Routine Ultrasound Screening
Cardiac Assessment

Mandatory components of fetal cardiac screening from the MFM perspective

Timothy L. Bennett, MD, FACOG
Medical Director, Fetal Health Center
Professor, Department of OB/GYN
University of Missouri – Kansas City
September 2014 (v3)
Who Needs an Ultrasound?

- What are current indications for u/s?
  - Routine vs. Indicated

- Can ultrasound identify fetal abnormalities?
  - With what precision? False positives, negatives

- Does it improve outcome?
  - Patient/Family counseling
  - Pregnancy options
  - In utero therapy
  - Antepartum monitoring
  - Preparation of delivery

- When to perform screening
  - GA assessment vs. anatomical review
  - Effect of obesity
Does Screening Change Outcome?

- Numerous criticisms of the RADIUS trial
- 35% vs 10% anomaly detection
- Infrequent decision for pregnancy termination
- Eurofetus trial (1999)
  - 56% (2593/4615) detection, many <24 weeks gestation

However beautiful the strategy, you should occasionally look at the results – Winston Churchill

Table 4. Adverse Perinatal Outcomes in the Ultrasound-Screening and Control Groups.

<table>
<thead>
<tr>
<th>OUTCOME</th>
<th>SINGLETON FETUSES</th>
<th>MULTIPLE GESTATION</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ULTRASOUND</td>
<td>CONTROL</td>
<td>ULTRASOUND</td>
</tr>
<tr>
<td></td>
<td>SCREENING (N = 7549)</td>
<td>(N = 7473)</td>
<td>SCREENING (N = 136)</td>
</tr>
<tr>
<td>Fetal death</td>
<td>31 (0.4)</td>
<td>22 (0.3)</td>
<td>3 (2.2)</td>
</tr>
<tr>
<td>Neonatal death</td>
<td>17 (0.2)</td>
<td>15 (0.2)</td>
<td>1 (0.7)</td>
</tr>
<tr>
<td>Severe morbidity</td>
<td>88 (1.2)</td>
<td>82 (1.1)</td>
<td>11 (8.1)</td>
</tr>
<tr>
<td>Moderate morbidity</td>
<td>215 (2.8)</td>
<td>213 (2.9)</td>
<td>17 (12.5)</td>
</tr>
<tr>
<td>All adverse outcomes</td>
<td>351 (4.6)</td>
<td>332 (4.4)</td>
<td>32 (23.5)</td>
</tr>
<tr>
<td>Fetuses</td>
<td>351 (4.6)</td>
<td>332 (4.4)</td>
<td>32 (23.5)</td>
</tr>
<tr>
<td>Pregnancies†</td>
<td>351 (4.6)</td>
<td>332 (4.4)</td>
<td>17 (25.0)</td>
</tr>
</tbody>
</table>

*Includes three infants from the only triplet pregnancy in the trial.
†The number of pregnancies shown is the number in which one or more fetuses had an adverse perinatal outcome. The total number of multiple-gestation pregnancies was 68 in the ultrasound-screening group and 61 in the control group.

RADIUS Trial - NEJM 1993;329:821
Ultrasound technology improving rapidly, but…

Obesity Trends* Among U.S. Adults
BRFSS, 1990
Obesity Trends* Among U.S. Adults
BRFSS, 2008
(*BMI ≥30, or ~30 lbs. overweight for 5’ 4” person)
AIUM Indications for Ultrasound Exam

- “Every fetus deserves a physical exam.”
- Optimal Time:
  - 18-22 weeks gestation
  - Anatomic survey
  - Gestational age assessment
  - Cervical Length (PTB assessment)
  - Pregnancy options available
Does Prenatal Diagnosis of CHD Result in Better Outcomes?

Table II. Arterial blood gases in the preoperative period

<table>
<thead>
<tr>
<th>Prenatal diagnosis</th>
<th>n</th>
<th>Mean</th>
<th>SEM</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest pH</td>
<td>Yes</td>
<td>67</td>
<td>7.31</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>293</td>
<td>7.28</td>
<td>0.01</td>
</tr>
<tr>
<td>Lowest BE (mEq/L)</td>
<td>Yes</td>
<td>67</td>
<td>-4.90</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>291</td>
<td>-7.26</td>
<td>0.35</td>
</tr>
<tr>
<td>Highest Pco₂ (mm Hg)</td>
<td>Yes</td>
<td>41</td>
<td>45.14</td>
<td>2.03</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>88</td>
<td>48.72</td>
<td>1.86</td>
</tr>
<tr>
<td>Lowest Po₂ (mm Hg)</td>
<td>Yes</td>
<td>41</td>
<td>42.90</td>
<td>2.46</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>83</td>
<td>42.68</td>
<td>2.49</td>
</tr>
<tr>
<td>Highest lactate (mmol/L)</td>
<td>Yes</td>
<td>11</td>
<td>3.14</td>
<td>0.57</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>99</td>
<td>6.33</td>
<td>0.58</td>
</tr>
</tbody>
</table>

Patients with and without prenatal diagnosis are compared.
### Screening Fetal Echocardiogram

**Who should get one?**

#### Table 2  Common indications for fetal echocardiography

<table>
<thead>
<tr>
<th>Maternal indications</th>
<th>Fetal indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family history</td>
<td>Suspected fetal heart anomaly</td>
</tr>
<tr>
<td>Pre-existing metabolic disease</td>
<td>Abnormal fetal karyotype</td>
</tr>
<tr>
<td>Maternal infections</td>
<td>Major extracardiac anomaly</td>
</tr>
<tr>
<td>Cardiac teratogen exposure</td>
<td>Abnormal nuchal translucency</td>
</tr>
<tr>
<td></td>
<td>Fetal cardiac rate or rhythm disturbances</td>
</tr>
<tr>
<td>First-degree relative of proband</td>
<td>≥ 3.5 mm before 14 weeks’ gestation</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Persistent bradycardia</td>
</tr>
<tr>
<td>Phenylketonuria</td>
<td>Persistent tachycardia</td>
</tr>
<tr>
<td>Parvovirus B19</td>
<td>Persistent irregular heart rhythm</td>
</tr>
<tr>
<td>Rubella</td>
<td></td>
</tr>
<tr>
<td>Coxsackie</td>
<td></td>
</tr>
<tr>
<td>Retinoids</td>
<td></td>
</tr>
<tr>
<td>Phenytoin</td>
<td></td>
</tr>
<tr>
<td>Carbamazepine</td>
<td></td>
</tr>
<tr>
<td>Lithium carbonate</td>
<td></td>
</tr>
<tr>
<td>Valproic acid</td>
<td></td>
</tr>
<tr>
<td>Anti-Ro (SSA)</td>
<td></td>
</tr>
<tr>
<td>Anti-La (SSB)</td>
<td></td>
</tr>
</tbody>
</table>

---

2010 ISUOG PRACTICE GUIDELINE - Fetal Echocardiography
III. Indications

Indications for fetal echocardiography are often based on a variety of parental and fetal risk factors for congenital heart disease.\textsuperscript{12,13} However, most cases are not associated with known risk factors. Common indications for a detailed scan of the fetal heart include but are not limited to the following:

A. Maternal Indications
   - Autoimmune antibodies, anti-Ro (SSA)/anti-La (SSB);
   - Familial inherited disorders (e.g., 22q11.2 deletion syndrome);
   - In vitro fertilization;
   - Metabolic disease (e.g., diabetes mellitus and phenylketonuria); and
   - Teratogen exposure (e.g., retinoids and lithium).
How Well Do We Identify Fetal CHD?

- 2009 CA Study
  - N=309
  - 28% Detection
- 2012 EPICARD Study
  - N=2867
  - 40% Detection (Isolated VSD excluded)

- Prenatal detection remains low
- Most cases de novo
  - Not identified by risk factors
  - Maintaining standards for cardiac examination for obstetrical ultrasound critical

Heart 2012;98:1667–1673
J Pediatr 2009;155;26-31
3 Groups of Sonographers

- **Group I:**
  - Have missed a cardiac defect

- **Group II:**
  - Are going to miss a cardiac defect

- **Group III:**
  - Are lying about missing a cardiac defect
2nd Trimester Screening

- Standard Anatomic Assessment
  - Cardiac Exam
    - Heart rate (Rhythm)
    - 4 Chamber view (<60% detection)
    - Left/Right outflow tracts (+<25 % detection)

ISUOG  Standards 2011
AIUM Practice Guideline – Obstetric Ultrasound, 2013
ii. Chest:

Heart\textsuperscript{41-43}:

Four-chamber view;
Left ventricular outflow tract; and
Right ventricular outflow tract.


4 Chamber View

- Normal situs
- Normal heart rate (110-160bpm) and rhythm
- Occupies 1/3 of chest
- No Effusion
- Normal axis
- Majority of heart in left chest
- Equal chamber sizes
- FO in left atrium
- Normal AV valve position and motion
- Normal atrial and ventricular septum
- Moderator band in right ventricle
4 Chamber View

4CH-HEART
2nd Trimester Screening

- Situs (Position)
- Axis (45 +/- 20 degrees)
- Cardiothoracic Ratio (<0.5)
4 Chamber View
LVOT

- Vessels equal in size (PA 15% >AO)
- Crossover visualized
- Normal valve movement
RVOT
Outflow Tracts - Crossover
Ductal/Aortic Arches
Suboptimal Views – Recommendation

- Repeat in 2-4 weeks gestation
- If suboptimal views on subsequent scan – refer
- Factors
  - Risk Factors
  - Fetal Position
  - Maternal Habitus
  - Provider Concern
  - Maternal Concern
Timing of Prenatal Diagnosis of CHD
Paradigm Change

- Identify extra-cardiac abnormalities
- Patient counseling (few options)
- Termination Option
- Preparation for delivery
  - Plan for neonatal resuscitation, assessment, transport

- Patient Counseling
  - Antenatal CHD Not Static Disease
  - In Utero Intervention (investigational)
  - Serial U/S, Echos for monitoring for change in status

- Preparation for delivery
  - Where, when and how
Antepartum Monitoring
“Work In Progress”
(Still birth rate 15/1000 births)

- Brief ultrasound imaging periodically looking for signs of
  - Pericardial, pleural effusions
  - Echogenicity (myocardium, valves)
  - Arrhythmia
  - Hydrops
  - Measure cardio-thoracic ratio (looking for increased cardiac size as well as risk of pulmonary hypoplasia)

- Biophysical profile with nonstress test weekly
  - Amniotic fluid volume, tone, gross movement, breathing, FHR reactivity

- Doppler studies with each biophysical profile to include
  - Waveforms (pulsed Doppler) of peripheral vessels (umbilical artery, ductus venosus)

- Additional testing if evidence of hemodynamic instability
  - Evaluation of AV and semilunar valves (pulsed/color Doppler)
  - Monitor specifically for evidence of tricuspid regurgitation
  - Evaluation of atrial septum and foramen ovale (pulsed/color Doppler)
  - Tei index, left and right ventricles
  - Cardiac output (combined)
Management

- Avoid prematurity
  - Spontaneous preterm labor
    - Review history for PTB
    - Cervical length assessment (<28 weeks gestation)
    - PTL Precautions
  - Iatrogenic preterm birth
Delivery Timing

Delivery 39 – 40 weeks optimal

Birth Before 39 Weeks' Gestation Is Associated With Worse Outcomes in Neonates With Heart Disease
Pediatrics 2010;126;277-284; originally published online Jul 5, 2010; DOI: 10.1542/peds.2009-3640
Delivery Method

– Tends to tolerate labor well in the absence of uteroplacental insufficiency
  - Growth appropriate
  - Normal peripheral blood flow (Doppler)
– Cesarean section not commonly indicated
  - For delivery timing (for conditions requiring immediate cardiac intervention)
Fetal Health Center Delivery Center
Cardiac Cases - Benefits

- Mother/Infant are in the same hospital
  - Bonding issues/Decision making
  - Improved maternal postpartum recovery
- Coordinated antepartum care
  - Enhanced antepartum surveillance
- Coordinated neonatal care
  - Planned delivery
  - Planned neonatal management
    - Resuscitation
    - Therapy
    - Surgery
  - No transport delay
- Improved outcome (Yes)
Fetal Health Center Delivery Unit
Delivery Statistics (as of 9/11/2014)

Total patients – 351 (100%)
Cardiac cases – 160 (46%)
Summary

- Quality of obstetrical ultrasound in prenatal detection of CHD important in identifying fetal CHD.
  - More than 50% of CHD is missed on screening ultrasound currently
  - Follow established guidelines (AIUM)
  - Refer to MFM or Cardiology for suboptimal screening or suspected anomaly

- In complex cases, coordination of resources important to outcome
  - Accurate diagnosis
  - Counseling
  - Antepartum management
  - Delivery planning
  - Neonatal resuscitation
  - Cardiac team – medical/surgical therapy
"If we do everything right, if we do it with absolute certainty, there's still a 30% chance we're going to get it wrong."

—Joe Biden, speaking to members of the House Democratic caucus who were gathered in Williamsburg, Va., for their annual retreat, Feb. 6, 2009