Studies on Fetal Movement and Fetal Heart Rate Changes at 20 to 32 Weeks' Gestation

TAKAMOTO MATSUNAGA, TEIJI HAMADA, TAKATSUGU MATSUNAGA, MASAHIRO TETSUO, SIGEKI IZUMI AND JUNICHI ISHIMATSU

Department of Obstetrics and Gynecology, Kurume University School of Medicine, Kurume, 830 Japan

Received for publication May 25, 1985

Summary: The non-stress test (NST), a measure of normal fetal movement and accompanying acceleration, is a useful method of perinatal fetal evaluation. The fetal movement and spontaneous onset of fetal acceleration observed in normal fetus suggests a coordinated control of both these functions, presumably arising in the fetal central nervous system (CNS). Since the developmental features of the regulation mechanism of fetal heart rate and fetal movement by the fetal brain in mid trimester are not known, interpretation would be rather speculative. The present prospective study was designed to evaluate the landmarks of normal fetal development in mid trimester by NST. The study revealed the following: 1) Maternal perception of fetal movements were closely associated with trunk movements observed to last for 1 second or longer by real-time B-scanning. 2) The ratio of fetal movement to total accelerations increased with the progression of pregnancy during 20 to 32 weeks' gestation. 3) The majority of accelerations in fetal heart rate had amplitudes within the range of 10-15 bpm before the 30th weeks' gestation and 15 bpm or greater at or after the 30th weeks' gestation.

Key words: fetal movement—fetal heart rate—perinatal fetal evaluation—maternal perception—perinatal period

Introduction

Simultaneous monitoring of fetal heart rate (FHR) and fetal movement (FM) is widely recognized as a useful means of evaluating fetal well-being in the perinatal period. The fetal movement and spontaneous onset of fetal acceleration observed in the normal fetus suggests a coordinated control of both these functions, presumably arising in the fetal central nervous system (CNS). Recent advances in neonatal care permits improvement in the neonatal survival rate at 28 weeks' gestation or earlier. An accurate assessment of fetal condition in utero would be prerequisite for performing suitable neonatal care and it may contribute to further reduction of neonatal mortality in this period. Sorokin et al. (1982) attempted to classify FM and associated changes of FHR in pregnancies between 20 and 30 weeks' gestation. Since the developmental features of regulation mechanism of FHR and FM by fetal brain in mid trimester are not known, interpretation would be rather speculative.

The present prospective study was designed to evaluate the landmarks of normal fetal development in mid trimester by non-stress test (NST).
Materials and Methods

Forty-two pregnant women who were judged to be normal were monitored at 20 to 32 weeks' gestation. The gestational age of the infant was later confirmed by Dubowitz examination. There were no neonatal abnormalities. The patients were studied in a quiet room, lying in the semi-Fowler position to avoid supine hypotension, in the morning between 9 a.m. and 12 noon, 1-2 hours after a meal. On the day of the examination, they were asked to refrain from drinking tea or coffee and were not on medication. The FHR was monitored with an abdominal fetal doppler or phonocardiogram (TOITU MT-810). Movements were detected with maternal perception and tocodynamometer placed on the maternal abdomen. Each monitoring session lasted for more than 50 minutes. Fetal movements in randomly selected subjects were also observed using real-time B-scanning. Fetal movements occurring within 10 seconds of each other were considered a single movement.

The FHR changes were defined as

1) Acceleration I (15 bpm<, 15 sec. <)
2) Acceleration II (10 bpm<, <15 bpm, 10 sec. <, <15 sec.)
3) Deceleration (10 bpm<)
4) Acceleration and deceleration

Results

1. Maternal perception of fetal movement.

In order to validate the fetal movement by maternal perception, ultrasonic examination was performed simultaneously on 11 patients whose gestational ages were less than 28 weeks. With respect to fetal movement lasting at least 1 second, fetal movement by maternal perception was found to be linearly related to those visualized by ultrasonography with the regression equation y=0.79x +1.24. The correlation coefficient was 0.976 and was significant at p<0.01 (Fig. 1).

2. Frequency of fetal movement determined by maternal perception at 20 to 32 weeks' gestation.

In normal pregnant women at 20 to 32 weeks' gestation, the frequency of fetal movement during a 30 minute period was in the range of 20 to 25. The value in each gestational week consistently ranged from 20 to 25 as is shown in Fig. 2.

3. Association of fetal movement with fetal heart rate changes.

a. Fetal movement associated with FHR/total FM ratio.

Acceleration I was not determined at

<table>
<thead>
<tr>
<th>FHR change</th>
<th>Gestational age (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 - 23</td>
</tr>
<tr>
<td>Acceleration I</td>
<td>0 %</td>
</tr>
<tr>
<td>Acceleration II</td>
<td>4.9±4.5</td>
</tr>
<tr>
<td>Deceleration</td>
<td>19±9.6</td>
</tr>
<tr>
<td>Decel. and Accel.</td>
<td>0.3±1.2</td>
</tr>
</tbody>
</table>

The values are mean ± SD.

TABLE 1

FM associated with FHR change/total FM ratio in normal pregnancy
Fig. 1. A comparison between maternal perception and ultrasonic assessment of fetal movement, lasting more than 1 second: \( y = 0.79x + 1.24 \) (\( r = 0.976 \))

Fig. 2. Number of fetal movement by maternal perception during 30 minutes

Fig. 3. Fetal movements associated with FHR/total fetal movements ratio
20 to 32 weeks' gestation. The percentage of acceleration I observed at 27 to 29 weeks' gestation and 30 to 32 weeks' gestation was 14% and 42%, respectively. With advancing gestational age, the numbers of acceleration I increased and changes were significant with p<0.05 (Fig. 3). Acceleration II was recognized at 20 to 23, 24 to 26 and 27 to 29 weeks' gestation with a percentage of 4.9%, 10% and 25%, respectively. The acceleration II increased until 27 to 29 weeks' gestation and stayed at highest level after 27 to 29 weeks of gestational age.

Deceleration was invariably recognized at 20 to 32 weeks' gestation in 11-19%.

b. Acceleration I associated with FM/total acceleration ratio.

Acceleration I was recognized at 27 to 29 and 30 to 32 weeks' gestation with a percentage of 50% and 71%, respectively (Fig. 4).

**Discussion**

The NST, which involves determination of fetal movement and the accompanying acceleration of fetal heart rate is an adequately reliable means of fetal assessment during the perinatal period. However, as indicated by Bishop (1981), non-reactive patterns are seen frequently in NST conducted at the 30th week of gestation or earlier. It is impossible, therefore, to make an accurate fetal assessment by NST in its present form during the mid trimester of pregnancy. The relationship between fetal movement and the change in fetal heart rate during this period must be seen as a state in the development of control of the heart rate by the central nervous system. Thus, FM itself is considered to reflect the active state of the fetus and is closely associated with CNS response. It is, therefore, important to analyze FM in detail, including such factors as type and duration of movements, as an ecological activity of the fetus. Generally, maternal
perception of FMs are widely accepted as convenient markers of FMs. Getringer et al. (1978) and Sakakibara et al. (1981) have reported on relationships between FMs and maternal perception of FMs and individual differences in maternal perception of FMs from patient to patient. According to their studies, only 30-40% of all fetal movements are perceived by the mother as perception of FMs, and there are considerable individual differences. Rayburn (1980), however, made observations by real-time B-scanning in order to elucidate the relationship between FMs and maternal perception of FMs and found that of various types of FMs, 100% of movements of the trunk, 82% of the movements of the extremities and 56% of the small movements of extremities were perceived as maternal perception of FMs. In addition, Sorokin et al. (1981) observed FMs from 4 different aspects, i.e. real-time B-scanning, tocodynamometry, maternal perception of FMs and observation by an observer, and analyzed the relationship between the duration of FM and its perception as a maternal perception of FM. According to their study, 64.9% of movements continuing for 1-3 seconds and 83.9% of those lasting over 3 seconds were perceived as FMs. Neldan (1982), meanwhile, reported that although during the mid trimester of pregnancy, FM is affected somewhat by the site of placental attachment, 62.3-79.2% of all FMs were recognized as maternal perception of FMs. The authors also found that when patients who had not reached the 28th weeks gestation were observed by real-time B-scanning, 79% of trunk movements lasting for 1 second or longer were recognized by the mothers as perception of FMs. In regard to the relationship between FMs and changes in FHR, Timor-Trish et al. (1978) reported that acceleration in FHR was seen with 91.2% of those FMs lasting 1-3 seconds, and 99.8% of those FMs lasting 3 seconds or longer. Lee et al. (1975) reported that the lag time between the FM and the acceleration of FHR was $1.3 \pm 1.2$ seconds. They stated that because this was similar to the lag time between body movement and the acceleration in heart rate seen in newborn infants during sleep, i.e., $1.0 \pm 0.7$ seconds, it indicated a connection between the FM and the acceleration. This acceleration in FHR involves the participation of the sympathetic spinal nerves and is regulated by a higher heart rate accelerating center than found in the superior portion of the medulla oblongata, hypothalamus and cerebral cortex. Hoff and Green (1936) found that stimulation of motor areas caused an increase in heart rate and an evaluation in blood pressure, while Delgado (1960) proved in experiments with dogs that the heart rate accelerating center and motor areas were located adjacent to each other. In addition, according to Smith (1971), in the control of FHR by autonomic nervous system, the sympathetic nervous system exerted its effect later than parasympathetic nervous system. He also reported that this control was seen always when the fetus was in the active state, and not in the excited state. It is believed, therefore, that as the fetus develops, the fetus is increasingly in the active state and the rate of occurrence of acceleration of FHR accompanying FMs increases as well. Sorokin et al. (1982), in investigations on fetuses at 20-22 weeks and at 28-30 weeks, reported that the percentage of FMs accompanied by acceleration of an amplitude of 10 bpm or more was 0.9% among the former fetuses and 36.3% among the latter. The authors also observed that during the period from the 20th to the 32nd weeks’ gestation, the ratio of occurrence of acceleration of FHR accompanying FMs increased with the progression of pregnancy. In the present study, investigations concerned with correlation of FMs and FHR changes during the mid trimester of pregnancy were as follows:
1) Maternal perception of FMs was closely associated with trunk movements observed to last for 1 second or longer by real-time B-scanning.

2) The ratio of fetal movement to total accelerations increased with the progression of pregnancy during 20–32 weeks' gestation.

3) The majority of accelerations in FHR had amplitudes within the range of 10–15 bpm before the 30th week and 15 bpm or greater at or after the 30th weeks' gestation.

Acknowledgment: I wish to express my gratitude to Prof. T. Kato, Kurume University School of Medicine for his advice and critical review of this manuscript.

References