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Original Article

Airflow limitations in pregnant women suspected of sleep-disordered breathing

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ABSTRACT

Background and aim: Pregnancy physiology may predispose women to the development of airflow limitations during sleep. The goal of this study was to evaluate whether pregnant women suspected of sleep-disordered breathing (SDB) are more likely to have airflow limitations compared to non-pregnant controls.

Methods: We recruited pregnant women referred for polysomnography for a diagnosis of SDB. Non-pregnant female controls matched for age, body mass index (BMI), and apnoea–hypopnoea index (AHI) were identified from a database. We examined airflow tracings for changes in amplitude and shape. We classified airflow limitation by (a) amplitude criteria defined as decreased airflow of $\geqslant$10 s without desaturation or arousal (FL 10), or decreased airflow of any duration combined with either 1–2% desaturation or arousal, (FL 1–2%); and (b) shape criteria defined as the presence of flattening or oscillations of the inspiratory flow curve.

Results: We identified 25 case-control pairs. Mean BMI was 44.0 ± 6.9 in cases and 44.1 ± 7.3 in controls. Using shape criteria, pregnant women had significantly more flow-limited breaths throughout total sleep time (32.4 ± 35.8 vs. 9.4 ± 17.9, $p < 0.0001$) and in each stage of sleep ($p < 0.0001$) than non-pregnant controls. In a subgroup analysis, pregnant women without a diagnosis of obstructive sleep apnoea (OSA) who had an AHI <5 had similar findings ($p < 0.0001$). There was no difference in airflow limitation by amplitude criteria between pregnant women and controls ($p = 0.22$).

Conclusions: Pregnant women suspected of OSA have more frequent shape-defined airflow limitations than non-pregnant controls, even when they do not meet polysomnographic OSA criteria.

1. Introduction

Changes in respiratory function during pregnancy can predispose gravid women to sleep-disordered breathing (SDB). Upper airway changes that amplify the risk of obstructive respiratory events include decreased nasal patency and increases in Mallampati score [1] and nasal congestion [2]. Other physiologic changes such as reduction in functional residual capacity also play a role by affecting airway collapsibility [3].

Snoring and obstructive sleep apnoea (OSA) have been associated with various adverse pregnancy outcomes [4]. Most studied is the association of snoring with gestational hypertensive disorders (GHDs) [5–7], a group of disorders characterised by hypertension with or without proteinuria. Women with GHD have more obstructive respiratory events during sleep than normotensive controls [8,9], and women with pre-eclampsia show a high prevalence of inspiratory airflow limitations [10,11]. As oxygen desaturations do not appear to be a prominent component of OSA in pregnancy [8,9], we speculated that gravidas suspected of OSA, including those who do not meet polysomnographic criteria for the disorder, may also have airflow abnormalities that do not meet criteria for apnoeas or hypopnoeas. Given the associations of SDB with adverse outcomes, the identification of subtle airflow

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limitations may prove to have a role in predicting adverse outcomes and may be important to recognise outside of clinically manifest pre-eclampsia.

In order to investigate the questions above, we conducted a case–control study in pregnant women suspected of SDB and matched non-pregnant controls. Our goal was to examine the prevalence of airflow limitations in pregnant women and controls and evaluate the presence of airflow limitations in a subgroup of pregnant women suspected but not diagnosed with OSA.

2. Methods

2.1. Participants

This study received approval from the Institutional Review Boards (IRBs) of both Rhode Island Hospital and Women and Infants Hospital of Rhode Island. Pregnant patients with signs and symptoms of SDB referred for in-laboratory polysomnography were recruited from an outpatient practice specialising in medical care of pregnancy and signed an informed consent. Patients on supplemental oxygen and those with a learning disability/mental retardation were excluded. Records were reviewed for adverse pregnancy outcomes. GHD was defined as elevated blood pressure on at least two recordings diagnosed after 20 weeks of gestation, with or without proteinuria. Patients with and without GHD were compared for respiratory parameters during sleep (see below).

Non-pregnant controls were identified retrospectively by reviewing databases at the sleep disorders centre. Controls were referred for polysomnography for suspicion of OSA and matched for gender, age, body mass index (BMI) and apnoea–hypopnoea index (AHI) categories of <5, 5–15, 16–30 and >30.

2.2. Polysomnography

Polysomnography data included electroencephalography, electro-oculograms from bilateral canthi, submental electromyogram, bilateral tibial electromyogram, electrocardiographic monitoring, pulse oximetry, body position, and snoring, piezoelectric strain sensors to measure chest/abdominal movement for earlier studies and inductance plethysmography for later studies according to laboratory protocol. An oronasal thermal sensor (SleepSense Nasal/Oral Thermocouple sensor, S.L.P. Inc., Elgin, IL, USA) was inserted under the nares with an oral piece adjusted over the mouth, and used to detect absence of airflow. A nasal air pressure transducer (Pro-Tech pressure Transducer Airflow – PTAF 2 or Pro-tech PTAF Lite-Respironics, Andover, MA, USA) and a DC channel was used to score hypopnoea according to American Academy of Sleep Medicine (AASM) recommendations. Low-frequency filter for nasal airflow was standardised at 0.1 Hz and high-frequency filter at 15 Hz, with a sampling rate of 100 Hz. The SomnoStar Pro (Viasys Inc., Yorba Linda, CA, USA) and XLTEC (Natus, Inc., San Carlos, CA, USA) data acquisition systems were used to record data. Patients were encouraged to sleep in the supine position and were awakened in the morning by technicians in accordance with the protocol. AHI is defined as the number of apnoeas and hypopnoeas per hour of sleep. Respiratory disturbance index (RDI) is defined as the number of apnoeas, hypopnoeas and respiratory effort-related arousals per hour of sleep.

2.3. Analysis of ventilation

Raw data were scored according to standard AASM criteria 2007 [12] by a single registered polysomnography technician who was blinded to the pregnancy status (RM). The 'Recommended' definition of hypopnoea according to the 'AASM Manual for Scoring of Sleep and Associated Events' was used [12]. Respiratory tracings were also scored for 'non-conventional' flow limitations in all subjects using two methods. The first method defined airflow limitation by reduction in amplitude as follows: (1) decreased airflow of at least 10 s, as described in previous studies [13], without desaturation or arousal (FL 10), or (2) decreased airflow for any duration but with either 1–2% oxygen desaturation or arousal (FL 1–2%) (Figs. 1A and 1B). Flow limitation index (FLI) was defined as the total number of flow limitations/total sleep time in hours. Flow limitations were scored independently by two of the co-authors (RM and GB) and assessed for inter-reader agreement.

The second method carefully assessed the shape of nasal airflow by visual analysis. A total of 10 random samples of 30-s epochs for each sleep stage (N1, N2, N3 and rapid eye movement (REM)) in each patient were selected and the percent of flow-limited breaths (number of flow-limited breaths/total number of breaths) in each epoch recorded. This method has been reported in a study assessing airflow limitation in pregnant women with pre-eclampsia [11]. Flow limitation shapes have been previously described [14,15] and an inspiratory curve was labelled as flow limited if it resembled one of these predefined shapes. Epochs with poor signal due to nasal prongs being partially or completely dislodged from the nose were discarded. Epochs in which the patient was clearly mouth breathing, evidenced by a prolonged large reduction in nasal tidal volume [VT] without a reduction in SaO_2, and no obvious signs of partial flow limitation such as oscillations or flattening in the nasal flow signal were also discarded. Epochs scored for either an arousal or an obstructive event such as apnoea, hypopnoea, or respiratory effort-related arousal were also excluded. Only polysomnograms performed on the SomnoStar Pro data acquisition systems were reviewed with this method. When one of the two subjects in the case/control pair was studied using the XLTEC data acquisition system, both subjects were then excluded.

2.4. Statistical analysis

Standard statistical analysis was performed using Microsoft Excel 2007 and STATA 10. Data are reported as means with standard deviation. Paired *t*-test was used for comparison of cases and controls. Mann–Whitney test was used in subgroup analyses. Kappa coefficient was calculated for concordance in scoring airflow limitation. Repeated measures analysis of variance (ANOVA) were used to adjust for body position.

3. Results

3.1. Patient characteristics

We recruited 25 matched case–control pairs. Mean age was 31.1 ± 5.8 in cases compared to 31.4 ± 5.8 in controls ($p = 0.64$). Mean BMI was 44.1 ± 6.9 in cases compared to 44.0 ± 7.3 in controls, $p = 0.94$. Mean gestational age at the time of polysomnography was 26.6 ± 7.6 in the pregnant group. Mean neck circumference in pregnant patients was 40.2 ± 3.4 cm but unavailable in controls. In the pregnant group, GHD and gestational diabetes were present in 24% and 44%, respectively, and all patients were obese with at least one risk factor for pre-eclampsia.

3.2. Polysomnography

Sleep measures are shown in Table 1. During the study night, there was a tendency towards less time in bed in pregnant women compared to controls. Pregnant women had significantly shorter total sleep time ($p = 0.03$) and non-rapid eye movement sleep