CT Pulmonary Angiography 2010

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CTPA 2010

- Utilization
- Technique
- DVT
- Radiation
- In Pregnancy
- Large
- Small PE
- Chronic PE
- Triple R/O
Guidelines for Management Suspected PE
British Thoracic Society

• **d-Dimer**
  - Not in high clinical probability
  - A negative test reliably excludes PE

• **Imaging**
  - **CTPA the recommended initial imaging modality**
    - A good quality -CTPA does not require additional tests
  - Negative isotope scan reliably excludes PE
  - Single normal leg US is not reliable to exclude sub-clinical PE
## Why CT?

### Interobserver agreement

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th># Pts</th>
<th>( \kappa )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mayo</td>
<td>1997</td>
<td>142</td>
<td>0.85</td>
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<tr>
<td>Grenier</td>
<td>1998</td>
<td>139</td>
<td>0.85</td>
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<tr>
<td>Heroki</td>
<td>1999</td>
<td>758</td>
<td>0.71</td>
</tr>
<tr>
<td>Blachere</td>
<td>2000</td>
<td>179</td>
<td>0.72</td>
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<tr>
<td>Coche</td>
<td>2003</td>
<td>94</td>
<td>0.94</td>
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</tbody>
</table>

**Patel & Kazerooni, AJR 2005;185:135**
Discordance between CT and Angiography in the PIOPED II Study

- Discordance in 20 of 226 CTA & cath results

<table>
<thead>
<tr>
<th>Findings at Angiography</th>
<th>Negative Findings at CT</th>
<th>Positive Findings at CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td>1 false-positive finding at angiography</td>
<td>13 false-negative findings at angiography</td>
</tr>
<tr>
<td>Positive</td>
<td>4 findings at both CT pulmonary angiography and angiography correct</td>
<td>0</td>
</tr>
<tr>
<td>Positive</td>
<td>2 false-negative findings at CT pulmonary angiography</td>
<td>0</td>
</tr>
</tbody>
</table>

- 40 hr interval: thrombi can remain the same, resolve, develop, or result from angio

# Diagnostic Approach

## Predicting probability of PE

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>Points</th>
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<tbody>
<tr>
<td>Clinical DVT</td>
<td>3</td>
</tr>
<tr>
<td>No alternative Dx</td>
<td>3</td>
</tr>
<tr>
<td>HR &gt; 100 bpm</td>
<td>1.5</td>
</tr>
<tr>
<td>Imobil/Surg 4 wks</td>
<td>1.5</td>
</tr>
<tr>
<td>Previous DVT/PE</td>
<td>1.5</td>
</tr>
<tr>
<td>Hemoptysis</td>
<td>1</td>
</tr>
<tr>
<td>Cancer</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLINICAL PROBABILITY</th>
<th>points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>Intermediate</td>
<td>2-6</td>
</tr>
<tr>
<td>High</td>
<td>&gt; 6</td>
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</tbody>
</table>

Wells PS al Thromb Haemost 2000;83:416-420
CTA in the evaluation of acute PE

- 575 CTPAs
  - PE: in 9.57%
- D-dimer: 224 (39%)
  - CTPA in 146 w nl or intermediate
- Suboptimal use of Wells criteria
- Overuse of CTA (screening rather than dx exam)

Costantino MM (Oregon U) AJR (Aug) 2008; 191:471-474
Technique at BIDMC

- 80 - 100 mL at 4 mL/sec
- Trigger at LA (100 HU)
- Shallow inspiration
- 1/2 sec rotation
- 120 kVp (?80)
- Variable mA (NI ~16)
- Scan acquire: 0.5 mm
- Scan display: 2.5 – 5 mm
- Axial, Coronal & Sagittal
Deep inspiration

Shallow inspiration

Chest pain: Ao & PA
**Iodine delivery rate**

I+ concentration & speed of injection
Proportional to vessel enhancement

A: 148 ml
300 mgI/ml @ 4.9 ml/s

B: 120 ml:
370 mgI/ml @ 4.0 ml/s

**Iodine delivery rate:**
1.47 vs. 1.48 gI/s

Adjust injection rate

Keil S et al. (Aachen U) Eur Radiol (Aug) 2008;18:1619-5:
Alternative IV contrast: Gadolinium

0.3-0.4 mmol/kg at 6 ml/sec – 15 ml saline flush
80-100 kVp

Remy-Jardin M et al. Radiology 2006; 238:1022
CAD in PE: Influence on radiologists performance

33 pts w 215 thrombi

Das M et al (U Aachen) Eur Radiol (Jul) 2008; 18:1350-5
Dual Energy CT for Iodine distribution

---41-year-old woman with pulmonary embolism

Occlusive thrombus

(Ludwig Maximilian U, Munich)
THROMBOEMBOLIC DISEASE - DVT

Indirect CT Venography

• Sens & Spec
  • CTA 86% & 96%
  • +Ven 90% & 95%
Stein et al NEJM 2006;354:2317

• CTA + Venography
  • ↑ Dx VTE by 27%
Ghaye et al Radiology 2006;249:256

• Minimal benefit from venography
Johnson et al Emerg Radiol
2006;12:160

CT Venography 2009 – 64 MDCT

DVT and PE (n = 306)

Nazaroglou, H. AJR (Mar) 2009; 192:654-661
CT Venography 2009 – Selective Use

- High risk patients
  - Signs of DVT or previous DVT
- Severely ill or ICU patients
  - Increased suboptimal studies
- Recent surgery in pelvis
- Cast or extremity surgery
- Can not do US

Goodman LR AJR (Feb) 2009; 250:327-330
Estimated cancers from CT

- 1991-96: \( \sim 0.4\% \) of all cancers in the US
- Adjusting for current use: 1.5 to 2.0%
mA: Reduced dose CTPA

Effect of mAs
(38 pts w low mod clot burden)

MacKenzie JD et al. AJR (Dec) 2007; 189:1371 (BWH)
kVp: image quality and radiation at CTPA with 100- or 120-kVp

- Prospective, randomized study
- 2 groups of 30 pts
- 200 mA
- 80 mL IV contrast
- **Effective dose:**
  
  1.37 vs 2.44 mSv
  
  (↓ 44%)

Heyer CM et al. (U Bochum, Germany) *Radiology* (Nov) 2007;245:577
**80 vs 120 kVp**

n = 400 scans

↓ energy → ↑ attenuation because high atomic # of I and K-edge

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>120 kVp</th>
<th>89 kVp</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main PA HU</td>
<td>309</td>
<td>376</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Noise in HU</td>
<td>19</td>
<td>25</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Image quality</td>
<td>3.8</td>
<td>3.9</td>
<td>NS</td>
</tr>
</tbody>
</table>

Matsuoka S et al *AJR* 2009 Jun; 192:1651-6 (BWH, Harvard U)
CTPA: vascular enhancement in pregnancy

16 pregnant and non-pregnant pts
120 kVp
80-400 auto mA
20 sec delay

PA: 260 HU vs 372 HU (p<0.001)

KVP

Pregnancy CTPA at BIDMC

- No C-
- 100 mL at 4 mL/sec
- Delay: 15 sec
- 100 kVp
- 200 mA

Litmanovich et al. JCAT (in press)
Pregnancy CTPA

Vessel Attenuation

Signal to noise

Acute PE – CTPA Findings

- Occlusion or filling defect
  - Branching
  - Multiple – more than 1 level
- Vessel enlargement
- Polo-mint or railway track
- Acute angle
- High attenuation (C-)
- Ancillary
  - Wedge shape opacities
  - Linear bands
  - Oligemia

Patel S & Kazerooni EA. AJR 2005;185:135
Segmental PE

Subsegmental PE
Pulmonary Infarction

Central Lucencies: 98% specificity & 46% sensitivity

Revel, MP et al *Radiology* 2007;244:875-882
Acute PE: Ground Glass Opacities

Acute PE induces GGO in unobstructed lung zones.

Redistribution of blood flow

Given constant cardiac output, this happens at a pressure consistent with pulmonary edema.

Thoma P et al. Radiology 2009 Aug;250:721-729 (Erasmus U)
Pitfalls – Misdiagnosis

Technical
• Poor bolus
• Resp & Cardiac motion
• High-Res. algorithm
• Noisy images (large pts)
• Streak artifacts (lines, tubes, arms)
• Beam hardening (SVC dense contrast)

Interpretation
• Lymph nodes
• Pulmonary vein,
• Mucoid impaction in bronchi
• Partial Volume averaging
• Tumor emboli

Patel S & Kazerooni EA. AJR 2005;185:135
Technical
- Poor bolus, large patient, noisy image
- Problems in subsegmental vessels

Interpretation
- Mucoid impaction
Acute RV failure / strain

- RV dilatation (RV/LV > 0.9)
- Hepatic vein reflux
- Deviation of IV septum to left
- PE Occlusion index > 60%

4 chamber view: RV/LV = 1
Interval increase in RV/LV diameter ratios at CT as mortality predictor

SMALL PE

Incidental Subsegmental PE (ISPE)

Rx
• Inadequate cardiopulmonary reserve
• Acute DVT
• Recurrent small PE

Withhold Rx
• No or few risk factors for VTE
• Transient (surgery) rather than persistent (cancer) risk factors
• Other CV disease that can explain symptoms
• Negative D-dimer

Goodman LR. Radiology 2005; 234:654 (Editorial) (Medical College of Wisconsin)
**CHRONIC PE**

**Pulmonary artery**
- Occlusion
- Eccentric thrombus
- Crescent – obtuse
- Thick wall
- Band or web
- Calcification

**Collateral systemic**
- Bronchial etc

**Pulmonary hypertension**
- $\uparrow$ PA > 29 mm ($\geq$ Ao)
- $\uparrow$ RV ($\geq$ LV)

**Parenchyma**
- Scars & pleural thickening
- Mosaic pattern
- Air trapping
- Bronchiectasis

Patel S & Kazerooni EA. AJR 2005;185:135
Chronic PE

Eccentric crescent thrombus

Mosaic pattern
Gated Chest - triple R/O

- Fujioka C et al from Hiroshima U (AJR July 2009) 100 kV; 30 pts
  - estimated effective dose ~7.5 mSv.

- Shuman W et al at the U Washington (AJR June 2009) prospective CTA in 41 pts w/o & 31 w/ prosp gating:
  - mean effective dose 32 vs for 9 mSv

Shuman, W. P. et al. AJR 2009;192:1662-1667

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Conclusions

• CTPA an established test (including in pregnancy)
• CTPA over utilized (preferred chest pain test)
• Use d-Dimer in high risk pts moderately successful
• Indirect venography, Small PE management & Thrombus burden assessment: controversial
• RV size changes: important prognostic sign
• Iodine delivery rate, Shallow inspiration
• Consider radiation risk, 100 kVp
• Triple rule out