Visualization and quantification of fetal cardiac function with doppler ultrasound gated cine imaging and 4D flow MRI

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Background
• Features of fetal cardiovascular system
• Typically evaluated with echocardiography
• MRI provides 3D views in a fixed frame of reference
• Challenging to identify and isolate the fetal heartbeat

PURPOSES:
• Detail our experience using DUS-gated cine MRI
• Evaluate fetal cardiac motion
• Demonstrate utility of 4D flow MRI to visualize and quantify fetal circulatory hemodynamics

Methods
• IRB-approved study of 11 healthy volunteers
• Gestational age = 34.3 ± 1.6 weeks
• 1.5T (n=6) or 3T (n=5) (Philips Ingenia MRI)
• Doppler ultrasound gating via recently FDA-approved North Medical device

<table>
<thead>
<tr>
<th>Imaging Parameters</th>
<th>1.5T</th>
<th>3T</th>
</tr>
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<tbody>
<tr>
<td>TR (ms)</td>
<td>4.8±1.6</td>
<td>4.8±1.6</td>
</tr>
<tr>
<td>TE (ms)</td>
<td>1.9±0.65</td>
<td>1.9±0.65</td>
</tr>
<tr>
<td>Flip angle (°)</td>
<td>75±5.75</td>
<td>75±5.75</td>
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<tr>
<td>Matrix (x,y,z)</td>
<td>64x256x256</td>
<td>512x256x256</td>
</tr>
<tr>
<td>Slice thickness (mm)</td>
<td>2.5</td>
<td>1.46</td>
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<tr>
<td>Axial FOV (mm)</td>
<td>275x209x209</td>
<td>512x256x256</td>
</tr>
<tr>
<td>Number of echo trains</td>
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<td>4</td>
</tr>
<tr>
<td>Number of averages</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Scan time (min:sec)</td>
<td>20:40</td>
<td>34:50</td>
</tr>
</tbody>
</table>
| Image quality and feature definition from qualitative scoring by two expert radiologists.

Clinical Case: Cardiac anomalies & suspected heterotaxy

Ventricular septal defect and double outlet right ventricle are well visualized on fetal cardiac MRI.

Results

No difference of image quality or feature definition from qualitative scoring by two expert radiologists.

Image blurring and artifacts through the placenta that are substantially reduced with breath hold.

Conclusions
• Average blood flow was quantified from 4D flow MRI in 5 fetuses:
  • Ascending aorta: 1.6 ± 0.8 mL/beat
  • Pulmonary artery: 2.4 ± 0.7 mL/beat
  • Umbilical vein: 1.4 ± 0.9 mL/beat
  • Results are in relative agreement with prior studies²
• Preliminary results demonstrate utility of 4D flow MRI
• Doppler ultrasound gating allows for use of standard sequences with online reconstruction
• Comparison between DUS-gated and self-gated cine bSSFP images planned

Implications
• Fetal cardiac MRI may help in the diagnosis and hemodynamic assessment of various congenital conditions:
  • Congenital heart disease
  • Heterotaxy
  • Coarctation
  • Pulmonary atresia
  • Congenital diaphragmatic hernia
• Provides supplemental information to fetal echocardiography

Disclosures
• None