L10: Pulmonay Embolism

Medicine433@yahoo.com

We suggest you watch this before you start:

1. Animation (2:36 mins long):
https://www.youtube.com/watch?v=0PEhvACEROI

2. Explains the whole lecture in a very nice way: (13 mins each)
Part 1:
https://www.youtube.com/watch?v=CfjGhwQiDOE

Part 2:
https://www.youtube.com/watch?v=PjizR8e1TvQ

MEDICINE 433

objectives

1. To know etiology & risk factors for pulmonary embolism.

2. How to diagnose pulmonary embolism & its major clinical presentations.

3. Lines of treatment of pulmonary embolism.

Color index: Step up to medicine , slide , Doctor's note , Davidson , Extra Explanation

General Characteristics

- A PE occurs when a thrombus in another region of the body embolizes to the pulmonary vascular tree via the RV and pulmonary artery. Blood flow distal to the embolus is obstructed.

- Consider PE and deep venous thrombosis (DVT) as a continuum of one clinical entity (venous thromboembolism)—diagnosing either PE or DVT is an indication for treatment.

- **Sources of emboli:**

  1- Lower extremity DVT— **PE is the major complication of DVT**.

  - (The most common) thromboses in the deep veins of lower extremities above the knee (iliofemoral DVT).
  - deep veins of the pelvis. Other veins: renal, uterine, right cardiac chamber.
  - (rare)calf veins thrombi .

  2- Upper extremity DVT is a rare source of emboli (it may be seen in IV drug abusers).

Note: the source of the embolus is often not identified, even at autopsy (either because the entire thrombus embolized, or because the remainder of the thrombus lies in a vein that is not identified).

Pathophysiology

A. Emboli block a portion of pulmonary vasculature, leading to **increased** :

- pulmonary vascular resistance.
- pulmonary artery pressure.
- right ventricular pressure.

If it is severe (large blockage), **acute cor pulmonale** may result.

B. Blood flow **decreases** in some areas of the lung. Dead space is created in areas of the lung in which there is ventilation but no perfusion. The resulting **hypoxemia** and **hypercarbia** drive respiratory effort, which leads to **tachypnea**.

C. If the size of the dead space is large (large PE), clinical signs are more overt (**SOB**, **tachypnea**).

In other words:

- Massive PE causes an increase in PVR "pulmonary vascular resistance" → right ventricular outflow obstruction → decrease left ventricular preload → Decrease CO.
- In patients without cardiopulmonary disease, occlusion of 25-30 % of the vascular bed → increase in Pulmonary artery pressure (PAP).
- Hypoxemia ensues → stimulating vasoconstriction → increase in (PAP).
- More than 50% of the vascular bed has to be occluded before (PAP) becomes substantially elevated.
- When obstruction approaches 75%, the RV must generate systolic pressure in excess of 50mmHg to preserve pulmonary circulation. (the normal pulmonary pressure is around 20mmHg)
- The normal RV is unable to accomplish this acutely and eventually fails.

Types of pulmonary emboli

Small/medium Pulmonary Embolism:

- In this situation an embolus has impacted in a terminal pulmonary vessel.
- Symptoms are pleuritic chest pain, breathlessness and hemoptysis occurs in 30% of cases.

Massive Pulmonary Embolism:

- It is a catastrophic entity which often results in acute right ventricular failure and death.
- Frequently undiscovered until autopsy.
- Fatal PE typically leads to death within one to two hours of the event.
- With the patient has severe central chest pain (cardiac ischemia due to lack of coronary blood flow) and becomes shocked (cardiogenic shock), pale and sweaty.
- The diagnosis of massive PE should be explored whenever **oxygenation** or **hemodynamic parameters** are severely compromised without explanation.

Multiple Recurrent Pulmonary Emboli:

- This leads to increased breathlessness, often over weeks or months.
- It is accompanied by weakness, syncope on exertion and occasionally angina.

Risk Factors For PE/DVT

- Age >60 years
- Malignancy
- Prior history of DVT, PE
- Hereditary hypercoagulable states (factor V Leiden, protein C and S deficiency, antithrombin III deficiency)
- Prolonged immobilization or bed rest, long-distance travel
- Cardiac disease, especially CHF
- Obesity
- Nephrotic syndrome
- Major surgery, especially pelvic surgery (orthopedic procedures)
- Major trauma
- Pregnancy, estrogen use (oral contraceptives)
- Postpartum
- Coagulation problems

Symptoms

Symptoms (frequency per the PIOPED study)	Signs (frequency per the PIOPED study)
• Dyspnea (73%): sudden onset. • Pleuritic chest pain (66%) • Cough (37%) • Hemoptysis (13%) • Note that only one-third of patients with PE will have signs and symptoms of a DVT. • Syncope seen in large PE.	• Tachypnea (70%). • Rales (51%). • Tachycardia (30%). • S4 (24%). • Increased P2 (23%). • Shock with rapid circulatory collapse in massive PE. • Other signs: low-grade fever, decreased breath sounds, dullness on percussion. • Right ventricular heave (in both massive PE and multiple recurrent PE). • Gallop rhythm and a widely split second heart sound (In massive PE). • Loud pulmonary second sound (In multiple recurrent PE).

Note: signs and symptoms are not a reliable indicator of the presence of PE. This often leads to confusion and delay in diagnosis and treatment. If, however, a patient has symptoms of a PE and a DVT is found, one can make the diagnosis of PE without further testing.

How To Diagnose

1. Atrial blood gas (ABG) levels are not diagnostic for PE.

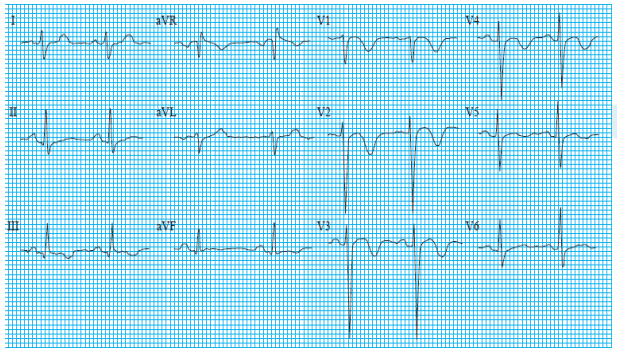
A. PaO_2 and $PaCO_2$ are low (the latter due to hyperventilation) and pH is high; thus, there is typically a **respiratory alkalosis**.

B. Alveolar–arterial gradient (A-a gradient) is usually elevated because, in PE, oxygen is not effectively transferred from the alveoli to the blood. A normal A-a gradient makes PE less likely, but cannot be relied on to exclude the diagnosis.

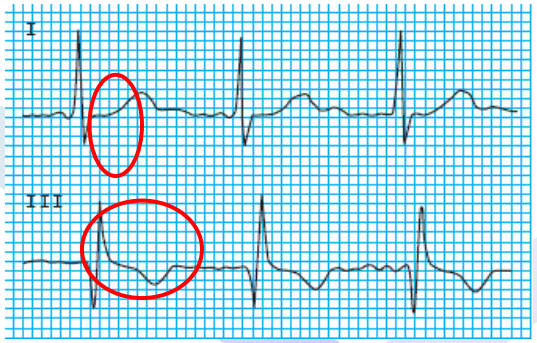
C. **Significant hypoxemia is** almost uniformly present when there is a hemodynamically significant PE.

2. ECG Findings:

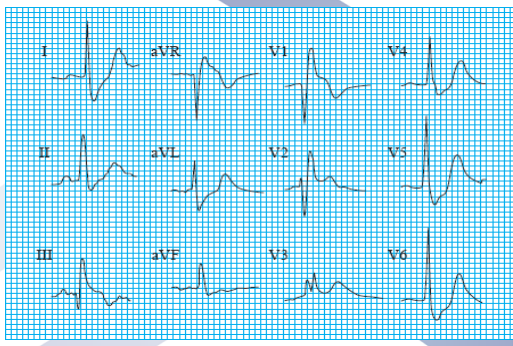
T wave inversion



S1 Q3 T3 Pattern



Rt. Bundle Branch Block

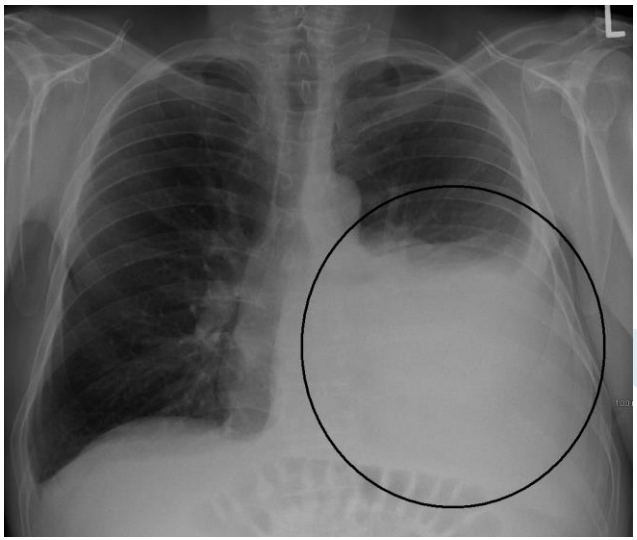


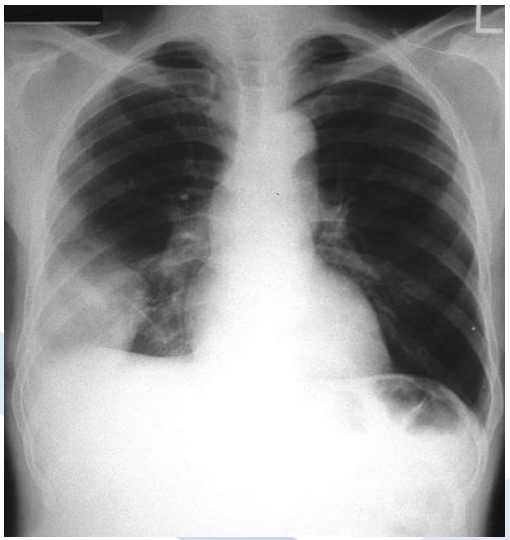
How To Diagnose

3. CXR—usually normal

A. The main usefu is in excluding other diagnoses e.g.(pneumonia)

B. Classic radiographic signs such as **Hampton's hump** or **Westermark's sign** are rarely present.





(Hampton's hump)
Chest radiograph showing pulmonary infarct in the right lower lobe. This patient had low-grade fever, hemoptysis, and pleuritic chest pain. The ventilation-perfusion scan was read as high probability for pulmonary embolism. A pleural-based density in the lower lobe with the convexity directed toward the hilum signifies pulmonary infarction.

How To Diagnose

4. Venous duplex ultrasound of the lower extremities

A. If there is a positive result, treat with IV anticoagulation (heparin); treatment of DVT is the same as for PE. Keep in mind that with this approach, a false positive ultrasound will result in anticoagulation of **some patients** who do not have DVT or PE. Also, a negative result is not helpful, as patient may still have a PE despite no DVT on ultrasound.

B. This test is very helpful when positive, but of little value when negative (negative results occur in 50% of patients with proven PE).

How To Diagnose

5. Helical (spiral) computed tomography scan of the chest with IV contrast— (CT-pulmonary angiography or CT-PA).

A. Has been found to have **good sensitivity** (>90%) and **specificity**.

B. Can **visualize very small clots** (as small as 2 mm); may miss clots in small sub-segmental vessels (far periphery)

C. It's the test of choice in many medical centers and has **replaced V/Q scan.**

D. In combination with clinical suspicion (Decision rule criteria), guides treatment (see the figures below & in the next slide)

E. Spiral CT scan **cannot** be performed in patients with **significant renal insufficiency** because of the IV contrast that is required.

F. Specificity is high (over 95%), but sensitivity is 85% (so it can miss up only to 15% of PEs).

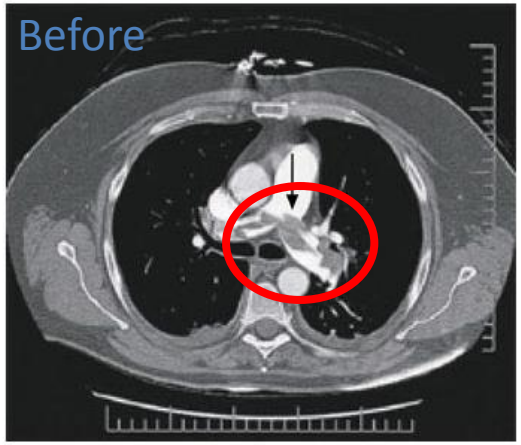
Note: Negative results should be interpreted with caution if patient has a high clinical probability of PE.

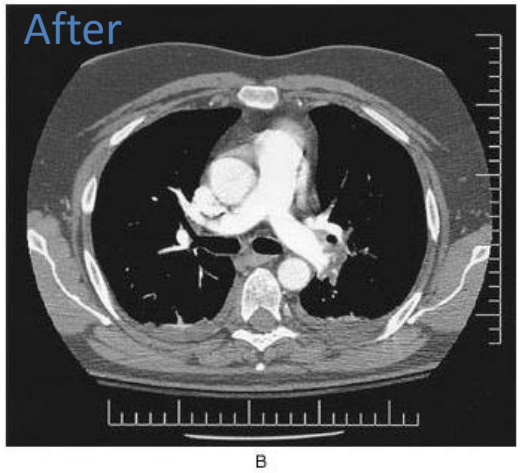
Dichotomized Clinical Decision Rule for Suspected Acute Pulmonary Embolism (Modified Wells Criteria)

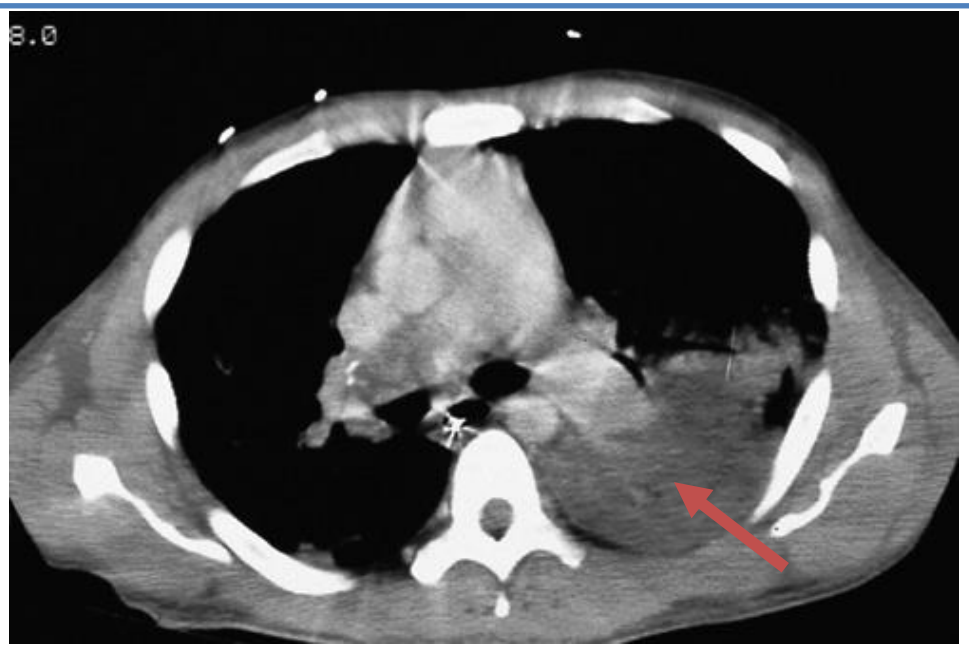
Factor	Points
Symptoms and signs of DVT	3.0
Alternative diagnosis less likely than PE	3.0
Heart rate >100 beats/min	1.5
Immobilization (>3 days) or surgery in previous 4 weeks	1.5
Previous DVT or PE	1.5
Hemoptysis	1.0
Malignancy (current therapy, or in previous 6 months, or palliative)	1.0

How To Diagnose

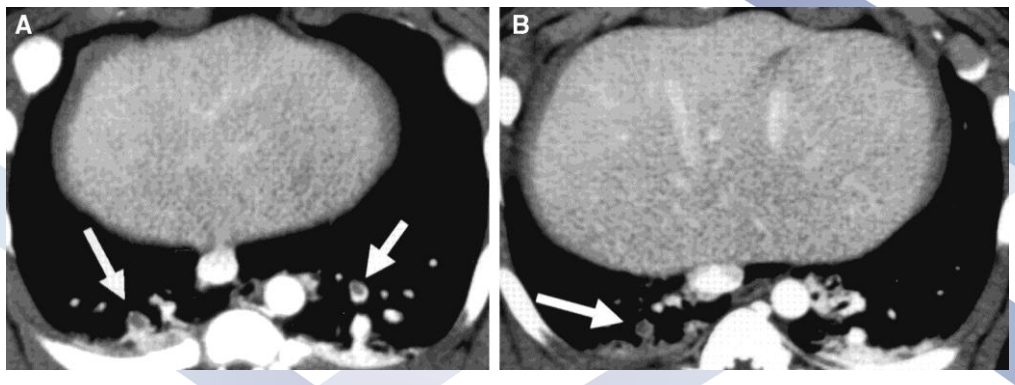
Spiral CT in patients with pulmonary embolism:







Computed tomographic scan demonstrating infarcted lung on left and large clot in the right main pulmonary artery



How To Diagnose

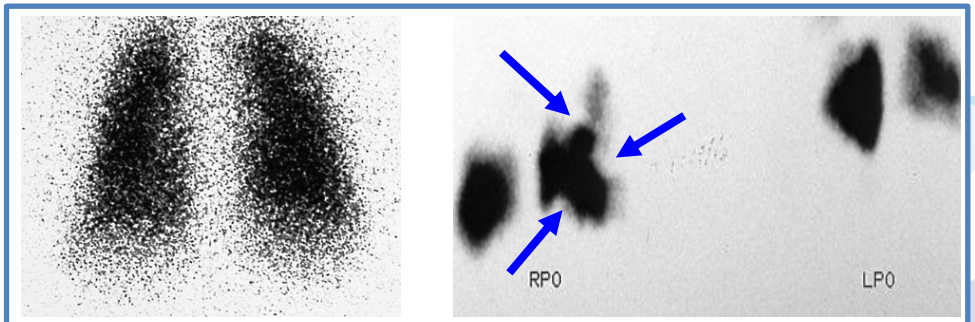
6. V/Q (Ventilation-perfusion lung) scan

A. V/Q Plays an important role in diagnosis when there is a contraindication to helical CT or in centers which are inexperienced in performing helical CT scans.

- May be particularly useful when the chest x-ray is clear (excluding other diagnoses) and when there is no underlying cardiopulmonary disease.

B. Interpretation of results: can be either normal, low-probability, intermediate-probability, or high-probability (treatment guidelines based on PIOPED study)

- **A normal V/Q scan virtually rules out PE**—no further testing is needed—but a scan is almost never "normal" in anyone.
- A **high** probability V/Q scan has a very high sensitivity for PE; treat with **heparin**.
- If there is **low** or **intermediate** probability, **clinical suspicion** determines the next step. If clinical suspicion is high, pulmonary angiography is indicated. Alternatively, perform a lower extremity duplex ultrasound to avoid pulmonary angiography.
  - If the duplex is positive, **treatment for DVT is the same as for PE**.
  - If the duplex is negative/uncertain, then **pulmonary angiography** is indicated to exclude PE.

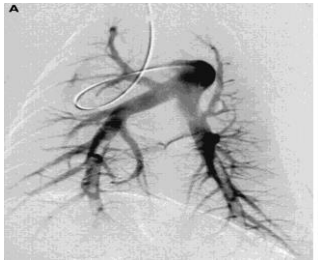


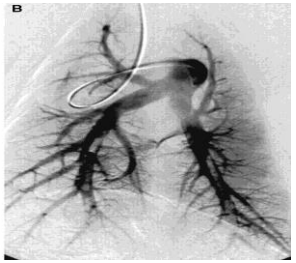
High-probability ventilation-perfusion scan

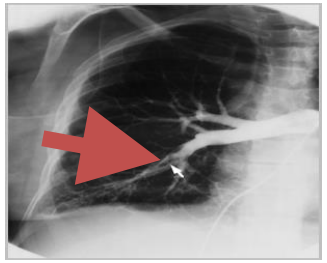
How To Diagnose

7. Pulmonary angiography is the gold standard.

- Definitively diagnoses or excludes PE, but is invasive. Contrast injected into pulmonary artery branch after percutaneous catheterization of femoral vein.
- Consider when **noninvasive testing is equivocal** and **risk of anticoagulation is high**, or if the patient is **hemodynamically unstable** and **embolectomy** may be required. Angiography is rarely performed because it carries a 0.5% mortality.





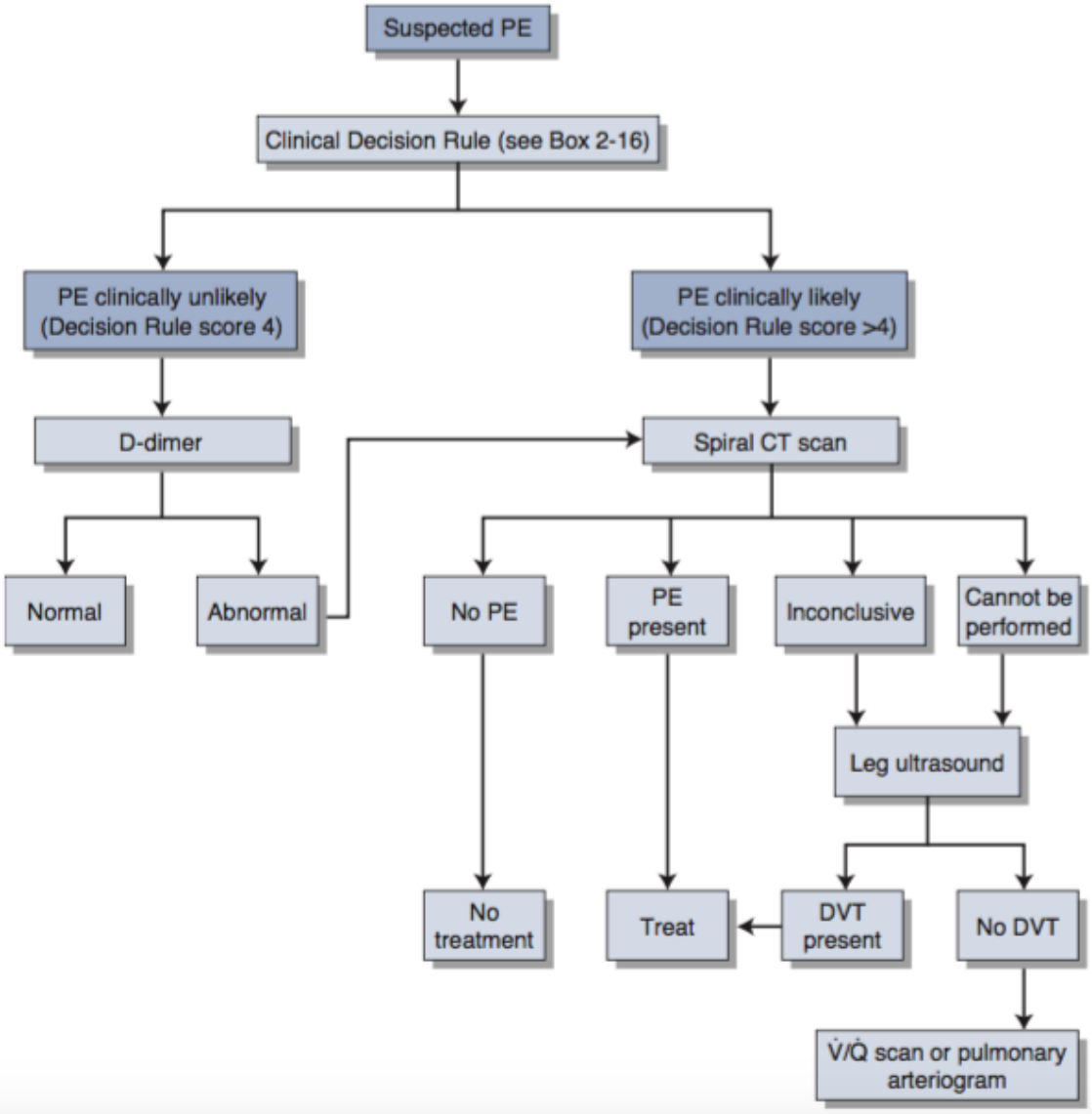


8. D-dimer assay:

- **D-dimer is a specific fibrin degradation product**; levels can be elevated in patients with PE and DVT.
- D-dimer assay is a fairly sensitive test (90% to 98%). If results are normal and clinical suspicion is low, PE is very unlikely.(so we can exclude PE. BUT for definitive is not specific).
- Specificity is low—d-dimer results may also be elevated in **MI**, **CHF**, **pneumonia**, and the **postoperative state**. **Any cause of clot or increased bleeding can elevate the d-dimer level**.

How To Diagnose

FIGURE 2-14 Workup in a patient with suspected pulmonary embolism.



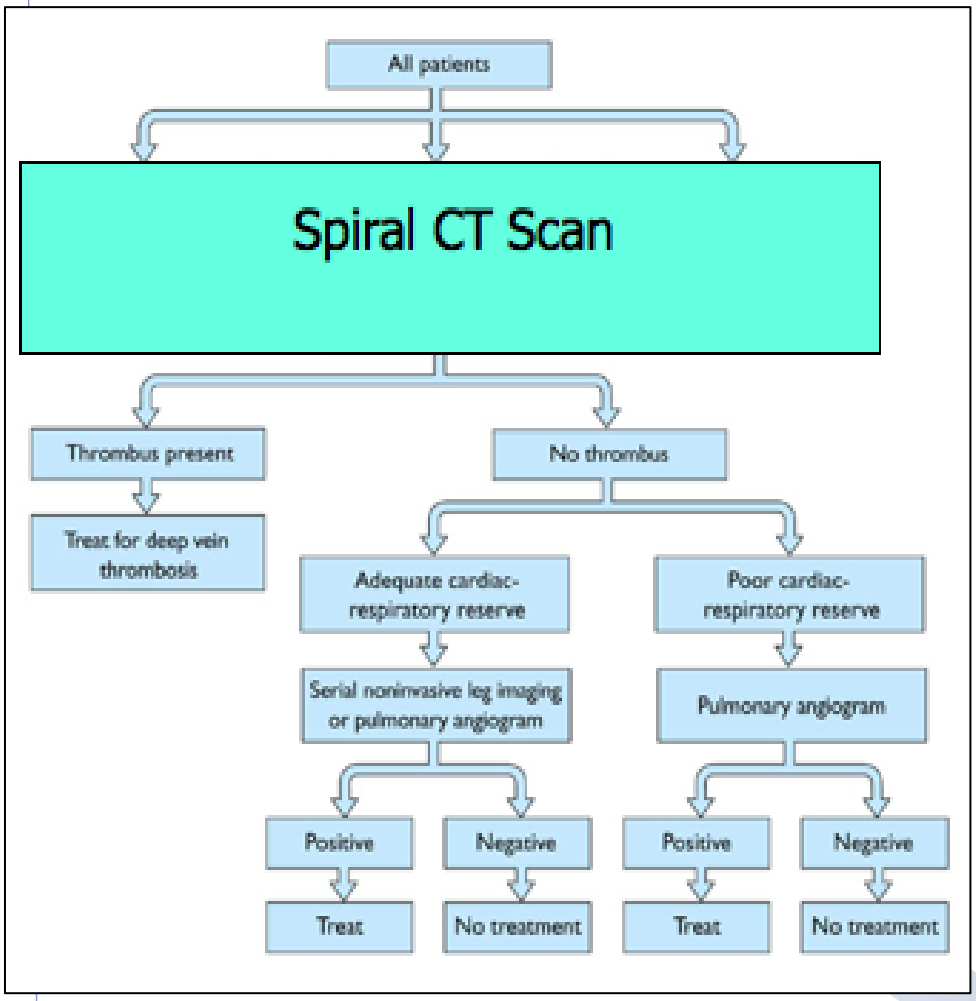
Workup of PE

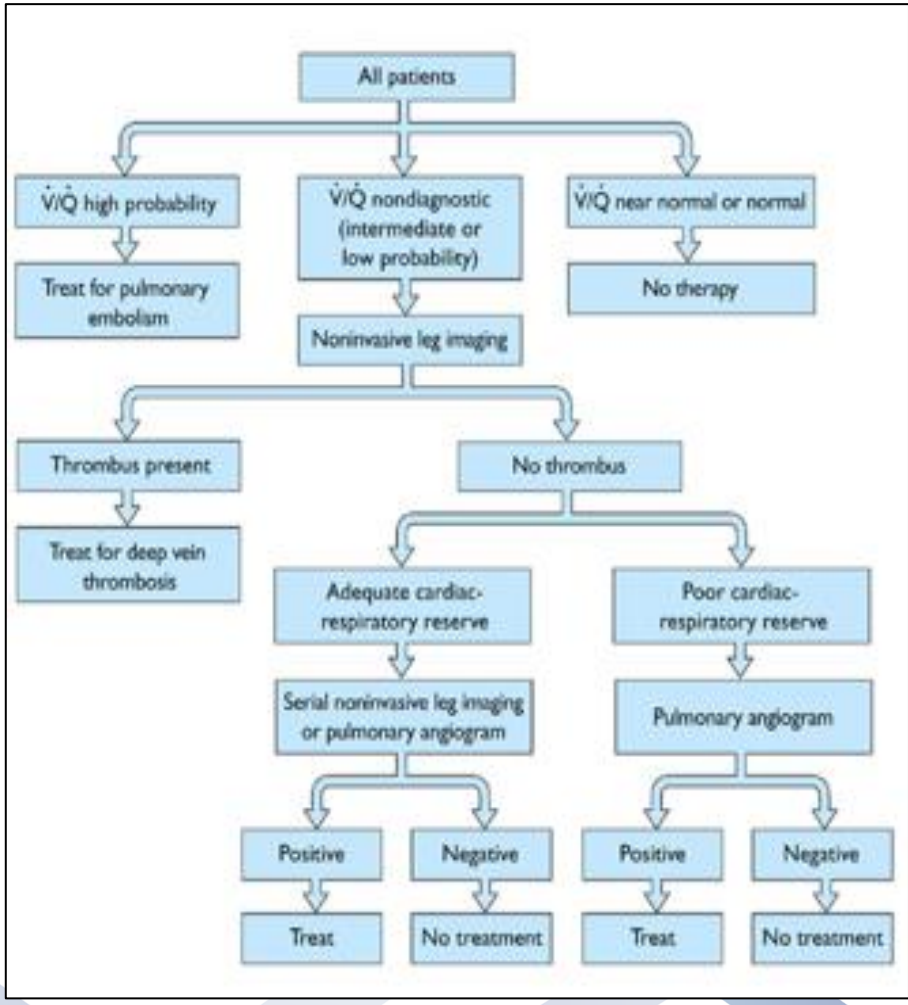
- It is often difficult to definitively diagnose or rule out PE. Thus following tests provide you to start **treating PE with anticoagulation**:
  - **Intraluminal filling defects** in central, segmental, or lobular pulmonary arteries on helical CT (or high probability with a scan) and clinical suspicion
  - **DVT diagnosed** with ultrasound and clinical suspicion
  - **Positive pulmonary angiogram** (definitely proves PE)

- The following can essentially **rule out PE**:
  - **Low-probability V/Q scan** (*or* normal helical scan) and low clinical suspicion
  - **Negative pulmonary angiogram** (definite)
  - **Negative D-dimer assay** plus low clinical suspicion

Treatment

Helpful figures to understand the treatment





Treatment

1. **Supplemental oxygen** (Unless they have significant chronic lung disease) to correct hypoxemia. Severe hypoxemia or respiratory failure requires **intubation** and **mechanical ventilation**.

2. **Acute anticoagulation therapy**

with either unfractionated or low-molecular-weight **heparin** to prevent another PE. **Anticoagulation** prevents further clot formation, but **does not** lyse existing emboli or diminish thrombus size.

A. Start immediately on a basis of clinical suspicion. Do not wait for studies to confirm PE if clinical suspicion is high.

B. Give one bolus, followed by a continuous infusion for 5 to 10 days. The goal is an aPTT (activated partial thromboplastin time) of 1.5 to 2.5 times control.

- Heparin acts by promoting the action of **antithrombin III**.
- **Contraindications** to heparin include **active bleeding**, **uncontrolled HTN**, **recent stroke**, and **heparin-induced thrombocytopenia (HIT).**
- **Low-molecular-weight heparin** has **better bioavailability** and **lower complication rates** that does unfractionated heparin. It has been shown to be at least as effective or more effective than unfractionated heparin.

Note: we use Heparin for pregnancy

Treatment

3. Oral warfarin for long-term treatment

A. Can start with heparin on day 1.

B. Therapeutic *(INR) is 2 to 3.

C. Continue for 3 to 6 months or more, depending on risk factors. Some patients at significant risk for recurrent PE (e.g., malignancy, hypercoagulable state) may be considered for lifelong anticoagulation.

*International Normalized ratio

Treatment

4. **Thrombolytic therapy**—e.g., streptokinase, tissue plasminogen activator (TPA)
   A. **Speeds up the lysis of clots**.
   B. There is no evidence that thrombolysis improves mortality rates in patients with PE. Therefore, its use is not well defined at this point.

Approved thrombolytics for pulmonary embolism:

- **Streptokinase.**
- **Urokinase.**
- **Recombinant tissue-plasminogen activator.**

To remember :

- **Anti-coagulations: for all types of PE**
- **Thrombolytics: only for massive PE:**
  - Hemodynamic instability
  - Hypoxia on 100% oxygen
  - Right ventricular dysfunction by echocardiography

Treatment

5. Thrombolytic therapy (cont.)

Contraindications:

Relative:

- Recent surgery within last 10 d
- Previous arterial punctures within 10 d
- Neurosurgery within 6 mo Bleeding disorder (thrombocytopenia, renal failure, liver failure)
- Ophthalmologic surgery within 6 wk
- Hypertension >200 mm Hg systolic or 110 mm Hg diastolic Placement of central venous catheter within 48 h
- Hypertensive retinopathy with hemorrhages or exudates
- Intracerebral aneurysm or malignancy
- Cardiopulmonary resuscitation within 2 wks
- Cerebrovascular disease
- Major internal bleeding within the last 6 month
- Pregnancy and the 1st 10 d postpartum
- Infective endocarditis
- Severe trauma within 2 month
- Pericarditis

Absolute:

- Active internal bleeding

Treatment

5. Inferior vena cava interruption (IVC filter placement)

A. Use has become more common but reduction in mortality has not been conclusively demonstrated.

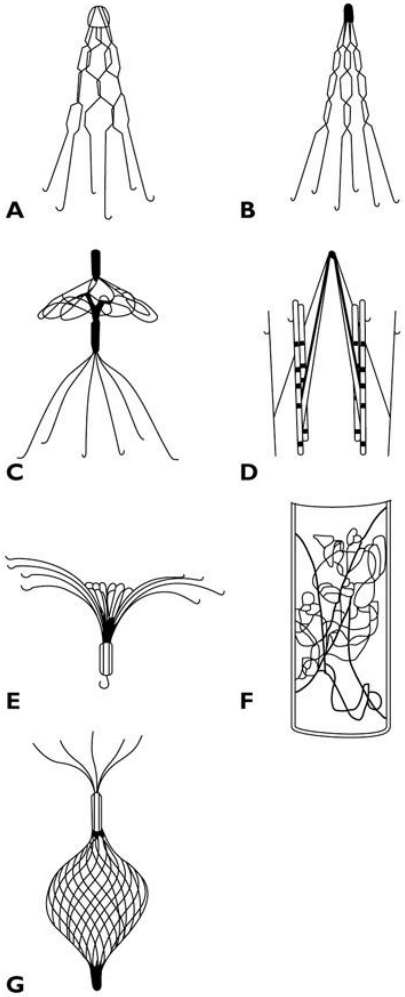
B. **Patients who have IVC filter placed are at higher risk of recurrent DVT (but lower risk of recurrent PE).**

C. **Complications** of IVC filter placement (rare): filter migration or misplacement, filter erosion and perforation of IVC wall, and IVC obstruction due to filter thrombosis.

D. **Indications** include:

- **<u>Contraindication to anticoagulation</u> in a patient with documented DVT or PE**
- **A <u>complication</u> of current anticoagulation**
- **Failure of adequate anticoagulation as reflected by <u>recurrent</u> DVT or PE**
- **A patient with low pulmonary reserve who is at high risk for death from PE**
- **Hemodynamic or respiratory compromise that is severe enough that another PE may be lethal**

Various inferior vena caval filters:



Treatment

6. Embolectomy:

- (ie, removal of the emboli) can be performed using catheters or surgically.
- It should be considered when a patient's presentation is severe enough to warrant thrombolysis (eg, persistent hypotension due to PE), but this approach either fails or is contraindicated.

Notes on treatment:

- Start therapeutic heparin as initial treatment. also start warfarin at same time. Goal is therapeutic INR of 2 to 3.
- Why PE and DVT are problematimatic for physicians?
  - Clinical findings are sometimes subtle in both.
  - Noninvasive imaging tests do not always detect either condition.
  - Anticoagulation carries significant risk.
- INR is a way of reporting the PT in a standardized fashion.
- Warfarin increases INR values.
- “Therapeutic” INR is usually between 2 and 3. Notable exceptions are prosthetic mechanical heart valves, prophylaxis of recurrent MI, and treatment of antiphospholipid antibody syndrome, for which 2.5 to 3.5 is recommended.
- If anticoagulation is contra- indicated in a patient with PE, a vena cava filter is indicated.

Course & Prognosis

A. Most often, PE is **clinically silent**. Recurrences are **common**, which can lead to development of **chronic pulmonary HTN** and **chronic cor pulmonale.**

B. When PE is undiagnosed, mortality approaches 30%. **A significant number of cases are undiagnosed** (as many as 50%).

C. When PE is diagnosed, mortality is 10% in the first 60 minutes. Of those who survive the initial event, approximately 30% of patients will die of a recurrent PE if left untreated. **Most deaths are due to recurrent PE within the first few hours of the initial PE**. Treatment with anticoagulants decreases the mortality to 2% to 8%.

Key points & Conclusion

1. **Most pulmonary emboli arise from thrombosis in the deep veins of the legs**, which is common in the immobilized patients and patients in the medical, surgical and obstetrics wards.
2. Assessment of patients with suspected pulmonary embolism involves proper assessment of suggestive clinical symptoms and risk factors and exclusion of alternative diagnoses.
3. **Spiral CT scan** of the chest is currently used as the main imaging modality for the diagnosis of PE.
4. **Heparin** is used to achieve rapid anti-coagulation followed by **warfarin**.
5. **Thrombolytic therapy** is reserved for patients with massive PE resulting in **circulatory compromise.**

Conclusion:

- PE is common and under-recognized serious medical problem
- Early diagnosis and treatment is essential for good outcome
- High index of suspicion is needed in high risk patients

Complications

Complications in patients with PE who survive the initial event include:

- Recurrent PE
- Pulmonary HTN (up to two-thirds of patients)

Complications of pulmonary embolism include the following:

- Sudden cardiac death
- Obstructive shock
- Pulseless electrical activity
- Atrial or ventricular arrhythmias
- Secondary pulmonary arterial hypertension
- Cor pulmonale
- Severe hypoxemia
- Right-to-left intracardiac shunt
- Lung infarction
- Pleural effusion
- Paradoxical embolism
- Heparin-induced thrombocytopenia
- Thrombophlebitis

MCQs

1) What is the commonest place and vein of DVT in pulmonary embolism ?

A- Lower extremities-saphenous vein B- Lower extremities-iliofemoral vein

C- IVC D- Upper extremities-Cephalic vein

2) Patient presented with symptoms highly suggestive of pulmonary embolism, what is the only reason we could give thrombolytic to this patient ?

A- Hypercoaguble state B- Normal BP

C- Shock (Hypotension) D- severe chest pain

3) Indication in patient with PE if anticoagulation is contraindicated ?

A- Thrombolytics B- IVC filter

4) Best modality to confirm PE in pregnant women ?

A- Spiral CT B- D-Dimer

C- Pulmonary Angiography D- V/Q Scan

5) 65-year-old woman who recently underwent hip replacement comes to the emergency department with the acute onset of shortness of breath and tachycardia. The chest x-ray is normal, with hypoxia on ABG, an increased A-a gradient, and an EKG with sinus tachycardia. What is the most appropriate next step in management? *

A- Heparin B- Thrombolytics

C- Spiral CT D- IVC filter

Answers : 1-B 2-C 3-B 4-D 5-A

* When the history and initial labs are suggestive of PE, it is far more important to start therapy than to wait for the results of confirmatory testing

DONE BY

Faroq Abdulfattah	Raneem AlOtaibi
Faisal S. AlGhamdi	Ghaida Alawaji
Waleed AlRajban	
Ibrahim Al-Saleem	

Medicine is a science of uncertainty and an art of probability

MEDICINE 433