Pulmonary embolism update

Tuesday 3rd June 2025, Oslo.

Nordic Forum, Trauma and Emergency Radiology

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Bergen, Norway

- No disclosures

Outline

- Incidence and risk factors
- CT protocol
- Acute PE imaging findings
- Imaging the pregnant patient
- Chronic PE imaging findings

Incidence for PE

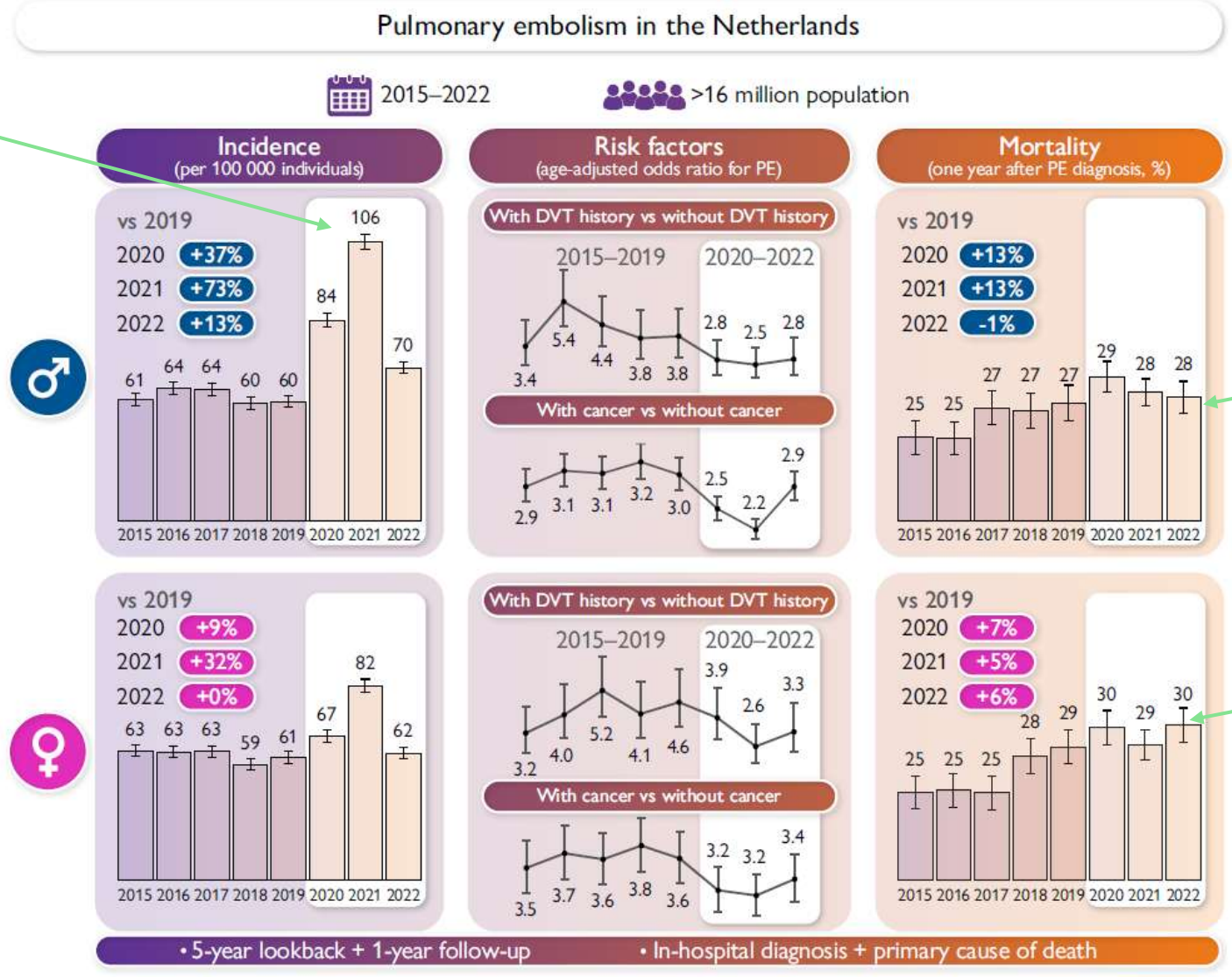
- No exact incidence is available, as asymptomatic ones cannot be counted
- Estimated that PE is the cause of 70-80 deaths/100 000 annually*
- A recent Dutch study studied changes during and after Covid-19

* Belohlavek et al. Exp Clin Cadiol 2013;18:129-138

** Chen et al, European Heart Journal (2025) **00**, 1–13

Incidence, risk factors, and mortality of pulmonary embolism in the Netherlands (2015–22): sex differences and shifts during the coronavirus disease 2019 pandemic (Chen et al 2025).

The COVID-19 pandemic has reshaped seemingly favourable pre-pandemic time trends in PE epidemiology in the Netherlands. These unfavourable changes appear to have reverted to pre-pandemic levels after 2022.



Predisposing factors for venous thromboembolism

Strong risk factors (OR > 10)
Fracture of lower limb
Hospitalization for heart failure or atrial fibrilla
(within previous 3 months)
Hip or knee replacement
Major trauma
Myocardial infarction (within previous 3 mont
Previous VTE
Spinal cord injury

Moderate risk factors (OR 2–9)
Arthroscopic knee surgery
Autoimmune diseases
Blood transfusion
Central venous lines
Intravenous catheters and leads
Chemotherapy
Congestive heart failure or respiratory failure
Erythropoiesis-stimulating agents
Hormone replacement therapy (depends on form
In vitro fertilization
Oral contraceptive therapy
Post-partum period
Infection (specifically pneumonia, urinary tract infection, and HIV)
Inflammatory bowel disease
Cancer (highest risk in metastatic disease)
Paralytic stroke
Superficial vein thrombosis
Thrombophilia

Weak risk factors (OR < 2)
Bed rest >3 days
Diabetes mellitus
Arterial hypertension
Immobility due to sitting (e.g. prolonged car or air travel)
Increasing age
Laparoscopic surgery (e.g. cholecystectomy)
Obesity
Pregnancy
Varicose veins

HIV = human immunodeficiency virus; OR = odds ratio; VTE = venous thromboembolism.

** 2019 ESC Guidelines for the diagnosis and management of acute pulmonaryembolism developed in collaboration with the Europea Respiratory Society (ERS). European Heart Journal (2020) 41, 543603

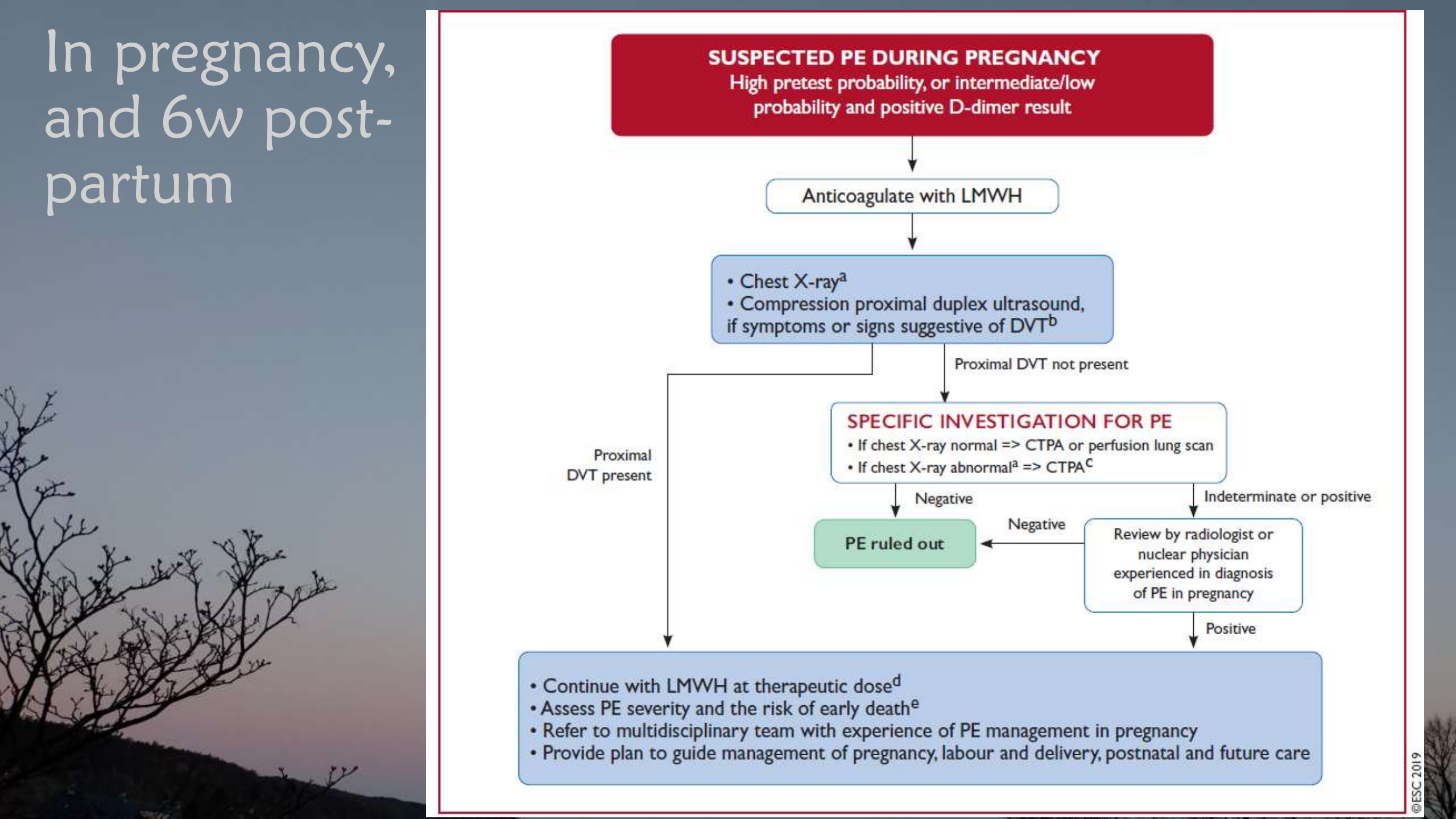
Suggested CT protocol

- Previously FOV “cropped the lung tops”, but no longer considered vital
- Some suggest “full” lungs when age >45yrs

- Use fixed 80 or 100kV tube voltage
- Use minimum 40ml contrast (min density 350mg I /ml)
- (We increase to 60ml, if not using dual energy)
- Injection rate 4-6ml/s
- Bolus tracking, that is 20ml in addition
- Use a saline flush 50ml
- RCR criteria state minimum 210HU in PA trunk

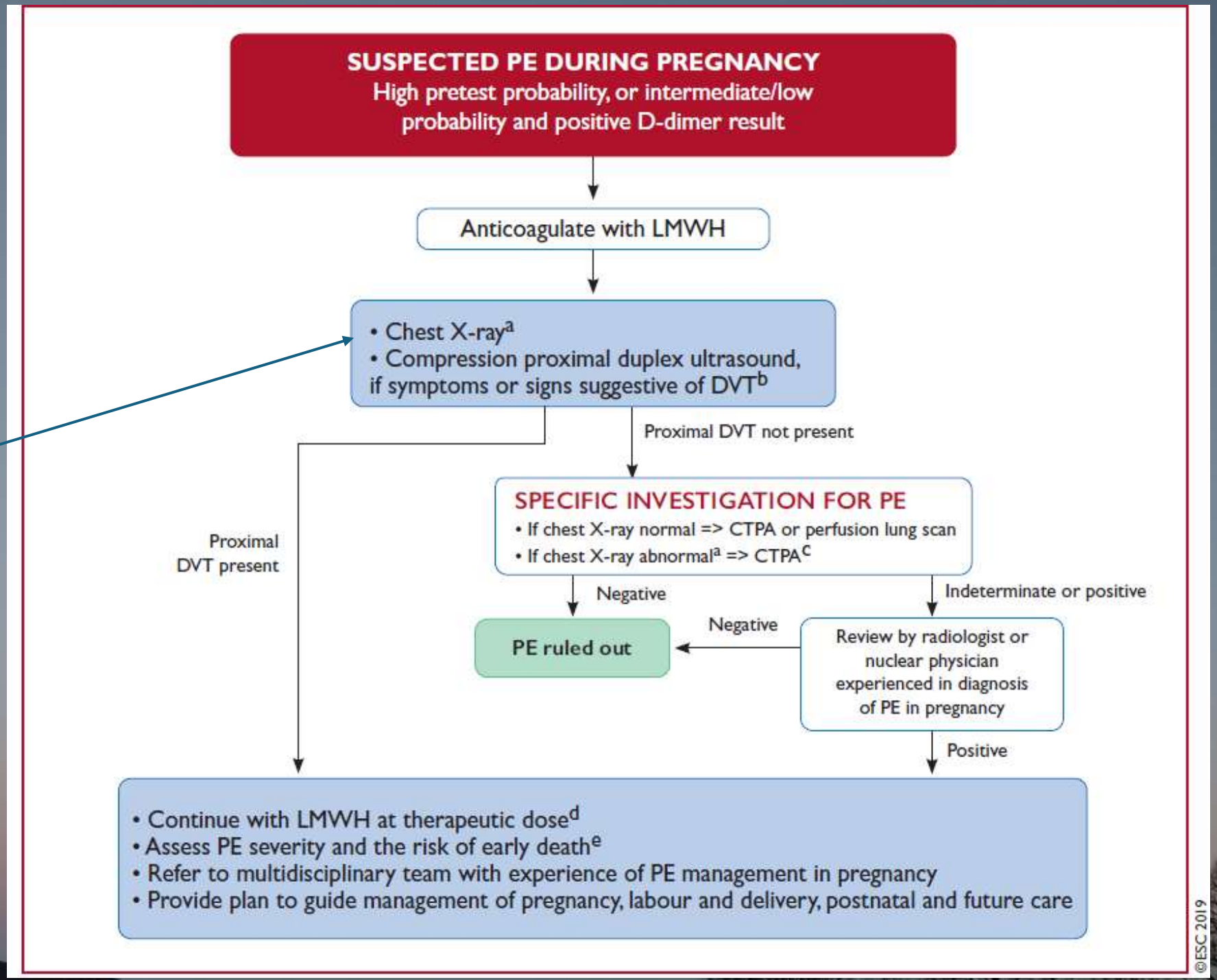
* https://www.rcr.ac.uk/audit/adequate-contrast-enhancement-ct-pulmonary-angiograms

In pregnancy, and 6w post-partum



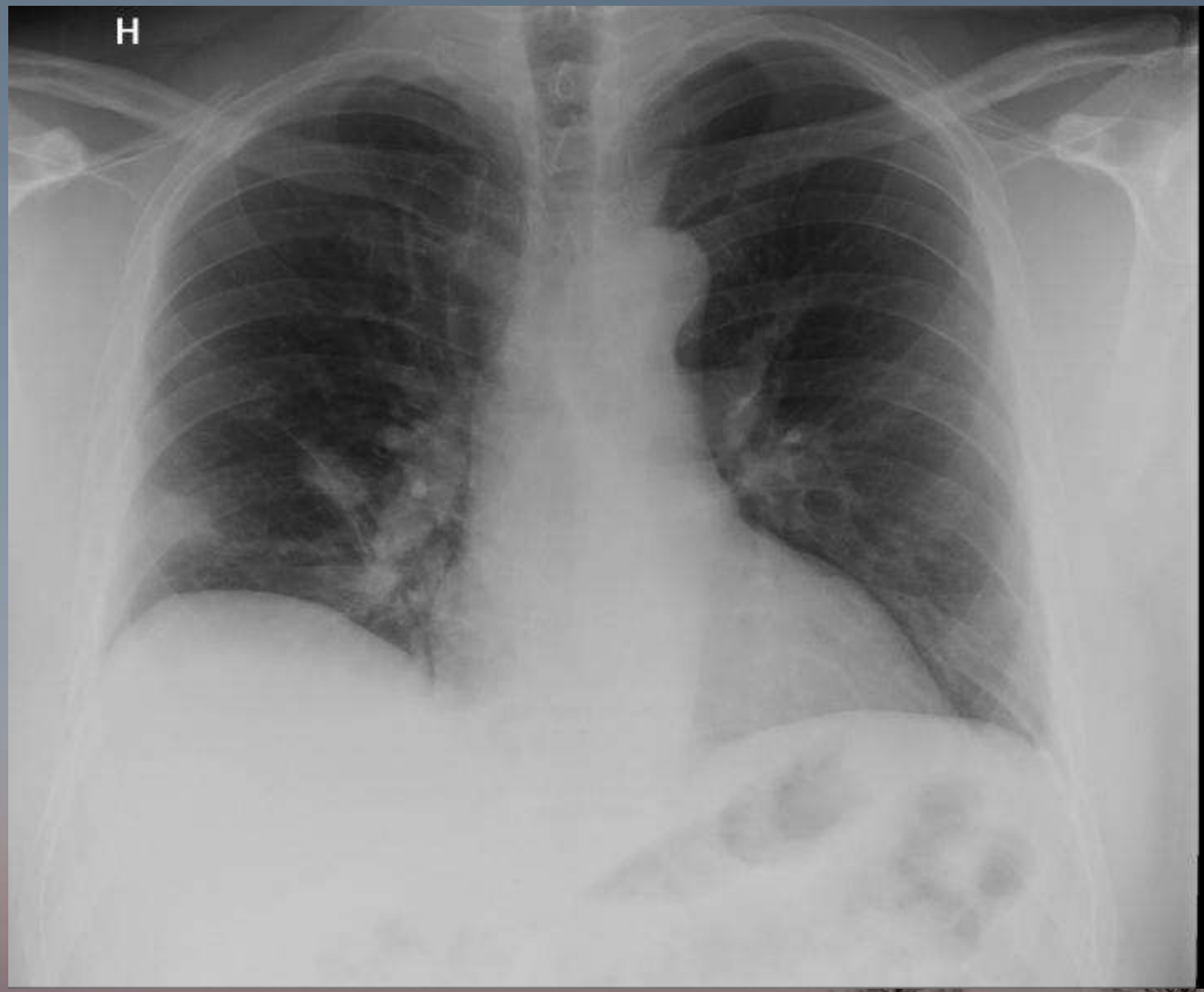
In pregnancy, and 6w post-partum

- If CXR abnormal, think of alternative diagnosis



Hamptons hump

- Wedge-shaped opacity at the lung base or periphery
- Indicating lung infarction due to pulmonary embolism



*Marshall et al. Signs in thoracic imaging, J Thorac Imaging Volume 21, Number 1, March 2006

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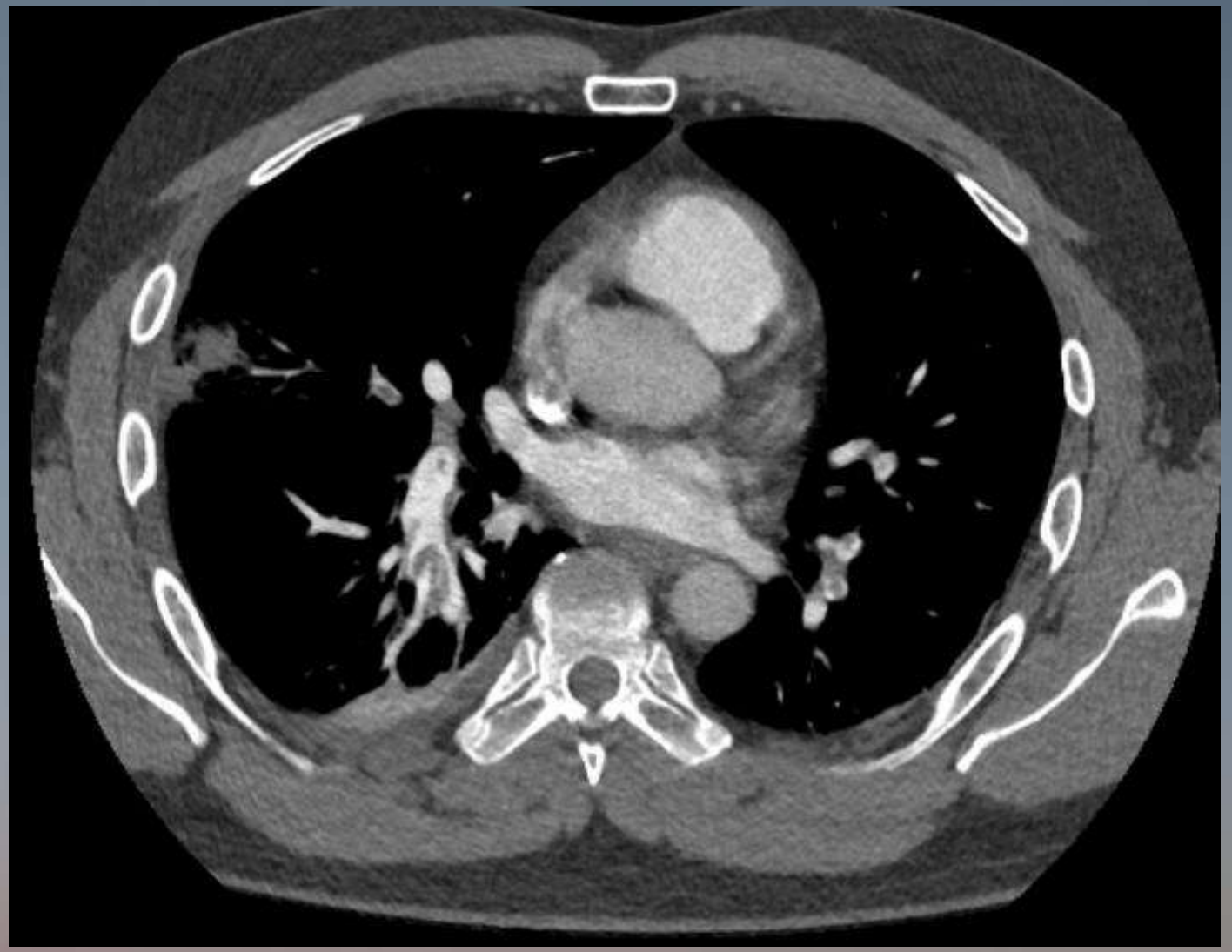

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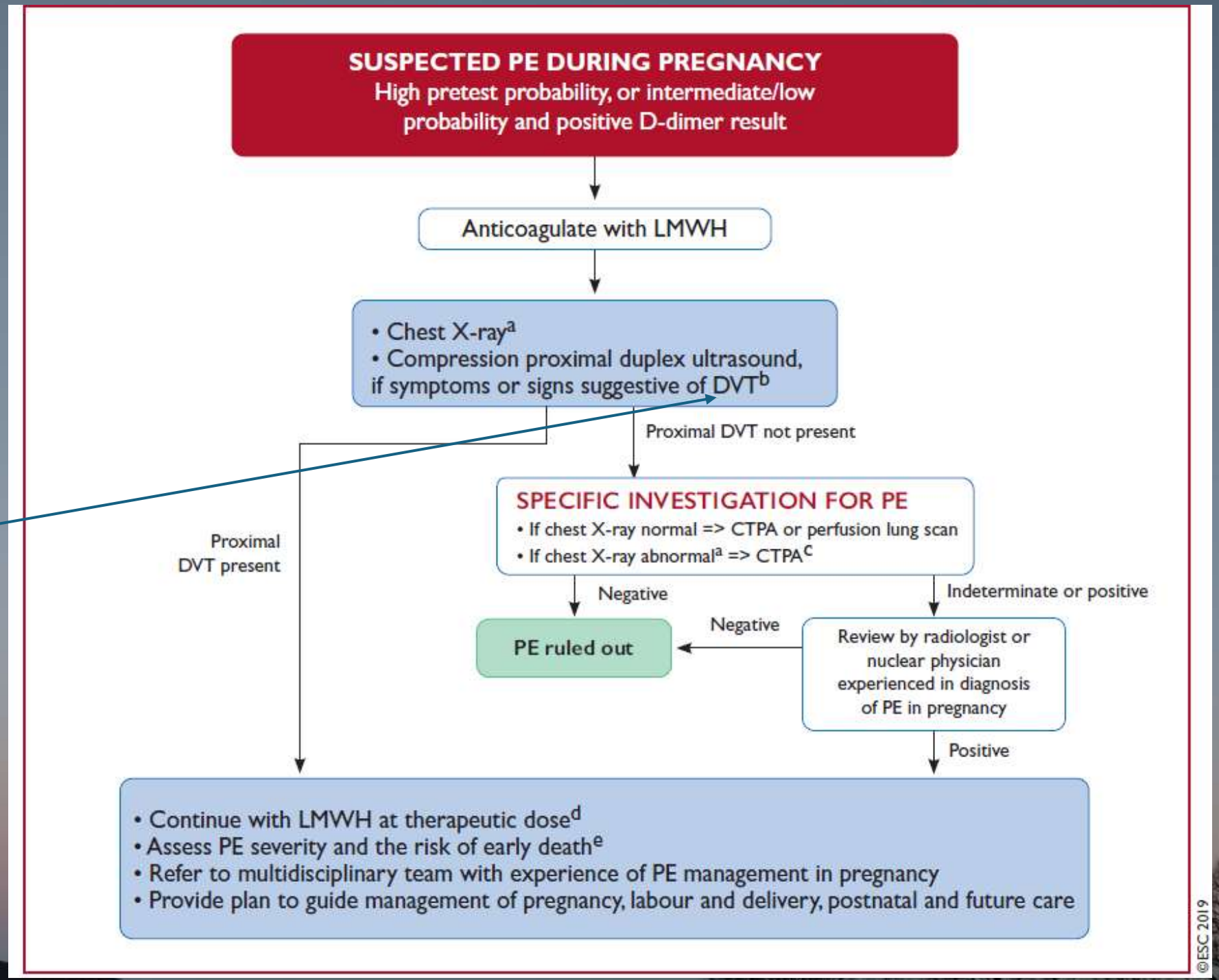
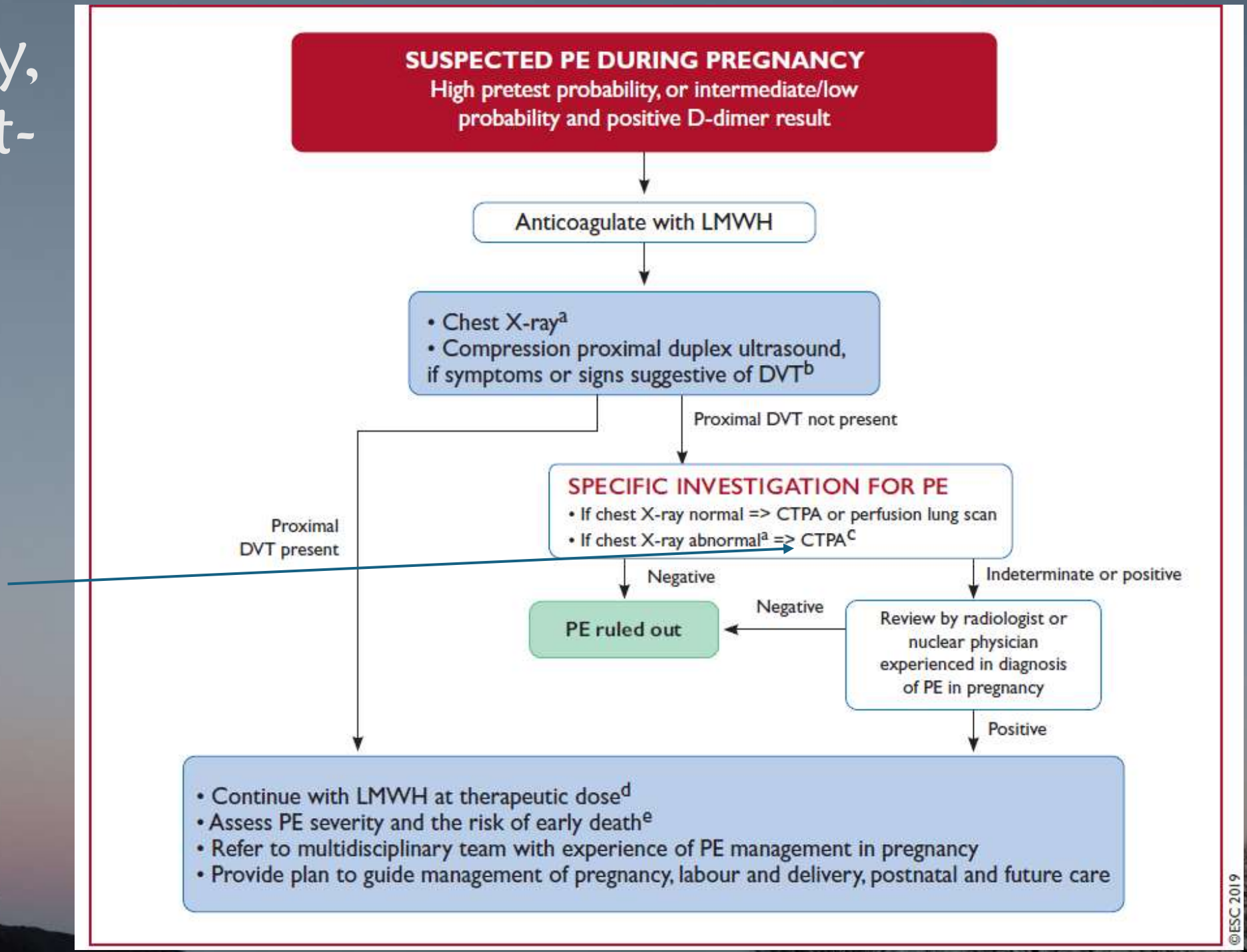
In pregnancy, and 6w post-partum

- Ultrasound is good, MR venography for pelvic veins



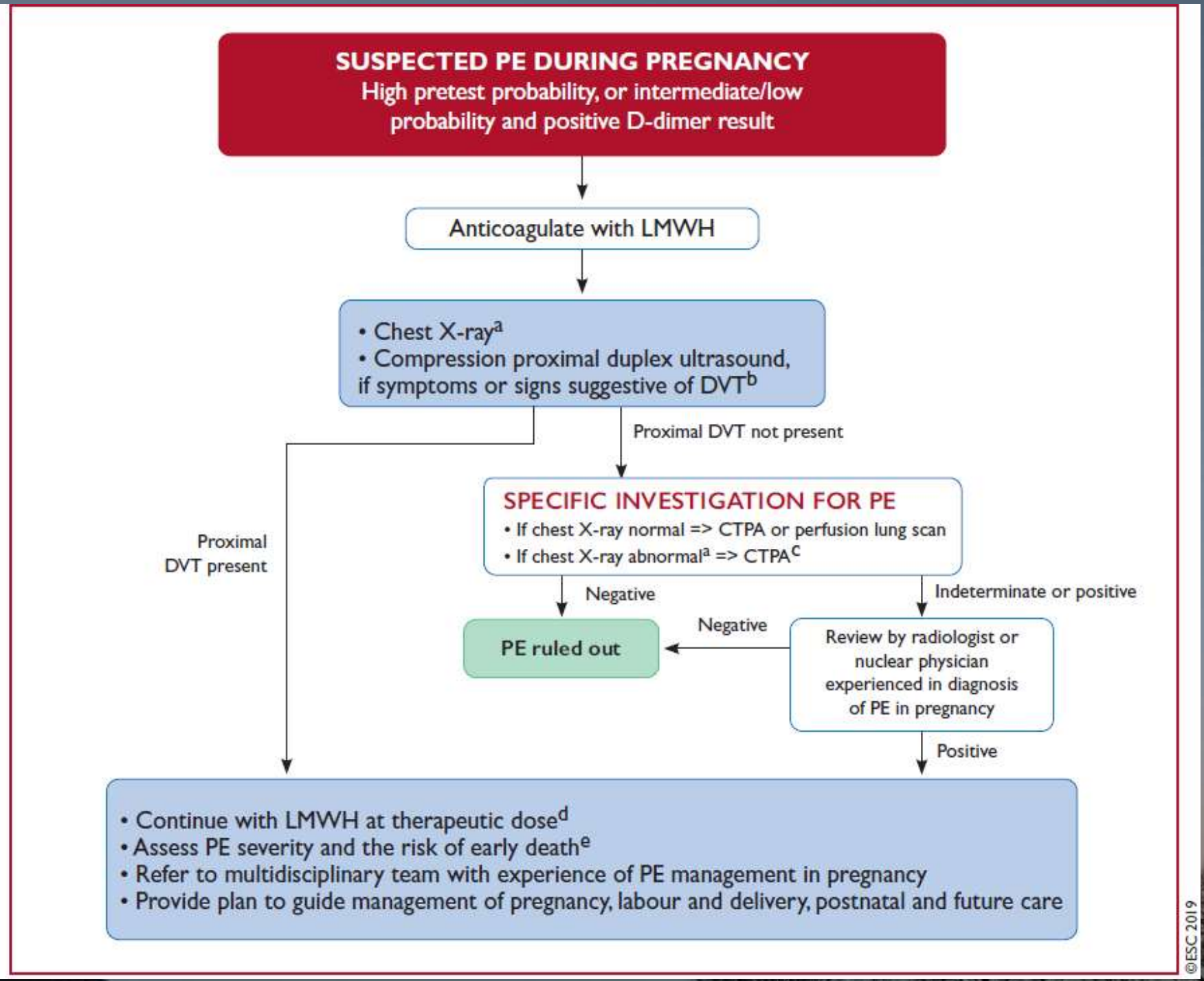
In pregnancy, and 6w post-partum

- CT protocol must be adjusted for low radiation to foetus, and also to breast tissue



In pregnancy, and 6w post-partum

Same contrast,
FOV
fix to 60-80kV



Slice thickness and window settings

- Slice reconstruction recommended
  - 1 to 1.5mm, with 0.7 to 1mm overlap
  - in obese pts 1.5-2mm (never above 2mm).
- W 400HU, L 30-40HU or
- W 700HU, L 100HU or

- according to actual enhancement:
- W ~ 2x of enhancement, L ~ 50%
- Example:250HU, W480 and L125

* Hartmann et al. State-of-the-Art Multi-Detector CT Angiography in Acute Pulmonary Embolism: Technique, Interpretation and Future Perspectives Intechopen DOI: 10.5772/22763

Examples PE and WL setting

W400HU, L 40HU

W700HU, L 100HU

W830HU, L 215HU

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W400HU, L 40HU

W700HU, L 100HU

W830HU, L 215HU

Examples PE and WL setting

W400HU, L 40HU

W700HU, L 100HU

W830HU, L 215HU

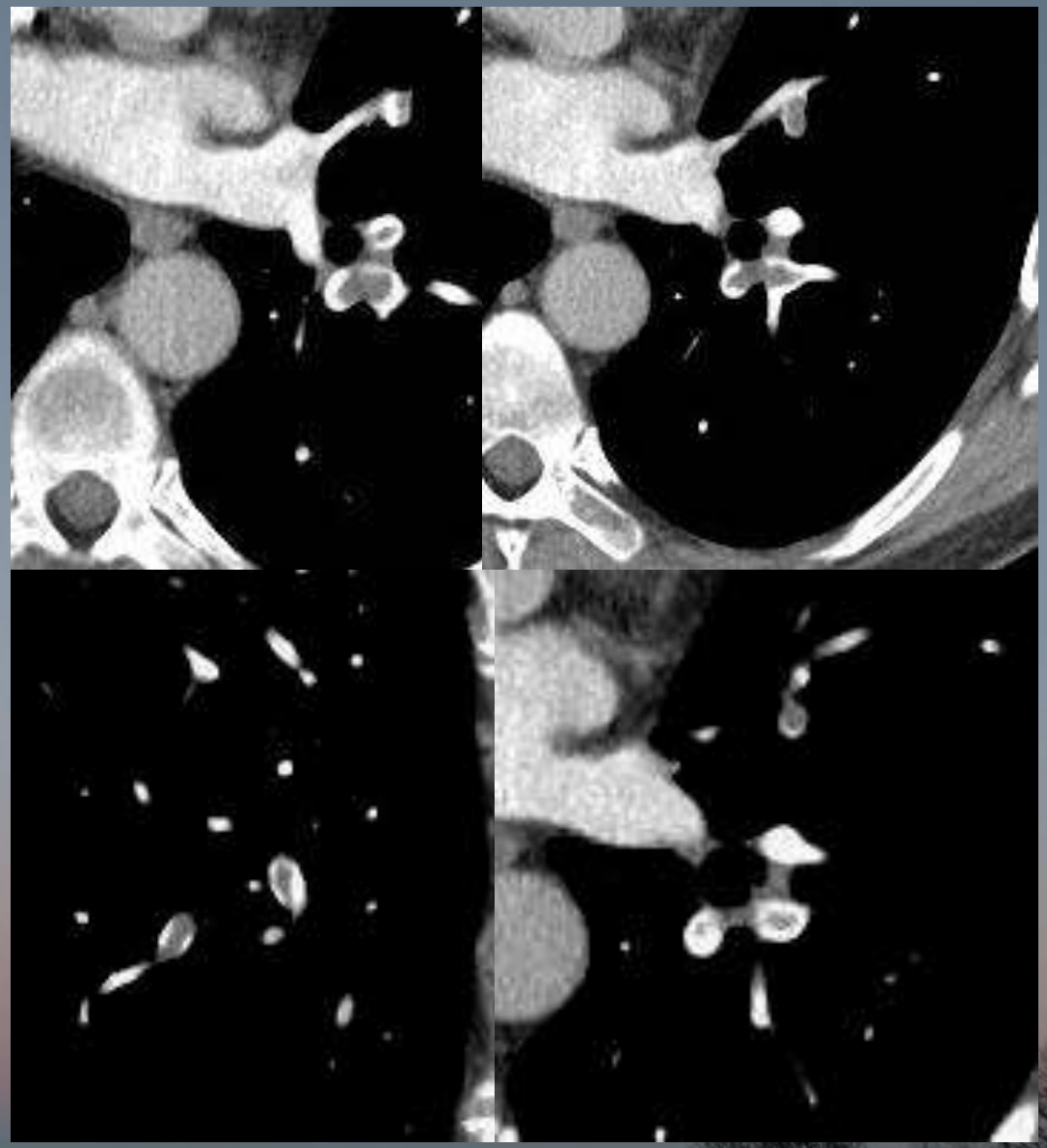
Imaging findings acute PE

- Filling defect in the pulmonary artery/ arteries, with contrast around
  - “railway track” or Polo sign
  - filling defects form acute angles within artery
- Total occlusion of an artery
- Peripheral wedge-shaped opacities “atoll sign”, infarction
- Signs of right heart strain

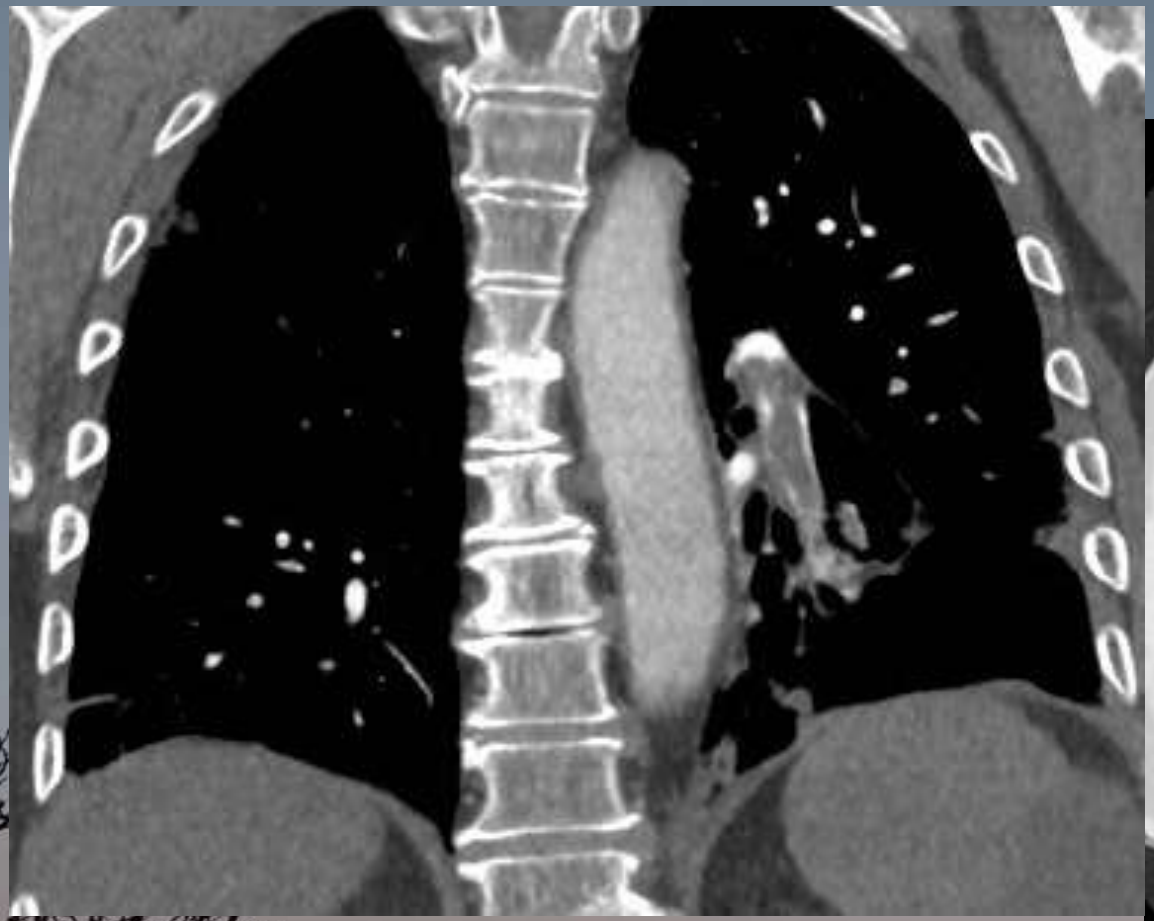
Wittram C. How I do it: CT pulmonary angiography. AJR Am J Roentgenol. 2007 May;188(5):1255-61.

Acute PE

- acute angles to thrombi
- contrast on both sides -"polo"
- local vessel size is same or enlarged

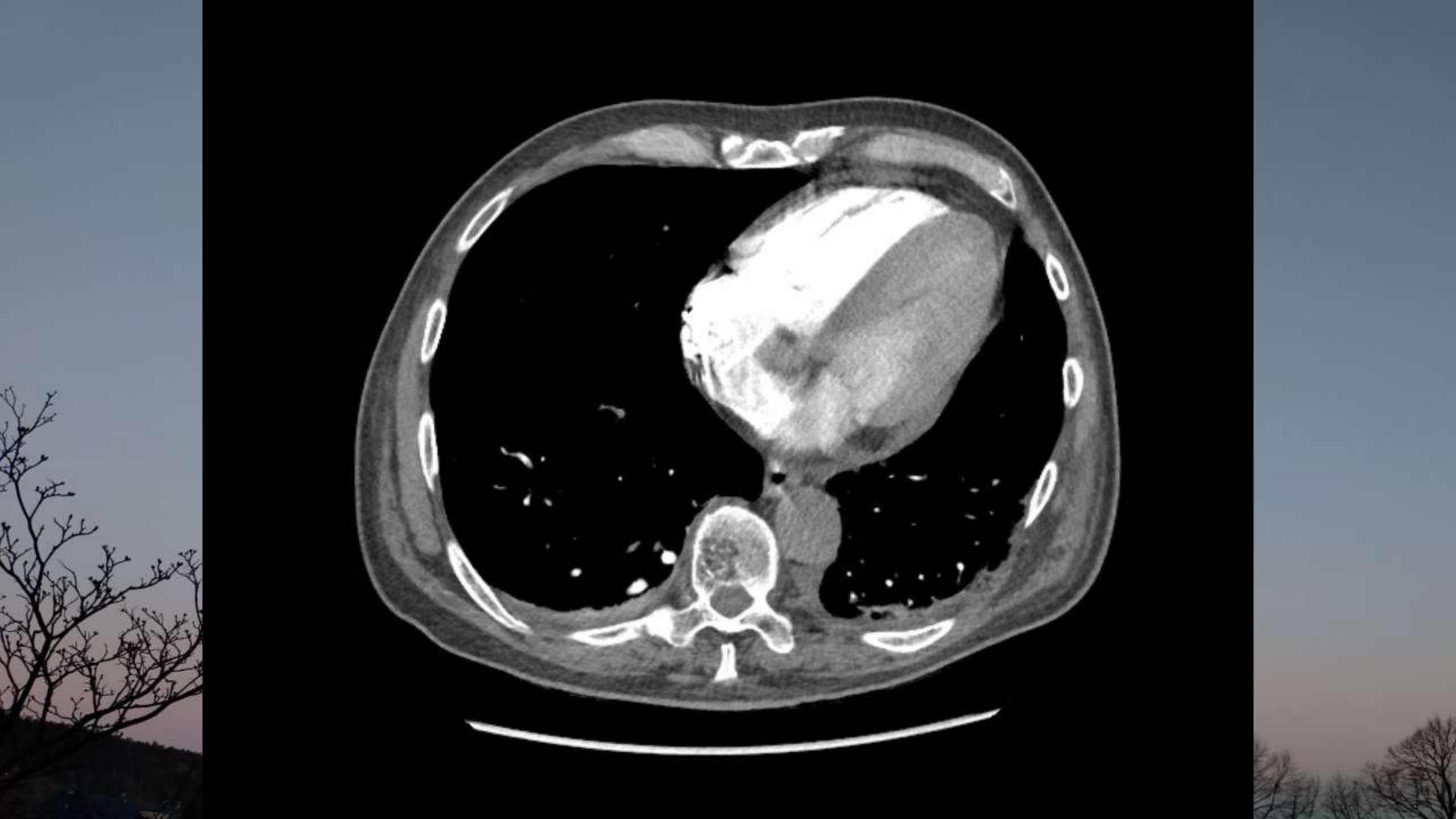


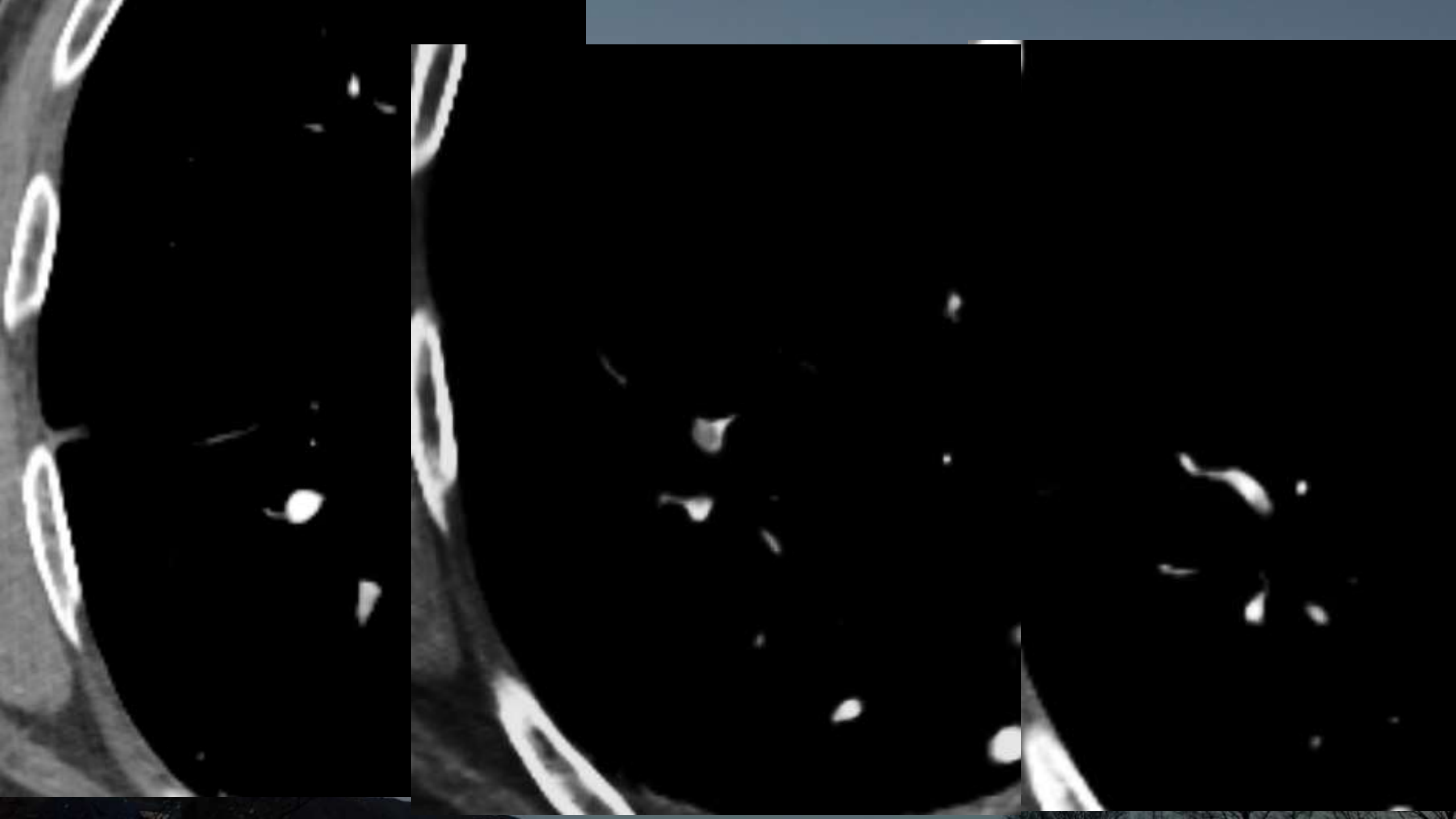
Addtional signs

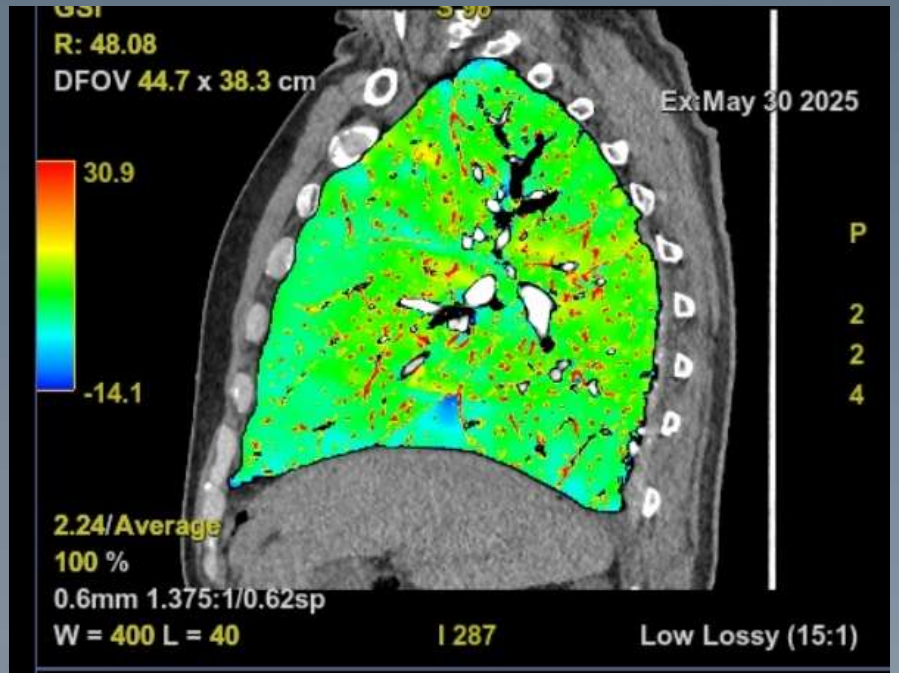


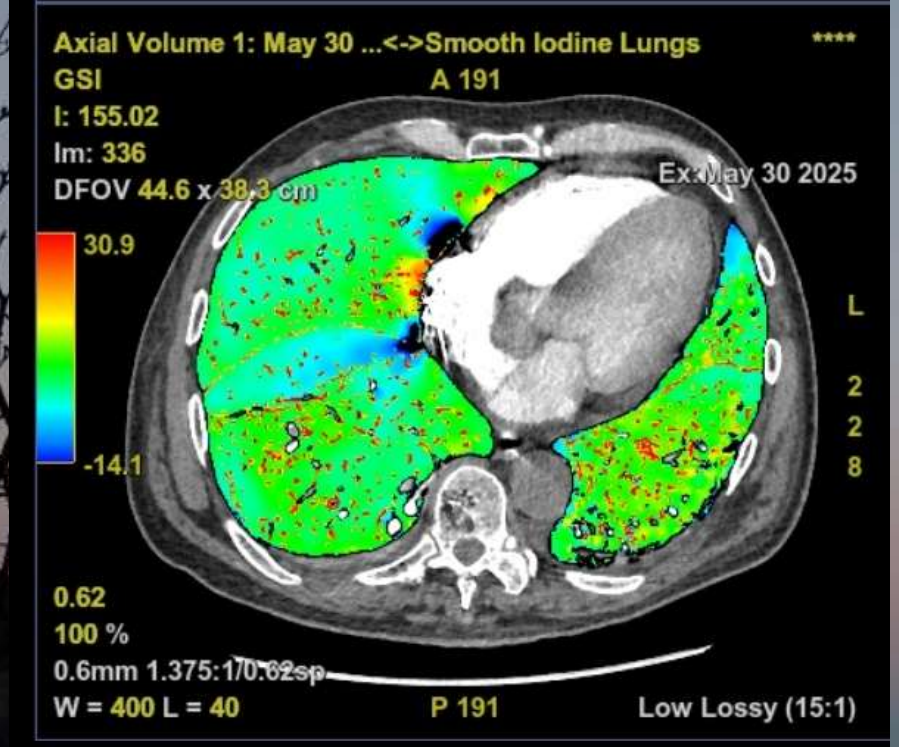
Atoll sign = lung infarction

* Godoy et al. The reversed halo sign: update and differential diagnosis Br J Radiol. 2012 Sep; 85(1017): 1226–1235.

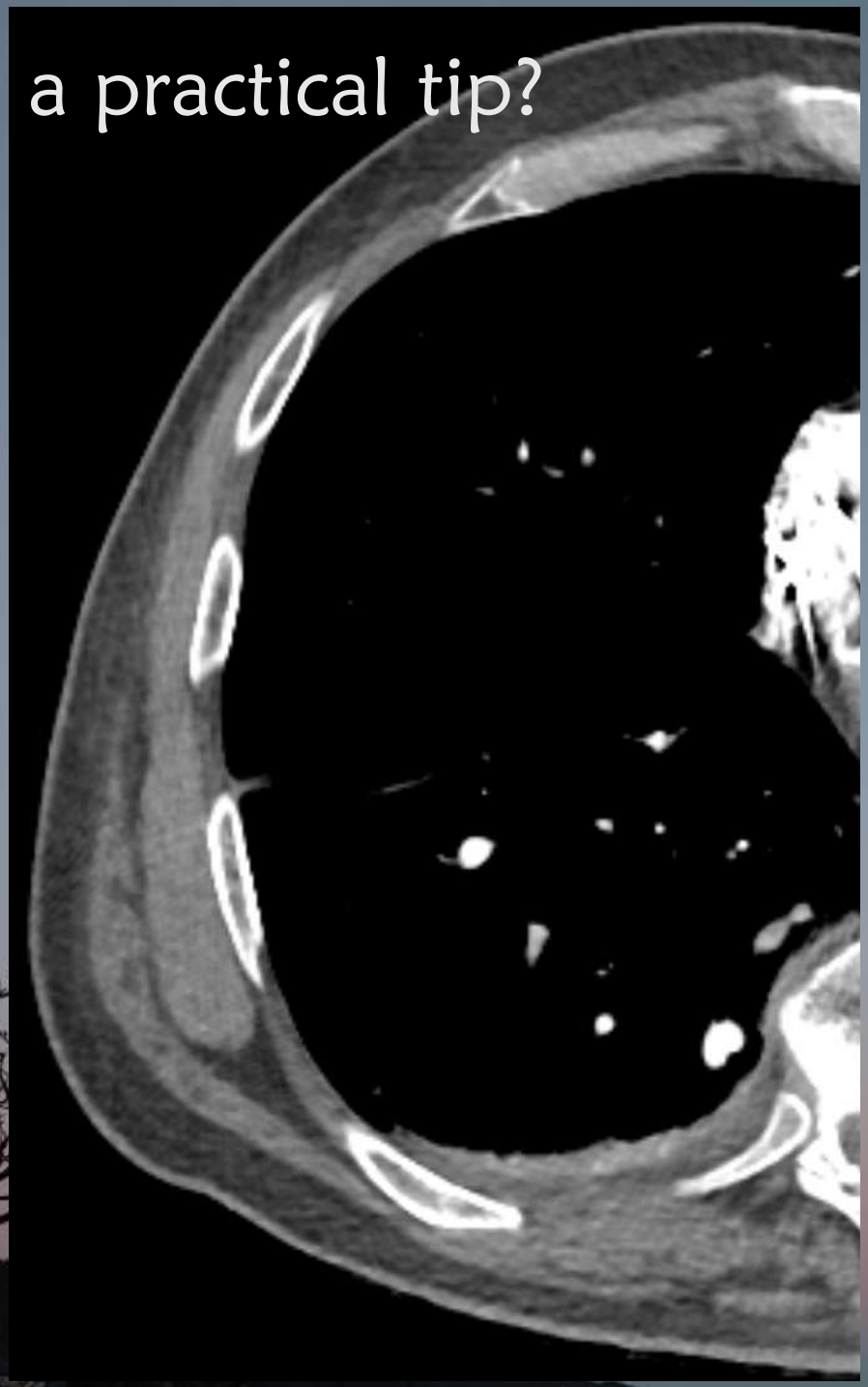


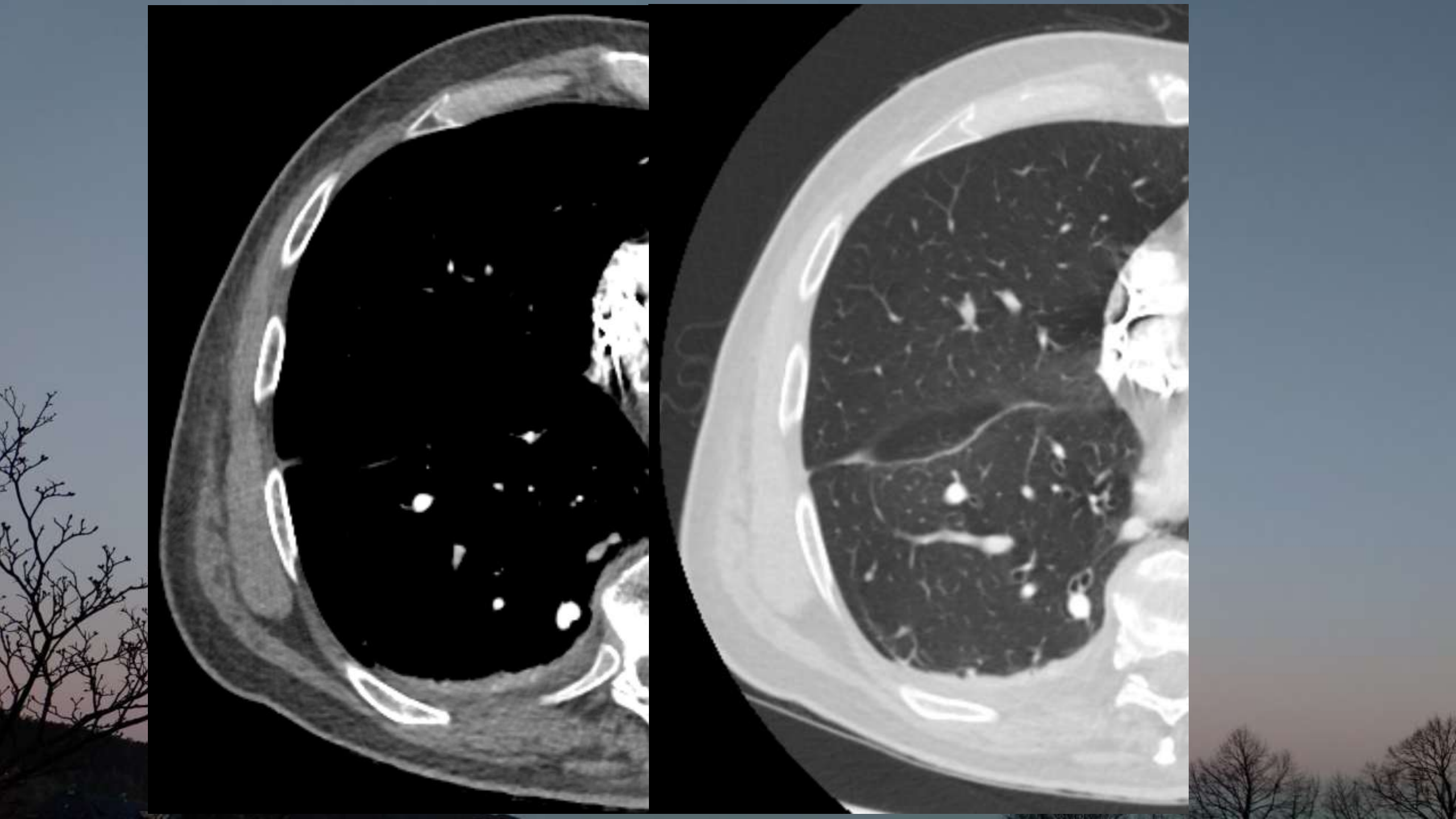



GSI
R: 48.08
DFOV 44.7 x 38.3 cm
Ex:May 30 2025
30.9
-14.1
P
2
2
4
2.24/Average
100 %
0.6mm 1.375:1/0.62sp
W = 400 L = 40
I 287
Low Lossy (15:1)


Axial Volume 1: May 30 ...<->Smooth Iodine Lungs
****
GSI
A 191
I: 155.02
Im: 336
DFOV 44.6 x 38.3 cm
Ex:May 30 2025
30.9
-14.1
L
2
2
8
0.62
100 %
0.6mm 1.375:1/0.62sp
W = 400 L = 40
P 191
Low Lossy (15:1)

a practical tip?





What else do we have to report??

5.2.2 Computed tomographic pulmonary angiography

CTPA parameters used to stratify the early risk of patients with PE are summarized in Supplementary Data *Table 3*. Four-chamber views of the heart by CT angiography can detect RV enlargement (RV end-diastolic diameter and RV/LV ratio measured in the transverse or four-chamber view) as an indicator of RV dysfunction. The prognostic value of an enlarged RV is supported by the results of a prospective multicentre cohort study in 457 patients.[184] In that study, RV enlargement (defined as an RV/LV ratio ≥0.9) was an independent predictor of an adverse in-hospital outcome, both in the overall population with PE [hazard ratio (HR) 3.5, 95% CI 1.6–7.7] and in haemodynamically stable patients (HR 3.8, 95% CI 1.3–10.9).[184] A meta-analysis of 49 studies investigating >13 000 patients with PE confirmed that an increased RV/LV ratio of ≥1.0 on CT was associated with a 2.5-fold increased risk for all-cause mortality [odds ratio (OR) 2.5, 95% CI 1.8–3.5], and with a five-fold risk for PE-related mortality (OR 5.0, 95% CI 2.7–9.2).[185]

ESC European Society of Cardiology
European Heart Journal (2020) 41, 543–603
doi:10.1093/eurheartj/ehz405
ESC GUIDELINES

2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS)

The Task Force for the diagnosis and management of acute pulmonary embolism of the European Society of Cardiology (ESC)

How to differentiate acute and chronic PE?

- Chronic PE
  - obtuse angles to thrombi
  - laminated thrombus

How to differentiate acute and chronic PE?

- Chronic
  - obtuse angles to thrombi
  - laminated throm.
  - vessel size distal to thrombus reduced
  - mosaic pattern

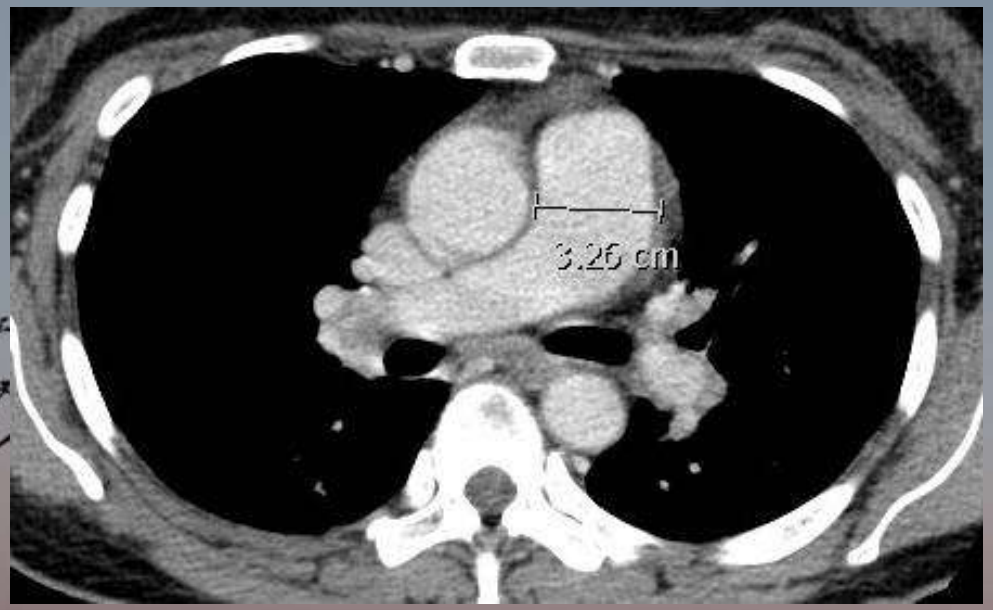
Additional findings which indicate chronicity

- Vascular
- Cardiac
- Upper abdominal
- Lung

- All findings indicate **pulmonary hypertension**
- Sometimes thrombus are not visible

1st vascular sign

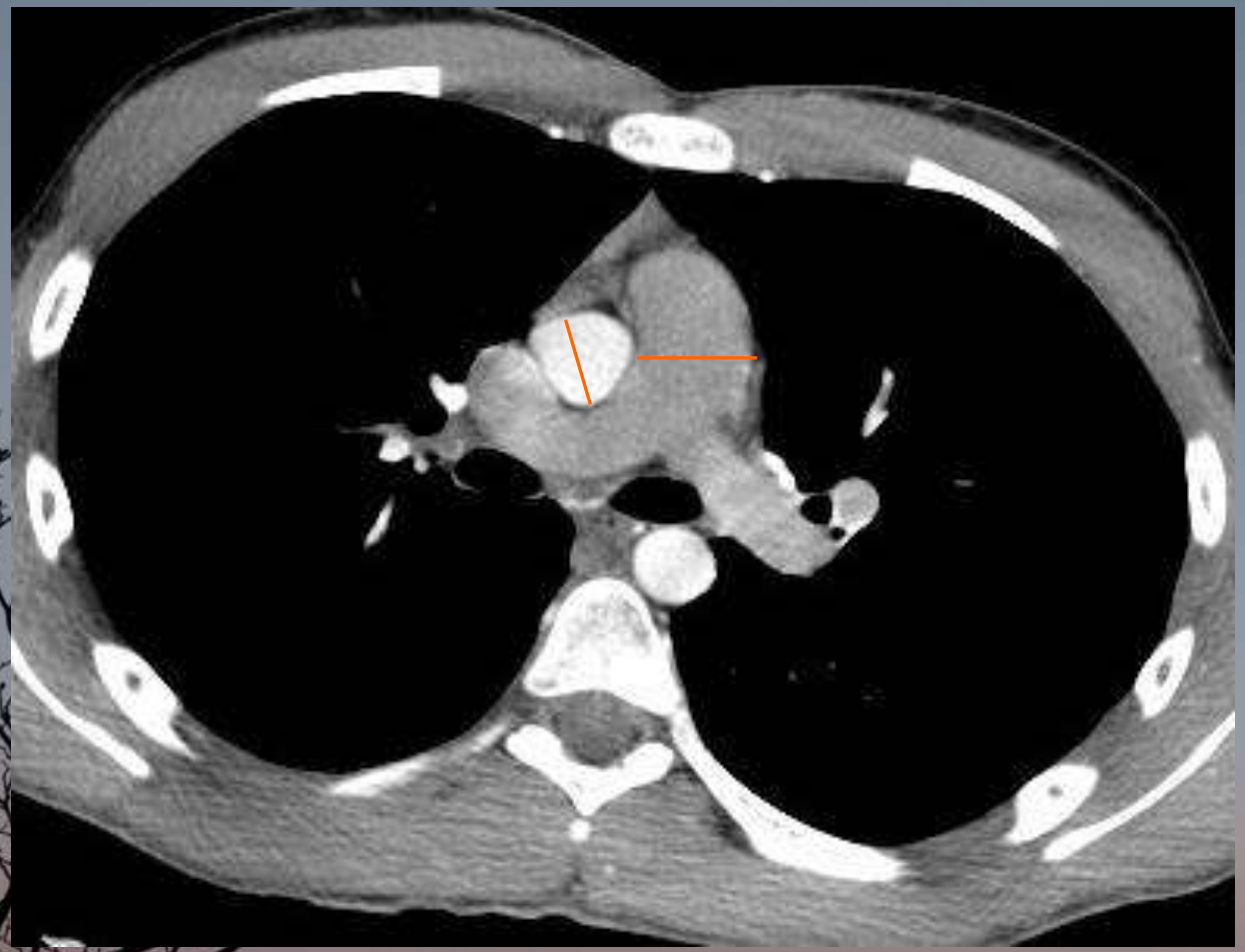
- Dilatation of pulmonary artery trunk
  - for men >29mm, for women >27mm (sens 87%, spec 89%)*
  - in patients with interstitial lung disease : >25mm, (sens 86%, spec 41%)**
  - in patients without ILD:> 31.6 mm (sens 47%, spec 93%)



* Tan et al.1998, 93 pts, and Truong et al. 2012, 3171pts

**Alhamad et al. 2011

2nd vascular sign

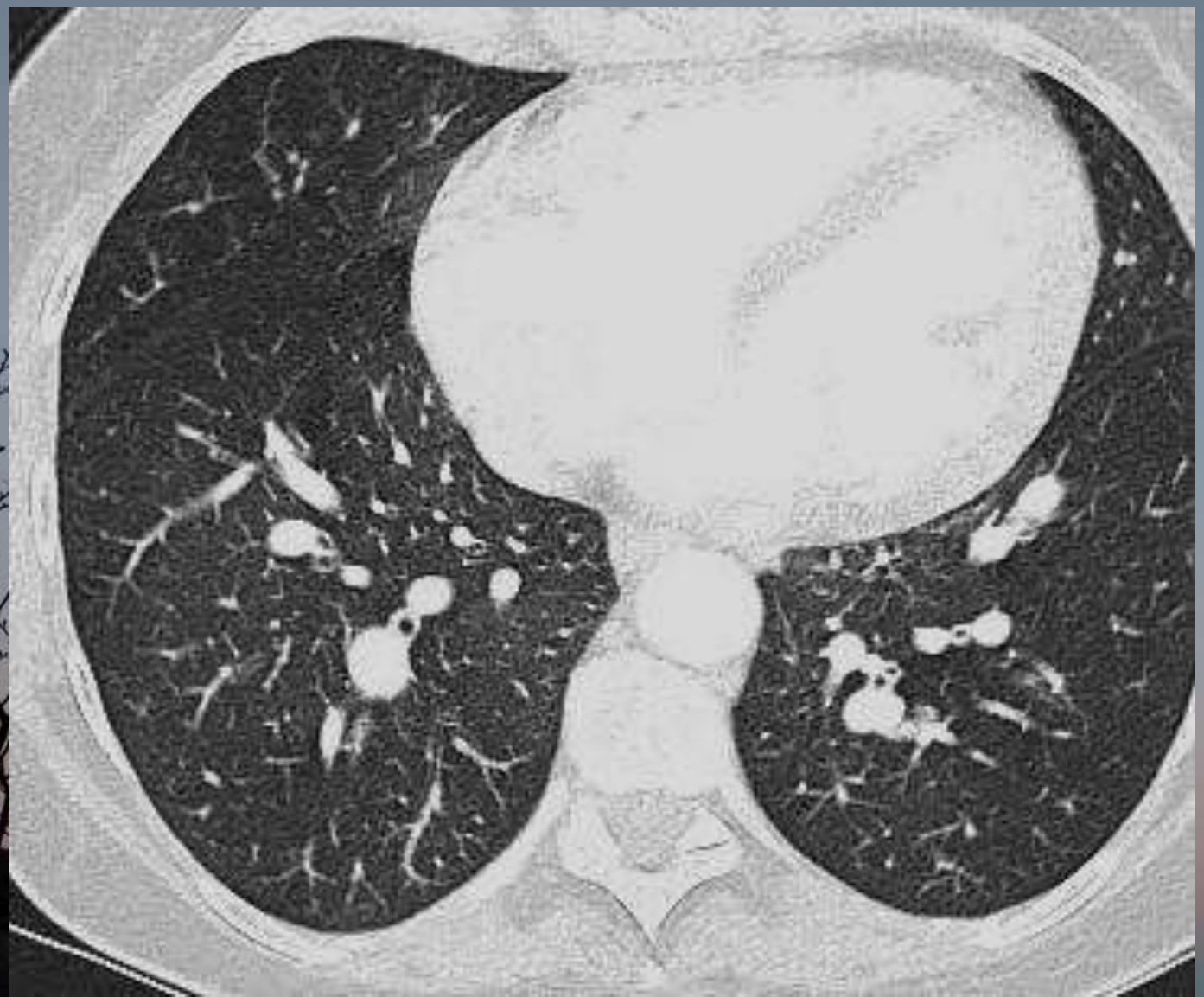


- Ratio of the main pulmonary artery to ascending aorta = PA/Ao
- measured at level of PA bifurcation ratio>1 (sens 70%, spec 92%)
- also suggested > 0.9 , as the aorta enlarges with age **

*Ng et al. 1999, and Truong et al. 2012,

** Alhamad et al. 2011

3rd vascular sign



- Segmental artery to adjacent bronchus
- ratio > 1
  - in more than three segment or lobes
  - use when seen in addition to dilated PA
  - 100% specificity

*Tan et al. 1998.

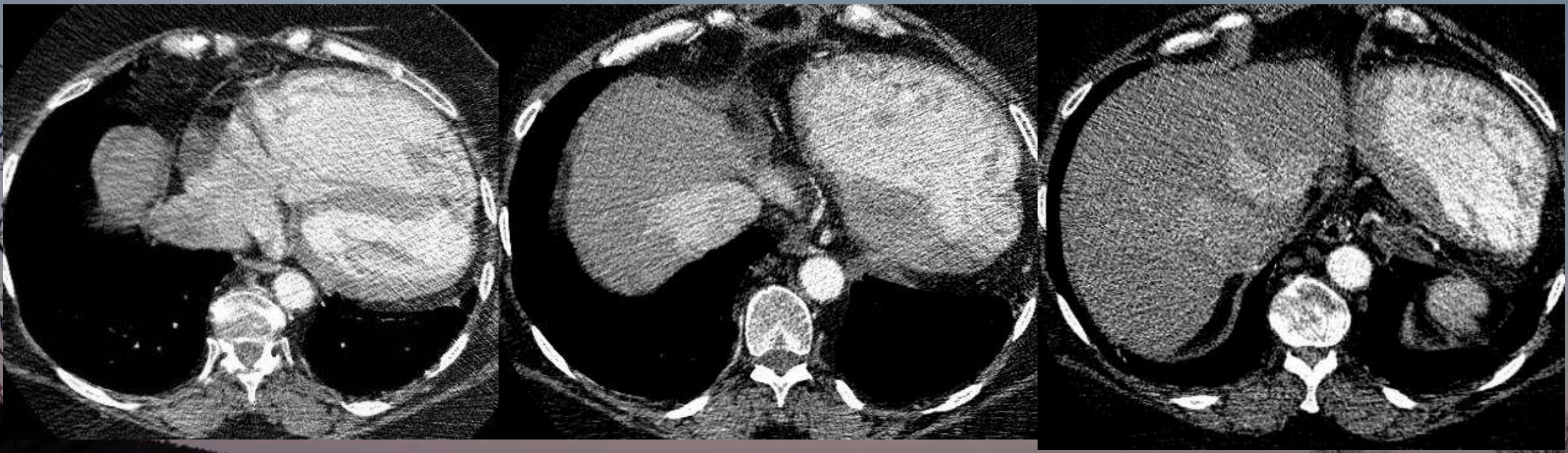
Cardiac signs

- Non gated axial images
  - Straightening/bowing of the interventricular septum
  - Ratio of the right to left ventricular diameter; RV/LV > 1
- On gated images
  - On cardiac 4 chamber views, RV/LV> 0.9
  - Diastolic right ventricular free wall thickening >4mm
  - Right pulmonary artery distensibility less than 16%, pathological

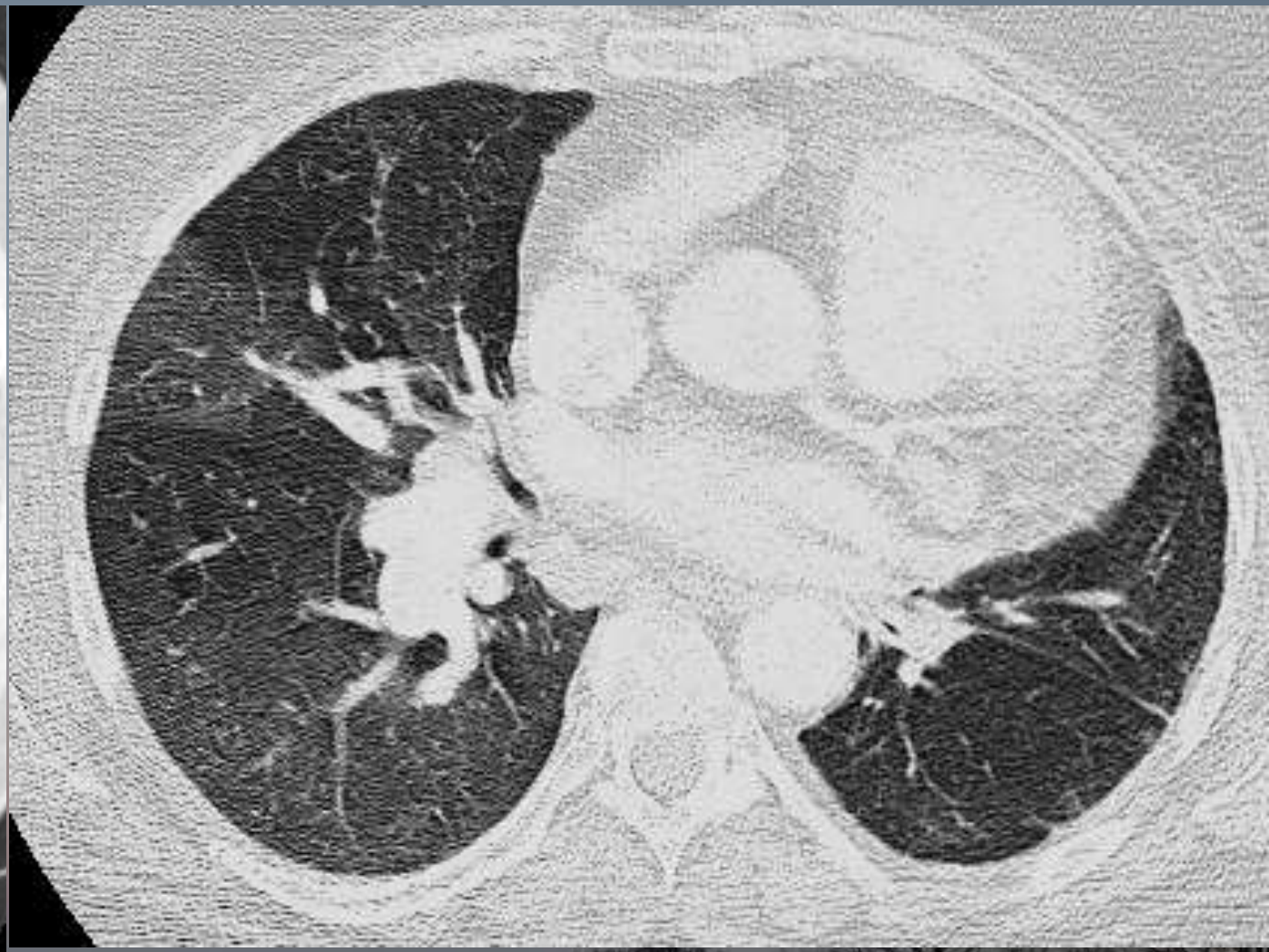
*Ng et al. A CT sign of chronic pulmonary arterial hypertension: the ratio of main pulmonary artery to aortic diameter. J Thorac Imaging. 1999 Oct;14(4):270-8. and ** Revel et al. Pulmonary hypertension: ECG-gated 64-section CT angiographic evaluation of new functional parameters as diagnostic criteria.. Radiology. ;250(2):558-66.

Upper abdominal

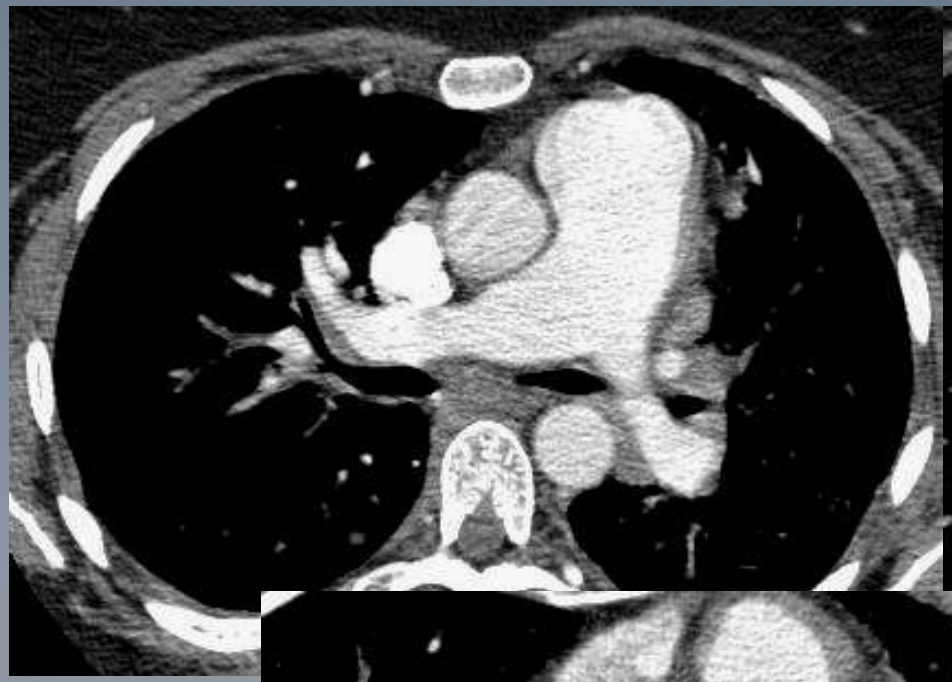
- Contrast reflux into the inferior vena cava and hepatic veins

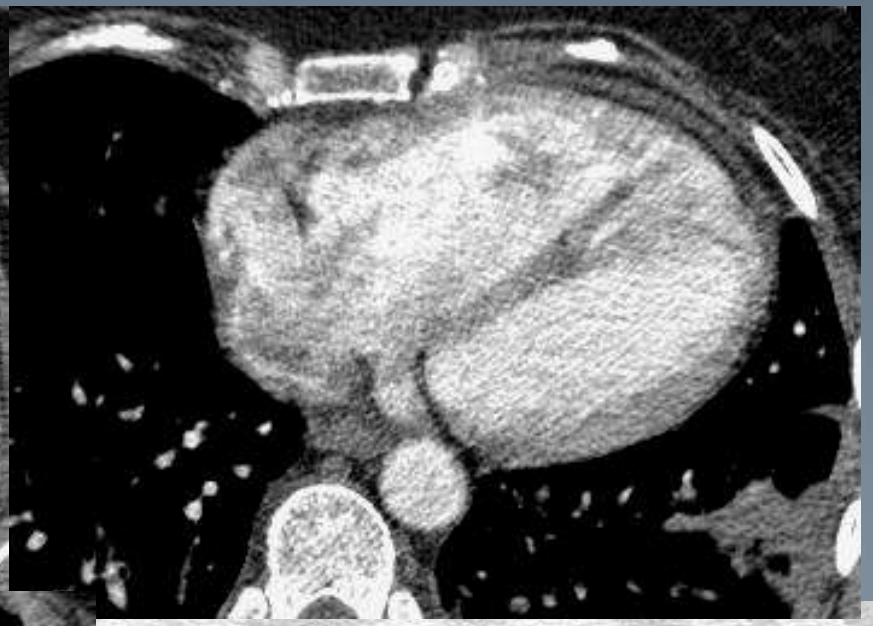


Lung findings: After some time; chronic obstruction causes oligemia → patchy areas of dark and white: mosaic pattern

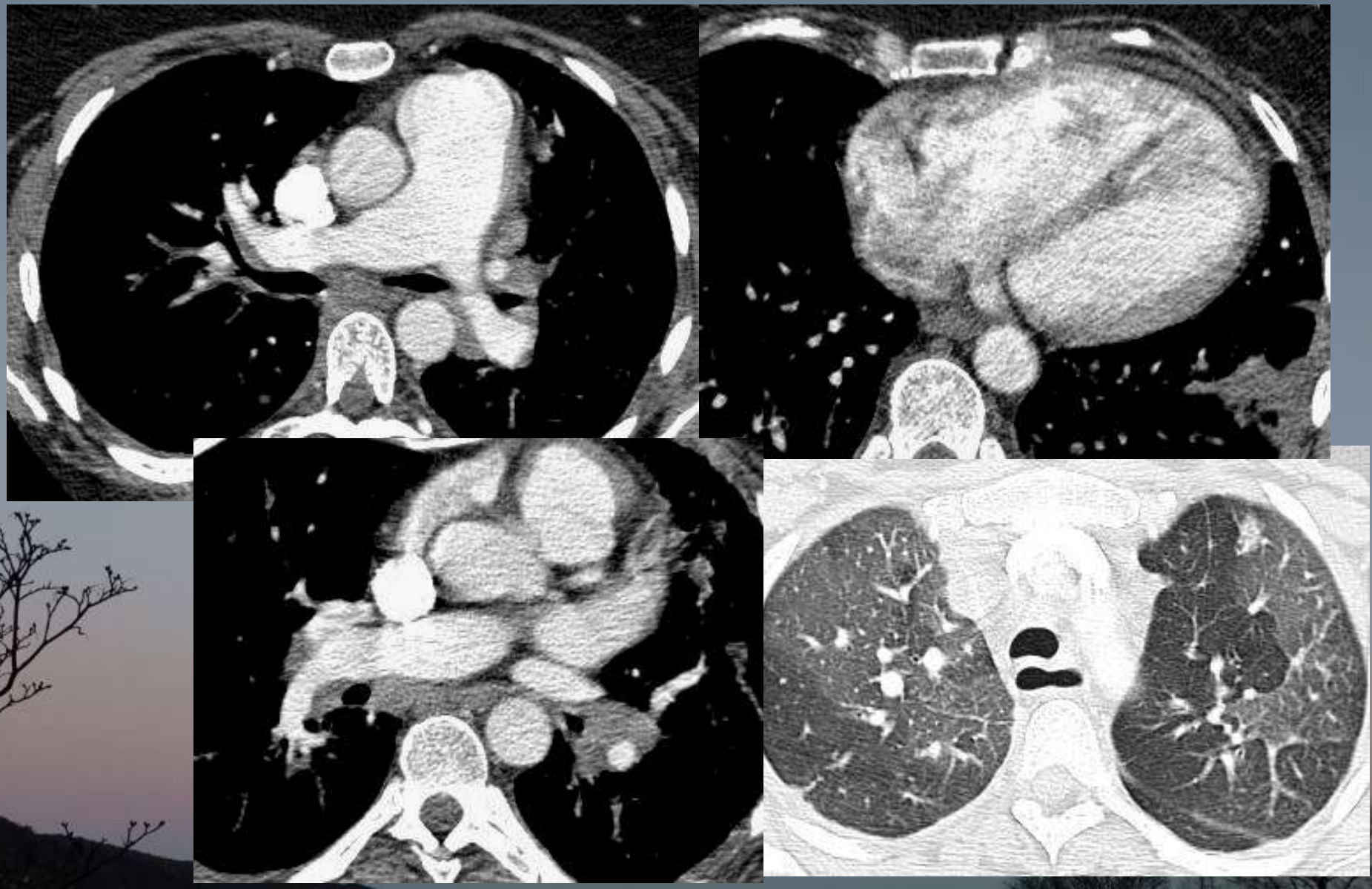


Visible (or non visible) chronic PE, and PA/Ao, RV/LV and mosaic pattern: CTEPH

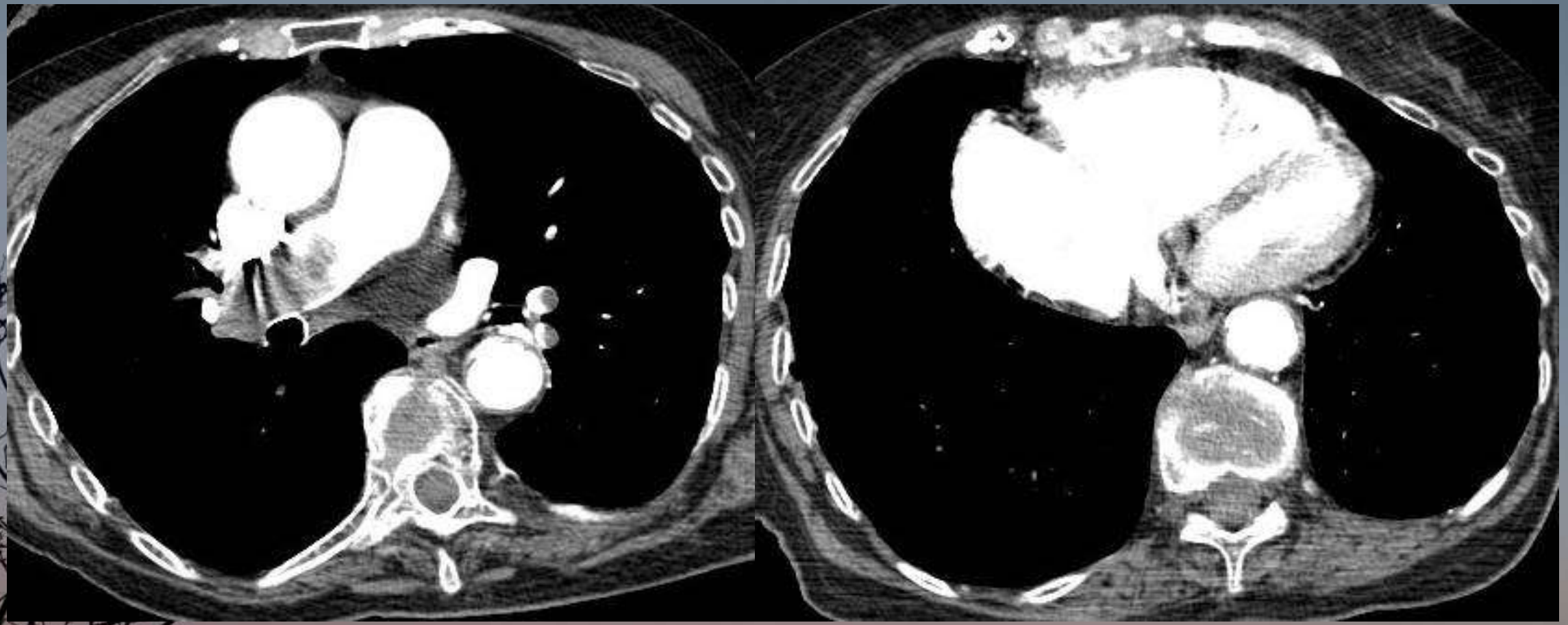




Chronic ThromboEmbolic Pulmonary Hypertension

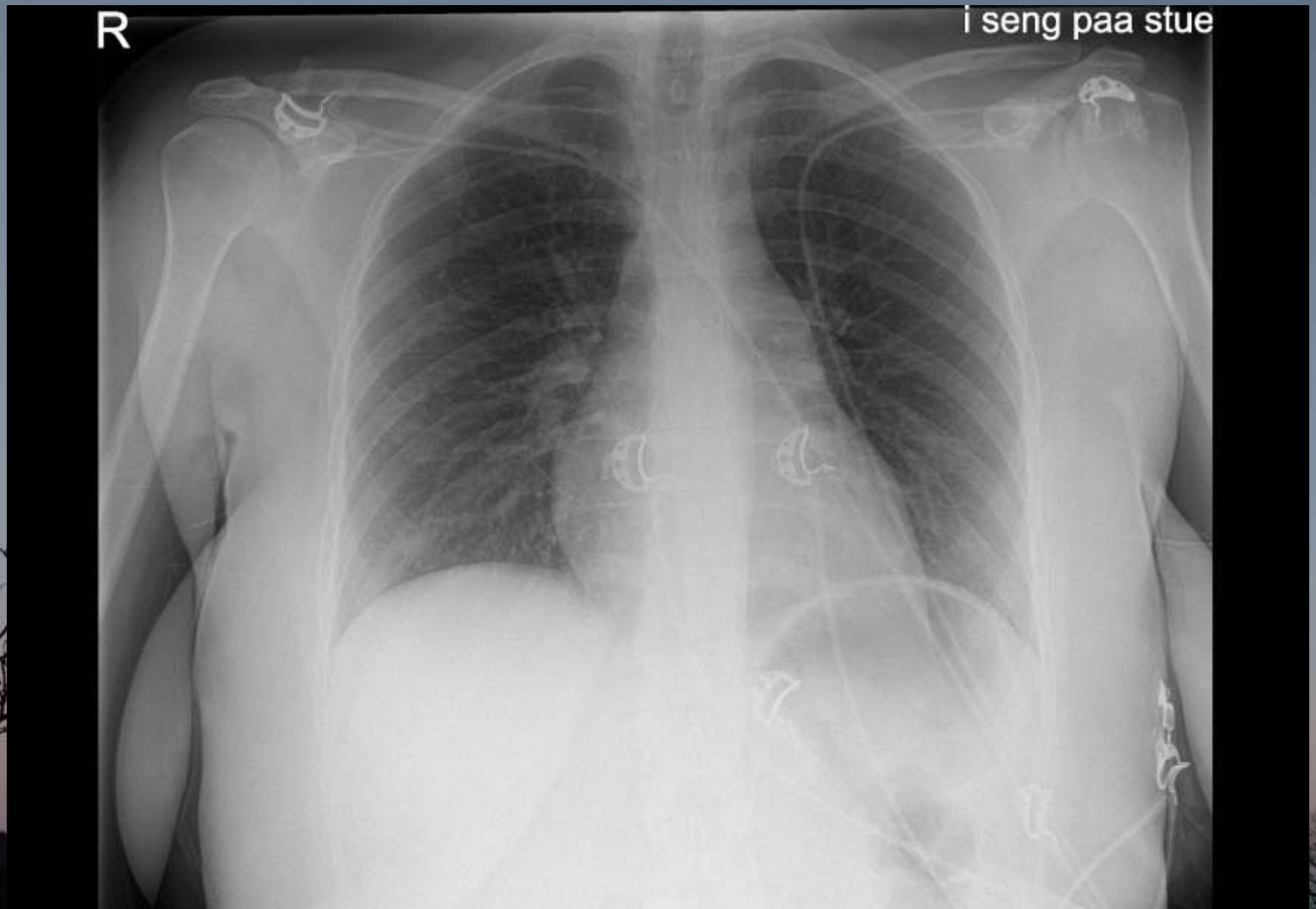


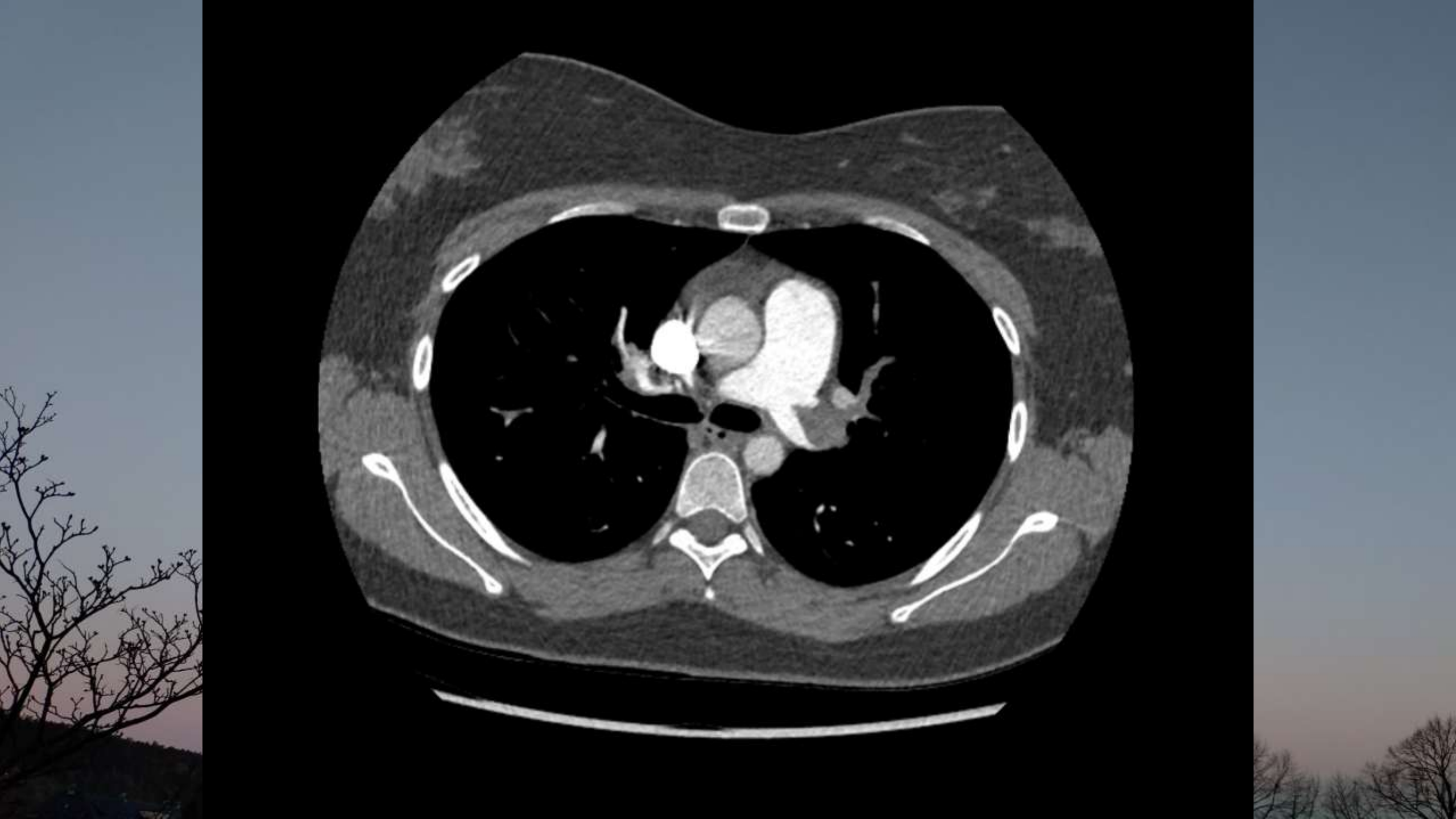
88 yr old female, increasing dyspnea, previous history of pulmonary embolism

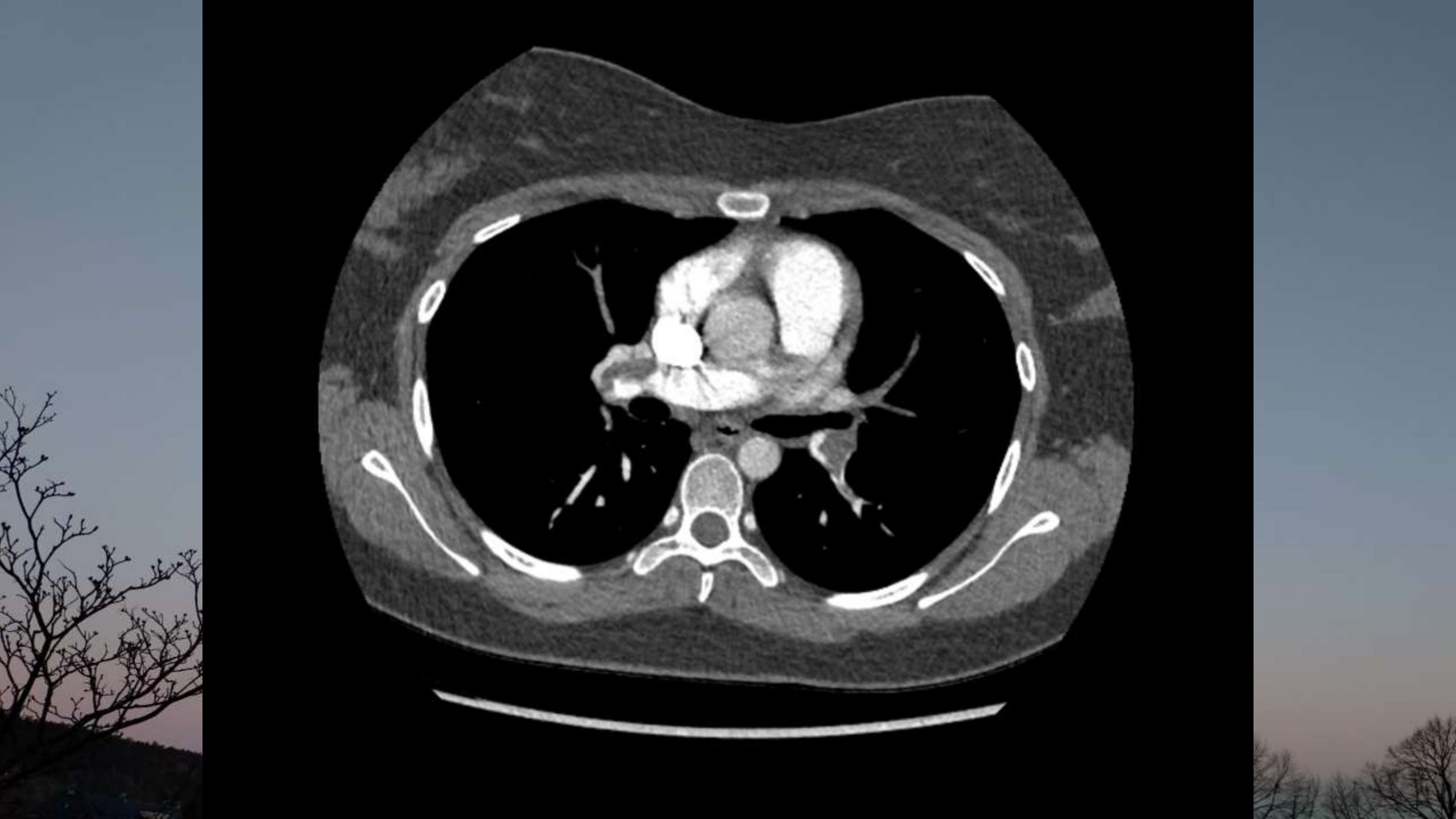


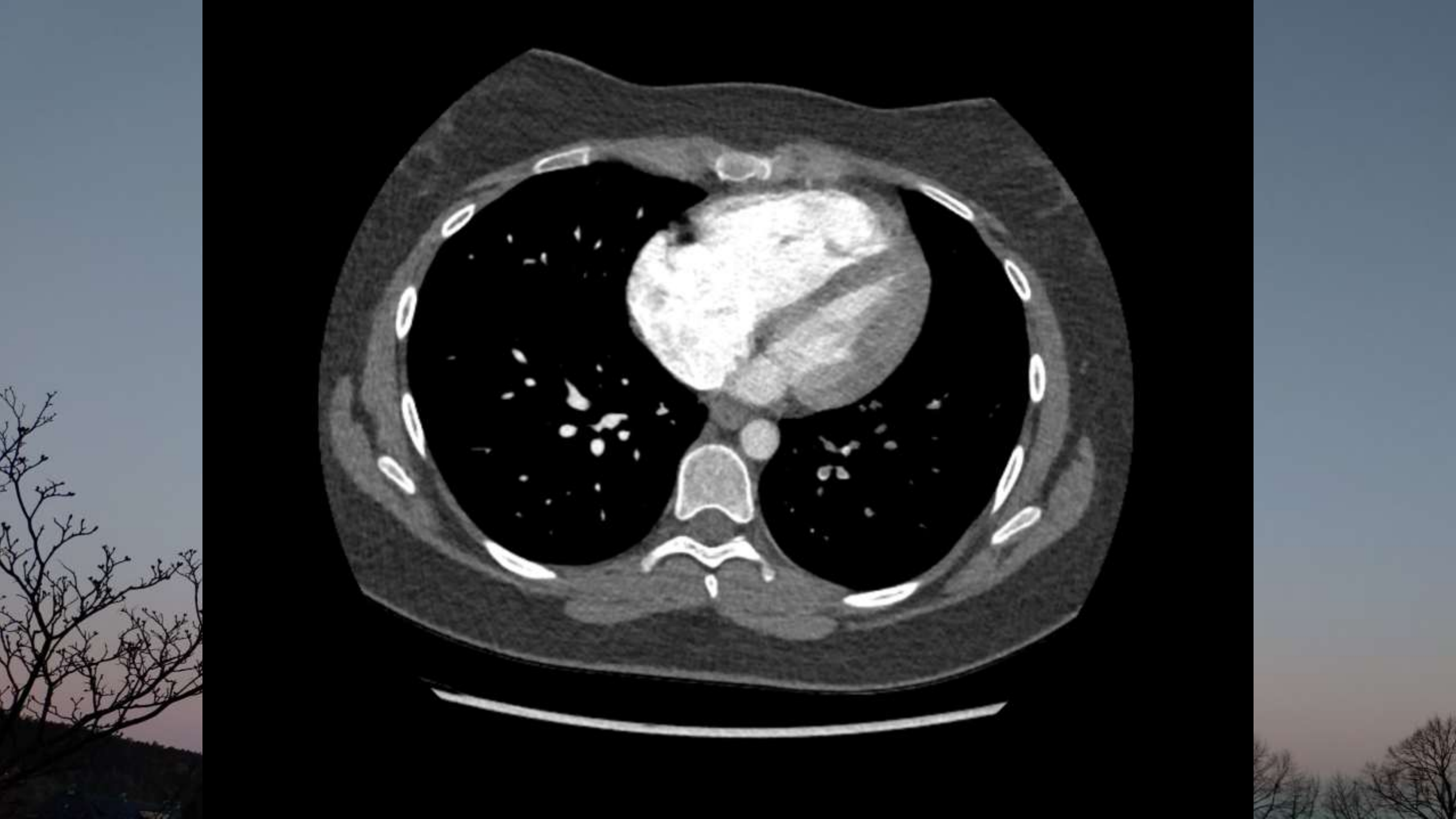
chronic embolus and vascular + cardiac signs

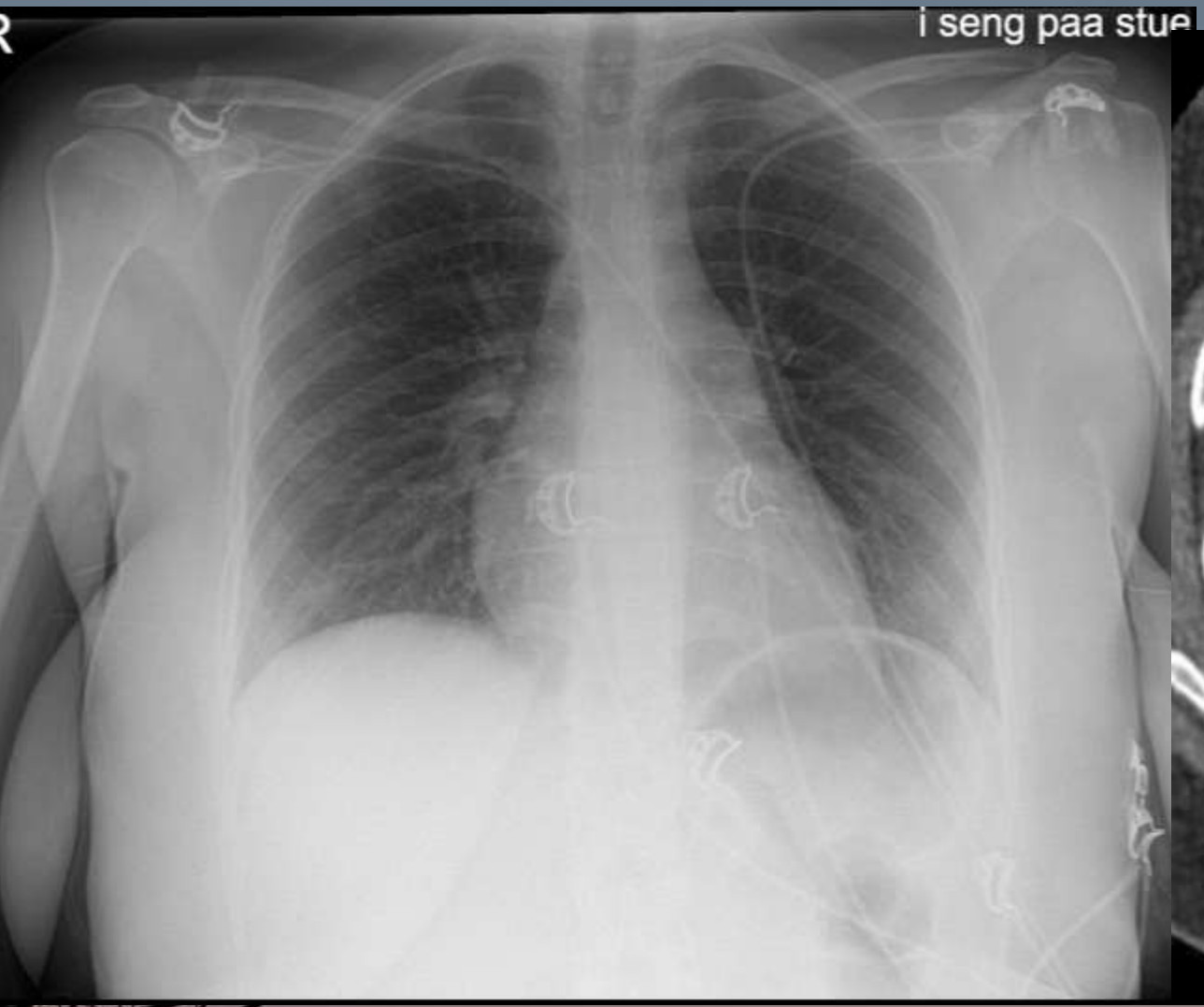
Last case: Sinus tachycardia, dyspnea, Troponin>500










R
i seng paa stue

Take home

- PE mortality has increased since the pandemic.
- Consider using specific W/L when reporting

- If you find PE, look for right ventricular dysfunction.

- Do not confuse chronic for acute PE.
- Remember the signs to look for (vascular, cardiac, lungs)

Thank you!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