PE Imaging in 2011

- Venous thromboembolism: PE & DVT
  - 350 – 600K cases / year
- MSCTPA widely accepted as diagnostically accurate for PE
  - overutilized
- DVT imaging: US or CTV
- Case fatality rate = 7.7% (age – dependent)
PE Imaging: Questions of Interest
Sadigh G, et. al AJR 2011; 196:497 - 515

- CTPA: from insensitive for subsegmental emboli to overly sensitive?
- Risk stratification
- Technical: ECG – gated MSCTPA & MR
- Radiation issues: 8:30 AM Monday
- Future directions:
  - dual energy CT
  - computer – aided diagnosis
CTPA: Rock & a Hard Place

- Initial concern with SSCT: insensitivity
- MSCTPA: improved visualization smaller arteries = improved sensitivity
- Concerns regarding overdiagnosis
  - increased rate of PE diagnosis, little change in PE – related mortality
- NPV high for SSCT and MSCTPA – why?
CTPA: Why the Discrepancy?

- How patients are selected
- CTPA comparisons to PA angiography flawed
- Isolated subsegmental PE uncommon
- PE not as deadly as previously thought
- PE is “complicated”
PE Severity: Risk Assessment

- PE severity: mortality risk rather than an anatomic embolic burden estimate
  - expressed as 30–day or in–hospital mortality risk
PE Risk Stratification: Why Bother?

- PE with hypotension: 5 – 10% (massive)
- Up to 50% with PE: normotensive, RVD
  - “submassive” or “RV strain”
  - worse prognosis
- PE severity estimate:
  - “high-risk”: >15% mortality
  - non – high risk:
    - intermediate risk: 3 – 15% (RV strain)
    - low risk: <1%
PE Risk Stratification: Imaging

- RV size, RV / LV ratio
- Leftward IV septal bowing
- Embolic load ("clot" scores)
  - number of vessels, weighted for occlusion
  - percent vessel occlusion
- MPA size (Ao / MPA ratio)
- IVC, hepatic vein reflux
- SVC, azygos vein distension
RV Strain
Embolic Load Assessment

- Angiographically – derived obstruction scores (Miller and Walsh):
  - Bankier
  - Qanadli

- Mastora
- “Central”
- Most proximal “clot” level
Embolic Load Assessment

- Mastora scores “run lower” than Miller – derived indices
- Mastora scores 20 – 30%: PA pressure ↑
- Mastora scores ≥ 50%: PA pressure ↑↑ significantly
- death rate ↑ at 40 – 60% obstruction
## Studies of CTPA PE Severity

<table>
<thead>
<tr>
<th>Author</th>
<th>RV / LV &gt; 1</th>
<th>VSB</th>
<th>Embolic Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>van der Meer</td>
<td>+</td>
<td>No</td>
<td>11.2x ↑ at 40%</td>
</tr>
<tr>
<td>Araoz</td>
<td>No</td>
<td>+/-</td>
<td>No</td>
</tr>
<tr>
<td>Venkaesh</td>
<td>No</td>
<td>No</td>
<td>OR: 1.1</td>
</tr>
<tr>
<td>Wu</td>
<td>------------</td>
<td>-----</td>
<td>2.32 ↑ for 10%</td>
</tr>
<tr>
<td>PIOPED II</td>
<td>No</td>
<td>No</td>
<td>------------------</td>
</tr>
<tr>
<td>Schoepf</td>
<td>(&gt; 0.9), 5.17x</td>
<td></td>
<td>------------------</td>
</tr>
<tr>
<td>Engelke</td>
<td>------------</td>
<td>-----</td>
<td>6.7x ↑ 21.3%</td>
</tr>
</tbody>
</table>
Why the Variability?

- Different patient populations
  - variable “clot” burdens (10% - > 50%)
- Variable study quality, end point numbers
- Interobserver variability
  - VSB → $\kappa = 0.54$
- Use of 4 – chamber reconstructed views of the RV
4 Chamber RV Reconstructions

4.3 cm

3.6 cm

4.3 cm

4.3 cm

4.2 cm
4 Chamber RV Reconstructions

Kang DK, et. al. CT signs of RV dysfunction. JACC CV Imag 2011; 4:841-9

Axial RV/LV = 0.98

4 Chamber RV/LV = 1.12
What to Report?

- Absence or presence of RV strain:
  - RVE, reconstruct on 4 – chamber view
  - flattening or leftward bowing of septum
  - additional findings: IVC / hepatic vein reflux, MPA enlargement
  - anything positive: consider echo, biomarkers

- Report embolic levels (at least most proximal)
MSCTPA: To Gate or Not to Gate?

• Advantages:
  ▪ reduction of cardiac motion
  ▪ RV assessment, automated calculations
  ▪ non – PE cardiac diagnoses

• Disadvantages:
  ▪ time (breath hold), tech hassle
  ▪ bolus timing
  ▪ radiation
  ▪ patient exclusion: dysrhythmia, ↑HR
ECG – Gated MCTPA

• Cardiac motion: isolated PE in RML or lingula rare
• XRT less of an issue with prospective ECG gating, high pitch CT
• Function
MR and PE Imaging

- **Advantages:**
  - no XRT, function, V/Q, DVT assessment, low contrast allergy frequency

- **Disadvantages:**
  - technical expertise, ↑ exam time, limited patient access, contraindications, fewer alternative diagnoses
MR and PE Imaging: Techniques

- Real – time, functional imaging (SSFP)
- First – pass
- Gd – MRA
- Ventilation – perfusion
- DVT assessment
MR and PE Imaging
Stein PD, et. al. PIOPED III

- Previous pooled data: sens: 77 – 100%
- PIOPED III (Gd-MRA):
  - overall: sensitivity = 78%, specificity = 99%
  - 25% exams technically inadequate
  - main, lobar PE: 79% sensitivity, 50%
    segmental, 0% subsegmental
  - pulmonary MRA & MRV:
    - technical inadequacy ↑ 52%, but ↑
      sensitivity = 92%, specificity = 96%
Due to technical expertise requirements, MR for PE limited to centers with experience.
PE: Radiation Dosimetry

- CTPA radiation dose in PIOPED II: 3.8 mSv to chest, 6 mSv to pelvis, 3.2 mSv thighs for CTV
  - CTV: axial technique, omit abdomen, upper pelvis
- Pulmonary dose reduction: ↓ kVp, mAs, iterative recon, filters, limit scan length, shielding, newer scanner technologies
Dual Energy PE Imaging

- Material decomposition: "extract" iodine component of lung to quantify perfusion

- Advantages:
  - V/Q = improved PE sensitivity?
  - risk stratification
  - perfusion defect: provide "relevance" for small emboli?

- Disadvantages:
  - + / - ↑ XRT dose, streak from dense SVC contrast
Dual Energy PE Imaging

- Moderate correlation between perfusion defects and vascular obstruction on a per - segment basis
  - partial occlusion = preserved perfusion
    - large, central emboli
  - microcirculatory disturbance: perfusion defect > obstruction
    - small, peripheral emboli
Computer – Aided Detection for PE

- **Potential benefits:**
  - improved sensitivity, specificity
  - automated risk stratification
  - training

- **Most current systems rely on vessel segmentation,** which can be time-consuming, limited sensitivity, ↑ FP rate
CAD for PE: Challenges

- Increase speed
- Real – time integration to workflow
- Reduce false positives, maintain TP
  - arteries from veins
  - lymph nodes
  - vessel bifurcations
CAD: Emboli Evaluation

- 43 patients, 33 with PE
  - CAD alone: 83% sens, 80% spec
  - rad sens ↑ 87% to 98% with use of CAD
- 2 – 5 FPs / case
- PE severity (Mastora): misclassification of PE severity by rads ↓ by CAD
Relevant References


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Relevant References

Relevant References


Relevant References


• Qanadli S, et. al. New CT index to quantify arterial obstruction in PE: comparison with angiography index & echo. AJR 2011; 176:1415-20.


• Kang DK, et. al. Reproducibility of CT signs of right ventricular dysfunction in acute PE. AJR 2010; 194:1500-06.
Relevant References

- Lu MT, et. al. Interval increase in right-left ventricular diameter ratios at CT as a predictor of 30-day mortality after acute PE: initial experience. Radiology 208; 246:281-87.


Relevant References

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