MDCT and Pulmonary Embolism

https://tinyurl.com/hmpe17

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Disclosures

- Consultant for Riverain Medical
- Minor stockholder in Hologic, Inc.
- Consultant for GE Healthcare
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- License and royalty fees from University of Chicago (UC Tech)
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

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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

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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.
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
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

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- 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
V/Q Scan accuracy for PE

V/Q Scan Results

<table>
<thead>
<tr>
<th>PE Prevalence</th>
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<tbody>
<tr>
<td>Normal or low probability + low clinical suspicion</td>
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<tr>
<td>High probability + high clinical suspicion</td>
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- Still a reasonable test for young women with low PE probability and normal CXR.
- or
- 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

PE Type Percent of Total Volume by Month

PE Type Volume by Month

Chronicity for Positive PE Volume by Month
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. Acute PE
Breast cancer patient with lung nodule
Acute PE

Resolving Infarct
Incidental RUL Nodule
Evolving Infarct: “Melting Ice Cube Sign”
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 PE
Chronic and Acute PE
Chronic PE – Mosaic Perfusion
Chronic PE – Decreased perfusion & bronchiectasis
Enlarged Bronchial Collaterals in Chronic PE
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
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
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
Asymptomatic Patient
Polymethylmethacrylate 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)
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.