

Pulmonary Embolism

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Statistics

- **1-2 out of 1000** adults annually are diagnosed with deep vein thrombosis (DVT) and/or pulmonary embolism (PE)
- About half of patients with DVT also have PE, sometimes asymptomatic
- The majority of DVT occurs in pelvic or lower limb veins
- One-month mortality about 10 % among patients with PE
- 3-4 % of PE patients develop chronic thromboembolic pulmonary hypertension

Symptoms of pulmonary embolism

- Dyspnea
- Cough
- Hemoptysis
- Pleuritic chest pain (worsened by deep breathing)
- Syncope

- May be asymptomatic

Wells criteria

Variable	Points
Clinically suspected DVT	3.0
Alternative diagnosis less likely than PE	3.0
Tachycardia (heart rate > 100)	1.5
Recent surgery or immobilization	1.5
Previous PE or DVT	1.5
Hemoptysis	1.0
Active malignancy	1.0
Probability of pulmonary embolism	Total points
Low (10 %)	< 2.0
Moderate (30 %)	2.0-6.0
High (65 %)	> 6.0

DVT = deep vein thrombosis, PE = pulmonary embolism

Diagnosis

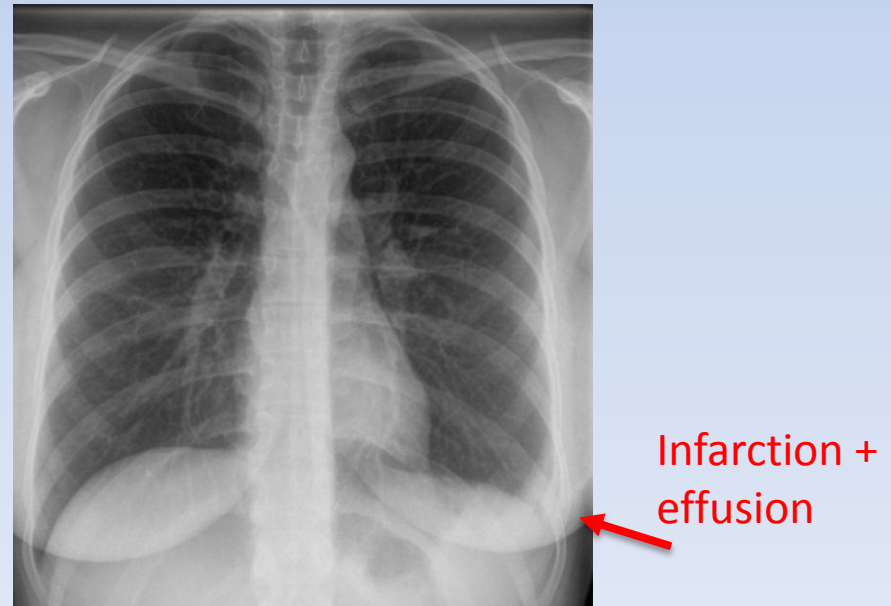
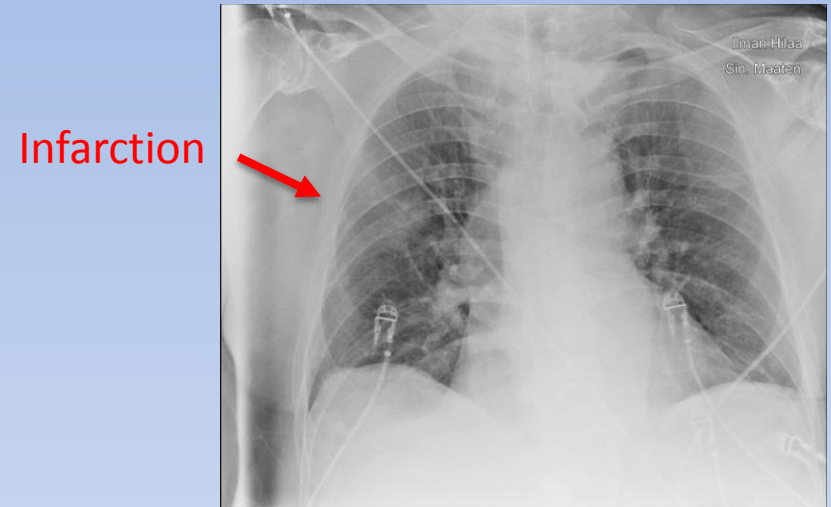
- With a low or moderate probability, a negative D-dimer will rule out pulmonary embolism, no imaging needed
- With a positive D-dimer or high probability by Wells criteria, imaging is necessary
- D-dimer is sensitive but not specific

Diagnosis: imaging

- **Chest X-ray** for differential diagnostic purposes
- **CT** is the primary imaging modality
- Compression **ultrasound** of the lower extremities
 - if patient has a DVT and typical clinical picture of PE
- **Ventilation/perfusion (VQ)** scan can be used when CT is contraindicated
- **Cardiac ultrasound** may be used to diagnose PE based on right ventricular strain on high risk patients in an emergency
- **MRI** not in routine use

Chest radiograph

- Cannot be used to diagnose or rule out pulmonary embolism
- Used for **differential diagnosis**
- Sometimes secondary findings of PE visible
 - pulmonary infarction
 - pleural effusion



MRI

- Not in routine use
- No radiation exposure
- A large proportion of undiagnostic exams
- Not very sensitive for peripheral emboli
- Gadolinium-based contrast medium contraindicated for pregnant patients
- Only in selected cases



Ventilation/perfusion scan

- An alternative for patients with contraindications for iodinated contrast medium
- Preexisting pulmonary conditions may cause false positive findings
 - chest radiograph
- Usually not available during on-call hours

Pulmonary CT angiogram

- The imaging modality of choice for PE
- Widely available
- Short scanning time
- Moderate radiation exposure
- Iodinated contrast medium necessary
- May offer an alternative diagnosis if negative for PE

CT scanning protocol

- kV
- Slice thickness
- Contrast medium
- Breath-hold technique
- ECG gating

CT scanning protocol

- Low kV improves vascular enhancement but increases noise with large patients
- kV selected manually based on patient weight (80-140 kV) **or** automatically by scanner
- Thin slices (1-1.5 mm) necessary for the evaluation of small artery branches
- Contrast medium injection at 4 ml/s
 - sometimes 5 or 6 ml/s

CT scanning protocol

- Breath-hold at **shallow inspiration**
 - Maximal inspiration may cause an influx of unopacified blood from the IVC
 - Not optimal for the evaluation of lung parenchyma
- ECG gating not routine in the imaging of acute embolism
 - reduces motion artifacts
 - increases radiation dose

CT scanning protocol

- Customized protocols for different patients
 - Higher CM flow for young and pregnant patients (5 or 6 ml/s)
 - Reduced CM dose and low kV (80) for patients with renal dysfunction
- CT perfusion possible with dual-energy scanners
- Triple-rule-out
 - An ECG-gated CT to evaluate the aorta, pulmonary and coronary arteries

CT radiation dose

- Image optimization
 - good enough image quality
- Special considerations
 - young patients
 - pregnant or nursing patients
- Typical dose equal to roughly 1-3 years of background radiation



The pregnant patient

- An elevated risk of DVT and PE, but also more non-specific symptoms
- US of lower extremities
- CT or ventilation/perfusion scan?
 - CT: A larger radiation dose to the maternal breast
 - V/Q: A larger radiation dose for the fetus
 - Perfusion scan without ventilation an option for lowering the dose
- An increased blood volume and higher cardiac output may require a higher contrast medium flow (6 ml/s) at CT



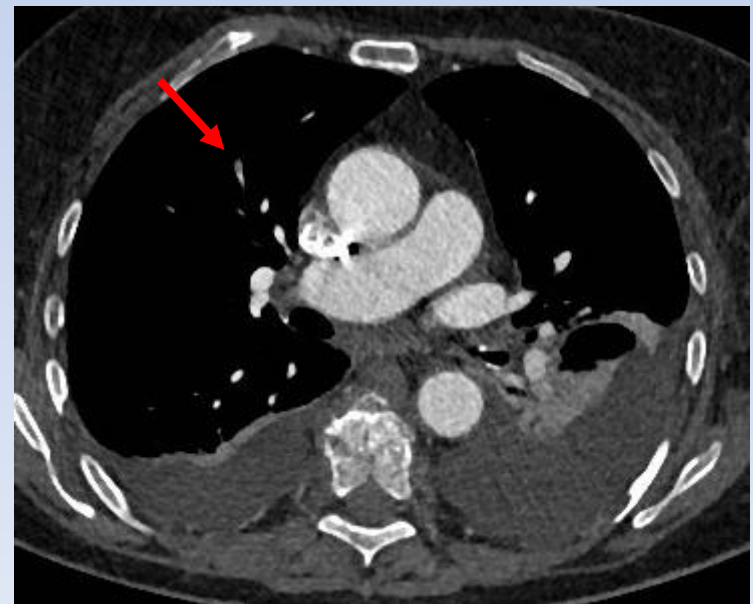
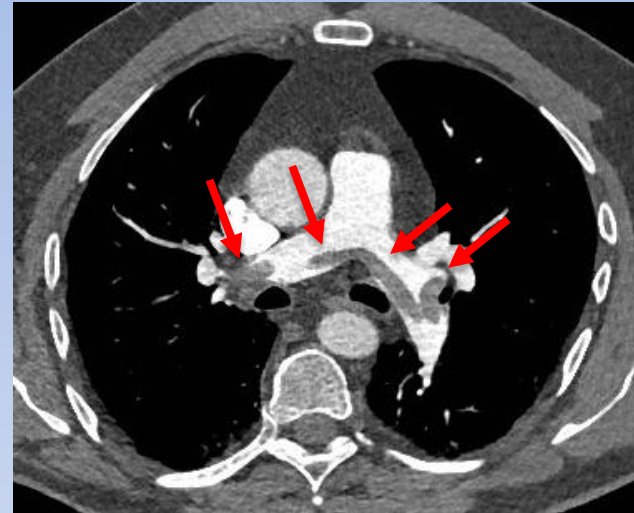
Imaging findings at CT

- Filling defects in pulmonary arteries
- Pulmonary infarction
- Right heart strain
- Pleural effusion



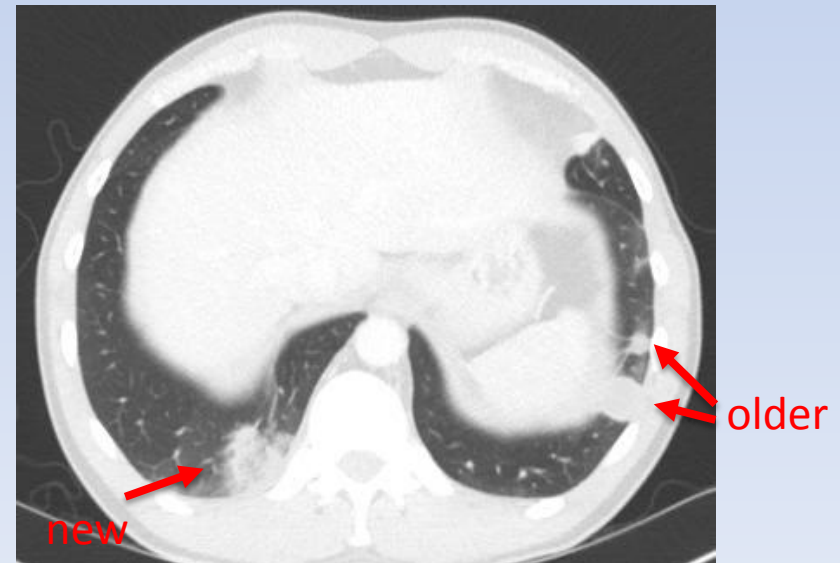
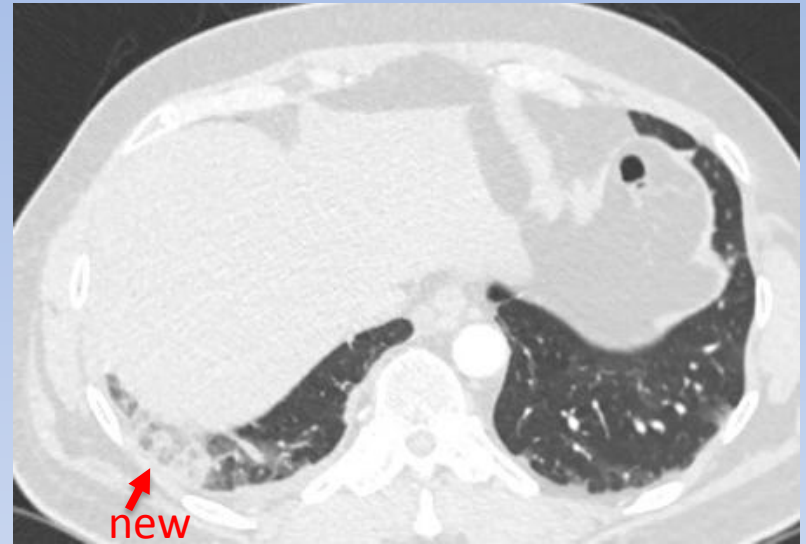
Filling defects

- Represent the actual emboli
- Often obvious in technically adequate exams
- False positives and negatives more common in peripheral arteries and suboptimal exams
- Remember to adjust the window width when necessary!



Pulmonary infarction

- Occurs in 10-30 % of PE patients
- (Somewhat) wedge-shaped opacities with a broad pleural base
- Older infarctions rounder and more defined
- Lower lobes most common
- Poor opacification with contrast medium (vs. atelectasis)



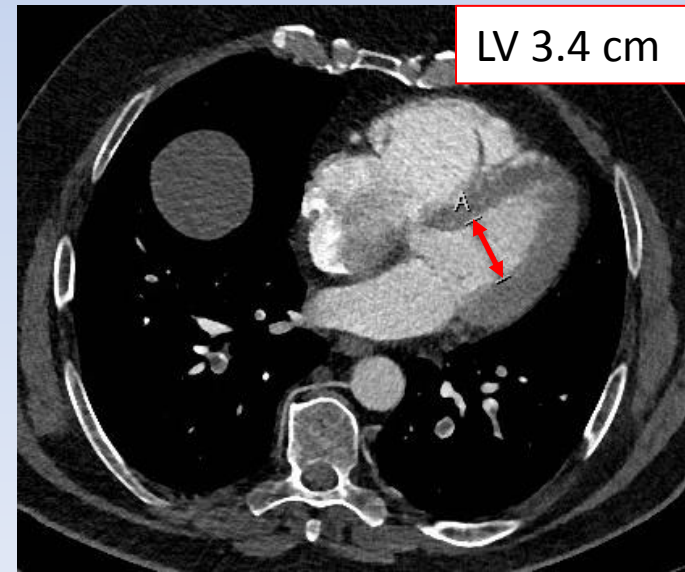
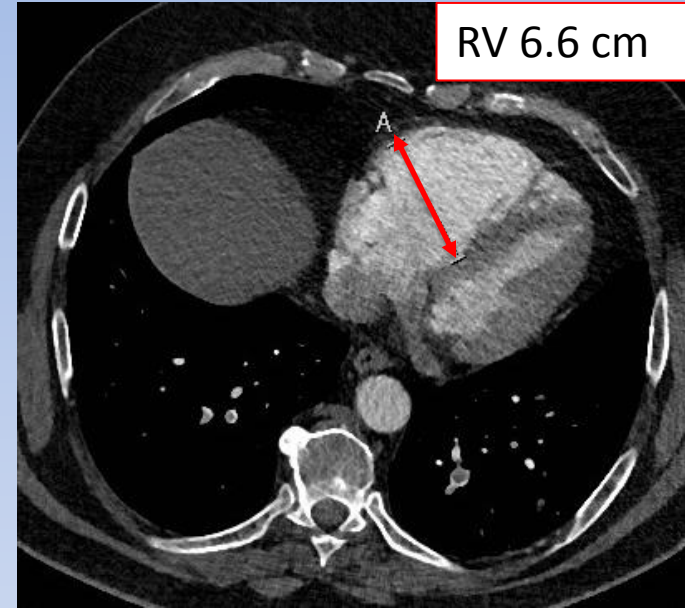
Pulmonary infarction

- Associated with pleuritic pain
- Rarely cavitates, possibly due to infection
 - cavitation much more common in septic embolism
- Takes months to resolve, may leave a scar
- Sometimes just hemorrhage without infarction, resolves fast



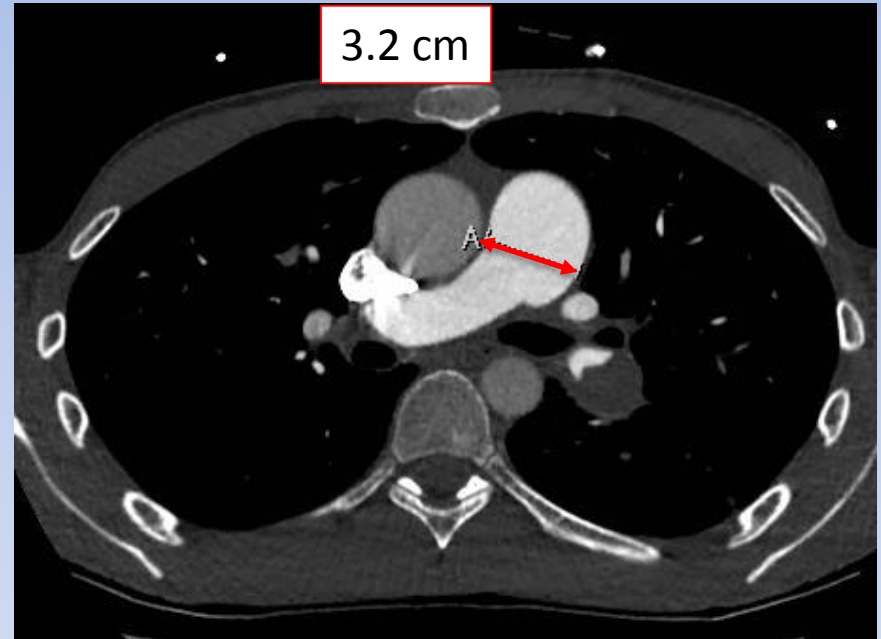
Right ventricular strain

- **RV/LV ratio >1**
 - measured at the **two axial slices** where each ventricle is at its widest
 - 4-chamber view sometimes used
- Bowing of the interventricular septum to the left



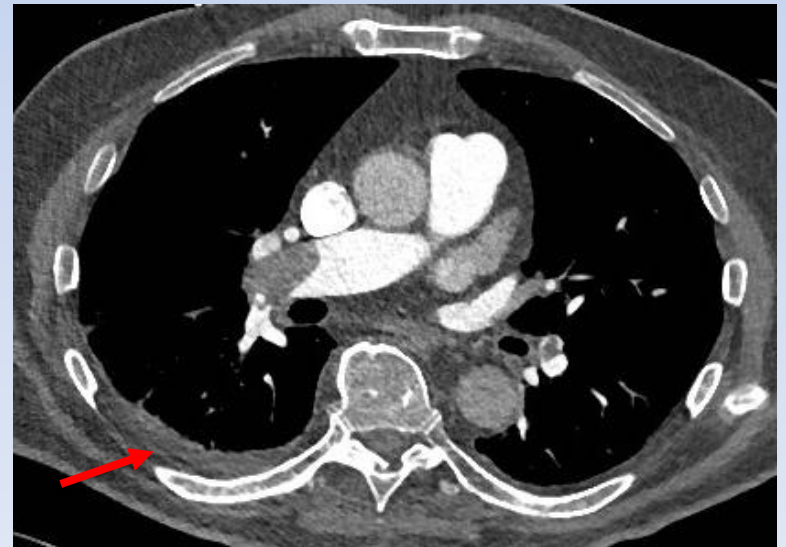
Right ventricular strain

- Dilated pulmonary trunk
 - >30 mm or larger than the ascending aorta
- Enlarged right atrium
- Contrast medium reflux into the inferior vena cava (IVC)



Pleural effusion

- Mostly unilateral
- Usually a small effusion
- Exudate
- May be related to an infarction

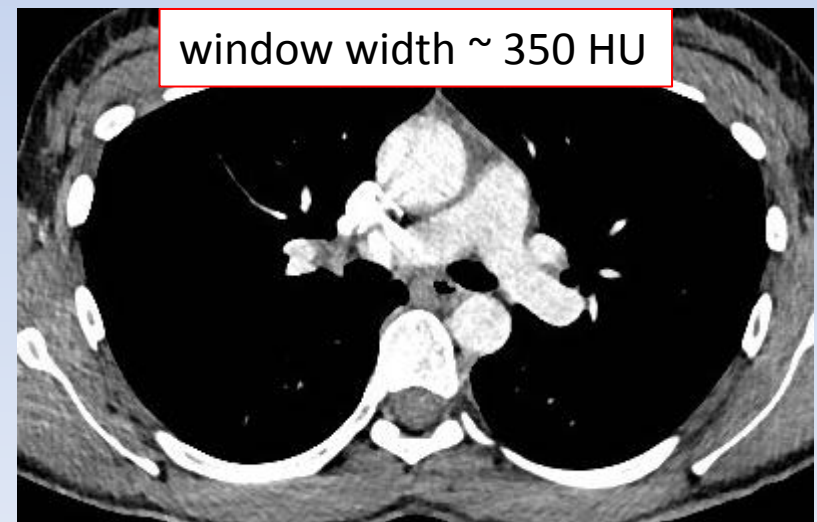
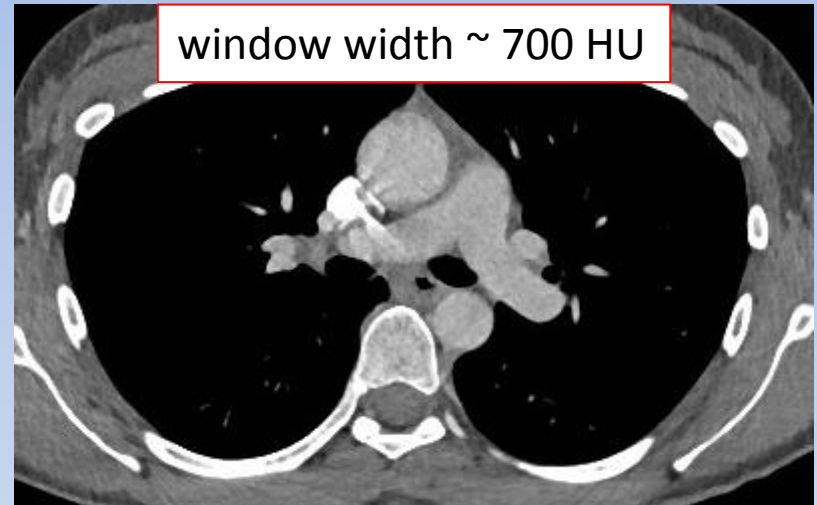


Suboptimal CT exams

- Inadequate contrast medium concentration
- Motion artifacts
 - respiration
 - heart
- Streak artifacts
- Low signal-to-noise ratio

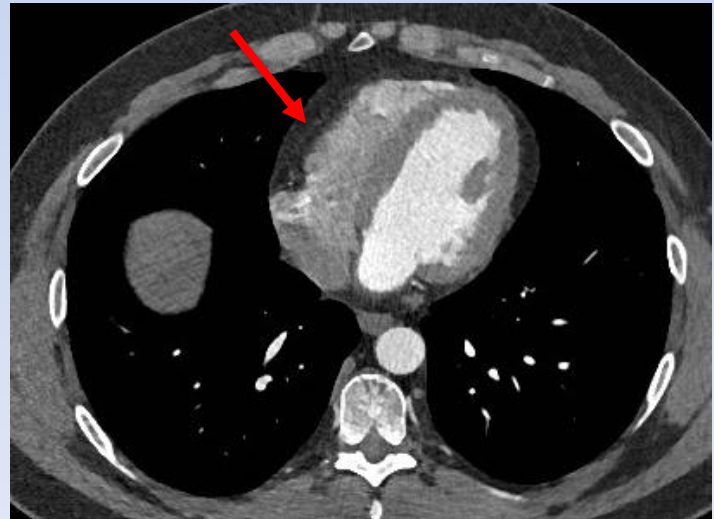
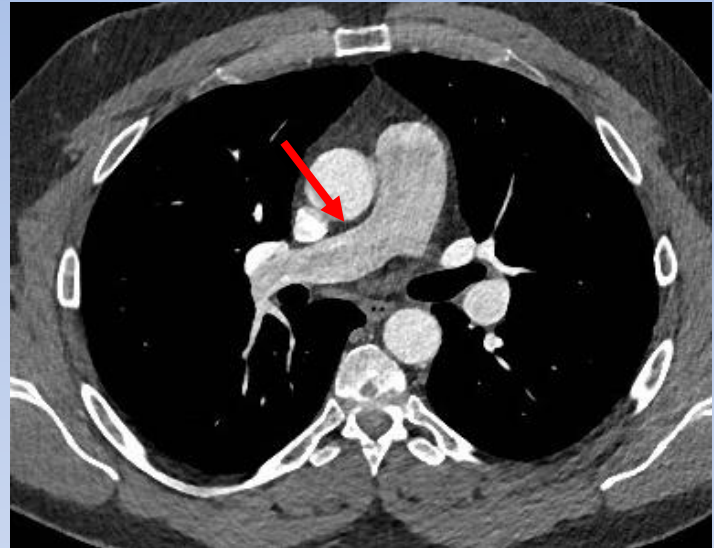
Inadequate contrast medium concentration

- Inadequate contrast medium flow
- Incorrect timing
- High cardiac output
 - young and pregnant patients
- Adjusting the window width may help with a suboptimal exam!
 - A narrower window increases contrast



Inadequate contrast medium concentration

- Influx of unopacified blood from the inferior vena cava due to deep inspiration
- A patent foramen ovale opening due to a Valsalva maneuver



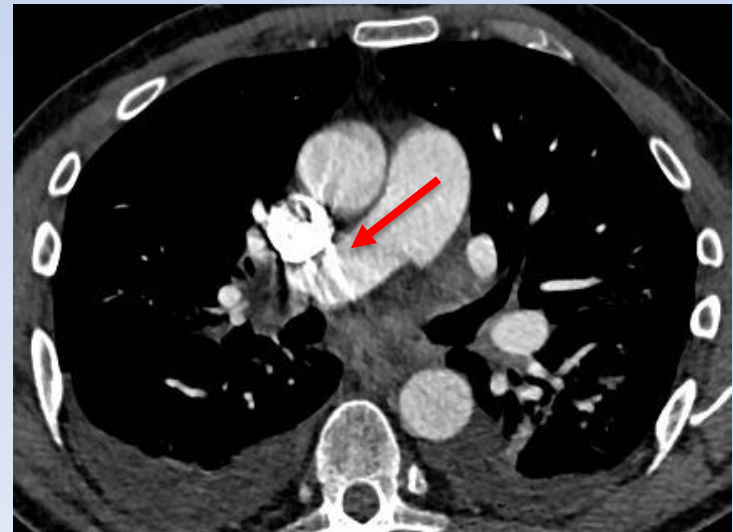
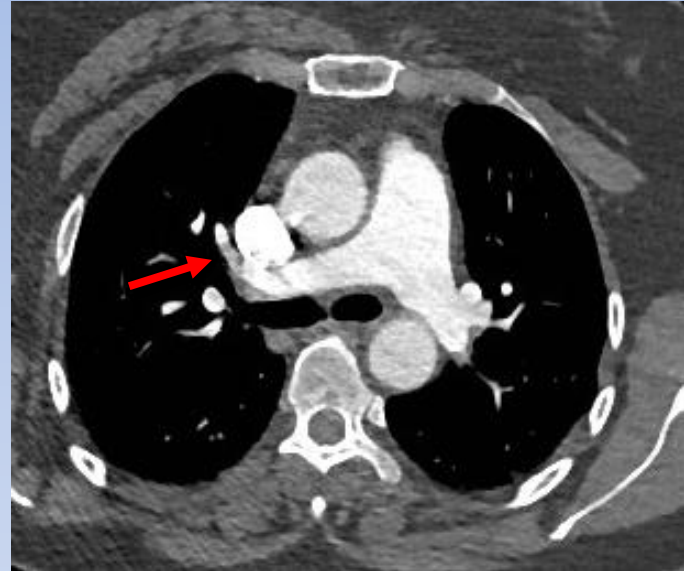
Motion artifacts

- Breathing during image acquisition
- Heart pulsation
- Patient movement



Streak artifacts

- Due to a high concentration of contrast medium in the superior vena cava
- Difficult to avoid due to necessary CM bolus
- High and low density streaks
- May obscure arteries or cause false positive filling defects



Incidental pulmonary embolism

- Incidental PE found in 1-4 % of scans of the chest
- More common among cancer and inpatients than outpatients
- Usually treated like a "nonincidental" embolism
- Treating isolated subsegmental incidental embolism controversial (more harm than good?)

Summary

- CT is the primary imaging modality for pulmonary embolism
- Use customized CT protocols for different patients
- Remember to check for right ventricular strain!