

Table 3. Predicted number of total disordered breathing events by STOPBANG score.

STOPBANG score	Predicted number of events (95% confidence interval)
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)

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

Variable	AIC*	AIC difference vs. best model	Inference
STOPBANG total	76.4	1.4	Essentially equivalent
Modified STOPBANG total	80.1	5.1	Plausible alternative
Snore	75.0	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; Akaike's Information Criterion – lowest value = best relative fit. 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.

Figure 1. STOP & 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