Massive and Sub-massive Pulmonary Emboli

Cindy Baker, MD, FACC
Clinical Assistant Professor
Division of Cardiovascular Medicine
The Ohio State University Wexner Medical Center

Outline

• Incidence
• Risk Stratification
• Pharmacologic therapy
• Percutaneous/ Surgical therapy
• Case Presentations
• Future Direction with Chronic Thromboembolic Pulmonary Hypertension (CTEPH)
Pulmonary Embolism- Statistics

- 300k-600k per year
  - 1-2 per 1000 people, or as high as 1 in 100 if > 80 years old
- 3rd leading cause of cardiovascular death behind myocardial infarction and stroke
- Most commonly from lower extremity DVT
  - Evidence of DVT in > 50%

cdc.gov; Agency for Healthcare Research and Quality

Trends in Annual Incidence Rates and Case Fatality Rates of Pulmonary Embolism

Risk Factors for Persistent VTE Incidence: Trends in VTE Risk Factor Prevalence


Pathophysiology of Massive Pulmonary Embolism

- Increased RV afterload
- RV dilation and RV wall tension
- RV ischemia, hypoxic injury
- RV contractility and RV output
- LV preload and CO
- Systemic BP
- Obstructive Shock
- Death
Pulmonary Embolism - Risk Stratification

Hemodynamic instability

High risk of death

Hemodynamic Stability

Clinical Imaging Laboratory

Comorbidities

Pulmonary Embolism - Risk Stratification

<table>
<thead>
<tr>
<th>High risk (massive PE)</th>
<th>Intermediate risk (submassive PE) (high or low)</th>
<th>Low risk PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemodynamic instability</td>
<td>Hemodynamic stability</td>
<td>Systemically normotensive</td>
</tr>
<tr>
<td>SBP &lt; 100 mmHg for &gt;15 minutes (secondary to PE) or requiring pressors</td>
<td>Systemically normotensive</td>
<td></td>
</tr>
<tr>
<td>Decrease in SBP &gt; 40 mmHg from baseline</td>
<td>RV dysfunction (strain) on TTE or CTPE</td>
<td></td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>Myocardial necrosis - elevated troponin and BNP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No RV dysfunction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No myocardial necrosis</td>
<td></td>
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</tbody>
</table>
Pulmonary Embolism- Risk Stratification

Simplified PESI Score

<table>
<thead>
<tr>
<th>Patient Characteristic</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt;80</td>
<td>1</td>
</tr>
<tr>
<td>History of Cancer</td>
<td>1</td>
</tr>
<tr>
<td>History of Cardiopulmonary Disease</td>
<td>1</td>
</tr>
<tr>
<td>HR ≥ 110</td>
<td>1</td>
</tr>
<tr>
<td>SBP &lt; 100</td>
<td>1</td>
</tr>
<tr>
<td>Oxygen Saturation &lt; 90%</td>
<td>1</td>
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</tbody>
</table>

≥ 1 point(s)= 30 day mortality risk 10.9% (95% CI 8.5-13.2%)


Imaging Evidence of RV Strain

Echocardiographic

- Enlarged RV with RV/LV ratio > 1 in the apical 4 chamber
- Flattened intraventricular septum- pressure overload
- McConnell's sign
- Dilated IVC
Imaging Evidence of RV Strain

![Image of RV strain evidence]

Imaging Evidence of RV Strain

![Image of RV strain evidence]
# Imaging Evidence of RV Strain

CTPE
RV/LV ratio >1

<table>
<thead>
<tr>
<th>Prevalence (%)</th>
<th>PE Classification</th>
<th>Mortality (%)</th>
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<tbody>
<tr>
<td></td>
<td>Low Risk</td>
<td>&gt; 30</td>
</tr>
<tr>
<td>55</td>
<td>Interm-low Risk</td>
<td>15</td>
</tr>
<tr>
<td>40</td>
<td>Interm-high Risk</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>High Risk</td>
<td>&lt;1</td>
</tr>
<tr>
<td></td>
<td>Low Risk</td>
<td></td>
</tr>
</tbody>
</table>

[Diagram showing the percentage distribution of PE classification and mortality]
Systemic Thrombolytics for Pulmonary Embolism

1960-1970s

- 1962 Streptokinase first used to lyse pulmonary emboli in dogs and humans
- 1967 NHLI organized clinical trial that showed 12 hrs of urokinase vs heparin increased the resolution rate of PE (especially massive) documented with angiogram, hemodynamics and lung scans
Systemic Thrombolytics for Pulmonary Embolism

**1960-1970s**

- Late 1980s recombinant tissue-type plasminogen activator (rt-PA) introduced in the treatment of PE.
- Randomized trial indicated its faster action and safety compared to urokinase.
- Multiple small trials in the 1990s shows clinically significant improvement in acute PE with rt-PA (alteplase)

**1980-1990s**

ALTEPLASE FOR CARDIAC ARREST SECONDARY TO PULMONARY EMBOLISM (PE)

Dose is 50 mg or 0.6 mg/kg (max 50 mg)

OSU Guidelines for Systemic Thrombolytics in PE

ALTEPLASE FOR PULMONARY EMBOLISM (PE) NOT ASSOCIATED WITH CARDIAC ARREST

Bolus of 10 mg followed by 90 mg infused over 2 hours
Contraindications to Systemic Thrombolytics

Absolute contraindications to thrombolysis become relative in patient with cardiac arrest or immediately life-threatening high-risk PE.

1. Known intracranial neoplasm, arteriovenous malformation or aneurysm
2. History of hemorrhagic stroke or stroke of unknown origin at any time
3. Active internal bleeding
4. Recent major trauma / major surgery / any neurosurgery / head injury / major bleeding within 3 weeks

Warning/Precaution Considerations

Check all that apply:

9. SBP > 180 mmHg or DBP > 110 mmHg
10. Known bleeding diathesis or acquired coagulopathies
11. Platelet count < 100,000/mm³
12. Therapeutic anticoagulation
13. Current or recent use of Ticagrelor (Brilinta®) within last 5 days or Prasugrel (Effient®) within last 7 days
14. Arterial puncture at non-compensable site, organ biopsy or lumbar puncture within last 7 days
15. Any history of ischemic stroke
16. Any neurosurgical procedure within 3 months, consider contacting surgeon to balance risk and benefit
17. Pregnancy, or within one week postpartum
18. Low body weight (< 60 kg), consider reduced dose (0.6 mg/kg)
19. Suspected or known infective endocarditis
20. Suspected or known pericardial effusion
21. Age < 18 years old

Pulmonary Embolism (PE) - Evaluation and Management OSU guidelines updated 2018

ICH with Thrombolysis for Acute PE

National database 1998-2008 n=49,500

Stein PD. Am J Med 2012; 125: 50-56
• Fibrinolysis is reasonable for patients with massive acute PE and acceptable risk of bleeding complications  (AHA 2011)

<table>
<thead>
<tr>
<th>Recommendations For Systemic Thrombolytics</th>
<th>Class</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Fibrinolysis is reasonable for patients with massive acute PE and acceptable risk of bleeding complications  (AHA 2011)</td>
<td>IIa B</td>
<td></td>
</tr>
<tr>
<td>• In patients with acute PE associated with hypotension (eg, systolic BP &lt;90 mm Hg) who do not have a high bleeding risk, we suggest systemically administered thrombolytic therapy over no such therapy (CHEST 2016)</td>
<td>II B</td>
<td></td>
</tr>
<tr>
<td>• Systemic thrombolytic therapy is recommended for high-risk (massive) PE  (ESC 2019)</td>
<td>I C</td>
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Systemic Thrombolytics for Pulmonary Embolism

- Multiple studies evaluating systemic thrombolytics in the Intermediate risk (submassive) population
- PEITHO (2014) –largest trial ~1000 pts randomized to heparin/ placebo vs heparin/tenectaplae.
- Primary outcome composite all cause mortality or hemodynamic decompensation/ collapse- better in tenectaplae group.
- 2% hemorrhagic stroke in lytic group
Recommendations For Systemic Thrombolytics

<table>
<thead>
<tr>
<th>Fibrinolysis is not recommended for patients with low-risk PE or submassive acute PE with minor RV dysfunction, minor myocardial necrosis, and no clinical worsening (AHA 2011)</th>
</tr>
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<tbody>
<tr>
<td>III</td>
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<td>B</td>
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<thead>
<tr>
<th>Routine use of primary systemic thrombolytics is not recommended in intermediate or low risk PE (ESC 2019)</th>
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<td>III</td>
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<td>B</td>
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Anticoagulation

- UFH recommended in Massive PE
- 80 U/kg bolus followed by 18 U/kg/hr (if less than 125kg) or 12 U/kg/hr (if greater to or equal than 125 kg)
- If lytics given then UFH is held during alteplase infusion and reinitiated at the end of this infusion.
- LMWH preferred in Submassive if no procedures planned
Percutaneous Therapies for Pulmonary Embolism

- Next step was to evaluate catheter directed therapies
- ??? Less bleeding and improved outcomes
- Mechanical fragmentation- pigtail catheter
- Rheolytic thrombectomy- Angiojet
- Catheter directed lysis- EKOS system, Unifuse
- Suction embolectomy- Flow Triever, Angiovac, Penumbrum

Ultrasound Accelerated Catheter Directed Fibrinolysis (EKOS)

- Fibrin Separation
  - Ultrasound separates fibrin without fragmentation of emboli
- Delivers thrombolytics directly into pulmonary artery thrombus.
- Alteplase 1mg/hr x 12 hrs per catheter
- Heparin gtt peripheral IV
- Without Ultrasound  With Ultrasound
Percutaneous Therapies for Pulmonary Embolism

- Catheter directed lysis (CDL) in patients with acute PE

- ULTIMA Trial 2013- randomized to EKOS thrombolysis + heparin vs heparin alone  N=59

- SEATTLE II Trial 2015 -single arm with EKOS (ultrasound accelerated thrombolysis ) using total 24mg alteplase  N=150  Massive 20%

- At 48hrs RV/LV ratio, PA pressures and modified Miller score all statistically significantly reduced in EKOS group. No intracranial hemorrhages.

Piazza GA et al. JACC Cardiovasc Interv 2015
The Ultima Trial


Percutaneous Therapies for Pulmonary Embolism

- Mechanical embolectomy devices introduced.
- FLARE trial 2019 – single arm multicenter trial of catheter directed mechanical thrombectomy (Flow Triever) in submassive PE
- At 48hrs RV/LV ratio reduction statistically significant

Tu t et al. JACC Cardiovasc Interv 2019

Mechanical Embolectomy

A

B
Mechanical Embolectomy

Recommendations for Catheter Directed Therapies

- Can be considered in patients with hemodynamic or respiratory deterioration on anticoagulation therapy
- Patients with massive PE who have contraindication for systemic thrombolytics
- Patients that receive systemic thrombolytics and remain unstable

AHA 2011
CHEST 2016
ESC 2019

IIa
### Surgical Therapies for Pulmonary Embolism

- The Society of Thoracic Surgeons (STS) Database from 2011-2015
- 1075 cases Isolated Acute Surgical Pulmonary Embolectomy without prior cardiac surgery
- Overall mortality 16% (NCS= 8%, CS= 23%, and CS/CA=44%)


### Indications for Surgical Embolectomy

- Massive or Submassive PE with any of the following:
  - Contraindication to thrombolytic therapy
  - Failed thrombolytic therapy
  - Patent foramen ovale
  - Pregnancy
  - Right heart failure or cardiogenic shock
  - Thrombus-in-transit within the right heart chambers

### Surgical Therapies for Pulmonary Embolism

- Mechanical support for cardiogenic shock
- IVC filters

### Adjunctive Therapies

- Mechanical support for cardiogenic shock
- IVC filters
Extracorporeal membrane oxygenation (ECMO)

- Allows for acute hemodynamic stabilization in the patient with massive PE
- Small studies at experienced centers have shown improved survival in patients with ECMO vs no ECMO prior to therapies for massive PE


Adjunctive Therapies in Massive and Sub-Massive PE

- Routine use of IVC filter is not recommended
- IVC filter is suggested in patients with PE and absolute contraindication to anticoagulation or recurrent PE despite anticoagulation.
- Placement of retrievable IVC filter in patients with hemodynamic compromise and residual proximal DVT is made on case by case basis

Author: BozMo (CC BY-SA 3.0)
Pulmonary Embolism Response Team (PERT)

- Respond quickly to treat patients with massive and submassive PE
- Multidisciplinary approach to coordinating care
- Provide best option(s) for treating patients
- Develop protocols for full range of therapies available to standardize care
Case Presentation

45 year old male presents to the ER with complaints of chest pain, shortness of breath and lightheadedness. He reports symptoms had begun 2 days prior. He reports the chest pain was worse with respirations. He had no prior cardiac history.

**PMH:**
- Hypertension
- Osteoarthritis
- Morbid obesity

**Medications:**
- Altace 10 mg daily
- Celebrex 200mg daily
- Multivitamin

**Social History:**
- + tobacco and EtOH.
- Denies illicit drugs.

**Family History:**
- No premature CAD
- No history of hypercoaguable states.

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**Case Presentation**

Physical Exam:
- Blood pressure 100/60
- Heart rate 105
- RR 20
- O2 sat RA 89%

**General:** anxious appearing
**HEENT:** Normal
**CV:** regular, tachycardia. No M/R/G
**Lungs:** tachypneic, clear
**Abdomen:** + BS, soft, obese
**Extremities:** Mild right pretibial and pedal swelling.
**Pulses:** intact and equal upper and lower extremities.

**Labs:**
- Troponin 0.85
- BNP 200
- BMP and CBC WNL
Hospital Course

- Placed on IV heparin gtt and admitted to the cardiac unit.

- Overnight O2 requirement increased with no improvement in blood pressure

- Decision was made to perform catheter directed lysis in the cardiac catheterization laboratory
Follow-up

- Patient discharged on day 3 with Xarelto

- Followed up in Cardiology office in 3 months with repeat imaging. Echo showed near normalization of RV size and function.

- Etiology likely obesity with decreased mobility. Hypercoaguuable workup after off OAC.

- Plan to continue OAC for 6 months.
60 year old male presents to the ED by squad with syncope and lethargy. He had been convalescing at home after recent admission for community acquired pneumonia. The patient’s family reports he had been sedentary since discharge from the hospital two weeks ago. Today they noticed he was short of breath and then passed out while walking from his bedroom to the restroom. His fall was witnessed. No head trauma.

PMH: Hypertension COPD CAD

Family History: CAD no hypercoagulable states

Medications: Aspirin 81 mg daily HCTZ 25 mg daily Metoprolol 25 mg BID Albuterol inhaler prn

Social History: Former smoker.

Physical Exam:
Blood pressure 80/40 Heart rate 140 RR 20 O2 sat on non-rebreather 90%


Labs: Troponin 1.2 BNP 158

CXR: mild LLL patchy infiltrate (improved from recent admission)
Follow-up

- Patient admitted to ICU
- BP normalized over the next several hours
- Echo showed dilated and hypokinetic RV
- Patient discharged home on day 4 with Xarelto
- Seen in Cardiology outpatient follow-up at 8 weeks. Doing well with no apparent sequelae.

Case Presentation

61 year old female that presented several day history of chest pain and shortness of breath. She had been admitted to the hospital several weeks prior for cholecystitis and sepsis. She had noticed swelling in her right lower extremity the week prior to presentation.

PMH:
Breast ca s/p resection chemo and radiation 2014

Family History:
No hypercoagulable states

Medications:
Aspirin 81 mg daily
Augmentin BID
Anastrazole 1 mg daily

Social History:
Nonsmoker.
Case Presentation

Physical Exam:
Blood pressure 117/77
Heart rate 129
RR 20
O2 sat 96%

General: anxious with pleuritic chest pain
HEENT: Normal
CV: regular, tachycardia. No M/R/G
Lungs: tachypneic, clear
Abdomen: + BS, soft, NTND
Extremities: right leg swollen and tender below the knee
Pulses: intact and equal upper and lower extremities.

Labs: CXR: atelectasis at the right lung base
Troponin 0.29
BNP 517

Case Presentation

- CTPE study showed bilateral pulmonary emboli with evidence of right heart strain.
- ER bedside echo concerning for mobile mass in the right atrium
- PERT consult placed.
Case Presentation

Hospital Course

• To the OR for right atrial thrombectomy.
• Was placed on veno-arterial ECMO during surgery.
• Patient weaned from ECMO 5 days later
• Discharged to SNF after 2 weeks on Coumadin
• Follow up echo showed mild RV enlargement but no evidence of pulmonary HTN. Patient back to work at daycare center.
**Follow up for Massive and Submassive PE**

- Need for hypercoagulable workup
- Duration of Anticoagulation
- Repeat echocardiogram
- Possible referral to Pulmonary HTN clinic

**Chronic Thromboembolic Pulmonary HTN (CTEPH)**

- CTEPH is mean PAP ≥ 25mmHg after at least three months of effective anticoagulation and residual chronic thrombus.

- Categorized by the WHO as Group 4 PH

- Between 500 and 2500 new cases of CTEPH diagnosed each year.

- In fact, as many as 1 out of every 25 previously treated PE patients (>3 months of anticoagulation) could develop CTEP
Chronic Thromboembolic Pulmonary HTN (CTEPH)
Results from an International Prospective Registry

CTEPH Patients

Operable 64%
In-Operable 36%

57% treated with Pulmonary Embolectomy


Balloon Pulmonary Angioplasty (BPA)- case
Pressure wire across the lesion

Proximal to the lesion  Distal to the lesion

Balloon Pulmonary Angioplasty (BPA)- case
Pressure wire guided BPA

PRE BPA

POST BPA

Balloon Pulmonary Angioplasty (BPA)- case
Conclusions

- Patients with massive and submassive pulmonary embolus require emergent intervention to prevent hemodynamic decompensation and/or death.

- Options for treatment vary and many times require a multidisciplinary approach to determine the best intervention.

- Close follow up of these high risk patients is important to prevent and treat longterm sequelae.