Radiologic Diagnosis of Pulmonary Embolism

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Background

- Incidence of venous thromboembolism 1/1000
- More than 500,000 cases of PE diagnosed every year
- More common in men and with increasing age
- Estimated that more than ½ of patients with PE remain undiagnosed
Anatomy of Pulmonary Vessels

R+L pulmonary arteries

Pulmonary veins

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Pathophysiology

- Pulmonary emboli usually arise from clots in deep venous system of lower extremities
- Clots propagate proximally, then embolize
- Emboli range from huge saddle emboli that cause death immediately to small clots that travel distally and may be asymptomatic
- Only 10% of emboli cause pulmonary infarction
- Most emboli multiple
- Lower lobes typically affected
Pathophysiology cont.

- Pulmonary arteries are obstructed which leads to dead space and thus impaired gas exchange.
- Also, clots cause release of inflammatory mediators leading to surfactant dysfunction, changes in vascular permeability and shunting.
- Mechanical obstruction and hypoxic vasoconstriction leads to increased pulmonary vasculature resistance.
- Increased RV afterload leads to dilation, ischemia and eventual failure of RV.
Mortality and Treatment of PE

- Untreated PE has mortality of 15-30%, usually as the result of recurrent embolism
- Tx with anticoagulants decreases mortality rate to 2-8%

Fam NP and A Verna NEJM 2002 347(15) 1161.
Risk Factors

**Injury**
- Age
- Trauma
- Surgery
- Smoking

**Stasis**
- Immobility
- Travel
- Obesity

**Hypercoagulability**
- Cancer
- Prior DVT
- Pregnancy
- Estrogen
- Thrombophilia
Clinical Presentation

- Most common sx: dyspnea (73%), pleuritic pain (66%), cough (37%), hemoptysis (13%)
- Most common signs: tachypnea (70%), rales (51%), tachycardia (30%), loud S2 (23%), fever (14%)
- Majority of patients with PE have no leg symptoms of DVT
Differential Diagnosis

- Pneumonia/bronchitis
- COPD flare
- Asthma
- MI
- Pulmonary edema
- Anxiety
- Aortic dissection

- Pneumothorax
- Lung cancer
- Primary pulmonary hypertension
- Rib fracture
- Pericardial tamponade
- Costochondritis
Modified Wells Criteria

- Clinical symptoms of DVT: 3.0
- Other dx less likely than PE: 3.0
- Heart rate >100: 1.5
- Immobilization or surgery in past 4 wks: 1.5
- Previous DVT/PE: 1.5
- Hemoptysis: 1.0
- Malignancy: 1.0

**Score**
- >6: High
- 2.0-6.0: Moderate
- <2.0: Low

**Probability**
Primary Diagnostic Modalities

- Lower extremity ultrasound
- Chest X-Ray
- Ventilation/perfusion lung scan
- CT
- Pulmonary angiogram
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Lower extremity ultrasound

- Color-flow Doppler ultrasound with compression looking for DVT
- Color flow Doppler has high sensitivity (89-100%) and high specificity (89-100%) for 1st episode of DVT
- Advantages: non-invasive, available, inexpensive, no radiation, few contraindications
- Disadvantages: detection much lower when asymptomatic, operator dependent, difficult with obesity and edema
- One study of patients with PE on angiography, only 29% had evidence of DVT on ultrasound
- **Normal results do not rule out PE if clinical suspicion is high**

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CXR Findings with PE

- Most frequent findings: atelectasis and/or parenchymal opacity
- Either or both of these findings were found in 69% of patients with PE and 58% w/o PE
- Pleural effusion found in 47% of patients with PE and 39% w/o PE
- Only 12% of CXR’s in patients with PE were interpreted as normal

Other CXR Findings

- Hampton’s Hump: pleural-based, wedge-shaped or rounded opacity, sign of pulmonary infarction
- Westermark’s sign: focal avascularity beyond occluded vessel

Sokolove, PE and SR Offerman, *NEJM* 2001; 345(18) 1311.
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Ventilation/perfusion Lung Scan

- Nuclear medicine study
- Perfusion Scan Procedure:
  - IV injection of albumin tagged with technetium-99m
  - particles are slightly bigger than rbc’s so get trapped in pulmonary capillaries
  - emit gamma rays while disintegrate that are recorded
  - emission of particles should be uniform
- Ventilation Scan Procedure:
  - inhalation of radioactive gas, usually xenon-133
  - image degree of ventilation throughout lung
  - ventilation should be uniform if no lung disease
- Compare any areas of perfusion and ventilation defects
Possible results of V/Q scan

1. Normal: normal perfusion rules out PE
2. Low probability/negative: 1 or more minor perfusion abnormalities with V/Q matches, thought not to be emboli
3. High probability/positive: 2 or more moderate-large segmental V/Q mismatches
4. Indeterminate: features of both low and high probability scans

- Results must be related to clinical probability

Note: normal scan not the same as negative scan
# How to interpret V/Q scan results

Likelihood of Pulmonary Embolism According to Scan Category and Clinical Probability in PIOPED Study†

<table>
<thead>
<tr>
<th>Scan Category</th>
<th>Clinical probability of emboli</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>High</td>
<td>95</td>
</tr>
<tr>
<td>Intermediate</td>
<td>66</td>
</tr>
<tr>
<td>Low</td>
<td>40</td>
</tr>
<tr>
<td>Normal or near normal</td>
<td>0</td>
</tr>
</tbody>
</table>

†Data from PIOPED Investigators, JAMA 1990; 263:2753.
Patient J.P.

- 31 y/o F
- 8 weeks pregnant
- No significant PMHx
- p/w 2 days of shortness of breath, dyspnea and pleuritic chest pain
- CXR read as normal
- Diagnosed as musculoskeletal pain and sent home with morphine
- Sx did not improve so PMD ordered V/Q scan
Normal Perfusion Scan
J.P. Ventilation/perfusion mismatch

Perfusion scan

Perfusion defects in LLL and RUL

Ventilation scan

Normal

PACS BIDMC
J.P. cont

- **Dx:** Pulmonary embolism
- **Pt was heparinized in ED**
- **Found to have Factor V Leiden mutation**
- **Discharged on Lovenox**
V/Q scan summary

- Not useful in patients with pulmonary disease
- Diagnostic in minority of cases i.e. rarely interpreted as normal or high probability
- Accuracy of results related to clinical probability
- V/Q scans have been replaced by CT as primary imaging modality
- Primarily done now for patients with renal failure or with contrast allergy
Primary Diagnostic Modalities

- Lower extremity ultrasound
- Chest X-Ray
- Ventilation/perfusion lung scan
- CT
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“PE Protocol CT”

- Translation: spiral/helical CT with IV contrast
- Emboli appear as intraluminal filling defects within opacified pulmonary vessels
- Most accurate in diagnosis of moderate-large central emboli
- Less accurate for small, peripheral emboli
- Primary diagnostic modality for patients with pulmonary disease
- Sensitivity ranges from 53-98%
- Specificity 90%
Patient E.S.

- 67 y/o F
- HPI: bilateral lower extremity edema, SOB and signs of R heart failure
- PMH: diabetes, anemia, hypertension
E.S. Chest X-Ray

Pleural effusions
E.S. CTA- axial views

Filling defects

Pleural effusions

Filling defects
E.S. CTA- sagittal reconstructions

Filling defects

PACS BIDMC
E.S. CTA- coronal reconstruction

Filling defect
CT Scan Summary

- Advantages: high specificity, availability, safety, rapid, good for patients with underlying lung disease, can make other diagnoses
- Disadvantages: expensive, requires contrast so has contraindications (renal failure & contrast allergy), may miss peripheral emboli
- PIOPED II should provide more information about accuracy of CT as diagnostic modality for PE
Primary Diagnostic Modalities

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Pulmonary Angiography

- Gold standard
- Catheter inserted into femoral artery and contrast injected into pulmonary artery, look for filling defects
- Invasive and expensive
- Used when non-invasive testing inconclusive, for example:
  - negative CT in patient with significant clinical evidence of PE and high risk for anticoagulation
  - indeterminate or low probability V/Q scan in patient with significant clinical evidence of PE
Take Home Points

- CT is primary imaging modality, but more evidence still needed on sensitivity and specificity
- Do not rule out PE based on lower extremity ultrasound or CXR, these should only be used as adjuncts
- V/Q scans not good for patients with lung disease but helpful in patients in whom CT contraindicated
- Pulmonary angiography still gold standard if non-invasive test inconclusive or negative in patient with clinical evidence of PE
- Clinical judgment key in deciding how to interpret radiographic findings
References

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