Massive Pulmonary Embolism
Objectives

1. Review the pathophysiology of a pulmonary embolism.
2. Describe the signs and symptoms of a patient experiencing a pulmonary embolism.
3. Identify treatment modalities and supportive therapies associated with the patient experiencing a pulmonary embolism.
Venous Thromboembolism

- Venous thromboembolism encompasses deep vein thrombosis and pulmonary embolism
- Third most frequent cardiovascular disease

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**THE FACTS**
A blood clot that forms in the leg is called deep vein thrombosis (DVT). If the blood clot breaks loose and travels up to your lungs, it is called a pulmonary embolism (PE).
Together, they are known as venous thromboembolism (VTE).

**THE NUMBERS**
1 in 4 people die from causes related to blood clots
1-3 top cardiovascular killers are linked to blood clots
1 cause of preventable death in hospitals is VTE
60% of all VTE cases occur during or following hospitalization

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Deep Vein Thrombosis (DVT)

- Clot in deep vein
  - Lower extremities
  - Pelvis
DVT

- Virchow's triad
  - Hypercoagulable state
  - Venous stasis
  - Endothelial injury
Hypercoagulable State

- Post-op
  - Hip
  - Knee
  - Urinary system
- Cancer
- Thrombophilia
- Estrogen therapy
- Pregnancy and post partum
- Inflammatory bowel disease
Venous status

- Immobility
- Paralysis
- Heart failure
- Venous insufficiency
- Varicose veins
- Venous obstruction due to tumor, obesity, or pregnancy
Endothelial Injury

- Invasive lines
- Surgery
- Trauma
- Heart valve replacement
- Heart valve disease
- Atherosclerosis
Acute Pulmonary Embolism

- Acute pulmonary embolism (PE) represents the sudden obstruction of part of the pulmonary arterial vasculature, which is usually caused by embolization of thrombus from the deep veins within the lower limbs and pelvis. It may also be caused by air, fat, or amniotic fluid.
Risk Factors for Pulmonary Embolism

- Surgery
- Increased age
- Fracture
- Decreased mobility
- Long travel
- Stroke
- Obesity
- Oral contraceptives
- Pregnancy
- Polycythemia
- Protein C deficiency
- Paralysis
- Cardiac disease
- Smoker
- Hx DVT
- Acute medical illness
- CVP line
- Cancer
- Inflammatory states
- Varicose veins
- Vascular disease
- Burns
Pulmonary Embolism

- Incidence Increases with age
- After 40y rates double with each decade of life
- 88% pts with DVT or PE >40yrs old
- 80y 100x more likely than 40y
Pulmonary Embolism

- Pulmonary Embolism is the most common cause of vascular death after myocardial infarction and stroke
- Leading preventable cause of death in hospital patients
Pulmonary Embolism

- > 90% of emboli come from deep vein thrombosis in iliofemoral system
- Other sites
  - Right side of heart
  - Pelvis
- Nonthrombotic emboli
  - Fat
  - Air
  - Amniotic fluid

critical care 6th edition
Pulmonary Embolism

- True incidence unknown
  - PE was found in 18% of autopsies and in most (70%) of these was considered to be the main or a contributory cause of death.

- 300,000 - 600,000 cases diagnosed a year

- 100,000-180,000 die per year
Massive Pulmonary Embolism

- Most patients with acute PE are (or appear to be) hemodynamically stable at presentation and are not considered to be at high risk
- High cause of morbidity and mortality among hospitalized patients
International Cooperative Pulmonary Embolism Registry

- Massive Pulmonary embolism 90 day mortality rate 52 %
- Sub - massive and non-massive 90 day mortality rate 15 %
Management Strategy and Prognosis of Pulmonary Embolism Registry

- 65% in hospital mortality for patients needing cardiopulmonary resuscitation
- 25% mortality if presenting with cardiogenic shock
- Right ventricular dysfunction has 2 fold increase in 90 day mortality
Pulmonary Embolism Classification

- Massive (high risk)
- Sub-massive (intermediate risk)
- Nonmassive (low risk)
Massive Pulmonary Embolism (High Risk)

- Acute Pulmonary Embolism with sustained hypotension (systolic blood pressure <90 mm Hg for at least 15 minutes or requiring inotropic support, not due to a cause other than PE, such as arrhythmia, hypovolemia, sepsis, or left ventricular dysfunction), pulselessness, or persistent profound bradycardia (heart rate 40 bpm with signs or symptoms of shock).

Sub-massive Pulmonary Embolism (Intermediate Risk)

- Acute Pulmonary embolism without systemic hypotension (systolic blood pressure 90 mm Hg) but with either RV dysfunction or myocardial necrosis.
  - RV dysfunction at least 1 of the following:
    - RV dilation or RV systolic dysfunction on echocardiography
    - RV dilation on CT
    - Elevation of BNP (90 pg/mL)
    - Elevation of N-terminal pro-BNP (500 pg/mL)
    - Electrocardiographic changes (new complete or incomplete right bundle-branch block, anteroseptal ST elevation or depression, or anteroseptal T-wave inversion

Sub-massive Pulmonary Embolism

- Myocardial necrosis is defined as either of the following:
  - Elevation of troponin I (0.4 ng/mL) or
  - Elevation of troponin T (0.1 ng/mL)

Nonmassive Pulmonary Embolism (Low Risk)

- Acute PE and the absence of the clinical markers of adverse prognosis that define massive or submassive PE.

Pathophysiology

- Thrombus lodges in pulmonary artery
- Release of vasoconstrictive mediators from thrombotic tissue
- Increased pulmonary vascular resistance = increased right ventricular afterload
- Right ventricular dilation = right heart failure
  - hypoxemia, dyspnea, hypotension, and syncope
Pathophysiology

- Hypoxia leads to hypoxic pulmonary vasoconstriction = increased afterload
- Decreased left ventricular filling = decreased left ventricular cardiac output
- Cardiac arrest
  - Pulseless electrical activity
Massive Pulmonary Embolism

- Death occurs in 1 hr
- Thrombus occludes more than 50% pulmonary vasculature
- Intrapulmonary dead space (ventilate but no perfusion)
- Obstructive shock
What happens in acute PE?

**Anatomy / physiology**

1. Hypoxemia from VQ mismatch (dead space)
2. Elevated pulmonary artery pressure
3. RV failure / hypotension
Signs and Symptoms of Pulmonary Embolism

- Acute onset of dyspnea ***
- Chest pain ***
- Tachypnea
- Tachycardia ***
- Hypotension
- Hemoptysis ***
- Syncope ***
- New murmur due to tricuspid regurgitation
- Increase in central venous pressure
- Distention of jugular vein
- Decrease in oxygen saturation
S/S Massive Pulmonary Embolism

- Classic sx
  - Dyspnea, Chest Pain, and hemoptysis
- Acute onset dyspnea and tachycardia
- Anxious, feeling of doom
- Syncope
- Dilated RV, tricusp regurg
Diagnostic Tests

○ EKG
  ● Inverted T waves in V1-V4 leads
  ● Acute right ventricular strain
     ○ S wave in lead I
     ○ Q wave in lead III
     ○ T-wave inversion in lead III
  ● New bundle branch block
Diagnostic Tests

- Chest X-ray
  - Rule out other causes
  - Atelectasis
  - Diaphragm elevation on affected side

- Westermark sign
  - Hypovolemia leading to collapse of vessel seen distal to a pulmonary embolism

- Hampton hump
  - shallow wedge-shaped opacity in the periphery of the lung with its base against the pleural surface
Diagnostic Tests

- **D-dimer**
  - Plasma degradation
  - Levels elevated in acute blood clot
  - Activation of the coagulation system is associated with fibrinolysis

- Fibrin produced in many conditions:
  - Cancer
  - Inflammation
  - Bleeding
  - Trauma
  - Surgery
  - Necrosis
Diagnostic Tests

- Troponin
  - Any increase up to a five-fold increase in the risk of death

- BNP
  - Reflects RV overload/dysfunction and is also associated with increased early mortality
Diagnostic Tests

- CT Pulmonary Angiography
- Gold standard
  - Showing either a partly bypassed hypodense defect
  - Complete occlusion
  - Visualize a lung infarction
- >95% sensitivity and specificity
Diagnostic Tests

- Echocardiography
  - Evidence of acute right ventricular overload
Goals of Treatment

- Regain / maintain hemodynamic stability
- Relieve pulmonary obstruction
- Stop clot growth
- Prevent clot recurrence
Treatment

- **Heparin**
  - 80 u /kg bolus
  - 18 u/kg/hr
- **Titrate to 1.5-2.5 times control**
- **Heparin-induced thrombocytopenia**
  - Argatroban
  - Bivalirudin
Treatment

- Circulatory support
  - Volume
  - Pressors
- Airway, O2
Treatment

- Intravenous fluids
  - 500 ml bolus

- Vasopressors
  - Norepinephrine
    - positive inotropic effect
    - Alpha-receptor stimulation
  - Dobutamine
  - Epinephrine
Treatment

- Phosphodiesterase inhibitors
  - Systemic
- Inhaled or systemic pulmonary vasodilators
- High flow oxygen
  - 50-70 L/min
Treatment

- Positive pressure ventilation
  - Reduced venous return
  - Decrease in right ventricle preload
  - Increase in right ventricle afterload

- PEEP use caution

- Low tidal volumes
  - 6 ml/kg

- Plateau pressure < 30
Treatment of Massive Pulmonary Embolism

- Systemic thrombolysis
- Surgical embolectomy
- Catheter-directed therapy
- ECMO
- Vena cava filter
Systemic Thrombolysis

- Thrombolytic convert native plasminogen to plasmin,
- Hydrolyzes the fibrin of thromboemboli resulting in clot lysis

NeurovascularMedicine.com stroke Thrombolysis
Systemic Thrombolysis

- Thrombolytic Therapy
  - Improve pulmonary artery pressure
  - Improve arteriovenous oxygenation
  - Improve pulmonary perfusion
  - Improve echocardiographic assessment

- Relieving symptoms, preventing recurrent PE, and reducing mortality
Treatment (unstable pt)

- Thrombolysis
  - Alteplase, urokinase or streptokinase
  - Fibrinolytic, non selective
  - Activate plasminogen-plasmin-degradation of clot
  - Bleeding complication, ICH
Systemic Thrombolysis

- Alteplase (tissue plasminogen activator (tPA))
  - Shorter infusion time
  - Faster clot lysis
  - Lower bleeding rates
- 100 mg over 2 hours
- 50 mg over 15 minutes
- Initial half life 5 minutes
- Fibrinolytic activity 1 hour after infusion
# THROMBOLYTICS (TPA- ALTEPLASE) PROTOCOL FOR PULMONARY EMBOLUS (PE) - ADULT

**Cardiac Monitoring** - ICU

<table>
<thead>
<tr>
<th>Activity Order</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONGOING</td>
<td>starting Today at 1355 Until Specified</td>
</tr>
<tr>
<td>Cardiac Monitoring Type</td>
<td>ICU</td>
</tr>
</tbody>
</table>

**Activity**

- P: A patient can only have 1 activity order, if there is an existing activity order it should be modified. Placing an additional activity order will discontinue the existing order.

**FREQUENT VITAL SIGNS**

- ONGOING | starting Today at 1355 until Tomorrow for 24 hours, During alteplase infusion monitor vitals every 15 minutes for 2 hours. Afterwards, monitor vital signs every 30 minutes for 4 hours, then every hour for 18 hours.

**NEURO CHECKS**

- ONGOING | starting Today at 1355 until Tomorrow for 24 hours, During alteplase infusion monitor vitals every 15 minutes for 2 hours. Afterwards, monitor Neuro Checks every 30 minutes for 4 hours, then every hour for 18 hours.

**Notify Provider for severe headache, nausea, neurologic changes and significant bleeding.**

- PRN | starting Today at 1355 Until Specified, Notify Provider for severe headache, nausea, neurologic changes and significant bleeding.

**PERIPHERAL IV**

- ONGOING | starting Today at 1355 Until Specified, If patient does not have a peripheral IV, please place 2 peripheral IV's. Minimize all other venipunctures

**Stop Heparin infusion prior to TPA administration.**

- PRN | starting Today at 1353 Until Specified, Stop Heparin infusion prior to TPA administration. Goal aPTT should be < 80 prior to TPA administration (may be adjusted based on clinical parameters at the discretion of the physician). Once the alteplase has been infused and aPTT is < 80, resume heparin drip per protocol without bolus.

**PTT (aPTT)**

- STAT, Lab Collect, ONCE | First occurrence Today at 1355, 2 hours after tPA has finished
## Contraindications

<table>
<thead>
<tr>
<th>Absolute Contraindications</th>
<th>Relative Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural intracranial disease</td>
<td>Systolic BP &gt; 180 mmHg</td>
</tr>
<tr>
<td>Previous intracranial hemorrhage</td>
<td>Diastolic BP &gt; 100 mmHg</td>
</tr>
<tr>
<td>Ischemic Stroke within three months</td>
<td>Recent Bleeding</td>
</tr>
<tr>
<td>Active bleeding</td>
<td>Recent surgery or invasive procedure</td>
</tr>
<tr>
<td>Recent brain or spinal surgery</td>
<td>Ischemic stroke &gt; 3 months previously</td>
</tr>
<tr>
<td>Recent head trauma with fracture or brain injury</td>
<td>Anticoagulation</td>
</tr>
<tr>
<td>Bleeding diathesis</td>
<td>Traumatic Cardiopulmonary resuscitation</td>
</tr>
<tr>
<td></td>
<td>Pericarditis or pericardial fluid</td>
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<tr>
<td></td>
<td>Diabetic retinopathy</td>
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<tr>
<td></td>
<td>Pregnancy</td>
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<tr>
<td></td>
<td>Age &gt; 75</td>
</tr>
<tr>
<td></td>
<td>Low body weight</td>
</tr>
<tr>
<td></td>
<td>Female</td>
</tr>
<tr>
<td></td>
<td>African-American</td>
</tr>
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<td>Caution is required. Thrombolysis is acceptable if the benefits outweigh the risks</td>
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Thrombolysis could cause a life-threatening situations. Caution is required. Thrombolysis is acceptable if the benefits outweigh the risks.
Surgical Embolectomy

- TEE first, may have extra-pulmonary thrombi
Catheter-Directed Therapy

- Consider when patient with pulmonary embolism have contraindication to thrombolysis
- Failed thrombolysis
- Shock which may cause death before thrombolysis takes effect
Catheter-Directed Therapy

- Dissolve
- Macerate
- Remove
Extracorporeal Membrane Oxygenation

- Venoarterial (VA) ECMO
  - Indications
    - Absolute contraindication - reperfusion therapies
    - Hemodynamically unstable despite reperfusion therapy
Extracorporeal Membrane Oxygenation

Benefits

- Decrease RV overload
- Improve RV function
- Improve hemodynamic status
- Restore tissue oxygenation
Vena Cava Filter

- Infrarenal portion of the inferior vena cava
- Absolute contraindications to anticoagulant drugs
- Experiencing major bleeding events during the acute phase
- Objectively confirmed recurrent PE, despite adequate anticoagulation treatment
- Increase use of permanent and retrievable Vena cava filter (U.S.)
Treatment

- **Heparin (IV or SQ) (massive)**
  - At least 5-10 days
  - 80u/kg load then 18u/kg/hr
  - Activates antithrombin III
  - LMWH submassive

- **Coumadin (Vitamin K Antagonist)**
  - Add while on Heparin
  - Once INR 2-3 stop Heparin
  - Usually takes 5 days, clearance of factors
  - Coumadin for 2-3 months

- **Argatroban**
Treatment

- Non–vitamin K dependent oral anticoagulant agents
  - Apixaban
  - Dabigatran
  - Edoxaban ***
  - Rivaroxaban
Non–vitamin K dependent oral anticoagulant agents

- Noninferior to heparin/VKA regimen in preventing VTE recurrence
- Probably safer in terms of major bleeding and fatal hemorrhage
- NOACs are recommended in the 2014 ESC Guidelines as an alternative to the standard heparin/VKA treatment
References


References


References


