Fetal Cardiac Flow Velocities in the Late 1st Trimester of Pregnancy: A Transvaginal Doppler Study

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In 30 normal women with a singleton pregnancy, transvaginal Doppler ultrasound was used to record flow velocity at the fetal atrioventricular (AV) valve and outflow tract levels (ascending aorta and pulmonary artery) at 11 to 13 weeks of gestation. Technically acceptable flow velocity waveforms were recorded at the AV valve level in 19 fetuses and in the ascending aorta and pulmonary artery in 15 and 17 fetuses, respectively. Successful documentation of both transmitral and transtricuspid flow velocity waveforms was achieved in six fetuses only.

Methods

Study patients. Thirty women with a normal singleton pregnancy were randomly selected to participate in the study. Maternal age ranged between 23 and 38 years (median 27). Gestational age ranged between 11 and 13 weeks (median 12). The study protocol was approved by the Hospital Ethics Committee in June 1989. All 30 pregnant women consented to participate in the study.

Recording technique (Fig. 1). A combined transvaginal real time and pulsed Doppler system (Hitachi E.U.B. 450 Medical) with a carrier frequency of 3.5 MHz (real time) and 6.5 MHz (Doppler) was used. The system operates at power outputs of <100 mW/cm² spatial peak temporal average by manufacturer’s specifications. Each woman was included in the study only once. Doppler studies were performed by one examiner (J.W.W.). Flow velocity waveforms at the fetal AV valve level were obtained from the four chamber view. Flow velocity waveforms from the fetal ascending aorta were recorded from the five chamber view and fetal pulmonary artery flow velocity waveforms were obtained from the echocardiographic short-axis view.

Doppler sample volumes were placed immediately distal to the AV valve and semilunar valves. The angle between the Doppler cursor and the assumed direction of flow was always ≤20°. Sample volume length was 0.1 to 0.3 cm. Peak velocities (cm/s) and time-averaged velocities (cm/s) were determined at both the AV valve and outflow tract levels. Heart rate (beats/min) was calculated from peak velocity time intervals in the ascending aorta. All Doppler studies were performed with the woman in the semirecumbent position and during fetal apnea because fetal breathing...
movements modulate blood flow velocity waveforms (7). The total examination time was limited to 10 min in each instance.

Data analysis. Hard copy recordings were obtained at all flow velocity waveforms. A microcomputer (Olivetti M 24) linked to a graphics tablet was used for analysis of the Doppler recordings. An average of three consecutive flow velocity waveforms with the highest velocity and of similar appearance was used to establish each value. The paired t test was applied to compare flow velocity waveforms from the ascending aorta and pulmonary artery. Data are presented as mean values ± 1 SD.

Results

Flow velocity waveforms. Among the 30 fetuses, acceptable flow velocity waveforms were obtained at the AV valve level in 19 (63%), from the ascending aorta in 15 (50%) and from the pulmonary artery in 17 (56%). Successful recording of both transmitral and transtricuspid flow velocity waveforms was achieved in six fetuses only; there were no significant differences between the peak and time-averaged velocities obtained at the two valve levels. In the other 13 fetuses, there was no assurance as to the origin of the flow velocity waveforms at the AV valve level. We therefore selected for each of the 19 fetuses the flow velocity waveforms with the highest velocity for further analysis.

Early and late diastolic velocities and outflow tract velocities (Table 1). Early diastolic filling velocities (E wave) and late diastolic velocities coinciding with atrial contraction (A wave), as well as outflow tract velocities are presented in Table 1. A wave peak velocities were nearly twice as high as E wave peak velocities. Comparison of aortic and pulmonary artery flow velocity waveforms was feasible in 15 fetuses; no statistically significant difference in peak and time-averaged velocity between the two vessels was found. Fetal heart rate ranged between 146 and 188 beats/min (mean 169 ± 5). No statistically significant correlation existed between cardiac flow velocities and heart rate.

Discussion

Safety of the procedure. The purpose of this study was to define fetal cardiac flow velocity waveforms in the late 1st trimester of pregnancy. There are several reasons to believe that fetal Doppler studies recorded with transvaginal ultrasound equipment in this period are safe. All measurements were carried out after the completion of embryonic structural development. The output levels for the transvaginal Doppler transducer are clearly situated in the lower regions for acoustic output of Japanese and American ultrasound diagnostic equipment (8). This placement is determined by the fact that the fetus is closer to the transducer with the transvaginal approach than with the transabdominal approach and needs to reflect less energy to be detected. Therefore, the fetus may be exposed to lower output levels.
Table 1. Peak and Time-Averaged Velocities at AV Valve and Outflow Tract Levels in Normal Fetuses During the Late 1st Trimester of Pregnancy

<table>
<thead>
<tr>
<th>AV Valve Level</th>
<th>E Wave</th>
<th>A Wave</th>
<th>A/E Ratio</th>
<th>Ascending Aorta</th>
<th>Pulmonary Artery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak velocity (cm/s)</td>
<td>20.5 ± 3.2</td>
<td>38.6 ± 4.7</td>
<td>0.53 ± 0.05</td>
<td>32.1 ± 5.4</td>
<td>29.6 ± 5.1</td>
</tr>
<tr>
<td>Time-averaged velocity (cm/s)</td>
<td>8.9 ± 1.4</td>
<td></td>
<td></td>
<td>11.2 ± 2.2</td>
<td>10.8 ± 2.1</td>
</tr>
</tbody>
</table>

Values are mean values ± 1 SD. AV = atrioventricular.

Flow velocities in the aorta and pulmonary artery. Flow velocities in the ascending aorta are higher than those documented in the pulmonary artery. However, this difference is not statistically significant. Differences have been established in late pregnancy (13) that were attributed to the relatively lower afterload to the left ventricle as a result of low cerebral vascular resistance. If afterload plays a role, it is of interest that late 1st trimester studies of the fetal internal carotid and middle cerebral arteries (Wladimiroff JW, unpublished observations) suggest that cerebral vascular resistance in this period is virtually similar to that observed in late gestation.

Conclusions. Despite the limitations of noninvasive Doppler techniques, transvaginal Doppler echocardiography can be used to study early human fetal cardiac function.

References