Pregnancy and Heart Disease
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DISCLOSURES

- I have no disclosures relevant to today’s talk
Cardiovascular Effects of Pregnancy

- **Anatomic**
  - Ventricular muscle mass increases (1\textsuperscript{st} trimester)
  - End-diastolic volume increases (2\textsuperscript{nd} and 3\textsuperscript{rd} trimester)
  - End-systolic volume unchanged

- **Physiologic**
  - Plasma Volume
  - Blood Volume
Plasma Volume

- 45% increase above non-pregnant values
  - 1200 to 1600 mL in total

- Unclear mechanism
  - Possible initiated by nitric oxide–mediated vasodilation
  - Stimulating renin-angiotensin-aldosterone system
  - Possibly adaptive in reducing hemodynamic instability after blood loss
Blood Volume

- Plasma volume increases disproportionately to red blood cell mass
- Mild net anemia
- Maximal in the middle of the third trimester
- Possibly adaptive by decreasing viscosity
  - Countering increased thrombotic risk
  - Improved intervillous perfusion
Increased Cardiac Output

Vascular changes

- General softening of vascular collagen
- Hypertrophy of the smooth muscle component
- Net increased compliance
- Further accentuated by vasodilator effects of progesterone and prostaglandin
<table>
<thead>
<tr>
<th>Parameter</th>
<th>1st Trimester</th>
<th>2nd Trimester</th>
<th>3rd Trimester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood volume</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Cardiac volume</td>
<td>↑</td>
<td>↑↑ to ↑↑↑</td>
<td>↑↑↑ to ↑</td>
</tr>
<tr>
<td>Stroke volume</td>
<td>↑</td>
<td>↑↑↑</td>
<td>↑, ↔, or ↓</td>
</tr>
<tr>
<td>Heart rate</td>
<td>↑</td>
<td>↑↑</td>
<td>↑↑ or ↑↑↑</td>
</tr>
<tr>
<td>Systolic BP</td>
<td>↔</td>
<td>↓</td>
<td>↔</td>
</tr>
<tr>
<td>Diastolic BP</td>
<td>↓</td>
<td>↓↓</td>
<td>↓</td>
</tr>
<tr>
<td>Pulse pressure</td>
<td>↑</td>
<td>↑↑</td>
<td>↔</td>
</tr>
<tr>
<td>SVR</td>
<td>↓</td>
<td>↓↓↓</td>
<td>↓↓</td>
</tr>
</tbody>
</table>
How do we risk stratify patients?

- No large randomized studies
- No standardized, evidence-based guidelines
- CARPREG score
- ZAHARA scoring
Low Maternal/Fetal Risk

- Asymptomatic Aortic Stenosis
  - Low mean gradient less than 25 mmHg
  - Valve area greater than 1.5 cm²
  - Normal LV systolic function (EF > 50%)

- Aortic Regurgitation
  - NYHA functional class I or II
  - Normal LV systolic function

- Mitral Regurgitation
  - NYHA functional class I or II
  - Normal LV systolic function
Low Maternal/Fetal Risk

- Mitral Valve Prolapse
  - Up to mild to moderate MR
  - Normal LV systolic function
- Mild mitral stenosis
  - MVA greater than 1.5 cm$^2$
  - Mean gradient less than 5 mmHg
  - Without severe pulmonary hypertension
- Mild to moderate pulmonary valve stenosis
High Maternal/Fetal Risk

- Severe AS with or without symptoms
- Aortic Regurgitation
  - NYHA functional class III-IV symptoms
- Mitral Stenosis
  - NYHA functional class II-IV symptoms
- Mitral Regurgitation
  - NYHA functional class III-IV symptoms
High Maternal/Fetal Risk

- Aortic and/or mitral valve disease
  - Resulting in severe pulmonary hypertension (>75% systemic)
  - Severe LV dysfunction (EF < 40%)
- Mechanical prosthetic valve requiring anticoagulation
- Marfan syndrome with or without AR
- Pulmonary hypertension
- Cyanotic heart disease
CARPREG Study

- Prospective study of 562 pregnant women with heart disease in Canada between 1994-1999.
- 546 women underwent 599 pregnancies.
- Live birth rate-98%
- 27% C-section
  - 96% for obstetrical reasons
CARPREG – Four Risk Factors

- Prior cardiac event
  - Heart failure
  - TIA or CVA
  - Arrhythmia

- Baseline NYHA class III-IV or cyanosis

- Left heart obstruction
  - MV area <2 cm²
  - AV area <1.5 cm²
  - Peak LVOT gradient >30 mmHg

- Myocardial dysfunction
  - Ejection fraction <40%
  - Hypertrophic cardiomyopathy
  - Restrictive cardiomyopathy
## TABLE 4. Accuracy of Risk Index

<table>
<thead>
<tr>
<th>No. of Predictors</th>
<th>Estimated Risk, %</th>
<th>Rate of Primary Cardiac Events</th>
<th>Rate of Primary or Secondary Cardiac Events, Revised Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Derivation Group, Revised Index</td>
<td>Validation Group</td>
</tr>
<tr>
<td>0</td>
<td>5</td>
<td>7/249 (3%)</td>
<td>5/137 (4%)</td>
</tr>
<tr>
<td>1</td>
<td>27</td>
<td>27/111 (24%)</td>
<td>17/64 (27%)</td>
</tr>
<tr>
<td>&gt;1</td>
<td>75</td>
<td>16/25 (64%)</td>
<td>8/13 (62%)</td>
</tr>
<tr>
<td>C statistic (95% CI)</td>
<td>0.83</td>
<td>0.80 (0.77–0.89)</td>
<td>0.79 (0.71–0.87)</td>
</tr>
</tbody>
</table>

Imaging in Pregnancy

- Echo
- MRI
- X-ray
- CT
- Nuclear Imaging
- Angiography

No Radiation Exposure; Tests of Choice
Marfan’s

- Collagen and vascular changes in pregnancy
- Increased risk for dissection for aorta > 4-4.5 cm in diameter
- Continue beta blockers
- Surveillance echocardiography imaging every 6-8 weeks
- Invasive arterial pressure monitoring and assisted second stage
Iodizing Radiation

- Majority of fetal exposure from cardiothoracic imaging is from scatter (Compton) radiation
- Shielding fetus is of little value

**TABLE 3: Cardiac Imaging with Radiography, Fluoroscopy, and CT**

<table>
<thead>
<tr>
<th>Examination</th>
<th>Estimated Fetal Dose (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest radiography</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Pulmonary CTA</td>
<td>0.01–0.66</td>
</tr>
<tr>
<td>Coronary CTA (prospective gating)</td>
<td>≈ 1</td>
</tr>
<tr>
<td>Coronary CTA (retrospective gating)</td>
<td>≈ 3</td>
</tr>
<tr>
<td>Abdominopelvic CTA</td>
<td>6.7–56</td>
</tr>
<tr>
<td>Direct fluoroscopy for groin-to-heart catheter passage(^a)</td>
<td>0.094–0.244/min</td>
</tr>
<tr>
<td>Coronary angiography</td>
<td>0.074</td>
</tr>
<tr>
<td>Complex electrophysiologic intervention</td>
<td>0.0023–0.012/min</td>
</tr>
</tbody>
</table>

Note—Reasonable estimates are presented. Fetal exposure increases as the fetus grows and ascends toward the maternal thorax. Larger patients requiring greater peak kilovoltage and tube current will have greater secondary fetal exposure. CTA = CT angiography.

\(^a\)Avoidable with upper-extremity vascular access.

### TABLE 4: Doses to the Fetus From Nuclear Medicine Examinations

<table>
<thead>
<tr>
<th>Examination</th>
<th>Activity (mCi)</th>
<th>Radiopharmaceutical and Exposure</th>
<th>Early Pregnancy(^a) Fetal Dose (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung perfusion</td>
<td>5.5 (200)</td>
<td>(^{99m}\text{Tc})-macroaggregated albumin (P)</td>
<td>0.56</td>
</tr>
<tr>
<td>Lung ventilation</td>
<td>30 (1100)</td>
<td>(^{133}\text{Xe}) gas</td>
<td>0.0054</td>
</tr>
<tr>
<td>Lung ventilation</td>
<td>30 (1100)</td>
<td>(^{99m}\text{Tc}) aerosol</td>
<td>0.1–0.9</td>
</tr>
<tr>
<td>Myocardial perfusion</td>
<td>1.5 (55)</td>
<td>(^{201}\text{TlICl}) (P, F, A)</td>
<td>5.3</td>
</tr>
<tr>
<td>Myocardial perfusion</td>
<td>30 (1100)</td>
<td>(^{99m}\text{Tc})-sestamibi (P)</td>
<td>17</td>
</tr>
<tr>
<td>Myocardial perfusion</td>
<td>30 (1100)</td>
<td>(^{99m}\text{Tc})-tetrofosmin (P)</td>
<td>8.45</td>
</tr>
<tr>
<td>Gated blood pool</td>
<td>25 (930)</td>
<td>(^{99m}\text{Tc})-tagged RBCs (P)</td>
<td>6.0</td>
</tr>
<tr>
<td>PET viability</td>
<td>10 (367)</td>
<td>(^{18}\text{F})-FDG (P, F, A)</td>
<td>6.3–8.1</td>
</tr>
<tr>
<td>PET perfusion</td>
<td>80 (2960)</td>
<td>(^{82}\text{RbCl}) (P, F, A)</td>
<td>(\approx 2)</td>
</tr>
</tbody>
</table>

Note—Data from [28, 29]. Values in parentheses are megabecquerels. Maternal hydration and frequent voiding can reduce the fetal dose after administration of a number of radiopharmaceuticals, especially \(^{99m}\text{Tc}\)-macroaggregated albumin, \(^{99m}\text{Tc}\) aerosol, \(^{201}\text{TlICl}\), \(^{18}\text{F}\)-FDG, and \(^{82}\text{RbCl}\). P = likely to enter placenta, F = likely to cross placental barrier, A = likely to enter amniotic circulation.  

\(^a\)Radiopharmaceutical is assumed to be administered at 12 weeks’ gestational age; administrations before or after 12 weeks postconception would likely deliver a lower fetal dose.
Radiation Exposure

**TABLE 2: Recommendations Regarding Fetal Irradiation**

<table>
<thead>
<tr>
<th>Fetal Estimated Exposure (mGy)</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 (total gestation)</td>
<td>General public limit</td>
</tr>
<tr>
<td>&lt; 5 (0.50/mo)</td>
<td>Nuclear Regulatory Commission fetus exposure limit</td>
</tr>
<tr>
<td>Fetal dose &lt; 50</td>
<td>Fetal risk negligible</td>
</tr>
<tr>
<td>Fetal dose &lt; 100</td>
<td>Termination not justified</td>
</tr>
<tr>
<td>Fetal dose 100–150</td>
<td>Consider individual circumstances</td>
</tr>
<tr>
<td>Fetal dose &gt; 150</td>
<td>Possible fetal damage; termination should be seriously considered</td>
</tr>
<tr>
<td>Fetal dose &gt; 200</td>
<td>Termination generally recommended</td>
</tr>
</tbody>
</table>

Contrast Agents

- Iodinated contrast
  - Readily cross placenta
  - Pregnancy Class B
  - Use only if necessary

- Gadolinium-based contrast
  - Easily cross placenta
  - Pregnancy Class C
  - Avoid if possible
  - Enters breast milk
FDA Drug Classification for Pregnancy

- Class A: Controlled clinical studies in humans show safety
- Class B: Human data reassuring (animal positive), animal studies show no risk.
  - Dobutamine
  - Normal saline
- Class C: Human data lacking, animal studies positive or not done (67%)
  - Adenosine
  - Echo contrast agents (Definity, Optison)
- Class D: Human data show risk, benefit may outweigh risk.
- Class X: Animal or human data positive for unacceptable risk.
Agitated saline (Bubble) studies and Pregnancy

- There is currently no data looking at the safety of bubble studies in pregnant women
- Generally felt as safe based on concept that normal saline is a category B drug to use in pregnancy (considered safe)
- Case reports of CVA/TIA in patients undergoing bubble studies
- Would wait until after first trimester if feasible
Residual Intracardiac Shunting

- Theoretical risk of paradoxical emboli
- Aspirin 81 mg daily
- IV filters
References


THANK YOU