Thrombus Removal in Acute Pulmonary Embolism: When and How?

Kenneth Rosenfield, MD, MHCDS, MSCAI
Cardiology Division
Section of Vascular Medicine and Intvn
MGH
Kenneth Rosenfield, MD, MHCDS
Conflicts of Interest

<table>
<thead>
<tr>
<th>Consultant</th>
<th>Equity</th>
<th>Research or Fellowship Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Abbott Vascular</td>
<td>- CardioMEMs</td>
<td>- Abbott Vascular</td>
</tr>
<tr>
<td>- Capture Vascular</td>
<td>- Contego</td>
<td>- Atrium</td>
</tr>
<tr>
<td>- Cardinal Health</td>
<td>- Embolitech</td>
<td>- NIH</td>
</tr>
<tr>
<td>- Contego</td>
<td>- Icon</td>
<td>- InspireMD</td>
</tr>
<tr>
<td>- CRUZAR Systems</td>
<td>- Janacare</td>
<td>- Lutonix-Bard</td>
</tr>
<tr>
<td>- Endospan</td>
<td>- MD Insider</td>
<td></td>
</tr>
<tr>
<td>- Eximo</td>
<td>- Micell</td>
<td></td>
</tr>
<tr>
<td>- InspireMD</td>
<td>- PQ Bypass</td>
<td></td>
</tr>
<tr>
<td>- MD Insider</td>
<td>- Primacea</td>
<td></td>
</tr>
<tr>
<td>- Micell</td>
<td>- Shockwave</td>
<td></td>
</tr>
<tr>
<td>- Shockwave</td>
<td>- Vortex</td>
<td></td>
</tr>
<tr>
<td>- Silk Road</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Surmodics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Valcare</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Board Member
  - VIVA Physicians (Not For Profit 501(c) 3 Organization)
    - www.vivapvd.com
Case 1

• 54 year old man
• Sudden onset SOB and left pleuritic chest pain
• BP – 100/60
• HR – 102 at rest
• RR – 22/min
• Sat – 89% RA  94% NC
Case 1 – Cont’d

- Troponin T – 1.5, BNP - 3400
- Echocardiogram

Will removal of thrombus make a difference in his clinical course and outcome?
Physiological Benefits of Early Clot Removal (Thrombolysis or Extraction)

- Improved clot resolution (faster? more complete?)
- Stabilization of hemodynamics $\rightarrow$ less need for pressors and life-support
- Reduced pulmonary arterial pressure and improved RV systolic function
- Improved early angiographic flow and lung perfusion

PIOPED Investigators. Chest. 1990; 97: 528-33
Goldhaber SZ. et al. Lancet. 1993; 341(8844): 517-11
Daniels LB. AJC. 1997; 80: 184-8
### PEITHO: Advantage driven by reduced hemodynamic collapse

<table>
<thead>
<tr>
<th></th>
<th>Tenecteplase (n=506)</th>
<th>Placebo (n=499)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>(%)</td>
<td>n</td>
</tr>
<tr>
<td>All-cause mortality within 7 days</td>
<td>6</td>
<td>(1.2)</td>
<td>9</td>
</tr>
<tr>
<td>Hemodynamic collapse within 7 days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need for CPR</td>
<td>1</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Hypotension / blood pressure drop</td>
<td>8</td>
<td>(1.6)</td>
<td>18</td>
</tr>
<tr>
<td>Catecholamines</td>
<td>3</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>Resulted in death</td>
<td>1</td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>
Additional Theoretical Benefits of Early Clot Removal

• Fewer in hospital complications from the PE (e.g. pressor requirements, etc.)?
• Removal of threatening “clot in transit”
• Less clot to become “impacted” into distal pulmonary arteries?
• Earlier discharge?
• Earlier return to functional baseline?
• Reduced incidence of CTEPH??
Thrombus removal...

- When to consider
- When to use clot extraction (versus lysis)

Kearon C et al. Chest 2008; 133: 454S-545S.
When to apply aggressive therapy: Markers of Increased Mortality

<table>
<thead>
<tr>
<th>Clinical markers</th>
<th>Shock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hypotension</td>
</tr>
<tr>
<td>Markers of RVD</td>
<td>RV dilatation, hypokinesis, or pressure overload on echocardiography</td>
</tr>
<tr>
<td></td>
<td>RV dilatation in CT</td>
</tr>
<tr>
<td></td>
<td>BNP of NT-proBNP elevation</td>
</tr>
<tr>
<td></td>
<td>Elevated right heart pressure at right heart catheterization</td>
</tr>
<tr>
<td>Markers of myocardial injury</td>
<td>Cardiac troponins</td>
</tr>
</tbody>
</table>
Numerous contraindications to thrombolysis

Table VII. Absolute and relative contraindications to thrombolysis

(1) Absolute contraindications
   a) Hemorrhagic stroke or stroke of unknown origin at any time
   b) Any prior intracranial hemorrhage
   c) Ischemic stroke in preceding 3 months
   d) Known structural intracranial cerebrovascular disease
   e) Central nervous system neoplasms
   f) Recent major trauma/surgery/head injury in previous 3 weeks
   g) Suspected aortic dissection
   h) Active bleeding or bleeding diathesis
   i) Recent surgery encroaching on the spinal canal or brain

(2) Relative contraindications
   a) Age >75 years
   b) Remote (>3 months) ischemic stroke;
   c) Major surgery within 3 weeks
   d) Transient ischemic attack in previous 6 months
   e) Current use of anticoagulant therapy
   f) Pregnancy or within 1 week postpartum
   g) Noncompressible puncture sites
   h) Internal bleeding (within 2–4 weeks)
   i) Traumatic or prolonged cardiopulmonary resuscitation (>10 min)
   j) Refractory hypertension (systolic blood pressure > 180 mm Hg)
   k) Dementia
   l) Advanced liver disease
   m) Infective endocarditis
   n) Active peptic ulcer

Davies et al, Ann Vasc Surg 2015
Even in those who have no contraindications → more bleeding with thrombolysis

<table>
<thead>
<tr>
<th></th>
<th>Tenecteplase (n=506)</th>
<th>Placebo (n=499)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-intracranial major bleeding</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>(%)</td>
<td>n</td>
</tr>
<tr>
<td>Severe</td>
<td>16</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Moderate</td>
<td>16</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>All strokes by day 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>(%)</td>
<td>n</td>
</tr>
<tr>
<td>Hemorrhagic</td>
<td>10</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Ischemic</td>
<td>2</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Serious adverse events (SAE)</td>
<td>29</td>
<td>(5.7)</td>
<td>39</td>
</tr>
</tbody>
</table>

Thrombus “Removal”
What are the options?

- Lysis…CDT/ultrasonic vs. Systemic
- Open thrombectomy
- Percutaneous clot extraction
  - Requirements…clot must be accessible to the device…central or proximal (or in transit)

Kearon C et al. Chest 2008; 133: 454S-545S.
Surgical Thromboembolectomy – early concern

But, mortality… concentrated in shock patients

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Total patients</th>
<th>Overall mortality</th>
<th>Mortality after CPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray</td>
<td>1988</td>
<td>71</td>
<td>30%</td>
<td>64%</td>
</tr>
<tr>
<td>Satter</td>
<td>1990</td>
<td>68</td>
<td>31%</td>
<td></td>
</tr>
<tr>
<td>Doetsch</td>
<td>1991</td>
<td>77</td>
<td>30%</td>
<td>83%</td>
</tr>
<tr>
<td>Meyer</td>
<td>1991</td>
<td>96</td>
<td>37%</td>
<td>58%</td>
</tr>
<tr>
<td>Schmid</td>
<td>1991</td>
<td>27</td>
<td>44%</td>
<td>45%</td>
</tr>
<tr>
<td>Bauer</td>
<td>1991</td>
<td>44</td>
<td>16%</td>
<td>47%</td>
</tr>
<tr>
<td>Kieny</td>
<td>1991</td>
<td>134</td>
<td>20%</td>
<td>48%</td>
</tr>
<tr>
<td>Meyens</td>
<td>1992</td>
<td>30</td>
<td>6%</td>
<td>50%</td>
</tr>
<tr>
<td>Stulz</td>
<td>1994</td>
<td>50</td>
<td>23%</td>
<td>60%</td>
</tr>
</tbody>
</table>

Jakob, EJCTS 1995
- 47 patients undergoing acute embolectomy over 5 year period
- 26% in cardiogenic shock, 11% in cardiac arrest

Revisiting the place of surgical embolectomy

- Massive PE and contraindications to fibrinolysis (Class IIa; LOE C).
- Massive PE who remain unstable after receiving fibrinolysis (Class IIa; LOE C).
- May be considered for submassive acute PE judged to have clinical evidence of adverse prognosis (new hemodynamic instability, worsening respiratory failure, severe RV dysfunction, or major myocardial necrosis) (Class IIb; LOE C).
Surgical Embolectomy: Embolus in Transit
Embolic Material

- Right atrium
- Left PA
- Right PA
Angiovac System

FDA 510(k) Approved for venous drainage during extracorporeal bypass for up to six hours to include removal of fresh, soft thrombi or emboli.
Suction Embolectomy (VORTEX)

- Rapid removal of clot
- Less invasive than surgery, with few complications, mostly local to sheath site
- Small case series
- Resource intensive

**Original Studies**

**Thrombectomy Using Suction Filtration and Veno-venous Bypass: Single Center Experience with a Novel Device**

Cameron W. Donaldson,1, MD, Joshua N. Baker,2, MD, Rajeev L. Narayan,1, MD, Tim S. Provias,1, MD, MPH, Andrew N. Rassi,1, MD, Jay S. Giri,3, MD, MPH, Rahul Sahuja,4, MD, Ido Weinberg,1, MD, Michael R. Jaff,1, DO, and Kenneth A. Rosenfield,1, MD, MSC

**Objectives**: To describe the first single center experience with a novel aspiration thrombectomy device. **Background**: The appearance of inferior vena cava or right-sided intracardiac thrombus may prompt consideration of percutaneous thrombectomy as a method to prevent new or worsening pulmonary embolism (PE). The AngioVac is a novel thrombectomy device composed of a cannula and extracorporeal circuit with filter.
Transesophageal Echocardiogram: Post Extraction
Novel Thrombectomy Devices
The Future For PE? Finding their niche…

• Aspiration catheters to vacuum the clot out of the vessel
  – Large Bore Angiovac (Angiodynamics) – en bloc thrombus removal
  – Small Bore Aspire (Control Medical Technology)
• Mechanical/Aspiration Thrombectomy
  – FlowTriever (Inari Medical)
  – Indigo (Penumbra Inc)

Will they be game changers??
FlowTriever
Retraction with Aspiration

Device and delivery catheter are retracted into the guide catheter

Retract

Aspirate

Aspiration Guide Catheter
FlowTriever in Acute PE

Pre

Post

Tod Engelhardt MD – East Jefferson General Hospital
Penumbra Indigo system is FDA 510(k) approved for the removal of thrombi and emboli in the peripheral vasculature.
• 44 y/o male with massive Pulmonary Embolism SBP 70s, right heart strain, Troponin elevation

Courtesy of Jim Benenati
RV dilatation and decreased wall motion

Courtesy of Jim Benenati
Saddle PE and increased RV/LV ratio

Courtesy of Jim Benenati
• Vacuum-assisted thrombectomy
Aspire Max
Mechanical Aspiration System

- FDA 510(k) approved for removal of thrombus and emboli from peripheral vasculature
- MAX Thrombectomy catheters
- ASPIRE Mechanical Aspirator
- One-handed aspiration of a large 30ml or 60ml barrel
- Dual one-way check valves to prevent accidental backflow and “burp” out any aspiration force induced air
- Single operator
- Potential to remove large thrombus burden through 6F sheath
What do we actually do?
PERT: Pulmonary Embolism Response Team

- **Goals:** *Improve patient outcomes with a collaborative, multidisciplinary team consult to treat massive and submassive PE.*

- **Functionality**
  - Multidisciplinary team convened via electronic meeting
  - Evaluate and offer full range of available treatments

*Chest* 2013;144:1738
“It will be necessary to elaborate on:

(i) whether reduced-dose intravenous thrombolysis is indeed safe and effective

(ii) whether catheter-directed treatment can evolve to become a widely available (and affordable) alternative option.”

Eur Heart J. 2014 Nov 14;35(43):3033-69, 3069a-3069k
2nd Annual Meeting
National PERT Consortium

June 27, 2016

The Royal Sonesta Boston
40 Edwin H. Land Boulevard
Cambridge, MA 02142

To learn more about consortium membership, please email:
Pert2016@pertconsortium.org
Thrombus Removal in Acute Pulmonary Embolism: When and How?

Kenneth Rosenfield, MD, MHCDS, MSCAI
Cardiology Division
Section of Vascular Medicine and Intvn
MGH