Radiologic Assessment of Paradoxical Embolism

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Index Patient DR: Clinical Presentation

- 79F h/o HTN, CAD s/p MI @55yo, DM, breast CA s/p resection 3yrs, on tamoxifen
- p/w acute onset dyspnea after 9hr car ride
- O/N→ cyanotic, unresponsive, agonal breaths
- Intubated in field
- Localized erythema, swelling in R calf noted
- In Needham ED, the following studies done…
3:56 AM – CXR Frontal supine

Read as: CLEAR Lungs w/ Normal Vascularity, Cardiac Size WNL
4:26 AM – Head CT w/o Contrast

**Axial view: Anatomy**
- No skull fracture
- No acute hemorrhage (hyperdense)
- No midline shift, mass effect
- No major vascular territory infarct:
  1) No effacement of sulci, ventricles
  2) Intact cortical gray-white differentiation
  3) No Insular ribbon sign
  4) Dense artery sign?

**Procedure of choice in ED:**
- Sensitive for acute bleed, bone eval
- Fast, readily available, less costly

**Annotations:**
- Genu, Corpus Callosum
- Caudate
- Insula
- Thalamus
- Putamen
- Lateral Ventricle, Frontal Horn
- Lateral Ventricle, Trigone
- Pineal Gland, Calcified 164 HU

**BIDMC**
LET US REVIEW SUBSEQUENT AXIAL SECTIONS (ROSTRAL → CAUDAL)

WHAT DO YOU SEE?
High Density in Basilar Artery: Intraluminal Thrombus

→ Urgent CTA / MRA (vs. angio)
MR/MRA would have been preferable to CT/CTA for evaluating soft tissue changes associated w/ cerebral ischemia/infarction.

But no MR machine was available at facility.

With CT/CTA available, conventional angiogram is unnecessary and dangerous in this critically-ill patient.
24hrs later – Head CT/CTA

**Intraluminal filling defect:**
- Distal Basilar Artery
- Proximal PCAs Bilaterally
- Collaterals from P. Comm. Artery

*Figure 1. Arterial Supply of the Brain Stem, Cerebellum, Occipital Lobes, Posterior Temporal Lobes, and Thalamus.*

*NEJM (2005) 352:2618*
CTA 3D Coronal Reformation

2.0 mm cuts
CT/CTA: Posterior Infarction +24hrs

- Extensive infarction seen as hypodensities involving midbrain, pons, cerebellar hemispheres, bilateral thalami and occipital lobes
- Effacement of fourth ventricle and basal cisterns from edema, associated obstructive hydrocephalus
DDx: Ischemic Stroke (80%)

- **Arterial Occlusive Disease**
  - Atherosclerotic plaque thrombosis, Arteriosclerosis
    
    *Pt DR: h/o CAD, HTN*

- **Cardiogenic Emboli**
  - MI w/ thrombus, AFib, Endocarditis, LA myxoma
    
    *Pt DR: h/o MI 25yrs prior*

- **Hypercoaguuable State**
  
  *Pt DR: h/o Breast CA 3yrs prior, on tamoxifen*

- **Nonatheromatous Disease**
  - Vasculitis, fibromuscular dysplasia, dissection
Consider patient DR’s clinical presentation…

What other test(s) would you order?
Extensive bilateral pulmonary emboli involving both main PAs, segmental and subsegmental arteries.
Pulmonary Embolism

3D CT/CTA Coronal Reformation

Wedge-Shaped Subpleural Parenchymal Density:
Atelectic Lung vs. Infarct (Hampton’s Hump)

Axial CT Ancillary Findings

Lung Window

2.5 mm cuts
How does this affect our patient’s differential diagnosis?
Revised DDx for Basilar A. Thrombosis

1) Slow flow due to circulatory collapse

2) Paradoxical embolus,
   e.g. most commonly secondary to Patent Foramen Ovale

 +/- Hypercoaguuable state
What is paradoxical embolism?
Paradoxical Embolism

- Passage of venous thromboembolism into arterial circulation via R→L intracardiac shunt

- Definitive Dx: Direct visualization of thrombus (rare)

- Presumptive Dx Triad:
  1) Venous thrombosis or PE
  2) Arterial embolism w/o obvious L heart source
  3) Abnl R → L shunt (e.g. Patent Foramen Ovale most common, also Atrial Septal Defect, Arteriovenous Malformation)
**Patent Foramen Ovale (PFO)**

- **Definition:** Communication b/w atria extending from opening in R atrial septum secundum (foramen ovale) to opening in L atrial septum primum (ostium secundum)
  
  When L>R pressure →
  
  Flap valve physiologically shuts, anatomically fuses in most adults

  Failure of fusion → PFO

- **Prevalence:** 27% autopsy vs. 15% echocardiography

- **Physiology:** Need R>L pressure to allow shunting
  Transiently w/ inspiration, cough, Valsalva

  **Pulmonary Hypertension, Cor pulmonale**

- **Dx:** Requires contrast echocardiogram (i.e. bubble study)

  Sensitivity: Transesophageal (TEE) > Transthoracic (TTE)

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*NEJM (2005) 353:2361*
Let us review imaging from companion patients with PFO...
Imaging PFO: Bubble Study

Transesophageal Contrast Echocardiography most sensitive to detect R→L shunt

Intravenous injection of agitated saline → Microbubbles opacify RA

W/ intracardiac shunt, bubbles appear in LA w/in 2-4 beats post-injection

**Companion Patient 1**

TEE: Direct thrombus visualization through PFO

**Companion Patient 2**

Bubble Study: RA opacification w/ passage of bubbles to LA

Echocardiography (2002) 19:77

NEJM (2005) 353:2361
Imaging PFO: Clues on CTA

Decreased enhancement of PA w/ abnl early enhancement of Ao

Can occur secondary to increased R→L shunt at deep inspiration

Companion Patient 3

Imaging PFO: Clues on CTA

Significant deviation of atrial septum may indicate aneurysm (ASA)
70% patients w/ ASA also have a PFO

Companion Patient 4
Paradoxical Embolism: Implications for the Radiologist

- **LOOK BEYOND PULMONARY CLOTS**
  - W/ patient w/ PE on CT, radiologist must also examine CV system for associated conditions
    - Patient DR: Basilar thrombosis and posterior stroke changes
      - management of thrombolysis, anticoagulation for PE
      - because of risk for hemorrhagic transformation of posterior infarct

- Acute, major PE + PFO = independent predictor of adverse outcome
    - Mortality significantly higher w/ PE + PFO vs. PE alone (33% vs. 14%)
    - Incidence of ischemic stroke higher (13% vs. 2.2%)

- Study of choice eval PFO: Contrast echocardiography (TEE>TTE)
  - Clues on CT
Summary of Presentation

- Patient DR: 2 Major Events Are Unusual
- Menu of Tests in Stroke and PE
- Relevant Anatomy: Brain, Chest, Cardiac
- Film Interpretation using Appropriate Terminology
- DDx and Revised DDx w/ clinical history
- Menu of Tests and Companion Patients in Assessing Paradoxical Embolism (radiologic entity)
- Relevance for the Radiologist
References


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