Analysis of fetal breathing movements at 30–38 weeks of gestation

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Abstract

Aims: This study reports the changes in patterns of fetal breathing movements recorded with a photogrammetric method in three successive periods of gestation.

Methods: Respiratory movements were studied in fetuses of 28 healthy women with uncomplicated pregnancies of 30–38 weeks of gestation. Women were divided into three groups according to gestational age of the fetus: 30–32 weeks, 7 fetuses; 33–36 weeks, 9 fetuses; and 37–38 weeks, 12 fetuses. Sonographic images of the fetuses were recorded on videotape, digitized (1 image per 0.12 s) and analyzed with specially developed software.

Results: The proportion of fetuses in each age group for which movements were detectable was similar in all three groups, as was the frequency of movements. Duration of a complete respiratory cycle, the inspiratory phase and the expiratory phase tended to be shorter at 33–36 weeks of gestation than in younger and older fetuses. Fetuses in the 30–32-week group had slower breathing rates than fetuses in the two older groups.

Conclusions: The photogrammetric technique revealed differences in some patterns of fetal breathing movements between weeks 30–32, 33–36 and 37–38 of gestation. The data provide a sound basis for relating changes in fetal breathing movements with physiological and anatomical changes that occur as the respiratory system matures.

Keywords: Fetal breathing movements; photogrammetry; ultrasonography.

Introduction

Fetal breathing movements are necessary to ensure normal maturation and development of the lungs [6, 19, 22], and the presence of such movements is associated with fetal wellbeing [14, 16, 17]. Most studies of fetal breathing movements have used Doppler ultrasonography [1, 13, 23] or high-resolution sonography [4, 16, 18]. Doppler studies [1] have shown that, as the fetus breathes, fluids are displaced between the amniotic sac and the fetal respiratory space. Analyses of the flow wave are used to study parameters such as fluid displacement velocity and the duration of different phases of the breathing cycle.

The widespread availability of real-time ultrasonographic techniques makes it possible to continually observe the chest and abdominal walls of the fetus, and this, in turn, has led to the development of methods to quantify fetal breathing movements [3]. However, it remains difficult to detect and measure such movements objectively, because of interference caused by maternal respiration and other fetal body movements [2, 5].

Many studies have described the changes that occur in fetal breathing patterns as gestation progresses [1, 7, 12, 14, 20]. These changes are believed to result from the functional maturation of respiratory and sleep centers in the fetal central nervous system. Some authors [1, 7, 8, 12, 20, 21] have claimed that the duration of breathing movement episodes increases with gestational age. Kislevsky and colleagues [11] reported that the number of breathing movements increased, and Kalache and colleagues [9, 10] reported that the volume of tracheal fluid increased with gestational age. These findings indicate that the pattern of fetal breathing movements changes during the final 10 weeks of gestation.

In this study we used a photogrammetric method, described in an earlier publication [3], to look for changes in the pattern of fetal breathing movements after 30 weeks of gestation. We chose this period because it is when the lungs undergo important changes associated with respiratory maturation.
Table 1  Fetal breathing movement parameters at different gestational ages.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Gestation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30–32 weeks (n = 7)</td>
</tr>
<tr>
<td>Presence of breathing movements (%)</td>
<td>53.8</td>
</tr>
<tr>
<td>Frequency of movements (n/s)</td>
<td>0.082*</td>
</tr>
<tr>
<td>Duration of inspiratory phase (s)</td>
<td>0.540 ± 0.15*</td>
</tr>
<tr>
<td>Duration of expiratory phase (s)</td>
<td>0.560 ± 0.19</td>
</tr>
<tr>
<td>Inspiratory distance (mm)</td>
<td>2.71 ± 0.95†‡</td>
</tr>
<tr>
<td>Expiratory distance (mm)</td>
<td>2.71 ± 0.87†</td>
</tr>
<tr>
<td>Inspiratory velocity (mm/s)</td>
<td>5.03 ± 1.43†</td>
</tr>
<tr>
<td>Expiratory velocity (mm/s)</td>
<td>5.36 ± 2.25†</td>
</tr>
<tr>
<td>Inspiratory/expiratory duration ratio</td>
<td>1.14</td>
</tr>
</tbody>
</table>

Values marked with the same symbol were significantly different at: *P < 0.1; †P < 0.05; ‡P < 0.01; and |P < 0.001; values with ± are mean ± standard deviation.

*Significantly different from the value for 30–32 weeks, but not significantly different from the value for 33–36 weeks.

Methods

We initially recruited 51 pregnant women selected at random from those who came to the outpatient sonography clinic of the Obstetrics and Gynecology Service of the Hospital General Básico in Baza (Granada province, southern Spain) for routine follow-up visits. All women who participated in this study were examined by the same clinician (E.C.). The inclusion criteria were gestational age between 30 and 38 weeks, no known disease or abnormality at any time during pregnancy, non-smoking mother, and no maternal medication during pregnancy. Sonographic examinations were carried out between 09.00 and 10.00 h, 1–2 h after the mother had breakfast. The sonographic apparatus was a Hitachi EUB-200 machine (Hitachi Medical Corporation, Tokyo, Japan), and sonographic images were recorded with a Hitachi VT-M340-E video recorder.

The mean maternal age was 28 years (range 18–38 years) and 47% were primigravida. Mean gestational age was 35 weeks. Fetal breathing movements were detected in 28 women (54.9%). The recordings were divided into three groups according to gestational ages: 30–32 weeks (n = 7); 33–36 weeks, (n = 9); and 37–38 weeks, (n = 12).

The reference point in the digitized images was the midpoint on the abdominal wall between the xiphoid process and the insertion of the umbilical vessels. This point was marked in images obtained 0.12 s apart (8.5 frames/s), and its movement from frame to frame was tracked with a specially designed computer program. The program detects breathing movements on the basis of a predetermined algorithm [3] that uses information provided by the operator and information from previous studies [12, 15]. Once fetal breathing movements are measured and recorded, the program calculates a series of physical parameters of distance, time and velocity.

We first determined the number of fetuses in each gestational age group that showed breathing movements. Total digitization time was taken as the total period of the sonographic video recording that was sampled for fetal breathing movement determinations [3]. Mean duration of the digitized recordings was 41.31 ± 18.17 s, with a range of 90.96–7.2 s. Images contaminated by either maternal or fetal body movements were excluded. The number of breathing movements was recorded, and this value, divided by total digitization time, yielded the frequency of fetal breathing movements. The inspiratory phase was defined as the time during which the reference point moved away from the fetal vertebral column through the sagittal plane, and the expiratory phase was defined as the time during which the reference point moved back towards the vertebral column. The distance that the reference point traveled during the inspiratory and expiratory phases represented the inspiratory and expiratory distance, respectively. The velocity of movement was calculated for both phases.

For each gestational age group we calculated the mean value and standard deviation for each parameter. Because the mean values did not show a normal distribution, differences between the means were tested with the Mann-Whitney U-test. Pearson coefficients were calculated for correlations between quantitative variables.

Results

Table 1 summarizes the results for the different parameters in each age group. The proportion of fetuses that showed breathing movements was similar in all three age groups. The frequency of breathing movements was also similar in all groups, although this figure was highest in the 33–36-week group.

The duration of the inspiratory phase was significantly shorter in the 33–36-week group than in the other two groups. The duration of the expiratory phase was also shorter in the 33–36-week group, although the difference in comparison to the other two groups was not significant.

Both inspiratory and expiratory distance increased with gestational age. Both parameters were significantly shorter in the 30–32-week group than in the two older groups.

Inspiratory and expiratory velocity were lowest in the youngest age group, and were highest at 33–36 weeks of gestational age. The differences were significant between the youngest age group and the other two groups. The ratio of inspiratory to expiratory duration was similar in all three age groups.
movements, the extent of movement (total distance traveled by the reference point), and respiratory velocity. These changes in breathing patterns may be related to events that take place within the lung during this period of fetal life, such as thinning of the respiratory epithelium, transformation of type II alveolar epithelial cells into type I cells, the beginning of septation, and maximum collagen production.

With the exception of duration of the inspiratory phase, there were no significant differences between the two older age groups. This finding supports earlier observations that the final stages of respiratory maturation take place during weeks 33–36 of gestation.

Movement of the fetal abdominal wall increases as gestation proceeds. The increase in the distance traveled by the reference point is a logical result of body growth during fetal development. However, the duration of the two phases of breathing movements did not show a steady increase with gestational age. After 33 weeks, fetal breathing movements were much faster than in fetuses at 30–32 weeks, with the shortest respiratory cycles appearing in the 33–36-week group. Because the duration of breathing movements did not differ significantly between the two older age groups, our findings suggest that lung immaturity is associated with slower and shorter breathing movements, whereas longer movements may reflect greater maturity in terms of both greater body size (larger distances covered by the moving reference point) and lung function (faster breathing rates).

These results are consistent with other reports [1, 20, 21] that described changes in respiratory frequency with increasing gestational age as a reflection of fetal maturation.

We conclude that the photogrammetric method we used was able to accurately detect significant differences in some parameters of fetal breathing movements between 30–32, 33–36 and 37–38 weeks of gestation. The data provide a sound basis for relating changes in fetal breathing movements with physiological and anatomical changes related with maturation of the respiratory system.

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References
