Cardiovascular Imaging in Pregnancy

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Cardiovascular disorders – 4% of all pregnancies

- PE
- DVT
- Aortic dissection
- Peripartum cardiomyopathy
- Acute coronary syndrome
- Hypertension
- Pneumonia
- Anxiety
Imaging in pregnancy: Challenging aspects

I. Changing physiology

- 40% ↑ Plasma volume at 24 weeks gestation
- 30–50% ↑ CO
- 30% ↑ Heart size
- Virchow's triad: hypercoagulability, venous stasis, and vascular damage
- ALL of the above - altered hemodynamics
Imaging in pregnancy: Challenging aspects

II. Safety aspects

• “2 in 1” imaging
• Imaging techniques optimal for the mother might be harmful for the fetus
• CTA MR US V/Q pros/cons
Lecture outline

Safety aspects

MR exposure/ Gadolinium
CT radiation exposure/ Iodine contrast

Cardiovascular diseases during pregnancy

PE
Acute coronary syndrome
Peripartum Cardiomyopathy
Aortic dissection
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ACR White Paper on MR safety:

“Pregnant patient should undergo MR only if:

• The required information cannot be obtained via non-ionizing means
• The information is likely to alter patient care
• The examination cannot wait until after completion of the pregnancy”

2007
MRI Safety - Tissue Heating

- Specific Absorption Rate (SAR) – regulated by FDA
- SAR units do not currently exist for pregnant patients
- Majority of the heating – superficial
- Single shot echo train spin echo – common in fetal imaging

- 1.5 T ≠ 3T

Chen MM et al Obstet Gynecol 2008
Leyendecker et al Radiographics 2004
MRI Safety-Teratogenesis

- **No** scientific evidence in humans of teratogenesis seen up to 9 years after MRI examination
- **Acoustic damage**: No scientific evidence in humans of acoustic damage

Chen MM et al. Obstet Gynecol 2008
Kok et al. Magn Reson Imaging 2004
MRI Safety - Gadolinium

• Crosses the placenta
• Excreted by fetal kidneys
• No evidence of teratogenesis in humans
• Sporadic evidence of animal teratogenesis (high and repeated doses)
• Toxic free gadolinium (minimal)
• Mother/Fetus concentration: 100/1
• No fetal adverse effects documented

Okuda et al J Toxicol Sci 1999
Chen MM etal. Obstet Gynecol, 2008
Webb et al Eur Radiol, 2005
MRI Safety - Gadolinium

- US FDA – **Category C agent**: administered if the potential benefit justifies the potential risk to the fetus
- ACR: 1. No sufficient evidence to conclude no risk  
  2. Gadolinium should not be given unless absolutely necessary

- If Gd has been administered – NO neonatal tests are necessary
- NO interruption of lactation

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Halvorsen et al Radiology 2008
Webb et al Eur Radiol, 2005
Lecture outline

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CT Safety
Radiation - Fetus

Stochastic effects
- Carcinogenesis
  - Baseline risk 0.05%
  - No threshold
  - 50 mGy exposure ~ RR 2

Deterministic effect
- Teratogenesis
  - 100–500 mGy – induced abortion
  - Organogenesis defects - above 100 mGy
  - No Adverse Effect Level

Brent et al. Saving lives…. Am J Obs&Gyn, 2009
ACR Practice guideline for imaging pregnant pts 2008
Fetal Radiation – Deterministic Effect

Hurwitz LM et al. AJR 2006
ACR Practice guideline for imaging pregnant pts, 2008
Fetal Radiation - Deterministic Effect

CT/VQ radiation X 50 less than 100mGy threshold for medical TOP

Hurwitz LM et al. AJR 2006
CT Safety
Radiation - Mother

CTA

• Estimated breast radiation - 10-50 mGy
  1 CTA ~15 mammograms
• 0.7-1% life time excess RR for breast cancer at age 25

V/Q

• Estimated breast radiation - 0.28 mGy
  1 V/Q ~ 0.1 mammogram ~ 0.01 CTPA

Einstein AJ et al. JAMA 2007
Hurwitz LM et al. Radiology 2007
CTA - Strategies to reduce radiation
BIDMC Pregnancy CTPA Protocol

- Reduce mAs <100
- Reduce kVp <100
- Reduce z-axis
- ↑Pitch
- Oral barium
- Consenting!

Maintained Image Quality

Low Radiation Dose

Litmanovich D et al. JCAT, 2009
Vollmar SV Eur Radiology 2008
Yousefzadeh HT et al. Radiology 2006
Breast, Lung, and Pelvic Organ Radiation – Phantom study

Breast - 4.9 mGy
Pelvis - < 0.2 mGy

Litmanovich et al. AJR, Oct. 2011
CT Safety

IV Iodinated contrast

• Crosses placenta, excreted by fetal kidneys
• Potential to produce neonatal hypothyroidism
• BUT no effect so far reported
• ACR 2008 - Iodinated contrast media may be given to pregnant patient if needed

• If iodine has been administered - neonate thyroid function should be checked
• NO interruption of lactation

Bona et al. Eur J Rad 1992
Ito n Engl J Med 2000
Consent is essential!

- Radiology facilities - process for evaluating pregnant patients
- Radiologists - knowledgeable about MRI/CT exposure effects, accessible to patients and referring physicians
- Discussion with patients about the risks/benefits should be documented in the radiology report

(a) Need for imaging and the importance of the diagnosis for the patient’s care
(b) Brief explanation of the ordered imaging test
(c) Summarize the estimated risks to mother and fetus
(d) Confirm the patient’s understanding of and consent to the diagnostic imaging test

Berlin L. AJR 1996
Lecture outline

Safety aspects

MR exposure/ Gadolinium
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• Technical safety aspects
  MR exposure
  CT radiation exposure
  IV contrast administration

• Cardiovascular diseases during pregnancy
  PE
  Acute coronary syndrome
  PPCM
  Aortic dissection
Peripartum cardiomyopathy

- Heart failure due to LV systolic dysfunction
- Last month of pregnancy till 5-6 months after delivery
- 16 kDa prolactin derivate
- Only 30-50% - recover back to baseline
- High risk of recurrence
Peripartum Cardiomyopathy

- Diagnosis of exclusion
- Echocardiography:
  - EF < 45%
  - Fractional shortening <30%
  - LV End Diastolic Dimension>2.7 cm/m2
- CMR – potential role in diagnosis and prognosis

Barone-Rochette et al Arch Cardiovasc Dis 2011
Kawano H et al; Intern Med 2008
Case 1

No late Gd enhancement

Case 2

Late Gd enhancement

Marmursztejn J et al. J of Cardio 2009
Peripartum Cardiomyopathy - MRI

- May be negative
- If positive - no specific pattern negative

↑ T2

- Normal signal
- Non-inflammatory
  - Better prognosis

- Delayed GDE
- Inflammatory
  - Worse prognosis
Venous thromboembolism

- DVT and PE
- VTE - 5 – 12 per 10,000 pregnancies (0.05-0.20%)
- PE - 2 – 3 per 10,000 pregnancies, 1.5 death per 100,000 pregnancies
- Second most common cause of maternal death overall
- Peak – immediate post-partum period
- Pregnancy-related Virchow's triad

Bourjeily G. Lancet  2009
Gherman  et al. Obstet Gynecology 1999
Venous thromboembolism

- Lower extremity vein thrombosis
- Pelvic vein thrombosis
- Upper extremity vein thrombosis - ART
- Pulmonary embolism
Lower body Deep Vein Thrombosis

- L > R side
- Proximal (iliac/femoral) >60%
- Site/Propagation of DVT depends on individual risk factors
- MRV - important complimentary technique in pregnancy

Torkzad MR et al. Thrombosis Research 2010
PE - Diagnostic Dilemma

- ↓ sensitivity and specificity of clinical findings
- Normal physiologic changes may mimic PE
- Use of D-dimers is relatively limited
- Novel serum markers (fibrin monomer complex)?
- Imaging is crucial – WHAT IMAGING?
- CTPA MRI V/Q scan

Stein et al. PIOPED III Ann Intern Med 2010
PE - Diagnostic Dilemma

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- **CTPA MRI V/Q scan**

Stein et al. PIOPED III Ann Intern Med 2010
CTPA - Advantages: Obvious

CTPA - Disadvantages

- Fetal radiation (indirect)
- Higher maternal ED CTPA : V/Q = 3:1
- Breast radiation

- More pronounced Valsalva effect
- ↑ body weight, ↑ plasma volume, ↑ cardiac output

Contrast - related non-diagnostic studies (8 -30%)

Andreou AK et al. Eur Radiology
U-King-Im et al. Eur Radiology
CTPA - Strategies to improve quality

• Careful inspiration instructions (stop breathing)
• Bolus triggering with short start delay
• High flow rates up to 6 ml/sec
• High contrast concentration (>350)
• Novel reconstruction technique (ASIR)
• Fast scanners (at least 64 MDCT)

Ridge et al. AJR in press
Schaefer-Prokop et al. Eur Radiology 2010
PE in pregnancy: Imaging Guidelines

No official guidelines

Multidisciplinary committee was tasked by the ATS and STR with creating evidence-based clinical practice guidelines

Will be published simultaneously in AJRCCM and Radiology in October 2011
Summary

• Use of CT and MR is safe pregnancy

• No adverse mother/fetal effect

• IV contrast can be used (with caution)

• Beware of breast radiation

• Inform consent is mandatory

• Specific cardiovascular diseases in pregnancy
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