Radiological Hallmarks of Pulmonary embolism

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Outline

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- Chest Radiology
- Anatomy of pulmonary vessels

Our Patient
- Our Patient
- Radiograph
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- Diagnosis

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- Pathophysiology
- Well’s Probability score
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- X-Ray and CT findings
- Management
- Our patient
Definition

• **Pulmonary embolism (PE)** refers to embolic occlusion of the pulmonary arterial system
  • Incidence of symptomatic PE - 20:100,000
  • Incidence of autopsy detected PE - 50:100,000 person years. [1]

• **Emboli:**
  – Thrombotic
  – Air embolism
  – Fat embolism
  – Tumour embolism
  – Hydatid pulmonary embolism
  – Septic pulmonary embolism
Radiology of Chest
Anatomy review of Pulmonary vessels

- vertebral artery RT
- common carotid artery RT
- common carotid artery LT
- vertebral artery LT
- subclavian artery RT
- subclavian artery LT
- brachiocephalic artery
- axillary artery RT
- axillary artery LT
- pulmonary veins RT
- pulmonary arteries RT
- ascending aorta
- heart
- descending thoracic aorta
Our Patient

- Pt is a 66 y/o gentleman with PMH of HTN, depression, presenting
- With sudden onset of R-sided back and shoulder pain
- In the setting of 3-4 weeks of hemoptysis
- Vitals: Temp-98.3; BP-193/82, Pulse-93, RR-20
- Examination: Crackles in Right lung base
- Labs: Unremarkable
Chest X Ray-PA view

Low lung volumes with probable bibasilar atelectasis
There is a large filling defect seen in the distal right main pulmonary artery.
CT Angiogram Image-2

- Thrombus extends into the upper and lower lobar branches, and middle segmental branch (Arrow points at lower lobar branch)
• An area of consolidation in the left lower lobe is seen distal to an obstructed segmental pulmonary artery
• Likely an infarct
CT-Angiogram Image-4

- Dilated pulmonary trunk - 3.5 cm
The RV to LV ratio is minimally greater than 1 which may be indicative of RV strain.
So we have seen till now:

- Filling defects in the pulmonary artery
- Extension into the lobar branches
- Areas of infarction
- Dilated Pulmonary artery
- Right heart strain

PULMONARY EMBOLISM
Types of Pulmonary embolism

- Massive Pulmonary embolism: Hypotension accompanied by increased venous pressure or distended neck veins that are not otherwise explained by acute MI, tension pneumothorax, pericardial tamponade or new arrhythmia.

- All other PE’s not meeting definition of massive PE are considered sub-massive

- Recurrent Pulmonary embolism: Increasing SOB, weakness exertional syncope and pulmonary hypertension.[1]
Pathophysiology

- Vaso-occlusive crisis
- Increased endothelial VCAM-1 expression and adhesion
- Increased erythrocyte adhesion in lung causing pulmonary infarction
- Microvasculature occlusion and bone marrow infarction
- Secretory phospholipase

- Decreased oxygen delivery
- Desaturated hemoglobin
- Regional hypoxia

- NO
- Shunt

Hypoventilation and atelectasis resulting from rib and vertebral infarction

Acute chest syndrome

Courtesy: Bello Yusuf et al, Acute chest syndrome, Sub-Saharan African Journal of Medicine; Volume 1 Issue 3; Year 2014
## Well’s Probability Score

<table>
<thead>
<tr>
<th>Variable</th>
<th>Points</th>
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<tbody>
<tr>
<td>Clinical signs and symptoms of DVT*</td>
<td>3.0</td>
</tr>
<tr>
<td>An alternative diagnosis is less likely than PE</td>
<td>3.0</td>
</tr>
<tr>
<td>Heart rate &gt;100 beats per minute</td>
<td>1.5</td>
</tr>
<tr>
<td>Immobilization or surgery in previous 4 weeks</td>
<td>1.5</td>
</tr>
<tr>
<td>Previous DVT/PE</td>
<td>1.5</td>
</tr>
<tr>
<td>Hemoptysis</td>
<td>1.0</td>
</tr>
<tr>
<td>Malignancy (on treatment, treated in the last 6 mos or palliative)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

*Minimum of leg swelling and pain with palpation of deep veins; DVT, deep-vein thrombosis; PE, pulmonary embolism

<table>
<thead>
<tr>
<th>Score</th>
<th>Category</th>
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<tbody>
<tr>
<td>&lt;2 points</td>
<td>low probability</td>
<td>&lt;4 points</td>
<td>unlikely PE</td>
</tr>
<tr>
<td>2–6 points</td>
<td>moderate probability</td>
<td>≥4 points</td>
<td>likely PE</td>
</tr>
<tr>
<td>&gt;6 points</td>
<td>high probability</td>
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</table>

Source: Lab Med © 2008 American Society for Clinical Pathology
Evaluation

Clinical Probability of PE

PE Unlikely
- D-dimer
  - Below Cut-off
    - No Treatment
  - Above Cut-off
    - CTA
      - Negative
        - No Treatment
      - Positive CTA / Positive D-dimer
        - Start Treatment

PE Likely
- CTA / D-dimer
  - Negative CTA / Positive D-dimer
    - V/Q and/or Serial CUS
  - Negative CTA / Negative D-dimer
    - No Treatment

Courtesy: Adam Torbicki et.al; Guidelines on the diagnosis and management of acute pulmonary embolism, European Heart Journal; Aug 2008
Diagnostic modalities

• D-Dimer- A screening test in patients with low probability. 100% negative predictive value

• Menu of Tests:
  – Chest X-RAY
  – Spiral CT angiogram
  – Lung scan (V/Q)
  – Pulmonary angiogram
  – Echocardiogram
Menu of tests

• Chest X-rays are not diagnostic, but may be helpful as only 12% with clinically significant PE have a normal X-Ray.

• Spiral CT: Fast, accurate but with less accuracy and often affected by patient movement. Can be considered adequate for detection of emboli only up to segmental level.

• CTPA is considered gold-standard, but is invasive and is usually unavailable immediately.

• V/Q Scan: V/Q scanning may reveal segmental areas of mismatch. It has fewer potential side effects than CTPA scanning and may be preferred in patients with impaired renal function, iodine allergy and in young women. PIOPED criteria-normal or near-normal, low, intermediate (non-diagnostic) and high probability of PE

• ECHO: Particularly helpful in emergency management decisions. Main role in prognostic stratification
X Ray findings

- Fleishner’s Sign-Enlarged pulmonary artery (20%)
- Hampton hump: Peripheral wedge of airspace opacity and implications (20%)
- Westermark’s sign: Regional oligemia
- Pleural effusion (35%)
- Knuckle sign
Figure 1. Chest radiograph demonstrating a prominent central pulmonary artery (early Fleishner’s Sign, red arrows) and a cut-off of the pulmonary arteries bilaterally (Westermark sign, black arrows).
CT-Acute pulmonary embolism

• Arterial occlusion with failure to enhance the entire lumen due to a large filling defect

• Contrast surrounding the filling defect:
  – Polo mint sign on perpendicular axis of vessel
  – Railway track sign on longitudinal axis

• Peripheral Wedge shaped infarct- Supported by V/Q scan

• Right heart failure- Dilation, inter ventricular septal deviation, PE index >60%[2]
CT Angiogram-Polo mint sign

2/7/2017

Courtesy: Dr Yuranga Weerakkody et al. Polo mint sign; Radiopedia.org

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CT- Chronic Pulmonary embolism

• Complete occlusion of a vessel that is smaller than an adjacent patent vessel
• Peripheral, crescent shaped luminal defect - obtuse angle (vs acute angle in acute PE) with vessel wall
• Contrast material seen to pass through thickened smaller arteries due to recanalization
• A flap within contrast filled artery[2]
Axial CT image shows a partial thrombus (stars) in the main and proximal left pulmonary artery that forms an obtuse angle with the vessel wall.

There is enlarged pulmonary artery and bronchial collaterals (arrows).
Complications of Pulmonary embolism

• Acute emboli - PEA in context of large saddle embolus
  - Right ventricular dysfunction:
    • Abnormal position of interventricular septum
    • Inferior vena caval contrast reflux
    • RVD:LVD >1

• Subacute- Chronic emboli-
  • Pulmonary infarction
  • Pulmonary hypertension
  • Chronic cor-pulmonale[3]
Differential Diagnosis

• Patient related
  Respiratory motion artefact
  Pulmonary artery catheter

• Technical factors:
  Window settings
  Streak artefact
  Misidentification of veins

• Pathologic factors
  Mucus plug
  Perivascular oedema
  Local increase in vascular resistance
  Pulmonary artery stump in-situ thrombosis
  Pulmonary artery sarcoma[2]
Management of Pulmonary embolism

Suspected high-risk PE
- i.e. with shock or hypotension

CT immediately available*
- no
- yes

Echocardiography
- RV overload

CT available and patient stabilized
- positive
- negative

Search for other causes
- Thrombolysis/embolectomy not justified

PE-specific treatment justified
- Consider thrombolysis or embolectomy

Search for other causes
- Thrombolysis/embolectomy not justified

*CT immediately available is not indicated in the image.
Treatment strategies

- Thrombolysis: Most beneficial in first 48 hrs
- Surgical embolectomy: High risk PE in whom thrombolysis is contraindicated
- Percutaneous catheter embolectomy: Alternative for surgical treatment
- Anti-coagulation: Initiated even when diagnostic work up is going on.
- Long term anticoagulation: Risk of recurrence
- Venous filters: Absolute contraindication to anti-coagulation with high risk of recurrence.
Back to our patient:

• Pt is a 66 y/o gentleman with PMH HTN and depression, presenting with sudden onset of R-sided back and shoulder pain in the setting of 3-4 weeks of scant hemoptysis, with CTA showing bilateral pulmonary emboli.

• Vitals: Stable
• Labs: Unremarkable
• ECG: Sinus Tachycardia
• CT Angiogram: Bilateral pulmonary emboli
Our patient’s course

- **Acute Pulmonary Embolism:** He was initiated on a heparin drip.

- He remained hemodynamically stable throughout his admission. He had a TTE that showed no right heart strain.

- He was transitioned to Rivaroxaban after reviewing the risks and benefits of anticoagulation options, with a plan to treat for 3-6 months.
Take home pearls

- *Pulmonary embolism presentation may be variable; and non-specific*
- *Symptoms may range from asymptomatic to dyspnoea, chest pain, haemoptysis and tachypnea*
- *Work up primarily involves radiological evidence of the occlusion and impact of the embolus*
- *Treatment is based on the evidence of severity of the embolus and time of presentation.*
- *If left undetected; could progress to recurrent or chronic emboli with cor pulmonale*
- *Radiology plays a vital role in the diagnosis and the therapeutic planning of pulmonary embolus.*
My sincere thanks to:

- Sean Burn, MD
- Gillian Lieberman, MD
- Laurel Baxter
- Nyca Bowen
References

1. Pulmonary embolism, Haematology. Red bacteria; Nov 26, 2014

2. Conrad Wittram, MB et.al, CT Angiography of Pulmonary Embolism: Diagnostic Criteria and Causes of Misdiagnosis, Radiographics, September 2004

3. Dr.Donna D’Souza et al. ;Pulmonary Embolism Radiopedia.org

4. Adam Torbicki et.al, Guidelines on the diagnosis and management of pulmonary embolism; European Heart Journal; Vol 29 Issue 18. Pg-2276-2315
Thankyou