MDCT and Pulmonary Embolism

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76 y/o with pleuritic chest pain
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Multiple Emboli with Small Infarcts
Pulmonary Embolism

- 500,000 episodes of PE / yr in USA
- 12 – 64% ICU patients at autopsy
- Contributing cause of death in 10-15% acute care pts
- Clinical diagnosis difficult
Risk Factors for PE

**Strong Risk Factors**
- Lower limb Fx, Hip or Knee Replacement
- Major Trauma
- MI in previous 3 mos.
- Spinal Cord Injury
- Previous VTE

Risk Factors for PE

Moderate Risk Factors

- CHF
- Infection
- Cancer
- Postpartum
- Oral contraceptives
- Autoimmune disease
- Blood transfusions
Weak Risk Factors

- Bed rest > 3 days
- Travel of 4 hr or more in the past month
- Pregnancy
- Obesity
- Advanced age
Most Common Symptoms of PE

Unexplained:
- Sudden-onset dyspnea
- Pleuritic pain
- Syncope/near syncope
Clinical Signs in PE

- Hypoxemia 70%
- Tachypnea/dyspnea 90%
- Tachycardia
- Arrhythmia
- Wheezing
- Hemoptysis
- Fever (but < 39.5°C)
Simplified Wells Criteria (≥2: PE likely)

- History of DVT or PE — 1 point
- Tachycardia (heart rate > 100) — 1 point
- Immobilization (≥ 3d)/surgery in previous four weeks — 1 point
- Hemoptysis — 1 point
- Malignancy (with treatment within 6 months) or palliative — 1 point
- Clinically suspected DVT — 1 point
- Alternative diagnosis is less likely than PE — 3.0 points
D-dimer for PE

- Cut-off value: 500 ug/L
- Negative predictive value: 98-99%
- Positive predictive value: 27-29%
- False positives associated with:
  - female sex; increasing age; black (vs. white) race; cocaine use; general, limb, or neurologic immobility; hemoptysis; hemodialysis; active malignancy; rheumatoid arthritis; lupus; sickle cell disease; prior venous thromboembolism (VTE; not under treatment); pregnancy and postpartum state; and abdominal, chest, orthopedic, or other surgery.
80 y/o female with seizures and “pneumonia”
Multiple PEs with infarcts
CXR in PE

- CXR often normal
- Focal subpleural dense opacity
- Westermarks Sign: Peripheral oligemia, mostly seen with chronic embolism
Westermark Sign
72 y/o with acute hypoxia
Large PE causing asymmetric pulmonary edema
CXR in PE

- CXR often normal
- Focal subpleural dense opacity
- Focal subpleural dense opacity
- Westermark Sign: Peripheral oligemia
- Fleischner Sign: Enlargement and sharp definition of central PA
Fleischner Sign
CXR in PE

- CXR often normal
- Westermark Sign: Peripheral oligemia
- Fleischner Sign: Enlargement and sharp definition of central PA
- Bibasilar atelectasis, subpleural opacity, effusions, suggestive in previously healthy individual
Unexplained Basilar Subsegmental Atelectasis
Multi-slice Helical CT

- Multislice acquisition 4, 8, 16, 64, 256 channel
- Very rapid scanning
- High resolution at high speed
Pulmonary Angiography

- Previously the “Gold standard” for pulmonary embolism
- Morbidity –2%, mortality <1%
- High cost
V/Q Scan accuracy for PE

<table>
<thead>
<tr>
<th>V/Q Scan Results</th>
<th>PE Prevalence</th>
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</thead>
<tbody>
<tr>
<td>Normal or low probability</td>
<td>4%</td>
</tr>
<tr>
<td>+ low clinical suspicion</td>
<td></td>
</tr>
<tr>
<td>High probability</td>
<td>96%</td>
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<tr>
<td>+ high clinical suspicion</td>
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</tbody>
</table>

- Still a reasonable test for young women with low PE probability and normal CXR.

  or

- Pts with contraindication to IV contrast
Accuracy of MDCT for PE

- **Sensitivity**
  - All series: 53% – 100%
  - Recent series: 90% +

- **Specificity**
  - All series: 78%-100%
  - Recent series: 95%
PE CT Results over 12 months at U Chicago
Pulmonary C.T. Angiography

- Rapid contrast infusion (3-6 cc/sec)
- Antecubital fossa vein
- 1-2 mm collimation
- Shallow breath hold
- Fixed delay, bolus tracking, timing bolus
Findings in Acute PE

- Intraluminal filling defects
- Abrupt contrast cutoff
- Dilated non-opacified vessel
Saddle and Subsegmental Emboli
Off-Axis Reformat
“Very small PE of uncertain chronicity and clinical significance”
Predictors of Mortality in PE

- Interventricular septal deviation (RV/LV ratio >1.0)
- High Percentage occlusion of pulmonary vascular bed (~50%+)

van der Meer et al. Radiology 2005;235:798-803
PE-related mortality predictors

- Age above 60 years
- RV/LV diameter >1.5 (odds ratio 48.8, P<0.001)
- RV/LV area >1 (odds ratio 8.6)
- Timing bolus upslope time > 6 seconds (odds ratio 23.3), 50% downslope time >6 seconds (odds ratio 20)
- Embolus load score >15 (odds ratio 25)

Li C, Lin CT, Kligerman SJ, Hong SN, White CS. JTI 2014
Abnormal Timing Bolus
Pulmonary Infarct - Hampton’s Hump
Pulmonary Infarct

- Only 15% cause true infarction
- Most in lower lobes
- Usually multiple
Pulmonary Infarct

- Sharply defined consolidation
- Central lucency
- Absence of air bronchogram
Pulmonary Infarcts

Likelihood Ratios:
23.0 for central lucencies
2.9 for vessel sign (enlarged vessel at apex)
0.2 for air bronchograms

Revel et al. Radiology: Volume 244: Number 3 September 2007
R flank pain. R/O kidney stone
Evolving Infarct: Melting Ice cube Sign

Baseline

3 weeks

3 months

6 months
Non-Diagnostic CTA

- Motion artifact
- Poor contrast enhancement
  - Flow obstruction
  - Deep inspiration > dilution
  - Contrast timing error
- Beam hardening and noise – obesity
Dilution by Unopacified IVC inflow
Dilution by Unopacified IVC inflow
60 y/o male with hemoptysis
60 y/o male with hemoptysis
60 y/o male with hemoptysis
Non-Contrast Scan
Non-Contrast Scan
Saddle Embolus on Non-Enhanced CT Scan
Chronic PE
Chronic PE
Chronic PE

Recanalized, organized or calcified thrombus
Arterial Web
2 yrs later - arterial web
Chronic PE

- Recanalized, organized or calcified thrombus
- Intraluminal webs or bands
- Pulmonary hypertension
Chronic and Acute PE
Chronic PE

- Recanalized, organized or calcified thrombus
- Intraluminal webs or bands
- Pulmonary hypertension
- Collateral vascularization
- Mosaic perfusion
Chronic PE – Mosaic Perfusion
Chronic PE – Decreased perfusion & bronchiectasis
Enlarged Bronchial Collaterals in Chronic PE
Enlarged Bronchial Collaterals in Chronic PE
Chronic PE, Mosaic Perfusion, Westermark Sign
Chronic PE, Mosaic Perfusion, Westermark Sign
Postpneumonectomy. R/O PE
Postpneumonectomy Arterial Stump Thrombus

- Occurs in about 12% of cases
- Likelihood related to length or arterial stump
- May propagate or resolve
- Benign course without treatment
Invasive Leiomyomatosis

- Typically 5\textsuperscript{th} decade
- Hx hysterectomy/myomectomy
- Surgery curative
CTA for PE: Common Pitfalls

- Failure to use proper window & level
CTA for PE: Common Pitfalls

- Failure to use correct window & level
- Use of lung (sharp) algorithm
Effect of lung filter
ECG Gated Cardiac Scan
CTA for PE: Common Pitfalls

- Failure to optimize window level/width
- Use of lung reconstruction filter
- Vascular bifurcations (false positives)
CTA for PE: Common Pitfalls

- Failure to optimize window level/width
- Use of lung reconstruction algorithm
- Vascular bifurcations (false positives)
- Motion/averaging artifact (false positive or negative)
Motion with Density Averaging
Density Averaging: Crossing Bronchus
Decreased flow with Incomplete Opacification
Pulsation Artifact
CTA for PE: Common Pitfalls

- Failure to use workstation (window/level)
- Use of lung reconstruction algorithm
- Vascular bifurcations (false positives)
- Motion/averaging artifact (false positive or negative)
- Bronchiectasis
PE: Take Home Points

- CTA is the preferred diagnostic test for PE except in young patients with low clinical probability.
- A diagnostic quality negative CTA makes life threatening PE very unlikely.
- Technique is important; use high injection rate with saline chaser and small inspiration.
- Significance of isolated subsegmental emboli is uncertain