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Screening extremely obese pregnant women for obstructive sleep apnea

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Abstract

BACKGROUND: Obesity is prevalent among pregnant women in the United States; obstructive sleep apnea is highly comorbid with obesity and is associated with adverse pregnancy outcomes. Screening for obstructive sleep apnea in pregnant women has remained a challenge because of a lack of validated screening tools.

OBJECTIVE: The purpose of this study was to evaluate established obstructive sleep apnea screening tools, a sleepiness scale, and individual component items in a cohort of pregnant women with extreme obesity in mid pregnancy with the use of objective testing to determine obstructive sleep apnea status and to describe the prevalence of obstructive sleep apnea among women with extreme obesity.

STUDY DESIGN: Adult pregnant subjects, between 24 and 35 weeks gestation, with a body mass index ≥40 kg/m^2 at the time of enrollment completed obstructive sleep apnea screening tools (Berlin Questionnaire, American Society of Anesthesiologists checklist, and STOP-BANG questionnaire) and the Epworth Sleepiness Scale; they also underwent physical examination of the neck, mouth, and airway. The obstructive sleep apnea in pregnancy prediction score proposed by Facco et al was calculated for each subject. Obstructive sleep apnea status for each subject was determined by the results of an overnight, unattended type III home sleep apnea test.

RESULTS: Twenty-four percent of pregnant women with extreme obesity had obstructive sleep apnea on home sleep apnea testing in mid pregnancy (Apnea-Hypopnea Index, ≥5 events per hour]. Established obstructive sleep apnea screening tools performed very poorly to screen for obstructive sleep apnea in this cohort. Age, body mass index, neck circumference, frequently witnessed apneas, and highly likely to fall asleep while driving were associated most strongly with obstructive sleep apnea status in this cohort.

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CONCLUSION: We found that 24% of pregnant women with body mass index ≥40 kg/m^2 between 24 and 35 weeks gestation have obstructive sleep apnea, defined as Apnea-Hypopnea Index ≥5 events per hour on an overnight type III home sleep apnea test. We found the Berlin Questionnaire, American Society of Anesthesiologists checklist, STOP-BANG, obstructive sleep apnea in pregnancy score by Facco et al, and the Epworth Sleepiness Scale were not useful screening tools for obstructive sleep apnea in a cohort of obese pregnant women. However, age, body mass index, neck circumference, frequently witnessed apneas, and likely to fall asleep while driving were associated with obstructive sleep apnea in this cohort. Further studies are needed to adjust the criteria and thresholds within the available screening tools to better predict obstructive sleep apnea in pregnant women with obesity.

Abstract

We found that 24% of parturients with extreme obesity have obstructive sleep apnea in mid pregnancy; previously defined screening tools perform poorly in this cohort.

Keywords

Apnea-Hypopnea Index; Berlin Questionnaire; Epworth Sleepiness Scale; home sleep apnea test; obesity; STOP-BANG

Obstructive sleep apnea (OSA) may affect 15–20% of obese pregnant women; one-half of all pregnant women in the United States are overweight or obese.[1–5] OSA is associated with several comorbidities in pregnancy: hypertensive disorders of pregnancy, gestational diabetes mellitus, and cardiomyopathy.[3,6–11] These associations are significant after investigators control for obesity, which is an important confounder that is associated with both OSA and adverse maternal outcomes. Large, retrospective database studies have also shown increased morbidity and mortality rates for pregnant women with OSA.[8,11] Some recent studies also suggest adverse fetal and neonatal outcomes that are associated with maternal OSA, although the results of these studies have been inconsistent.[9,12,13]

Women with OSA in pregnancy have a 2-fold increased risk of the development of preeclampsia and a 1.5–3.5-fold increased risk of the development of gestational diabetes mellitus after investigators control for obesity.[3,8,11] Despite the association of OSA with adverse pregnancy outcomes and interest in the identification of these women so that treatment can be initiated, screening for OSA in pregnancy has remained a challenge. The gold-standard method of the diagnosis of OSA is in-laboratory, overnight polysomnography, which is a diagnostic test that is time-consuming and costly to implement on a wide scale. Furthermore, wait times for in-laboratory polysomnography in many healthcare settings range from 2–3 months or longer; this poses an additional hurdle to the timely diagnosis and treatment of OSA during a woman's pregnancy. As an alternative to polysomnography, portable at-home, unattended sleep apnea testing is emerging as a reliable, convenient, and cost-effective method of screening for OSA in some populations and has been used in several studies of OSA in pregnancy.[2–4,6,14] However, these home sleep apnea tests are impractical to administer as a primary screening tool, and a number of investigators have tried to validate established OSA screening questionnaires in parturients or to create new screening tools that would help identify which pregnant women should be referred for

further diagnostic sleep testing.[2,12,14–16] In pregnancy, these screening tools are associated with a high false referral rate for polysomnography.[17] The proportion of obese women in these cohorts ranged from approximately 20–50%, but none enrolled only women with extreme obesity (body mass index [BMI], ≥40 kg/m^2).[18] In each of these studies, BMI or prepregnancy BMI was an important risk factor for the prediction of OSA status in pregnancy; further, BMI has been established as an important risk factor for OSA in nonpregnant populations.[19] The purpose of this study was to evaluate established OSA screening questionnaires, a sleepiness scale, their individual component items, and physical examination findings in a cohort of pregnant women with extreme obesity in mid pregnancy with the use of objective home sleep testing to determine OSA status and to describe the prevalence of OSA among women with extreme obesity. The questionnaires have not been found to be useful in other studies of pregnant women, but they have not been tested previously in a cohort of extremely obese women.

Materials and Methods

This study was approved by the Duke University Medical System Institutional Review Board and registered in ClinicalTrials.gov(). We prospectively enrolled adult pregnant, nulliparous, and multiparous subjects who were 24–35 weeks gestation from a university-affiliated prenatal clinic. Women were included if they had a BMI ≥40 kg/m^2 at the time of enrollment and were ≥18 years old. The World Health Organization classification of obesity was used to define class 3 (extreme) obesity.[18] Women with an established diagnosis of OSA or chronic opiate use and subjects who did not speak English were excluded.

After informed consent, demographic data were recorded (including prepregnancy BMI from chart review), and the subjects completed 3 sleep disordered breathing screening questionnaires: the Berlin Questionnaire[20] (BQ), the STOP-BANG[21,22] questionnaire, and the American Society of Anesthesiologists' (ASA) checklist.[23] Subjects also completed the Epworth Sleepiness Scale (ESS), which is used to assess sleepiness that can be associated with OSA.[24] An OSA risk score was also calculated for each subject with the use of the method proposed for use in pregnant women by Facco et al[2]: OSA risk score-=age +$BMI_{prepregnancy}$+15 (if frequent snoring)+15 (if chronic hypertension).

The BQ, STOP-BANG questionnaire, ASA checklist, and ESS were scored by the published methods.[20,23–25] The BQ contains 10 items that are classified into 3 categories: category 1 concerns snoring; category 2 concerns daytime sleepiness; and category 3 relates to BMI >30 kg/m^2 and chronic hypertension. The BQ considers high risk for OSA if 2 of 3 categories were scored as positive.[20] Similarly, the ASA checklist contains 12 items in 3 categories: (1) clinical signs and symptoms, (2) history of apparent airway obstruction during sleep, and (3) somnolence. If ≥2 of these categories are endorsed, the patient is considered at high risk for OSA.[23] Each item on the STOP-BANG questionnaire receives 1 point, with the highest total possible score in this cohort equal to 6 (because male gender and age >50 years do not apply to any of the subjects).[19,25] The ESS is considered concerning for excessive daytime sleepiness if scores are in the 11–24 range.[24]

Study data were entered into and managed with the use REDCap electronic data capture tools hosted at Duke University. REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing (1) an intuitive interface for validated data entry, (2) audit trails for tracking data manipulation and export procedures, (3) automated export procedures for seamless data downloads to common statistical packages, and (4) procedures for importing data from external sources.[26]

Vital signs were recorded, and subjects underwent a physical examination of the neck and upper airway by trained research assistants in the Department of Anesthesiology to measure neck circum-ference[22] and thyromental distance and to assess retrognathia, tongue scalloping,[27] Mallampati score (MMS),[28] modified MMS,[29] tonsil size, and lateral pharyngeal wall narrowing. MMS is a 1–4 numeric rating system that commonly is used to assess the airway and predict difficulty of intubation that is assessed by asking the subject to open their mouth as wide as possible with the tongue protruding. The modified MMS leaves the tongue inside the mouth. Neck circumference was measured with a disposable measuring tape at the midpoint of the neck just below the thyroid cartilage. Thyromental distance was measured with a disposable paper measuring tape from the mandible to the top of the thyroid cartilage. Retrognathia, tongue scalloping, MMS, modified MMS, tonsil size, and lateral pharyngeal wall narrowing were rated with the use of an illustrated numeric scoring tool.

Subjects received an unattended type III home sleep apnea test (ApneaLink Air; ResMed, Poway, CA) and instructions for wearing it during 1 night of sleep. The home sleep test consists of a pulse oximeter for recording of oxygen saturation and heart rate, a respiratory effort belt for measurement of respiratory effort, and a nasal sensor for detection of flow limitation, Apnea-Hypopnea Index (AHI), and snoring. The software on the device calculates AHI from the sum average number of apneas (80–100% reduction in airflow with respiratory effort ≥10 seconds) and hypopneas (50–80% reduction in airflow with respiratory effort ≥ 10 seconds) per hour during the recording time, based on the standard definitions of the American Academy of Sleep Medicine.•• The software also generates a report with details regarding variation in oxygen saturation during the study. Subjects with an AHI >5 per hour on the home sleep test were referred to a sleep medicine physician for further evaluation.

Pregnancy outcomes that included maternal death, gestational diabetes mellitus, cerebrovascular accident, spontaneous labor, induction of labor, oxytocin administration during labor, cesarean delivery, estimated blood loss, neonatal weight, composite outcomes of adverse maternal cardiovascular and peripartum events, and adverse fetal outcomes were followed for all subjects. A composite adverse maternal cardiovascular outcome combined cases of gestational hypertension, mild and severe preeclampsia, eclampsia, cardiomyopathy, and congestive heart failure. A composite adverse peripartum outcome included cases of postpartum hemorrhage, maternal intensive care unit admission, and postoperative wound infections. A composite adverse fetal outcome included cases of neonatal intensive care unit admission, fetal growth restriction, preterm delivery (<37 weeks gestation), and fetal death.

OSA outcome was defined as AHI ≥5 events per hour among patients with at least 2 hours of recorded nasal air flow time. This measure was chosen to assess outcome because it

represents the threshold for referral for in-laboratory polysomnography, and an OSA screening measure must be able to indicate sensitively and specifically when a referral for polysomnography is needed. We summarized the patient demographic, physical and clinical characteristics and the questionnaire responses in each outcome group. We assessed univariate associations of patient characteristics and questionnaire responses with OSA outcome via *t*-test or Wilcoxon rank sum test for numeric variables, and chi-square test or Fisher Exact test for categoric variables.

We assessed the performance and agreement of the previously defined OSA risk scores with the use of receiver operating curve (ROC) area under the curve analysis, logistic regression, and Kendall Tau correlation for the numeric scores and with the use of sensitivity and specificity, net reclassification indices, and Kappa statistics for the binary risk stratification.

We designed the study with an expectation of an OSA-positive rate of 30–40% in our high-risk population.[1,2] A study of 80 patients (24–32 with OSA) with completed valid home sleep test achieves 79% power in a logistic regression with a 2-sided alpha score of .05 to detect an odds ratio of 2.5 for a numeric risk score when the OSA rate is 35%. For the Kappa statistic used to assess agreement with 80 subjects and an OSA rate of 35%, we will achieve 82% power at an alpha score of .05 to detect the difference between a kappa of 0.45 (fair agreement) and 0.75 (strong agreement). Power and sample size calculation were performed in NQuery software (version ••••; Statistical Solutions Ltd, ••••); statistical analysis was performed in SAS software (version 9.4; SAS Inc, Cary, NC). Significance was set at .05 level.

Results

To collect a detailed home sleep test of the required 80 subjects, we enrolled 108 subjects in the study from March 2015 until August 2017. Twelve subjects did not complete the home sleep study. Sixteen subjects were excluded because of improperly wearing the device or wearing the device for <2 hours. Eighty subjects completed valid, home sleep tests of ≥2 hours.

Nineteen women (24%) had AHI ≥5 events per hour on their home sleep test. Sixteen of these subjects had mild OSA (5–14.9 per hour; mean AHI per hour±standard deviation, 7.8±2.5; range, 5–12.1; 2 subjects had moderate OSA (AHI=16 and 28 per hr), and only 1 subject had severe OSA (AHI=47 per hr). Women with OSA were significantly older and of higher BMI than women without OSA (Table 1). There was no significant difference in chronic hypertension diagnosis or gestational age at enrollment between the 2 groups. 68% and 26% of our cohort self-identified as African American or white, respectively; the remaining women self-identified as either multiple races/ethnicities or Hispanic. There was no significant association between race/ethnic group and OSA status. Home sleep test results are described in Table 2.

Analysis of the performance of the previously defined OSA risk scores (BQ, ESS, STOP-BANG questionnaire, ASA checklist, and score by Facco et al) found that only the score by Facco et al was significantly associated with OSA status in our cohort (odds ratio, 1.06; 95%

confidence interval, 1.02–1.11; *P*=.001; Table 3). The other 3 risk indices were not associated significantly with OSA outcome, although STOP-BANG results approached statistical significance (*P*=.09). The binary risk stratification of the BQ, STOP-BANG questionnaire, ASA checklist, and Facco et al scores had very low specificity (range, 0.05–0.36). The ESS failed to identify any patients as high risk for OSA; the Facco et al score identified all patients as high risk.

In terms of agreement between the established OSA screening tools, the numeric risk scores of the BQ, Facco et al score and STOP-BANG were all correlated positively, but no pair had more than a weak correlation. Facco et al scores had Kendall τ values of 0.22 and 0.26 with BQ and STOP-BANG, respectively; the strongest correlation was between BQ and STOP-BANG, with a value of 0.31 (all *P*<.05). Although the ASA checklist had moderate positive correlation with BQ (τ=0.51; *P*<.01) and was correlated with STOP-BANG (τ=0.26; *P*=.01), there was no evidence of correlation between the ASA checklist and Facco et al. scores (τ=0.05; *P*=.59).

Of all the individual component items and physical examination findings on the OSA screening assessments that were administered, only a few were associated significantly with AHI ≥5 per hour (Supplementary Table). Neck circumference was greater in pregnant subjects with OSA compared with those with AHI <5 per hour (mean, 42.1±3.0 cm vs 40.6±2.7 cm; *P*=.05). Subjects who responded affirmatively to the question “Has anyone noticed that you stop breathing during your sleep?” and said that this occurs > 3–4 times per week were also more likely to have AHI ≥5 per hour (21% vs 3%; *P*=.026). A similar question in the STOP-BANG questionnaire that did not discriminate for frequency of witnessed apneas was endorsed by more subjects, but there were no significant differences between groups. On the ESS, 16% of OSA-positive subjects endorsed a moderate-to-high chance of dozing off while stopped in traffic while driving compared with none in the OSA-negative group (*P*=.012). Snoring and fatigue were common among both groups, regardless of OSA status.

We found no evidence of significant differences in maternal or neonatal outcomes between the 2 groups in our exploratory analysis (Table 4). There was a trend towards more adverse composite cardiovascular outcomes in the OSA-positive group when we combined cases of gestational hypertension, mild and severe preeclampsia, eclampsia, cardiomyopathy, and congestive heart failure (42 % vs 21%; *P*=.07). There was also a trend towards more adverse composite peripartum adverse outcomes in the OSA group (postpartum hemorrhage, maternal intensive care unit admission, and postoperative wound infections; 31.6% vs 14.8%; *P*=.10).

Comment

Principal findings

We found an OSA prevalence of 24% among pregnant women from 24–35 weeks gestation with extreme obesity, where OSA is defined as AHI ≥5 events per hour on a type III, unattended home sleep test. Of the patient factors and physical examination findings that were analyzed, age, BMI, neck circumference, frequently witnessed apneas, and likely to

fall asleep while driving were associated positively with AHI ≥5 per hour. However, frequently witnessed apneas and falling asleep while driving were specific, but not sensitive, for OSA status; relatively few women in the OSA group endorsed these signs. We found very poor performance of the previously defined OSA screening tools (BQ, STOP-BANG questionnaire, ASA checklist, and Facco et al score) and sleepiness scale (ESS) to predict OSA status in this cohort of obese pregnant women in mid pregnancy. Although the Facco et al OSA prediction score that was developed in pregnant women was significantly associated with OSA status, it had very low specificity with 100% of the subjects in our cohort who were identified as high risk.[2] There was no significant association between race or ethnicity and OSA status. Although there were trends towards more composite adverse cardiovascular and peripartum outcomes in the OSA-positive group, the study was underpowered to detect differences in maternal and neonatal outcomes by OSA status.

Meaning/clinical implications

Our finding of a 24% prevalence of OSA among pregnant women with extreme obesity was lower than we expected, but it was clinically significant, given the high prevalence of obesity among reproductive age women. Our prevalence may have been underestimated by limitations in the home sleep test device, which cannot detect wakefulness and may underestimate AHI. A recent large, multicenter study suggested a prevalence of OSA among pregnant women of 3–8%, depending on the trimester of pregnancy.[3] In this longitudinal cohort, prepregnancy BMI was an important predictor of OSA both early in pregnancy and in OSA that developed during pregnancy, as we demonstrated here.[16]

We found that the BQ, ESS, STOP-BANG questionnaire, and ASA checklist were poor discriminators of OSA status in a cohort of pregnant women with extreme obesity, which is consistent with the findings reported by other groups.[2,12,14,30] Screening tools that previously were validated in nonpregnant populations have not performed well in several studies of pregnant women. However, in our study, the STOP-BANG score approached statistical significance, and a larger study may have detected a significant difference. Facco et al used home sleep (Watch-PAT100 device; ••••) to study the reliability of BQ and ESS in a group of pregnant women considered at high risk for OSA (chronic hypertension and/or pregestational diabetes mellitus and/or BMI >30 kg/m^2 and/or a history of preeclampsia in a previous pregnancy) between 6–20 weeks gestation and found poor sensitivity and specificity with both questionnaires for AHI ≥5 per hour.[2] When they used a multivariable logistic regression analysis on individual components in the questionnaires, they found that prepregnancy BMI, age, chronic hypertension, and frequent snoring were independent risk factors for OSA in a group of pregnant women at high risk for OSA (area under the curve, 0.850; 95% confidence interval, 0.77–0.93; P<.001). However, the mean BMI in that study was 31.9 kg/m^2, whereas in our study the mean BMI was 47.3 kg/m^2. When we applied the Facco et al tool to this population, 100% of our subjects showed to be at high risk for OSA, whereas only 24% had AHI ≥5 per hour on home sleep testing. Although screening tools validated in other populations may not be useful in pregnant women, our study confirms that age, prepregnancy BMI, neck circumference, and frequently witnessed apneas are important risk factors for OSA in pregnancy, even in a cohort of women with a high BMI.

Other studies of pregnant women have also found age and BMI to be important risk factors, although our study was the first to examine these risk factors in a cohort of extremely obese women.[1,14] Louis et al[16] recently proposed a prediction model for OSA risk in pregnancy from the mothers-to-be cohort. They also found that age and prepregnancy BMI were important risk factors for OSA in both early and mid gestation but included women of all BMIs. In this cohort, frequent snoring (>3 times per week) was also considered predictive of OSA status. Age and BMI are considered important risk factors for OSA in nonpregnant populations, but the age and BMI cut-offs that are used in screening questionnaires are not appropriate to pregnant women. We found a high prevalence of frequent snoring among pregnant women, regardless of OSA status, with no significant differences between the 2 groups (57% vs 74%; P=.28). However, our ability to explore this variable may have been limited by our study size and the tendency of the home sleep apnea test to underestimate AHI. Therefore, some women who would have put into the OSA-positive group by more rigorous in-laboratory polysomnography may have been classified as OSA negative by the methods used in this study.

With the exception of neck circumference, we did not find any of the physical examination findings to be associated with OSA status in women with extreme obesity. Physical examination of the upper airway and neck are often used in clinical practice to identify patients at risk for difficult intubation and OSA. The MMS has been studied as an independent predictor of OSA diagnosed by polysomnography.[28] This has not been validated in pregnancy, but it has been shown that MMS changes as pregnancy progresses.[31] The modified MMS (obtained without a protruding tongue) has also been associated with sleep disordered breathing.[29] Neck circumference >41 cm (for women) is included in the STOP-BANG questionnaire.[19] Some studies have also assessed the predictive value of other physical examination findings for OSA, such as dental malocclusion or retroplacement of the mandible, thyro-mental space, tongue scalloping, lateral pharyngeal wall narrowing, and tonsil size in their evaluation of the upper airway.[27,32–34]

Recent studies have associated OSA in pregnancy with a number of adverse pregnancy outcomes: hypertensive disorders of pregnancy;, gestational diabetes mellitus, cardiomyopathy, congestive heart failure, pulmonary edema, and perinatal death.[3,8,11] These studies have increased interest in the identification of at-risk women during pregnancy, although future studies are needed to determine whether OSA treatment can mitigate these adverse pregnancy outcomes. In this study, although there were trends towards more composite adverse cardiovascular and peripartum outcomes in the OSA-positive group, the study was underpowered to detect differences in maternal and neonatal outcomes by OSA status.

Strengths and weaknesses

This study was the first study to examine OSA in pregnancy in a high-risk cohort of extremely obese women with the use of objective testing to determine OSA status. The study was also the first to evaluate the OSA in pregnancy risk tool proposed by Facco et al in a novel cohort and to evaluate the value of the physical examination findings (thyromental

distance, retrognathia, tongue scalloping, MMS, and modified MMS) to assess OSA risk in obese pregnant women.

This study has several limitations. Although we enriched our sample by enrolling only women with BMI ≥40 kg/m^2, the study was small and underpowered to study pregnancy outcomes. Because the observed rate of OSA was lower than expected, only large effect sizes and strong associations were detectable in this cohort. The power of our final analysis was affected negatively by the lower than expected rate of OSA in this patient population, which in and of itself is a novel and reportable result. The poor performance of the risk scores is evidenced not only by the lack of association, which may have been impacted by power, but also by the sensitivity and specificity metrics, which are more robust to sample size. Although our assessment of individual question association may be underpowered to detect effect sizes <2.5, our conclusions about the poor performance of the preexisting risk scores would likely not change given a larger study.

We were able to study women only once during pregnancy at 24–35 weeks gestation and thus cannot determine whether OSA in our cohort was present before pregnancy or whether it developed during pregnancy. Observational studies have shown that the prevalence of OSA increases with gestational age.[1,3]

In addition, we used home sleep apnea testing, not in-laboratory polysomnography, to classify OSA status. Although portable at-home, unattended sleep apnea testing is emerging as a reliable, convenient, and cost-effective method of screening for OSA, in-laboratory overnight polysomnography remains the gold standard for the diagnosis of OSA. Some home sleep test devices have been validated in a pregnant population.[2,4,35] The device used in this study, ApneaLink Air, has also been used as a diagnostic tool in other studies of pregnant women[12] and has been validated in other populations, which have included obese, nonpregnant women.[36] One limitation of this home sleep device was its acceptance by pregnant women; 26% of our subjects were excluded from the study because they applied the device incorrectly or for <2 hours. Home sleep apnea testing has limitations in its ability to diagnose OSA. The main limitation of this and other unattended, home sleep apnea assessment devices is that they cannot collect electroencephalography and electromyography results and thus cannot estimate actual sleep time. Therefore, they may overestimate sleep time and underestimate the AHI. Because we used a minimum threshold of AHI ≥5 per hour to define OSA positive, we believe that we captured most of the women with clinically significant OSA. However, this may have biased our results towards fewer women in the OSA group than would have been found with in-laboratory testing. Another limitation of this study was that we included all sleep studies of at least 2 hours. Longer sleep studies would have captured a more complete picture of the sleep cycle variations.

Conclusion with future research implications

In conclusion, we found that 24% of pregnant women with BMI ≥40 kg/m^2 between 24–35 weeks gestation have OSA. We did not find the BQ, ESS, STOP-BANG questionnaire, ASA checklist, or Facco et al score to be useful screening tools for OSA in a cohort of obese pregnant women. However, age, BMI, neck circumference, frequently witnessed apneas, and likely to fall asleep while driving were associated with OSA in this cohort. Further studies

are needed to validate novel screening tools that incorporate these important risk factors to better predict OSA in pregnant women with obesity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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AJOG at a Glance

Why was this study conducted?

This study was conducted to test established obstructive sleep apnea screening tools and their individual component items in a cohort of morbidly obese pregnant women with the use of objective testing to determine obstructive sleep apnea status and to describe the prevalence of obstructive sleep apnea among mid-pregnancy pregnant women with body mass index ≥40 kg/m^2 (extreme obesity).

Key Findings

The key findings of this study are that nearly one-quarter of pregnant women with extreme or class 3 obesity have obstructive sleep apnea on home sleep apnea testing in mid pregnancy and that previously defined obstructive sleep apnea screening tools (Berlin Questionnaire, STOP-BANG questionnaire, American Society of Anesthesiologists checklist, and Epworth Sleepiness Scale) perform very poorly to screen for obstructive sleep apnea in this cohort. The obstructive sleep apnea in pregnancy prediction score by Facco et al was significantly associated with obstructive sleep apnea status, but its risk stratification had very low specificity with 100% of the subjects in our cohort who were identified as high risk. Age, body mass index, neck circumference, frequently witnessed apneas, and likely to fall asleep while driving were associated most strongly with obstructive sleep apnea status.

What does this add to what is known?

This study is the first to show that, in a cohort of pregnant women with extreme (class 3) obesity, clinical risk factors that include age, body mass index, and neck circumference are important risk factors for obstructive sleep apnea and may require pregnancy-specific thresholds and that none of the established obstructive sleep apnea screening tools provide adequate or informative assessments of obstructive sleep apnea status in this cohort. It also showed that endorsement of frequently witnessed apneas and falling asleep while driving were associated with obstructive sleep apnea status.

TABLE 1

Subject characteristics at enrollment

Variable	No obstructive sleep apnea (Apnea-Hypopnea Index, <5/hr; n=61)	Obstructive sleep apnea (Apnea-Hypopnea Index, ≥5/hr; n=19)	*P* value
Age, y[a]	27 [26, 32]	33 [29, 35]	.01
Race, n[b]			.36
White	17±29.3	3±16.7	
African American	37±63.8	15±83.3	
Multiple	4±6.9	0	
Hispanic ethnicity, n[b]	2±3.5	0	>.99
Chronic hypertension, n (%)	19 (31.1)	7 (36.8)	.64
Prepregnancy body mass index, kg/m^2[a]	45.0 [41.0,51.0]	53.0 [45.0, 55.0]	.01
Body mass index at enrollment, kg/m^2[a]	46.6 [43.9, 50.7]	54.4 [44.2, 59.6]	.01
Gestational age, wk[a]	29.7 [27.6, 32.3]	30 [28.0, 33.1]	.65

[a]Data are given as median [Q1, Q3];

[b]Data are given as mean±standard deviation.

TABLE 2

Results of home sleep apnea testing

Sleep study characteristics	No obstructive sleep apnea (Apnea-Hypopnea Index, <5/hr; n=61)	Obstructive sleep apnea (Apnea-Hypopnea Index, ≥5/hr; n=19)	*P* value
Nasal air flow duration, hr[a]	4.6 [4.0, 5.4]	4.7 [4.0, 6.0]	.5415
Apnea-Hypopnea Index, events/hr[a]	1.3 [0.5, 2.8]	8.7 [6.1, 12.1]	<.0001
Oxygen desaturation index, events/hr[a]	2.9 [1.4, 5.2]	14.4 [9.2, 29.0]	<.0001
Average oxygen saturation, ••••[a]	95 [94, 96]	94 [93, 95]	.1284
Nadir oxygen saturation, ••••[a]	86 [82, 89]	80 [72, 82]	<.0001
Average heart rate, ••••[b]	86.0±9.0	88.5±9.9	.3117
Time spent with flow limited breathing with snoring, %[a]	0 [0, 7]	3 [0, 5]	.3459

[a]Data are given as median [Q1, Q3];

[b]Data are given as mean±standard deviation.

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TABLE 3

Performance of obstructive sleep apnea screening tools and sleepiness scale

Screening tool	Obstructive sleep apnea status		*P* value	Odds ratio (95% confidence interval)	Area under the receiver operating characteristic curve, ••••	High risk for obstructive sleep apnea by tool, ••••		
	No (n=61)	Yes(n=19)				High risk	Sensitivity	Specificity
Berlin Questionnaire[a]	2 [2, 3]	2 [2, 3]	.567	1.20 (0.59,2.43)	0.541 (0.394, 0.688)	64 (80.0)	0.79	0.20
STOP-BANG questionnaire[a]	3 [3, 4]	4 [2, 5]	.092	1.58 (1.00,2.49)	0.625 (0.466, 0.784)	34 (42.5)	0.63	0.36
Epworth Sleepiness Scale Epworth Sleepiness Scale[a]	3 [2, 5]	2 [2, 5]	.810	1.09 (0.85, 1.40)	0.519(0.356, 0.681)	0 (0.0)	0.00	1.00
American Society of Anesthesiologists American Society of Anesthesiologists checklist, n (%)	58 (95.1)	17 (89.5)	.588	0.44 (0.07, 2.85)	0.528 (0.452, 0.604)	75 (93.8)	0.23	0.05
Facco et al score[a]	87 [78, 93]	98 [88, 112]	.001	1.06 (1.02, 1.10)	0.752 (0.637, 0.868)	67 (83.8)	1.00	0.21

[a]Data are given as median [Q1, Q3].

TABLE 4

Maternal and neonatal outcomes by obstructive sleep apnea status

Outcomes	No obstructive sleep apnea status (Apnea-Hypopnea Index, <5/hr; n=61), n (%)	Obstructive sleep apnea (Apnea-Hypopnea Index, ≥5/hr; n=19), n (%)	*P* value
Uncomplicated pregnancy	27 (44.3)	5 (26.3)	.19[a]
Gestational diabetes mellitus	9 (14.8)	1 (5.3)	.4374[a]
Cesarean delivery	36 (59.0)	14 (73.7)	.2488[b]
Estimated blood loss, ••••	750 [350, 850][c]	750 [400, 800][c]	.5576[d]
Spontaneous labor	11 (18.0)	3 (15.8)	.8222[b]
Induction of labor	26 (42.6)	6 (31.6)	.3909[b]
Oxytocin during labor	26 (42.6)	5 (26.3)	.2026[b]
Adverse cardiovascular outcome[e]	13 (21.3)	8 (42.1)	.0720[b]
Gestational hypertension	7 (11.5)	2 (10.5)	NT
Preeclampsia, w/o severe features	0	1 (5.3)	NT
Preeclampsia, w/severe features	7 (11.5)	3 (15.8)	NT
Eclampsia	0	0	NT
Cardiomyopathy	0	0	NT
Congestive heart failure	0	2 (10.5)	NT
Adverse peripartum outcome[f]	9 (14.8)	6 (31.6)	.1009[b]
Postpartum hemorrhage	8 (13.1)	3 (15.8)	NT
Maternal intensive care unit admission	0	1 (5.3)	NT
Postoperative wound infection	2 (3.3)	2(10.5)	NT
Maternal death	0	0	1.0000[a]
Cerebrovascular accident	1(1.6)	0	1.0000[a]
Adverse neonatal outcome[g]	18 (29.5)	5 (26.3)	.7883[b]
Neonatal intensive care unit admission	9 (14.8)	2 (10.5)	NT
Fetal growth restriction	6 (9.8)	2 (10.5)	NT

Outcomes	No obstructive sleep apnea status (Apnea-Hypopnea Index, <5/hr; n=61), n (%)	Obstructive sleep apnea (Apnea-Hypopnea Index, ≥5/hr; n=19), n (%)	*P* value
Preterm delivery (< 37 wk)	13 (21.3)	3 (15.8)	NT
Fetal death	1 (1.6)	0	NT
Neonatal weight, g	3198 [2778, 3625][c]	3285 [2885, 3570][c]	.8544[d]

NT, not tested.

[a]Fisher Exact test;

[b]Chi-square test;

[c]Data are given as median [Q1, Q3];

[d]Wilcoxon test;

[e]Gestational hypertension, mild and severe preeclampsia, eclampsia, cardiomyopathy, and congestive heart failure;

[f]Postpartum hemorrhage, maternal intensive care unit admission, and postoperative wound infections;

[g]Neonatal intensive care unit admission, fetal growth restriction, preterm delivery (<37 weeks gestation), and fetal death.

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