Pulmonary Embolism in Pregnancy

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**Imaging of Pulmonary Embolism in Pregnancy**

- Leading cause of maternal death in developed countries
- Nonspecific signs and symptoms may be associated with normal pregnancy
- No validated clinical prediction rules in assessing pretest likelihood of disease
- <10% of pregnant women with suspected VTE have disease

**D-Dimer Test**

- D-dimer is a fibrin derivative generated by the endogenous fibrinolytic system
- Low levels of D-dimer useful in excluding VTE in nonpregnant population
- Reduced diagnostic yield in pregnancy
  - D-dimer levels increase with progression of pregnancy
  - Negative D-dimer does not exclude VTE
  - D-dimer used in combination with other tests

**Optimal Imaging Paradigm**

- Controversial
- Data sparse – observational studies or extrapolated from nonpregnant population
- Dilemma centered on use of V/Q scan versus CTPA
  - respective long-term potential radiation effects on mother and fetus
  - consequent maternal/fetal trade-offs

**Radiation Issues: Fetus**

- Potential effects dependent on gestational age at exposure and dose of radiation
- NCRP: "The risk is considered negligible at 50 mGy or less."
- Induction of malignancy is major concern
- Reported measured fetal doses for two techniques in literature inconsistent
  - CTPA: .01 - .23 mGy
  - V/Q: .10 - .32 mGy

**Radiation Issues: Mother**

- CTPA delivers higher radiation dose with radiosensitive fibroglandular breast tissue most susceptible
- Reported average values: 10 – 35 mGy
- Delivery of 10 mGy of radiation to breast of 30 yr old results in 0.2% - 14% lifetime increase in relative risk of breast cancer
- Bismuth shields reduce dose with some degradation of image quality
WORK-UP (NEJM 2008; 359:19)

- Suspected PE
  - Ultrasound
    - Positive: Rx
    - Negative: CXP
  - Abnormal CTPA
    - Normal: CTPA or V/Q
  - Normal: Clinical FU

ULTRASOUND

- DVT as indirect evidence for PE
- Advantage – No radiation
- Disadvantage – cost-effectiveness?
  - DVT found by CUS in approx 9 - 10% of nonpregnant patients with suspected PE (prevalence of PE 21 – 25%)
  - 10 – 11 bilateral CUS exams required to identify 1 patient with DVT
  - Diagnostic yield lower in pregnancy (prevalence of PE 1 – 2%)

RECOMMENDATIONS AND PRACTICE

<table>
<thead>
<tr>
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<th>V/Q</th>
<th>CTPA</th>
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<tr>
<td>PIOPED II (2007)</td>
<td>69%</td>
<td>31%</td>
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<td>NEJM (2008)</td>
<td>±</td>
<td>+</td>
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<td>RCOG (2007)</td>
<td>±</td>
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<tr>
<td>STR (2003)</td>
<td>30%</td>
<td>53%</td>
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</tbody>
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PIOPED II: Radiology 2007; 242: 15.  
Marik et al. NEJM 2008; 359:19.  
RCOG Guideline No 28. www.rcog.org.uk  
Schuster et al. AJR 2003; 181: 1495.

EFFECTIVENESS OF V/Q SCANNING

- Chan et al, Arch Intern Med 2002;162; 1170
  - 120 consecutive pregnant women with suspected PE
    - 2% high prob; 74% normal; 24% nondiagnostic
- Scarsbrooke et al, Eur Radiol 2007;17:2554
  - 105 consecutive patients triaged by CXR/hx
    - 96 underwent V/Q: 1% high prob; 92% normal; 7% nondiagnostic

PREFERENCE FOR CTPA

- Higher sensitivity (83% vs 77%) and comparable specificity (96% vs 98%)
- Negative predictive value similar to low probability V/Q scan
- Faster to perform and more easily obtained after hours
- Alternate diagnoses suggested in 39% - 67% of patients

36 year-old woman in third trimester of pregnancy presents with chest pressure, shortness of breath, and low grade fever
MILIARY COCCIDOIDOMYCOSIS

CTPA QUALITY IN PREGNANCY

- Are measures of CTPA accuracy applicable to pregnant population?
- Increased cardiac output and increased plasma volume result in lower pulmonary arterial enhancement
  - U-King Im et al., Eur Radiol 2008; 18:2709
  - Andreou et al., Eur Radiol 2008; 18:2716

DIAGNOSTIC QUALITY: CTPA VS V/Q

- Ridge et al., AJR 2009;193: 1223
  - 50 pregnant women underwent CTPA or V/Q
  - Higher rate of nondiagnostic study on CTPA (35.7% vs 4%, p<.01)
- Cahill et al., Obstet Gynecol 2009;114: 124
  - 304 pregnant or postpartum women underwent CTPA (35.1%) or V/Q (64.95%)
  - In pts with normal CXRs, higher rate of nondiagnostic CTPA (30.0% vs 5.6%, p<.01)
  - In pts with abnormal CXRs, higher rate of nondiagnostic V/Q (16.4% vs 40.0%)

OPTIMIZED CTPA PROTOCOL IN PREGNANCY

- Increase arterial enhancement
  - Increase flow rate (4.5 – 6 ml/s)
  - Use high concentration contrast (350 – 370 mg I/ml)
- Bolus triggering
- Use fast scanners
- Practice breath-holding
- Minimize dose
  - Automatic tube current modulation
  - kVp: 100 – 120
  - Caudal extent at apex of right hemidiaphragm

Schaefer-Prokop, Eur Radiol 2008; 18: 2705
**EXTERNAL SHIELDING: FETUS**
- McCullough et al, Radiographics 2007: “dose from external radiation is minimal”
- Lead apron placed at lower extent of scan volume results in dose reduction
  - Doshi et al, Br J Radiol 2008; 81:653
- Theoretical dose reduction: $.35 \times .1 \text{ mGy} = .035 \text{ mGy}

**EXTERNAL SHIELDING: MOTHER**
- Bismuth shields reduce breast dose by 30% – 50%
- Streak artifacts and increased noise may degrade diagnostic performance
- If resulting noise levels acceptable, reduction of tube current more efficient way to achieve overall dose reduction
  - Geleijns et al, Eur Radiol 2006; 16: 2334
  - Vollmar, Kalendar, Eur Radiol 2008; 178:1674

**MR ANGIOGRAPHY**
- Advantage – No radiation
- Disadvantages
  - Noncontrast techniques lack specificity
  - Safety of gadolinium in pregnancy uncertain
  - Not readily available after hours
- PIOPED III results forthcoming
  - goal is to determine accuracy of MRA/MRV in dx of acute PE
  - Pregnant women excluded from study entry

**INFORMED CONSENT**
- Performance of radiation-associated studies in pregnancy involve medico-legal risk
- Risk mitigation through communication process that results in a patient’s informed decision to proceed/refuse a medical procedure
- Consent practice patterns in academic institutions
  - CTPA: 60% (Schuster, AJR 2003;181:1495)
  - Abdominal CT: 68% (Jaffe, AJR 2007;180:1128)

**CLINICAL GUIDELINES DOCUMENT**
- Multidisciplinary effort with multiple stakeholders (STR, ATS, SNM, AAPM, ACOG)
- Development of guidelines based upon current evidence and expert consensus opinion
- Dual publication in AJRCCM and Radiology