Contemporary Treatment of Pulmonary Thromboembolism

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PE is a Serious Problem

VTE (PE + DVT) 900,000/yr in US

PE Hospitalizations 150,000-250,000/yr

PE Deaths 100,000-200,000/yr

PE sequela 50%

CTEPH 4%
VTE INCIDENCE: INCREASING

First-Time Occurrence

Annual Event Rate, per 100,000

VTE

DVT

PE

(85/86/88/89 // 1999 2001 2003 2005 2007 2009)

PE is the #3 cause of CV death

PE Natural History

30% recurrence within 10 yrs

>90% complete resolution

>90% complete resolution

Full recovery

Partial recovery

Acute PE

CTEPH

4% CTEPH

Adapted from Fedullo
American Classifications of PE

Low Risk
- Normotensive
- No RV dysfunction
- Normal biomarkers

Submassive (Intermediate Risk)
- Normotensive
- RV strain (CT/TTE)
  - RV dilation
  - RV dysfunction
  - BNP > 90 pg/mL, pro-BNP > 500 pg/mL
- Myocardial necrosis
  - Trop I > 0.4 ng/mL, Trop T > 0.1 ng/mL

Massive (High Risk)
- Hypotension (SBP < 90 for > 15 min)
- Shock (on pressor)
- Pulselessness

Jaff. Circ 2011
### European Classifications of PE

<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>Intermediate-high</td>
</tr>
<tr>
<td></td>
<td>Intermediate-low</td>
</tr>
<tr>
<td>Low</td>
<td>–</td>
</tr>
</tbody>
</table>
Adapted from Dudziski
Integrated Prognostic Factors

- PESI score
- Imaging (Echo/CT)
- Biomarkers (Trp/BNP)
## PE Severity Index (PESI)

<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></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%)  
  (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%)

\(^a^{218}\) A point(s) = 30-day mortality risk 10.9%  
(95% CI 8.5%–13.2%)

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Aujesky. Am J Respir Crit Care Med 2005  
Jimenez. Arch Intern Med 2010  
Zamorano. European Heart J 2014
Imaging

Echo

- RV:LV > 0.9 or RV dysf
  - Sens 74%, Spec 54%
  - 7% in-hospital mortality
  - 41% worse outcomes (pressors, thrombolysis, CPR)

CT scan

- \( \text{RV}_D: \text{LV}_D > 0.9 \)
  - Sens 84%, Spec 35%
  - 5-fold risk for PE-related mortality
  - Thrombus load and central PE not associated with mortality

J Am Coll Cardiol 1997
Int J Cardiovasc Imaging 2015
## Biomarkers

<table>
<thead>
<tr>
<th>Test</th>
<th>Cut-off value</th>
<th>NPV (%)</th>
<th>PPV (%)</th>
<th>OR or HR (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Troponin I</td>
<td>Different cut-off values</td>
<td>NR</td>
<td>NR</td>
<td>4.0 (2.2-7.2)</td>
</tr>
<tr>
<td>Troponin T</td>
<td>14 pg/mL</td>
<td>98</td>
<td>9</td>
<td>5.0 (1.7-14.4)</td>
</tr>
<tr>
<td>BNP</td>
<td>75-100 pg/mL</td>
<td>98</td>
<td>14</td>
<td>6.5 (2.0-21)</td>
</tr>
<tr>
<td>NT-pro BNP</td>
<td>600 pg/mL</td>
<td>99</td>
<td>7</td>
<td>6.3 (2.2-7.2)</td>
</tr>
</tbody>
</table>

Konstantinides. European Heart J. 2014
Combined Approach to Risk Stratification

<table>
<thead>
<tr>
<th>Parameter</th>
<th>30-day complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>sPESI</td>
<td>10%</td>
</tr>
<tr>
<td>sPESI + BNP</td>
<td>14%</td>
</tr>
<tr>
<td>sPESI + BNP + Troponin</td>
<td>20%</td>
</tr>
<tr>
<td>sPESI + BNP + Troponin + DVT</td>
<td>26%</td>
</tr>
</tbody>
</table>

Handoko. Am J Respir Crit Care Med. 2014
Management Alternatives

Anticoagulant

IVC Filter

MCS

Mechanical

Percutaneous Fragmentation & Aspiration

Pharmacomechanical

Surgical Embolectomy

~More likely with ↑ severity
Acute PE Team (PERT)

• A multidisciplinary group with expertise in the diagnosis, medical, surgical and interventional management of PE who collaborate to improve patient care

• Goals
  • Improve patient care
  • Facilitate multidisciplinary consultation with rapid mobilization
  • Outpatient follow up: Post-PE clinic
  • Regular meetings to discuss cases
  • Facilitate research (PE registry, clinical trials)
  • National PERT consortium
Multidisciplinary Collaboration

- Pulmonary/Critical Care
- Vascular Surgery
- Interventional Cardiology
- Cardiac Surgery
- Emergency Medicine
- Hematology

PE Team
Previous Paradigm

Adapted from Rosenfield, Kabrhel
New Model

PE diagnosed or suspected

PE Team Consult

PE Team Meeting
(Pulmonary, interventionalist, surgeon, floor team, ED, ICU)

Immediate plan implementation
How to Consult the PE Team?

- **Operator**
- UPMC **MedCall** 412-647-7000 and ask for PE Team consult

- UPMC **MedTrack**: type PE Team
If clinical decompensation

SBP < 90 for > 15 min or requiring pressor

Yes

No

ACUTE PE

High-risk PE (Massive)

PERT consult

Bleeding risk*

High

Moderate

Low

Surgical/mechanical /catheter thrombectomy or AC alone

Cath-lysis

Syst-lysis

If clinical decompensation

Intermediate-risk PE (Submassive)

sPESI ≥ 1 and RV dil/dys and ↑Trp/↑BNP

AC

Low-risk PE

sPESI = 0 and RV dil/dys or ↑Trp/↑BNP

AC

Low-Intermediate risk PE

Bleeding risk*

If clinical decompensation

High

Low/Moderate

AC

Cath-lysis

If clinical decompensation

Yes

No

CT w RV dil, TTE w RV dil/dys, or ↑Trp, ↑BNP

AC

Cath-lysis

If clinical decompensation

Bleeding risk*
If clinical decompensation

Cardiac Arrest

ECMO or RV assist device

High-risk PE (Massive)

PERT consult

Bleeding risk*

High

Surgical/mechanical/catheter thrombectomy or AC alone

Moderate

Cath- lysis

Low

Syst- lysis

If clinical decompensation
CT w RV dil, TTE w RV dil/dys, or ↑Trp, ↑BNP

Yes

Intermediate-risk PE (Submassive)

sPESI ≥ 1 and RV dil/dys and ↑Trp/↑BNP

PERT consult

High-Intermediate risk PE

Bleeding risk*

High

AC alone or Cath-thrombectomy

Low/Moderate

Cath-lysis

No

Low-risk PE

sPESI ≥ 1 and RV dil/dys or ↑Trp/↑BNP

AC
New ACCP Anticoagulation Guidelines 2016

- **VTE w/o cancer**: 1st line tx NOAC (dabigatran*, rivaroxaban, apixaban and endoxaban*)
  - * Bridging required
  - 39% lower major bleeding, 64% lower fatal bleeding, 63% lower ICH
  - Reversal agent for dabigatran: Idarucizumab (Praxbind ®). Dexanet alpha awaiting FDA approval

- **VTE w cancer**: 1st line tx LMWH

- **Provoked** VTE: treat x 3 mo
- **Unprovoked** VTE: treat indefinitely (until risk of bleeding>clotting)

- No AC for **Subsegmental PE** (single PE, low risk for recurrence, no DVT in LE dopplers, no sx)
- No IVC Filter unless unable to tolerate AC

Antithrombotic Therapy for VTE Disease. CHEST. 2016
Blood 2014
Out of Hospital PE Treatment

- Low-risk PE
- Clinically stable with good cardiopulmonary reserve
- No contraindications (recent bleeding, severe renal or liver disease, or low platelets)
- Compliant
- Patient feels well enough to be treated at home
- PESI score <85 or sPESI = 0

Antithrombotic Therapy for VTE Disease. CHEST. 2016
Systemic Thrombolysis in High Risk (Massive) PE

• Meta analysis of 11 RCT comparing lysis vs UFH
  • All PE (748 pts): OR 0.67 (CI 0.4-1.12)
  • Massive PE: 9.4% vs 19%, OR 0.45 (CI 0.22-0.92)

  Wan. Circulation 2004

• Cohort study of 72,230 HD unstable patients 1999-2008
  • HD unstable = shock or ventilator
  • Mortality 15% vs 47%, RR 0.2 (p < 0.001)

Systemic Thrombolysis in Intermediate Risk (Submassive) PE

- **PEITHO Trial**: RCT lysis/heparin vs placebo/heparin
- 1006 patients w RV dysfunction (CT/TTE) and myocardial injury (Trop I or T)
- Primary endpoint: All cause mortality **or** Hemodynamic collapse within 7 days of randomization (CPR, SPB < 90 mmHg for 15 min or drop ≥ 40 mmHg with end organ hypoperfusion, pressor initiation)

NEJM 2014; 370: 1402-11
PEITHO: Primary efficacy outcome

<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 or hemodynamic collapse within 7 days of randomization</td>
<td>13 (2.6)</td>
<td>28 (5.6)</td>
<td>0.015</td>
</tr>
</tbody>
</table>

Odds ratio

Thrombolysis superior

Meyer. NEJM 2014
<table>
<thead>
<tr>
<th>Outcome</th>
<th>Tenecteplase (N = 506)</th>
<th>Placebo (N = 499)</th>
<th>Odds Ratio (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary outcome — no. (%)</td>
<td>13 (2.6)</td>
<td>28 (5.6)</td>
<td>0.44 (0.23–0.87)</td>
<td>0.02</td>
</tr>
<tr>
<td>Death from any cause</td>
<td>6 (1.2)</td>
<td>9 (1.8)</td>
<td>0.65 (0.23–1.85)</td>
<td>0.42</td>
</tr>
<tr>
<td>Hemodynamic decompensation</td>
<td>8 (1.6)</td>
<td>25 (5.0)</td>
<td>0.30 (0.14–0.68)</td>
<td>0.002</td>
</tr>
<tr>
<td>Time between randomization and primary efficacy outcome — days</td>
<td>1.54±1.71</td>
<td>1.79±1.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recurrent pulmonary embolism between randomization and day 7 — no. (%)</td>
<td>1 (0.2)</td>
<td>5 (1.0)</td>
<td>0.20 (0.02–1.68)</td>
<td>0.12</td>
</tr>
<tr>
<td>Fatal</td>
<td>0</td>
<td>3 (0.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonfatal</td>
<td>1 (0.2)</td>
<td>2 (0.4)</td>
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<td></td>
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<tr>
<td>Other in-hospital complications and procedures — no. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>8 (1.6)</td>
<td>15 (3.0)</td>
<td></td>
<td></td>
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<tr>
<td>Surgical embolectomy</td>
<td>1 (0.2)</td>
<td>2 (0.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catheter thrombus fragmentation</td>
<td>1 (0.2)</td>
<td>0 (0.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vena cava interruption</td>
<td>5 (1.0)</td>
<td>1 (0.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrombolytic treatment other than study medication</td>
<td>4 (0.8)</td>
<td>23 (4.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Death from any cause between randomization and day 30 — no. (%)</td>
<td>12 (2.4)</td>
<td>16 (3.2)</td>
<td>0.73 (0.34–1.57)</td>
<td>0.42</td>
</tr>
<tr>
<td>Patient still hospitalized at day 30 — no. (%)</td>
<td>59 (11.7)</td>
<td>50 (10.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rehospitalization between randomization and day 30 — no. (%)</td>
<td>22 (4.4)</td>
<td>15 (3.0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 4. Safety Outcomes in the Intention-to-Treat Population.*

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Tenecteplase (N=506)</th>
<th>Placebo (N=499)</th>
<th>Odds Ratio (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bleeding between randomization and day 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major extracranial bleeding</td>
<td>32 (6.3)</td>
<td>6 (1.2)</td>
<td>5.55 (2.3–13.39)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Minor bleeding</td>
<td>165 (32.6)</td>
<td>43 (8.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major bleeding†</td>
<td>58 (11.5)</td>
<td>12 (2.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stroke between randomization and day 7</td>
<td>12 (2.4)</td>
<td>1 (0.2)</td>
<td>12.10 (1.87–93.39)</td>
<td>0.003</td>
</tr>
<tr>
<td>Ischemic stroke</td>
<td>2 (0.4)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemorrhagic stroke‡</td>
<td>10 (2.0)</td>
<td>1 (0.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serious adverse events between</td>
<td>55 (10.9)</td>
<td>59 (11.8)</td>
<td>0.91 (0.62–1.34)</td>
<td>0.63</td>
</tr>
<tr>
<td>randomization and day 30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>

### B. Major Extracranial Bleeding

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Tenecteplase (N=506)</th>
<th>Placebo (N=499)</th>
<th>Odds Ratio (95% CI)</th>
<th>P Value for Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no. of events/total no. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤75 yr</td>
<td>14/344 (4.1)</td>
<td>5/335 (1.5)</td>
<td>2.80 (1.00–7.86)</td>
<td>0.09</td>
</tr>
<tr>
<td>&gt;75 yr</td>
<td>18/162 (11.1)</td>
<td>1/164 (0.6)</td>
<td>20.38 (2.69–154.53)</td>
<td>0.13</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>11/242 (4.5)</td>
<td>4/231 (1.7)</td>
<td>2.70 (0.85–8.61)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>21/264 (8.0)</td>
<td>2/268 (0.7)</td>
<td>11.49 (2.57–49.53)</td>
<td></td>
</tr>
</tbody>
</table>
How about Low-dose Thrombolysis?

• Meta-analysis of 5 studies
• **Low-dose tPA** (50mg) vs. standard dose (100mg)
• No difference in all-cause mortality or recurrent PE
• Less major bleeding with low-dose tPA (OR 0.33, 95% CI 0.12-0.91)

Sharifi M et al. Am J Cardiol 2013
Zhang Z et al. Thromb Res. 2013
Armstrong PW et al. Am Heart J 2015
ACCP Antithrombotic Guidelines 2016: Systemic Thrombolysis

• PE with hypotension and low bleeding risk
• PE with deterioration after starting AC, but yet to develop hypotension and with low bleeding risk
• PE w/o hypotension, with severe symptoms or marked cardiopulmonary impairment - may benefit from lytics

Antithrombotic Therapy for VTE Disease. CHEST. 2016
Catheter-directed tPA in Intermediate Risk (Submassive) PE

- **ULTIMA (ULTrasound accelerated thrombolysis of pulMOnAry embolism with EKOS):** Heparin/EKOS vs Heparin
- 59 patients with submassive PE (RV:LV ratio >1)
- Primary outcome: Δ RV/LV at 24 hrs

Kucher. Circulation 2014
RV/LV ratio (echo)

- **Baseline**
  - EKOS+Heparin: 1.28
  - Heparin: 1.20
  - P=0.09

- **24 hrs**
  - EKOS+Heparin: 0.99
  - Heparin: 1.17
  - P=0.31

- **90 days**
  - EKOS+Heparin: 1.20
  - Heparin: 1.17
RV/LV ratio (echo)

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>24 hrs</th>
<th>90 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>EKOS + Heparin</td>
<td>1.28</td>
<td>0.99</td>
<td>0.95</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;0.0001</td>
<td>P&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>24 hrs</th>
<th>90 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heparin</td>
<td>1.20</td>
<td>1.17</td>
<td>0.98</td>
</tr>
<tr>
<td>P-value</td>
<td>0.31</td>
<td>P&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>
Catheter-directed tPA in Intermediate Risk (Submassive) PE

• **SEATLE II Trial:** Submassive and massive pulmonary Embolism treatment with ultrasound **AcceleraTed Thrombolysis thErapy**
  - Single arm, prospective, multicenter trial
  - 150 patients (119 submassive, 31 massive)
  - Results at 48 hrs:
    • ↓ 25% CT-measured RV:LV
    • ↓ 30% in PASP by echo
    • ↓ 30% clot burden by PA angiogram
• **Bleeding risk:** moderate 10%, severe <1%, ICH none
Does catheter-based interventions improve outcomes?

- **PERFECT trial**: prospective, multicenter registry
- 101 patients (Massive 28; Submassive 73)
- Primary outcome: clinical success (stabilization of HD + improvement in PH or RV strain) and survival to discharge

**Results:**
- Clinical success 24/28 Massive; 71/73 Submassive
- Decrease mPA from 51 to 37 mmHg
- Improved RV strain in 89%
- No major complications related to procedure or bleeding
- No differences among various techniques/devices
What about survival benefit?

- National Inpatient Sample 2010-2012 identified 110,731 PE → 1,521 (1.4%) patients received thrombolysis
  - 77% systemic and 23% catheter-directed (CDL)
  - ↓ in-hospital mortality 22% vs. 13%, OR 0.55 (CI 0.36-0.85, p = 0.007)
  - Similar length of stay 7 days
  - ↑ cost of hospitalization $23,799 vs $17,218

- UPMC Registry w submassive and massive PE
  - CDL higher clinical success rate (87% vs. 68%, p = 0.001)
  - Lower rate of major bleeding (7% vs. 22%, p = 0.001)

Patel et al. Cath and Card Interv 2015
Avgerinos, Rivera-Lebron et al. Society of Vascular Surgery
Catheter-based Embolectomy

- Thrombus fragmentation/aspiration
- Can be alone or in combination CDL
- Fragmentation may cause distal embolization and worsen obstruction
ACCP Antithrombotic Guidelines 2016: Catheter-based interventions

- Recommend systemic over CDL
- PE with hypotension with high bleeding risk or failed systemic thrombolysis or shock that will lead to death before systemic thrombolysis can take effect – recommend catheter-assisted thrombus removal +/- CDL

Antithrombotic Therapy for VTE Disease. CHEST. 2016
Surgical Embolectomy

- Requires median sternotomy with bypass
- Mortality rate 5%
- Preoperative thrombolysis increases risk of bleeding but is not absolute contraindication

RV assist devices

- Impella, ECMO
- Reserved for cardiac arrest or refractory shock

Life after PE: Post-PE Sequelae

- All patients after PE
- Reported symptoms of reduced functional status
- Persistent thrombi
- Measurable limitations in cardiopulmonary function
- CTEPH
- Post-PE syndrome

Klok. Blood Reviews 2014
Chronic Clots

• Residual perfusion defects after PE
  • 66% at 3 mo; 30% at 12 mo
  • ↑ dyspnea
  • ↓ 6MWD (374 vs 427 m, p = 0.004)
  • ↑ PASP on echo (39 ± 12 vs 31 ± 8 mmHg, p <0.001)

• Risk factors for incomplete resolution:
  • Larger, more central PE
  • Longer duration of PE symptoms before treatment
  • Older age
Chronic ThromboEmolic Pulmonary Hypertension (CTEPH)

• PH caused by chronic PE (>3 mo)

• 4% of acute PE (20,000/yr US)

• 25-40% of patients with CTEPH lack a history of PE or DVT ("silent PE")

Tapson. PATS 2006
Pengo. NEJM 2004
PE Follow-Up: INFORM Study

- Retrospective claims database analysis
- 87% PH-related symptoms (syncope, dyspnea, chest pain, dizziness, edema)
- Only 61% had diagnostic test
CTEPH Workup

Screening
- Echo
- VQ scan

Diagnosis
- RHC

Surgical Candidacy
- CTA
- PA angiogram
- Comorbidities
CTEPH Survival is poor if left untreated

- **Untreated** CTEPH (only AC) 5 yr-survival
  - With mPAP > 40 mmHg 30% survival
  - With mPAP > 50 mmHg 10% survival

Lewczuk. Chest 2011
Preferred Treatment: Surgery

• **Pulmonary thromboendarterectomy (PTE)** can be curative

• Surgical selection: clot accessibility, comorbidities, hemodynamics

• PTE: cardiopulmonary bypass with cooling (20°) with circulatory arrest (20 min on- 10min off). Mortality < 5%

Adapted from Madani Fedullo. Am J Respir Crit Care 2011
CTEPH Medical Treatment

• **Riociguat** (Adempas ®) a soluble cGMP stimulator
  • Non-operable or Persistent PH after PTE
  • ↑ 6MWD by 39 m and ↓ PVR by 2.8 WU

• **Lifelong anticoagulation**

• Do NOT deprive a patient of a life-saving procedure for medical management trial!
Interventional Treatment: **Balloon Pulmonary Angioplasty**

- For non-operable CTEPH
- Requires sequential angioplasties
- Good results:
  - ↓ mPA, ↑ 6MWT
  - No restenosis 1 yr-post BPA
Take Home Points

• PE is the 3rd most common cardiovascular disorder in the USA with a high mortality in Massive and Submassive PE
• Systemic thrombolysis – reserved for Massive PE - associated with increased bleeding and ICH
• Catheter-directed thrombolysis acutely decreases clot burden and may help in Massive and Submassives
• PE is associated with acute and long-term negative cardiopulmonary outcomes, including CTEPH
• Acute PE Team and CTEPH program are here to help!
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Thank you!