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Role of imaging in the diagnosis of pulmonary embolism

By

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Pulmonary embolism

- **pulmonary embolism** :-

An obstruction of the pulmonary artery or one of its branches by a thrombus or embolus.

- The majority of cases result from thrombotic occlusion

Other embolic sources include:

- Fat embolism
- Air embolism
- Amniotic fluid embolism

Risk factors for pulmonary embolism

- recent surgery
- pregnancy
- prolonged bed rest/immobility
- malignancy
- oral contraceptive use
- known or previous DVT
- presence of certain venous aneurysms

Risk factors for pulmonary embolism

- Pacemaker, implantable cardiac defibrillator leads, or central venous catheter.
- Advance age .
- Obesity
- Congestive heart failure
- hypercoagulable states including:
  - protein C deficiency
  - protein S deficiency
  - antithrombin III deficiency
  - lupus anticoagulant

Diagnosis of pulmonary embolism

The most common modalities used:-

- ECG
- Chest X Ray
- Echocardiography
- V/Q scan
- Pulmonary Angiography
- MRI
- Duplex of veins of lower limbs
- Spiral CT

Key ECG findings include:

- Sinus tachycardia
  the most common abnormality
- Complete or incomplete RBBB
- Right ventricular strain pattern
- Right axis deviation
- Dominant R wave in V1
- **$S_I Q_{III} T_{III}$ pattern**
  deep S wave in lead I, Q wave in III, inverted T wave in III.

Key ECG findings include

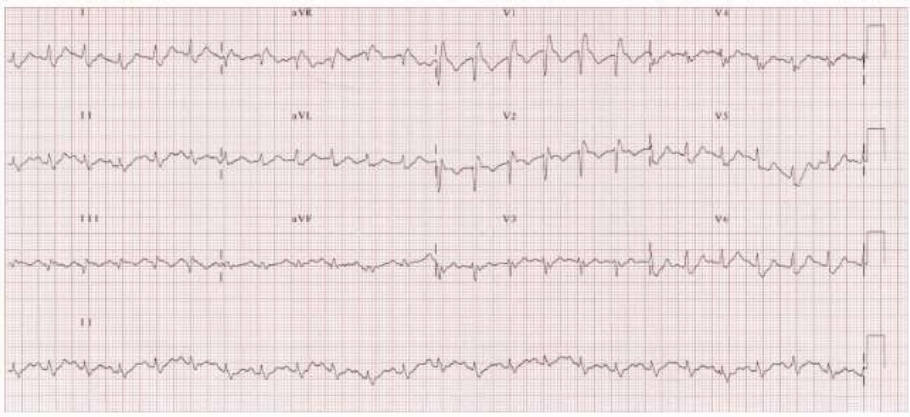
- Right atrial enlargement (P pulmonale)
- Clockwise rotation

  shift of the R/S transition point towards V6 with a

  persistent S wave in V6
- **Atrial tachyarrhythmias**

AF, flutter, atrial tachycardia. Seen in 8% of patients.

- **Non-specific ST segment and T wave changes**



- Sinus tachycardia
- RBBB
- T-wave inversions in the right precordial leads (V1-3) as well as lead III

ECG:-

- **The main value of ECG is exclusion of other diagnoses, such as MI or pericarditis rather than diagnosis of pulmonary embolism.**

Chest X ray

- A chest x-ray is neither sensitive nor specific for a pulmonary embolism. It is used to assess for differential diagnostic possibilities such as pneumonia and pneumothorax rather than for the direct diagnosis of PE.

Some described chest radiographic signs include:

- Fleischner sign: enlarged pulmonary artery (20%)
- Hampton hump: A peripheral wedge-shaped density above the diaphragm and implies lung infarction (20%)
- Westermark sign: regional oligaemia indicates massive central embolic occlusion with marked decrease in vascularity
- pleural effusion (35%)
- Elevated diaphragm

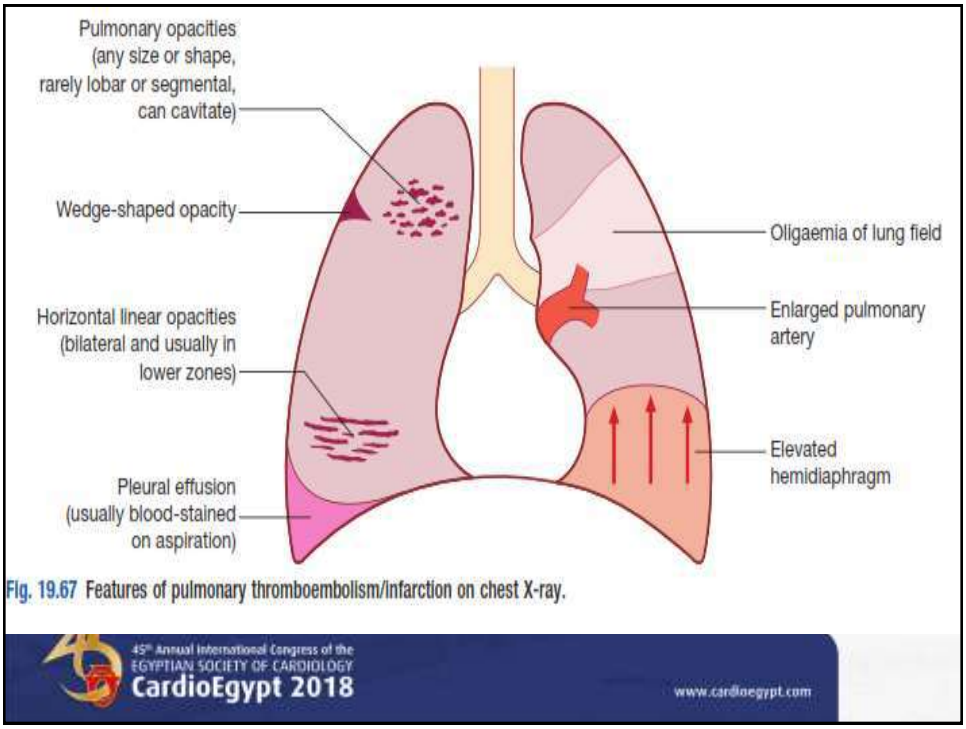
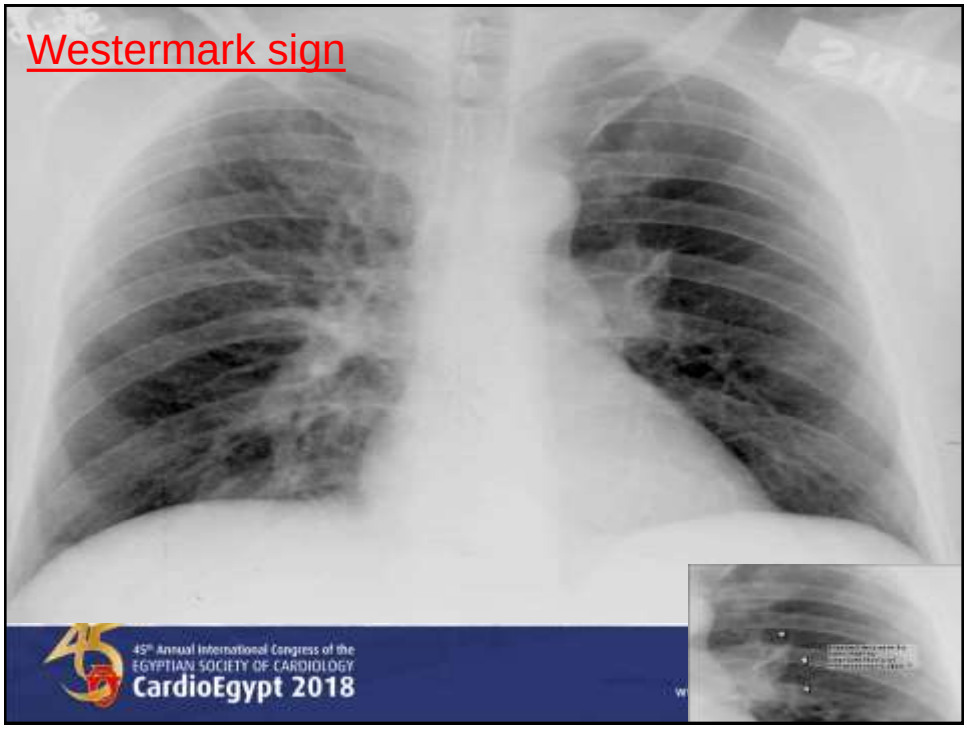


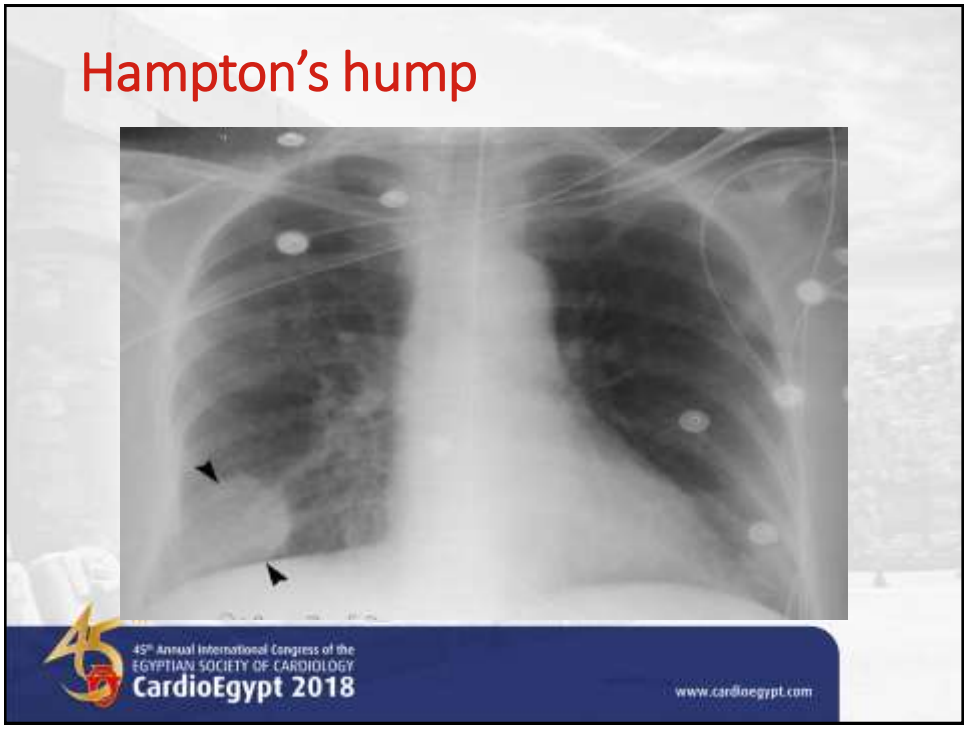
Fig. 19.67 Features of pulmonary thromboembolism/infarction on chest X-ray.

Chest x ray showing pulmonary infarction in right lower lobe

Westermark sign



Hampton's hump



Incidence of chest x ray finding in pulmonary embolism

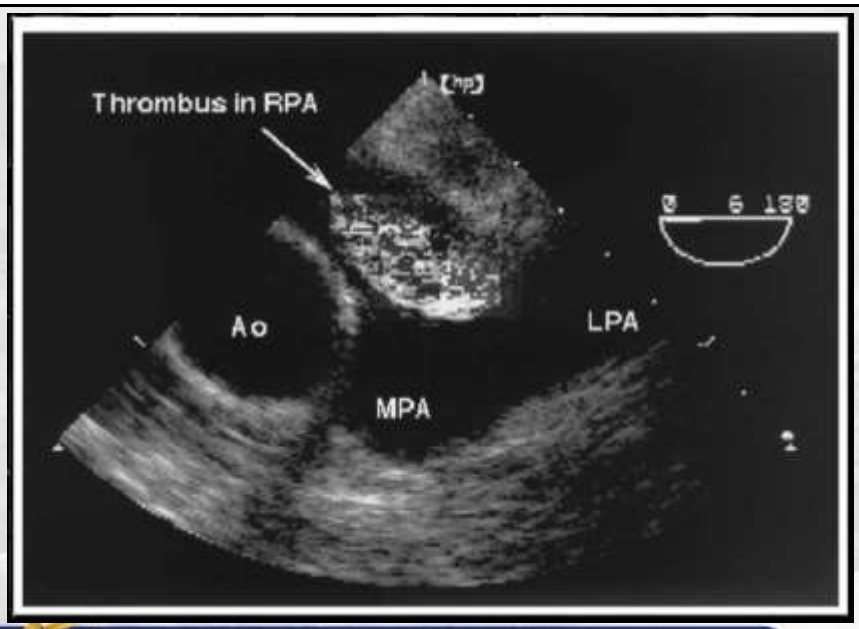
- **14% Normal**
- **68% Atelectasis**
- **48% Pleural Effusion**
- **35% Pleural based opacity**
- **24% Elevated diaphragm**
- **15% Prominent central pulmonary artery**
- **7% Westermark's sign**
- **7% Cardiomegaly**
- **5% Pulmonary edema**

Echocardiographic Signs of Pulmonary Embolism

- Right ventricular enlargement or hypokinesis, especially free wall hypokinesis, with sparing of the apex (the McConnell sign)
- Interventricular septal flattening and paradoxical motion toward the left ventricle, resulting in a D-shaped left ventricle in cross section
- Tricuspid regurgitation

Echocardiographic Signs of Pulmonary Embolism

- Pulmonary hypertension with a tricuspid regurgitant jet velocity >2.6 m/sec
- Dilated inferior vena cava
- Loss of respiratory-phasic collapse of the inferior vena cava with inspiration
- Direct visualization of thrombus (more likely with transesophageal echocardiography)



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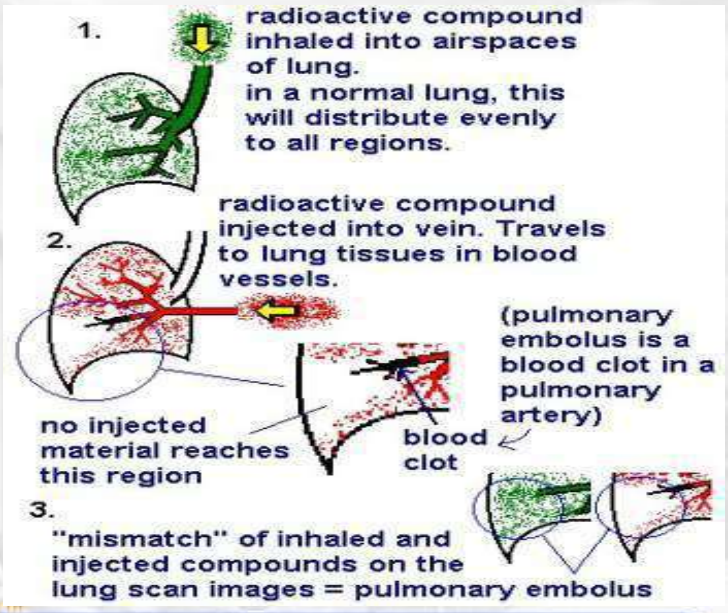
V/Q scan

- Test is used to identify areas of the lung not receiving air flow or blood flow.
- Ventilation without perfusion suggests the probability of a pulmonary embolus
- Two parts of the test:

1. Perfusion scan: Radioisotope IV injection.

Scans to detect anything in the pulmonary circulation

2. Ventilation scan: Inhale radioactive gas (xenon). This displays how the gas within the lungs



V/Q scan

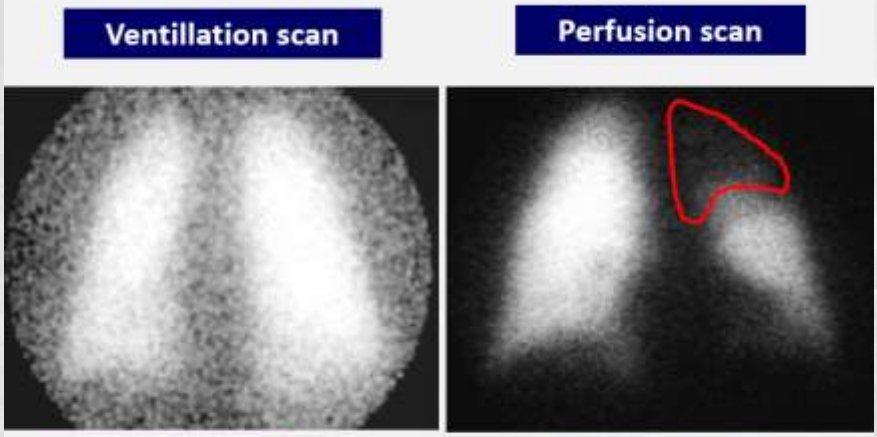
- There is still some indications to obtain a lung scan :-

(1) renal insufficiency,

(2) anaphylaxis to intravenous contrast agent that

cannot be suppressed with high-dose corticosteroids

(3) pregnancy (lower radiation exposure to the fetus).



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Diagnosis

Recommendations	Class	Level
CT angiography		
Normal CT angiography safely excludes PE in patients with low or intermediate clinical probability or PE-unlikely.	I	A
Normal CT angiography may safely exclude PE in patients with high clinical probability or PE-likely.	IIa	B
CT angiography showing a segmental or more proximal thrombus confirms PE.	I	B
Further testing to confirm PE may be considered in case of isolated sub-segmental clots.	IIb	C
Scintigraphy		
Normal perfusion lung scintigram excludes PE.	I	A
High probability V/Q scan confirms PE.	IIa	B
A non-diagnostic V/Q scan may exclude PE when combined with a negative proximal CUS in patients with low clinical probability or PE-unlikely.	IIa	B

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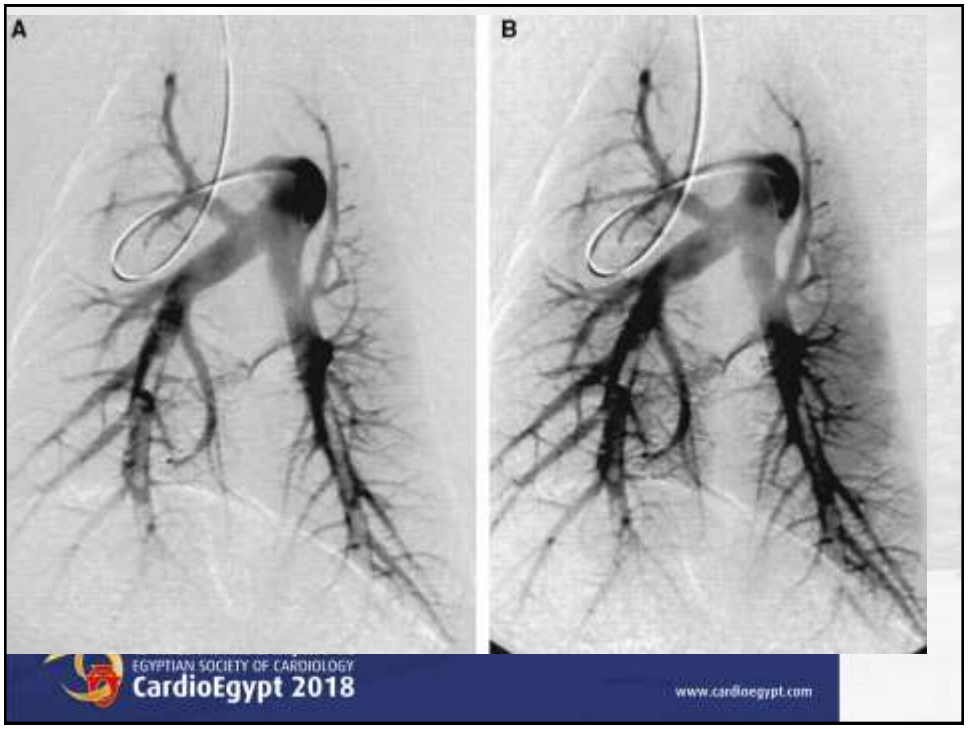
Pulmonary angiography

- This is an invasive procedure, a catheter is inserted via the femoral vein to pulmonary artery
- The dye is injected through the left or the right branch of the pulmonary artery.
- Normal Findings: Pulmonary vessels fill symmetrically and quickly with no defects or obstruction.

Pulmonary angiography

- Invasive pulmonary angiography was formerly the reference standard for diagnosis of PE, but it is now rarely performed.
- However, pulmonary angiography is required when interventions are planned, such as

1. suction catheter embolectomy,
2. mechanical clot fragmentation, or
3. catheter directed thrombolysis.


A
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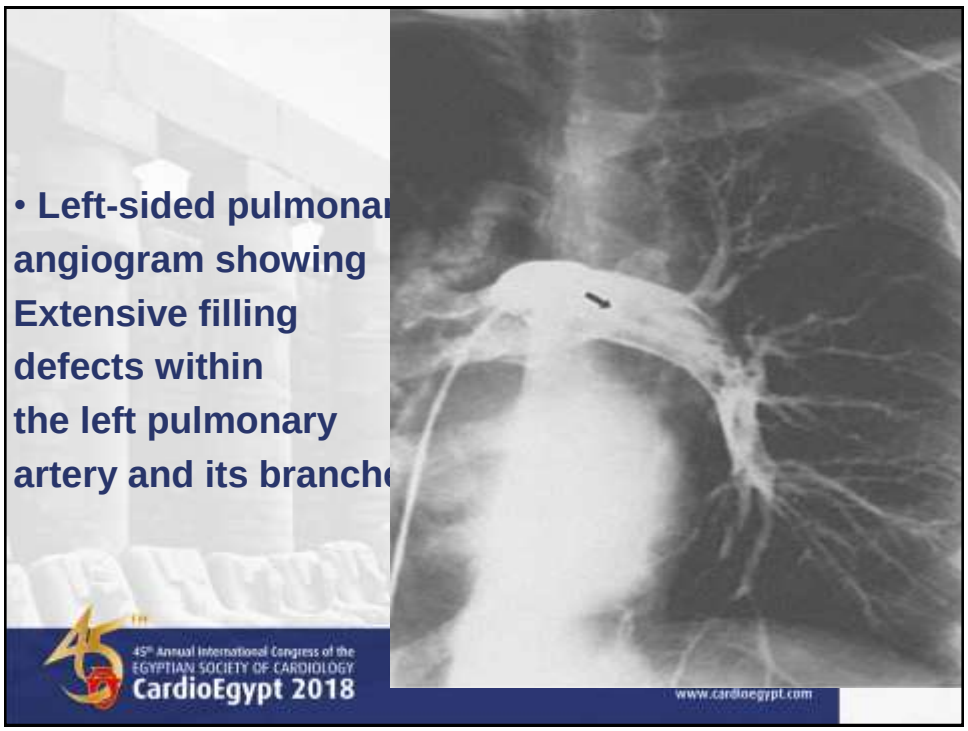
• Left-sided pulmonar
angiogram showing
Extensive filling
defects within
the left pulmonary
artery and its branch
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Diagnosis

Recommendations	Class	Level
Lower limb CUS		
Lower limb CUS in search of DVT may be considered in selected patients with suspected PE to obviate the need for further imaging test if the result is positive.	IIb	B
CUS showing a proximal DVT in a patient with clinical suspicion of PE confirms PE.	I	B
If CUS shows only a distal DVT, further testing should be considered to confirm PE.	IIa	B
Pulmonary angiography		
Pulmonary angiography may be considered in cases of discrepancy between clinical evaluation and results of non-invasive imaging tests.	IIb	C
MRA		
MRA should not be used to rule out PE.	III	A

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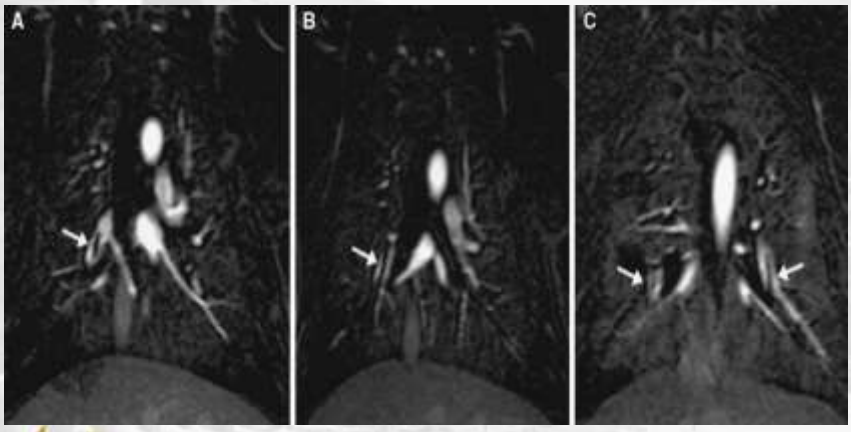
Magnetic Resonance Imaging

- Gadolinium-enhanced magnetic resonance angiography (MRA) is far less sensitive than CT for the detection of PE.
- However, unlike chest CT or catheter-based pulmonary angiography, MRA does not require ionizing radiation or injection of iodinated contrast agent.
- In addition, magnetic resonance pulmonary angiography can assess right ventricular size and function.

MRA



Diagnosis

Recommendations	Class	Level
Lower limb CUS		
Lower limb CUS in search of DVT may be considered in selected patients with suspected PE to obviate the need for further imaging test if the result is positive.	IIb	B
CUS showing a proximal DVT in a patient with clinical suspicion of PE confirms PE.	I	B
If CUS shows only a distal DVT, further testing should be considered to confirm PE.	IIa	B
Pulmonary angiography		
Pulmonary angiography may be considered in cases of discrepancy between clinical evaluation and results of non-invasive imaging tests.	IIb	C
MRA		
MRA should not be used to rule out PE.	III	A

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Duplex on veins of lower limbs

- A noninvasive test known as a duplex venous ultrasonography, uses high- frequency sound waves to check for blood clots in lower limb veins.
- Duplex scanning with compression will aid to detect any thrombus.
- Highly sensitive and specific for diagnosing DVT.
- Look for:- loss of flow signal, intravascular defects or non collapsing vessels in the venous

Diagnosis

Recommendations	Class	Level
Lower limb CUS		
Lower limb CUS in search of DVT may be considered in selected patients with suspected PE to obviate the need for further imaging test if the result is positive.	IIb	B
CUS showing a proximal DVT in a patient with clinical suspicion of PE confirms PE.	I	B
If CUS shows only a distal DVT, further testing should be considered to confirm PE.	IIa	B
Pulmonary angiography		
Pulmonary angiography may be considered in cases of discrepancy between clinical evaluation and results of non-invasive imaging tests.	IIb	C
MRA		
MRA should not be used to rule out PE.	III	A

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Spiral CT

- Spiral CT is similar to the regular CT, but the spiral CT actually spirals around the body giving a 3D image.
- Detect size, location, and extent of thrombus
- Detect other diagnoses that may coexist with PE : Pneumonia , Pericardial effusion or Pneumothorax.

Spiral CT

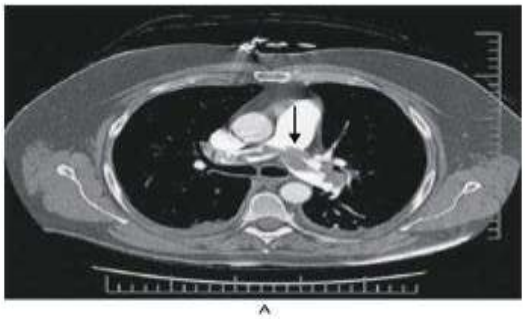
- Detect right ventricular enlargement
- Detect contour of the interventricular septum
- Detect incidental masses or nodules in the lung
- Risks: exposure to radiation, allergic reaction to

contrast medium

Spiral CT

Spiral CT

Spiral CT



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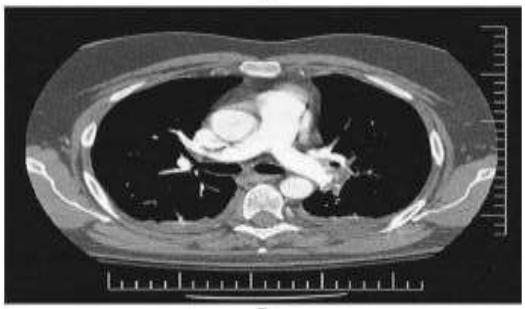

B

Diagnosis

Recommendations	Class	Level
CT angiography		
Normal CT angiography safely excludes PE in patients with low or intermediate clinical probability or PE-unlikely.	I	A
Normal CT angiography may safely exclude PE in patients with high clinical probability or PE-likely.	IIa	B
CT angiography showing a segmental or more proximal thrombus confirms PE.	I	B
Further testing to confirm PE may be considered in case of isolated sub-segmental clots.	IIb	C
Scintigraphy		
Normal perfusion lung scintigram excludes PE.	I	A
High probability V/Q scan confirms PE.	IIa	B
A non-diagnostic V/Q scan may exclude PE when combined with a negative proximal CUS in patients with low clinical probability or PE-unlikely.	IIa	B

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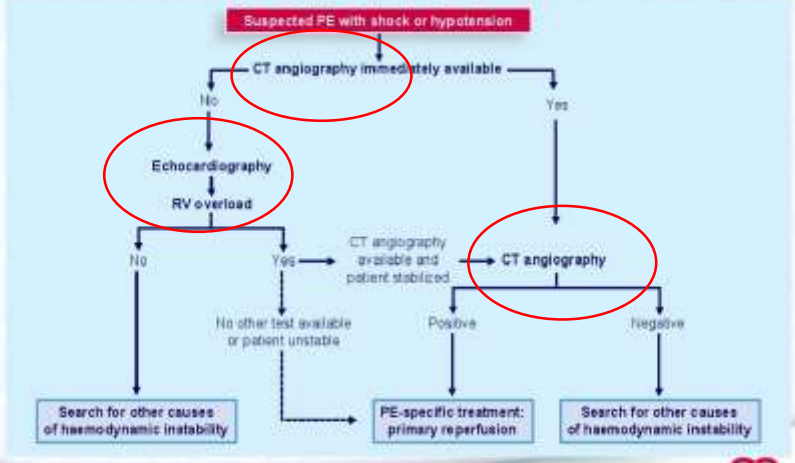
Diagnostic algorithm: high-risk PE



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Diagnosis

Recommendations	Class	Level
Suspected PE with shock or hypotension		
In suspected high-risk PE, as indicated by the presence of shock or hypotension, emergency CT angiography or bedside transthoracic echocardiography (depending on availability and clinical circumstances) is recommended for diagnostic purposes.	I	C
In patients with suspected high-risk PE and signs of RV dysfunction who are too unstable to undergo confirmatory CT angiography, bedside search for venous and/or pulmonary artery thrombi with CUS and/or TOE may be considered to further support the diagnosis of PE, if immediately available.	IIb	C
Pulmonary angiography may be considered in unstable patients admitted directly to the catheterization laboratory, in case coronary angiography has excluded an acute coronary syndrome and PE emerges as a probable diagnostic alternative.	IIb	C

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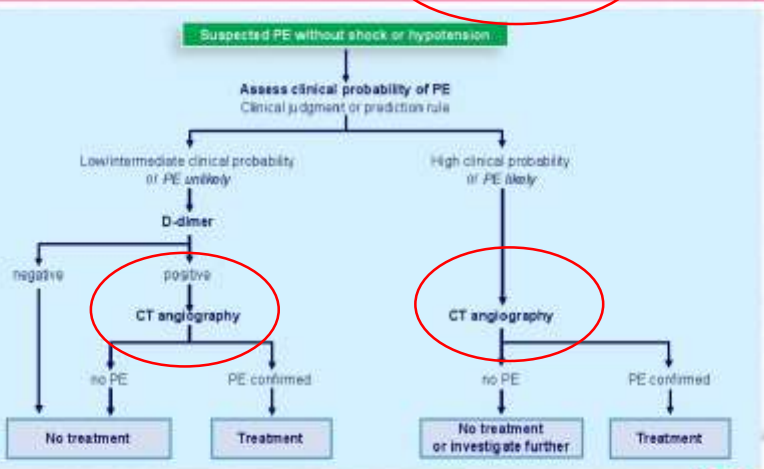
Diagnostic algorithm: not high-risk PE



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Diagnosis

Recommendations	Class	Level
Suspected PE without shock or hypotension		
The use of validated criteria for diagnosing PE is recommended.	I	B
Clinical evaluation		
It is recommended that the diagnostic strategy be based on clinical probability assessed either by clinical judgement or a validated prediction rule.	I	A
D-Dimer		
Plasma D-dimer measurement is recommended in outpatients / emergency department patients with low or intermediate clinical probability, or PE-unlikely, to reduce the need for unnecessary imaging and irradiation, preferably using a highly sensitive assay.	I	A
In low clinical probability or PE-unlikely patients, normal D-dimer level using either a highly or moderately sensitive assay excludes PE.	I	A
Further testing may be considered in intermediate probability patients with a negative moderately sensitive assay.	IIb	C
D-dimer measurement is not recommended in patients with high clinical probability, as a normal result does not safely exclude PE, even when using a highly sensitive assay.	III	B

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D-dimer

- D-dimer is commonly used as a screening test in patients with **a low and moderate probability clinical assessment.**
- normal D-dimer has almost **100% negative predictive value** (virtually excludes PE): no further testing is required.
- raised D-dimer is seen with PE but has many other causes and is, therefore, **non-specific**: it indicates the need for further testing if pulmonary embolism is suspected .

D-dimer

- On patients **with a high probability clinical assessment**, a D-dimer test is not helpful.
- because a negative D-dimer result does not exclude pulmonary embolism in more than 15%.
- Patients are treated with anticoagulants while awaiting the outcome of diagnostic tests .

Take home message :-

- 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
- In high risk patients and high clinical probability ,spiral CT is the first line if available
- D dimer is the first line in low and intermediate clinical probabiity