Fetal heart rate monitoring during nocturnal polysomnography

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Summary

Study Objectives: To evaluate the success rate of adding continuous electronic fetal heart rate monitoring (EFM) during full night polysomnography (PSG), in women with both gestational hypertension (GH) with uncomplicated singleton pregnancies. *Method:* As part of a larger study evaluating for the presence of sleep disordered breathing (SDB) in women with GH compared to women with uncomplicated pregnancies, continuous EFM was added to usual polysomnography. *Results:* Forty-eight EFM studies (26 with GH and 22 with uncomplicated pregnancies) were evaluated. EFM studies were categorized by the percentage of time that interpretable tracings were obtained: < 25% of the time; 25-50% of the time; or > 50% of the time. We deemed > 50% of the time to be ideal, but under the test conditions 25-50% of the time to be acceptable. For women with GH, 71% of women had ideal or acceptable overnight EFM tracings compared to 82% for women with uncomplicated pregnancies. Of those women who were diagnosed with SDB, 77% had an acceptable or ideal EFM tracing. *Conclusions:* Adding EFM to conventional polysomnography is feasible and safe. It may prove an important adjunct as interest in sleep disorders of pregnancy continues to expand.

Key words: Electronic fetal heart monitoring; Polysomnography; Gestational hypertension; Sleep disordered breathing.

Introduction

Sleep disordered breathing (SDB) is a recognized cause of hypertension in non-pregnant adults [1, 2]. Furthermore, recent evidence suggests that SDB may be a contributing factor in gestational hypertension (GH) [3-7] and may result in nocturnal fetal distress [8] as well as fetal growth restriction [9]. Polysomnography (PSG) is the gold standard for assessing SDB, particularly when there are a number of mitigating factors contributing to poor quality sleep and fatigue, as is the case in pregnancy. Continuous electronic fetal monitoring (EFM) is the cornerstone of obstetrical evaluation for fetal distress. It seems plausible that the addition of EFM to conventional PSG could provide useful information. However, only recently has this area of investigation been explored [10, 11]. Leech did report a high success rate in obtaining continuous EFM during full-night PSG in a small group of healthy volunteers. However, PSG testing and EFM would be expected to be most useful in patient groups that are associated with obesity (SDB and GH). The success of EFM in studies involving these types of patients might not be as high as in healthy volunteers and this needs further evaluation. We report our experience with continuous EFM of late trimester pregnant women with uncomplicated pregnancies as well as those with GH.

Materials and Methods

This study was approved by the Institutional Review Board of the University of Saskatchewan and received operational approval from the Saskatoon Health Region (Clinical Trials Registry #NCT00259688). Subjects were recruited to participate in a study assessing for SDB in women with GH compared to women with uncomplicated pregnancies. GH subjects were recruited from the fetal assessment and antepartum units at Royal University Hospital between February 2006 and February 2008. Healthy women with uncomplicated pregnancies were recruited through local advertising during the same time period.

Full night PSG was performed at a single university-based sleep laboratory. Standard monitoring was performed and included limited electroencephalogram; electrooculogram; submental electromyogram; pulse oximetry; nasal pressure and oronasal thermister sensors, chest excursion; snore sensor; intercostal diaphragmatic and anterior tibialis electromyogram and electrocardiogram. The usual abdominal excursion belt was eliminated, so as not to interfere with positioning of the EFM probe. Signals were recorded digitally using the Sandman 8.0 diagnostic program (Mallinckrodt Inc., Ottawa, Canada.). Sleep scoring was performed according to the new American Academy of Sleep Medicine Manual [12] recommendations. SDB was defined as a respiratory disturbance index (RDI) of ≥ 5 events per hour - that is ≥ 5 episodes per hour of upper airway obstruction, each lasting ≥ 10 sec and associated with either a drop in oxygenation by ≥ 3% or evidence of arousal on electroencephalogram..

Continuous fetal monitoring was performed using a Doppler signal (Hewlett Packard 8041A fetal monitor, Boeblingen, Germany) The tocometry probe for monitoring uterine contractility was not applied as our subjects were not in labor. Sleep technicians were given educational sessions about monitoring and interpreting EFM patterns prior to initiating this research project. Furthermore, electronic EFM was always initiated by a registered nurse trained in obstetrics. The nurse remained the entire night to monitor and adjust the EFM for women with GH. For women with uncomplicated pregnancies, the sleep technician maintained the EFM for the remainder of the night. After completion of the sleep study, a 10-minute EFM recording was taken while the mother was awake, to ensure a reassuring tracing. This 10-minute recording was not included in our assessment of EFM quality during PSG. Technicians and nurses were instructed to only adjust the EFM probe while the patient was awake, and not to disturb the mothers while sleeping even if the signal was lost.

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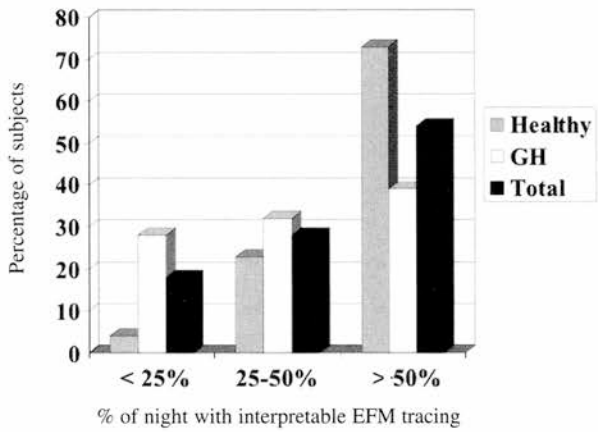

Figure 1. — EFM success according to GH diagnosis.

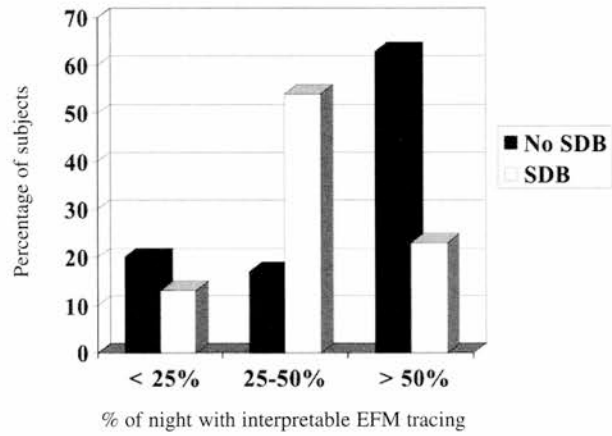

Figure 2. — EFM success according to SDB diagnosis.

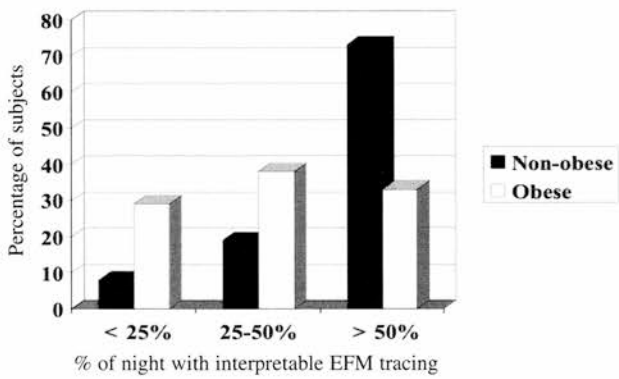

Figure 3. — EFM success: obese vs non-obese.

Figure 1. — Success rate of obtaining interpretable EFM signals during nocturnal polysomnography, grouped into three categories: < 25% of the night; 25-50% of the night; and > 50% of the night and stratified according to diagnosis of GH. Healthy = healthy control subjects; GH = subjects with gestational hypertension; Total = all subjects combined.

Figure 2. — Success rate of obtaining interpretable EFM signals during nocturnal polysomnography, grouped into three categories: < 25% of the night; 25-50% of the night; and > 50% of the night and stratified according the presence or absence of sleep disordered breathing (SDB).

Figure 3. — Success rate of obtaining interpretable EFM signals during nocturnal polysomnography, grouped into three categories: < 25% of the night; 25-50% of the night; and > 50% of the night and stratified by body mass index (BMI). Obese = pre-pregnancy BMI ≥ 30; Non-obese = pre-pregnancy BMI < 30.

All EFM tracings were reviewed for total recording time and total time with interpretable tracing. Tracings were further interpreted by a single obstetrician, who was blinded to all clinical information, to determine the adequacy of the tracing and clinical relevance of the findings. There is no standard for what is an acceptable time period to have an interpretable EFM under these study circumstances. Recognizing that maintaining a fetal heart tracing with an external monitor when women change position during sleep would be difficult, an interpretable tracing for 25% of the night was considered the minimal acceptable and greater than 50% was considered ideal. An interpretable signal for less than 25% of the study period was considered unacceptably low.

Table 1. — *Characteristics of 'Healthy' and 'GH' women.*

	Healthy	GH	*p* value
Number	22	26	–
Age	28.6 ± 4.6	28.8 ± 6.3	NS*
Pre-pregnancy BMI	23.2 ± 6.0	29.5 ± 6.9	0.02
BMI	29.7 ± 0.6	36.3 ± 7.9	< 0.001
Gestational age	34.3 ± 3.2	34.4 ± 2.9	NS*
Sleep time (min)	310 ± 56	271 ± 67	0.04
Mean RDI	2.1 ± 1.8	9.7 ± 10.1	<0.001
PSG diagnosis of SDB	1 (4.5%)	11 (42%)	< 0.001

*NS = Non-significant. GH = gestational hypertension; BMI = body mass index; RDI = respiratory disturbance index; PSG = polysomnography; SDB = sleep disordered breathing.

Results

We reviewed the first 50 consecutive PSGs performed as part of our larger study. Two studies were excluded - the first because it was a repeat study on a subject whose initial study had already been included in our evaluation and the second due to minimal sleep time of only six minutes. Remaining were 48 PSG studies on 48 different women with third-trimester, singleton pregnancies, all of whom had concurrent EFM. Twenty-six studies were performed on women with GH and 22 studies were conducted on healthy women with uncomplicated singleton pregnancies. Baseline data is presented in Table 1. Not surprisingly, the groups differed significantly in body mass index (BMI), but were comparable for maternal and gestational ages.

The PSG data on the two groups of subjects is presented in Table 1. The mean sleep duration for the entire group was 290 ± 64 min (range 137-402) with a mean sleep efficiency of 68%. The Doppler band did require repositioning throughout the night in many, but not all of the subjects. Loss of signal was often associated with the

mother turning positions during sleep. The mean RDI of the entire group was 6.1; and 27% of women met our predetermined criteria for SDB (RDI of ≥ 5).

An EFM tracing was achievable at the beginning of the study in all subjects, most of the time within only a few minutes. Interpretable tracings were obtained for a mean of 52% (220 minutes) of the entire night study duration. Studies were categorized according to the percentage of study time an interpretable tracing was obtained: < 25% of time; 25%-50%; or > 50% (Figure 1). Acceptable tracings were more difficult to obtain in women with GH compared to those with uncomplicated pregnancies. Seventy-seven percent of women with SDB had either 'ideal' or 'acceptable' EFM recordings (Figure 2). As obesity is a risk factor for both GH and SDB, we also looked at our results stratified according to pre-pregnancy BMI of greater or less than 30 kg/m^2. Figure 3 demonstrates that the success rate of EFM during PSG was much lower in obese women. However, we were still able to obtain an interpretable EFM for an acceptable length of time, in most of the obese subjects. None of the EFM tracings were considered by our obstetrician to be worrisome for fetal distress.

Discussion

EFM monitoring is a vital tool that is widely utilized in the assessment of fetal health. Continuous EFM before labor is not usually performed during sleep, unless there are compelling maternal or fetal risk factors. Maternal obesity and very frequent fetal movements may make a good trace difficult to obtain. As well, frequent change of maternal position necessitates repositioning of the transducer to obtain a good trace. The woman's comfort must be weighed against the need to monitor the EFM continuously.

Pregnant women may occasionally undergo PSG, either for research purposes or clinical indications. Fluctuations in maternal hemodynamic status and oxygenation as a consequence of SDB may compromise fetal oxygenation during sleep. Therefore, there may be a role for EFM monitoring during PSG of pregnant women. The literature has only a few individual reports of utilizing EFM during sleep [8, 10, 11] and the only case series we are aware of that specifically addresses success of EFM during PSG was published by Leech in 2008 [10]. Leech reported a very high success rate, but the study included only six subjects, none of whom had a sleep disorder. Our series includes 48 subjects, many of whom were obese and over a quarter of whom were found to have at least mild SDB. We believe our study is important because it is a relatively large series of subjects and includes a patient group that is likely to receive PSG testing on clinical grounds. Although our signal pick up was not as impressive as Leech reported, we have shown that an interpretable EFM tracing can be obtained in most subjects during PSG. While this monitoring technology is clearly more challenging in obese women, it can still be applied with reasonable success. Furthermore, a higher yield would likely have been attainable had maintaining EFM been our primary objective. Rather, for our study allowing the subjects to maintain sleep was paramount.

Conclusion

Continuous EFM during sleep is feasible and safe, and requires only minimal additional nursing effort. Although successful pick up is likely to be more challenging in the patient subgroups of interest compared to healthy volunteers, an interpretable tracing can be obtained during much of the night with minimal intervention by trained health care professionals. In addition to supporting the use of EFM during future sleep research, our findings may also have clinical implications for antepartum monitoring of selected late-trimester women.

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References

[1] Canadian Hypertension Education Program: "The 2008 Canadian Hypertension Education Program recommendations: the scientific summary - an annual update". *Can J. Cardiol.*, 2008, *24*, 447.

[2] Endeshaw Y.W., Bloom H.L., Bliwise D.L.: "Sleep-disordered breathing and cardiovascular disease in the Bay Area Sleep Cohort". *Sleep*, 2008, *31*, 563.

[3] Sahin F.K., Koken G., Cosar E., Saylan F., Fidan F., Yilmazer M., Unlu M.: "Obstructive sleep apnea in pregnancy and fetal outcome". *Int. J. Gynaecol. Obstet.*, 2008, *100*, 141.

[4] Edwards N., Middleton P.G., Blyton D.M., Sullivan C.E.: "Sleep disordered breathing and pregnancy". *Thorax*, 2002, *57*, 555.

[5] Edwards N., Blyton D.M., Kirjavainen T., Kesby G.J., Sullivan C.E.: "Nasal continuous positive airway pressure reduces sleep-induced blood pressure increments in preeclampsia". *Am. J. Respir. Crit. Care Med.*, 2000, *162*, 252.

[6] Connolly G., Razak A.R., Hayanga A., Russell A., McKenna P., McNicholas W.T.: "Inspiratory flow limitation during sleep in pre-eclampsia: comparison with normal pregnant and nonpregnant women". *Eur. Respir. J.*, 2001, *18*, 672.

[7] Champagne K., Schwartzman K., Opatrny L., Barriga P., Morin L., Mallozzi A. *et al.*: "Obstructive sleep apnoea and its association with gestational hypertension". *Eur. Respir. J.*, 2009, *33*, 559.

[8] Joel-Cohen S.J., Schoenfeld A.: "Fetal response to periodic sleep apnea: a new syndrome in obstetrics". *Eur. J. Obstet. Gynecol. Reprod. Biol.*, 1978, *8*, 77.

[9] Franklin K.A., Holmgren P.A., Jönsson F., Poromaa N., Stenlund H., Svanborg E.: "Snoring, pregnancy-induced hypertension, and growth retardation of the fetus". *Chest*, 2000, *117*, 137.

[10] Leech J.A.: "The feasibility of adding fetal heart rate to the nocturnal polysomnogram". *J. Clin. Sleep Med.*, 2007, *3*, 277.

[11] Olivarez S.A., Maheshwari B., McCarthy M. *et al.*: "Prospective trial on obstructive sleep apnea in pregnancy and fetal heart rate monitoring". *Am. J. Obstet. Gynecol.*, 2010.

[12] Iber C., Ancoli-Israel S., Chesson A., Quan S.F.: "The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications". Westchester, Ill.: The American Academy of Sleep Medicine, 2007.

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