Catheter Directed Interventions for Pulmonary Embolism

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Georgia Vascular Society
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Disclosures

- No financial disclosures
- Co-PI SUNSET-PE trial
PE - Increasing Incidence

- Most common preventable cause of in-hospital death
- 3rd most common CV disease after MI and stroke
- 4% will develop Pulmonary Hypertension at 2-3 years

Huang et al - Am J Med 2014
Introduction

• Acute pulmonary embolism (PE)
  – Accounts for 5-10% of in-hospital deaths

• Treatment strategies
  – Anticoagulation
  – Surgical thrombectomy
  – IV (systemic) thrombolysis
  – Catheter-directed thrombolysis
PE Clinical Presentation – Non Homogenous

- **Massive**
  - High Risk
  - Hypotension

- **Non Massive**
  - Low Risk
  - No RVD
  - No + Biomarkers

- **Submassive**
  - Intermediate Risk
  - +/- ECHO RVD
  - +/- Biomarkers
• 57 year old man
• Sudden onset SOB
• Chest pain
• BP – 100/60
• HR – 102 at rest
• RR – 22/min
• Sat – 89%
• Troponin 1.5
• BNP – 3,400

Will Removal of Thrombus Make a Difference in his Clinical Course and Outcome?
PUBMED CITATIONS
PULMONARY EMBOLISM & CATHETER

![Graph showing the number of PUBMED citations for pulmonary embolism and catheter over the years from 1995 to 2020.](graph_image)
Physiological Benefits of Early Clot Removal (Thrombolysis or Extraction)

- Improved clot resolution
  - Faster?
  - More complete?
- Improved angiographic flow and lung perfusion
- Reduction PA pressure and improvement RV function
- Stabilization of hemodynamics
  - Less need for pressors and life support

*Jaff et al Circulation 2011*
Additional Theoretical Benefits of Early Clot Removal

• Fewer in hospital complications from PE
• Removal of threatening “clot in transit”
• Earlier discharge & return to functional baseline
• Reduced incidence of pulmonary hypertension

Avgerinos ED, Chaer RA. J Vasc Surg 2014
**Insufficient Evidence Limits the Guidelines New PE trial Data may be Changing the Landscape…**
Systemic Thrombolysis

Thrombolysis for Pulmonary Embolism and Risk of All-Cause Mortality, Major Bleeding, and Intracranial Hemorrhage
A Meta-analysis

“Systemic thrombolysis vs. AC is associated with lower mortality (OR 0.53) but more major bleeding events (OR 2.73)”

- **Mortality:** 47% Relative Risk Reduction
- **Major Bleed:** 9.2%
- **Stroke:** 1.5%

Chatterjee et al JAMA 2014
Catheter Directed Interventions

Randomized, Controlled Trial of Ultrasound-Assisted Catheter-Directed Thrombolysis for Acute Intermediate-Risk Pulmonary Embolism

“In intermediate risk PE ultrasound assisted catheter directed thrombolysis was superior to heparin alone in reversing RV dilatation at 24 hours, without an increase in bleeding events”

Kucher et al Circulation 2014

US National Inpatient Sample
Catheter Interventions for PE

It is more than a catheter…
Catheter Interventions for PE

- Standard Catheter Thrombolysis
- Ultrasound Assisted Thrombolysis
- Percutaneous clot extraction

When to use them? Which technique?
## Mortality Risk

<table>
<thead>
<tr>
<th>Early mortality risk</th>
<th>Risk parameters and scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shock or hypotension</td>
</tr>
<tr>
<td>High</td>
<td>+</td>
</tr>
<tr>
<td>Intermediate</td>
<td>-</td>
</tr>
<tr>
<td>Intermediate–high</td>
<td>-</td>
</tr>
<tr>
<td>Intermediate–low</td>
<td>-</td>
</tr>
<tr>
<td>Low</td>
<td>-</td>
</tr>
</tbody>
</table>

Interventions for PE

Who to Intervene on?

- Careful patient selection
- Low bleeding risk
- Massive PE
- Submassive PE
  - Severe RV strain
  - Myocardial necrosis
  - Deteriorating respiratory function

Mortality Reduction
Prevent
Decompensation
Pulm. Hypertension
(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

Catheter Interventions for PE

- Catheter Directed Interventions (CDIs)
  - Thrombolysis
    - Catheter directed dripping
    - Ultrasound assisted dripping
    - Pharmacomechanical (PMT)
  - Thrombus fragmentation/aspiration w/o lytics
- Combined techniques
Interventions for PE
Interventions for PE – Thrombolysis

Standard Catheter Thrombolysis

- Multisidehole catheter introduced within the clot
- 12-24 hour tpa infusion 0.5-2mg/hour
- tPA penetrate & “soften” clot particles
Interventions for PE – Thrombolysis

Ultrasound Assisted Thrombolysis (EKOS)

- Technically similar to catheter directed dripping
- Ultrasound may reduce dripping time & tPA dose (?)
- Most literature supporting it – FDA approved
  - ULTIMA RCT
  - SEATTLE II Registry
  - Multiple small series
  - OPTALYSE PE

- No evidence of superiority

UPMC Randomized Trial 2016
SUNSET PE
EKOS vs Standard Catheter Lysis
ULTIMA trial

Randomized Controlled Trial of Ultrasound-Assisted Catheter-Directed Thrombolysis for Acute Intermediate-Risk Pulmonary Embolism

- Anticoagulation vs. USAT
- 10-20 mg tPA over 15 hours
- USAT superior in reversing RV dilatation at 24 hrs.
- Equivalent hemodynamic outcomes at 90 days

Circulation, November 2013
Interventions for PE – Thrombolysis

Pharmacomechanical Thrombolysis (mPE)

- Shorter procedural time
- Faster reperfusion
- Lower (or no) lytic dose
- Bradycardia / arrest
- Death
- Hemolysis
- Renal failure
- FDA Black box warning

Rapid Lysis
- Lower rate of bleeding complications
Interventions for PE - Clot Extraction

Thrombectomy Devices

• Small bore Aspiration Catheters/Systems
• Large bore Aspiration Catheters/Systems
Interventions for PE - Clot Extraction

Thrombectomy Devices

• Small bore Aspiration Catheters/Systems
  • Pronto Catheter (Vascular Solutions)
  • Aspire (Control Medical Technology)
Interventions for PE
Interventions for PE

Thrombectomy Devices

- Large bore Aspiration Catheters
  (Rapid debulking of proximal thrombus)

- Angiovac (Angiodynamics) – en bloc removal
- Indigo (Penumbra Inc)
- Flowtriever (Inari medical)
AngioVac (Angiodynamics)

- Open or Percutaneous DVT, PE
- Large bore (22F), OTW
- Specialized funnel shaped tip
- Remotely deployable
- Prevent vessel collapse
- No longer recommended for PE given the risk of valvular injury
# Suction Thrombectomy

<table>
<thead>
<tr>
<th>Device</th>
<th>Sheath size</th>
<th>Mechanism of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penumbra Indigo</td>
<td>6-8 Fr</td>
<td>Suction pump aspiration</td>
</tr>
<tr>
<td>Inari Flowtriever</td>
<td>22 Fr</td>
<td>Disruption, retraction, aspiration</td>
</tr>
<tr>
<td>Angiovac</td>
<td>26 Fr</td>
<td>Large volume aspiration with return of filtered blood</td>
</tr>
<tr>
<td>Pronto XI Catheter</td>
<td>6-14 Fr</td>
<td>Manual aspiration</td>
</tr>
</tbody>
</table>
## Interventions for PE

### Efficacy & Safety Outcomes

<table>
<thead>
<tr>
<th>Trial</th>
<th>Pts</th>
<th>CDI Failure</th>
<th>Major Bleed</th>
<th>ICH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuo et. al 2009</td>
<td>594</td>
<td>~13.5%</td>
<td>~3.2%</td>
<td>0.1%</td>
</tr>
<tr>
<td>ULTIMA-2014</td>
<td>30</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>PERFECT 2015</td>
<td>101</td>
<td>~5.9%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>SEATTLE II 2015</td>
<td>150</td>
<td>~14.0%</td>
<td>10%</td>
<td>0%</td>
</tr>
<tr>
<td>NIS Data 2015</td>
<td>352</td>
<td>~13.9%</td>
<td>~3.7%</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

**RCT**
<table>
<thead>
<tr>
<th></th>
<th>Intermediate High Risk</th>
<th>High Risk (Massive)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AHA 2011 Guidelines</strong></td>
<td>Cath. Thrombectomy when 1. Lysis is contraindicated 2. Lysis failed</td>
<td>Cath. Thrombectomy when 1. Lysis is contraindicated 2. Lysis failed</td>
</tr>
<tr>
<td><strong>ESC 2014 Guidelines</strong></td>
<td>Cath. Treatment when 1. Lysis is contraindicated</td>
<td>Cath. Treatment when 1. Lysis is contraindicated 2. Lysis failed</td>
</tr>
<tr>
<td><strong>ACCP 2016 Guidelines</strong></td>
<td>Syst. Lysis should be preferred over Catheter lysis unless higher risk of bleeding</td>
<td>Suction Thrombectomy when 1. Lysis is contraindicated 2. Lysis failed</td>
</tr>
</tbody>
</table>
Interventions for PE – UPMC Experience

Acute PE Team

- PERT (Pulmonary Embolism Response Team)
- Members
  - Pulmonary
  - Vascular
  - Cardiology
  - Cardiac Surgery
  - Hematology

Referring Physician pages the PE Team Consult (Pulmonary)

Attending quickly reviews the case, assesses patient and consults on-call interventional teams

PE Team discusses treatment options
Who is the Pulmonary Interventionalist?

- PE intervention is not owned by any specialty
- Depends on each individual institution and local policies
- Whoever answers the call first

COMMENTARY

The PERT Movement – Vascular surgeons must answer the call

Publish date: February 2, 2017

By: Charles B. Ross, MD, Efthymios D. Avgerinos, MD

PERT

continued from page 7

Significant variability in the management of both massive and submassive PE patients beyond therapeutic anticoagulation, e.g., upon whom to offer intervention and how, is the point where a PERT may have greatest impact. Rapid, collaborative decision making between physicians/surgeons from multiple specialties offers hope for minimizing morbidity and improvement of best outcomes.
Assess Bleed Risk

- **High Risk**
- **Intermediate - High**
- **Intermediate - Low**
- **Low Risk**

**Low**
- Systemic tPa + Heparin +/- ECMO

**High**
- Surg. Thrombectomy or Suction Thrombectomy +/- ECMO

AC vs IVC Filter

- **Low or Intermediate**
  - AC
  - IVC filter

- **High**

Low
- Catheter-directed tPA + AC

Intermediate
- AC

High
- IVC filter
67 year old female
Admitted to outside hospital for nausea, vomiting, lightheadedness and syncope on 6/27/16
In setting of newly diagnosed colon cancer status post sigmoid resection and ileostomy creation May 2016
Last chemo 1 week before
Treated with IVF and improving
HPI

- On 7/1/2016 had sudden PEA arrest
- Underwent 12 minutes of CPR and had ROSC
- Post-arrest EKG: New RBB
- Post-arrest Echo: RV strain
- Transferred to UPMC
- On presentation, hypotensive requiring levophed
- Large groin hematoma from central line placement
Exam

- Vitals
  - HR 115
  - BP 126/69 (on levophed)
  - Sats 100% on 100% FiO2
- Responding to commands, moving all four extremities
- Right groin hematoma
- Pedal doppler signals
Laboratory

- H/H: 9.5/29.4
- Platelets 85
- Cr 1.69
- Troponin 0.38
Imaging

• **Echo**
  – RV strain
  – RV hypokinesis with preserved apical function (McConnell sign)

• **CTA**
  – Near occlusion of the distal left PA
  – Clot burden extends into the left upper lobe lingula and left lower lobe PA branches
  – Subocclusive clot within the branches of the right upper lobe right middle lobe as well as right lower lobe PAs
# Mortality risk

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Original version(^{214})</th>
<th>Simplified version(^{218})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Age in years</td>
<td>1 point (if age &gt; 80 years)</td>
</tr>
<tr>
<td>Male sex</td>
<td>+10 points</td>
<td>–</td>
</tr>
<tr>
<td>Cancer</td>
<td>+30 points</td>
<td>1 point</td>
</tr>
<tr>
<td>Chronic heart failure</td>
<td>+10 points</td>
<td>1 point</td>
</tr>
<tr>
<td>Chronic pulmonary disease</td>
<td>+10 points</td>
<td>1 point</td>
</tr>
<tr>
<td>Pulse rate ≥110 b.p.m.</td>
<td>+20 points</td>
<td>1 point</td>
</tr>
<tr>
<td>Systolic blood pressure &lt;100 mm Hg</td>
<td>+30 points</td>
<td>1 point</td>
</tr>
<tr>
<td>Respiratory rate &gt;30 breaths per minute</td>
<td>+20 points</td>
<td>–</td>
</tr>
<tr>
<td>Temperature &lt;36 °C</td>
<td>+20 points</td>
<td>–</td>
</tr>
<tr>
<td>Altered mental status</td>
<td>+60 points</td>
<td>–</td>
</tr>
<tr>
<td>Arterial oxyhaemoglobin saturation &lt;90%</td>
<td>+20 points</td>
<td>1 point</td>
</tr>
</tbody>
</table>

## Risk strata\(^{a}\)

- **Class I**: ≤65 points  
  - very low 30-day mortality risk (0–1.6%)  
  - 0 points = 30-day mortality risk 1.0%  
  - (95% CI 0.0%–2.1%)

- **Class II**: 66–85 points  
  - low mortality risk (1.7–3.5%)  

- **Class III**: 86–105 points  
  - moderate mortality risk (3.2–7.1%)  

- **Class IV**: 106–125 points  
  - high mortality risk (4.0–11.4%)  

- **Class V**: >125 points  
  - very high mortality risk (10.0–24.5%)  
  - ≥1 point(s) = 30-day mortality risk 10.9%  
  - (95% CI 8.5%–13.2%)

- **PESI Score**: 187
### Mortality risk

<table>
<thead>
<tr>
<th>Early mortality risk</th>
<th>Risk parameters and scores</th>
<th>30d MORTALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shock or hypotension</td>
<td>52%</td>
</tr>
<tr>
<td></td>
<td>PESI class III-V or sPESI &gt;1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Signs of RV dysfunction on an imaging test</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cardiac laboratory biomarkers</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(+)^d</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(+)^d</td>
<td></td>
</tr>
<tr>
<td>Intermediate</td>
<td>Intermediate–high</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>Both positive</td>
</tr>
<tr>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Intermediate–low</td>
<td>-</td>
<td>Either one (or none) positive</td>
</tr>
<tr>
<td>Low</td>
<td>-</td>
<td>Assessment optional; if assessed, both negative</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>
Bleeding risk

- Recent CPR
- Right groin hematoma
- Thrombocytopenia

High Risk of Bleed
Assess Bleed Risk

Low risk

High risk

Intermediate-high risk

Intermediate-low risk

Low risk

Systemic tPa + Heparin +/- ECMO

Surg. Thrombectomy or Catheter Intervention +/- ECMO
Intervention: Suction Thrombectomy
Intervention

Place catheter proximal to clot. If there is flow, advance catheter until clot is engaged. If flow is stopped, cycle the Separator™ to clear Indigo® Catheter and restore flow through tubing. Repeat as needed until vessel is clear.
Suction thrombectomy
Initial PA pressure 53, HR 115
Suction thrombectomy
Suction thrombectomy
Final PA Pressure 49, HR 80
• Extubated the following day
• Expanding groin hematoma while transitioning to coumadin
  – Managed conservatively
• Discharged to home on POD 9
Interventions for PE – UPMC Experience

~135 cases (12% massive PE) over 4 years

EVIDENCE SUMMARY

Midterm outcomes of catheter-directed interventions for the treatment of acute pulmonary embolism

Nathan L Liang¹, Rabih A Chaer¹, Luke K Marone², Michael J Singh¹, Michel S Makaroun¹ and Efthymios D Avgerinos¹

Vascular
## Interventions for sPE – UPMC Experience

### Outcomes

<table>
<thead>
<tr>
<th></th>
<th>AC (64)</th>
<th>sPE CDI (64)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Major Bleeding</strong></td>
<td>3 (4.7%)</td>
<td>4 (6.3%)</td>
<td>1.000</td>
</tr>
<tr>
<td><strong>Minor Bleeding</strong></td>
<td>0</td>
<td>6 (9.4%)</td>
<td>0.028</td>
</tr>
<tr>
<td><strong>Stroke</strong></td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Arrest</strong></td>
<td>0</td>
<td>3 (4.7%)</td>
<td>0.244</td>
</tr>
<tr>
<td><strong>Decompensation</strong></td>
<td>0</td>
<td>3 (4.7%)</td>
<td>0.244</td>
</tr>
<tr>
<td><strong>In hospital death</strong></td>
<td>3 (4.7%)</td>
<td>1 (1.6%)</td>
<td>0.619</td>
</tr>
<tr>
<td><strong>In hospital PE death</strong></td>
<td>1 (1.6%)</td>
<td>1 (1.6%)</td>
<td>1.000</td>
</tr>
<tr>
<td><strong>ICU Days</strong></td>
<td>5.6±7.5</td>
<td>2.7±2.1</td>
<td>0.04</td>
</tr>
<tr>
<td><strong>90-Day Death</strong></td>
<td>3</td>
<td>1</td>
<td>0.332</td>
</tr>
<tr>
<td><strong>02 dependence at FU</strong></td>
<td>5</td>
<td>4</td>
<td>0.737</td>
</tr>
</tbody>
</table>
Echocardiographic parameters:
Trend for a greater decrease in the mean RV/LV ratio in the CDI group at 30 days:

\[ 0.27 \pm 0.15 \text{ vs. } 0.17 \pm 0.12 \text{ for AC (P=.076),} \]

At 1 year, echo parameters were similar between the groups and pulmonary hypertension (PAP>40mmHg) was present in 7/15 of the AC group vs 6/19 of the CDI group (P=.484).

Dyspnea and/or oxygen dependence were present in 12% of patients in the AC group, vs. 14% in the CDI group (P=.774).
Interventions for PE – UPMC Experience

- **Clinical Success**: 87% (Massive: 50%, Submassive: 92%)
- Faster RV function recovery (vs Anticoagulation or SL)
- 7.4% major adverse events (1 ischemic stroke)
  - Systemic Bleed (7)
  - Heart/valve Injury (2)
- Less complications than systemic lysis (more than AC)
- Conversion to surgical thrombectomy: 2.9%
- Mortality: 3%
CDT vs USAT. Presented at the AVF 2015.

Demographics

<table>
<thead>
<tr>
<th></th>
<th>CDT (n=27)</th>
<th>USAT (n=36)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>57.07 ± 17.49</td>
<td>60.63 ± 12.78</td>
<td>0.35</td>
</tr>
<tr>
<td>Male Sex</td>
<td>37%</td>
<td>47%</td>
<td>0.45</td>
</tr>
<tr>
<td>PE Severity</td>
<td></td>
<td></td>
<td>0.065</td>
</tr>
<tr>
<td>High risk</td>
<td>22%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Intermediate risk</td>
<td>78%</td>
<td>94%</td>
<td></td>
</tr>
<tr>
<td>Hypercoagulable State</td>
<td>11%</td>
<td>8%</td>
<td>1.00</td>
</tr>
<tr>
<td>Recent Surgery</td>
<td>33%</td>
<td>17%</td>
<td>0.15</td>
</tr>
<tr>
<td>Malignancy</td>
<td>11%</td>
<td>19%</td>
<td>0.49</td>
</tr>
<tr>
<td>Hormone Therapy</td>
<td>7%</td>
<td>8%</td>
<td>1.00</td>
</tr>
<tr>
<td>Recent Travel</td>
<td>15%</td>
<td>22%</td>
<td>0.53</td>
</tr>
<tr>
<td>DVT</td>
<td>44%</td>
<td>56%</td>
<td>0.45</td>
</tr>
<tr>
<td>History of DVT</td>
<td>22%</td>
<td>14%</td>
<td>0.51</td>
</tr>
<tr>
<td>History of PE</td>
<td>22%</td>
<td>11%</td>
<td>0.30</td>
</tr>
<tr>
<td>CAD</td>
<td>15%</td>
<td>11%</td>
<td>0.72</td>
</tr>
<tr>
<td>CHF</td>
<td>4%</td>
<td>6%</td>
<td>1.00</td>
</tr>
<tr>
<td>Pulmonary HTN</td>
<td>4%</td>
<td>6%</td>
<td>1.00</td>
</tr>
</tbody>
</table>
# Echocardiographic Changes at One Year

<table>
<thead>
<tr>
<th></th>
<th>CDT</th>
<th>USAT</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline 1-year</td>
<td>Baseline 1-year</td>
<td></td>
</tr>
<tr>
<td><strong>RV/LV Ratio</strong></td>
<td>1.10 ± 0.06</td>
<td>0.86 ± 0.12</td>
<td>1.13 ± 0.19</td>
</tr>
<tr>
<td><strong>Tricuspid Regurg. Jet</strong></td>
<td><strong>Velocity (m/s)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.25 ± 0.90</td>
<td>2.48 ± 0.48</td>
<td>3.34 ± 0.64</td>
</tr>
<tr>
<td><strong>Systolic PA Pressure</strong></td>
<td>(mmHg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>58.33 ± 24.96</td>
<td>36.42 ± 9.50</td>
<td>57.01 ± 17.10</td>
</tr>
<tr>
<td><strong>RV Dilation</strong></td>
<td>10 (90%)</td>
<td>2 (17%)</td>
<td>15 (100%)</td>
</tr>
<tr>
<td><strong>RV Systolic Dysfunction</strong></td>
<td>10 (90%)</td>
<td>0 (0%)</td>
<td>11 (73%)</td>
</tr>
</tbody>
</table>

* comparisons accounting for repeated measures
Conclusions

• CDT/USAT for sPE can result in faster restoration of RV function and shorter ICU stay, though with similar midterm outcomes with AC alone.
  – Lower dose of thrombolytic compared to systemic lysis
  – Minimal bleeding complication

• There may be no difference in outcomes or adverse bleeding risk between CDT and USAT.
Conclusions

• Catheter Interventions are increasingly used in sPE

• Catheter interventions are safe and effective
  • Major bleed 2.9% (vs. 7.7% for SL (JAMA 2014))
  • 81% of patients showed ECHO RV dysfunction improvement
Conclusions

- Faster Clot removal & RV function recovery
- Prevention of RV failure / decompensation
- Prevention of Pulmonary Hypertension?
  - The potential impact of CDI on mortality and pulmonary hypertension needs further investigation through larger studies
- They are not complication-free but complications are less than with systemic lysis
- Pulmonary Embolism Response Team function facilitates optimal decision making