The Feasibility of Adding Fetal Heart Rate to the Nocturnal Polysomnogram

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Study Objectives: To demonstrate that fetal heart rate measured by ultrasound can be successfully captured and monitored throughout the nocturnal polysomnogram.

Methods: Fetal heart rate by ultrasound using an abdominal belt (Hewlett Packard Fetal Monitor 8040A) was measured during 1 overnight polysomnogram in volunteers in late pregnancy and added to a digitized polysomnography system (Alice 4, Respironics)

Results: In 6 women with a single fetus in their third trimester, the fetal heart rate monitor band only infrequently needed to be readjusted. Fetal kicks and movements resulted in signal loss, usually with subsequent recapture without having to awaken the mother.

Conclusions: Fetal heart rate, 1 of the classic signals of fetal distress, can be added to the nocturnal polysomnogram with minimal disruption of maternal sleep and with signal capture throughout the night.

Keywords: polysomnography, tocography, fetal heart rate


There is growing evidence that snoring and sleep-disordered breathing may contribute to the development or severity of toxemia of pregnancy.1-3 Snoring alone has been related to growth retardation of the fetus and lower Apgar scores.4 Although questionnaires, nocturnal polysomnograms, and fetal outcomes have been used to examine these questions, the addition of a direct measurement of fetal physiology would be ideal. Single case reports5,6 have demonstrated that tocography can be measured at the same time as the nocturnal polysomnogram.

This brief report explores the feasibility of capturing fetal heart rate, one of the classic signals of fetal distress, during the nocturnal polysomnogram for future studies of patients with sleep-disordered breathing.

METHODS

This study was approved by the Institutional Review Board of The Ottawa Hospital, and each mother gave signed informed consent.

A single-night polysomnogram was obtained in 6 women with single fetus pregnancies in the third trimester of pregnancy. These women had a variety of sleep-related third-trimester complaints (ie, increase in urinary frequency, nocturnal abdominal discomfort, occasional heartburn, or snoring) but no actual sleep disorder. Measurements included 4-lead electroencephalogram (C4A1, C3A2, O1A2, O2A1); 2-lead electrooculogram placed 1 cm above and below the right and left outer canthus, respectively, and referenced to the opposite mastoid; submental electromyogram; right and left tibialis anterior electromyogram; airflow by oronasal thermistor (Braebon, Ogdensburg, NY); oxygen saturation by finger oximetry; and maternal electrocardiogram (approximate to lead II). A thoracic piezoelectric band was placed at the level of the xiphoid; an abdominal piezoelectric band was placed just above the often protuberant and sensitive umbilicus. The third band to obtain the Doppler signal of the fetal heart rate (Hewlett Packard fetal monitor 8040A, Boeblingen, Germany) was placed below the umbilicus with probe location identified by palpating the fetal spine and confirmed with the audible heart rate sound, which was subsequently turned off before lights out. All of these signals were recorded simultaneously on the Alice 4 system (Respironics, Murrysville, PA).

As part of the biocalibrations, the mother was asked to report during set up both fetal kicks and fetal movements to observe the effects on fetal heart rate and on signal capture.

Mothers were asked to void immediately before set up to decrease potential readjustments during the night; subjects were given bedpans during the night to minimize signal disruption.

RESULTS

Six women with single-fetus pregnancies were studied and ranged in age from 27 to 41 years. The estimated gestational age was from 32 to 37 weeks. All were normal low-risk pregnancies; 5 were first babies. Mothers were not on any medications apart from prenatal vitamins.

Subjects were able to tolerate the 3 bands (thorax, abdomen, and fetal heart rate abdominal band) all night, and none asked to have them removed. It took from 5 to 45 minutes to locate and continuously record the fetal heart rate, but, once located, the signal usually remained relatively stable throughout the night. The echo sound was used to help capture the signal but then was turned off during
the night. The ultrasound band had to be readjusted by the technologist twice (1 subject), once (2 subjects), or not at all (3 subjects) to recapture the fetal heart signal during the night. Based on maternal report during the biocalibrations, a fetal kick was defined as a drop-out in fetal heart rate in 1 second with recapture in less than 5 seconds (Figure 1). When the mother reported a fetal movement, there was a sudden drop in fetal heart rate in 1 second with recapture in greater than 5 seconds (figure 2), usually more than 20 seconds. These were distinguished from falls and rises in fetal heart rate unassociated with fetal movement, which were much more gradual, and from heart rate gradual decelerations, described elsewhere related to apnea. The definition of kick versus fetal movement here is quite arbitrary, both in terms of the number of seconds used and sometimes even in maternal ability to distinguish between the two when awake.

Table 1 outlines maternal characteristics and the sleep architecture characteristics. The sleep latency was prolonged in 2 subjects. One of these 2 subjects also had the lowest sleep efficiency at only 24% of the night. The sleep efficiency was generally decreased, as has been described by questionnaire responses from women in their third trimester of pregnancy. It ranged from as low as 24% to 87%, with a mean value of 59%.

Both stage 3 and 4 non-rapid eye movement sleep (NREM) and rapid eye movement (REM) sleep were generally decreased in comparison to normal predictions for this age group. There was 11% stage 3 and 4 NREM sleep and 12% REM sleep seen on average.

Table 1—Characteristics of the 6 Study Subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age, y</td>
<td>39</td>
<td>27</td>
<td>41</td>
<td>39</td>
<td>32</td>
<td>29</td>
<td>35</td>
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<tr>
<td>Estimated gestational age, mo.</td>
<td>32</td>
<td>32</td>
<td>36</td>
<td>35</td>
<td>34</td>
<td>37</td>
<td>34</td>
</tr>
<tr>
<td>Height, ft-in</td>
<td>5-7</td>
<td>5-2</td>
<td>5-6</td>
<td>5-3</td>
<td>5-5</td>
<td>5-5</td>
<td></td>
</tr>
<tr>
<td>Weight, lb</td>
<td>231</td>
<td>188</td>
<td>259</td>
<td>166</td>
<td>162</td>
<td>186</td>
<td></td>
</tr>
<tr>
<td>Sleep latency, min</td>
<td>3</td>
<td>86</td>
<td>16</td>
<td>15</td>
<td>75</td>
<td>38</td>
<td>39</td>
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<tr>
<td>Sleep efficiency, %</td>
<td>75</td>
<td>24</td>
<td>74</td>
<td>67</td>
<td>52</td>
<td>43</td>
<td>59</td>
</tr>
<tr>
<td>Sleep stage, % of TST REM</td>
<td>3</td>
<td>32</td>
<td>1</td>
<td>7</td>
<td>14</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>3-4 NREM</td>
<td>6</td>
<td>12</td>
<td>11</td>
<td>14</td>
<td>23</td>
<td>4</td>
<td>12</td>
</tr>
</tbody>
</table>

TST refers to total sleep time; REM, rapid eye movement; NREM, non-rapid eye movement.
DISCUSSION

The difficulties with maintaining a fetal heart signal reported by our obstetrical nurse specialists in third-trimester patients throughout the day are likely related to maternal activities. There was little need for band replacement during these sleep studies. Interestingly, the mothers with the lowest sleep efficiencies had the highest rate of fetal movements, but, whether this was cause or effect, these activities did not result in sustained signal loss or need to replace the fetal band.

The fetal ultrasound heart monitor is used widely in both outpatient and inpatient obstetrical units to observe for fetal heart rate decelerations in high-risk pregnancies in the daytime and so might easily be available to many hospital-based sleep laboratories at night, with the only extra equipment needed being a patch cord to link to the sleep-acquisition software system.

CONCLUSION

This simple study demonstrates that fetal heart rate in the third trimester of normal pregnancies can be captured by ultrasound signal from abdominal bands, successfully measured throughout the night, and entered continuously into a digitized polysomnography system. The band is not uncomfortable for the mothers, and taking time at biocalibration to identify fetal kicks and fetal movements can help distinguish these events from other potentially clinically significant changes in fetal heart rate. Future studies of sleep-disordered breathing and hypoxia may consider the

Table 2—Fetal Heart Rate Capture in 6 Study Subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal sleep efficiency, %</td>
<td>75</td>
<td>24</td>
<td>74</td>
<td>67</td>
<td>52</td>
<td>43</td>
<td>59</td>
</tr>
<tr>
<td>Abrupt failures, no.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Briefa</td>
<td>20</td>
<td>29</td>
<td>16</td>
<td>10</td>
<td>14</td>
<td>10</td>
<td>17</td>
</tr>
<tr>
<td>Prolongeda</td>
<td>8</td>
<td>14</td>
<td>6</td>
<td>8</td>
<td>4</td>
<td>24</td>
<td>11</td>
</tr>
<tr>
<td>Total signal failurec, %</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>9</td>
<td>6</td>
</tr>
</tbody>
</table>

*aFetal kick
bFetal movement
cAs a percentage of time in bed

Figure 2—Fetal movement. At 11:40:18 PM, there is a sudden fall in fetal heart rate, which is recaptured 49 seconds later. The abdominal band was not capturing at this time. This signal pattern is similar to that of the fetal movement that the mother described during biocalibrations. LEOG and REOG refer to left and right electrooculogram, respectively; ECG, electrocardiogram; LEMG, leg electromyogram; NAF, nasal airflow; FHR, fetal heart rate; THO, thoracic wall movement; SAO2, oxygen saturation; BODY, body position; STAGE, sleep stage.
use of fetal heart monitoring to assess potential fetal responses to maternal events during the night.

ACKNOWLEDGEMENTS

This study was funded by the Ontario Thoracic Society. We wish to thank Dr. George Tawagi and Mrs. Elaine O’Shea, obstetrical nurse, for their advice and guidance.

REFERENCES