Diagnosis of Pulmonary Embolism

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Diagnosis of Pulmonary Embolism

Magnitude of problem

- **The clinical assessment alone is unreliable (nonspecific & inconsistent)**
- **The consequences of misdiagnosis are serious**
  - **Over Ð → risks of anticoagulants**
  - **Under Ð → high mortality**

Diagnosis of Pulmonary Embolism

Magnitude of problem

- **PE is present in only a third of patients in whom it is suspected**
- **So, objective testing for PE is crucial**
- **There are a plethora of tests**
- **No single test is ideal (100% sensitive & specific, no risks, low cost)**

Nonimaging Diagnostic Methods

All are nonspecific

- **Plasma D-dimer ELISA (VTE)**
- **Biomarkers of cardiac:**
  - **Injury → Troponins (I & T)**
  - **Stretch → Natriuretic peptide (NT-proBNP & BNP)**
- **Thrombophilia screen (VTE)**
- **Arterial blood gases**
- **ECG**

Plasma D-dimer ELISA

- VTE represents the spectrum of one disease
- Natural Break down of endogenous ineffective fibrinolysis
- Measured by ELISA & Latex (bedside)
- Highly sensitive test for acute VTE
- It is nonspecific being elevated in many other conditions

Plasma D-dimer ELISA

Causes of elevation

- **Postoperative state**
- **Myocardial infarction**
- **Pneumonia**
- **Cancer, DIC**
- **Sepsis, trauma, aging**
- **Pregnancy**
- **Other systemic illness**

Some are mimics & all are risk factors of VTE

Plasma D-dimer ELISA

Clinical significance

- **Normal D-dimer (<500 µg/L), has a high NPV (no PE, no DVT)**
- **It provides a useful screening test**
- **It is ideally suited for outpatients (ED)**
- **It is not useful for inpatients (surgery)**

Troponins & Natriuretic peptides

- They are released from myocardium in acute PE due to RV microinfarctions (ischemia) & stretch
- Their elevation is an adverse prognostic sign in PE (massive):
  - Increased mortality rate
  - Requirement for inotropic support
  - Requirement for mechanical ventilation

Thrombophilia Screen

- It is suspected in:
  - Patients <50 years with recurrent VTE
  - Patients with strong family history of VTE

Causes of Thrombophilia

Hereditary =Primary Hypercoagulable States

Common	Uncommon
■Factor V Leiden mutation ■Prothrombin gene mutation ■Anticardiolipin antibodies ■Hyperhomocysteinemia	■ATIII deficiency ■Protein C deficiency ■Protein S deficiency ■↑ factors VIII or XI

Arterial Blood Gases

Findings- all are nonspecific

TRIAD

- **Hypoxemia (V/Q mismatch, shunting within lung or heart "PFO")**
- **Hypocapnea due to hyperventilation**
- **Widened Alveolar-arterial oxygen gradient (A-a) > 20 mm Hg**

Arterial Blood Gases

- This triad is suggestive of acute PE
- Its absence does not exclude the Đ of acute PE
- So, it should not be used as a screening test for suspected PE

Electrocardiogram

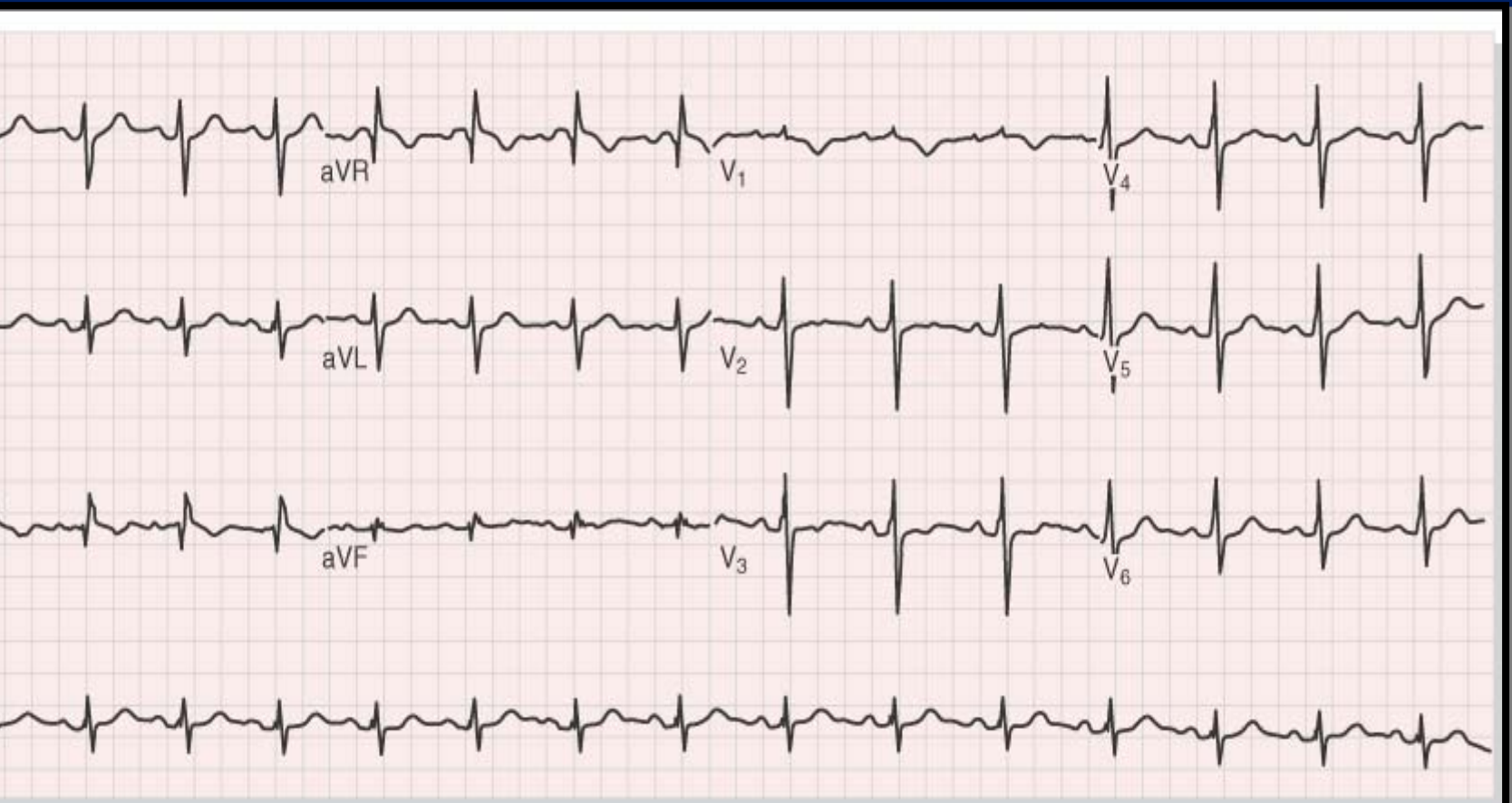
- Excludes other diagnoses as AMI or pericarditis
- Raises suspicion of PE
- Suggests the diagnosis of PE
- Nonspecific

Electrocardiogram

Findings– all are nonspecific

- It may be entirely normal
- Sinus tachycardia (most common)
- Minor ST & T wave abnormalities
- P pulmonale
- Right axis deviation
- Negative T waves in V1-V4
- New incomplete or complete RBBB
- Arrythmias
- New S1Q3T3 (most specific but rare, 10%)

ECG Findings of PE



maging Diagnostic Methods

- X-ray chest
- Echocardiography
- CT scanning
- MRI
- Lung scanning (V/Q)
- Pulmonary angiography
- Imaging studies for deep vein thrombosis

Chest Radiography

Findings- all are nonspecific

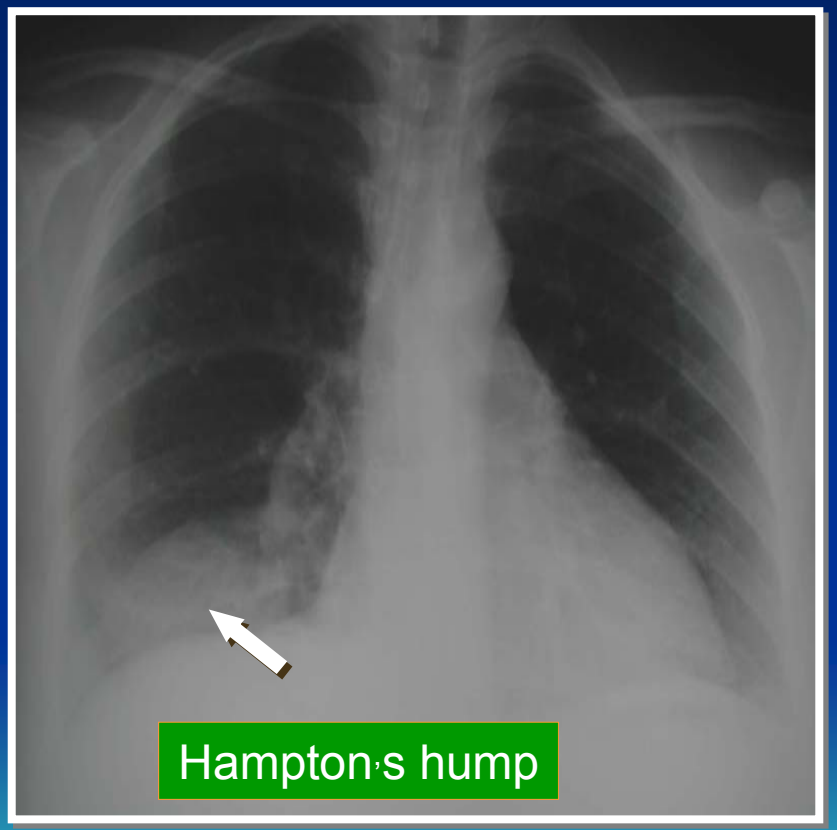
- **Abnormal in ¼ of patients**
- **May show alternative Ð as pneumonia pneumothorax, rib fracture**
- **Small pleural effusion**
- **Atelectasis**
- **Pulmonary infiltrates**
- **Raised diaphragm**

Chest Radiography

Rare but occasionally pathognomonic

- **Focal oligemia (Westermark's sign) = massive central embolic occlusion**
- **Peripheral wedge-shaped density above the diaphragm (Hampton's hump) = pulmonary infarction**
- **Enlarged right descending pulmonary artery = (Palla's sign)**

Chest Radiography



Echocardiography

Findings

- RV dilatation & hypertrophy
- RV free wall hypokinesis (sparing apex) = McConnell sign
- Abnormal septal motion (flattening & paradoxical)
- Tricuspid regurge & RA dilatation
- PA hypertension & dilatation

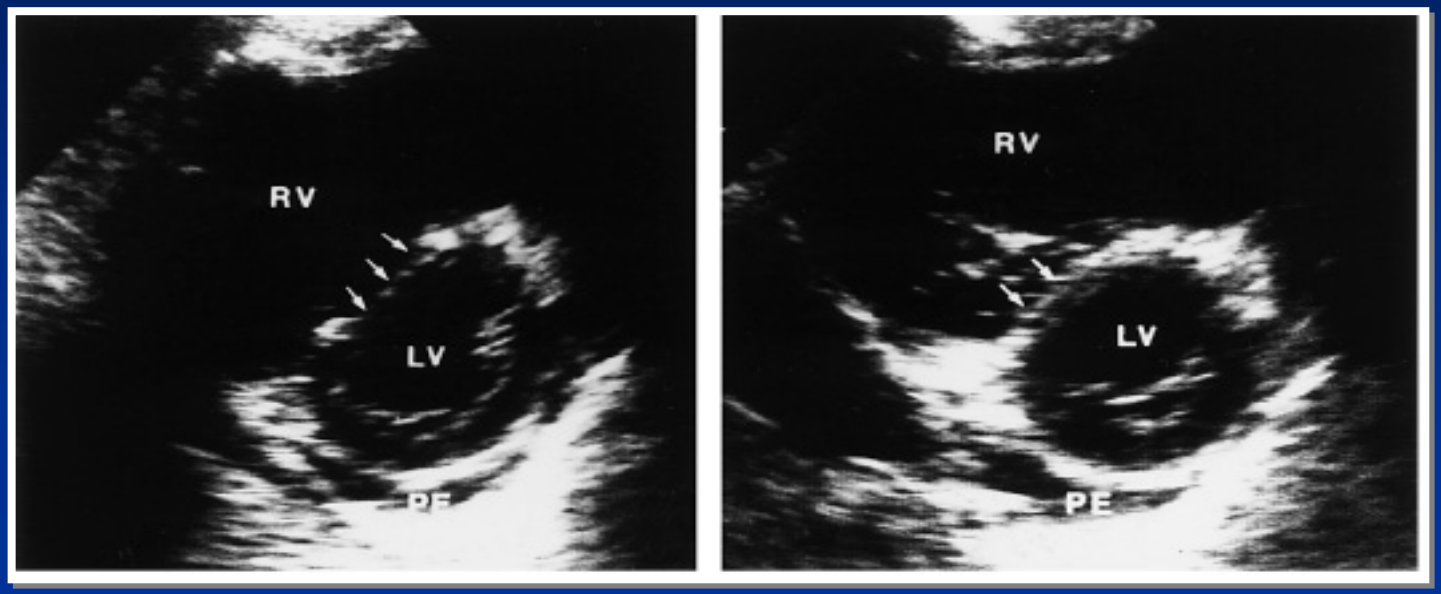
Echocardiography

Findings

- **Diastolic LV impairment**
- **Lack of inspiratory collapse of the IVC (due to ↑ CVP)**
- **Direct visualization of thrombus in PA (rare)**
- **Floating emboli (In-transit)**
- **PFO (worsening hypoxemia or stroke)**

Echocardiography

RV dilatation & abnormal septal motion

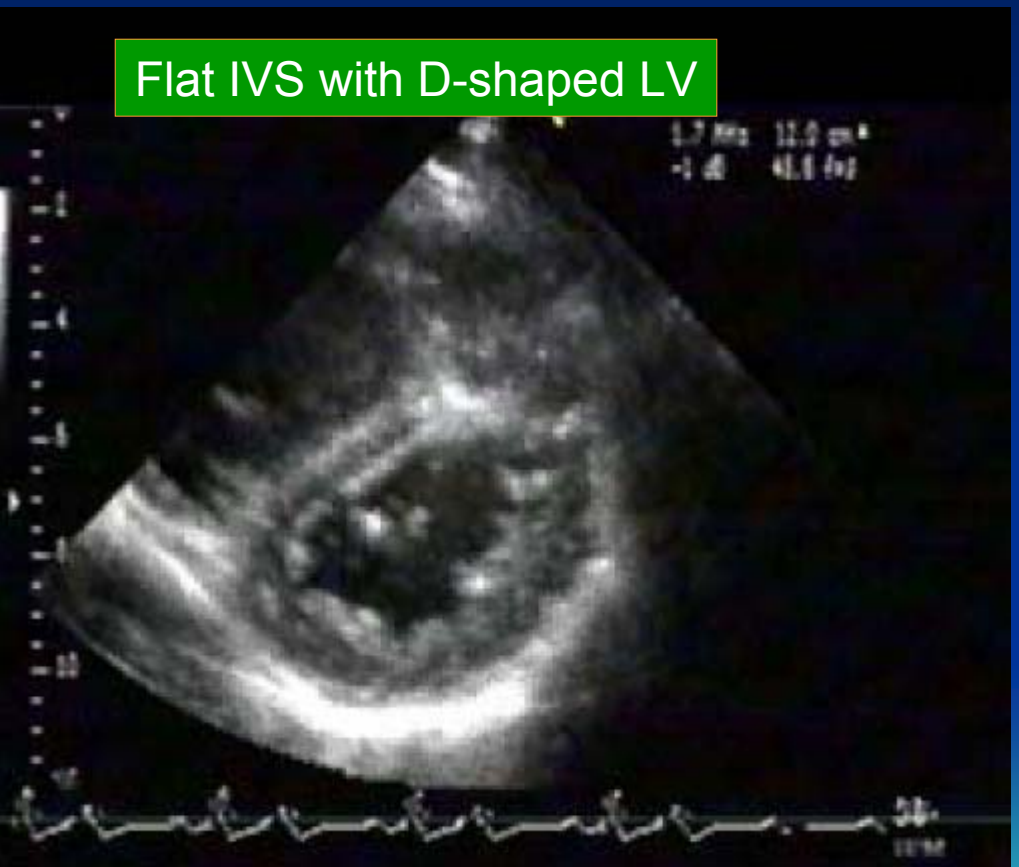


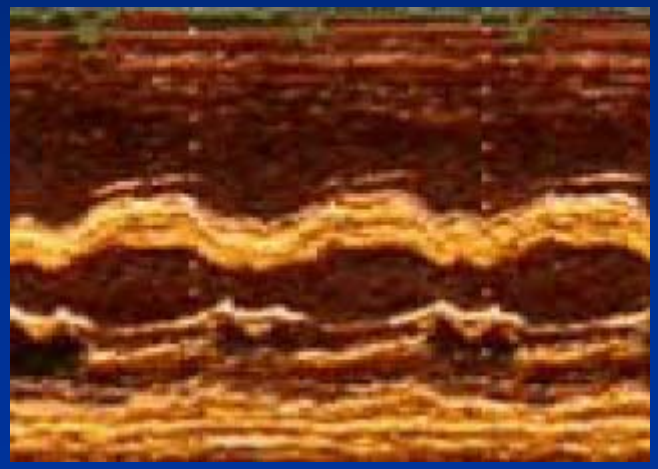
Diastolic frame **Systolic frame**

Echocardiography

Abnormal septal motion

Flat IVS with D-shaped LV

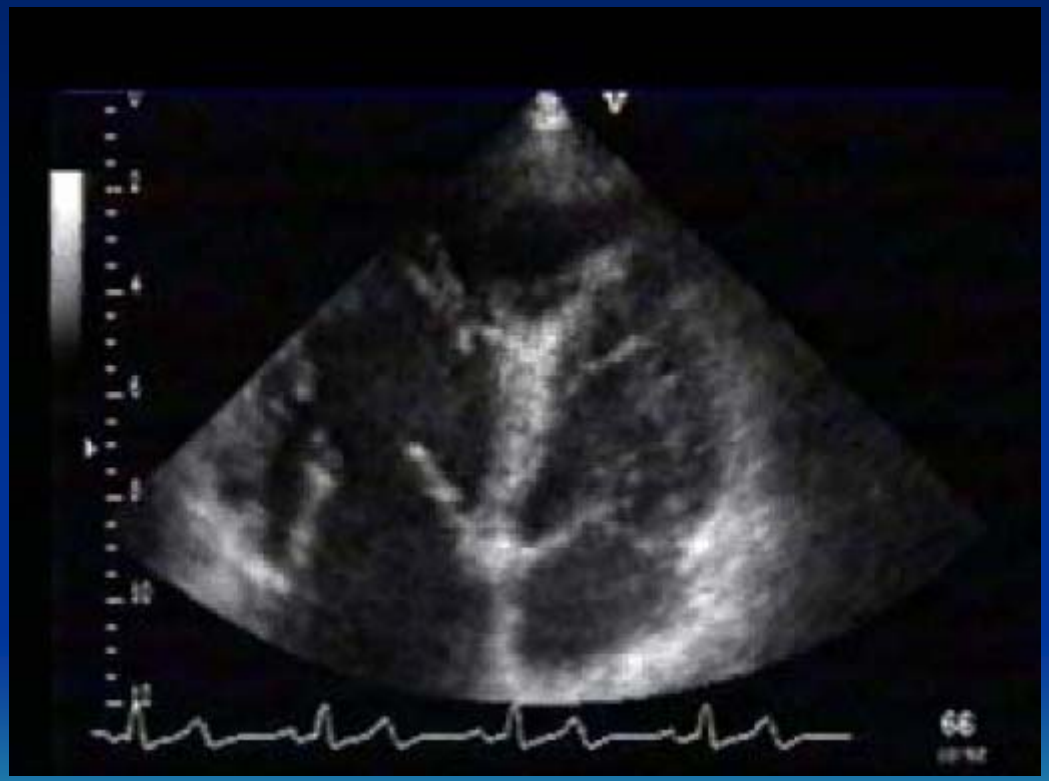




Paradoxical septal motion

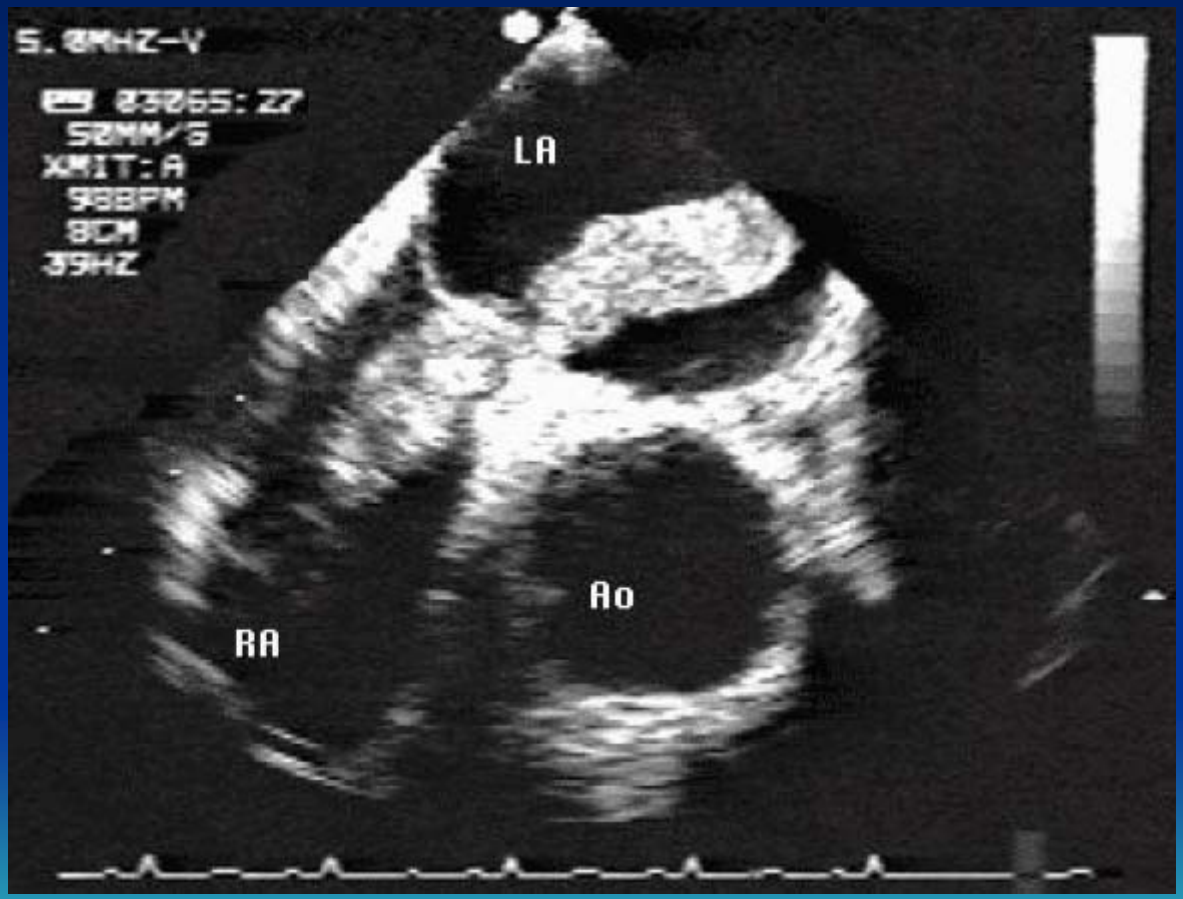
Echocardiography

RV hypertrophy & dilatation



Echocardiography

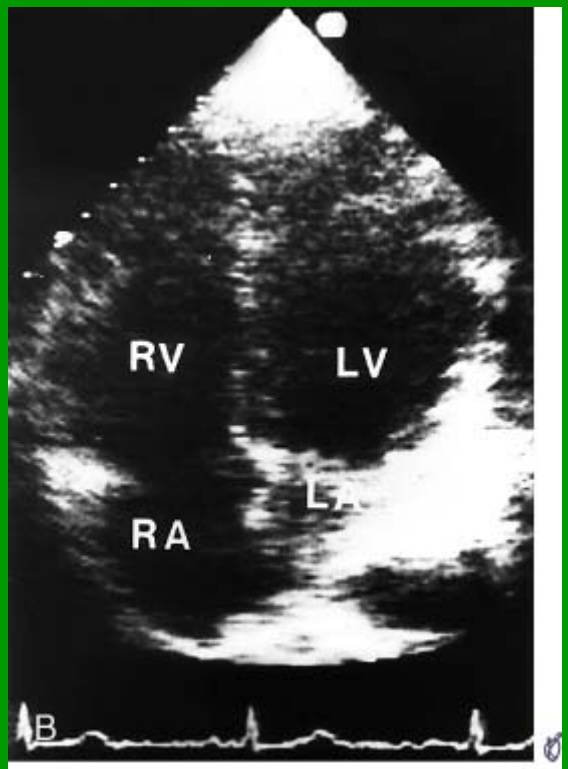
TEE-Emboli in transit-PFO



Echocardiography

Follow-up of treatment

Before treatment



3 hours after t-PA

Echocardiography

Clinical significance

- Should be the initial test in hemodynamically unstable patient
- Should not be used routinely for Ð of PE being nonspecific & normal in about 50% in patients with PE
- Used for risk stratification, prognostication, treatment guidance & follow-up (before & after thrombolysis) .

Echocardiography

Clinical significance

- Useful when DD includes; pericardial tamponade, RVI, aortic dissection & PE
- TEE is useful in detecting unexplained SCD & collapse due to acute PE
- TEE for visualization of centrally located clots
- IVUS for large emboli

Chest Computed Tomography (Helical=Spiral & Multidetector)

Advantages

- Replacing V/Q scan as the initial imaging test in suspected PE (multidetector-row)
- Replacing pulmonary angiography as the gold standard diagnostic tool in PE (multidetector-row)
- More accessible, more specific, relatively safe (noninonic, low osmolar contrast media) & relatively rapid
- Diagnostic even in the presence of an abnormal chest radiograph

Chest Computed Tomography

Advantages

- Provides alternative diagnosis in 30% of cases as pneumonia, aortic dissection and malignancy
- Give information about the size and function of RV
- Advancing technology
- May be extended to look for concomitant DVT

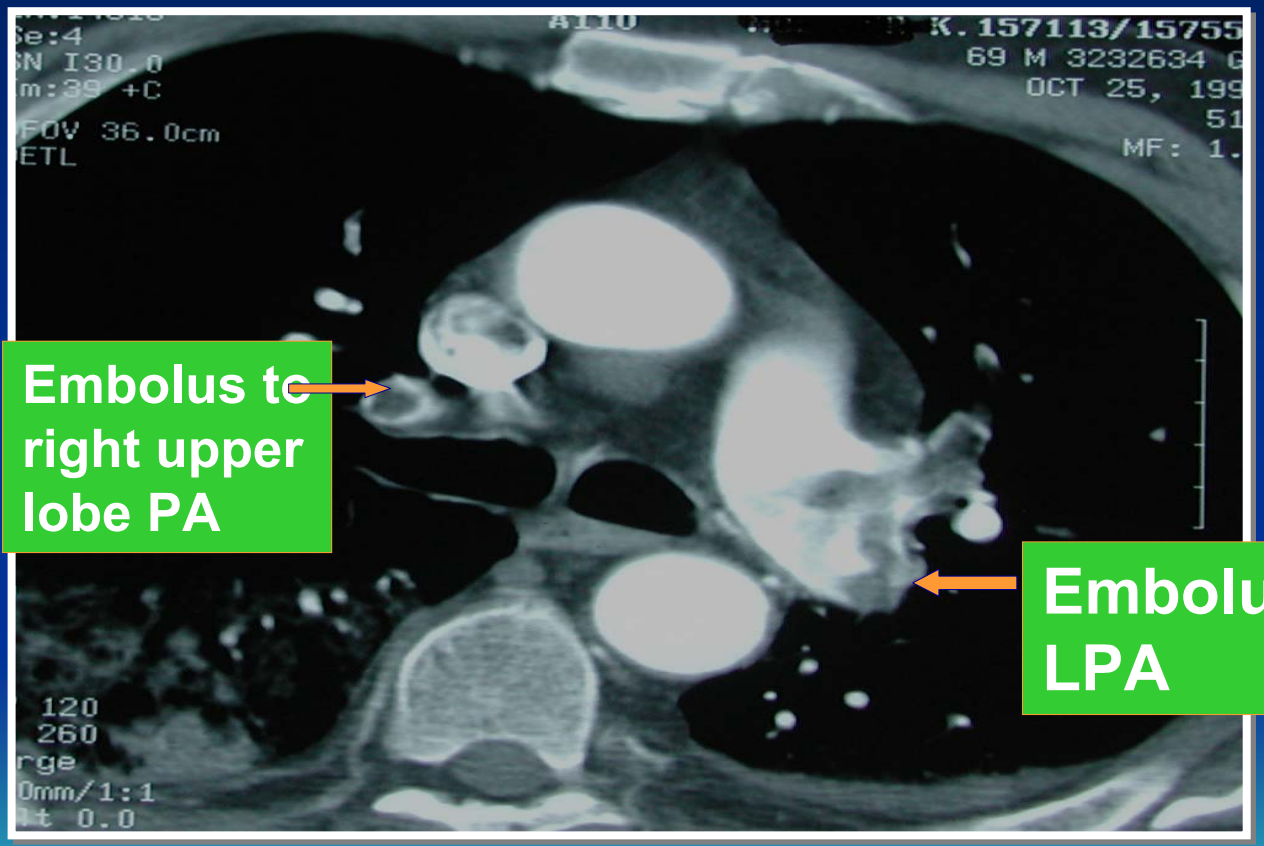
Chest Computed Tomography

Disadvantages

- Reader expertise required
- Expensive
- Not portable
- Poor visualization of certain regions as subsegmental (distal) emboli (first & second-generation machines)
- Requires a high dose of injected contrast

Chest Computed Tomography

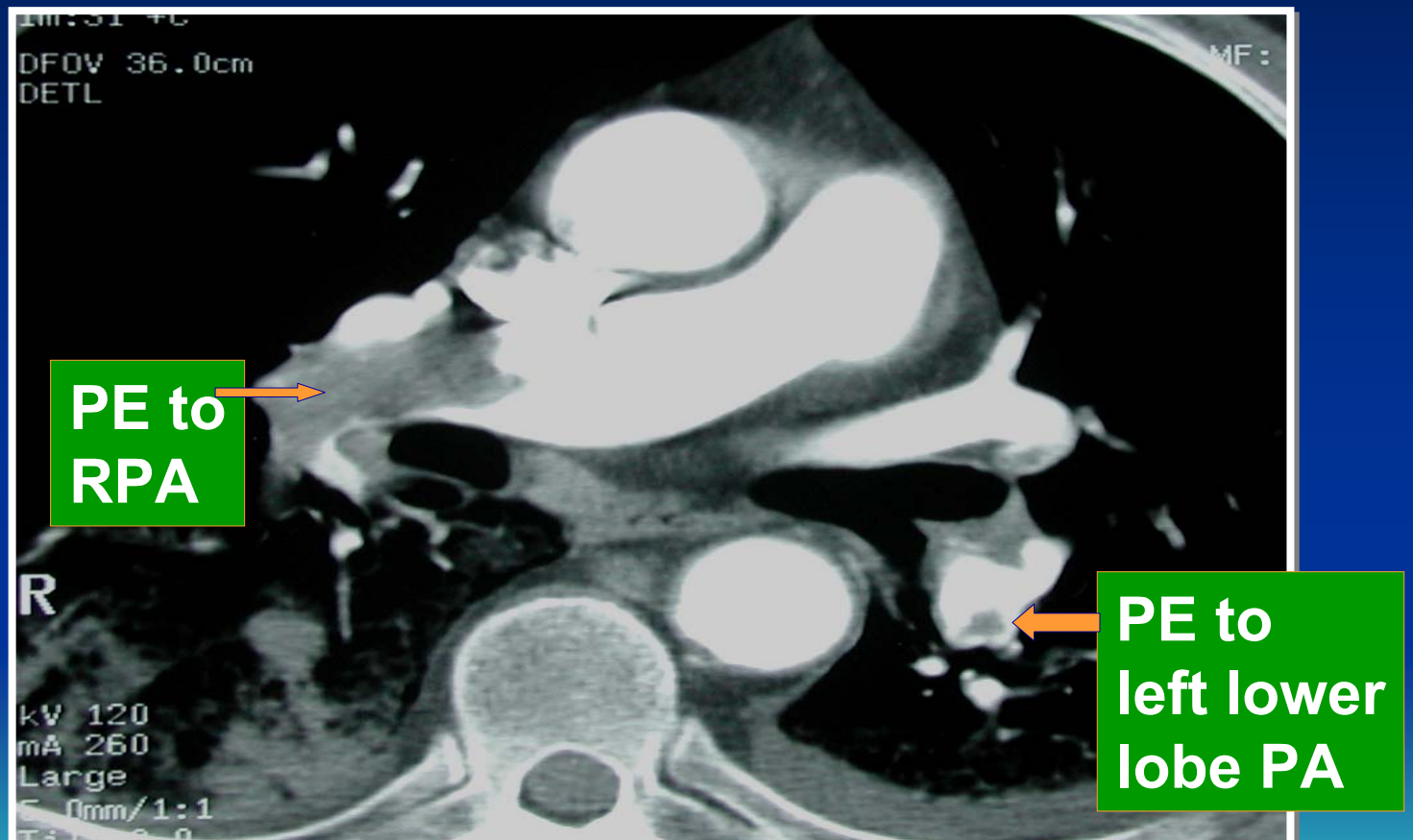
Intaluminal filling defect



Chest Computed Tomography

Saddle shaped embolus

Chest Computed Tomography



Ventilation-Perfusion (V/Q) Lung Scanning (almost outdated)

Technique

Perfusion scan

- Radioactive technetium 99m
- Injected IV

Ventilation scan

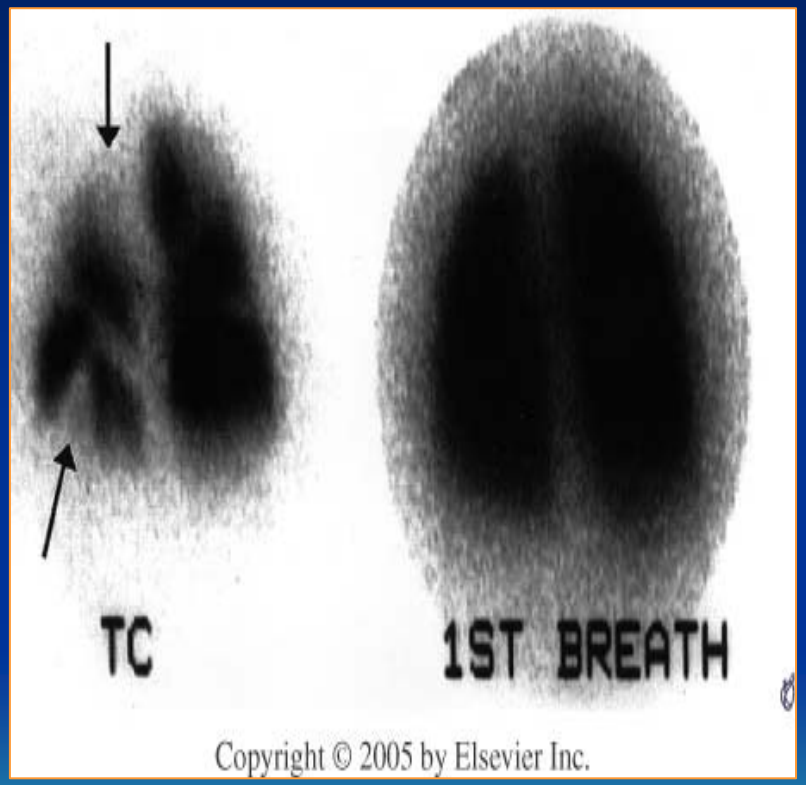
- Radioactive xenon gas
- Inhaled

6-8 standard views are obtained with gamma camera

Ventilation-Perfusion Lung Scanning

Ventilation-perfusion (V/Q) mismatch

Normal ventilation + Abnormal perfusion defects = high probability for PE



Ventilation-Perfusion Lung Scanning

Ventilation-perfusion mismatch

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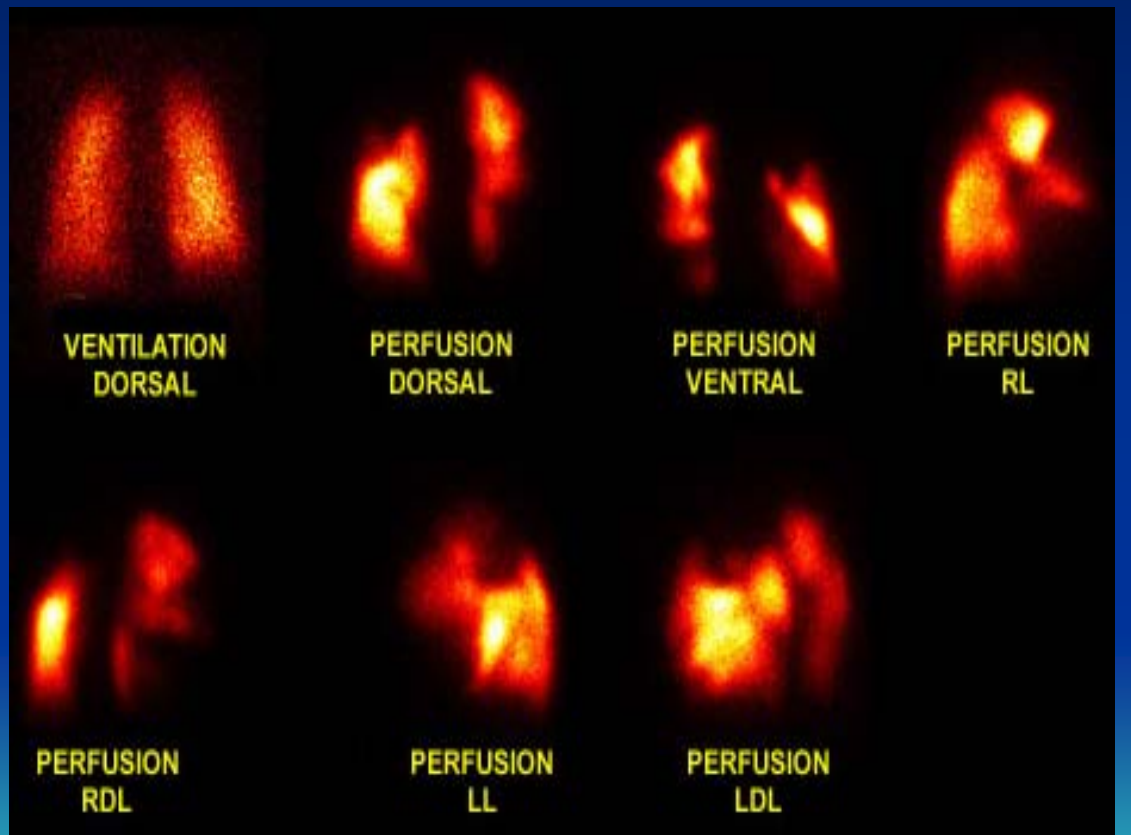
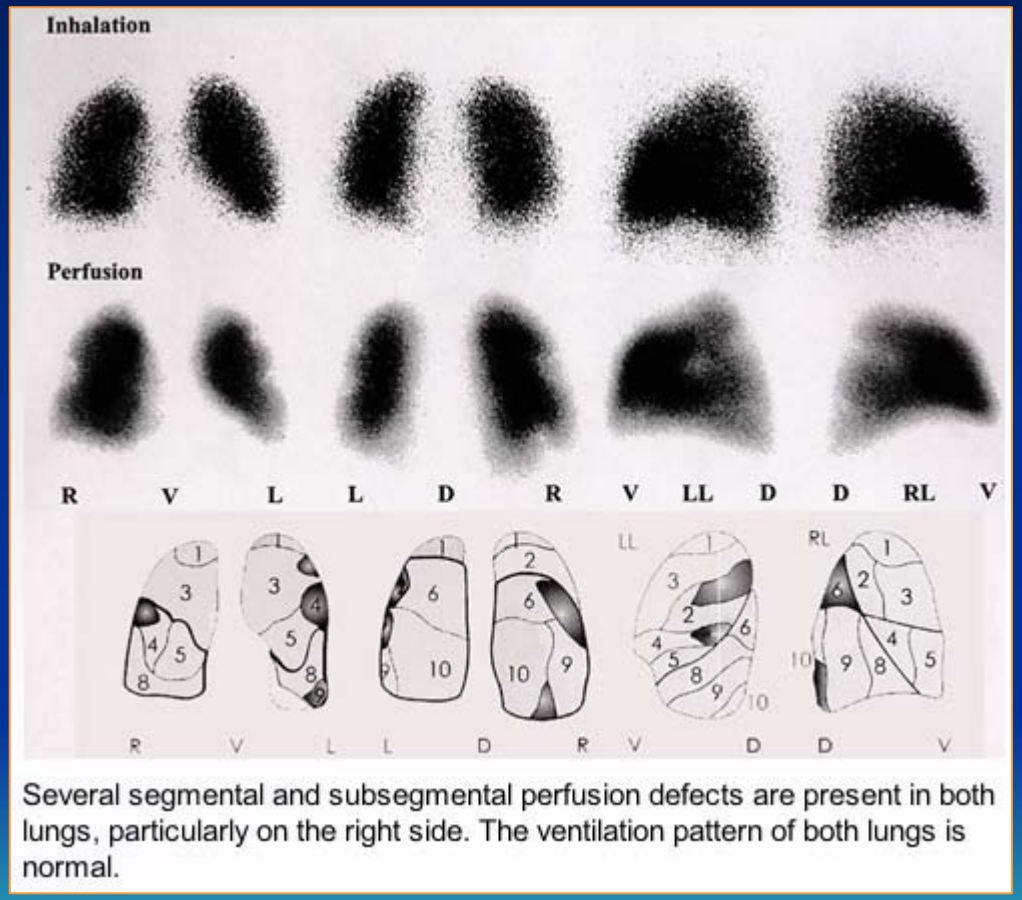


Ventilation-Perfusion Lung Scanning

Ventilation-perfusion mismatch



Several segmental and subsegmental perfusion defects are present in both lungs, particularly on the right side. The ventilation pattern of both lungs is normal.

Ventilation-Perfusion Lung Scanning

Clinical value

- **Rarely done nowadays**
- **Usually reserved for patients with renal impairment, contrast allergy or pregnancy**
- **Good in the presence of a normal chest radiograph**
- **Not helpful in abnormal CXR, cardiac & pulmonary diseases**

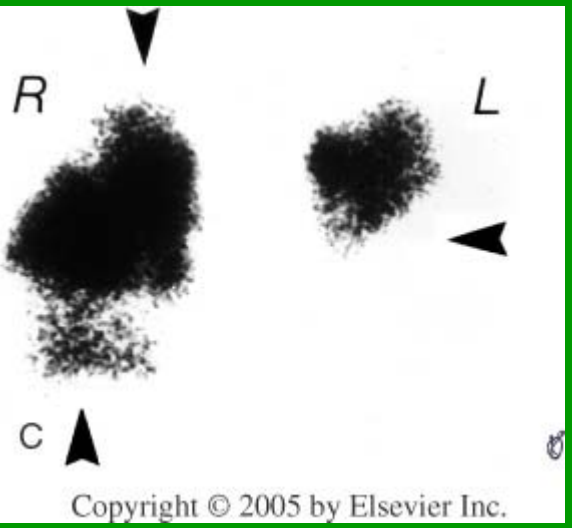
Ventilation-Perfusion Lung Scanning

Clinical value

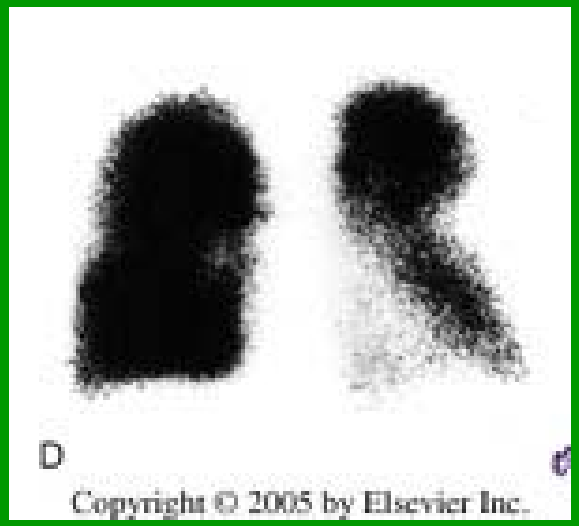
- **Does not provide an alternative Ð**
- **High-probability (A) & normal (B) scans are diagnostic**
- **Most scans are neither A nor B**
  - **Most (70%) have intermediate- probability = equivocal (nondiagnostic)**

Ventilation-Perfusion Lung Scanning

Follow-up of treatment



Before treatment



After treatment

Pulmonary Angiography

Clinical value

- t is highly sensitive & specific for PE
- Was the “gold standard”, now replaced by the new multidetector CT. It is rapidly becoming a lost art
- t is invasive, costly and uncomfortable
- t is less accurate for smaller (subsegmental emboli)
- Required when therapeutic interventions are planned as:-
  - Suction catheter embolectomy
  - Mechanical clot fragmentation
  - Catheter directed thrombolysis

Pulmonary Angiography

Technique

- A catheter is inserted into femoral vein, up the IVC through into right-sided cardiac chambers and into pulmonary arteries
- Optimal recording of right heart pressure tracings
- Contrast injected directly into pulmonary arteries
- To avoid damaging the intima of PA, a soft, flexible catheters with side holes are used (as pigtail)

Pulmonary Angiography

Technique

- Low-osmolar, non-ionic contrast agents are used (to minimize transient hypotension, heat and coughing)
- Contraindicated if thrombus is found in right heart
- Can be done with DSA to reduce contrast volume

Pulmonary Angiography

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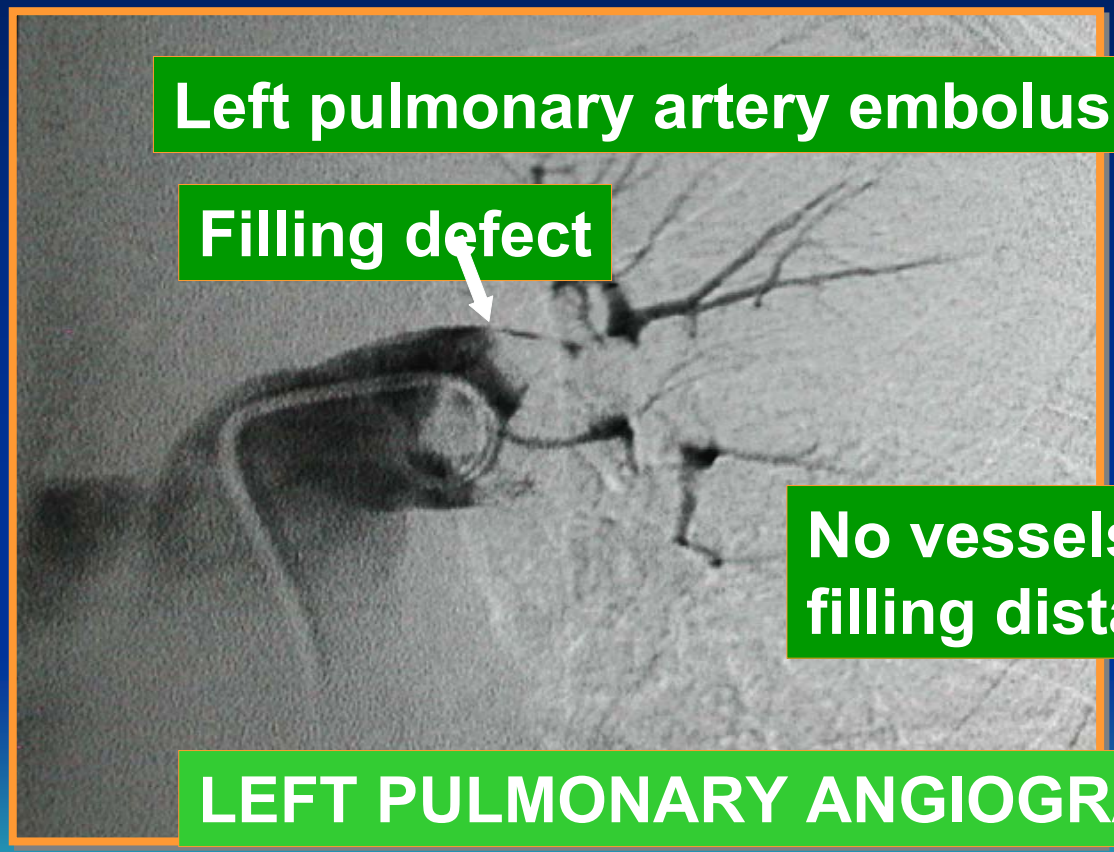

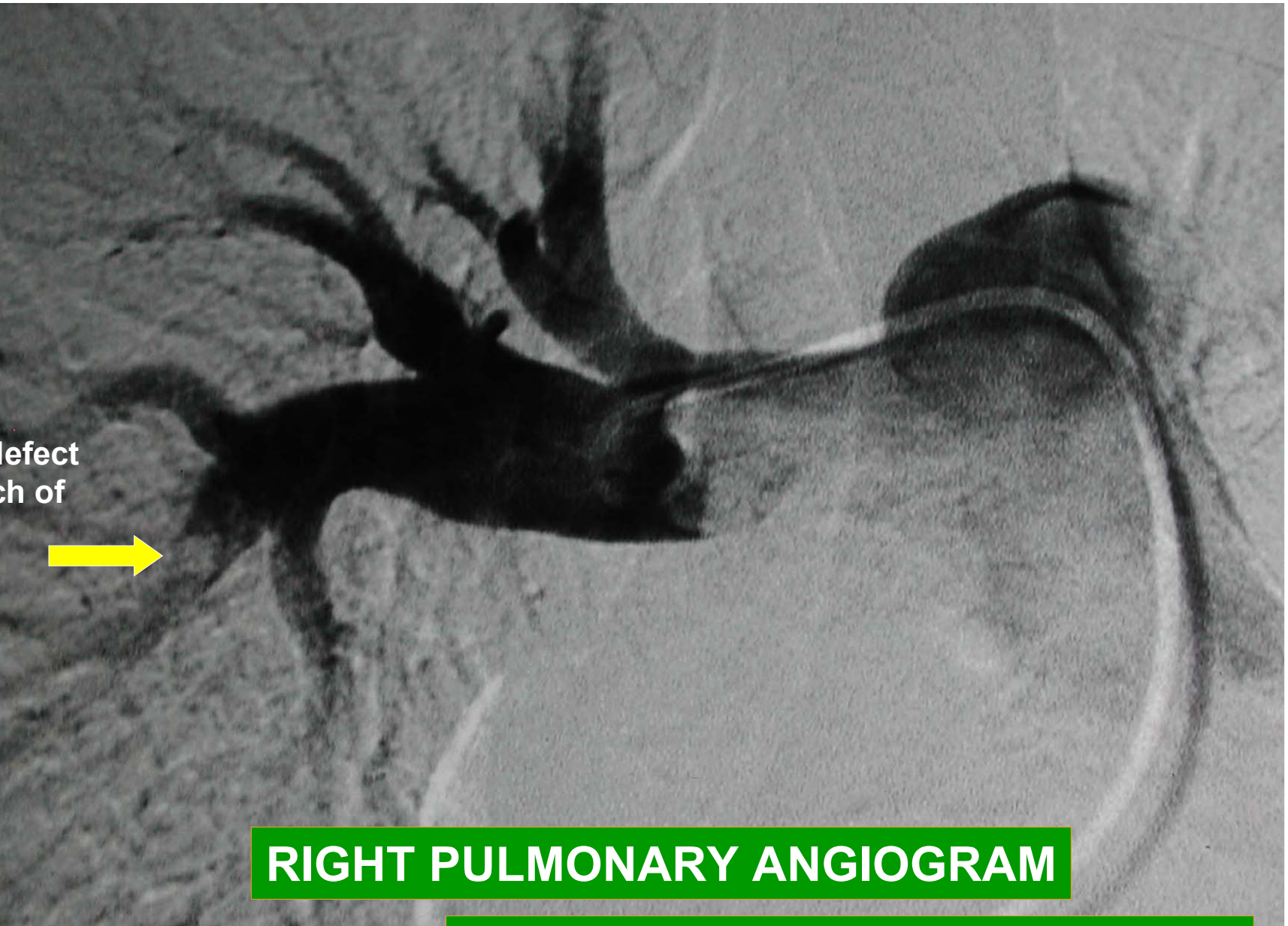
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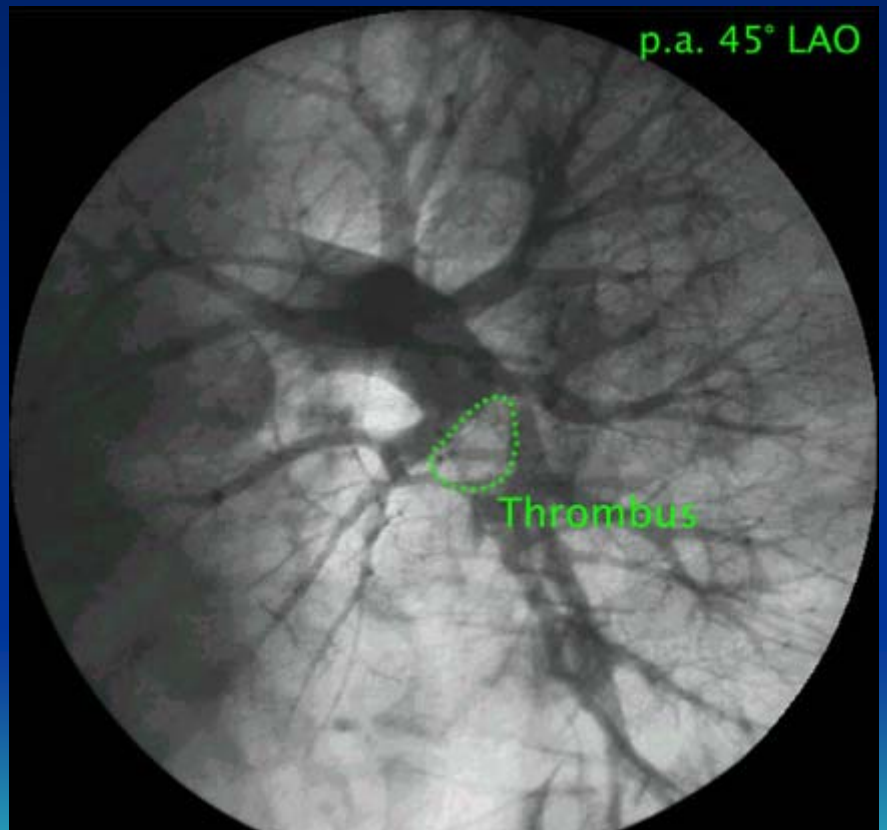
RIGHT PULMONARY ANGIOGRAM

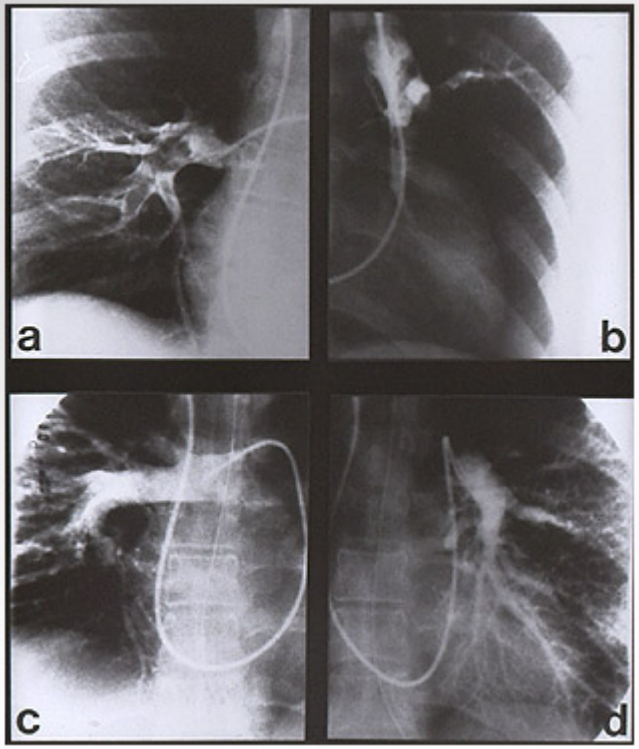
Pulmonary Angiography

Large thrombus occluding the lower lobar branch of left pulmonary artery



Pulmonary Angiography

Follow-up of treatment



a: Multiple large, partially occluding thrombi are seen within the right pulmonary artery as well as in its middle and lower lobar branch.

b: There is almost complete thrombotic occlusion of the upper and lower lobar branch of the left pulmonary artery.

c: Follow-up pulmonary angiography 7 days after the start of heparin shows absence of thrombotic material in the right pulmonary artery.

d: On follow-up examination the left pulmonary artery is also free of thrombus.

Gadolinium-Enhanced Magnetic Resonance Angiography

- It is a promising imaging test for suspected PE
- Sensitive and specific for segmental or larger PE
- Safe in patients with renal impairment (no contrast media nor ionizing radiation)
- Excellent sensitivity & specificity for the Ð of DVT especially for pelvic thrombosis
- Assessment of LV & RV size and function (important for risk stratification)

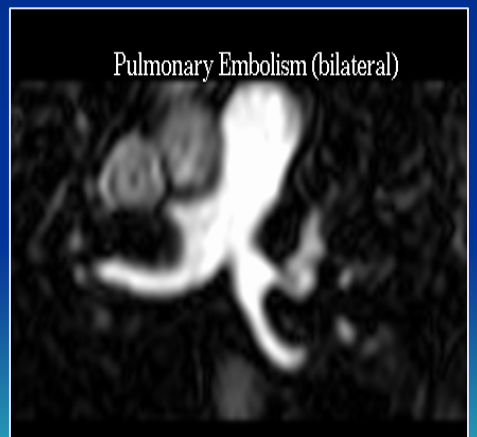
Gadolinium-Enhanced MRA

Sagittal Oblique

Coronal MIP

Gadolinium-Enhanced MRA

Acute PE



Imaging Studies For Deep Vein Thrombosis

- Compression ultrasound
- Contrast venography
- mpedance plethymography (outdated)
- CT venography
- MR venography

Colored Duplex Venous Ultrasonography

Compression Ultrasound

- The most commonly used method for symptomatic & proximal DVT (surrogate for PE)
- Noninvasive, portable, accurate & cheap
- Detection of other pathologies as hematomas, lymphadenopathy, abscesses

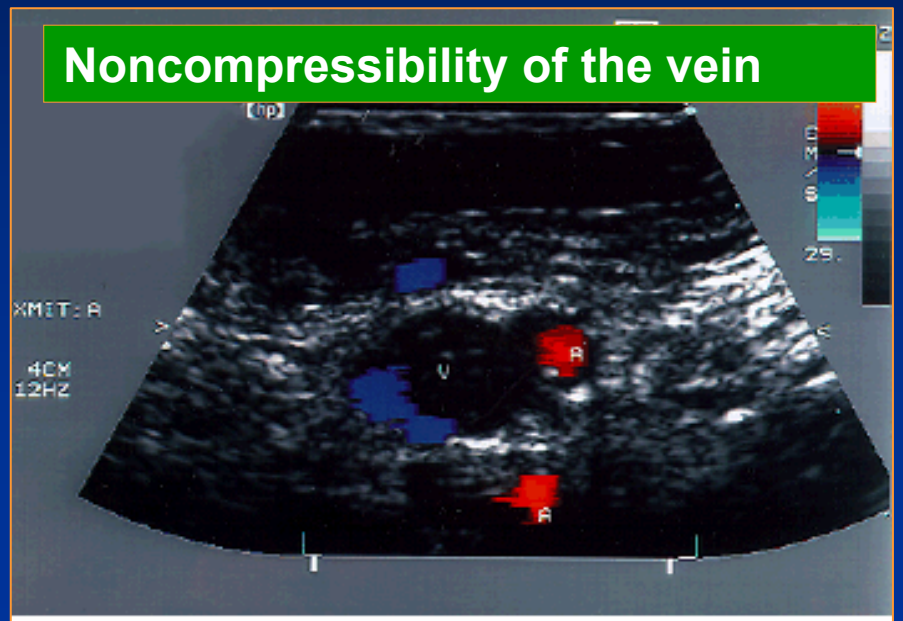
Colored Duplex Venous Ultrasonography

Limitations

- Insensitive for asymptomatic & distal (calf) DTV
- Operator dependence
- Inability to distinguish acute from chronic DVT
- DVT may have embolized completely, resulting, in normal scan
- Difficult for pelvic DVT & acute upon a chronic one

Colored Duplex Venous Ultrasonography

Noncompressibility of the vein



Duplex-Doppler ultrasound image of an acute superficial femoral vein thrombosis (labelled "V"). Blue color indicates venous blood flow and red indicates arterial blood flow (labelled "A"). Echogenic white speckles are seen in the vein which was non-

Contrast Venography (almost outdated)

Advantages & Disadvantages

lsed to be gold tandard

xcellent for calf eins

lecessary for atheter-based nterventions

- **It causes chemical phlebitis or allergy**
- **Invasive, and costly**
- **Fail to diagnose massive DVT**

Overall Strategy of PE Diagnosis

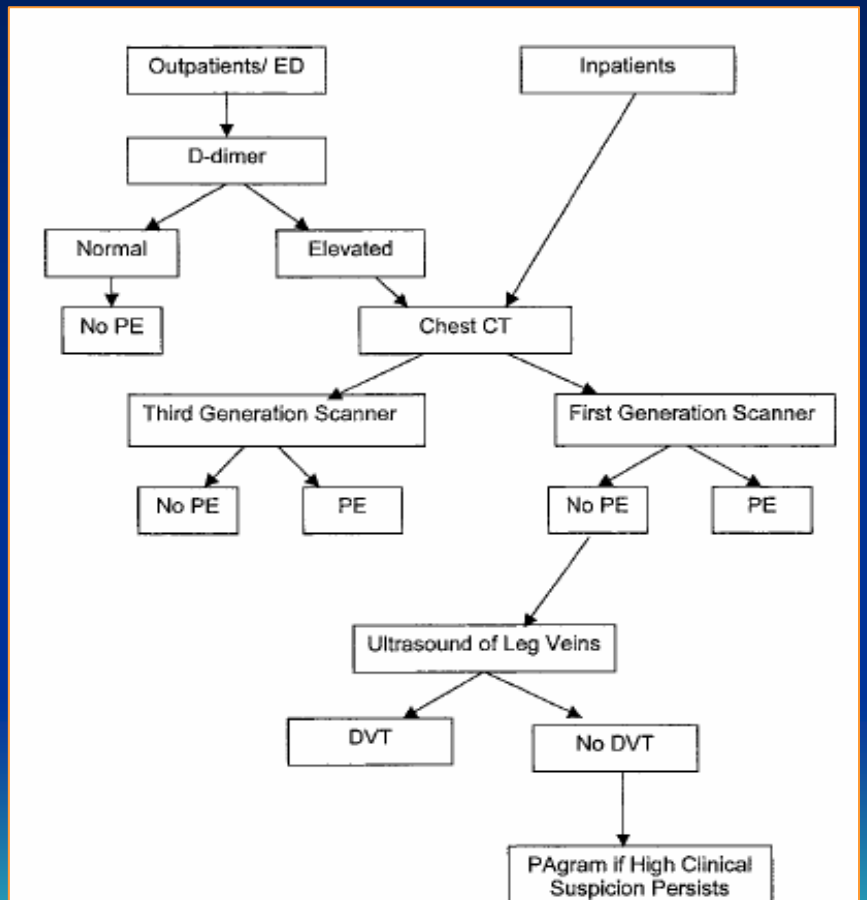
Components

- Pretest clinical probability
- Patient setting (inpatient or outpatient)
- D-dimer testing
- CT scan
- Venous US
- Pulmonary angiography

Overall Strategy of PE Management

An Integrated Diagnostic Approach
Concise & streamlined protocol

oice of test
Availability
Familiarity



Summary of Diagnostic Tests

xcluded by	Confirmed by
ormal pulmonary ngiogram **ormal multislice CT** **ormal D-dimer by LISA**	**Filling defect on pulmonary angiogram** **Filling defect on spiral CT** **Evidence of acute DVT + non-diagnostic spiral CT**

isk Stratification of Pulmonary Embolism

Importance of Risk Stratification

PE presents with a wide spectrum of
llness (mild-to-severe) with varying
prognoses & treatment modalities

From asymptomatic emboli to massive PE

Treatment strategy:

- Low-risk patients → anticoagulation (outpatient)
- High-risk patients → anticoagulants + thrombolysis or embolectomy + intensive support

Methods of Risk Stratification

- Clinical evaluation as Geneva Prognostic Index
- Cardiac biomarkers as troponins & natriuretic peptides
- Echocardiography (most important)
- Others as ECG, CTPA, MRI

Geneva Point Score

Variable	Point score
Cancer	+2
Heart failure	+1
Prior DVT	+1
Hypotension	+2
Hypoxia	+1
DVT on US	+1

Geneva Adverse Outcome Score

Number of points	Number of patients	% of patients with adverse outcome (n)
0	52	0 (0)
1	79	2.2 (2)
2	49	4.1 (2)
3	56	17.8 (10)
4	22	27.3 (6)
5	7	57.1 (40)
6	3	100 (3)

Markers of Poor Prognosis

- Geneva point score ≥ 5
- Severe dyspnea, cyanosis & syncope
- Hypoxia despite Oxygen
- Clinical evidence of PH or RV strain
  - ↑ pulmonic S2
  - Left parasternal heave, TR
  - Distended neck veins
- Elevated cardiac biomarkers
- ECG evidence of RV strain
- Echo/Doppler evidence of:
  - RV dysfunction
  - PH (>5 weeks)