Imaging in the Evaluation of Suspected Pulmonary Embolism

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Mrs. BW

- Mrs. BW is a 74-year-old woman with a history of HTN, DM, obesity and COPD who presents to the EW with acute worsening of her baseline dyspnea.
- On exam she is dyspneic and tachycardic, with oxygen saturation of 85% on room air. She has an elevated JVP, an RV heave, and an audible S4.
- Clinical suspicion for PE is high. What now?
Agenda

- Briefly discuss pulmonary embolism and the controversy surrounding its diagnosis.
- Examine the menu of imaging options, and discuss their advantages, disadvantages, and appropriate use.
- Review current recommendations for the work-up of suspected pulmonary embolism.
**Pulmonary Thromboembolism**

- Hypercoaguability leads to thrombus formation in deep veins of extremities. Thrombi propagate proximally, and may dislodge and embolize to pulmonary vasculature.
- Outcomes range from incidental thromboembolism to severe hypoxemia and acute right sided heart failure.
- Incidence in US exceeds 600,000 per year; PE results in at least 250,000 hospitalizations annually\(^{(4)}\).
- Risk factors include \(^{(2)}\):
  - Age >40
  - History of venous thromboembolism
  - Recent surgery, prolonged immobility
  - CVA or CHF
  - Malignancy
  - Pelvis, hip, or tibia fracture
  - Obesity
  - Pregnancy or recent delivery
  - IBD
  - Inherited or acquired thrombophilia (Factor V Leiden, lupus anticoagulant, etc.)
Presentation and Differential Diagnosis of Acute PE

- PE can present with dyspnea, tachycardia, hemoptysis, chest pain, cough, and even syncope.
- The differential diagnosis is very broad and includes:
  - Pneumonia or bronchitis
  - Asthma or COPD exacerbation
  - Myocardial infarction
  - Pulmonary edema
  - Anxiety
  - Aortic dissection
  - Pericardial tamponade
  - Lung cancer
  - Primary pulmonary hypertension
  - Rib fracture
  - Pneumothorax
  - Costochondritis
  - Musculoskeletal pain
The Importance of Accurate Diagnosis

- Mortality rate with therapy falls from 30% to 5%, and 94% of annual deaths from PE are in patients who never received treatment (1). Sensitivity in diagnosis is essential to institute therapy in all appropriate cases.

- Anticoagulation therapy for PE is associated with mortality and morbidity; specificity in diagnosis is essential to avoid unnecessary treatment.

- Bedside tests, including ABG, and ECG are unreliable. D-Dimer has been shown to be close to 100% sensitive, but is non-specific (2).
Imaging

- Pulmonary Angiography remains the gold-standard for diagnosis, and has the potential for therapeutic intervention (through percutaneous thrombectomy).
- It is associated with a 0.5% mortality risk, and a 0.8% risk of major complications (2).
- Non-Invasive Imaging
  - CXR
  - V/Q
  - CTA
  - MRI/MRA
  - US
- V/Q scanning was standard for decades; CTA is gaining wide acceptance as speed, availability, and sensitivity improve.
CXR Findings

- CXR is an essential first step in the work-up of PE to rule out other diagnoses, but it is not sufficiently sensitive or specific for PE diagnosis.
- Common findings in PE include cardiomegaly, atelectasis, pleural effusion, elevation of hemidiaphragm, pulmonary edema and prominent pulmonary arteries.
- Two signs are thought to be more suggestive of PE
  - Westermark’s sign – regional pulmonary oligemia (decreased vascularity).
  - Hampton’s hump – wedge-shaped, pleural-based opacity in region of infarction.
Hampton’s Hump

Patient Presenting with PE…

Widening of mediastinum secondary to increased pulmonary artery pressure

Lower lung zone consolidation; difficult to characterize as pleural or parenchymal

… and the same patient after attempted thoracentesis led to hydropneumothorax

Two Hampton’s humps are now clearly visible as pleural-based “truncated cones”

Air-fluid level indicates hydropneumothorax

Images courtesy of Dr. Steven Weinberger
Ventilation-Perfusion Scanning

- V/Q scan is a nuclear study using radiolabeled aerosol to trace ventilation and radiolabeled albumin aggregates to trace perfusion.
- Perfusion defects are interpreted in the setting of ventilation defects (if any).
- Scans are normal or abnormal; abnormal scans are further stratified as low, intermediate, and high probability for PE.
- Advantages of VQ scan over CTA include low-dose radiation and accurate representation of physiology.
PIOPED
(Prospective Investigation Of Pulmonary Embolism Diagnosis)

- PIOPED study prospectively compared VQ to pulmonary angiography, and showed high sensitivity of abnormal scan (98%) and high specificity (97%) of high probability abnormal scans\(^{(7)}\).
- Problematically, few patients with PE had high probability scans (sensitivity 42%) and most patients without PE had abnormal scans (specificity 10%) \(^{(7)}\).
- PIOPED concluded that V/Q scanning ruled out PE or was diagnostic only in a minority of patients who had unequivocal scan findings and concordant clinical findings \(^{(7)}\).
Normal VQ Scan

- Normal VQ scan is highly sensitive; the patient here can be ruled out for PE.
- But recall from PIOPED that very few patients without PE had normal scans (specificity of abnormal scan 10%)
- Patients with preexisting lung disease are especially unlikely to have a normal scan.

Image courtesy of Dr. Kevin Donohoe, BIDMC
High Probability VQ Scan

- High probability scan in the setting of high clinical suspicion is very specific.
- But recall from PIOPED that only 42% of patients with PE will have a high probability scan; most will be low or intermediate.
- VQ scan, therefore, was very useful for this patient, who had normal ventilation.
- It will, however, be non-diagnostic in a majority of patients.

Image courtesy of Dr. Kevin Donohoe, BIDMC
CTA

- Advantages include speed, availability, and convenience.
- Patients with renal insufficiency or other contraindications to contrast are not good candidates.
- CTA is specific, ranging from 78-100% \(^{(2)}\).
- Sensitivity varies widely between studies, from 57-100\% \(^{(2)}\). Variation can be attributed to:
  - Differing technology; as scanners improve resolution and minimize motion artifact, sensitivity increases.
  - Location of embolus; sensitivity improves with size of vessel.
Mrs. BW’s CTA:
Pulmonary saddle embolus

Images from PACS, BIDMC
Summary of CTA v. VQ

- **CTA Advantages**
  - Convenient, fast, and specific.
  - Sensitivity of newer CT scanners is likely underestimated by much of the current data.
  - Appropriate for patients with preexisting lung disease, in whom V/Q is particularly low-yield.

- **V/Q Advantages**
  - Normal scan is very sensitive; high probability scan is very specific.
  - Lower dose radiation.
  - Unlike CTA, can visualize physiologic impact of disease.
  - Can be used in patients who are not candidates for IV contrast.

So, how should we approach patients like Mrs. BW?
One Current Diagnostic Algorithm
(NEJM, September 2003)

The Future of Suspected PE Evaluation

- MRI angiography has shown potential in evaluation of PE, with sensitivity of 75-100% and specificity of 95-100% in one recent study\(^{(6)}\)

- MRI is more expensive, less convenient, and more time consuming than CTA and has yet to be widely used.

- PIOPED II: currently recruiting, will assess CTA for evaluation of pulmonary embolism\(^{(5)}\).

- As CT technology improves, the sensitivity and specificity of CTA for PE will also likely improve; PIOPED II may not accurately represent this.

- The convenience, speed and availability of CTA are likely to only solidify its position as a mainstay of evaluation for suspected PE, but V/Q scanning still has a role and is an important weapon in our diagnostic arsenal.
References

- 5. Gottschalk A, Stein PD, Goodman LR, Sostman HD. *Overview of Prospective Investigation of Pulmonary Embolism Diagnosis II.* Seminars in Nuclear Medicine 2002; 32:3.
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