HEART FAILURE IN PREGNANCY

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3 million women age 18-44 in the US have heart disease
~ 1% of pregnant women
### Pregnancy Related Deaths

North Carolina 1996-99

<table>
<thead>
<tr>
<th>Cause of Death</th>
<th>% of All Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiomyopathy</td>
<td>21%</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>14</td>
</tr>
<tr>
<td>PIH</td>
<td>10</td>
</tr>
<tr>
<td>CVA</td>
<td>9</td>
</tr>
<tr>
<td>Chronic condition</td>
<td>9</td>
</tr>
<tr>
<td>AFE</td>
<td>7</td>
</tr>
<tr>
<td>Infection</td>
<td>7</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>6</td>
</tr>
</tbody>
</table>

Berg CJ et al. Obstet Gynecol 2005

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### Important cause of maternal morbidity and mortality

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- **What causes it?**
  - The basics of cardiac physiology
  - Underlying cardiac disease
  - Pregnancy induced cardiac failure

- **Can we prevent?**
Heart Failure in Pregnancy

- Structural Cardiac Disease
- Pregnancy induced cardiac dysfunction
- Arrhythmias
- Other

What causes it?
- The basics of cardiac physiology
- Underlying cardiac disease
- Pregnancy induced cardiac failure

Can we prevent?
Hemodynamic changes
- Plasma volume
- Heart rate
- Stroke volume
- Cardiac output

Hemodynamic Changes During Pregnancy

Plasma Volume


Cardiac Output

PHYSIOLOGIC CHANGES

- **AUSCULTATION**
  - 96% have a “functional murmur”
    - Mid-systolic and low intensity - LUSB
  - Third heart sound is common

- **EKG CHANGES**
  - QRS axis deviation
  - ST-T wave changes
  - Sinus tachycardia and arrhythmias

Chest X-ray During Normal Pregnancy

Cardiac Chamber Dimensions (mm) During Normal Pregnancy and Puerperium

<table>
<thead>
<tr>
<th>Table 2.6</th>
<th>Cardiac Chamber Dimensions (mm) During Normal Pregnancy and Puerperium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chamber</td>
<td>8th-12th</td>
</tr>
<tr>
<td>-----------</td>
<td>----------</td>
</tr>
<tr>
<td>LV</td>
<td>41 ± 3</td>
</tr>
<tr>
<td>LA</td>
<td>30 ± 2</td>
</tr>
<tr>
<td>RV</td>
<td>30 ± 2</td>
</tr>
<tr>
<td>RA</td>
<td>43 ± 2</td>
</tr>
</tbody>
</table>

Abbreviations: LA, left atrium; LV, left ventricle; RA, right atrium; RV, right ventricle
Source: Reproduced with permission from Cantor G. Ecocardiografia 1990;12:135-165
**PHYSIOLOGIC CHANGES**  
*“Pregnancy Mimics Heart Disease”*

- **SYMPTOMS**
  - Reduction of exercise tolerance
  - Hyperventilation - shortness of breath

- **SIGNS**
  - Edema
  - JVD
  - Murmurs

**What causes it?**
- The basics of cardiac physiology
- **Underlying cardiac disease**
- Pregnancy induced cardiac failure

**Can we prevent?**

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**Valvular Heart Disease in Pregnancy**

- **Case**
  - 24 yo Hispanic female G1 @ 33 wks
  - Progressive dyspnea for 3 months
  - SOB and productive cough
  - CXR: Bilateral infiltrates
  - EKG: Sinus tachycardia
  - Treated for pneumonia x 5 days
  - No improvement
SYMPTOMS OF MITRAL STENOSIS

DYSPEA - Increased left atrial pressure
FATIGUE - Fixed cardiac output
ANKLE EDEMA - Right heart failure

Cardiac Risk in Rheumatic Mitral Stenosis

Silversides et al. AJC 2003:91:1382
Aortic Stenosis

- Rare in pregnancy
- Pregnancy contraindicated if symptomatic

**Symptoms of Aortic Stenosis**
- Chest pain
- Dizziness/Syncope
- Dyspnea

**Aortic Stenosis in Pregnancy - Case -**

- 36 yo Hispanic female G2 P1 at 16 3/7 wks
- NYHA functional class II
- EKG: Normal sinus rhythm
- Echocardiogram:
  - EF 66%,
  - Bicuspid aortic valve, AVA 0.9 cm$^2$, Peak gradient 64 mm Hg
Valvular Disease in Pregnancy -Case-
- Symptoms of CHF at ~ 27 weeks
- Percutaneous Aortic balloon valvuloplasty @ 28 weeks
  - AVA 1.2
  - Peak gradient 40 mm Hg
- Delivery at 36 weeks after fetal lung maturity

Aortic Stenosis and Pregnancy
Maternal Outcome

What causes it?
- The basics of cardiac physiology
- Underlying cardiac disease
- Pregnancy induced cardiac failure

Can we prevent?
Cardiomyopathy
Case # 1
- 34 year old AA gravida 1 @ 20 weeks
- Pregnancy complicated by hypercalcemia, pancreatitis, parathyroidectomy
- Uncomplicated course thereafter
- Normal delivery at 40 weeks, male infant 3450 gm with Apgars of 9 and 9

--------- Case #1
- Presented with shortness of breath and cough 7 days after delivery
- CXR: bilateral alveolar infiltrates
- Echo:
  - Global hypokinesis with EF 35%
  - No wall motion or valvular abnormality
- Treatment: Loop diuretics, ACE inhibitors, beta blockers, digoxin

--------- Case #1
- Follow up at 3 months
- NYHA functional class I
- Echo:
  - Normal left ventricular function
  - EF 55%
Peripartum Cardiomyopathy (PPCM)

What is PPCM?
An idiopathic dilated CMP presenting in the 2nd or 3rd trimester of pregnancy or within several months postpartum associated with depressed LV systolic function

What is PPCM?
- Development of HF in the last month of pregnancy or within 5 months of delivery
- Absence of identifiable cause for HF
- Absence of recognizable heart disease prior to the last month of pregnancy
- Left ventricular systolic dysfunction demonstrated by echocardiography

Incidence of peripartum cardiomyopathy in various populations

- Recent surveys in the US and Canada found a ratio of 1~2300 live births (~1300 cases/year)
- Higher incidence reported in South Africa (1:1000) and in Haiti (1:300)

Circ 2004;110:III 520

Peripartum Cardiomyopathy

Risk Factors

- The exact cause of PPCM remains unknown
  - Age >30
  - Poor nutrition - Selenium deficiency
  - African American
  - Multiple gestation
  - Long term tocolytic therapy
  - History of preeclampsia
  - Immunological mechanisms / Myocarditis
  - Stress-activated proinflammatory cytokines (TNF-α or interleukin 1)
  - Abnormalities of relaxin, prolactin
Who is at Risk?

Pregnancy Associated Cardiomyopathy

Index Pregnancy

- 1st: 42%
- 2nd: 17%
- 3rd: 17%
- 4th: 10%
- ≥ 5th: 14%

n=123

Elkayam et al. Circulation 2005;111:2050

How Does it Present?

- Heart failure
- Arrhythmias +/- HF
- Thromboembolism
- Asymptomatic LV dysfunction
Outcome of PPCM

123 Patients

- Recovery EF ≥ 50% (at last f/u) 54%
- Persistent LV dysfunction (at last f/u) 41%
- Cardiac Transplantation 4%
- Death 9% (2 pts died post transplant)

Predictors of LV dysfunction?

- Severe of LV dilatation and systolic dysfunction @ diagnosis
- Evidence for myocardial cell damage (Troponin T level >0.04 ng/ml within 2 weeks of diagnosis)
  (Hu CL et al Heart 2007;93:488-90)
- Lack of recovery at 2-6 months
- African American race

When Does the LV Recover?
Recovery of LVEF in 40 Patients

LVEF %

Dx 6 m PP 12 m PP Last F/U

45 ± 13% 48 ± 11% 46 ± 14%

p=0.000001 vs LVEF at diagnosis

Elkayam et al. Circulation 2005;111:3090

Is the normalization of LV function complete post PPCM?

Contractile Reserve in Patients With PPCM and Recovered Left Ventricular Function

Lampert et al. AM J Ob Gyn 1997; 176:189
Survival According to the Underlying Cause of Heart Failure

Felker et al NEJM 2000;342:1077

Peripartum Cardiomyopathy

Treatment

- ACE - I, Beta blockers, aldosterone receptor antagonists + AC until LV nl
  - Nitrates, hydralazine, diuretics
  - **Unsafe**: ACE-I, Nitroprusside, Amiodarone, Coumadin

- Temporary mechanical support – IABP or LVAD may be useful as a bridge to recovery of LV function

Peripartum Cardiomyopathy

Experimental Therapy

- Preliminary data suggest benefit of:
  - immunosuppressive and immunomodulating therapy (pentoxifylline)
  - Bromocriptine – prolactin inhibitor
Previous Pregnancy with PPCM

What is the Risk of Subsequent Pregnancy?

Maternal and Fetal Outcomes of Subsequent Preganacies in Women With PPCMP

Outcomes of Subsequent Pregnancy in Patients with Persistent LV Dysfunction

- Fett et al (Ann Int Med 2006;145:30-34)
  - 16 pregnancies in 15 patients
  - 8 had worsening HF
  - 1 died 10 month postpartum

- Sliwa et al (Am J Cardiol 2004;93:1441-1443)
  - 5 pregnancies
  - 4 had deterioration of LV function
  - 2 died within 8 weeks postpartum
Subsequent pregnancy may lead to a significant and persistent depression of LVEF, CHF and even death.
Dilated Cardiomyopathy

- DCM – dilated ventricle with reduced LVEF in the absence of coronary, valvular, congenital, or any systemic diseases known to cause myocardial dysfunction

Dilated CMP in Pregnancy

- Rare
- Worsening during pregnancy
- Pregnancy termination recommended
- Reported postpartum complications
  - Stroke
  - Thromboembolism
  - Death

Pregnancy Outcomes in women With Dilated Cardiomyopathy

- 36 pregnancies (32) women vs. 18 non-pregnant women – 16 m fu
- LVEF <45%
- Maternal outcomes
- Fetal outcomes
- Obstetrical Complications

Grewal et al. JACC 2010
**DCM – Incidence of Adverse Cardiac Events According to Maternal Risk Factors**

- Cardiac complications in 39%
  - Pulmonary edema, arrhythmia, stroke, angina/MI, cardiac arrest, death
- No maternal deaths
- Fetal complications 20%
  - Preterm delivery, IUGR, RDS, IVH, IUFD, neonatal death

Grewal et al. JACC 2010

**DCM – Maternal Cardiac Outcomes**

- Moderate or severe LV dysfunction +/- NYHA functional class III or IV +/- history of cardiac events
  - 70-75% events in EF<45%
  - 50% of these women had hx
  - 25% were in NYHA class III/IV

**DCM – Obstetrical and Fetal Outcomes**

<table>
<thead>
<tr>
<th>Adverse obstetrical outcomes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total events</td>
<td>5/36</td>
</tr>
<tr>
<td>Pre-eclampsia</td>
<td>3 (8%)</td>
</tr>
<tr>
<td>Post-partum hemorrhage</td>
<td>2 (5%)</td>
</tr>
<tr>
<td>Noncardiac death</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adverse fetal outcomes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total events</td>
<td>7/35  (20%)</td>
</tr>
<tr>
<td>Live birth weight &lt;2500 gm</td>
<td>3 (14%)</td>
</tr>
<tr>
<td>Pre-term delivery &lt;37 weeks</td>
<td>3 (14%)</td>
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<tr>
<td>Intraventricular hemorrhage</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Respiratory distress</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Fetal death</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Neonatal death</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Intrauterine growth retardation</td>
<td>2 (2)</td>
</tr>
</tbody>
</table>

Grewal et al. JACC 2010
How Does Pregnancy Impact Cardiac Events?

- Pregnant (72%[13/18]) vs. Non-pregnant (17%[3/18])
- Event free survival worse in pregnant women

Grewal et. al. JACC 2010

What causes it?

- The basics of cardiac physiology
- Underlying cardiac disease
- Pregnancy induced cardiac failure

Can we prevent?

Cardiac Evaluation During Pregnancy

- Complicated by pregnancy related anatomical and functional changes
- Signs and symptoms that can either simulate or obscure heart disease
Can We Prevent Heart Failure?
- Pre pregnancy evaluation
- Optimize cardiac status
- Careful follow up through pregnancy
- Attention to sign/symptoms

Maternal Evaluation
- Detailed history and physical examination
- Cardiac testing:
  - EKG +/- CXR
  - Echocardiogram
  - Holter monitor
  - Exercise stress testing or echocardiogram
  - Cardiac catheterization
- Fetal echocardiogram if congenital heart disease

Maternal Evaluation – Functional Capacity
- Class I: Asymptomatic
- Class II: Symptoms with > normal activity (>2 blocks)
- Class III: Symptoms with normal activity (<2 blocks)
- Class IV: Symptoms at rest
Pregnancy Risk Assessment for all Cardiac Patients

1. NYHA class II or cyanosis
2. Obstruction – AVA <1.5 cm², MVA <2 cm² or peak LVOT gradient 30 mm Hg
3. Previous history – CHF, arrhythmia, TIA, or stroke
4. Ejection fraction <40%

*Risk of CHF, arrhythmia, stroke, cardiac arrest or death


Cardiac Biomarkers

- Troponin
- Creatine kinase
- BNP

Troponins - Pregnancy

- Minimal increase in pregnancy
  - Well below the threshold levels
- Increased levels seen in hypertensive disorders of pregnancy
  - 0.155 ng/ml vs. 0.089 ng/ml*
- Troponins increase with prolonged tocolytic therapy
  - 0.08 ug/l vs. 0.35 ug/l

Creatine Kinase - CK

- Normal levels during pregnancy
- Increases in the immediate postpartum period and peaks at 24 hours

B Type Natriuretic Peptide

- Neurohormone secreted from cardiac ventricles in response to ventricular volume expansion and pressure overload

BNP levels in Normal Pregnancy

[Image: Short Communication: Longitudinal Changes in the B-Type Natriuretic Peptide Levels in Normal Pregnancy and Postpartum]
**Conclusion**

- Median BNP values followed longitudinally in normal healthy pregnancies are:
  - 1st trimester: 19.5 pg/mL
  - 2nd trimester: 18.0 pg/mL
  - 3rd trimester: 26.5 pg/mL
  - Postpartum: 18.5 pg/mL
- No statistically significant difference in BNP levels throughout pregnancy and puerperium

**Markers of myocardial damage have similar utility during pregnancy**

- BNP levels are useful in follow up of pregnant patients with heart failure

**Summary**

- Early diagnosis is critical
- Cardiac symptoms in pregnancy should be evaluated similar to those outside of pregnancy
- Most patients with significant cardiac disease benefit by multidisciplinary management