Introduction to Fetal Doppler

Assessment of Fetal Cardiac Function

Timothy L. Bennett, M.D.
Elizabeth J. Ferrell Endowed Chair
Medical Director, Children’s Mercy Fetal Health Center
September 2016
Objectives

Identify most common Doppler flow patterns in fetal vessels
Discuss pathophysiology associated with Doppler patterns
Use of Doppler analysis in fetal cardiac disease
Case study
Disclaimer

Practical overview

Doppler not generally considered as a screening tool

Cardiac Doppler application not discussed
Christian Doppler (1842)

Über das farbige Licht der Doppelsterne und einiger anderer Gestirne des Himmels

From Wikipedia, the free encyclopedia

Über das farbige Licht der Doppelsterne und einiger anderer Gestirne des Himmels is a treatise by Christian Doppler (1842) in which he postulated his principle that the observed frequency changes if either the source or the observer is moving, which later has been coined the Doppler effect. The original German text can be found in wikisource. The following annotated summary serves as a companion to that original.

Summary

The title "Über das farbige Licht der Doppelsterne und einiger anderer Gestirne des Himmels - Versuch einer das Bradley'sche Aberrations-Theorem als integrierenden Theil in sich schliessenden allgemeineren Theorie" (On the coloured light of the binary stars and some other stars of the heavens - Attempt at a general theory including Bradley's theorem as an integral part) specifies the purpose: describe the hypothesis of the Doppler effect, use it to explain the colours of binary stars, and establish a relation with Bradley's stellar aberration.
Doppler Effect

\[ f_d = \frac{2(f_o \cdot \cos A \cdot V)}{c} \]
Use of Doppler in Fetal Assessment

- Umbilical artery
- MCA
- Ductus venosus
- Umbilical vein
Umbilical Artery

Normal pattern

Abnormal pattern

Quantitative assessment

Indices

*S/D*  [Most common, easy to use, values erratic as diastolic flow nears 0]*

*PI* \( PI = \frac{S-D}{Avg} \)  [Machine calculated]*

*RI* \( RI = \frac{S-D}{S} \)  [Range 0-1]*
Middle Cerebral Artery (MCA)
MCA - Fetal Growth Restriction (Cephalization)
Doppler Applications:

• IUGR
  • Abnormal placentation causing downstream impedance
    • Umbilical artery
    • Middle cerebral artery (MCA)
    • Ductus venosus

• Cardiac dysfunction
  • RV dysfunction affecting flow into right atrium
    • Ductus venosus
    • MCA
    • Inferior vena cava (IVC)
    • Umbilical vein
Assessment of fetal cardiovascular function (quantitative)

- 2-D
  - Cardiac size
    - Cardiothoracic Ratio
    - Circumference >0.55
    - Area >0.35

- Doppler flow (extra-cardiac)
  - IVC, Hepatic venous flow
  - Ductus venosus flow
  - Umbilical vein flow (pulsation)

- Doppler flow
  - Myocardial performance index (Tei index)
  - AV valve inflow
  - Combined cardiac output
Doppler Assessment of Venous Flow

IVC
DV
Umbilical Vein
Inferior Vena Cava
Ductus Venosus

PIV

PVIV
Flow velocity waveforms of the ductus venosus with low pulsatility (top) and high pulsatility (bottom), which is caused by a decrease of early diastolic forward flow (D) and in particular by very low velocities during atrial contraction.

Umbilical Vein Flow
Assessment of diastolic dysfunction

• Right-sided diastolic dysfunction most commonly occurs prior to systolic or global dysfunction

• Assessment
  • Fetal venous system ***
  • A-V valves

• Venous flow affected progressively
  • IVC >>> Ductus venosus >>> Umbilical vein
### Causes of global cardiac dysfunction

- **Myocardial disease**  
  - Myocarditis  
  - Cardiomyopathy  
- **High-volume and/or high-pressure cardiac load**  
  - Congenital heart disease with severe valvular regurgitation  
  - Congenital heart disease with biventricular outflow obstruction  
  - Congenital heart disease with obstructed single outlet  
  - Twin-twin transfusion syndrome  
  - Atrioventricular malformations; acardiac twin; vascularized tumours  
  - Ductus venosus agenesis  
- **Major arrhythmias**  
  - Supraventricular tachycardia  
  - Complete heart block  
- **Anemia; ischemia**  
  - Parvovirus B19 infection  
  - \( \alpha \)-Thalassemia  
- **Cardiac compression**  
  - Pleural and pericardial effusions  
  - Chest mass
Case
Summary

• In obstetrical practice, abnormal Doppler flow associated with placental dysfunction and growth restriction

• In the fetus with cardiac disease, Doppler interrogation is useful to assess stability of cardiac function and may assist in delivery timing
Absent EDF

**Compiled from 1126 reported cases**

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perinatal Mortality</td>
<td>450/1000</td>
</tr>
<tr>
<td>Mean GA at delivery</td>
<td>32 wks</td>
</tr>
<tr>
<td>SGA</td>
<td>68%</td>
</tr>
<tr>
<td>CS for Fetal Distress</td>
<td>73%</td>
</tr>
<tr>
<td>Apgar at 5min &lt;7</td>
<td>26%</td>
</tr>
<tr>
<td>Admission to NICU</td>
<td>84%</td>
</tr>
<tr>
<td>Congenital Anomaly</td>
<td>10%</td>
</tr>
<tr>
<td>Aneuploidy</td>
<td>6%</td>
</tr>
<tr>
<td>Condition</td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Tetralogy of Fallot with absent pulmonary valve</td>
<td></td>
</tr>
<tr>
<td>AV septal defect with AV valve regurgitation</td>
<td></td>
</tr>
<tr>
<td>Ebstein anomaly of the tricuspid valve</td>
<td></td>
</tr>
<tr>
<td>Single ventricle</td>
<td></td>
</tr>
<tr>
<td>Bilateral semilunar valve stenosis</td>
<td></td>
</tr>
<tr>
<td>Fetal cardiomyopathy</td>
<td></td>
</tr>
<tr>
<td>Fetal tachyarrhythmia</td>
<td></td>
</tr>
<tr>
<td>Complete atrioventricular block</td>
<td></td>
</tr>
<tr>
<td>Anemia</td>
<td></td>
</tr>
<tr>
<td>Arteriovenous fistulae</td>
<td></td>
</tr>
<tr>
<td>Cystic hygroma</td>
<td></td>
</tr>
<tr>
<td>Placental insufficiency</td>
<td></td>
</tr>
<tr>
<td>Sacrococcygeal teratoma</td>
<td></td>
</tr>
<tr>
<td>Twin-twin transfusion syndrome</td>
<td></td>
</tr>
<tr>
<td>Twin-reversed arterial perfusion (TRAP) sequence</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2. Conditions commonly associated with fetal cardiac compromise**
Ascites