Radiological Diagnosis and Treatment of Pulmonary Embolism

Eduardo Borquez, Harvard Medical School Year III
Gillian Lieberman, MD
Presentation Overview

I. Patient Summary
II. Disease Introduction
III. Radiologic Diagnosis
IV. Radiologic Treatment
I. Patient Summary

- S.I. 54 y/o ᵃ
- Hx:- chronic + acute lower extremity **DVT**
  - atrial flutter
  - brain abscess 2° to dental procedure
  - Tx w/ craniotomy June 2002
Patient Summary

- **HPI:** ↓ mobility following craniotomy
  - SOB w/ dyspnea on exertion of 4 days duration prior to admission

- **PE:** Afebrile, BP 136/96, HR 107, RR 18
  - O2Sat 95% on room air.
  - Well appearing, but mild distress.
  - Cardiopulmonary: tachycardia, clear lungs.
  - Dark ecchymosis and tenderness on L ant. Thigh
  - Palpable clot in R popliteal fossa.

Index case courtesy of Matthew Spencer, MD
Patient Summary

Diagnosis:
- US → R+L popliteal vein DVT
- CXR noncontributory
- CT revealed heavy PE burden
- Angiogram

Treatment
- Thrombectomy

Index case courtesy of Matthew Spencer, MD
## II. Disease Introduction

<table>
<thead>
<tr>
<th>Incidence</th>
<th>300,000 Diagnosed, 50,000 deaths annually. (200,000 deaths according to Robbin’s). Estimated 600,000 undiagnosed annually.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Etiology</td>
<td>Virchow’s triad (injury, stasis, hypercoag.). DVT: 90% arise from large deep veins of lower legs.</td>
</tr>
<tr>
<td>Signs/Sx</td>
<td>Dyspnea, pleuritic pain, cough, hemoptysis. Tachypnea, rales, tachycardia.</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Hx/PE, CXR, ABG, ECG, Hemodynamics, V/Q scan, CT, Angio.</td>
</tr>
<tr>
<td>Pathology</td>
<td>↑ vascular pressure (blocked flow/ vasospasm), ischemia.</td>
</tr>
<tr>
<td>Surgery/ Tx</td>
<td>Medical and Mechanical (Radiologic and Surgical) thrombolysis, embolectomy and secondary prevention.</td>
</tr>
<tr>
<td>Prognosis</td>
<td>Without tx: 30% mortality. With effective tx: 2-8% mortality.</td>
</tr>
</tbody>
</table>

Thompson BT, Hales, CA UpToDate Clinical manifestations of and diagnostic strategies for acute pulmonary embolism [http://www.utdol.com](http://www.utdol.com)

Tapson, VF, UpToDate Massive pulmonary embolism [http://www.utdol.com](http://www.utdol.com)

Cotran: Robbins Pathologic Basis of Disease, 6th ed., Copyright 1999 W. B. Saunders Company
Difficulty in Diagnosis

<table>
<thead>
<tr>
<th>Symptom</th>
<th>PE %</th>
<th>No PE %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyspnea</td>
<td>73</td>
<td>72</td>
</tr>
<tr>
<td>Pleuritic pain</td>
<td>77</td>
<td>59</td>
</tr>
<tr>
<td>Cough</td>
<td>43</td>
<td>36</td>
</tr>
<tr>
<td>Leg swelling</td>
<td>33</td>
<td>22</td>
</tr>
<tr>
<td>Leg pain</td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>Hemoptysis</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>Palpitations</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>Wheezing</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Angina-like pain</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

Stein, PD et al, Clinical, Laboratory, Roentgenographic and Electrocardiographic findings in patients with acute pulmonary embolism and no pre-existing cardiac or pulmonary disease. Chest 100(3):598.
# Difficulty in Diagnosis

<table>
<thead>
<tr>
<th>Signs</th>
<th>PE %</th>
<th>No PE %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tachypnea</td>
<td>70</td>
<td>68</td>
</tr>
<tr>
<td>Crackles</td>
<td>51</td>
<td>40</td>
</tr>
<tr>
<td><strong>Tachycardia (&gt;100)</strong></td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>4\textsuperscript{th} heart sound</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>↑ P2</td>
<td>23</td>
<td>13</td>
</tr>
<tr>
<td>Deep venous thrombosis</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Diaphoresis</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>Temp. &gt; 38.5 C</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Wheezes</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Right ventricular lift</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Pleural friction rub</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3\textsuperscript{rd} heart sound</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Cyanosis</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

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III. Radiologic Diagnosis

A. Chest X-Ray
B. Ventilation-Perfusion scan
C. CT with contrast
D. Angiography
E. Ancillary tests: Doppler US
A. CXR

1. Classic Findings

- Atelectasis
- Pleural effusion
- Parenchymal opacification
- Elevation of hemidiaphragm
- Hampton’s Hump (wedge shaped pleural-based triangular opacity with apex pointing toward hilus.
- Westermark’s sign (decreased vascularity).

Garg, K. CT of Pulmonary Thromboembolic disease. Radiologic Clinics of North America 40(1); 2002
Felson, B. Gamuts in Radiology. 2nd Edition
1. Classic Findings

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Differential

1. Bronchial adenoma
2. Bronchiectasis
3. Carcinoma, bronchogenic
4. Compression atelectasis
5. Contraction atelectasis (fibrosis)
6. Foreign body
7. Mucus plugs

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A. CXR

1. Classic Findings
   - Atelectasis
   - Pleural effusion
   - Parenchymal opacification
   - Elevation of hemidiaphragm
   - Hampton’s Hump (wedge shaped pleural-based triangular opacity with apex pointing toward hilus.
   - Westermark’s sign (decreased vascularity).

Differential
   1. Abscess
   2. Ascites
   3. Collagen disease
   4. Infection
   5. Lymphoma
   6. Metastasis
   7. Pancreatitis
   8. Trauma

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- Parenchymal opacification
- Elevation of hemidiaphragm
- Hampton’s Hump (wedge shaped pleural-based triangular opacity with apex pointing toward hilus.
- Westermark’s sign (decreased vascularity).

Differential

1. Atelectasis
2. Consolidation (ex. pneumonia)
3. Pleural Effusion
4. Pneumonectomy

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A. CXR

1. Classic Findings

- Atelectasis
- Pleural effusion
- Parenchymal opacification
- Elevation of hemidiaphragm
- Hampton’s Hump (wedge shaped pleural-based triangular opacity with apex pointing toward hilus.)
- Westermark’s sign (decreased vascularity).

Differential

1. Atelectasis
2. Distended stomach or spleen
3. Rib fracture (guarding)
4. Phrenic nerve paralysis
5. Pleural disease
6. Pneumonia
7. Postoperative
8. Ruptured liver or spleen
9. Scoliosis

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Felson, B. Gamuts in Radiology. 2nd Edition
## CXR findings patients with no previous cardiac or pulmonary disease

<table>
<thead>
<tr>
<th>Finding</th>
<th>PE %</th>
<th>No PE %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Atelectasis</td>
<td>66</td>
<td>48</td>
</tr>
<tr>
<td>2) Pleural effusion</td>
<td>48</td>
<td>31</td>
</tr>
<tr>
<td>3) Pleural based opacity</td>
<td>35</td>
<td>21</td>
</tr>
<tr>
<td>4) Elevated diaphragm</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>5) Decreased vascularity</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>6) Prominent central pulmonary artery</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>7) Cardiomegaly</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>8) Westermark’s sign (defined as 4 and 5 above)</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>9) Pulmonary edema</td>
<td>4</td>
<td>13</td>
</tr>
</tbody>
</table>

Stein, PD et al, Clinical, Laboratory, Roentgenographic and Electrocardiographic findings in patients with acute pulmonary embolism and no pre-existing cardiac or pulmonary disease. Chest 100(3):598.
CXR S.I.: Normal Findings

S. I. 6-25-02 Comparison film

S.I. 8-8-02
CXR

- CXR is usually nonspecific for PE
- Value is in excluding other diagnosis that may mimic PE and in interpreting V/Q scan

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Ventilation/Perfusion Scan

1. Procedure
   - Technetium (Tc) 99m or Xenon aerosol
   - Tc-99m macroaggregated albumin
   - Take different views.

Ventilation/Perfusion Scan

2. An example of a normal Scan (not our patient S. I.)

Image courtesy of Dr. Kevin Donohoe
Ventilation/Perfusion Scan

2. An example of a high probability scan
(not our patient S.I.)
**V/Q: Normal vs. Abnormal**

Example of a normal scan

Example of a high probability scan

Image courtesy of Dr. Kevin Donohoe
# Ventilation/Perfusion Scan

## 3. Pitfalls and advantages

<table>
<thead>
<tr>
<th>Pitfall / Advantage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronchospasm</td>
<td>+ Physiologic</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>+ Can visualize past 4(^{th}) generation vessels</td>
</tr>
<tr>
<td>Poor circulation</td>
<td>+ Future in GPIIb/III receptor imaging</td>
</tr>
<tr>
<td>Logistics</td>
<td></td>
</tr>
<tr>
<td>Non-radiologist bias</td>
<td></td>
</tr>
</tbody>
</table>

Ventilation/Perfusion Scan

4. Interpretation continued

<table>
<thead>
<tr>
<th>Scan Category</th>
<th>Clinical Science Probability %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High (80-100)</td>
</tr>
<tr>
<td>High probability</td>
<td>96</td>
</tr>
<tr>
<td>Intermediate</td>
<td>66</td>
</tr>
<tr>
<td>Low</td>
<td>40</td>
</tr>
<tr>
<td>Near normal/normal</td>
<td>0</td>
</tr>
</tbody>
</table>

# CT with Contrast

<table>
<thead>
<tr>
<th>+</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directly shows emboli</td>
<td>High sensitivity for central vessels (near 100) but low for segmental (53-91)</td>
</tr>
<tr>
<td>Non-invasive</td>
<td></td>
</tr>
<tr>
<td>Relatively cheap</td>
<td></td>
</tr>
<tr>
<td>Info about alternative diagnosis</td>
<td></td>
</tr>
<tr>
<td>“One-stop” imaging for DVT and PE</td>
<td></td>
</tr>
</tbody>
</table>

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CT Anatomy

A brief orientation for the CT scans of our patient S.I.

Ribbs

T5 Intervertebral disk

CT Anatomy

Superior vena cava

CT anatomy

Right pulmonary artery

Left pulmonary artery

Pulmonary trunk

Intermediate and left principle bronchi

CT S.I. Findings

Emboli
Angiogram

- Gold standard
- Iodinated contrast injected into the pulmonary artery
- Positive result consists of filling defect or sharp cutoff.
- Mortality ~0.5%  Morbidity ~5%

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Angiogram Anatomy

S.I. Findings

**Right**
- Clot in upper lobe vessels
- Free floating clot in proximal R descending pulmonary artery
- Clot in lower lobe vessels

**Left**
- Clot in L main
- 2 globular clots which fill nearly the entire descending pulmonary artery

Angiogram S.I. Findings

Upper Lobe Vessel Embolus

S. I. Proximal R descending clot

Normal

BIDMC PACS
Angiogram S.I. Findings

**Left Main Embolus**

**Left descending**

**Normal**
Decision making can be complex and many algorithms and neural networks have been developed.

This is an example of a simple, radiology centered algorithm.

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IV. Radiologic Treatment

A. Treatment Overview
B. Radiologic Treatment
# A. Treatment Overview

<table>
<thead>
<tr>
<th></th>
<th>Primary Treatment</th>
<th>Secondary Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medical</strong></td>
<td>Thrombolysis</td>
<td>Unfractionated heparin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LMW heparin</td>
</tr>
<tr>
<td><strong>Mechanical</strong></td>
<td>Catheter embolectomy</td>
<td>IVC (or SVC) filters</td>
</tr>
<tr>
<td></td>
<td>Catheter based</td>
<td></td>
</tr>
<tr>
<td></td>
<td>thrombolysis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Surgical embolectomy</td>
<td></td>
</tr>
</tbody>
</table>
Radiologic Treatment

- **Catheter Embolectomy**
  - Vacuum-cup catheter technique
  - Rheolytic embolectomy catheter (Angiojet embolectomy system)
  - Direct, intraembolic, low dose thrombolytic infusion.

- **Filters**

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Rheolytic Embolectomy Catheter

- Angiojet

http://www.wfubmc.edu/interneuro/techpg1.html
### Summary

<table>
<thead>
<tr>
<th>Incidence</th>
<th>Common</th>
</tr>
</thead>
<tbody>
<tr>
<td>Etiology</td>
<td>DVT of lower extremities</td>
</tr>
<tr>
<td>Signs/Sx</td>
<td>Varied and nonspecific, but include dyspnea, pain, cough, tachypnea, tachycardia, crackles</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Complex. Most often V/Q or CT. Angio is gold standard.</td>
</tr>
<tr>
<td>Pathology</td>
<td>↓Flow → ↑ pressure, ischemia.</td>
</tr>
<tr>
<td>Surgery/Tx</td>
<td>Thrombolysis, embolectomy and prevention.</td>
</tr>
<tr>
<td>Prognosis</td>
<td>High mortality without treatment</td>
</tr>
</tbody>
</table>

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Acknowledgments

- Gillian Lieberman, MD
- Matthew Spencer, MD
- Dr. Kevin Donohoe
- Pamela Lepkowskil
- Our patient S.I.
- Our webmasters Larry Barbaras and Cara Lyn D’amour

http://radiology.bidmc.harvard.edu/education/default.htm
http://home.caregroup.org/departments/radiology/internet/staff/residents.html
References

- Thompson BT, Hales, CA UpToDate Clinical manifestations of and diagnostic strategies for acute pulmonary embolism http://www.utdol.com
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