The VQ Scan: State-of-the-Art - 2013 Controversies

Darlene Metter, MD, FACR
New Orleans, LA
January 26, 2013
Learning Objectives

• Understand the probability vs outcome-based interpretation schemes for VQ scans

• Compare the rationale for VQ planar vs VQ SPECT
Venous Thromboembolism

DVT
PE

PE issues:
1) Interpretation criteria
2) VQ SPECT
• PE: life threatening disease
• PE: > 90% have DVT
• DVT: 30-50% PE
• DVT: unRX, up to 30% die
Scan Interpretation Criteria
Basic Principle

• Importance of diagnosing PE
• Survived the insult (PE)
• Treat to prevent the fatal PE
• PE recurrence:
  - untreated: 25%
  - treated: 7%
Interpretation Schemes

• **US**: PIOPED I & II, mod PIOPED I (probabilities)

• **Europe/Canada/Australia**: modified PIOPED II with Q scan/CXR & PISAPED (outcomes)

• survey 15/18 acad sites*; 1 hybrid

* PE present, PE absent & few non-dx; 2/18 sites
PIOPED I* (1990)

- Multi-site prospective (> 900)
- S/S of VQ scans
- V/Q & pulm angio c/w clinical outcomes
- Dev categ & criteria for prob of acute PE, later modified (1993)**
- Prevalence: 33% (68% inpt)

* Prospective Investigation of Pulmonary Embolism Diagnosis
** One segmental MM (low → intermediate)
1. Only 28% definitive diagnosis
   • 72% inconclusive, 44% intermed
2. Low prob had unacceptable high frequency of PE
3. High prob had a low sensitivity (41%)
PIOPED II (2002)

• Multi-site prospective (> 800)
• Assess efficacy of CTA-CTV in acute PE & evaluate the “very low probability” V/Q scan
• V/Q, CTA, CTV/USN, DSA
• Prevalence: 23% (11% inpt)
• 1990’s to 2000’s dec VQ scans
  – High # of “non-diagnostic” VQ
  – Inc CTA in PE
• 2013: CTA procedure of choice in PE; reported PE +/-; 6% tech
• Propose VQ results as “outcomes” (like CT)
• 2008 Sostman*
• Retrospective analysis of PIOPED II pt using V/Q
• 74% classified as PE+/PE-

• 2 versions:
  – V/Q & CXR
  – Q scan & CXR*

• Reporting:
  – V/Q: High, nondx, very low, normal
  – Q: PE present, PE absent, nondx

*1994 Stein (Gottschalk): perfusion only
PISAPED* (1995)

• Clinical prob + CXR + Q scan
  – 176 pt; prevalence 35%; 1 inpt
• PE present, PE absent, non-Dx
  - S/S: 89%/92%
  - PPV 95%; NPV 81%; accuracy 90%

* Prospective Investigative Study of Acute Pulmonary Embolism Diagnosis
• **PE present**: $\geq 1$ wedged shaped Q defect (SHAPE is important)

• **PE absent**: non-wedged shaped Q defect, near normal or normal Q

• **Non-diagnostic**: Cannot classify as PE+ or PE-

* 2011 SNM Practice Guideline For Lung Scintigraphy*
1. ¼ abn but PE(-): no angio or F/U
2. ½ abn: no angio (contraindications)
3. PE(+): not all had angio
4. No angios on normal/near normal
5. Same reviewer for clinical assessment & scan interpretation (clinical bias)
L Freeman on PISAPED

• Need dedicated readers with good plain film experience

• Safer to have the ventilation study
• PIOPED II re-selected: prevalence 19%
• Q & CXR: Mod PD II vs PISAPED (2/2)
• Non-Dx: mod PD II 21%, PISAPED 0
• If exclude nondx, S/S
  – mod PD II: 85%/93%
  – PISAPED: 80%/97%

• PISAPED = Mod PD II & PD II, but **less non-Dx studies**

2008: 2 reports by PIOPED II authors*

- Use PD II database
- \[ \text{PPV} \quad \text{NPV} \]
- PISAPED 80% 97% c/w CT
- PD II (Q) 85% 93% post DC nonDx
- CT 86% 95% post DC 6% tech

38 yo M with shortness of breath.

What is the interpretation by PIOPED II, Mod PIOPED II & PISAPED?
Normal ventilation
One large segmental mismatch
One large segmental mismatch

- Mod PIOPED I & II: Intermediate
- Mod PIOPED II (V/Q): Non-Dx
- Mod PIOPED II (Q): Non-Dx
- PISAPED: PE present
<table>
<thead>
<tr>
<th>Procedure</th>
<th>Sens</th>
<th>Spec</th>
<th>Non-Dx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mod PD II VQ</td>
<td>85%</td>
<td>93%</td>
<td>21-27%</td>
</tr>
<tr>
<td>Mod PD II Q</td>
<td>77%</td>
<td>98%</td>
<td>No low &amp; intermed</td>
</tr>
<tr>
<td>PISAPED</td>
<td>80-86%</td>
<td>93-97%</td>
<td>Near 0</td>
</tr>
<tr>
<td>CTA</td>
<td>83%</td>
<td>96%</td>
<td>6%</td>
</tr>
</tbody>
</table>

A *Trinary* Reporting System

- Freeman (2011)
- Retrosp,* 6 months, 664 pt
- PE present (Hi prob): 8.4%
- PE absent (low, v low, normal): 88.1%
- Non-Dx (intermed): 3.5%
- FN: 1.14%

* Began in 2008; 1200-1400/yr
“Experienced NM physicians may provide a more accurate interpretation than is provided by the listed criteria.”

* 2011 SNM Practice Guideline For Lung Scintigraphy
1. Probability reporting understood by readers & clinicians

2. PISAPED: small with limitations
   - no large multi-site prosp trial, diverse pt pop & disease, satisfactory outcomes with wide range of readers
   - reproducible: McClean* 238 pt, unable

3. Identify wedge vs non-wedge defects. Not easy.

4. Essentially a binary reporting system, highly dependent on pretest probability.
• PIOPED II discordant (pretest/result)
  - PPV VQ 56%
  - PPV CTA 58%
  
  e.g. low prob: pretest
  - low 4% risk
  - intermediate 10% risk
  - high 35% risk
23 yo F @ 23 wk IUP. Acute on chronic dyspnea.

CXR, USN for DVT & (-) chest CT neg.

Echo:
↑PA 50 mmHg

VQ requested. Rad resident refusing, pt w/o dyspnea now. Team unsure.
Normal ventilation
>2 large segmental VQ mismatches

Normal CXR
• High probability for acute PE
• High clinical suspicion: PPV 97%
• Discordant: PPV 56%
5. Litigation
   - “PE present” – NO PE & severe complication or death
   - “PE absent” – NO anti-coagulate, die from PE
To SPECT or NOT to SPECT
1. Ventilation agents
   - US: $^{133}$Xe, $^{99m}$Tc DTPA
   - EAC: Technegas, $^{99m}$Tc DTPA, Krypton*

2. V scan
   - US: often
   - EAC: VQ SPECT vs Q

* $^{133}$Xe limited availability
US vs Europe/Australia/Canada

3. Modality
   - US: planar
   - EAC: SPECT*

4. Interpretation
   - US: probabilities (PIOPED)
   - EAC: outcomes (PISAPED)

• European Assoc of NM “VQ SPECT should be the preferred modality whenever possible”
No major US advocate for SPECT

1. Planar vs SPECT
2. Ideal ventilation agent
3. SPECT interpretation
4. Will outcome change?
1. Planar vs SPECT
2. Ideal ventilation agent
3. SPECT interpretation
4. Will outcome change?

No major US advocate for SPECT
Planar vs SPECT

- No major prospective trial (SPECT vs CT)
- **Planar**: 1970s, L Freeman “VQ planar has stood the test of time”

- **SPECT**: Inc contrast resolution → inc diagnostic value; ↑ S/S, ↓ indeterminate (3%), accuracy* 94% c/w CT
  - ↑ intra-observer reproducibility**: Planar 91%; SPECT 94%
  - ↑ inter-observer**: Planar 79%; SPECT 88%

*2012 L Freeman “deals with accuracy rather than outcome
### Reinartz et al (2004)*

<table>
<thead>
<tr>
<th></th>
<th>SPECT</th>
<th>CT</th>
<th>Planar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>97%</td>
<td>86%</td>
<td>76%</td>
</tr>
<tr>
<td>Specificity</td>
<td>91%</td>
<td>98%</td>
<td>85%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>94%</td>
<td>93%</td>
<td>81%</td>
</tr>
</tbody>
</table>

22 yo F h/o VSD & pulm stenosis repair with SOB.

CXR & Vent: normal 1 mod seg MM defect
Non-segmental defect: L hilum

Very low probability for PE w/ SPECT vs Intermediate probability w/ planar
No major US advocate for SPECT

1. Planar vs SPECT
2. Ideal ventilation agent
3. SPECT interpretation
4. Will outcome change?
Ventilation Agents

- VQ SPECT: needs a superior ventilation agent
- **Technegas** (Australia): ideal agent, ultrafine Tc-labeled carbon; not in US
- $^{99m}\text{Tc}$ DTPA: “very satisfactory”
- **Krypton**: $$$
1. Planar vs SPECT
2. Ideal ventilation agent
3. SPECT interpretation
4. Will outcome change?

No major US advocate for SPECT
SPECT Interpretation

• Generate planar-like images: 2 methods
  1) Angular summed: blurred images, harder to read than true planar
  2) Re-projected planar

• MIP is of little diagnostic value
• Need CXR
• False negative with non-occlusive clot
Planar & Planar-like images

True Angular summed

Reprojected

Note: advocating SPECT, but viewing in “planar-like” images

1. **No PE**
   - Normal Q, nonseg MM, matched or reverse MM VQ defects

2. **PE present**
   - 1 seg VQ MM or 2 subseg VQ MM

3. **Non-diagnostic for PE**
   - multiple VQ abn not typical for any dis

*European Association of Nuclear Medicine*
• 1-3% solitary subseg VQ defect is nondx, per EANM is “No PE”

• **EANM**
  - -> 3000 VQ SPECT using EANM rec
  - NPV 97-99%
  - S/S 96-99% and 91-98%
  - nondx 1-3%
Non-segmental defect: L hilum

Very low probability for PE w/ SPECT vs Intermediate probability w/ planar

EANM: No PE
No major US advocate for SPECT

1. Planar vs SPECT
2. Ideal ventilation agent
3. SPECT interpretation
4. Will outcome change?
Subsegmental Emboli: the Solitary Small Clot

- Improved technology, inc PE dx: **NO change in recurrence rate or death.**
- **Problem**: Clinical signif of a small clot
- Cath pulm angio (CPA) & planar VQ
  - long hx: CPA & planar NPV 99-100%
  - miss small clots (CPA, VQ, CTA)
Advocates “outcomes” over “accuracy” in diagnosing & managing PE

“Planar is good enough”
The Small Clot

• More reports: the small PE does not need treatment in healthy people

• L Freeman: “…most such thrombi are not clinically significant & do not need to be treated & therefore do not need to be detected”
“Healthy patients often pass clots from the legs to the lungs, which are trapped by the lung capillary bed and lysed by intrinsic fibrinolysis protecting the systemic circulation”

- Peripheral veins do not (DVT)
- Rationale for aggressive RX

* Radiology 2005
In the Past

- PE diagnosed: readily anticoagulate*
- A solitary small clot? Unknown (don’t see)
- Autopsy: 51-90% old/recent PE, most not fatal
- Meta-analysis (23 studies): CTA (-)
  - 4657 pt, no Rx, 3 mo VTE 1.4%, fatal PE 0.51%
- NO studies for unRx subsegmental clot

* Solitary small clot not an issue
One 1994 study

- Nielsen (Denmark)
- RCT, 87 outpt with +DVT (venography)
- No PE symptoms, 49% occult PE
- ½ anticoagulated (44 pt); ½ anti-inflam (43 pt)
- 3 months: 19 pt each group progressed in DVT or PE
- No deaths from VTE. 1 anticoagulated pt died
- **NO DIFFERENCE in RX vs NO RX**

Stein* PIOPED I untreated PE

- 20/376 unRx PE (initially neg angio)
- 1 pt (5%) died from PE; 1 pt nonfatal PE
- All pt < 3 seg MM VQ defects (60% Rx pt)
  - lower clot burden
- UnRx & Rx pt grouped to size of VQ defects: NO difference in outcomes

- “Mild untreated PE”- lower mortality from recurrent PE than prior overt PE

What to Do with the Small Clot?
Is Treatment Justified?

- Outpt + adequate cardiopulmonary reserve + one small clot = NO treat

- Risk of RX (warfarin):

<table>
<thead>
<tr>
<th></th>
<th>Major bleed</th>
<th>Die</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 month</td>
<td>3%</td>
<td>0.5%</td>
</tr>
<tr>
<td>1 year</td>
<td>1%</td>
<td>7%</td>
</tr>
</tbody>
</table>
Anticoagulation: strongly consider

1. Inadequate cardiopulmonary reserve
2. Coexisting acute DVT
3. Recurrent small PE possibly from thrombophilia to prevent chronic PE and PAH
Take Home: What to do

- A small clot w/o DVT
- Need to know if the risk of fatal PE > risk of major anticoagulation complication to include death.
• Interpretation schemes:
  – PIOPED: probabilities – clinical familiarity
  – Mod PIOPED II (Q only) & PISAPED: outcomes – no large trials
Summary

- Wedge vs non-wedge shaped defects – not always easy
- Binary reporting needs clinical input
- Litigation
1. VQ planar: “good enough” withstood the “test of time” – L Freeman

2. No ideal ventilation agent or reporting
3. Beware of over DX & over Rx clinically inconsequential clot

“Outcomes over Accuracy”