Goals

• Learn diagnostic evaluation steps of pulmonary embolism
• Learn indications, contraindications, and morbidity associated with inferior vena cava filter placement
Pulmonary Embolism

JAMA Patient Page: Pulmonary Embolism
Patient C.L.

- 71 yo male
- presenting with shortness of breath
- after surgical repair of comminuted tibia fracture, caused by high speed motor vehicle accident
- PMH: prostate cancer treated with Brachy therapy 11 years ago
Differential Diagnosis for PE\(^5\)

- Other pulmonary processes (pneumothorax, pneumonia, asthma, pleural effusion, pleurisy)
- Cardiac Processes (Myocardial Infarction, Congestive Heart Failure, Pericarditis, pericardial tamponade, aortic dissection)
- GI (esophageal rupture, gastritis, ulcer)
- Musculoskeletal Diagnoses
- Anxiety disorder with hyperventilation
## Common Symptoms of PE

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Percentage present when PE present</th>
<th>Percentage present when PE not present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyspnea (sudden)</td>
<td>78%</td>
<td>29%</td>
</tr>
<tr>
<td>Dyspnea (gradual)</td>
<td>6%</td>
<td>20%</td>
</tr>
<tr>
<td>Chest Pain (pleuritic)</td>
<td>44%</td>
<td>30%</td>
</tr>
<tr>
<td>Chest Pain (substernal)</td>
<td>16%</td>
<td>10%</td>
</tr>
<tr>
<td>Fainting</td>
<td>26%</td>
<td>13%</td>
</tr>
<tr>
<td>Hemoptysis</td>
<td>9%</td>
<td>5%</td>
</tr>
<tr>
<td>Cough</td>
<td>11%</td>
<td>15%</td>
</tr>
<tr>
<td>Palpitations</td>
<td>18%</td>
<td>15%</td>
</tr>
</tbody>
</table>
## Common Signs of PE

<table>
<thead>
<tr>
<th>Sign</th>
<th>Percentage present when PE present</th>
<th>Percentage present when PE not present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tachycardia</td>
<td>78%</td>
<td>23%</td>
</tr>
<tr>
<td>Cyanosis</td>
<td>16%</td>
<td>15%</td>
</tr>
<tr>
<td>Hypotension</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Neck Vein Distension</td>
<td>12%</td>
<td>9%</td>
</tr>
<tr>
<td>Leg Swelling (unilateral)</td>
<td>17%</td>
<td>9%</td>
</tr>
<tr>
<td>Fever &gt;38°C</td>
<td>7%</td>
<td>21%</td>
</tr>
<tr>
<td>Crackles</td>
<td>18%</td>
<td>13%</td>
</tr>
<tr>
<td>Pleural Friction Rub</td>
<td>4%</td>
<td>4%</td>
</tr>
</tbody>
</table>
Other Limited Utility Evaluations

- EKG
- Chest Radiographs are abnormal in 69% of PE patients with common findings of elevated hemidiaphragm, atelectasis, or effusions.
- Two other rare findings are Westermark’s sign and Hampton’s Hump.
Westermark’s Sign - Patient A

Focal avascularity in the right upper lung field.

Sensitivity: 14%
Specificity: 92%\(^{10}\)

NEJM: 2001;345 (18): 1311.
Hampton’s Hump - Patient A

A pleural-based, wedge-shaped pulmonary infarction at left lung base

Sensitivity: 22%
Specificity: 82%\textsuperscript{10}

NEJM: 2001;345 (18): 1311.
PE Diagnostics Tools and Tests

- Wells Criteria for estimating clinical probability
- Additional risk factors
- D-Dimer Testing
- Ventilation-Perfusion (VQ) Scanning
- CT Angiography, MR Angiography
- Ultrasonography
- Pulmonary Angiography – the gold standard
Clinical Prediction: Wells Criteria\textsuperscript{3}

3.0 pts Clinical signs and symptoms of DVT
3.0 pts Alternative diagnosis deemed less likely than PE
1.5 pts HR > 100 bpm
1.5 pts Immobilization or surgery within 4 weeks
1.5 pts Previous DVT or PE
1.0 pt Hemoptysis
1.0 pt Cancer (receiving treatment, or treated within 6 months)

Low clinical probability: <2 pts
Intermediate clinical probability: 2-6 pts
High clinical probability: >6 pts
Risk Factors for Venous Thromboembolism

- Age >40 y
- History of venous thromboembolism
- Surgery requiring >30 min anesthesia
- Prolonged immobilization
- CHF
- Fracture of pelvis, femur, or tibia
- Obesity
- Pregnancy or recent delivery

- Cerebrovascular accident
- Cancer
- IBD
- Obesity
- Estrogen therapy
- Genetic or acquired thrombophilia
  - Antithrombin III deficiency
  - Protein C deficiency
  - Protein S deficiency
  - Prothrombin G20210A mutation
  - Factor V Leiden
  - Anticardiolipin antibody syndrome
  - Lupus anticoagulant
D-Dimer

- Sensitivity: 80-100%² (ELISA)
- Excellent for ruling out PE in low clinical probability patients
Ventilation-Perfusion Scan - Patient B

Plymouth Hospital, UK,
http://www.derriford.co.uk/nucmed/teaching/images/lungs
Comparison of Ventilation-Perfusion Scan Category with Angiogram Findings (PIOPED)

<table>
<thead>
<tr>
<th>Scan Category</th>
<th>Sensitivity %</th>
<th>Specificity %</th>
</tr>
</thead>
<tbody>
<tr>
<td>High probability</td>
<td>41%</td>
<td>97%</td>
</tr>
<tr>
<td>High or intermediate probability</td>
<td>82%</td>
<td>52%</td>
</tr>
<tr>
<td>High, intermediate or low probability</td>
<td>98%</td>
<td>10%</td>
</tr>
</tbody>
</table>
Computed Tomography
Angiography – Patient CL

Axial
Coronal

Courtesy Jim Busch, MD, BIDMC
Magnetic Resonance Angiography\textsuperscript{7} – Patient C

<table>
<thead>
<tr>
<th>Angiogram</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MRA</td>
<td>PE+</td>
<td>PE-</td>
<td>Total</td>
</tr>
<tr>
<td>PE+</td>
<td>27</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>PE-</td>
<td>8</td>
<td>81</td>
<td>89</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>83</td>
<td>118</td>
</tr>
</tbody>
</table>

Oudkerk, \textit{Lancet}, 2002
Ultrasound – Patient CL

No Compression

Compression

BIDMC, PACS
Pulmonary Angiography – Patient D

The Gold Standard -- Expensive – Morbidity

Normal

Lobar Defect

Segmental Defect

Wake Forest School of Medicine, Duncan Hite, MD,
http://intmedweb.wfubmc.edu/download/venous.pdf. (Slide 27)
Diagnostic Approaches

- Low clinical probability
- Intermediate clinical probability
- High clinical probability
Low clinical probability of PE

Highly sensitive D-dimer assay

Negative: Dx ruled out

Positive: Ventilation-perfusion scanning or CT scanning

Fedullo, *NEJM*, 2003
Low clinical probability of PE

CT angiography or ventilation-perfusion scanning

Positive CT angiogram

Dx confirmed

Pulmonary angiography

Negative

Dx ruled out

Ventilation-perfusion scan indicating high probability of PE

Duplex US

Positive

Dx confirmed

Neglected CT angiography or ventilation-perfusion scan

Negative CT or ventilation-perfusion scan indicating low/intermediate probability of PE

Duplex US

Positive

Dx confirmed

Negative

Dx ruled out

Negative ventilation-perfusion scan

Dx ruled out

Fedulio, *NEJM, 2003*
Intermediate clinical probability of PE

CT angiography or ventilation-perfusion scanning

Positive CT angiogram
- Dx confirmed

Negative CT or ventilation-perfusion scan indicating low/intermediate/high probability of PE
- Duplex US
  - Negative
    - Pulmonary angiography
      - Negative
        - Dx ruled out
      - Positive
        - Dx confirmed
  - Positive
    - Dx confirmed

Negative ventilation-perfusion scan
- Dx ruled out
High clinical probability of PE

CT angiography or ventilation-perfusion scanning

- Positive CT angiogram or ventilation-perfusion scan indicating high probability of PE
  - Dx confirmed

- Negative CT or ventilation-perfusion scan indicating low/intermediate probability of PE
  - Duplex US
    - Negative
      - Pulmonary angiography
        - Negative
          - Dx ruled out
        - Positive
          - Dx confirmed
    - Positive
      - Dx confirmed

- Negative ventilation-perfusion scan
  - Dx ruled out

Fedullo, *NEJM*, 2003
Treatment²

- Unfractionated heparin or Low Molecular Weight Heparin
- Coumadin for 6 months
- Inferior Vena Cava Filter
- Thrombectomy
Inferior Vena Cava (IVC) Filters

**Indications**
-- Contraindication to anticoagulation therapy
-- Failure of anticoagulation therapy
-- Prophylaxis for patients at high risk for thromboembolic events

**Low Morbidity**
-- Vena Cava thrombosis
-- Malpositioning and migration

A. Greenfield, B. Modified Greenfield, C. Bird’s Nest, D. Simon nitonol, Vena Tech

Picture Source: Streiff, Blood, 2002
Filters vs. Anticoagulation Therapy

- Initial significant beneficial effect of filters (<12 days and < 1 year) in prevention of PE
- Counterbalanced after 1 year by increased symptomatic PE and DVT for those with filters
- No long-term difference in mortality
Removable Filters

- Benefits include decreased risk of IVC occlusion and filter migration
- Two week stay
- Nov 2002: FDA approved Recovery filter that can remain as long as needed and then removed.
Conclusions

• Acute pulmonary embolism is a major, preventable cause of death
• Diagnosis is difficult, but combining Wells Criteria with Laboratory and Radiologic tests improves the accuracy of the diagnosis.
• When anticoagulation therapy is contraindicated, IVC filters are indicated for prevention of recurrent PE.
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References


References - Continued


10. Sokolove, Peter E.; Offerman, Steven R. Pulmonary Embolism Images in Clinical Medicine, NEJM, 2001;345 (18): 1311


Image Sources

- Slide 9: Image Source: NEJM: 2001;345 (18): 1311
- Slide 17 and 19: Image Source Jim Busch, MD, BI
- Slide 20: Image Source: Wake Forest School of Medicine, Duncan Hite, MD. http://intmedweb.wfubmc.edu/download/venous.pdf