

Pulmonary Embolism

Pathophysiology

- A thrombus in another area of the body **embolizes to the pulmonary vasculature via the RV and PA**.
- Blood flow distal to the embolus is obstructed, causing **increased PVR, PA pressure, and RV pressure**. If severe, acute **cor pulmonale** can occur.
- Blood flow decreases in some areas, **dead space** is created where there is **ventilation but no perfusion**.
- **Hypoxemia and hypercarbia** occur and drive **tachypnea**. If dead space is large, signs are more overt (SOB). PE and DVT are on a continuum.

Pulmonary Embolism (cont)

Source

- Most PE arise from **thromboses of deep veins** of lower extremities above the knee (iliofemoral DVT).
- Can also arise from deep veins of pelvis.
- Calf vein thrombi have a low incidence of embolizing to the lungs, but they can progress into the proximal veins and increase the risk of PE.
- Upper extremity DVT is rare (seen in IVDU).
- **Fat emboli** from long bone fractures, amniotic fluid emboli during or after delivery, air emboli (trauma, lines), septic emboli (IVDU), schistosomiasis.

Symptoms

- Not a reliable indicator of the presence of PE.
- **Dyspnea (73%), cough (37%), pleuritic chest pain (65%), hemoptysis (13%)**.
- Only 1/3 of patients will have signs and symptoms of a DVT.
- Syncope seen in large PE.

Pulmonary Embolism (cont)

Signs

- **Tachypnea** (70%), rales (51%), **tachycardia** (30%), S4 (24%), increased P2 (23%).
- Shock with rapid circulatory collapse in massive PE.
- Others include low-grade fever, decreased breath sounds, and dullness on percussion.

Risk Factors for DVT and PE

- Age>60, **malignancy**, prior history, hereditary, **hypercoagulable states**, prolonged immobilization, cardiac disease (esp. CHF), obesity, **nephrotic syndrome**, major surgery (esp. pelvic or orthopedic), major trauma, pregnancy, and estrogen use.



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Published 14th January, 2017.

Last updated 16th January, 2017.

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Pulmonary Embolism (cont)

Prognosis

- PE is usually clinically silent.
- Recurrences are common, which can lead to **chronic pulmonary HTN and chronic cor pulmonale**.
- When undiagnosed, mortality approaches 30%.
- When PE is diagnosed, mortality is 10% in first 60 minutes. Of those who survive initial event, 30% will die of recurrent PE if untreated.
- Most are recurrent in the first few hours.
- Treatment with **anticoagulation** decreases mortality to 2-8%.

Diagnosis

- If suspected PE, stabilize with **IVF and O2**.
If PE is likely, **start anticoagulation before diagnostic tests**.
- If PE is unlikely, get testing first.
- If the patient has contraindications to anticoagulation, get testing first and then **consider IVC filter**.

Testing

D-Dimer

- **Specific fibrin degradation product** whose levels can be elevated in PE or DVT.
- Sensitive (90-98%).
- If results are normal and clinical suspicion is low, PE is very unlikely.
- **Specificity is low**, as it can be elevated in **MI, CHF, pneumonia, and postop**.
- Any cause of clot or increased bleeding can elevate D-Dimer.

Testing (cont)

Venous Duplex Ultrasound

- If positive, **treat with IV heparin**.
- False positives will lead to anticoagulation in patients without PE.
- If negative, the test is of very little value and the patient may still have a PE (up to 50% of patients with PE).

Echocardiogram

- **Acute massive PE** is accompanied by **RV dilation and failure due to RV outflow obstruction and increased PVR**.
- The **dilated RV** pushes the **septum towards the LV**, causing further **decrease in LV preload and CO**.
- This shows up as **dilated RV cavity and hypokinesis of the RV free wall** with sparing of the apex (**McConnell's sign**).

Helical CT

- **>90% sensitivity and good specificity**.
- Can visualize very small clots (>2mm). Can miss clots in small sub segmental vessels.
- **Test of choice**.
- If negative and high clinical probability of PE, there is a 5% incidence of PE.
- Contraindicated in patients with renal insufficiency because of **IV contrast**.

Testing (cont)

CXR

- Usually normal. **Atelectasis or pleural effusion** may be present.
- Mainly useful to exclude competing diagnoses.
- Hampton's hump or Westermark's sign are rarely present

V/Q Scan

- Important when there is a contraindication to helical CT.
- Results can either be normal, low-probability, intermediate-probability, or high-probability.
- A normal V/Q scan rules out PE and no further testing is needed.
- A high probability scan is **very sensitive for PE** and indicates treatment with heparin.
- If low or intermediate probability, clinical suspicion determines next step.
- If high, pulmonary angiography is indicated.

Arterial Blood Gas

- Not diagnostic.
- **PaO2 and PaCO2 are low** (latter due to hyperventilation) and **pH is high**.
- **Typically respiratory alkalosis**.
- **The A-a gradient is usually elevated**. A normal A-a gradient makes PE less likely but does not exclude it.



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Published 14th January, 2017.

Last updated 16th January, 2017.

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Testing (cont)

Pulmonary Angiography

- **Gold standard.** Definitively diagnoses or excludes PE.
- But the test is invasive.

Contrast is injected into the PE branch after percutaneous catheterization of the femoral vein.

- Consider when noninvasive testing is equivocal and risk of anticoagulation is high, or if the patient is unstable and embolectomy may be required. Rarely performed due to 0.5% mortality.

Rules Out PE

Normal or low-probability V/Q scan or helical scan and low clinical suspicion, negative pulmonary angiogram (definite), and negative D-Dimer with low suspicion

Wells Criteria

Symptoms and signs of DVT (3 points), alternative diagnosis less likely than PE (3 points), HR > 100 (1.5 points), immobilization > 3 days or surgery in last 4wks (1.5 points), previous DVT or PE (1.5 points), hemoptysis (1 point) and malignancy (1 point). If > 4, PE is likely.

Testing (cont)

Indications for Treatment

intraluminal defects in central, segmental or lobular PAs on helical CT (or high probability with a scan) and clinical suspicion, DVT diagnosed with clinical suspicion, and positive pulmonary angiogram (definitively proves PE).

Treatment

Oxygen Therapy

- To correct **hypoxemia**.
- Severe hypoxemia or respiratory failure requires intubation and mechanical ventilation.

Heparin

- Either unfractionated or LMWH (enoxaparin) to prevent recurrence.
- Prevents further clot formation but **does not lyse existing emboli or diminish thrombus size**.
- Start immediately based clinical suspicion. Do not wait for studies if high.
- Give one bolus, followed by infusion for 5-10days.
- Goal aPTT of 1.5-2.5x normal.
- Acts by **promoting antithrombin III**.
- Contraindications include active bleeding, uncontrolled HTN, recent stroke, and HIT.
- LMWH has less complications but NOT used in ESRD.

Treatment (cont)

Warfarin

- For long-term treatment. **Can start with heparin on day 1.**
- Goal INR is 2-3. Continue for 3-6 months depending on risk factors.
- Some patients with significant risk for recurrence (malignancy, hyper coagulable state) should receive lifelong therapy.

Thrombolytic Therapy

- Streptokinase, TPA.
- **Speed up lysis of clots.**
- Does not improve mortality rates.
- Should be considered for use in patients with **massive PE** who are **unstable**, and patients with **evidence of RHF**.

IVC Filter

- Have not been proven to reduce mortality.
- Patients are at a higher risk of recurrent DVT but lower risk of recurrent PE.
- Complications include filter migration or misplacement, filter erosion and perforation of IVC, and IVC obstruction due to filter thrombosis.
- Indicated for patients with contraindications to anticoagulation, complication of current anticoagulation, failure of adequate anticoagulation evidence by recurrence, and low pulmonary reserve (high risk of death due to PE).



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Treatment (cont)

NOACs Fondaparinux is an injectable factor Xa inhibitor. Rivaroxaban is an oral factor Xa inhibitor. Neither can be used in severe CKD (GFR<30). Elixaban is approved for use in CKD.



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