Pulmonary Embolism

- Risk Factors & pre-test probability
- CXR findings
- CT technique
- Dx on contrast and non-contrast CT scans
- Acute vs Chronic PE
- Non thrombotic PE
Pulmonary Embolism

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

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:
- Dyspnea (50%) – Esp. sudden onset
- Pleuritic pain (39%)
- Substernal (15%)
- Hemoptysis (8%)
- Syncope/near syncope (6%)

More specific
Clinical Signs in PE

- Hypoxemia (70%)
- Tachypnea/dyspnea (90%)
- Tachycardia (40%)
- Arrythmia
- Wheezing
- Hemoptysis
- Fever (but < 39.5°C)
- Signs of DVT
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; 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
76 y/o with pleuritic chest pain
Multiple Emboli with Small Infarcts
CXR in PE

- CXR often normal
- Focal subpleural rounded opacity, esp. CP angles
- Westermark Sign: Peripheral oligemia, caused by chronic embolism, but often with superimposed new acute episode
Westermark Sign
72 y/o with acute hypoxia
Large PE causing asymmetric pulmonary edema
CXR in PE

- CXR often normal
- Focal subpleural rounded opacity, esp. CP angles
- Westermark Sign: Peripheral oligemia, caused by chronic embolism, but often with superimposed new acute episode
- Fleischner Sign: Enlargement and sharp definition of central PA
CXR in PE

- CXR often normal
- Focal subpleural rounded opacity, esp. CP angles
- Westermark Sign: Peripheral oligemia, caused by chronic embolism, but often with superimposed new acute episode
- Fleischner Sign: Enlargement and sharp definition of central PA
- Bibasilar atelectasis, subpleural opacity, effusions, suggestive in previously healthy individual
Unexplained Basilar Subsegmental Atelectasis
<table>
<thead>
<tr>
<th>V/Q Scan Results</th>
<th>PE Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal or low probability</td>
<td></td>
</tr>
<tr>
<td>+ low clinical suspicion</td>
<td>4%</td>
</tr>
<tr>
<td>High probability</td>
<td></td>
</tr>
<tr>
<td>+ high clinical suspicion</td>
<td>96%</td>
</tr>
</tbody>
</table>

- Still a reasonable test for young women with low PE probability and normal CXR.
- Patients with contraindication to IV contrast
Pulmonary C.T. Angiography

- Rapid contrast infusion (3-6 cc/sec)
- Antecubital fossa vein
- 1 – 1.5 mm collimation
- Shallow breath hold
- Fixed delay, bolus tracking, timing bolus
Test bolus vs Bolus Tracking

• Test bolus: Visual estimation by tech of optimal contrast timing.
  • Makes cursor placement less critical.
  • Subjective judgement

• Bolus Tracking: Automatic trigger for scan based on bolus arrival
  • Cursor placement critical
  • Adds several seconds to scan delay
Test Bolus. Cursor on PA
Normal Circulation Time
Abnormal Test Bolus – Slow Circulation
Main Contrast Bolus – Slow Circulation
Test Bolus using Descending Aorta
Non-Diagnostic CTA

- Bolus Timing
- Motion artifact
- Poor contrast enhancement
  - Flow obstruction
  - Deep inspiration > dilution
  - Contrast timing error
- Beam hardening and noise – obesity
Dilution by unopacified IVC inflow
“Relax, take in a small breath and hold it”
PE CT Results over 12 months at U Chicago

Pulmonary Embolization Tracker

**PE Type Percent of Total Volume - January 2017 Only**

- Negative: 80.0%
- Positive: 17.6%
- Indeterminate: 2.4%

**PE Type Percent of Total Volume by Month**

- January: 82.7%
- February: 61.6%
- March: 75.4%
- April: 84.4%
- May: 81.2%
- June: 82.9%
- July: 76.5%
- August: 61.3%
- September: 88.5%
- October: 62.3%
- November: 84.2%
- December: 50.0%

**PE Type Volume by Month**

- January: 131
- February: 173
- March: 156
- April: 130
- May: 151
- June: 121
- July: 142
- August: 148
- September: 154
- October: 149
- November: 120
- December: 104

**Chronicity for Positive PE Volume by Month**

- January: 22
- February: 26
- March: 35
- April: 14
- May: 20
- June: 15
- July: 28
- August: 25
- September: 19
- October: 14
- November: 10
- December: 14

Data: 1/1/2016 to 12/31/2016
Saddle Embolus

Saddle and Subsegmental Emboli
“Very small PE of uncertain chronicity and clinical significance”
Clinical Significance and Prognosis in Acute PE

PA diameter

Septal deviation
PE-related mortality predictors

- Age above 60 years
- RV/LV area >1 (odds ratio 8.6)
- RV/LV diameter >1.5 (odds ratio 48.8, $P<0.001$)
- 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
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
R flank pain. Acute PE
Breast cancer patient with lung nodule
Acute PE

Resolving Infarct
Incidental RUL Nodule
Evolving Infarct: “Melting Ice Cube Sign”

Baseline

3 weeks

3 months

6 months
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

- 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 – Mosaic Perfusion
Chronic PE – Decreased perfusion & bronchiectasis
Enlarged Bronchial Collaterals in Chronic PE
Chronic PE

- Recanalized, organized, calcified thrombus
- Intraluminal webs or bands
- Pulmonary hypertension
- Mosaic perfusion
- Collateral vascularization
CTA for PE: Common Pitfalls

- Failure to use proper window & level
Standard ST Window

Narrow window setting
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
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
Postpneumonectomy. R/O PE
Arterial Stump Thrombus

- Occurs in up to 12% of cases
- Likelihood related to length of arterial stump
- May propagate or resolve
- Benign course without treatment
Non-embolic thrombus & Non-thrombotic emboli

- Post-op Lobectomy or Pneumonectomy thrombosis in situ
51 y/o woman with severe SOB
Uterine Leiomyosarcoma
Non-embolic thrombus & Non-thrombotic emboli

- Post-op Lobectomy or Pneumonectomy thrombosis in situ
- Tumor Embolism
  - Tumor embolism from remote solid tumors (breast, lung, stomach)
  - Propagation of tumor via IVC (renal, hepatic, uterine)
  - Primary arterial sarcomas
Asymptomatic Patient
Polymethymethacrylate Cement Embolism
Polymethylmethacrylate cement embolism
- 4-23% of procedures
- <1% symptomatic
Non-embolic thrombus & Non-thrombotic emboli

- Post-op Lobectomy or Pneumonectomy thrombosis in situ

- Tumor Embolism
  - Tumor embolism from remote solid tumors (breast, lung, stomach)
  - Propagation of tumor via IVC (renal, hepatic, uterine)
  - Primary arterial sarcomas

- Foreign material (Surgical cement, filter fragments, Needle fragments)
Take Home Points

- CTA is the preferred diagnostic test for PE except in young patients with low clinical probability.
- PE can often be recognized on CXRs and non contrast CT scans
- Technique is important; use high injection rate with saline chaser, thin sections, and small inspiration.
- Use bolus time to aorta to estimate timing
- Significance of isolated subsegmental emboli is uncertain