Imaging Pulmonary Embolism

New ways to look at a diagnostic dilemma

Emily Willner, HMS III
Gillian Lieberman, MD
Core Radiology Clerkship, BIDMC
New approaches to imaging PE: 

Agenda

1. Review two patients who had new diagnostic modalities used for diagnosing and/or treating PE
2. Review anatomy, differential diagnosis and menu of tests available for PE imaging.
3. Discuss algorithmic approach to use of imaging modalities, and the strengths and limitations of available tests.
Patient J.R.: A classic story

- 64 year old man with recent diagnosis of metastatic pancreatic CA. Known mets to the liver.
- Presents to the ED with acute onset of sharp, L-sided pleuritic chest pain. Mild SOB for a few days.
- No cough or hemoptysis. No fevers or chills. No leg symptoms
- PMHx: Pancreatic CA. C4-5 ruptured disc.
J.R.: Physical Exam

- Vitals: Afebrile, HR 72, BP 121/64, RR 18, Sat 98% RA
- Thin man, mildly uncomfortable.
- Chest clear.
- Heart RRR, II/VI SEM, no rubs or gallops.
- Mild abdominal tenderness, + hepatomegaly
- Normal lower extremity exam
J.R.: Chest X-ray

Poor inspiratory effort, but otherwise clear lungs. No pneumothorax, no effusions.
J.R.: Ventilation/Perfusion Scan

**Ventilation**
- Essentially normal

**Perfusion**
- Shows possible defect in LLL

Image from BIDMC PACS
J.R.: Chest CT Angiogram w/ contrast showing embolus
Embolus easier to visualize scrolling through CT cuts
Patient R.S.: An emergency on call

- 58 y.o. man s/p cholecystectomy 2 weeks ago, re-hospitalized for mental status changes
- Abdominal/pelvic CT the day of admission incidentally showed L femoral and ileac DVT; heparin was started
- The following day, he became acutely SOB, O2 sat 88%, tachy to 146, EKG: S1, Q3, T3.
- Bedside echo: severe RV enlargement and hypokinesis
R.S.: CT on admission revealed DVT in left iliac v.
R.S.: Chest X-ray while SOB

AP upright film: Bilateral lower lung atelectasis. Otherwise clear lungs.
R.S.: Large saddle embolus in L and R pulmonary arteries
R.S.: Saddle embolus in R PA
R.S.: Angiography and suction thrombectomy

Pre-thrombectomy

Large filling defect. Virtually no flow to L lung.

Post-thrombectomy

After suction thrombectomy, flow restored to L upper lung.
Differential Diagnosis of chest pain with SOB

- **Respiratory**: PE, pneumonia, pneumothorax, pulmonary edema, asthma/COPD, bronchitis, lung CA
- **Cardiac**: Pericarditis, angina, MI, aortic dissection
- **GI**: GERD, esophageal spasm, cholecystitis
- **Musculoskeletal**: Muscle spasm, pulled muscle, rib fracture, costochondritis
- **Psychiatric**: Anxiety
Classic presentation of PE

- Risk factors
  - Immobilization, surgery within 3 mo., trauma, malignancy, CHF, MI, h/o VTE, postpartum or hormone use

- Symptoms
  - Pleuritic chest pain, dyspnea, cough, hemoptysis, syncope

- Signs
  - Tachypnea, rales, tachycardia, S4, loud P2, fever <102 F
Lung Anatomy
Arteries run with Bronchi
Pulmonary vasculature and bronchi

**Pulmonary arterial anatomy**
- Pulmonary trunk
  - 2 Main pulmonary arteries
  - Lobar arteries
  - Segmental arteries
  - Subsegmental arteries

CT correlation and cross-sectional anatomy T5-6

Aorta

Pulmonary artery bifurcation

Mainstem bronchus

Pulmonary artery bifurcation

Mainstem bronchus

Pulmonary artery bifurcation

Mainstem bronchus

Aorta

Imaging tests in suspected PE

- Plain chest film: First test; r/o other etiology
- Ventilation/perfusion scanning
- Pulmonary angiography: the “Gold Standard” test

- Helical CT scan/CT angiography
- MR imaging/angiography
- Other: LE Venous duplex Doppler US, echocardiography
Chest X-ray findings in PE

- Most films (86%) are abnormal. Common findings are:
  - atelectasis
  - parenchymal opacity
  - pleural effusion
  - cardiomegaly
  - hemidiaphragm elevation
  - central pulmonary artery prominence

- Few show "classic PE" findings:
  - Westermark’s sign = loss of pulmonary vasculature distal to central embolus.
  - Hampton’s hump = wedge-shaped, pleural based opacity representing infarct
  - Fleischner's sign = regional oligemia in the presence of an ipsilateral enlarged pulmonary artery
Westermark sign
Hampton’s Hump
Ventilation/perfusion scanning

- Nuclear medicine test, IV injection of 99Tc labeled to albumin maps perfusion
- Inhalation of radioactive tracer shows ventilation
- Read as high, intermediate, low probability, or normal

- Normal perfusion r/o embolus
- High prob scan, 42% have emboli; 96% if correlated with high clinical prob
- Intermediate and low prob scans = indeterminate
Normal V/Q scan

Ventilation

Perfusion

Image from BIDMC PACS
High Probability V/Q scan

Ventilation
- Few small defects

Perfusion
- Multiple unmatched perfusion defects

Image from BIDMC PACS
Following up indeterminate V/Q

- 72% pts have indeterminate scan
- Emboli detected in 30% of intermediate scans and 14% of low prob scans
- THUS, PIOPED recommends f/u with PAgram in this group
- Only 5% in this group have pulmonary angiography!! Management is instead based on clinical judgment.
Diagnosing PE using V/Q scans: one algorithm

1. **V/Q Scan**
   - **Normal perfusion**
     - Clinically stable: Eval bilateral lower extrem.
       - Nondiagnostic/ negative: Serial leg studies v. angio
         - **No treatment**
       - + DVT: TREAT
         - **TREAT**
   - **Non-diagnostic/ negative**
     - No PE: No treatment
       - **No treatment**
     - PE present: TREAT
       - **TREAT**
   - **High probability**
     - Clinically unstable: Pulmonary angiography
       - **TREAT**

*Chart adapted from UpToDate, ATS guidelines 1999.*
Pulmonary Angiography

- The “gold standard” test for PE
- Trans-venous; mortality < 1%, morbidity 2-5%
- Interobserver variability: PIOPED found a 92% concordance in PE cases
- Least sensitive for subsegmental emboli
- Diagnostic test can be combined with intervention (Greenfield (IVC) filter, thrombolysis, thrombectomy)
Normal Pulmonary Angiogram

Images from BIDMC PACS
CT angiography in PE diagnosis

- Helical CT with iodinated contrast bolus; 20-30 sec. scan, may be done in 2 breath-holds.
- Sensitivity: 86% for proximal vessels (main through segmental a.); 53-100% overall.
- Specificity: 93% for proximal vessels; 81-100% overall.
- CT has similar sensitivity to V/Q scanning, but a negative CT is not as good as normal perfusion in r/o PE.
- Should we re-think the algorithms? What is the role for CTA?
Diagnosing PE: an algorithm using helical CT as the initial test

- Consider V/Q scan if contraindication to IV contrast.
- V/Q has good utility as first test when patient has no pathology on CXR and no hx of cardiac or pulmonary disease
Normal CTA
Helical CT angio overview

**Plus**
- Very fast
- Evolving technology
  - faster scans and thinner slices
- May give alternate diagnosis if negative for PE
- 3-D reconstructions
- Negative scan → safe to withhold anticoagulation

**Minus**
- Iodinated contrast (renal insufficiency)
- Radiation exposure
- Poor visualization of clots in subsegmental arteries and obliquely oriented vessels

Emily Willner, HMS III
Gillian Lieberman, MD
3-D CT reconstruction: R.S.
CT in diagnosis of DVT: One stop shopping?

- Recent data has suggested that CT of the lower extremities may be done at the same time as chest CTA to yield greater diagnostic accuracy
- One contrast bolus and one scan
- In future, possibly replace venous US in patient already undergoing CT?
Role of MRA in diagnosis of PE

**Plus**
- Excellent images
- No iodinated contrast
- Sensitivity and specificity similar range to CTA
- Real-time reconstructions/flow images
- Future: ventilation scanning

**Minus**
- Longer scan time (minutes v. seconds)
- Prolonged breath-holding (30+ sec.)
- Expensive
- Poor sensitivity in subsegmental a. clots
Gadolinium contrast MRA

Normal

MRA of a large embolus

Image from www2.medical.philips.com/mri/Applications/Cardiac/Angiography.asp

Image courtesy of Dr. Thomas Vrachliotis
CXR remains the initial test of choice.

V/Q scanning retains a role in healthier patients.

Helical CT is sensitive, specific, fast, and gives alternate diagnoses. Potential for LE imaging. Needs more investigation to fully delineate role.

Pulmonary angiography has a role especially in patients who will need interventions.

MR is promising but currently scans too long and test too expensive.
References

- Ryu JH, Swensen SJ, Olson EJ, Pellikka PA. Diagnosis of pulmonary embolism with use of computed tomography.
Acknowledgements

Many thanks to Dr. Michelle Swire for her help with cases and images, Dr. Lieberman for her ideas and suggestions, and to Dr. Thomas Vrachliotis for his MR images.

Thanks to my Radiology classmates who made doing this presentation much more fun.

Thanks to Beverlee Turner for all her technical help.

Special thanks to Larry Barbaras and Cara Lyn D’amour, our WebMasters.