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Pregnancy and fetal outcomes of symptoms of sleep-disordered breathing

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ABSTRACT: The physiological changes of pregnancy may predispose females to develop sleep-disordered breathing (SDB) or protect against it. Studies evaluating outcomes of SDB symptoms in pregnancy are scarce. The goal of this study was to evaluate the prevalence of SDB symptoms in pregnancy and their relationship with pregnancy and neonatal outcomes.

A cross-sectional survey of randomly selected immediate postpartum females was performed using the multivariable apnoea prediction index. Record review, including demographics and medical history, was performed. Main outcome measures included pregnancy and neonatal outcomes.

1,000 subjects were recruited. Mean±SD age was 29.1±6.1 yrs. Factors used in the regression analysis included age, body mass index, diabetes, chronic hypertension, multifetal gestations, smoking and renal disease. Snoring was present in 35.1% of subjects. Symptoms of SDB were associated with a higher likelihood of pregnancy-induced hypertension and pre-eclampsia (adjusted OR 2.3, 95% CI 1.4–4.0), gestational diabetes (adjusted OR 2.1, 95% CI 1.3–3.4) and unplanned Caesarean deliveries (adjusted OR 2.1, 95% CI 1.4–3.2) after multivariable regression analysis. Gasping may have been associated with a higher likelihood of preterm delivery, after adjusting for age and multifetal pregnancies (adjusted OR 1.8, 95% CI 1.1–3.2) but this association appeared to be mediated by pre-eclampsia.

Symptoms of SDB are common in pregnancy and associated with a higher likelihood of gestational hypertensive disorders, gestational diabetes and unplanned Caesarean deliveries.

KEYWORDS: Diabetes, fetal outcomes, gestational, hypertension, pregnant females, snoring

Sleep-disordered breathing (SDB) occurs in 9% of young–middle aged females [1] and 56% of older females [2]. Females report snoring less commonly than males and have significant differences in sleep latency, sleep architecture, prevalence of obesity, and predictive power of certain anthropometric features [3].

SDB is associated with adverse cardiovascular outcomes in females. Snoring has been associated with higher risk of elevated glycosylated haemoglobin in premenopausal females, [4] and obstructive sleep apnoea (OSA) is linked to decreased insulin sensitivity [5]. Associations with the metabolic syndrome have been described [6, 7], especially in females with severe OSA [7]. Despite the controversy in the development of new onset hypertension in patients with OSA in the Wisconsin Sleep Cohort Study [8] and the Sleep Heart Health Study [9], the association of OSA with hypertension was described in females [8, 10, 11]. In a recent study, the relative risk of hypertension in subjects with OSA was higher than controls (apnoea/hypopnoea index <15) and similar in males and females [11]. Another study reported that normotensive females snoring occasionally or regularly have a 29% and 55% increased risk of developing hypertension, respectively, compared with non-snorers [10].

Many physiological changes that predispose to the development of SDB occur in pregnancy [12]. Although studies have reported that snoring occurs in 14–45% of pregnant females [13–15], the incidence of SDB remains unknown. A few studies suggest a significant association between habitual snoring and gestational hypertensive disorders [16]. Others have assessed a potential association with neonatal outcomes [14, 17], with some showing growth restriction in snorers compared with non-snorers [14] and others failing to show a correlation [17]. Despite an association

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between SDB, glucose intolerance and insulin resistance outside pregnancy [18, 19], no studies have evaluated a link in pregnancy. In addition, there are no studies evaluating an association between SDB symptoms and mode of delivery, although a potential effect of total sleep duration on delivery mode has been described in some studies [20] but not in others [21].

The aim of this study was to determine the incidence of SDB symptoms in pregnancy in a large cohort of patients, and to assess potential associations between SDB symptoms and cardiovascular and obstetric maternal outcomes, as well as neonatal birth outcomes.

METHODS

Subjects and protocol

Female subjects

The study protocol was approved by the Institutional Review Board (Women and Infants Hospital of RI, Providence, RI, USA) and consent was obtained. Subjects were selected randomly from daily lists of all deliveries and recruited at a tertiary care obstetric hospital over 18 months. English-speaking patients $\geqslant$18 yrs old were surveyed 24–48 h postpartum, with or without a bed partner. Deliveries with fetal or neonatal demise were excluded.

The questionnaire elicited information regarding demographics, medical history, sleep-related symptoms, medications, and pregnancy-related conditions. Neck circumference was measured at the time of consent. Patients' records were reviewed to corroborate patient-reported outcomes and any discrepancies between sources were resolved by the principal investigator. Pre-eclampsia was classified based on the American College of Obstetricians and Gynecologists' definition [22]. The definition of gestational diabetes was based on CARPENTER and COUSTAN's criteria [23], and the American Diabetes Association [24]. Mode of delivery was vaginal, planned Caesarean delivery or unplanned Caesarean delivery.

SDB symptoms in the 3 months preceding delivery were assessed using index 1 of the Multivariable Apnoea Prediction Index (MAPI) [25]. Questions read as follows. In the last 3 months of your pregnancy, how often have you experienced (or were you told) about the following symptoms? 1) You snored loudly; 2)You snorted or gasped; 3)Your breathing stopped, you choked or you struggled for breath. Answers: 0) Never; 1) Rarely (less than once a week); 2) Sometimes (1–2 times a week); 3) Frequently (3–4 times a week); 4) Always (5–7 times a week).

MAPI was calculated using both pre-pregnancy body mass index (BMI) obtained at the time of the first prenatal visit and BMI at delivery and the two results were compared but not correlated with outcomes since this tool has not been validated in pregnancy.

2 weeks following delivery, patients were surveyed by telephone regarding interim complications.

Newborn subjects

Outcomes evaluated included weight for gestational age, and 1 and 5-min Apgar scores. Growth restriction was defined based on data by ALEXANDER *et al.* [26] on normal fetal growth based on gestational age. Low birth weight was defined as <2,500 g and growth restriction as <10th percentile for gestational age.

Statistical analysis

Data analysis was performed with SAS version 9.1 (SAS Institute, Cary, NC, USA). SDB symptom frequencies were categorised as never/rarely, sometimes, or frequently/always. Unsure or missing responses were excluded.

Categorical variables were compared by Fisher's exact test and continuous variables were compared between groups by ANOVA. Continuous variables were examined for deviations from normality and homoskedasticity prior to ANOVA. Two-tailed p-values were reported, with $p<0.05$ considered statistically significant.

Unconditional multivariable logistic regression was used to estimate adjusted OR (aOR) and 95% CI for the association of SDB symptom frequency and pregnancy outcomes. Factors used in the regression analysis included age, BMI, diabetes mellitus, chronic hypertension, multifetal gestations, renal disease, and cigarette smoking. Because pre-eclampsia- and pregnancy-induced hypertension were uncommon in the study cohort, they were analysed together as one outcome. Delivery method was examined by multinomial logistic regression with successful vaginal delivery as the referent. Preterm delivery (<37 weeks gestational age) and neonatal outcomes were examined by logistic regression. Robust variance estimates were obtained for neonatal outcomes to account for correlation within multiple births. For all models, continuous variables were entered as linear covariates, since testing of polynomial terms did not suggest nonlinearity. Model fit was checked by the Hosmer–Lemeshow test (logistic regression) or inspection of residuals.

RESULTS

1,000 females agreed to participate in the study with a rate of decline <3%. Patient demographics and clinical characteristics are detailed in table 1. Over 22% had a pre-pregnancy BMI $\geqslant$30. Bed partners were present at the time of interview for 36% of the patients and 78% of patients reported having a bed partner.

Symptoms of SDB

Loud snoring occurred frequently/always in 35% of subjects (table 2), and 37% reported at least one symptom. There was a trend toward statistical significance in snoring frequency ($p=0.05$) between the groups with and without a bed partner present in the room. However, the presence of the bed partner during the interview did not affect symptom frequency among patients with a bed partner. Greater symptom frequency was associated with neck circumference (fig. 1) and older age but not smoking. Snoring frequency was significantly correlated with pre-pregnancy BMI, delivery BMI, and pregnancy weight gain (fig. 1).

MAPI was calculated using both BMI values. As expected, the MAPI predicting $\geqslant$50% likelihood of SDB was lower using pre-pregnancy BMI. However, the sensitivity of frequently/always snoring, gasping and choking for MAPI $\geqslant$50% was higher using pre-pregnancy BMI. These findings suggest that pre-pregnancy obesity may be a more important risk factor than pregnancy weight gain.

TABLE 1 Demographics and clinical characteristics

Age yrs	29.1±6.1
Race/ethnicity n	984
White, non-Hispanic %	69
Black, non-Hispanic %	10
Hispanic %	16
Asian %	3
Other %	2
BMI	
Pre-pregnancy	26.1±6.2
At delivery	32.1±6.3
Weight gain lbs	34.7±16.2
Neck circumference cm	36±2.7
Cigarette smoking n	998
Nonsmoker %	76
Prior to pregnancy %	14
Current smoker %	9
Medical conditions	
DM, type I or II %	0.7
Gestational diabetes %	10
Pregnancy induced hypertension, current or prior pregnancy %	11
Pre-eclampsia, current or prior pregnancy	8
Multi-gestational pregnancy %	2.5
Delivery method n	1000
Vaginal %	53
Cesarean section %	33
Vaginal to Cesarean section %	14
Birth weight (total) g	3265±667
Singles	3312±635
Multiples	2345±611
Low birth weight (<2500 g) %	9.9
Small for gestational age (total) %	3.4
Singles %	2.9
Multiples %	12.5

Data are presented as mean±SD, unless otherwise stated. BMI: body mass index; DM: diabetes mellitus. Percentages may not sum to 100% due to rounding.

TABLE 2 Sleep-disordered breathing (SDB) symptom frequency and patient age[#]

SDB symptom	Subjects n (%)	Mean±SD	p-value
Snoring loudly			<0.0001
Never/rarely	483 (51)	28.2±6.0	
Sometimes	133 (14)	29.6±5.9	
Frequently/always	333 (35)	30.3±6.0	
Gasping/snorting			<0.0001
Never/rarely	777 (79)	28.6±6.1	
Sometimes	101 (10)	30.8±6.3	
Frequently/always	104 (11)	30.5±5.4	
Choking/stopped breathing			0.02
Never/rarely	891 (90)	29.0±6.1	
Sometimes	55 (6)	28.6±5.7	
Frequently/always	48 (5)	31.4±6.8	

Percentages may not sum to 100% due to rounding. ''Unsure'' responses for snoring (n=51), gasping (n=18), and choking (n=6) were omitted. [#]: n=1,000.

Symptoms of SDB and pregnancy outcomes

Snoring significantly correlated with current pregnancy-induced hypertension and pre-eclampsia. The association remained significant even after adjusting for multiple factors (table 3).

Snoring and gasping were associated with gestational diabetes and this association remained significant in a multivariable regression analysis (table 3). When all three symptoms were combined, the association with gestational diabetes was stronger (OR 6.1, 95% CI 2.3–16.2) even when adjusted for the other factors (aOR 4.0, 95% 1.4–11.1).

Delivery outcomes

Delivery rates are detailed in table 1. Although the rate of Caesarean sections was higher than that of the general population, the association between SDB symptoms and pregnancy-related conditions in the Caesarean section group were otherwise similar to the vaginal delivery group. There was a significantly higher prevalence of Caesarean sections in patients with loud snoring and gasping even after adjusting for multifetal gestations, smoking and fetal weight (table 4). However, when the statistical model was further adjusted for pre-eclampsia, pregnancy-induced hypertension, gestational diabetes, and BMI at delivery, only the association with unplanned Caesarean sections remained significant for both snoring (aOR 1.7, 95% CI 1.1–2.6) and gasping (aOR 3.6, 95% CI 2.0–6.4).

Mean gestational age at birth was 38.6±2.4 weeks, and 12% of births were preterm (delivery before 37 weeks gestational age). Gasping was associated with a significantly higher likelihood of preterm delivery, even after adjusting for age, smoking and multifetal pregnancies (aOR 1.9, 95% CI 1.1–3.3).

Fetal outcomes

When birth weight for gestational age was assessed, there was a trend towards an association between snoring and growth restriction (OR 1.9, 95% CI 0.8–4.3) but the outcomes were too few for a multivariable logistic regression analysis. Gasping was significantly associated with Apgar scores at 1 min (fig. 2) even after adjusting for multifetal pregnancy, smoking and maternal age (aOR 1.9, 95% CI 1.0–3.4), but not after adjusting for pre-eclampsia. However, >98% of 5-min Apgar scores were ⩾7. For that reason, although 5-min scores appear significant (aOR 3.7, 95% CI 1.1–11.9), this may be due to bias and small numbers.

Follow-up questionnaire

A total of 227 patients were not available for follow-up. When compared to patients who were available, those lost to follow-up were 2 yrs older and more likely to be Hispanic, but otherwise showed no difference in outcomes studied. Of those 227, 16 (7%) had returned to the emergency room within 2 weeks of delivery, most commonly for hypertension. Since this record review would not identify all patients with postpartum hypertension, this group was excluded from further follow-up analysis.

Of the 773 patients who completed follow-up, 5.4% had delivery complications and 6.2% returned to the hospital. These

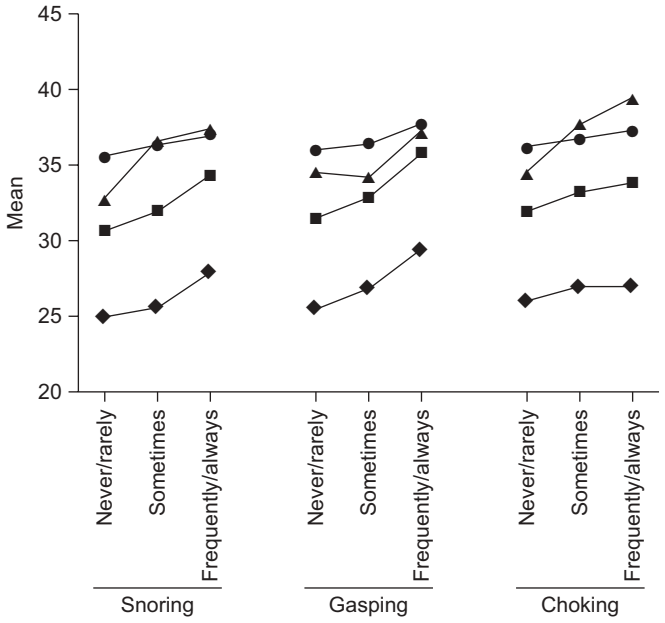

FIGURE 1. Frequency of sleep-disordered breathing symptoms and mean neck circumference, weight gain, and body mass index (BMI). ●: neck circumference cm; ▲: weight gain lbs; ■: BMI at delivery; ◆: BMI pre-pregnancy. $p<0.05$ for all comparisons except for choking and BMI pre-pregnancy ($p=0.3$) and at delivery ($p=0.05$) and gasping and weight gain ($p=0.3$).

complications were significantly associated with gasping (OR 3.0, 95% CI 1.4–6.7, and 2.4, 95% CI 1.3–4.6, respectively) and choking (OR 4.0, 95% CI 1.4–11.1, and 3.7, 95% CI 1.6–8.3, respectively). Hypertension or pre-eclampsia were the most common postpartum conditions reported (13.1%). After excluding patients with all types of antenatal hypertension, there was a significant association between SDB symptoms and the development of postpartum hypertension in the 2 weeks following delivery (OR 2.6, 95% CI 1.2–5.5, for snoring).

DISCUSSION

Symptoms of SDB were common in our randomly selected cross-sectional evaluation of immediate postpartum pregnant females. Our results are consistent with other studies showing a prevalence of snoring in 14–45% of pregnant females [14, 15, 27]. Although having a bed partner was thought to result in more frequent reporting of SDB symptoms among pregnant females, our study did not substantiate this theory. Snoring is a good predictor of SDB in nonpregnant patients; however, the predictive power of this and other symptoms in pregnancy is not well established and may be lower. In a small study by SAHIN *et al.* [28], only four out of 35 (11.4%) pregnant females suspected of having OSA based on the Berlin questionnaire were found to have OSA on polysomnography, suggesting a suboptimal positive predictive value of the questionnaire in this patient population. Snoring could be indicative of flow limitation, for instance, which would not meet criteria for apnoea or hypopnoea. A recent study has found a significantly elevated apnoea/hypopnoea index, with hypopnoeas defined as a flow limitation without desaturation in females with gestational hypertension; however, the study did not evaluate the association of these findings with symptoms of SDB [29]. Evidence evaluating the association of symptoms of SDB with polysomnographic evidence of SDB in pregnancy is lacking. Therefore, the higher prevalence of symptoms in pregnancy does not necessarily portend a higher incidence of SDB.

TABLE 3 Association of sleep-disordered breathing symptoms with pregnancy-induced hypertension, pre-eclampsia and gestational diabetes[#] in current pregnancy

Symptom	Total	Hypertension and/or pre-eclampsia			Gestational diabetes		
		n (%)	OR (95% CI)		n (%)	OR (95% CI)	
			Unadjusted	Adjusted[¶]		Unadjusted	Adjusted[+]
Snoring loudly							
Never/rarely	480	25 (5)	1.0 Ref.	1.0 Ref.	31 (6)	1.0 Ref.	1.0 Ref.
Sometimes	133	14 (11)	2.1 (1.1–4.3)	1.7 (0.8–3.5)	11 (8)	1.3 (0.6–2.7)	1.2 (0.6–2.4)
Frequently/always	331	59 (18)	4.0 (2.4–6.5)	2.3 (1.4–4.0)	52 (16)	2.7 (1.7–4.3)	2.1 (1.3–3.4)
Gasping/snorting							
Never/rarely	775	61 (8)	1.0 Ref.	1.0 Ref.	60 (8)	1.0 Ref.	1.0 Ref.
Sometimes	101	17 (17)	2.4 (1.3–4.2)	1.9 (1.0–3.6)	16 (16)	2.2 (1.2–4.1)	1.8 (0.9–3.3)
Frequently/always	102	23 (23)	3.4 (2.0–5.8)	2.1 (1.1–3.9)	22 (22)	3.3 (1.9–5.6)	2.4 (1.4–4.3)
Choking/stopped breathing							
Never/rarely	887	86 (10)	1.0 Ref.	1.0 Ref.	81 (9)	1.0 Ref.	1.0 Ref.
Sometimes	55	9 (16)	1.8 (0.9–3.9)	1.6 (0.7–3.6)	6 (11)	1.2 (0.5–2.9)	1.2 (0.5–3.0)
Frequently/always	48	6 (13)	1.3 (0.6–3.2)	0.9 (0.3–2.4)	10 (21)	2.6 (1.3–5.5)	2.0 (0.9–4.3)

[#]: analysis was restricted to 996 patients with complete data on outcomes, covariates, and at least one symptom; [¶]: the model for each symptom included history of diabetes mellitus, chronic hypertension, renal disease, and pre-eclampsia; age, body mass index at delivery, current smoking, and multifetal pregnancy; [+]: the model for each symptom included age, body mass index at delivery, current smoking and multifetal pregnancy.

TABLE 4 Association of sleep-disordered breathing symptoms with method of delivery

Symptom	Total	Planned Caesarean delivery *versus* vaginal[#]			Unplanned Caesarian delivery *versus* vaginal[#]		
		n (%)	OR (95% CI)		n (%)	OR (95% CI)	
			Unadjusted	Adjusted[¶]		Unadjusted	Adjusted[¶]
Snoring loudly							
Never/rarely	481	150 (31)	1.0 Ref.	1.0 Ref.	52 (11)	1.0 Ref.	1.0 Ref.
Sometimes	133	43 (32)	1.2 (0.8–1.9)	1.3 (0.8–1.9)	24 (18)	1.9 (1.1–3.4)	2.0 (1.1–3.5)
Frequently/always	331	117 (35)	1.4 (1.0–1.9)	1.4 (1.0–1.9)	60 (18)	2.1 (1.4–3.2)	2.1 (1.4–3.2)
Gasping/snorting							
Never/rarely	774	240 (31)	1.0 Ref.	1.0 Ref.	96 (12)	1.0 Ref.	1.0 Ref.
Sometimes	100	42 (42)	2.4 (1.5–3.9)	2.4 (1.5–4.0)	26 (26)	3.7 (2.1–6.5)	3.8 (2.2–6.7)
Frequently/always	103	44 (43)	1.9 (1.2–2.9)	1.9 (1.2–3.0)	16 (16)	1.7 (0.9–3.1)	1.7 (0.9–3.2)
Choking/stopped breathing							
Never/rarely	886	285 (32)	1.0 Ref.	1.0 Ref.	120 (14)	1.0 Ref.	1.0 Ref.
Sometimes	55	23 (42)	1.7 (0.9–3.1)	1.8 (1.0–3.3)	9 (16)	1.6 (0.7–3.5)	1.7 (0.7–3.7)
Frequently/always	48	19 (40)	1.6 (0.8–3.1)	1.6 (0.8–3.1)	9 (19)	1.8 (0.8–4.1)	1.8 (0.8–4.2)

[#]: three patients with Caesarean deliveries by maternal request were excluded. The OR compares each delivery method to vaginal delivery by multinomial logistic regression. [¶]: the model for each sleep-disordered breathing symptom included multifetal pregnancy (yes/no), current smoking, and fetal weight as estimated by birth weight (<2,500 g, 2,500–3,999 g, ⩾4,000 g). Weights were summed for multifetal pregnancies.

In our sample population, about 22% of subjects met criteria for obesity (BMI >30), a lower prevalence than the National Health and Nutrition Examination Survey [30] for adult females, suggesting that our population may be less overweight than the general population, potentially underestimating the incidence of SDB symptoms.

SDB symptoms and gestational hypertensive disorders

Our study shows a significant correlation between SDB symptoms and gestational hypertensive disorders, even after correcting for major risk factors, and is consistent with prior reports [13, 14, 16, 31]. The association in this study could have been negatively affected by our definition of pre-eclampsia [22], which was more conservative than the one recently outlined by the Canadian Society of Obstetrics and Gynecology [32]; regardless, the association remained significant.

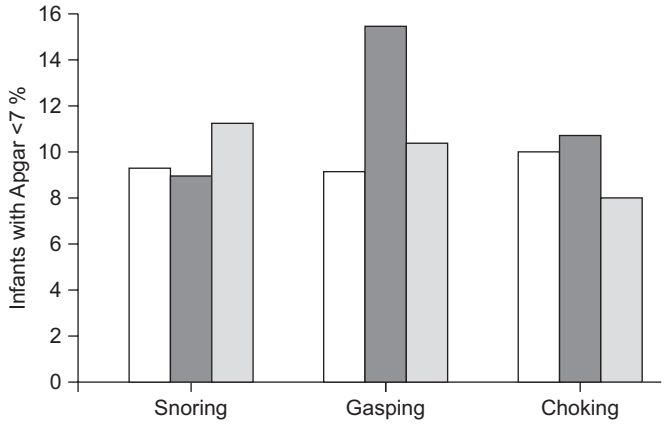

FIGURE 2. Sleep-disordered breathing symptoms and 1-min Apgar scores. □: never/rarely; ■: sometimes; ■: frequently/always. Gasping sometimes *versus* never or rarely was associated with Apgar 1-min <7 (15.4% *versus* 9.1%; p=0.04). All other comparisons were nonsignificant.

The underlying mechanism for the association of SDB with pregnancy-induced hypertension and pre-eclampsia has not been elucidated. Hypoxaemia may be a potential contributor. Data from chronically hypoxic high-altitude residents strongly suggest higher rates of pre-eclampsia and fetal growth restriction compared to low-altitude residents [33, 34]. Data on intermittent hypoxia and pregnancy outcomes are scarce, but intermittent hypoxia may lead to endothelial dysfunction, which is present in patients with OSA in all severity categories [35, 36]. Endothelial dysfunction and angiogenic–antiangiogenic disequilibrium have been implicated as a possible underlying mechanism in pre-eclampsia. A recent study has tied both disorders with endothelial dysfunction and showed a significant association between pre-eclampsia, OSA and endothelial dysfunction in pregnant women [37]. These data suggest intermittent hypoxia in OSA as a potential link leading to placental hypoxaemia, triggering a cascade of events resulting in pre-eclampsia.

It is also possible that flow limitations play a mechanistic role in the development of gestational hypertensive disorders. Frequent, prolonged flow limitations without desaturations have been identified in patients with pre-eclampsia [38] or with risk factors for pre-eclampsia [39]. Treatment of patients with risk factors for pre-eclampsia and flow limitations (without SDB) with continuous positive airway pressure (CPAP) throughout pregnancy has favourable effects on blood pressure [39, 40] and fetal outcomes compared to controls [40]. Although these findings indirectly suggest that flow limitation may have a causative role in blood pressure control in pregnancy, the numbers are quite small, hence the need for larger studies. Moreover, nocturnal CPAP treatment for one

night increases cardiac output [41] and improves blood pressure control [42] in patients with pre-eclampsia, suggesting several potential beneficial effects. Therefore, it is possible that even in the absence of hypoxia and re-oxygenation, haemodynamic changes associated with flow limitations may be implicated in the pathogenesis of pre-eclampsia in patients with SDB symptoms but without SDB.

Another possibility is that pre-eclampsia predisposes to the development of SDB. Patients with pre-eclampsia have lower oncotic pressures than normal pregnant females, a larger neck circumference and a smaller upper airway [43]. Additional studies are needed to evaluate this theory further.

Gestational diabetes

Our study is the first to examine the association of gestational diabetes and obstetric outcomes with symptoms of SDB. There was a significant association between SDB symptoms and gestational diabetes even after controlling for BMI at delivery, suggesting a potentially different mechanism than obesity-related insulin resistance. The association with gestational diabetes was even stronger when all three symptoms were combined, suggesting that gestational diabetes is more likely in patients with a higher likelihood of SDB, rather than in those with an isolated symptom. Although no prior studies have suggested this association in pregnancy, data from the non-pregnant population suggest an association between SDB, insulin resistance and glucose intolerance [18, 19, 44, 45]. The mechanism behind this association in pregnancy that is independent of BMI needs to be elucidated further.

Mode of delivery

Our study has also shown that unplanned Caesarean deliveries were more likely to occur in snorers compared to non-snorers, even after adjusting for potential confounders, suggesting that snoring may be an independent predictor of unplanned Caesarean sections. Although existing data suggest that obesity is associated with higher rates of Caesarean sections [46], the mechanism in our study seemed to be independent of BMI. A possible hypothesis to explain this association may be that anthropometric measures associated with failed vaginal deliveries may also be associated with SDB.

The effects of sleep duration on labour and delivery outcomes have been inconsistent [20, 21]. While the study of EVANS *et al.* [20] showed no effect of sleep duration on delivery outcomes, studies using actigraphy showed that females with sleep deprivation at term had significantly longer labour and more Caesarean deliveries [21]. The link between sleep characteristics and the mode of delivery is not clear, but the association of symptoms of SDB with a higher BMI, gestational hypertensive disorders and gestational diabetes may in part explain higher rates of Caesarean sections. Another possibility would be whether sleep fragmentation is associated with adverse outcomes irrespective of SDB. Polysomnography may help elucidate the potential role of hypoxaemia and/or arousal indices.

Neonatal outcomes

A small number of studies have evaluated the association between SDB symptoms and fetal outcomes [14, 17, 29, 47] and are somewhat conflicting [14, 17] with some lacking a control arm [29]. A large study has shown an association between snoring and fetal growth restriction [14]. However, that study did not report comorbidities or adjust for confounders such as diabetes, hypertension and gestational hypertensive disorders. Our study did not show a significant association with growth restriction and is consistent with other studies [13, 17, 29, 48]. A limitation of most existing studies, including this study, relates to the lack of confirmation of gestational age by early gestation ultrasound in some subjects and the lack of longitudinal fetal growth data, leading to the possibility of missing a true effect. Future studies should take this factor into account. Our findings suggest that SDB symptoms may be associated with low 1-min Apgar scores, consistent with other studies [14], but not 5-min scores. However, 5-min scores are more predictive of future outcomes. Preterm birth seems to be associated with SDB symptoms; however, this association appears to be mediated by pre-eclampsia.

Limitations of the study

Our study is limited by the lack of a validated questionnaire for use in screening the pregnant population for SDB, and by a and lack of polysomnographic data. However, findings from our study suggest that, irrespective of the presence of SDB, the symptoms evaluated were common and did correlate with adverse outcomes. Future studies are needed that consider correlation of outcomes with polysomnography findings and validation of screening tools in this population.

Conclusions

In summary, our findings show that symptoms of SDB in pregnant females are associated with adverse pregnancy, delivery and fetal outcomes. Further studies are warranted to evaluate the mechanisms by which SDB causes these adverse outcomes, and to evaluate whether screening and treatment of SDB during pregnancy might improve outcomes.

SUPPORT STATEMENT

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STATEMENT OF INTEREST

None declared.

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