Learning Objectives

1. Discuss epidemiology of cardiovascular disease in pregnancy

2. Discuss normal physical exam and echocardiographic findings in pregnant women
Learning Objectives

3. Discuss the pre-pregnancy counseling for patients with cardiovascular disease considering pregnancy

4. Discuss the evaluation and management of valvular heart disease, cardiomyopathies and aortic disorders in pregnant patients
Scope of the problem

- **0.4- 4% of all pregnancies involve maternal cardiovascular disease**

  - 2014 – 3.8 million individual pregnancies in the US (that resulted in at least one live birth, correcting for multiple births)

    - ~153,928 pregnancies per year in the US that involve maternal cardiovascular disease

Cardiovascular disease is the largest cause of death of pregnant women in the developed world.

U.S. Data 2011-2012


Note: The cause of death is unknown for 6.2% of all pregnancy-related deaths.


*Note: Number of pregnancy-related deaths per 100,000 live births per year.

And we aren’t getting better...

![Graph showing increase in maternal death from cardiac disease in the UK.](image)

**Figure 2** Increase in maternal death from cardiac disease in the UK (deaths/1,000,000 maternities).

U.S. Data - 2011-2012

3,404 deaths due to cardiovascular disease complicating pregnancy

Why?

Things change during pregnancy...

- Significant maternal hemodynamic changes

- Due to the change in hemodynamic conditions, cardiac disease is often first manifested during pregnancy

The 40 week stress test...

**Hemodynamic changes during delivery**

- Further increase in cardiac output during the second stage of labor through delivery (additional 50% augmentation)

- 500 mL of blood is auto-transfused through to the maternal circulation with each contraction
Hemodynamic changes during delivery

- Significant blood loss (400cc – 800cc) during delivery
- Abrupt increase in venous return due to relief of IVC compression

Hemodynamic changes post-partum

Chronic cardiovascular conditions affecting U.S. births


Pre-pregnancy counseling

- Risk scores estimate maternal morbidity and mortality in addition to fetal morbidity and mortality

- CARPREG
- ZAHARA
- WHO
CARPREG – Cardiac Disease in Pregnancy

- Prospectively enrolled 562 pregnant women with known heart disease between 1994 and 1999
  - Enrolled 617 pregnancies → analyzed the 599 pregnancies that did not end in miscarriage before 20 weeks
  - Mean age 28 +/- 6 years
  - Receiving care in specialized cardiac or OB hospitals (Canada)

Results

- **Primary Cardiac Event**
  - Pulmonary edema
  - Sustained arrhythmia
  - Stroke
  - Cardiac arrest
  - Cardiac death

- **Secondary Cardiac Event**
  - Decline in NYHA Class
  - Need for urgent or emergent CV procedure
### TABLE 3. Multivariate Analyses

<table>
<thead>
<tr>
<th>Complications</th>
<th>Predictor</th>
<th>Odds Ratio (95% Confidence Interval)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac</td>
<td>Prior cardiac event or arrhythmia</td>
<td>6 (3-14)</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>NYHA functional class &gt;II or cyanosis</td>
<td>6 (2-22)</td>
<td>0.009</td>
</tr>
<tr>
<td></td>
<td>Left heart obstruction</td>
<td>6 (3-14)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Systemic ventricular dysfunction</td>
<td>11 (4-34)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Neonatal</td>
<td>NYHA functional class &gt;II or cyanosis</td>
<td>3 (1.1-6.1)</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>Heparin/ warfarin during pregnancy</td>
<td>3 (1.4-8.2)</td>
<td>0.0093</td>
</tr>
<tr>
<td></td>
<td>Smoking</td>
<td>2 (1.3-3.9)</td>
<td>0.0045</td>
</tr>
<tr>
<td></td>
<td>Multiple gestation</td>
<td>22 (6-85)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Left heart obstruction</td>
<td>2 (1.01-2.9)</td>
<td>0.044</td>
</tr>
<tr>
<td>Pregnancy-induced hypertension</td>
<td>Nulliparity</td>
<td>5 (2-17)</td>
<td>0.012</td>
</tr>
<tr>
<td></td>
<td>Systemic lupus erythematosus</td>
<td>24 (5-108)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Coarctation of the aorta</td>
<td>3 (2-10)</td>
<td>0.027</td>
</tr>
<tr>
<td>Postpartum hemorrhage</td>
<td>Peripartum heparin or warfarin</td>
<td>7 (2-22)</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Cyanosis</td>
<td>27 (4-177)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Predictors of pregnancy complications with congenital heart disease, ZAHARA.

- 1802 Belgian women with 1302 completed pregnancies
  - In the Congenital Corvitia (CONCOR) registry
  - All received care at a tertiary care facility

Cardiac Complications

- Cardiac Complications
  - episodes of arrhythmia
  - heart failure
  - thromboembolic complications
  - myocardial infarction
  - cerebrovascular accident
  - endocarditis (including first 6 months post-partum)

- Obstetric complications
  - pregnancy-induced hypertension
  - Preeclampsia/eclampsia
  - (HELLP) syndrome
Table 4: Multivariable model for the composite endpoints of cardiac and neonatal complications corrected for maternal age and parity

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Odds ratio (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of arrhythmias</td>
<td>4.3 (1.8–10.2)</td>
<td>0.0011</td>
</tr>
<tr>
<td>Other cardiac medication before pregnancy</td>
<td>4.2 (2.1–8.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>NYHA functional class</td>
<td>2.2 (1.1–4.5)</td>
<td>0.0298</td>
</tr>
<tr>
<td>LHO (PG &gt; 50 mmHg or AVA &lt; 1.0 cm²)</td>
<td>12.9 (3.9–42.3)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Syst AV valve regurgitation (moderate/severe)</td>
<td>2.0 (1.0–4.0)</td>
<td>0.0427</td>
</tr>
<tr>
<td>Pulm AV valve regurgitation (moderate/severe)</td>
<td>2.3 (1.1–5.0)</td>
<td>0.0287</td>
</tr>
<tr>
<td>Mechanical valve prosthesis</td>
<td>74.7 (5.3–1057)</td>
<td>0.0014</td>
</tr>
<tr>
<td>Cyanotic heart disease (corrected and uncorrected)</td>
<td>3.0 (1.7–5.0)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WHO class</th>
<th>Maternal mortality</th>
<th>Maternal morbidity</th>
<th>Types of CHD</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO I</td>
<td>No</td>
<td>No or mildly ↑</td>
<td>Mild pulmonary stenosis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Small uncomplicated PDA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Successfully repaired ASD, VSD, PDA, PAPVR</td>
</tr>
<tr>
<td>WHO II</td>
<td>Small ↑</td>
<td>Moderate ↑</td>
<td>Unoperated ASD or VSD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Repaired tetralogy of Fallot</td>
</tr>
<tr>
<td>WHO II–III</td>
<td>Depends on individual</td>
<td>Depends on individual</td>
<td>Mild LV impairment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nonsmoker or mild pulmonary disease, not WHO class I or IV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Marfan syndrome without aortic dilation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bicuspid aortic valve with &lt; 45 mm aortic root</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Repairable aortic coarctation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hypertrophic cardiomyopathy</td>
</tr>
<tr>
<td>WHO III</td>
<td>Significantly ↑</td>
<td>Severe</td>
<td>Systemic right ventricle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fontan circulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unrepaired cyanotic heart disease</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Other complex CHD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Marfan syndrome with aortic dilation of 40–45 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bicuspid aortic valve with aortic dilation of 45–50 mm</td>
</tr>
<tr>
<td>WHO IV</td>
<td>Extremely high</td>
<td>Severe</td>
<td>Pulmonary hypertension of any cause</td>
</tr>
<tr>
<td></td>
<td>Pregnancy is contraindicated</td>
<td></td>
<td>Severe systemic ventricular dysfunction (EF &lt; 30%, NYHA class III–IV)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Previous PPCM with residual LV dysfunction</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Severe symptomatic AS or MS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nonsmoker severe coarctation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Marfan syndrome with &gt; 45 mm aorta</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bicuspid aortic valve with &gt; 50 mm aorta</td>
</tr>
</tbody>
</table>

**Normal Findings In Pregnancy**
Normal Physical Exam Findings

- Bounding pulse
- **Systolic ejection murmur** (90% in 3rd trimester)
- **Third heart sound** (80% in 3rd trimester)
- Mammary souffle
- **Relative sinus tachycardia** (10-20 beats above baseline)
- Peripheral edema
- Elevated JVP (late in third trimester)


Normal Echocardiographic Changes During Pregnancy

- Mild 4-chamber dilatation
- Increase in LV mass
- **Trivial mitral regurgitation**
- Physiological tricuspid regurgitation
- Small pericardial effusion

Normal Lab Findings

- Anemia of pregnancy
  - Hemoglobin levels as low as 11 g/dL
- Elevated renin (increased intracellular volume)
- Elevated BNP (atrial and ventricular dilation)
  - Still generally within normal limit


Specific Cardiovascular Conditions and Management in Pregnancy
Valvular Heart Disease

- Any patient with known VHD or suspected significant stenosis should undergo pre-pregnancy evaluation (1,C)
  - H&P
  - EKG
  - TTE with doppler
  - Assessment of functional capacity (CPST)
    - Severe AS (1,C) → limited tolerance or drop in BP


Valvular Heart Disease

- Antenatal Visits through 28 weeks
  - Monthly in patients with mild disease
  - Q2 weeks in patients with moderate-severe disease

- Weekly after 28 weeks through delivery

- Repeat imaging with any change in symptoms (1,C)

Stages of Labor

- Stage 1 – Dilation of cervix to 10 cm
- Stage 2- Delivery of baby
- Stage 3- Delivery of placenta

Delivery Recommendations

- Vaginal Delivery preferred
  - Appropriate anesthesia
    - Reduced fluctuation in cardiac output
  - Shortened/ Assisted second stage of labor
  - C-section is associated with 2x blood loss

Delivery Recommendations

- Hemodynamic monitoring recommended during labor/delivery
  - Symptomatic patients
  - Moderate/severe valvular stenosis

- Patients with severe stenosis should be monitored in a tertiary care center with a dedicated team (1,C)


Native Mitral Stenosis

- Severe symptomatic or asymptomatic MS (MVA < 1.5 cm²) should be offered balloon valvuloplasty pre-pregnancy, if candidate (1,C)

- Mild MS (MVA > 1.5 cm²) tolerate pregnancy without intervention

Already pregnant?

- Mitral balloon valvuloplasty for patients with severe MS and symptoms (NYHA class III to IV HF) despite medical therapy (IIa,B)

- Mitral valve morphology is not amenable, mitral valve surgery (IIa,C)
  - 30-40% fetal mortality rate
  - 9% maternal mortality rate


Native Mitral Stenosis - Medication

- Anticoagulation should be given to pregnant patients with MS and AF (1, C)


Native Mitral Stenosis - Medication

- **Use of beta blockers** as required for rate control is reasonable. (IIa, C)
  - Beta 1 preferred over mixed agents (uterine relaxation)
  - **Metoprolol** is the preferred agent; Atenolol is associated with fetal growth restriction


Native Mitral Stenosis - Medication

- **Diuretics may be reasonable** for pregnant patients with MS and HF symptoms (stage D). (IIb: C)

Native Aortic Stenosis

- **Valve intervention** is recommended before pregnancy for **symptomatic** patients with **severe AS** (1,C)
  - It is reasonable for asymptomatic severe AS (IIa, C)

- **Medical therapy of AS during pregnancy** is limited to **cautious use of diuretics**

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Early and Intermediate-Term Outcomes of Pregnancy With Congenital Aortic Stenosis

- **39 women with 49 pregnancies**
- Followed at Toronto General and Mount Sinai Hospitals between 1986 and 2000

  - No cardiac complications occurred in women with mild to moderate AS during
  - **10% (3 of 29) of pregnancies** in patients with severe AS experienced cardiac complication AS (p 0.001)

---

Mechanical Valves
Warfarin Teratogenicity

- Increase in spontaneous abortion throughout pregnancy

- Vulnerable Period 6-12 weeks:
  - Characteristic facial malformations
    - cartilage maldevelopment
    - nasal hypoplasia
    - depressed nasal bridge
  - bifid spine
  - hydrocephalus
  - optic atrophy
  - spasticity

- 2nd and 3rd trimester exposure
  - microcephaly
  - mental retardation
  - optic atrophy

Anticoagulation of Pregnant Women with Heart Disease

- Chan et al. Literature review
  - 40 articles reviewed – 28 included
    - Only 6 were cohort studies
  - 976 women with 1234 pregnancies
  - Original studies published between 1966 - 1997

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. of Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve type</td>
<td></td>
</tr>
<tr>
<td>Cape and ball</td>
<td>369</td>
</tr>
<tr>
<td>Starr-Edwards</td>
<td>39</td>
</tr>
<tr>
<td>Cutter</td>
<td>34</td>
</tr>
<tr>
<td>Single-tilting disc</td>
<td>273</td>
</tr>
<tr>
<td>Bjork-Shiley</td>
<td>44</td>
</tr>
<tr>
<td>Lifshitz-Kottor</td>
<td>39</td>
</tr>
<tr>
<td>Medtronic Hall</td>
<td>29</td>
</tr>
<tr>
<td>Bi-leaflet</td>
<td>55</td>
</tr>
<tr>
<td>St. Jude</td>
<td>7</td>
</tr>
<tr>
<td>DuraMedics</td>
<td>7</td>
</tr>
<tr>
<td>Other</td>
<td>9</td>
</tr>
<tr>
<td>Cross-Jones</td>
<td>11</td>
</tr>
<tr>
<td>Savin</td>
<td>11</td>
</tr>
<tr>
<td>Heterograft</td>
<td>2</td>
</tr>
<tr>
<td>Carpentier-Edwards</td>
<td>1</td>
</tr>
<tr>
<td>Total*</td>
<td>647</td>
</tr>
</tbody>
</table>

* Data are not known for 194 women.
### Table 2. Frequency of Fetal Complications Reported With Various Anticoagulation Regimens

<table>
<thead>
<tr>
<th>Anticoagulation Regimen</th>
<th>Spontaneous Abortion</th>
<th>Congenital Anomaly</th>
<th>Fetal Wasteage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regimen 1 (oral anticoagulants throughout)</td>
<td>196/792 (24.7%) [18.5-29.6%]</td>
<td>65/49 [13.6-41.8%]</td>
<td>120/792 (15.4%) [10.4-20.4%]</td>
</tr>
<tr>
<td>Regimen 2 (heparin 1st trimester, oral anticoagulants)</td>
<td>19/28 (6.8%) [2.6-11.5%]</td>
<td>0/108 (0.0%) [0.0-0.3%]</td>
<td>21/28 (16.9%) [9.2-28.4%]</td>
</tr>
<tr>
<td>Heparin use after 6 wk</td>
<td>19/28 (6.8%) [2.6-11.5%]</td>
<td>0/108 (0.0%) [0.0-0.3%]</td>
<td>21/28 (16.9%) [9.2-28.4%]</td>
</tr>
<tr>
<td>Heparin use at unknown time in 1st trimester</td>
<td>19/28 (6.8%) [2.6-11.5%]</td>
<td>0/108 (0.0%) [0.0-0.3%]</td>
<td>21/28 (16.9%) [9.2-28.4%]</td>
</tr>
<tr>
<td>Total</td>
<td>57/230 (24.8%) [13.6-41.8%]</td>
<td>6/174 (3.4%) [1.4-7.7%]</td>
<td>61/230 (26.5%) [16.7-42.8%]</td>
</tr>
<tr>
<td>Regimen 3 (heparin throughout)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted-dose heparin</td>
<td>4/16 (25.0%) [8.4-52.4%]</td>
<td>0/12 (0.0%) [0.0-0.3%]</td>
<td>7/16 (43.8%) [20.9-69.3%]</td>
</tr>
<tr>
<td>Low-dose heparin</td>
<td>1/5 (20.0%) [1.0-69.8%]</td>
<td>0/5 (0.0%) [0.0-0.3%]</td>
<td>2/5 (40.0%) [7.3-82.7%]</td>
</tr>
<tr>
<td>Total</td>
<td>5/21 (23.8%) [9.2-47.4%]</td>
<td>0/17 (0.0%) [0.0-0.3%]</td>
<td>9/21 (42.9%) [22.7-66.5%]</td>
</tr>
<tr>
<td>Regimen 4 (no anticoagulation)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nothing</td>
<td>2/35 (5.7%)</td>
<td>2/33 (6.1%)</td>
<td>7/35 (20.0%)</td>
</tr>
<tr>
<td>Antithrombotic agent</td>
<td>8/67 (11.9%)</td>
<td>1/59 (1.7%)</td>
<td>13/67 (19.4%)</td>
</tr>
<tr>
<td>Total</td>
<td>10/102 (9.9%) [5.1-17.7%]</td>
<td>3/62 (4.8%) [0.9-9.9%]</td>
<td>20/102 (19.6%) [12.7-26.9%]</td>
</tr>
</tbody>
</table>

### Table 4. Frequency of Maternal Complications Reported With Various Anticoagulation Regimens

<table>
<thead>
<tr>
<th>Anticoagulation Regimen</th>
<th>Thromboembolic Complications</th>
<th>Death (All Causes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regimen 1 (oral anticoagulants throughout)</td>
<td>30/780 (3.9%) [2.9-5.5%]</td>
<td>10/561 (1.8%) [0.9-3.4%]</td>
</tr>
<tr>
<td>Regimen 2 (heparin 1st trimester, oral anticoagulants)</td>
<td>21/224 (9.4%) [5.9-13.9%]</td>
<td>7/159 (4.4%) [1.9-8.8%]</td>
</tr>
<tr>
<td>Regimen 3 (heparin throughout)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted-dose heparin</td>
<td>4/16 (25.0%) [8.4-52.4%]</td>
<td>1/15 (6.7%) [0.0-32.1%]</td>
</tr>
<tr>
<td>Low-dose heparin</td>
<td>2/6 (33.3%) [17.3-92.5%]</td>
<td>2/6 (33.3%) [7.5-82.7%]</td>
</tr>
<tr>
<td>Total</td>
<td>7/21 (33.3%) [15.6-56.8%]</td>
<td>3/20 (15.0%) [3.9-37.2%]</td>
</tr>
<tr>
<td>Regimen 4 (no anticoagulation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nothing</td>
<td>6/38 (15.8%)</td>
<td>2/37 (5.4%)</td>
</tr>
<tr>
<td>Antithrombotic agent</td>
<td>20/69 (29.0%)</td>
<td>3/69 (4.3%)</td>
</tr>
<tr>
<td>Total</td>
<td>26/107 (24.3%) [16.6-33.4%]</td>
<td>5/106 (4.7%) [1.8-11.2%]</td>
</tr>
</tbody>
</table>
Conclusions

- 4-33% risk of valve thrombosis with pregnancy
  - Lowest risk with Warfarin throughout
  - Risk of valve thrombosis increases most drastically when Heparin used exclusively in 1st trimester
Conclusions

- Risk of Warfarin embryopathy is 6% when Warfarin is used throughout pregnancy
  - Risk reduced when replaced with Heparin between week 6-12 (~3.4%)

Conclusions

- Fetal Wastage (spontaneous abortion or still birth) is significant throughout pregnancy independent of method or timing of anticoagulation
  - 26.5-42.9% on Heparin only, Heparin then Warfarin or Warfarin only

Conclusions

1-4% maternal mortality in pregnancy with mechanical valve


Warfarin associated teratogenicity

- Vitale et al.
  - Data collected from December 1987 to May 1997
  - 43 women on warfarin with mechanical heart valves
    - 58 pregnancies were studied
      - 31 healthy babies
      - 27 fetal complications

<table>
<thead>
<tr>
<th>Dose</th>
<th># of Pregnancies</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5 mg / day</td>
<td>33 (28 healthy full term)</td>
<td>4 spontaneous abortions, 1 growth retardation</td>
</tr>
<tr>
<td>&gt;5mg /day</td>
<td>25 (3 healthy full term)</td>
<td>2 warfarin embryopathy, 18 spontaneous abortions, 1 still-birth, 1 VSD</td>
</tr>
</tbody>
</table>


![Diagram of dose and complications](image-url)
Maternal complications and pregnancy outcome in women with mechanical prosthetic heart valves treated with enoxaparin

C McLintock," LME McCowan,³ RA North¹

Table 3. Maternal thromboembolic and haemorrhagic complications

<table>
<thead>
<tr>
<th>Maternal complications</th>
<th>Number of events (n = 47 pregnancies)</th>
<th>Percentage (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thromboembolism</td>
<td>7</td>
<td>14.9 (7.0–27.7)</td>
</tr>
<tr>
<td>Enoxaparin related</td>
<td>5</td>
<td>10.6 (4.2–22.6)</td>
</tr>
<tr>
<td>Antepartum</td>
<td>3</td>
<td>6.4 (2.2–17.2)</td>
</tr>
<tr>
<td>Postpartum</td>
<td>2</td>
<td>4.2 (1.2–10.3)</td>
</tr>
<tr>
<td>Unrelated to enoxaparin</td>
<td>2</td>
<td>4.2 (1.2–10.3)</td>
</tr>
<tr>
<td>Antepartum bleeding*</td>
<td>8</td>
<td>17.0 (8.9–29.1)</td>
</tr>
<tr>
<td>Enoxaparin related</td>
<td>5</td>
<td>10.6 (4.6–22.6)</td>
</tr>
<tr>
<td>Unrelated to enoxaparin</td>
<td>3</td>
<td>6.6 (2.2–17.2)</td>
</tr>
<tr>
<td>Postpartum bleeding*</td>
<td>9</td>
<td>19.1 (10.6–32.5)</td>
</tr>
<tr>
<td>Enoxaparin related</td>
<td>6</td>
<td>12.7 (4.0–25.2)</td>
</tr>
<tr>
<td>Unrelated to enoxaparin</td>
<td>3</td>
<td>6.6 (2.2–17.2)</td>
</tr>
</tbody>
</table>

*Includes secondary PPH and other major bleeding; primary PPH were excluded.

Author, Year, Study Size (N), Type of Anticoagulant, Study Type, Endpoints, Summary

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Study Size (N)</th>
<th>Type of Anticoagulant</th>
<th>Study Type</th>
<th>Endpoints</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>James, 2006</td>
<td>76 pregnancies</td>
<td>LMWH throughout pregnancy</td>
<td>Meta-analysis</td>
<td>22% thrombotic events, 4% maternal mortality</td>
<td>No congenital anomalies, 8 spontaneous abortions</td>
</tr>
<tr>
<td>Oran, 2004</td>
<td>81 pregnancies in 75 women</td>
<td>LMWH 1st trimester, then warfarin vs. LMWH throughout pregnancy</td>
<td>Meta-analysis</td>
<td>12% had thromboembolism-all MVR</td>
<td>Spontaneous abortion in 7.4%</td>
</tr>
</tbody>
</table>
And... Aspirin!

- **Low-dose aspirin** (75mg to 100 mg) once per day is recommended for pregnant patients in the **second and third trimesters** (1, C)

  - “Although there are no data regarding the addition of aspirin to anticoagulation in pregnant patients with prosthetic valves, the addition of aspirin is effective in lowering the thromboembolic risk in non-pregnant patients”
Pre-existing Cardiomyopathies

- Patients with dilated cardiomyopathy (LVEF <40%) have been advised to avoid pregnancy
  - Limited data
Followed 32 women (36 pregnancies) over 16 months

Idiopathic or doxorubicin-induced DCM with LVEF of <45%
- Peri-partum cardiomyopathy excluded

Non-pregnant women with DCM were matched with pregnant women

Enrolled between December 1994 and July 2008

---

**Table 2**

<table>
<thead>
<tr>
<th>Any Cardiac Event</th>
<th>Cardiac Arrest or Death</th>
<th>Heart Failure</th>
<th>Arrhythmia</th>
<th>Stroke/TIA</th>
<th>Angina or MI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>17</td>
<td>0</td>
<td>9</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Timing of events</td>
<td></td>
<td>14/36 = 39% of pregnancies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antepartum</td>
<td>10</td>
<td>0</td>
<td>4</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Labor and delivery</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Post-partum (6 months)</td>
<td>5</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Events are not mutually exclusive. Fourteen pregnancies complicated by 1 or more event. MI = myocardial infarction; TIA = transient ischemic attack.
HF Medication Therapy

- **Goal to stay on prior to pregnancy therapy** with some exceptions
  - ACEi/ARB and Aldosterone Antagonists (Class D)


HF Medication Therapy

- **Vasodilator** therapy can be accomplished with Isordil/Hydralazine (both Class C)
  - Use caution with precipitous drop in BP

HF Medication Therapy

- Beta 1 Selective Beta Blockers are preferred
  - Metoprolol (Class C) preferred over Atenolol
  - Infants born to mothers on BB should be observed for 72 hours (neonatal hypoglycemia and bradycardia)


Delivery Recommendations

- Vaginal Delivery preferred except for OB reasons
  - Left lateral decubitus position
    - Reduce compression on the IVC
  - Appropriate anesthesia
    - Reduced fluctuation in cardiac output
    - Decreased sympathetic activity
    - Decreased Valsalva maneuver
  - Hemodynamic monitoring recommended during labor/delivery
  - Fetal head should descend without active pushing
  - Shortened/ Assisted second stage of labor
  - C-section is associated with 2x blood loss

Ascending Aortic Aneurysm

- **High risk features**
  - Aortic root enlargement (> 4cm)
  - Increase of aortic root size during pregnancy
  - Bicuspid aortic valve disease
  - Marfan syndrome

- Gestational hormones may be additive to the hemodynamic strain


Ascending Aortic Aneurysm

- **Bicuspid Aortic Valve**
  - Recommend against pregnancy if > 5.0 cm
  - Risk/benefit conversation if the aorta is between 4.5 and 5 cm
  - Pregnancy is reasonable if ≤ 4.5 cm

- Prophylactic C section if aorta is >4.5 cm

Ascending Aortic Aneurysm

- **Marfan Syndrome**
  - **Recommend against pregnancy** if > 4.5 cm
  - **Vaginal Delivery** is lower risk if ≤ 4.0 cm
  - **However, there is no guarantee…**
    - Dissection in 1% in women with aortic diameter <40 mm
    - **Dissection in 10% in high-risk patients**
      - aortic root diameter >40 mm
      - rapid dilatation
      - previous dissection of the ascending aorta


Ascending Aortic Aneurysm Management

- **Strict blood pressure** control is recommended (1,C)
- **Monthly or bimonthly TTE** is recommended (1,C)
- Pregnant women with aortic aneurysms should be delivered where cardiothoracic surgery is available (1,C)

Ascending Aortic Aneurysm

- Delivery via cesarean section is reasonable for patients with significant aortic enlargement, dissection (IIa,C)


Who needs invasive monitoring in the ICU?

- Severe or symptomatic valvular stenosis
- Depressed LV function or symptomatic CHF

Maxwell et al. Peripartum outcomes and anaesthetic management of parturients with moderate to complex congenital heart disease or pulmonary hypertension. Anaesthesia. 2013; 68, 52-59
Common situations... quick pearls

- Contraception
- Hypertension

Contraception

- Estrogen is associated with thromboembolism and hypertension

Contraception

- Other options
  - Progestin only oral contraception
    - “Mini-pill” – high rate of failure (5-10%)
  - Injectable or implantable progestin only formulations
Hypertension in Pregnancy

- **Gestational hypertension (>140/90) after the 20th week of pregnancy without proteinuria**
  - 50% of patients with GA will develop pre-eclampsia
  - 25% of patients with chronic hypertension will develop pre-eclampsia
- **Drugs of choice include Labetalol and Methyldopa**

Summary

- Cardiovascular disease complicating pregnancy is not uncommon and carries a serious prognosis
- Significant maternal hemodynamic changes accompany pregnancy
- Valvular heart disease confers significant maternal morbidity and mortality
- Pre-existent dilated cardiomyopathy may progress as a result of the hemodynamic strain of pregnancy
Thank-you