Diagnosis of pulmonary embolism

Introduction

- obstruction of the pulmonary artery or one of its branches thrombus originated elsewhere in the body
- Massive PE => acute right ventricular failure and death
  - hypotension
    - systolic blood pressure <90 mmHg
    - drop in systolic blood pressure of ≥40 mmHg from baseline for a period >15 minutes
  - elevated central venous pressure (or neck vein distension)
  - exclude AMI, tension pneumothorax, pericardial tamponade, or a new arrhythmia

Symptoms and signs

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyspnea</td>
<td>73 percent</td>
</tr>
<tr>
<td>Pleuritic chest pain</td>
<td>66 percent</td>
</tr>
<tr>
<td>Cough</td>
<td>37 percent</td>
</tr>
<tr>
<td>Hemoptysis</td>
<td>13 percent</td>
</tr>
<tr>
<td>Tachypnea</td>
<td>20 percent</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>10 percent</td>
</tr>
<tr>
<td>Fourth heart sound</td>
<td>24 percent</td>
</tr>
<tr>
<td>Accentuated pulmonic component of second heart sound</td>
<td>23 percent</td>
</tr>
<tr>
<td>Circulatory collapse</td>
<td>5 percent</td>
</tr>
</tbody>
</table>


Wells criteria

<table>
<thead>
<tr>
<th>Probability</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>&gt;6.0</td>
</tr>
<tr>
<td>Moderate</td>
<td>2.0 to 6.0</td>
</tr>
<tr>
<td>Low</td>
<td>&gt;0.0</td>
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</tbody>
</table>

Traditional clinical probability assessment (Wells criteria)

- Clinical symptoms of DVT (leg swelling, pain with palpation)
- Other diagnosis less likely than pulmonary embolism
- Heart rate >100
- Immobilization (≥3 days) or surgery in the previous four weeks
- Previous DVT/PE
- Hemoptysis
- Malignancy

Simplified clinical probability assessment (Modified Wells criteria)*

- PE likely
- PE unlikely


Lab data

- Nonspecific!!!
  - leukocytosis
  - Increased ESR
  - elevated serum LDH or AST with a normal serum bilirubin

- 52 studies, comprising 55,268 patients
- Meta-analysis
- Clinical impression alone
  - Sensitivity: 85%
  - Specificity: 51%
- the need for additional diagnostic evaluation whenever acute PE is suspected

ABG

- Hypoxemia
  - PaO2 between 85 and 105 mmHg: 18%
- Hypocapnia
- Respiratory alkalosis
- SaO2<95% under room air
  - respiratory failure
  - cardiogenic shock
  - death

- massive PE with hypotension and respiratory failure
  - hypercapnia
  - respiratory and metabolic acidosis (the latter due to lactic acidosis)

- In our patient:
  - pH: 7.382
  - PaO2: 56 mmHg
  - PaCO2: 25.5 mmHg
  - BE: -10 mmol/L
  - HCO3: 15.2 mmol/L
  - SaO2: 89%

- Troponin-I
  - elevated in 30~50% patients
  - acute right heart overload
  - usually resolve within 40 hrs
    - more prolonged elevation after AMI
    - associated with adverse outcomes
  - In our patient: 0.188 ug/L

- D-dimer
  - degradation product of cross-linked fibrin
  - >500 ng/mL: abnormal
    - good sensitivity and negative predictive value
      - D-dimer levels are abnormal in 95% of all patients with PE
    - poor specificity and positive predictive value
      - normal in only 40~68% of patients without PE
      - malignancy or recent surgery
  - In our patient: >10000 ng/mL

- EKG
  - Abnormal EKG in 70% PE patients
    - most commonly nonspecific ST-segment and T-wave changes
  - S1Q3T3 pattern
  - TWI over V1~V4
  - new incomplete RBBB
    - Not common
    - massive acute PE and cor pulmonale
    - more severe RV dysfunction
normal in only 12% of patients with PE
- atelectasis/increased opacity/pleural effusion
  - Most common
  - not significantly different from that in patients without PE
- Oligemia (the Westermark sign)
- prominent central pulmonary artery (the Fleischner sign)
- pleural-based area of increased opacity (the Hampton hump)
  - also poor predictors of PE


shallow wedge-shaped opacity in the periphery of the lung with its base against the pleural surface
Westermark sign represents a focus of oligemia (vasoconstriction) seen distal to a pulmonary embolus.

Ultrasound
- Lower extremity venous ultrasound is sometimes performed during the diagnostic evaluation of PE.
- Only 29% of patients with PE (determined by V/Q scan or pulmonary angiogram) had venous thrombosis detected by compression ultrasound.

Angiography
- Gold standard
  - Injecting contrast into a pulmonary artery
  - Filling defect or abrupt cutoff of a small vessel is indicative of an embolus
- Generally safe and well tolerated
  - Absence of hemodynamic instability caused by acute, severe pulmonary hypertension

V/Q scan
- V/Q scan should combined with clinical probability

<table>
<thead>
<tr>
<th>Scan Category</th>
<th>Clinical probability of embol</th>
<th>Clinical probability of embol</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>95</td>
<td>86</td>
</tr>
<tr>
<td>Intermediate</td>
<td>85</td>
<td>28</td>
</tr>
<tr>
<td>Low</td>
<td>80</td>
<td>15</td>
</tr>
<tr>
<td>Normal or near normal</td>
<td>0</td>
<td>10</td>
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V/Q scan
- Result
  - Normal: No perfusion deficit, excludes pulmonary thromboembolism
  - Low probability: Perfusion deficit with matched ventilation deficit, non-diagnostic
  - Intermediate probability: Perfusion deficit that corresponds to parenchymal abnormality on chest x-ray, non-diagnostic
  - High probability: Multiple segmental perfusion deficits with normal ventilation, diagnostic for pulmonary thromboembolism

CT pulmonary angiography
- Sensitivity: 83%
- Specificity: 96%
CT-PA vs V/Q scan

- CT-PA was not inferior to V/Q scan in ruling out pulmonary embolism
- More patients were diagnosed with pulmonary embolism using the CT-PA approach

JAMA. 2007;298(23):2743.

The Christopher study

- Prospective cohort study of 3306 patients
  - Sudden onset of dyspnea
  - Deterioration of existing dyspnea
  - Onset of pleuritic chest pain without another apparent cause
- Modified Wells criteria for PE, patients were categorized as "PE likely" (score >4) or "PE unlikely" (score ≤4)


Diagnosis algorithm

PE rule-out criteria

- Age less than 50 years
- Heart rate less than 100 bpm
- Oxyhemoglobin saturation ≥ 95 percent
- No hemoptysis
- No estrogen use
- No prior DVT or PE
- No unilateral leg swelling
- No surgery or trauma requiring hospitalization within the past four weeks

Anticoagulation therapy

- Initiated immediately !!!
  - High clinical suspicion of pulmonary embolism
  - Continued during the diagnostic evaluation

- Mortality rate of recurrent PE: approximately 30%
- Mortality rate of major bleeding due to anticoagulation therapy: < 3%

Thrombolysis

- Indication
  - Persistent hypotension (SBP < 90 mmHg or a drop in systolic blood pressure of 240 mmHg from baseline)
  - Severe hypoxemia
  - Large perfusion defect on ventilation-perfusion scans
  - Extensive embolic burden on computed tomography (CT)
  - Right ventricular dysfunction
  - Free-floating right atrial or ventricular thrombus
  - Patent foramen ovale

- Only hemodynamic compromise is a widely accepted indication

multicenter, prospective cohort study of 8138 emergency department patients with suspected PE

- Chest pain or dyspnea was the chief complaint of 85 percent of the patients.
- Low suspicion for PE + PERC(-): in 1666 patients (20%)
- In the 1666 patients, only 15 patients (less than 1%) developed a DVT or PE within 45 days.

- accelerates clot lysis
- short-term physiologic benefits
- mortality benefit ??
- considered only after PE has been confirmed
- adverse effects of this therapy can be severe
  - In a retrospective analysis of 104 patients with PE who received tPA, 20 patients (19 percent) had major bleeding


- Contraindication to thrombolysis

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<tbody>
<tr>
<td>History of hemorrhagic stroke</td>
<td>Active intracranial neoplasm</td>
<td>Recent (&lt; 2 months) intracranial surgery or trauma</td>
<td>Active or recent internal bleeding in prior 6 months</td>
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<tr>
<th>Relative</th>
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</thead>
<tbody>
<tr>
<td>Bleeding diathesis</td>
<td>Uncontrolled severe hypertension (systolic BP &gt;200 mmHg or diastolic BP &gt;110 mmHg)</td>
<td>Nonhemorrhagic stroke within prior 2 months</td>
<td>Surgery within the previous 10 days</td>
<td></td>
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<tr>
<td>Thrombocytopenia (&lt;100,000 platelets per mm3)</td>
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- via a peripheral IV catheter
- Unnecessary invasive procedures (particularly arterial punctures) should be minimized
- tPA
  - 100 mg IV over two hours
- Streptokinase
  - 250,000 units IV over the initial 30 minutes
  - 100,000 units/hour for 24 hours
- Urokinase
  - 4,400 units/kg IV over the initial 10 minutes
  - 4,400 units/kg per hour for 12 hours

- Anticoagulant therapy is generally discontinued during the thrombolytic infusion
- aPTT should be measured when infusion of the thrombolytic therapy is complete.
  - aPTT < 2*UNL => continue heparin treatment
  - aPTT > 2*UNL => recheck every four hours until it is less than twice its upper limit, at which time heparin should be resumed

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