



Imperial College
London



υπό την αιγίδα των
Ομάδων Εργασίας Πνευμονολογίας,
Απεικονιστικών Τεχνικών και
Εκπαιδευτικής Αντιμέτωπης της
Ελληνικής Καρδιολογικής Εταιρείας

1ο ΣΥΝΕΔΡΙΟ ΚΑΡΔΙΑΓΓΕΙΑΚΗΣ ΑΠΕΙΚΟΝΙΣΗΣ ΣΤΗΝ ΚΛΙΝΙΚΗ ΠΡΑΞΗ

12-14 | 5 | 2016
HILTON, ΑΘΗΝΑ



Οξεία & Χρόνια Πνευμονική Εμβολή: Ο βασικός ρόλος της καρδιαγγειακής απεικόνισης

Αναστασία Ανθη

Β' Κλινική Εντατικής Θεραπείας & Ιατρείο Πνευμονικής Υπέρτασης
Π.Γ.Ν. «ΑΤΤΙΚΟΝ»

Disclosures

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Epidemiology of pulmonary embolism

Venous thrombo-embolism (VTE)

which includes deep-vein thrombosis
and pulmonary embolism

- is the **third** most common cause
of vascular disease–related deaths
after myocardial infarction and stroke

30-day all-cause mortality : 9% - 11%

three-month mortality : 8.6% - 17%

Registries and hospital discharge datasets of unselected patients

Epidemiology of pulmonary embolism

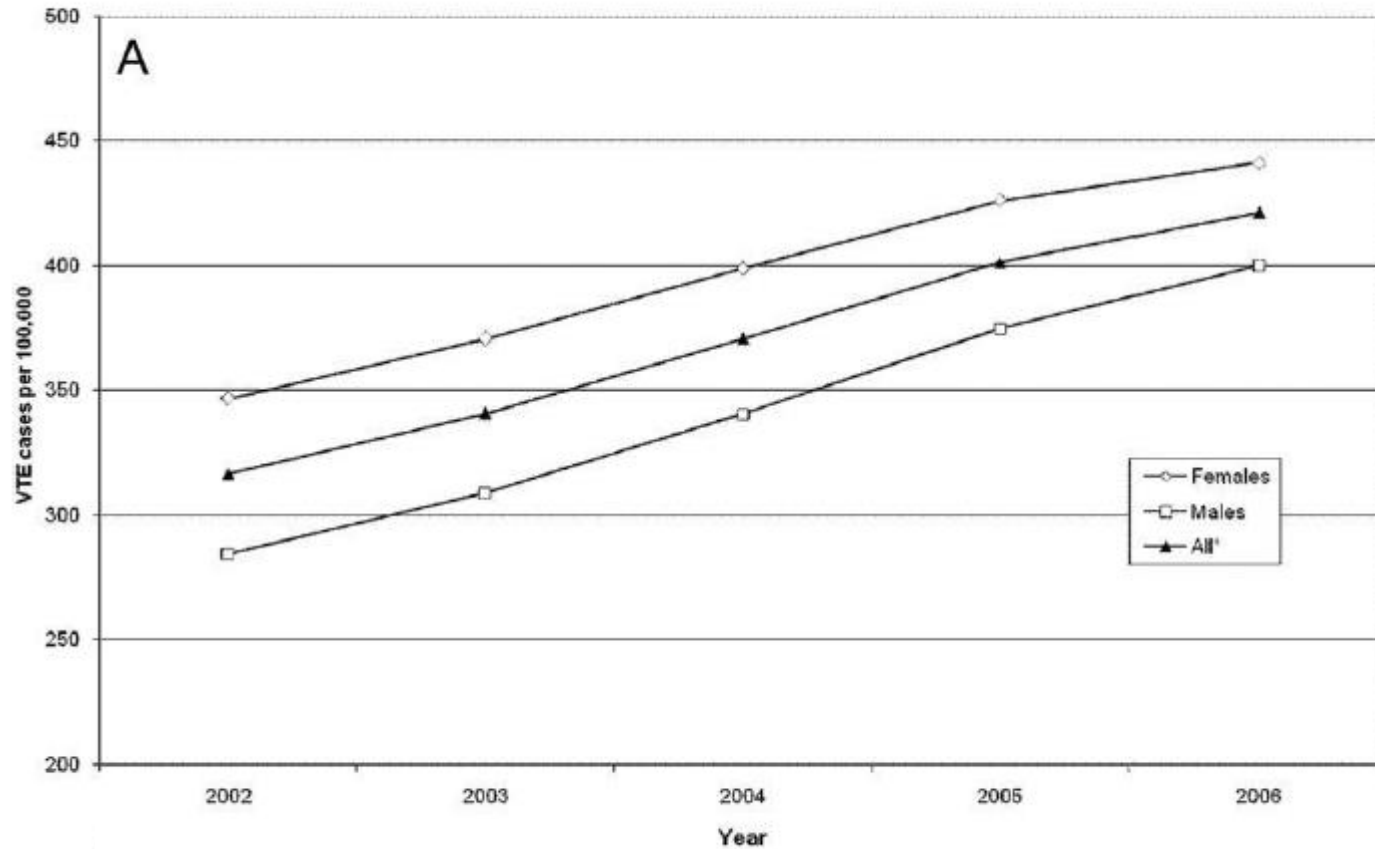
Venous thrombo-embolism (VTE)

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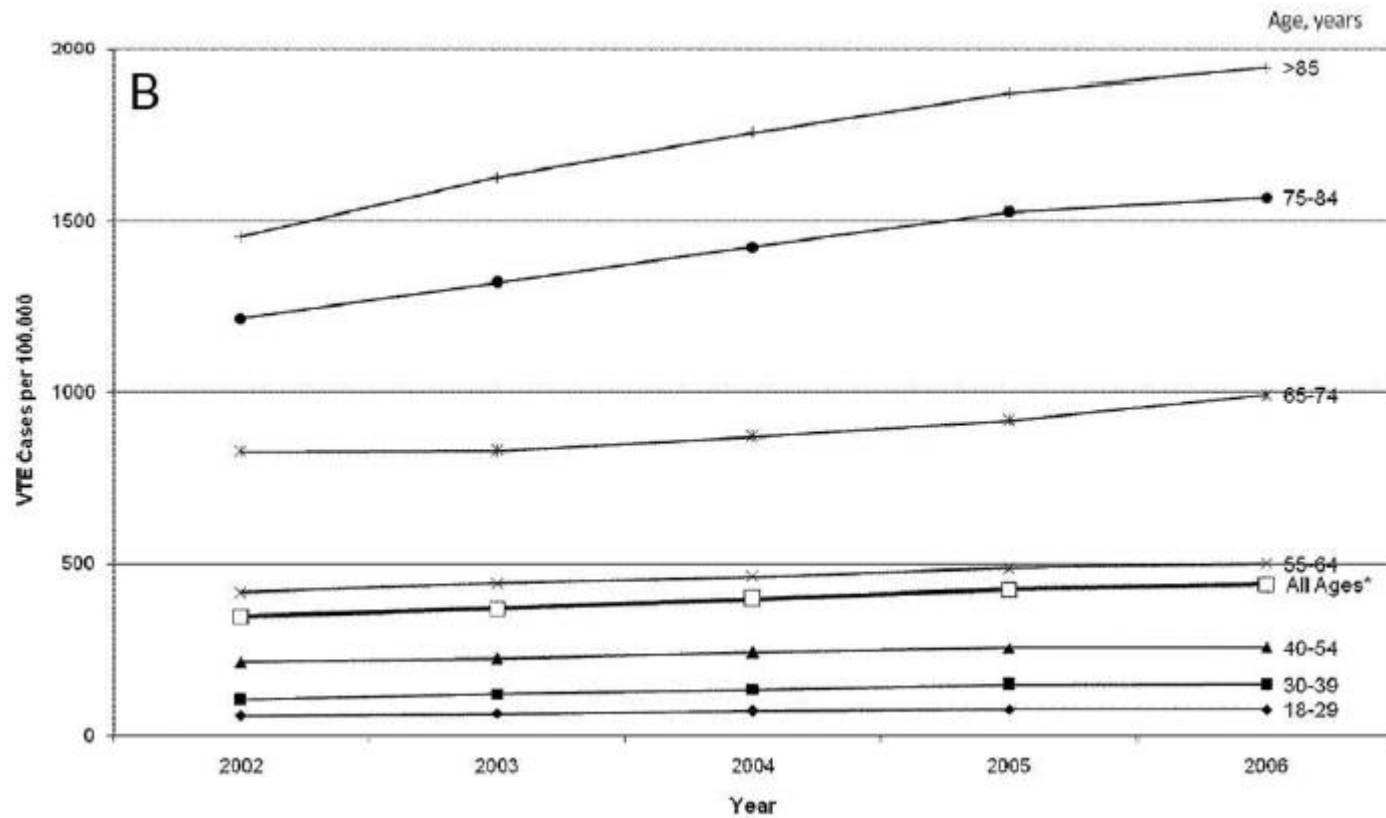
- is the **third** most common cause
of vascular disease–related deaths
after myocardial infarction and stroke

- with an annual incidence of
1 - 2 cases / 1000 in the general population
- is increasingly prevalent despite efforts to prevent the disease

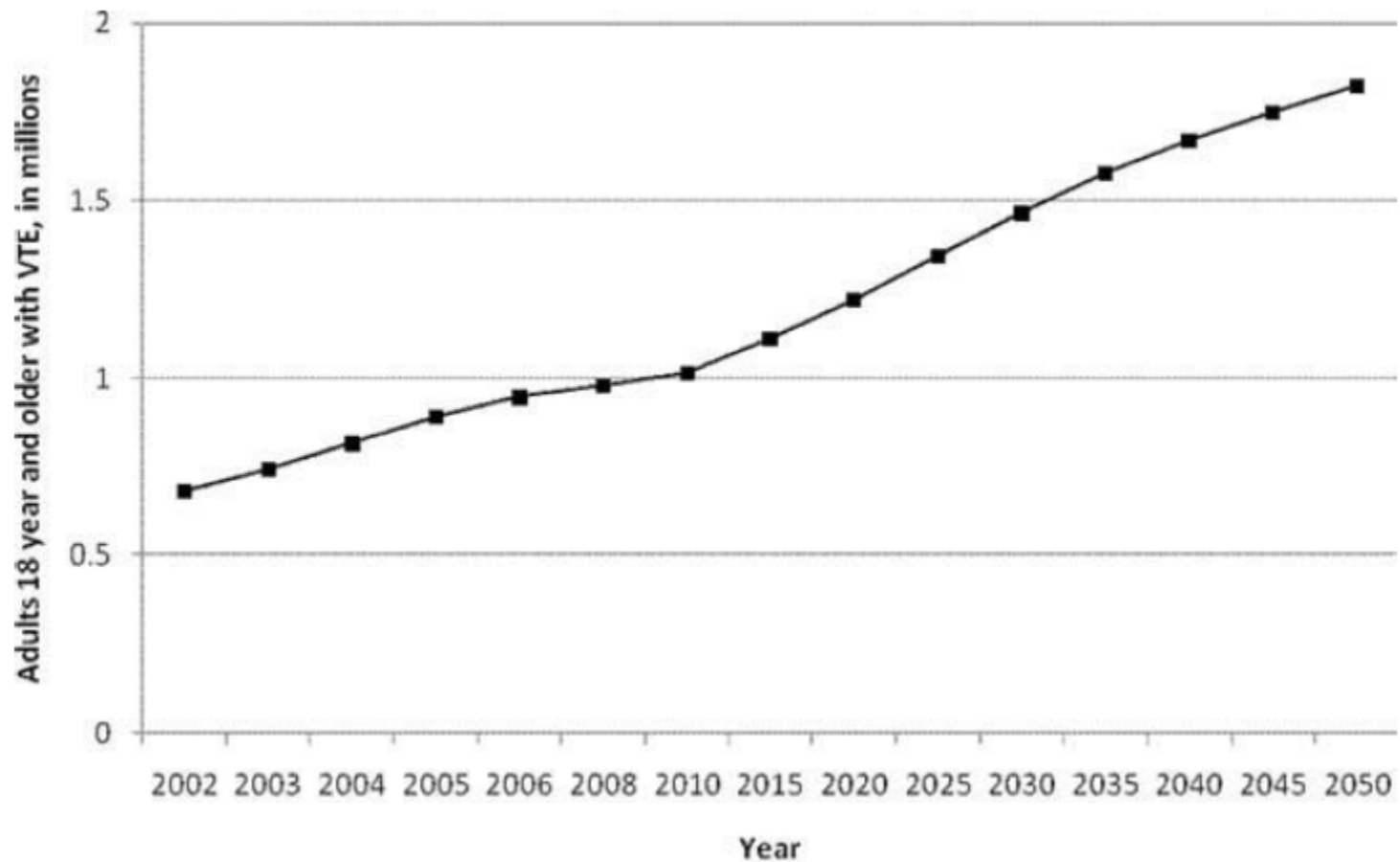
Prevalence of clinical venous thromboembolism in the USA (2002 - 2006)



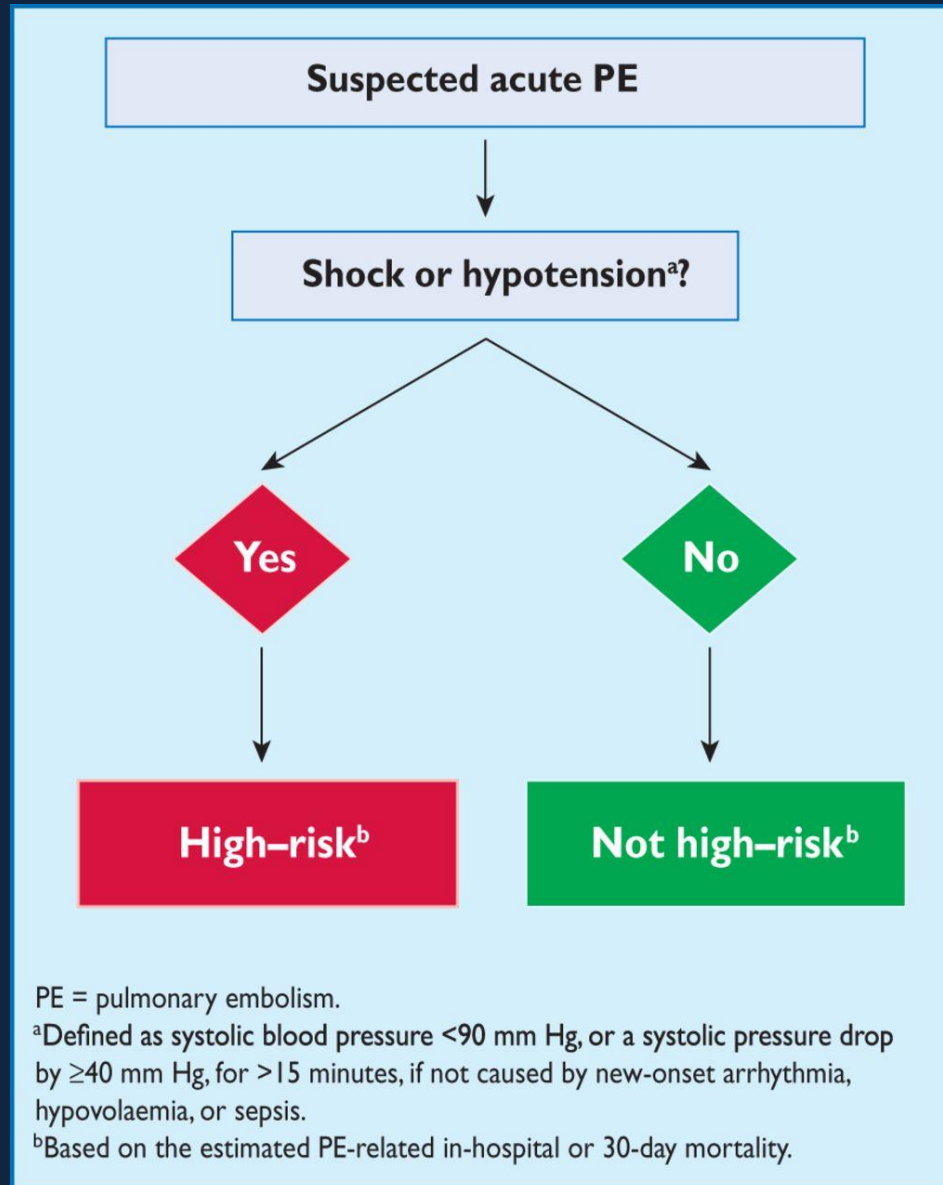
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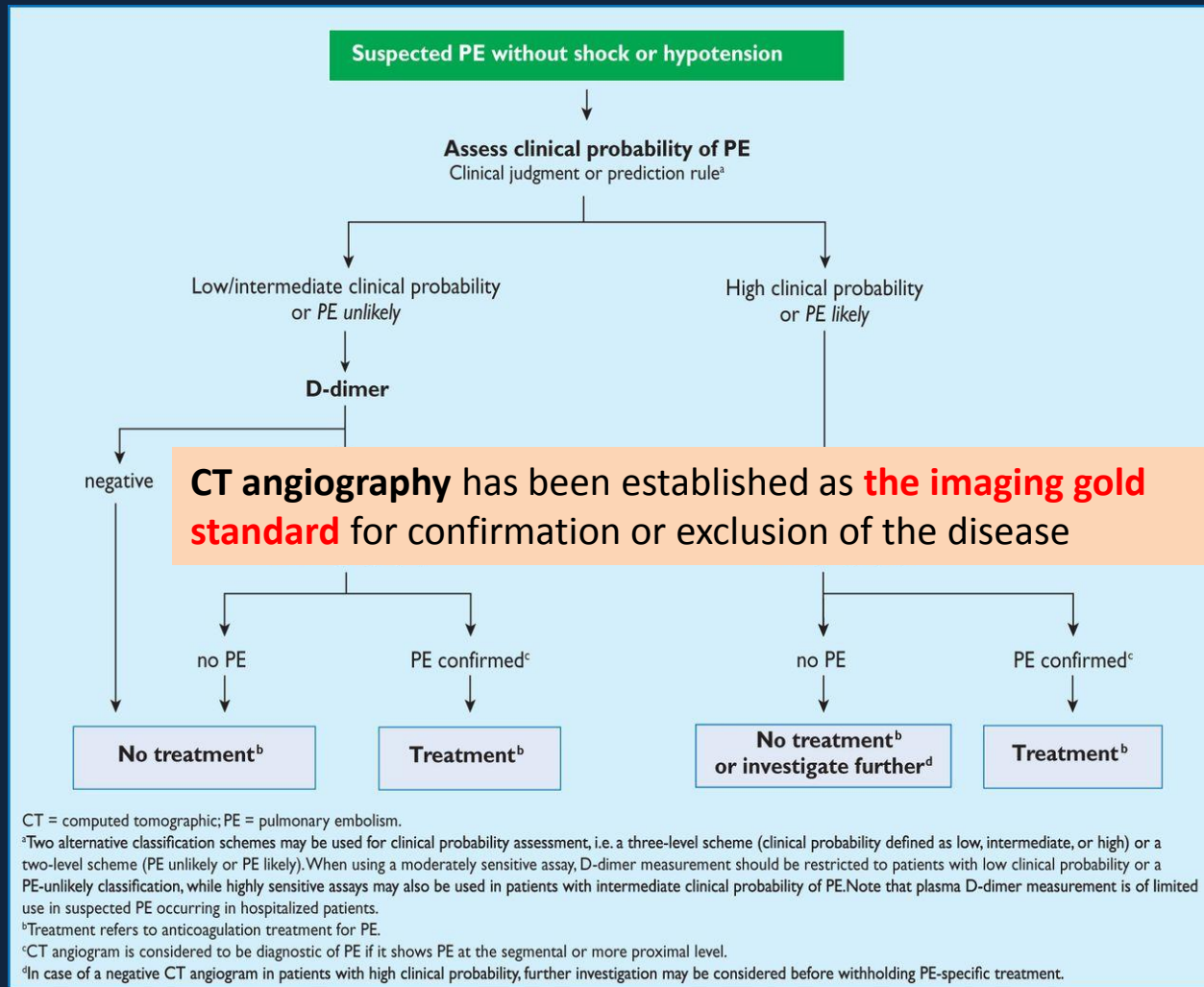
Prevalence of clinical venous thromboembolism in the USA



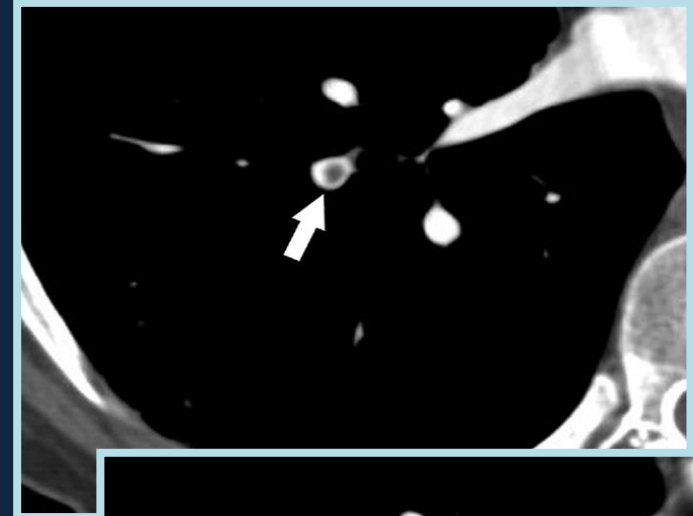
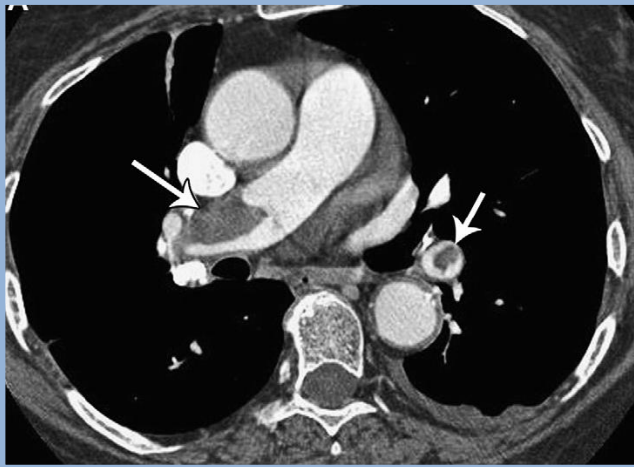
Initial risk stratification of acute PE



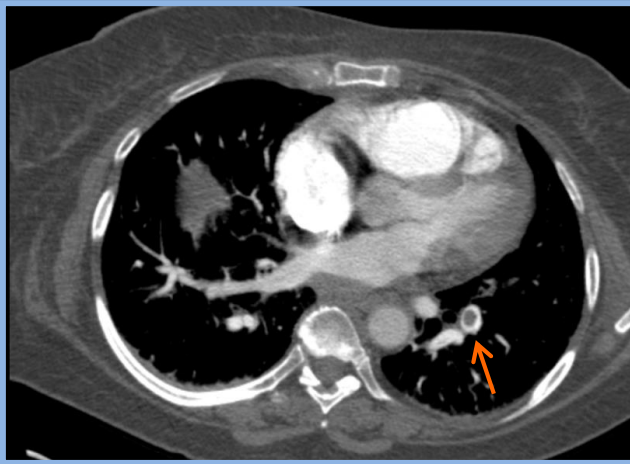
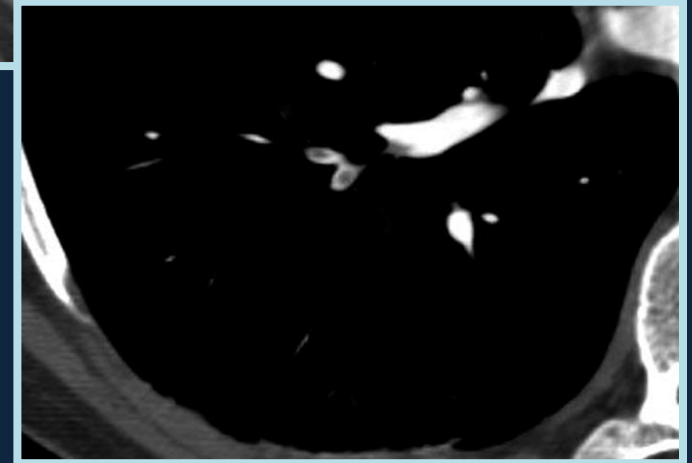
Proposed diagnostic algorithm for patients with suspected not high-risk pulmonary embolism



CTPA



Rim sign

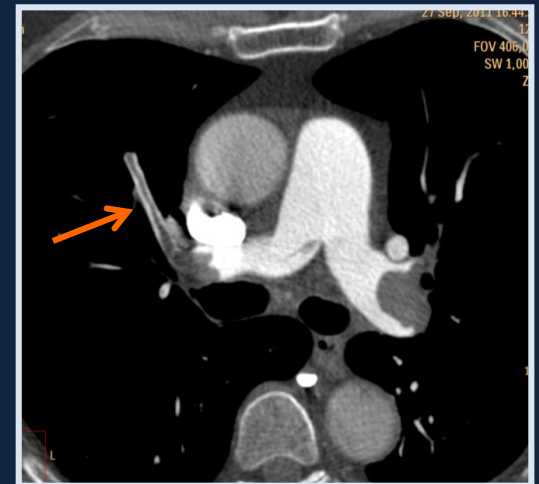
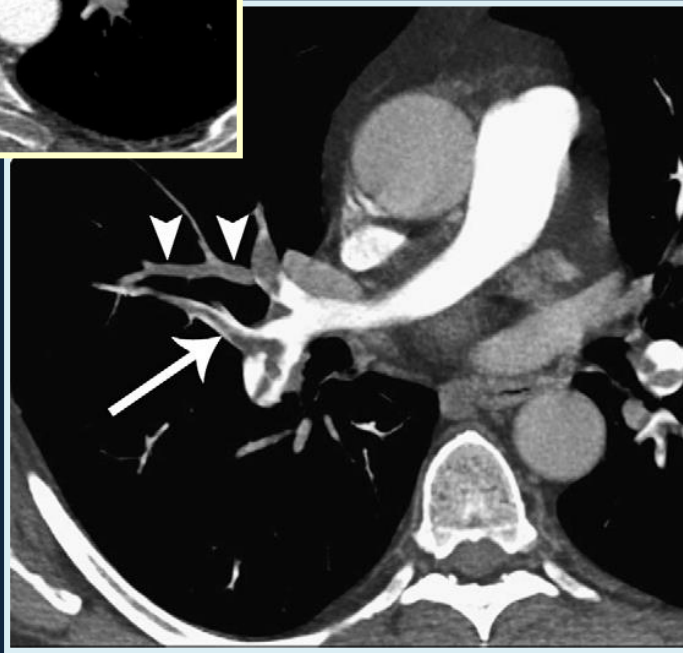
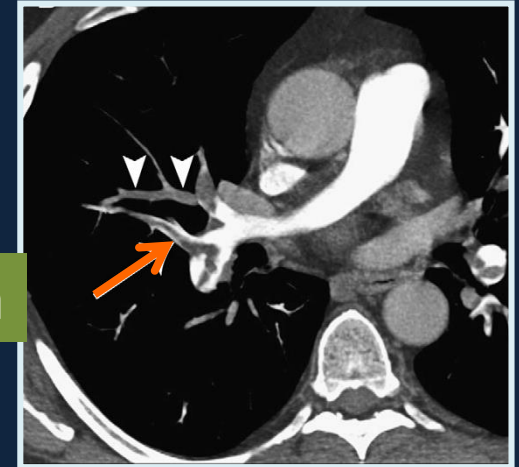


Ελλείμματα που περιβάλλονται από σκιαγραφικό

CTPA

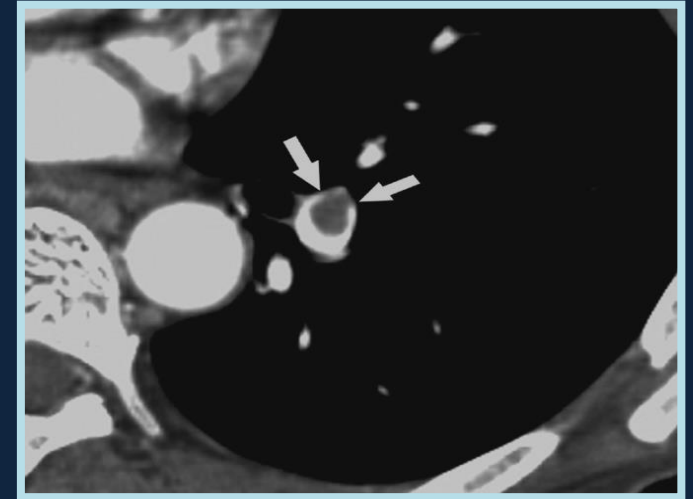
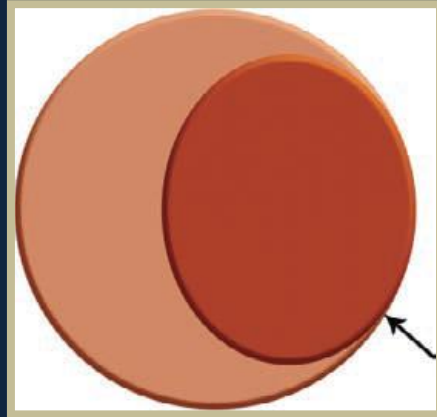
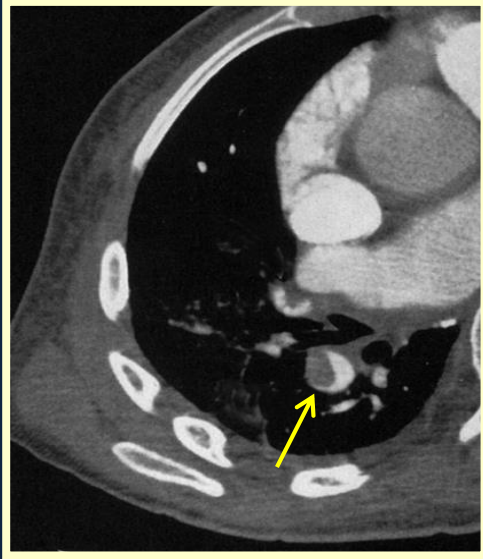


Railroad track sign



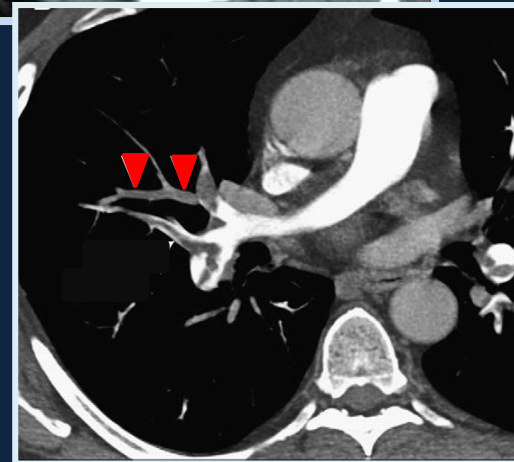
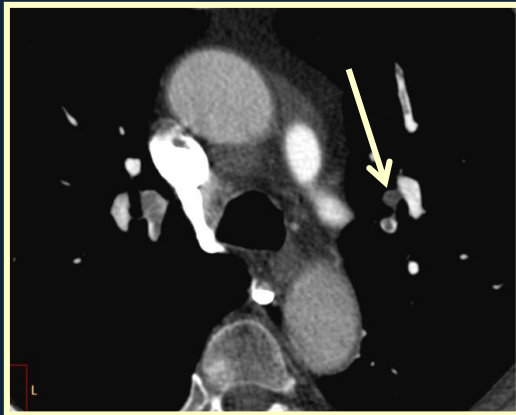
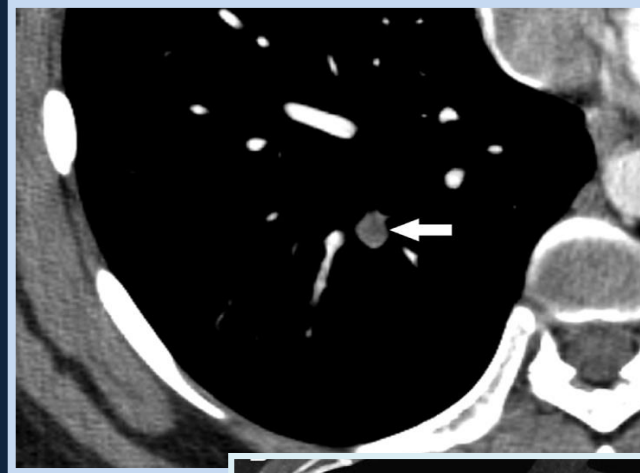
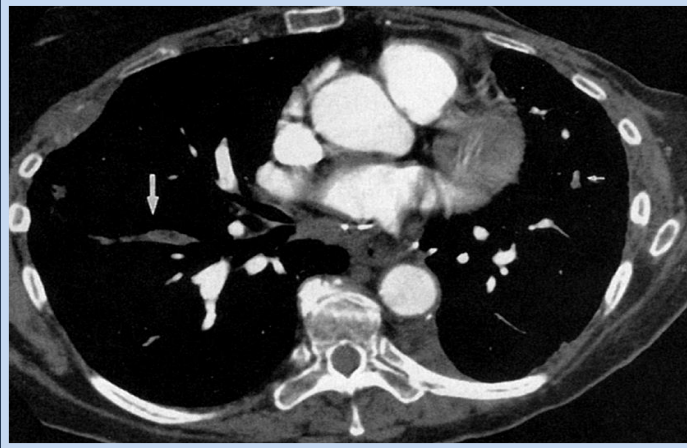
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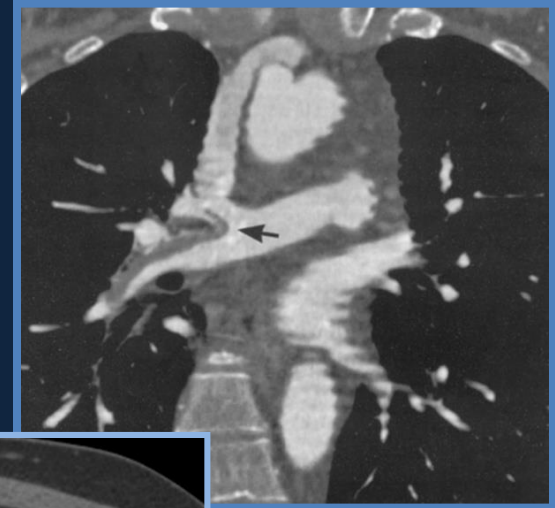
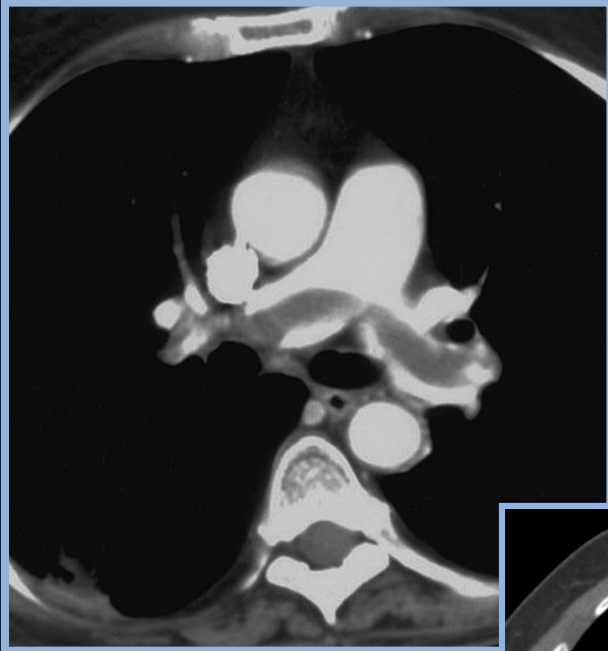
Ελλείμματα σε επαφή με το τοίχωμα (σχηματισμός οξείας γωνίας)

CTPA



Απόφραξη του αγγείου - απουσία σκιαγράφησης - ΠΙΘΑΝΗ ΔΙΑΤΑΞΗ σε σύγκριση με τα αντίστοιχης τάξης αγγεία

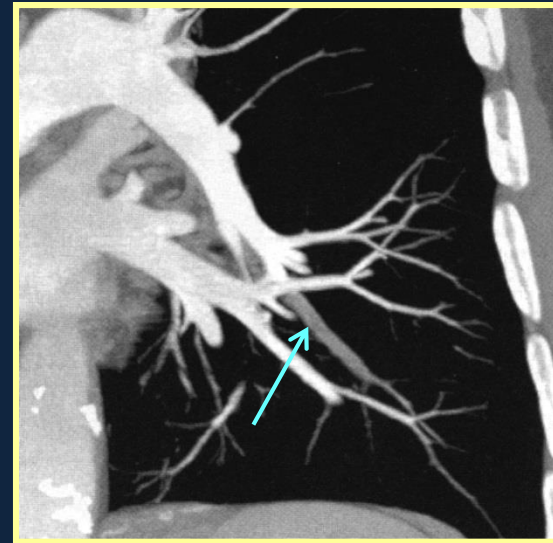
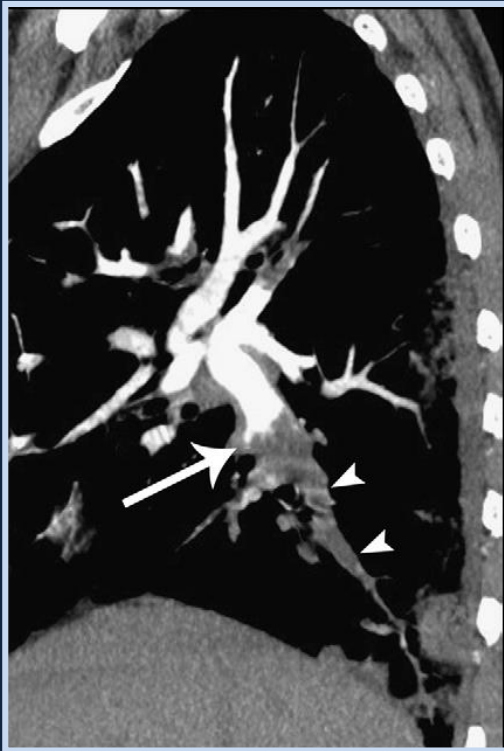
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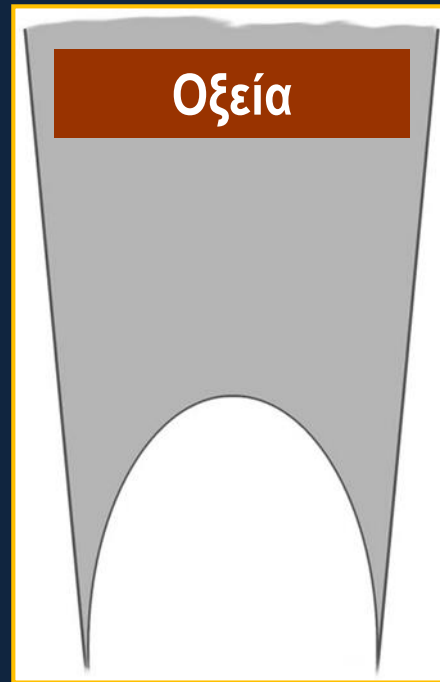
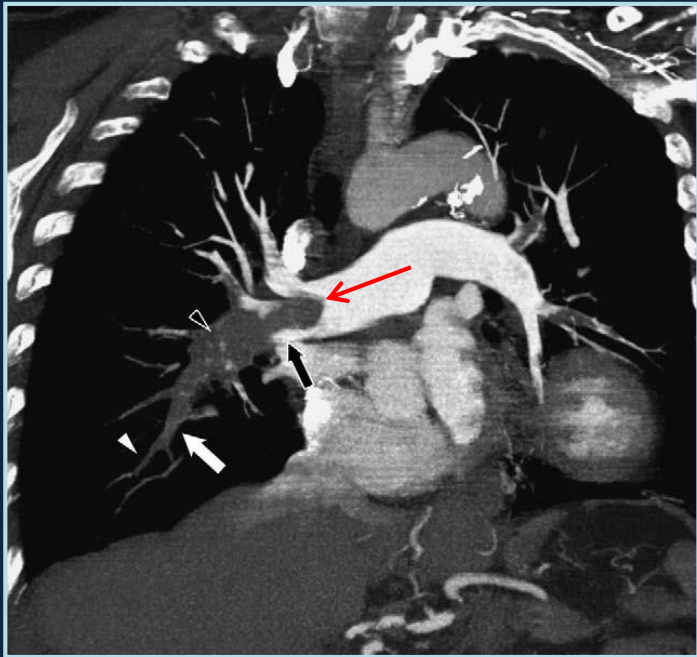
Riding or saddle embolus

CTPA

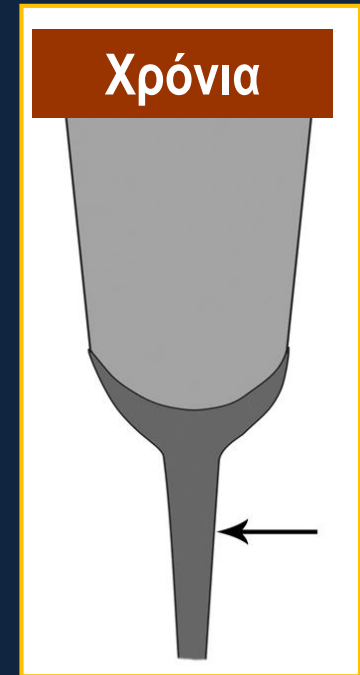
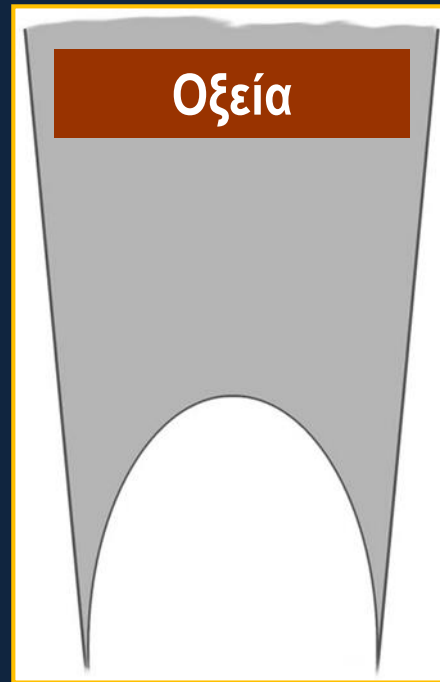
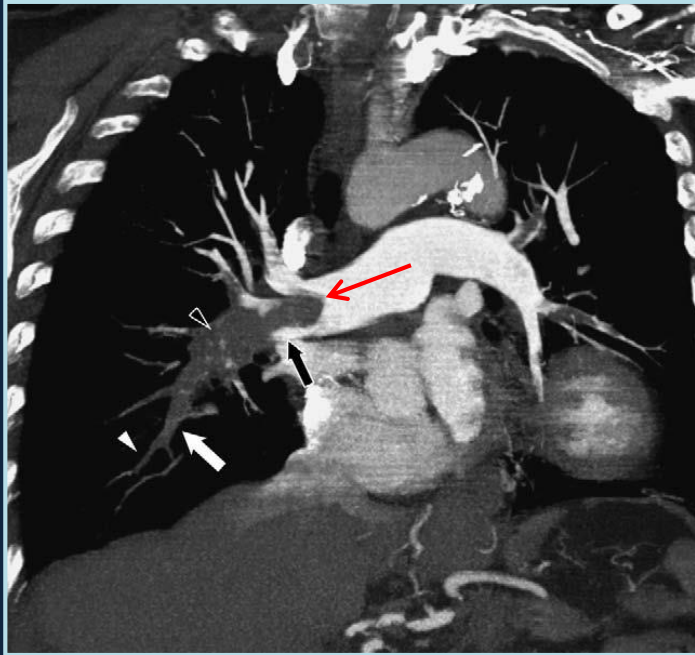
Vessel "cut-off" sign



CTPA



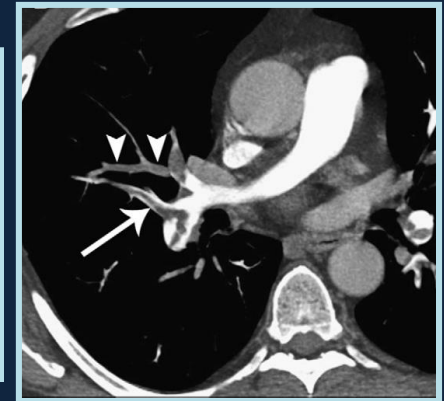
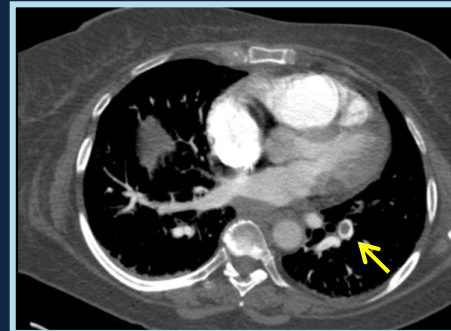
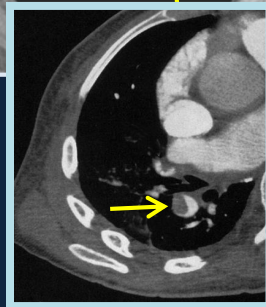
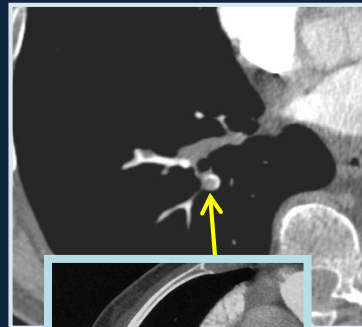
CTPA



CTPA

Table 4 Direct Imaging Findings of Acute PE on MDCTPA

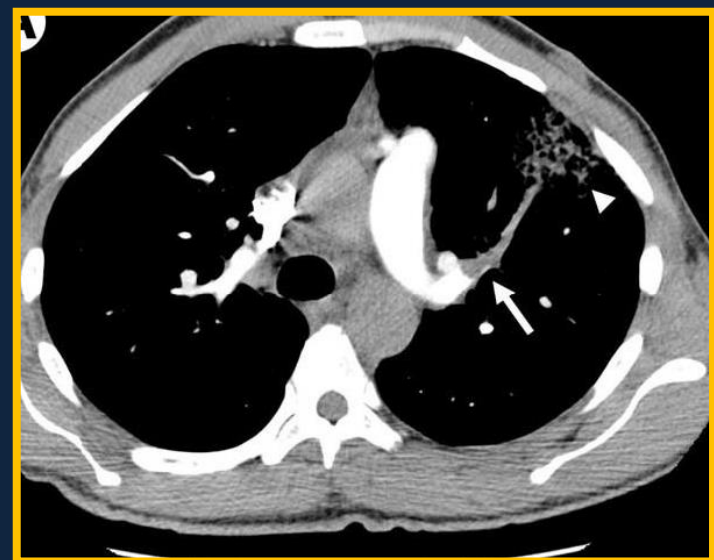
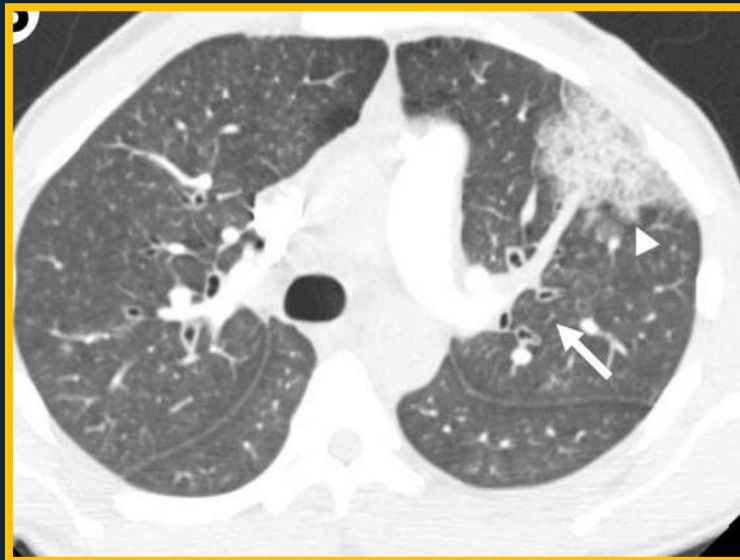
CT Finding	Key to Interpretation of Acute PE
Complete arterial occlusion	Dilated artery compared with adjacent bronchus
Nonobstructive eccentric intraluminal filling defect	Forms acute angles with arterial wall
Partial central filling defect surrounded by contrast material	"Rim-sign" in axial plane and "railway-track" sign along long axis of vessel



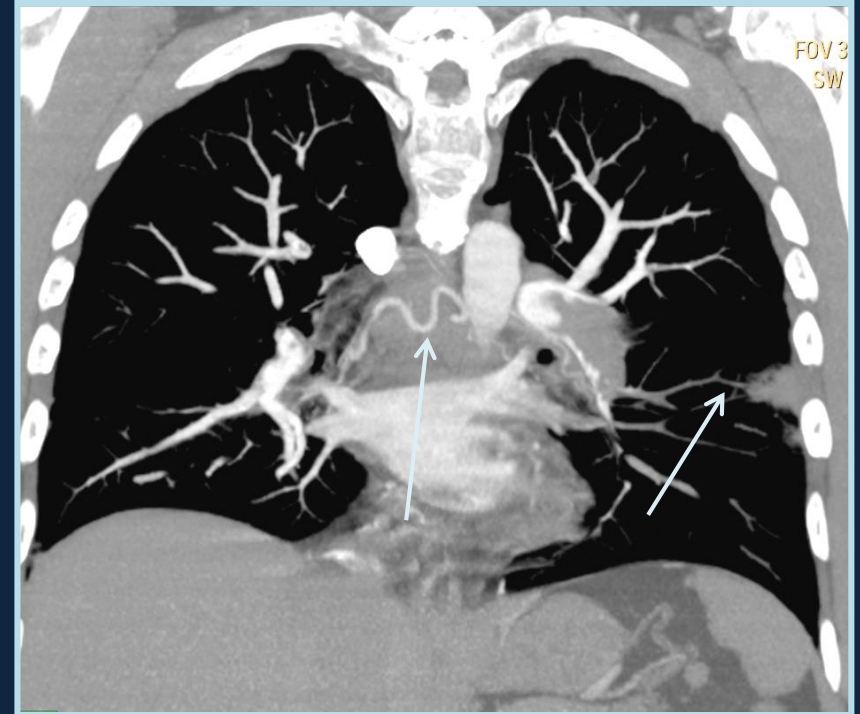
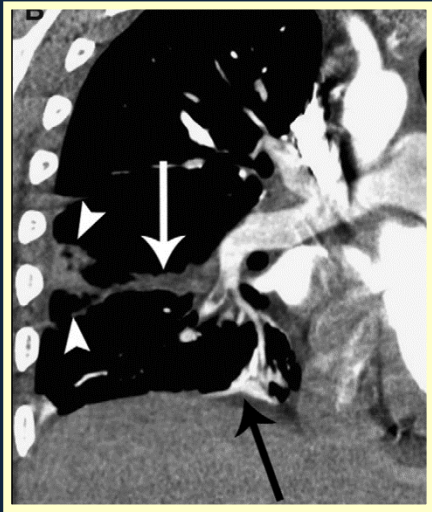
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Παρουσία εμφράκτων σε ποσοστό 10-30%

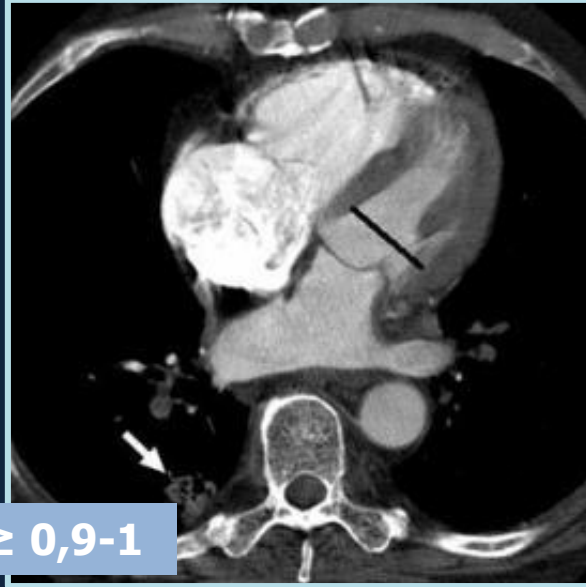
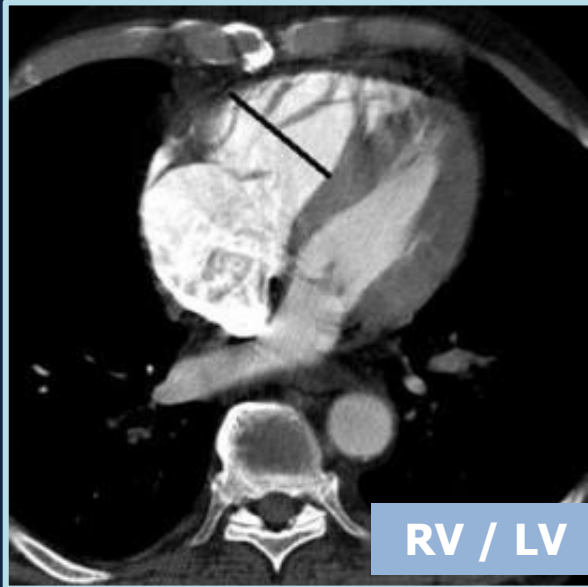


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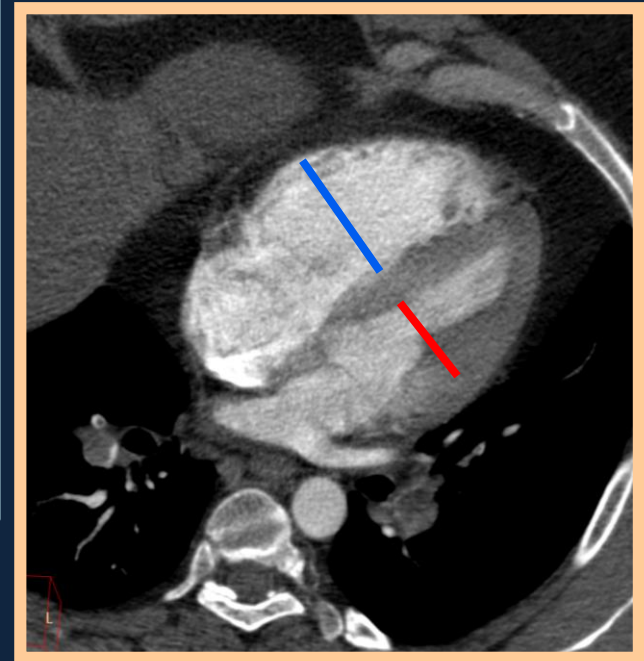
Vascular sign

CTPA



RV / LV \geq 0,9-1

The RV and LV diameter from inner wall to inner wall at their widest point is measured on axial images at the level of the tricuspid and mitral valves, respectively.



4 chamber view

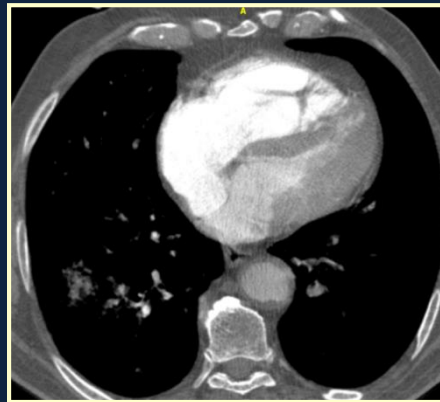
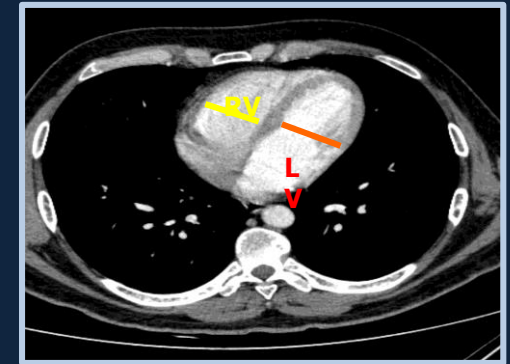
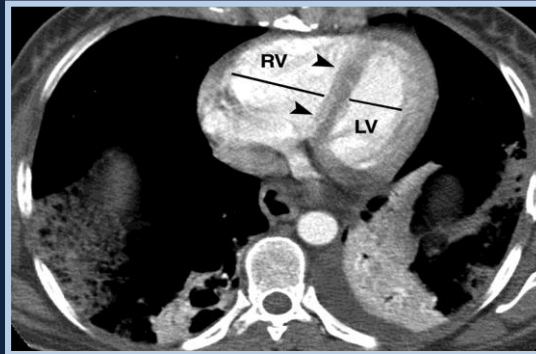
CTPA

Box 3

CT features of right ventricular dysfunction

1. Main indicators of right ventricular dysfunction
 - Dilatation of the right ventricle
 - Interventricular septal shift (*displaced to the left*)
 - Compression of the left ventricle
2. Secondary effects of right ventricular dilatation and dyskinesia
 - Tricuspid regurgitation
 - Right atrial enlargement
 - Reflux of contrast material within the inferior vena cava and hepatic veins
 - Dilatation of the coronary sinus, superior vena cava, and azygos vein

From Reid JH, Murchison JT. Acute right ventricular dilatation: a new helical CT sign of massive pulmonary embolism. *Clin Radiol* 1998;53:694-8; with permission.



Multidetector computed tomography for acute pulmonary embolism: diagnosis and risk stratification in a single test

Cecilia Becattini^{1*}, Giancarlo Agnelli¹, Maria Cristina Vedovati¹, Piotr Pruszczyk², Franco Casazza³, Stefano Grifoni⁴, Aldo Salvi⁵, Marina Bianchi⁶, Renée Douma⁷, Stavros Konstantinides⁸, Mareike Lankeit⁹, and Michele Duranti¹⁰

¹Stroke Unit, Department of Internal and Cardiovascular Medicine, University of Perugia, Perugia 06129, Italy; ²Department of Internal Medicine and Cardiology, Warsaw Medical University, Poland; ³Ospedale San Carlo Borromeo, Milano, Italy; ⁴Azienda Ospedaliero-Universitaria Careggi, Florence, Italy; ⁵Azienda Ospedaliero-Universitaria, Ancona, Italy; ⁶Valduce Hospital, Como, Italy; ⁷Department of Vascular Medicine, Academic Medical Center, Amsterdam, The Netherlands; ⁸Department of Cardiology, Democritus University of Thrace, Greece; ⁹Department of Cardiology and Pulmonology, University of Göttingen, Göttingen, Germany; and ¹⁰Department of Radiology, S. Maria della Misericordia Hospital, Perugia, Italy

Received 16 December 2010; revised 1 March 2011; accepted 20 March 2011; online publication ahead of print 18 April 2011

Aims

In patients with acute pulmonary embolism (PE), right ventricular dysfunction at echocardiography is associated with increased in-hospital mortality. The aims of this study in patients with acute PE were to identify a sensitive and simple criterion for right ventricular dysfunction at multidetector computed tomography (MDCT) using echocardiography as the reference standard and to evaluate the predictive value of the identified MDCT criterion for in-hospital death or clinical deterioration.

Methods and results

Right ventricular dysfunction at MDCT was defined as the right-to-left ventricular dimensional ratio and was centrally assessed by a panel unaware of clinical and echocardiographic data. A right-to-left ventricular dimensional ratio ≥ 0.9 at MDCT had a 92% sensitivity for right ventricular dysfunction [95% confidence interval (CI) 88–96]. Overall, 457 patients were included in the outcome study: 303 had right ventricular dysfunction at MDCT. In-hospital death or clinical deterioration occurred in 44 patients with and in 8 patients without right ventricular dysfunction at MDCT (14.5 vs. 5.2%; $P < 0.004$). The negative predictive value of right ventricular dysfunction for death due to PE was 100% (95% CI 98–100). Right ventricular dysfunction at MDCT was an independent predictor for in-hospital death or clinical deterioration in the overall population [hazard ratio (HR) 3.5, 95% CI 1.6–7.7; $P = 0.002$] and in haemodynamically stable patients (HR 3.8, 95% CI 1.3–10.9; $P = 0.007$).

Conclusion

In patients with acute PE, MDCT might be used as a single procedure for diagnosis and risk stratification. Patients without right ventricular dysfunction at MDCT have a low risk of in-hospital adverse outcome.

Keywords

Pulmonary embolism • Venous thrombo-embolism • Echocardiography • Computed tomography

Multidetector computed tomography for acute pulmonary embolism: diagnosis and risk stratification in a single test

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Patients without right ventricular dysfunction at MDCT have a low risk of in-hospital death or clinical deterioration

Clinical deterioration occurred in 14 patients with and in 6 patients without right ventricular dysfunction at MDCT (14.5 vs. 5.2%; $P < 0.004$). The negative predictive value of right ventricular dysfunction for death due to PE was 100% (95% CI 98–100). Right ventricular dysfunction at MDCT was an independent predictor for in-hospital death or clinical deterioration in the overall population [hazard ratio (HR) 3.5, 95% CI 1.6–7.7; $P = 0.002$] and in haemodynamically stable patients (HR 3.8, 95% CI 1.3–10.9; $P = 0.007$).

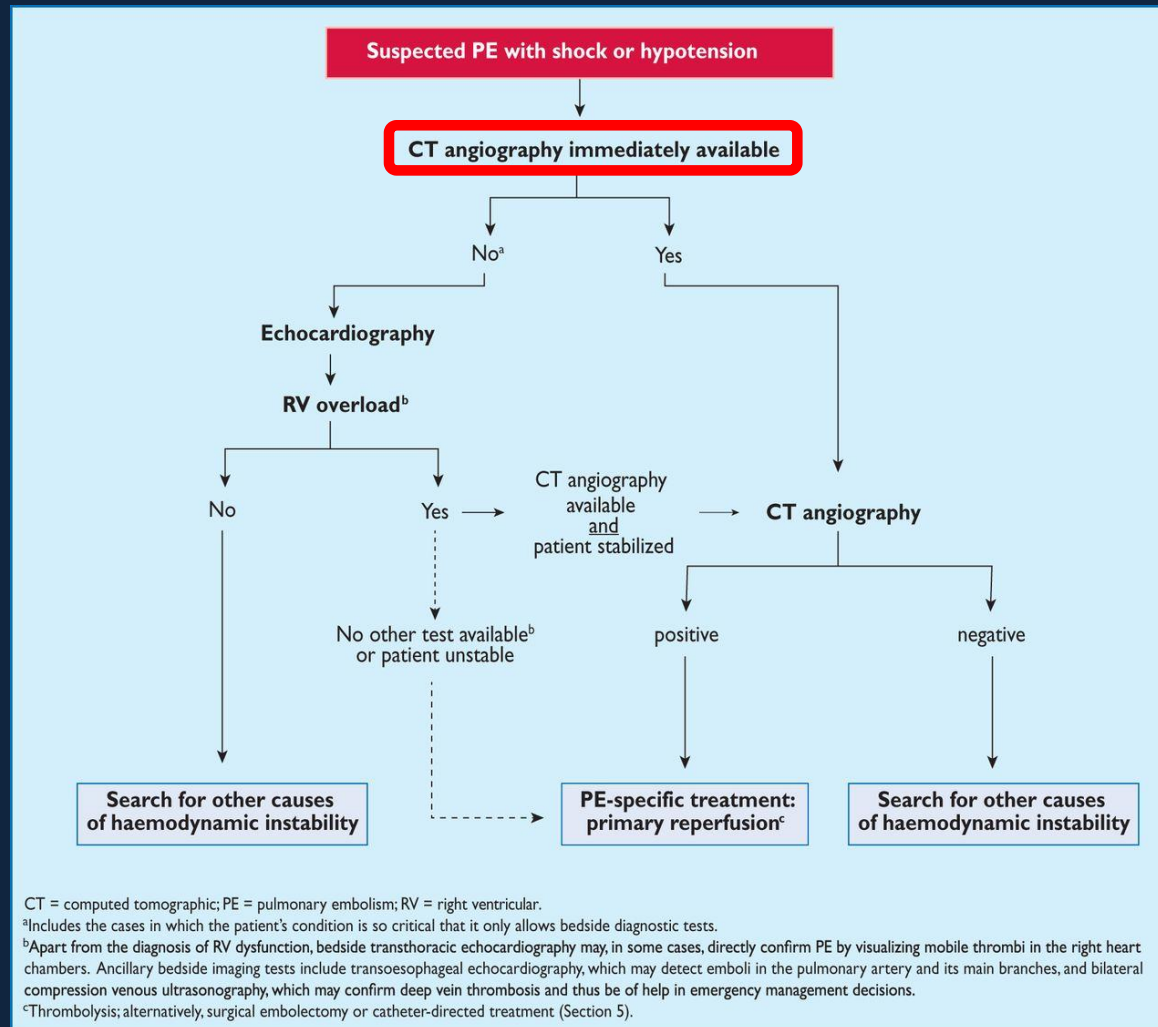
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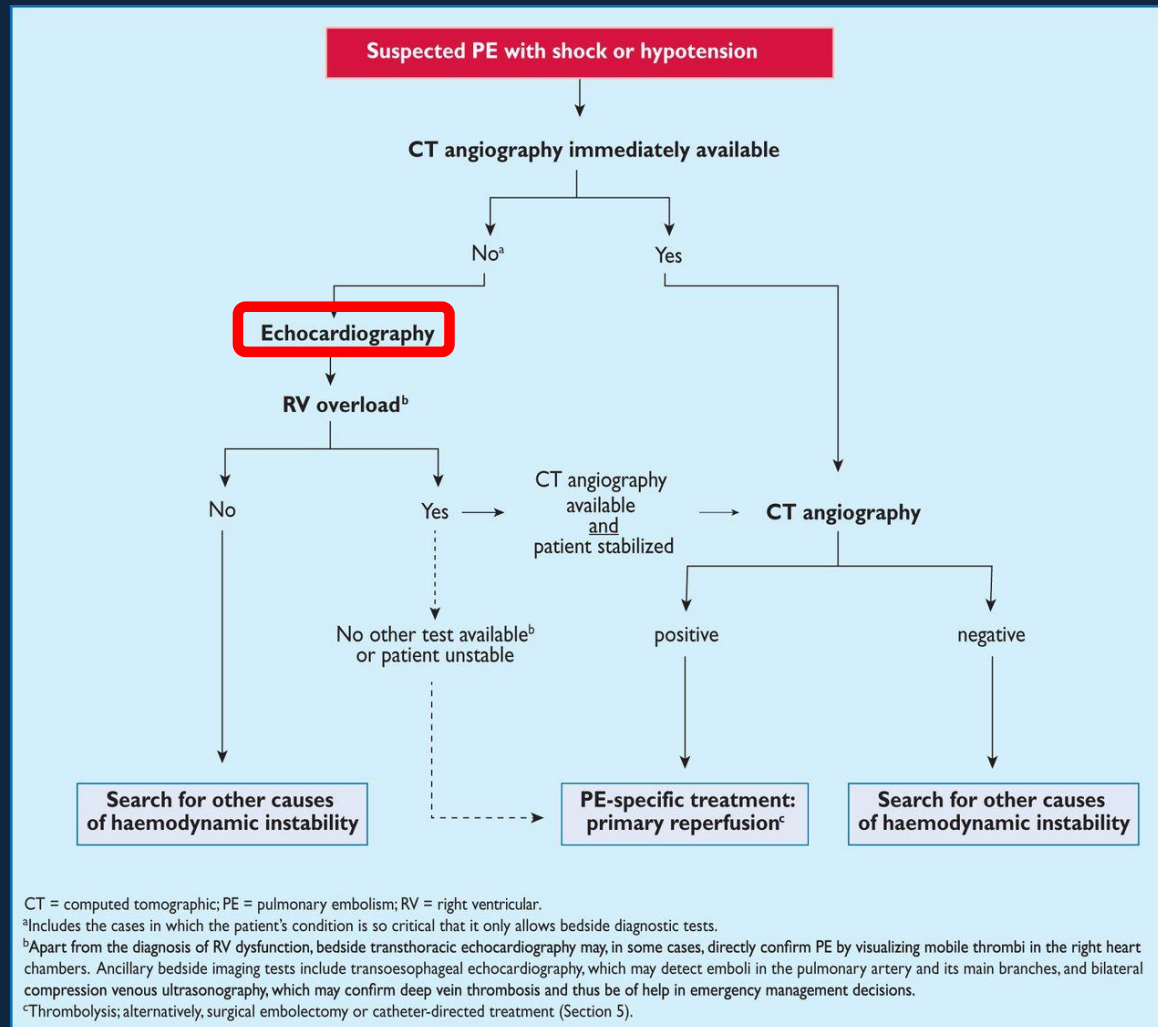
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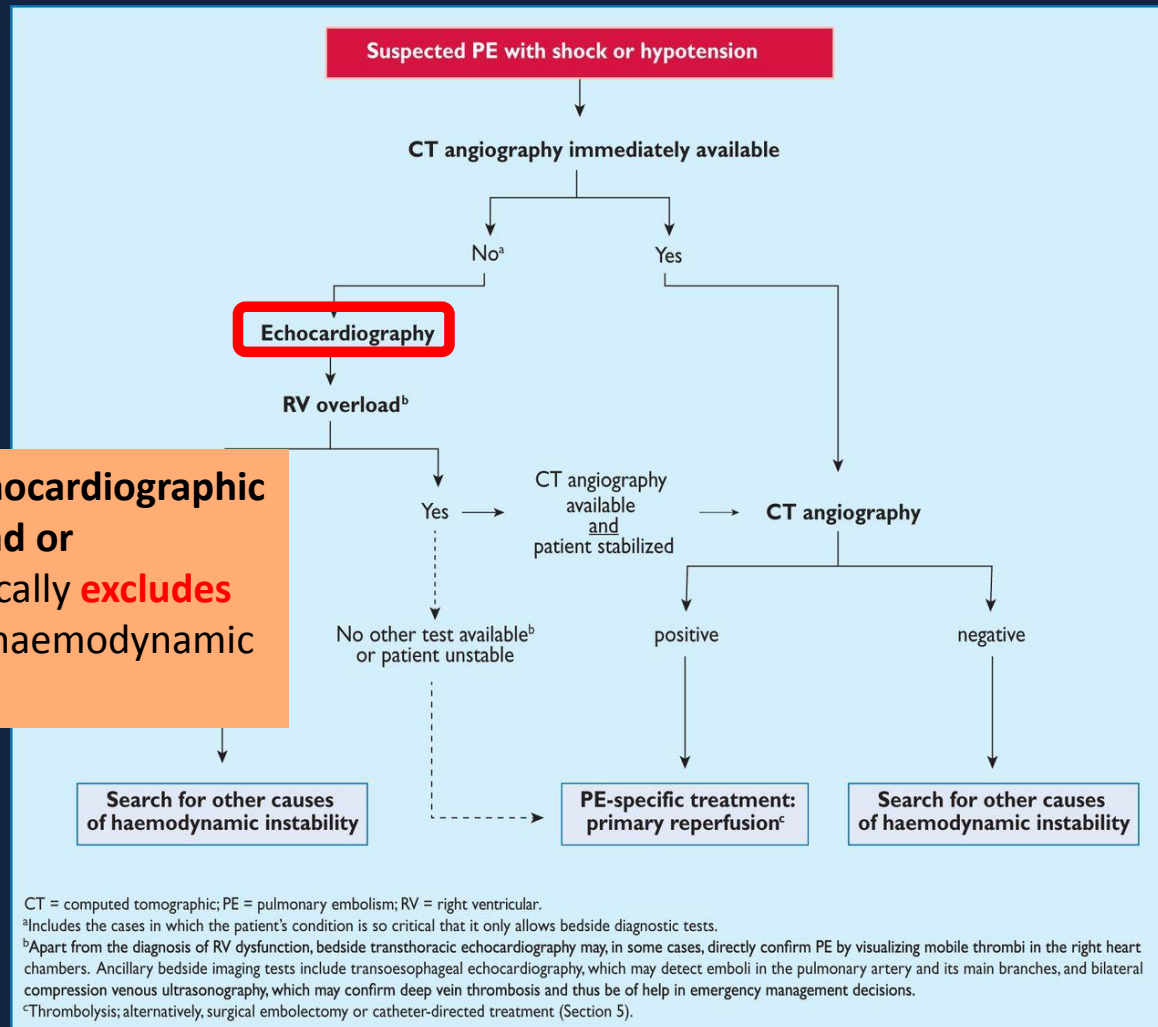
Proposed diagnostic algorithm for patients with suspected high-risk PE



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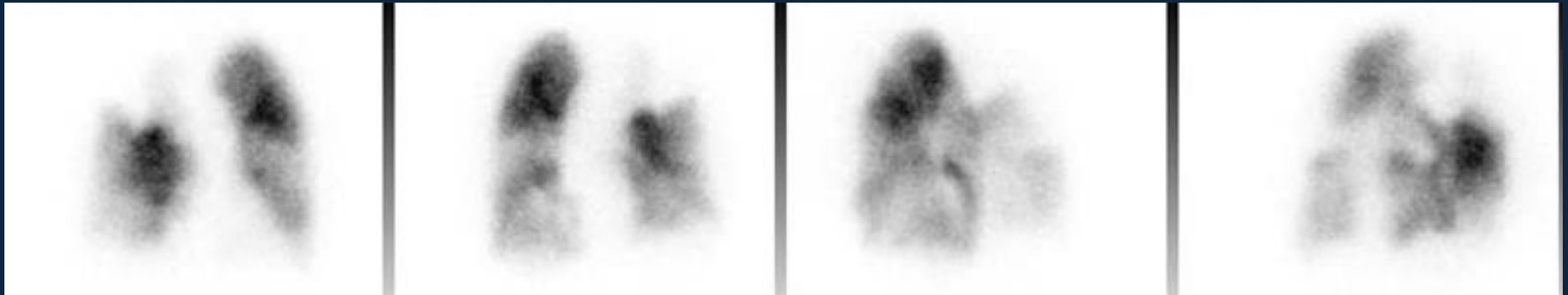


Proposed diagnostic algorithm for patients with suspected high-risk PE

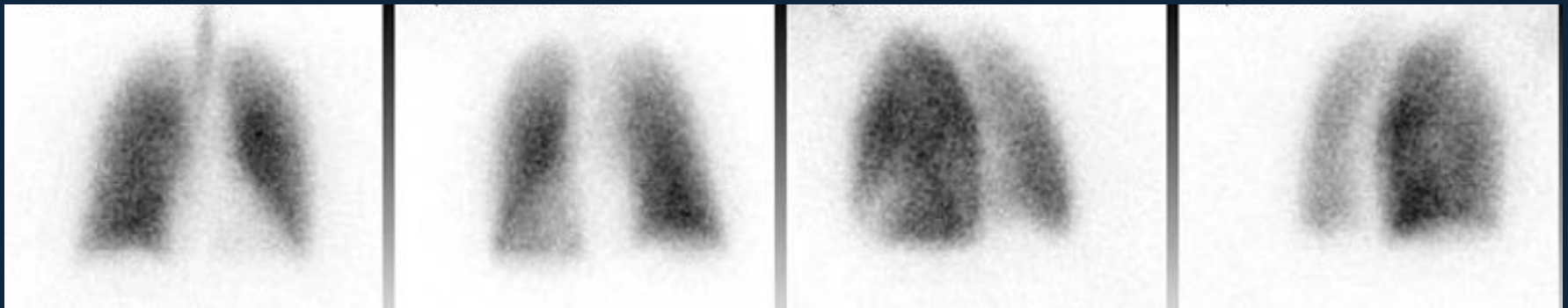


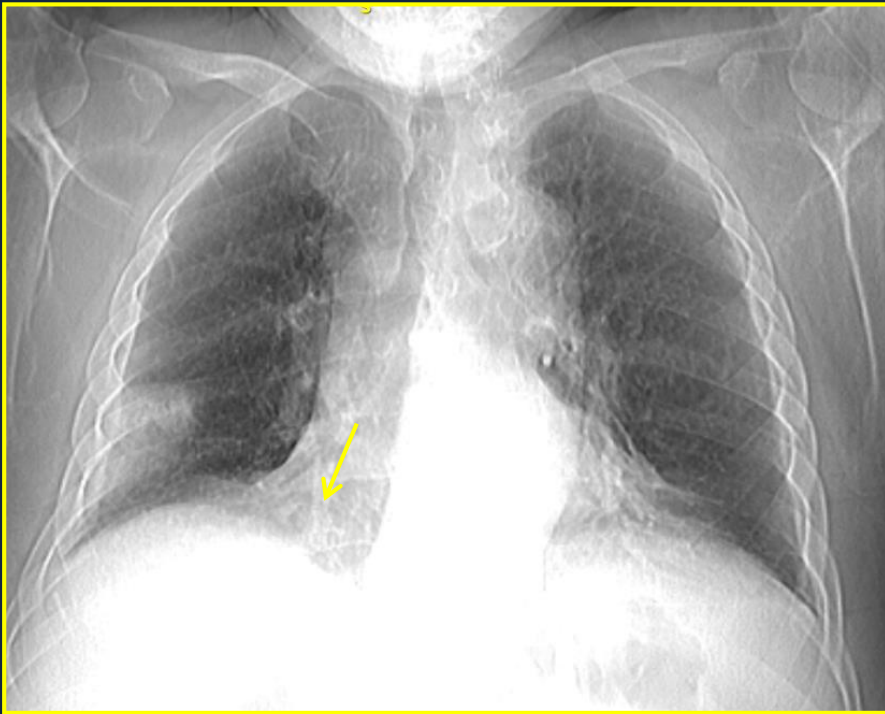
V/Q scan

perfusion



ventilation





Hampton's Hump:

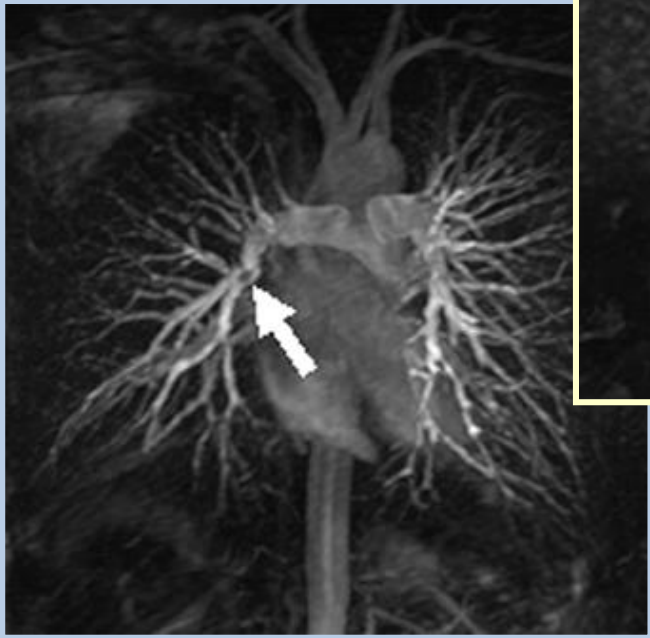
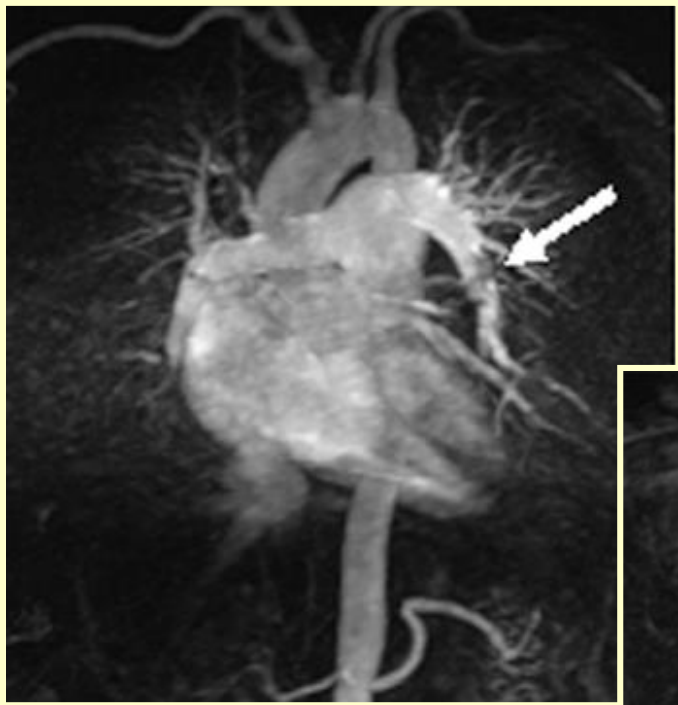
a pleura based shallow wedge – shaped consolidation in the lung periphery with the base against the pleural surface



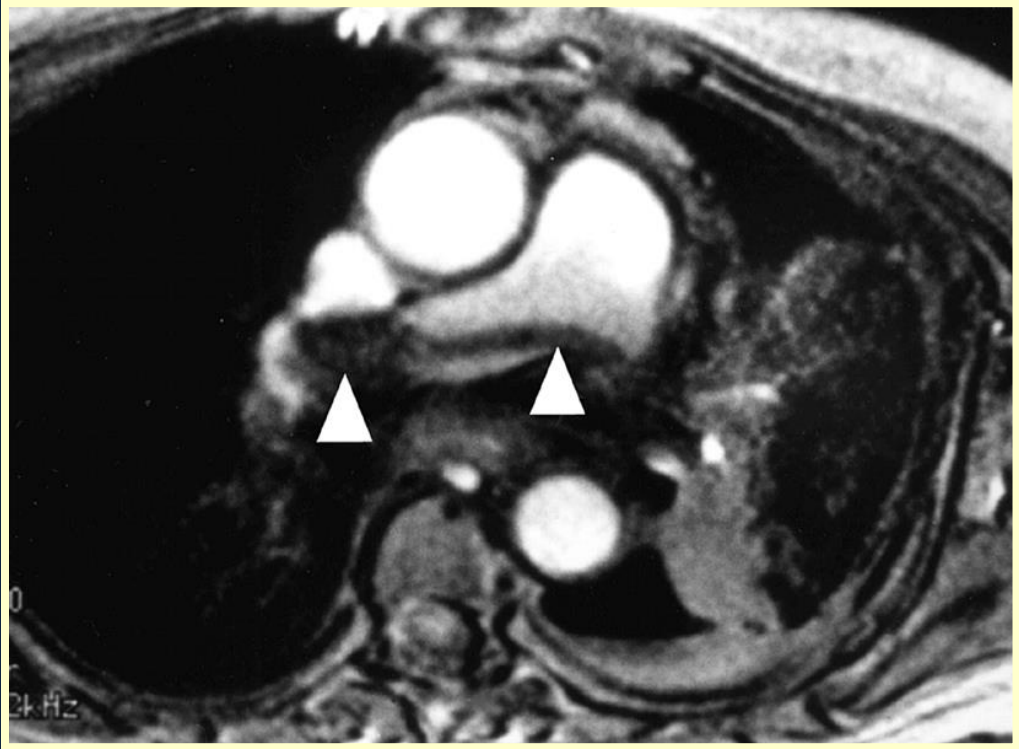
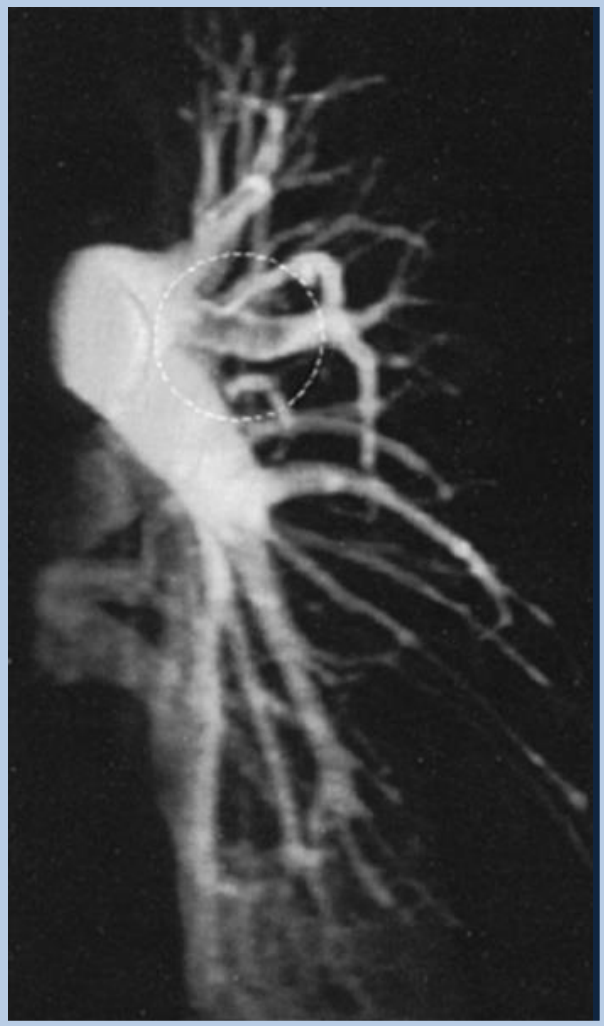
Westermark sign:

dilatation of pulmonary vessels proximal to embolism along with collapse of distal vessels, often with a sharp cut off

MR Angiography



MR Angiography



Gadolinium-Enhanced Magnetic Resonance Angiography for Pulmonary Embolism

A Multicenter Prospective Study (PIOPED III)

Paul D. Stein, MD; Thomas L. Chenevert, PhD; Sarah E. Fowler, PhD; Lawrence R. Goodman, MD; Alexander Gottschalk, MD; Charles A. Hales, MD; Russell D. Hull, MBBS, MSc; Kathleen A. Jablonski, PhD; Kenneth V. Leeper Jr., MD; David P. Naidich, MD; Daniel J. Sak, DO; H. Dirk Sostman, MD; Victor F. Tapson, MD; John G. Weg, MD; and Pamela K. Woodard, MD, for the PIOPED III (Prospective Investigation of Pulmonary Embolism Diagnosis III) Investigators*

Background: The accuracy of gadolinium-enhanced magnetic resonance pulmonary angiography and magnetic resonance venography for diagnosing pulmonary embolism has not been determined conclusively.

Objective: To investigate performance characteristics of magnetic resonance angiography, with or without magnetic resonance venography, for diagnosing pulmonary embolism.

Design: Prospective, multicenter study from 10 April 2006 to 30 September 2008. (ClinicalTrials.gov registration number: NCT00241826)

Setting: 7 hospitals and their emergency services.

Patients: 371 adults with diagnosed or excluded pulmonary embolism.

Measurements: Sensitivity, specificity, and likelihood ratios were measured by comparing independently read magnetic resonance imaging with the reference standard for diagnosing pulmonary embolism. Reference standard diagnosis or exclusion was made by using various tests, including computed tomographic angiography and venography, ventilation-perfusion lung scan, venous ultrasonography, D-dimer assay, and clinical assessment.

Results: Magnetic resonance angiography, averaged across centers, was technically inadequate in 25% of patients (92 of 371). The proportion of technically inadequate images ranged from 11% to

52% at various centers. Including patients with technically inadequate images, magnetic resonance angiography identified 57% (59 of 104) with pulmonary embolism. Technically adequate magnetic resonance angiography had a sensitivity of 78% and a specificity of 99%. Technically adequate magnetic resonance angiography and venography had a sensitivity of 92% and a specificity of 96%, but 52% of patients (194 of 370) had technically inadequate results.

Limitation: A high proportion of patients with suspected embolism was not eligible or declined to participate.

Conclusion: Magnetic resonance pulmonary angiography should be considered only at centers that routinely perform it well and only for patients for whom standard tests are contraindicated. Magnetic resonance pulmonary angiography and magnetic resonance venography combined have a higher sensitivity than magnetic resonance pulmonary angiography alone in patients with technically adequate images, but it is more difficult to obtain technically adequate images with the 2 procedures.

Primary Funding Source: National Heart, Lung, and Blood Institute.

Ann Intern Med. 2010;152:434-443.

www.annals.org

For author affiliations, see end of text.

* For a list of the PIOPED III investigators, see the **Appendix** (available at www.annals.org).

Gadolinium-Enhanced Magnetic Resonance Angiography for Pulmonary Embolism

A Multicenter Prospective Study (PIOPED III)

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Background: The accuracy of gadolinium-enhanced magnetic resonance pulmonary angiography and magnetic resonance venography for diagnosing pulmonary embolism has not been determined conclusively.

Objective: To investigate performance characteristics of magnetic resonance angiography, with or without magnetic resonance venography, for diagnosing pulmonary embolism.

Design: Prospective, multicenter study from 10 April 2006 to 30 September 2008. (ClinicalTrials.gov registration number: NCT00241826)

Setting: 7 hospitals and their emergency services.

Patients: 371 adults with diagnosed or excluded pulmonary embolism.

Measurements: Sensitivity, specificity, and likelihood ratios were

52% at various centers. Including patients with technically inadequate images, magnetic resonance angiography identified 57% (59 of 104) with pulmonary embolism. Technically adequate magnetic resonance angiography had a sensitivity of 78% and a specificity of 99%. Technically adequate magnetic resonance angiography and venography had a sensitivity of 92% and a specificity of 96%, but 52% of patients (194 of 370) had technically inadequate results.

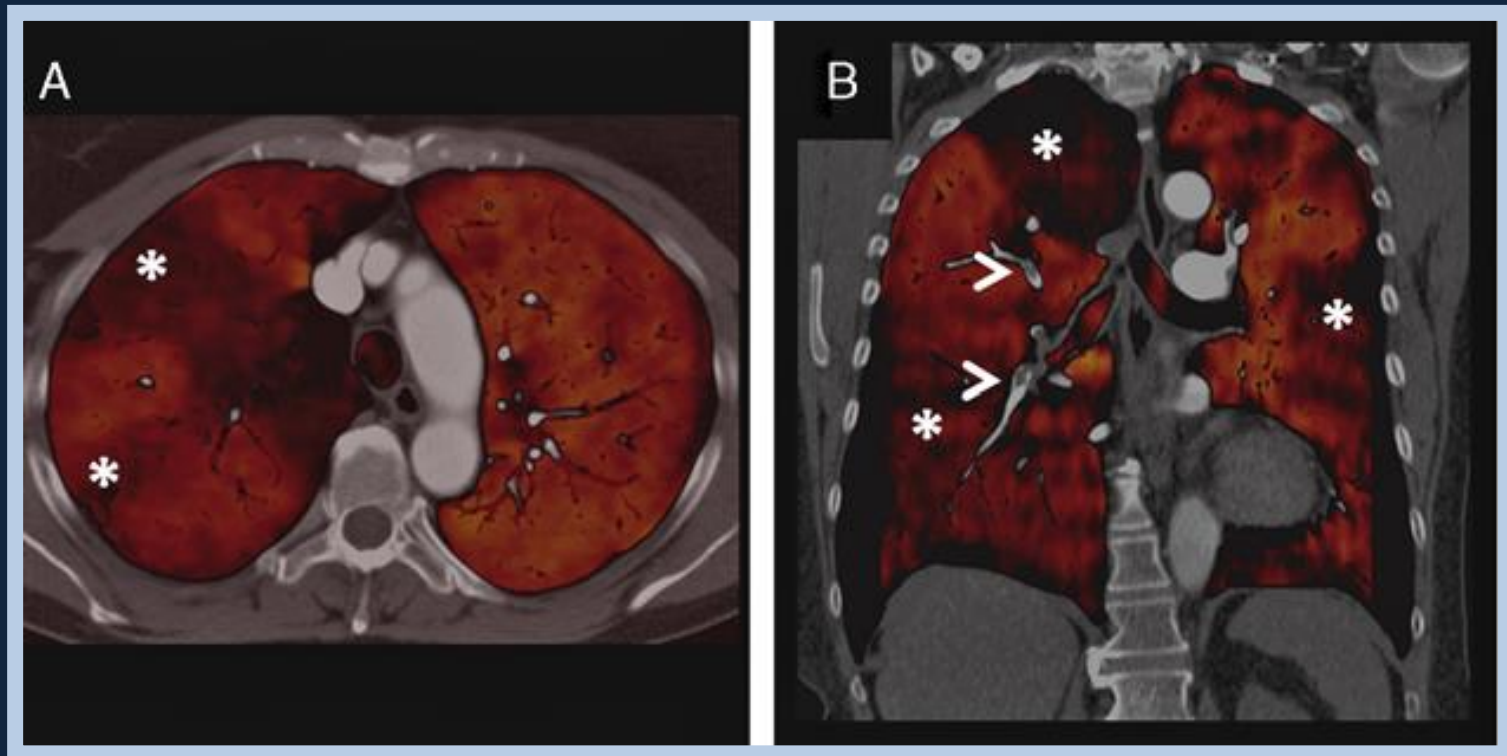
Limitation: A high proportion of patients with suspected embolism was not eligible or declined to participate.

Conclusion: Magnetic resonance pulmonary angiography should be considered only at centers that routinely perform it well and only for patients for whom standard tests are contraindicated. Magnetic resonance pulmonary angiography and magnetic resonance venography combined have a higher sensitivity than magnetic resonance pulmonary angiography alone in patients with technically adequate images, but it is more difficult to obtain technically adequate im-

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Νέες Εφαρμογές: Dual Energy CT Perfusion

Dual Energy: Χάρτες κατανομής ιωδίου που επιτρέπουν απεικόνιση αιμάτωσης



Classification of patients with acute PE based on **early mortality risk**

Early mortality risk		Risk parameters and scores			
		Shock or hypotension	PESI class III-V or sPESI ≥ 1 ^a	Signs of RV dysfunction on an imaging test ^b	Cardiac laboratory biomarkers ^c
High		+	(+) ^d	+	(+) ^d
Intermediate	Intermediate-high	-	+	Both positive	
	Intermediate-low	-	+	Either one (or none) positive ^e	
Low		-	-	Assessment optional; if assessed, both negative ^e	

Imaging & laboratory tests for prediction of early mortality in acute PE

Test or biomarker	Cut-off value	Sensitivity, % (95% CI)	Specificity, % (95% CI)	NPV, % (95% CI)	PPV, % (95% CI)	OR or HR (95% CI)	No. patients	Study design (reference)	Remarks
Echocardiography	Various criteria of RV dysfunction	74 (61–84)	54 (51–56)	98 (96–99)	8 (6–10)	2.4 (1.3–4.3)	1249	Meta-analysis ²²⁶	RV dysfunction on echocardiography or CT was one of the inclusion criteria in two randomized trials investigating thrombolysis in normotensive patients with PE. ^{252,253}
CT angiography	RV/LV ≥ 1.0	46 (27–66)	59 (54–64)	93 (89–96)	8 (5–14)	1.5 (0.7–3.4)	383	Meta-analysis ²²⁶	
	RV/LV ≥ 0.9	84 (65–94)	35 (30–39)	97 (94–99)	7 (5–10)	2.8 (0.9–8.2)	457	Prospective cohort ²²⁸	
BNP	75–100 pg/mL	85 (64–95)	56 (50–62)	98 (94–99)	14 (9–21)	6.5 (2.0–21)	261	Meta-analysis ²³²	The optimal cut-off value for PE has not been defined.
NT-proBNP	600 pg/mL	86 (69–95)	50 (46–54)	99 (97–100)	7 (5–19)	6.3 (2.2–18.3)	688	Prospective cohort ^{234c}	NT-proBNP <500 pg/mL was one of the inclusion criteria in a single-armed management trial investigating home treatment of PE. ²³⁷
Troponin I	Different assays/cut-off values ^c	NR	NR	NR	NR	4.0 (2.2–7.2)	1303	Meta-analysis ²³⁹	A positive cardiac troponin test was one of the inclusion criteria in a randomized trial investigating thrombolysis in normotensive patients with PE. ²⁵³
Troponin T	Different assays/cut-off values ^c	NR	NR	NR	NR		682	Meta-analysis ²³⁹	
	14 pg/mL ^d	87 (71–95)	42 (38–47)	98 (95–99)	9 (6–12)	5.0 (1.7–14.4)	526	Prospective cohort ^{76c}	
H-FABP	6 ng/mL	89 (52–99)	82 (74–89)	99 (94–99)	28 (13–47)	36.6 (4.3–304)	126	Prospective cohort ^{244c}	

Chronic thromboembolic pulmonary hypertension

Epidemiology

long-term complication of PE

incidence : **0.1–9.1%** within the first two years after
a symptomatic PE event

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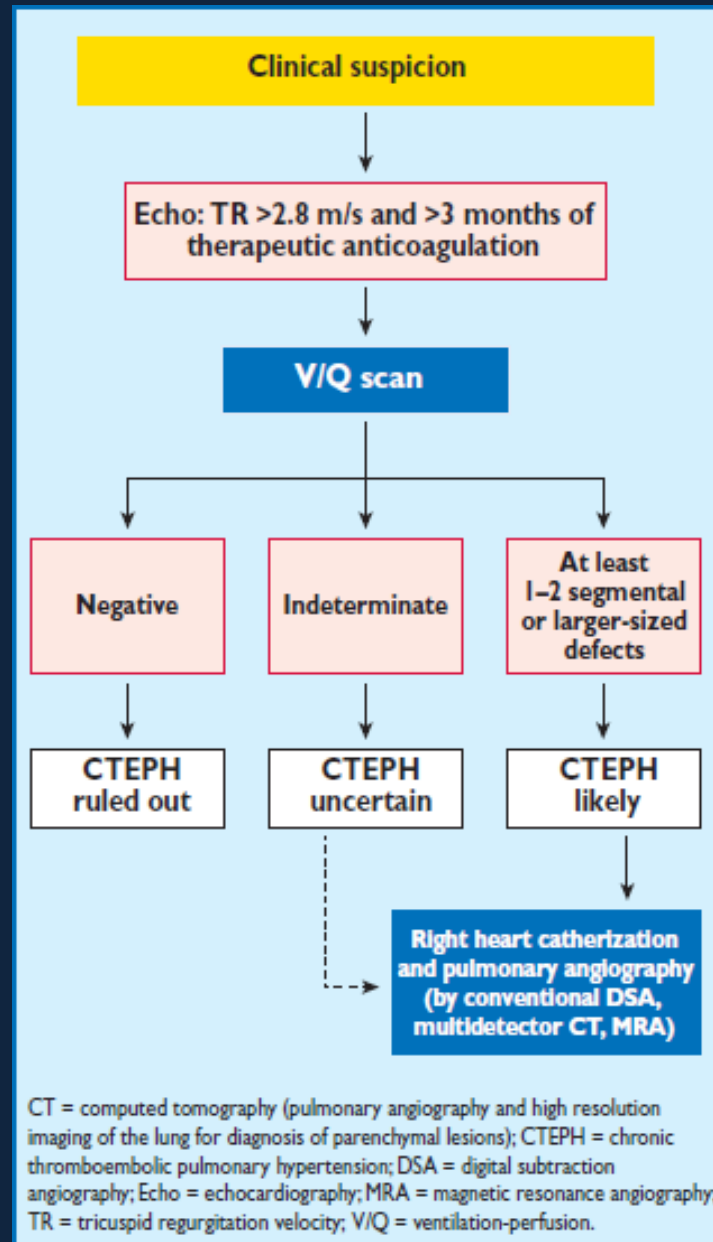
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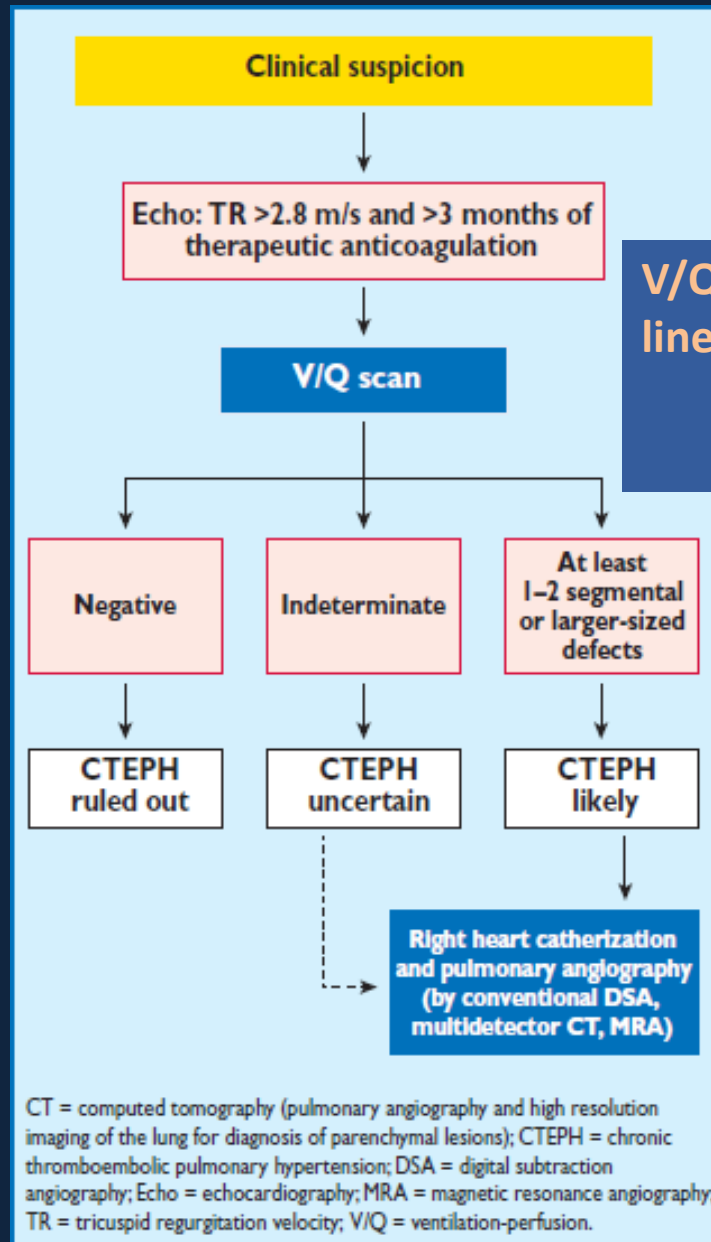
80% of patients with CTEPH have clinical history of VTE
(*recent international registry*)

*routine screening for CTEPH after PE is not supported
by current evidence*

Algorithm for the diagnosis of chronic thromboembolic pulmonary hypertension

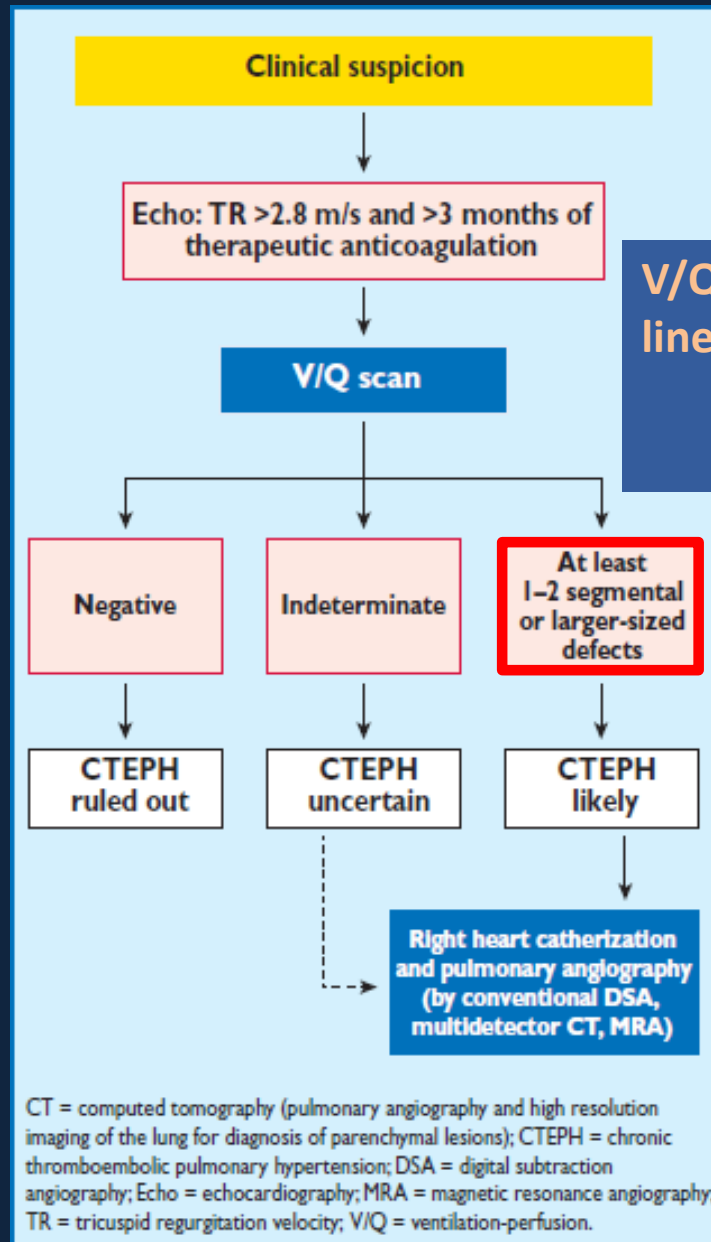


Algorithm for the diagnosis of chronic thromboembolic pulmonary hypertension



V/Q lung scan is the main first-line imaging test for CTEPH
96–97% *sensitivity*
90–95% *specificity*

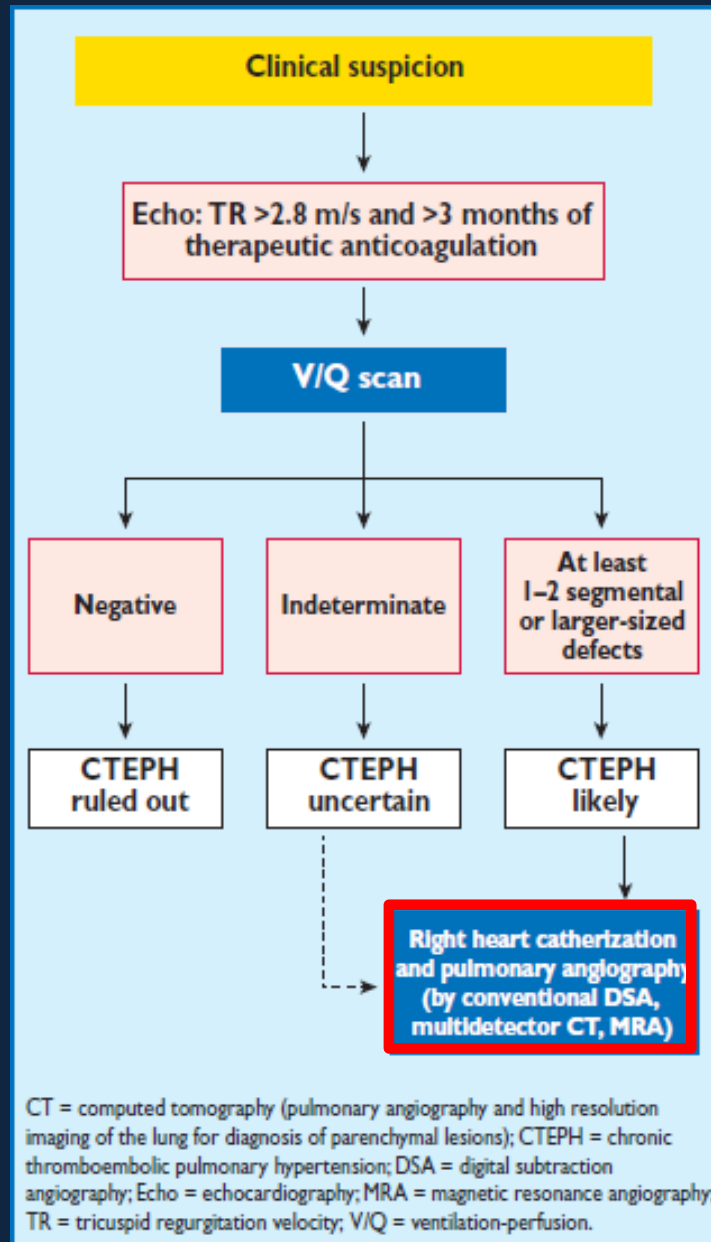
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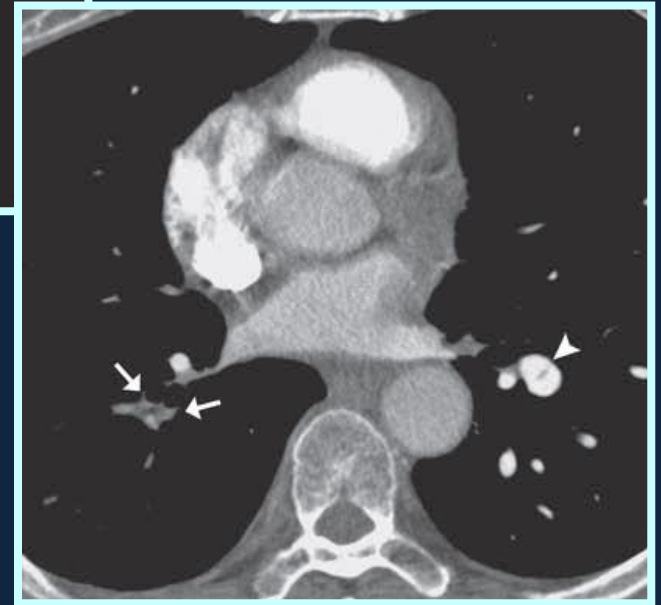
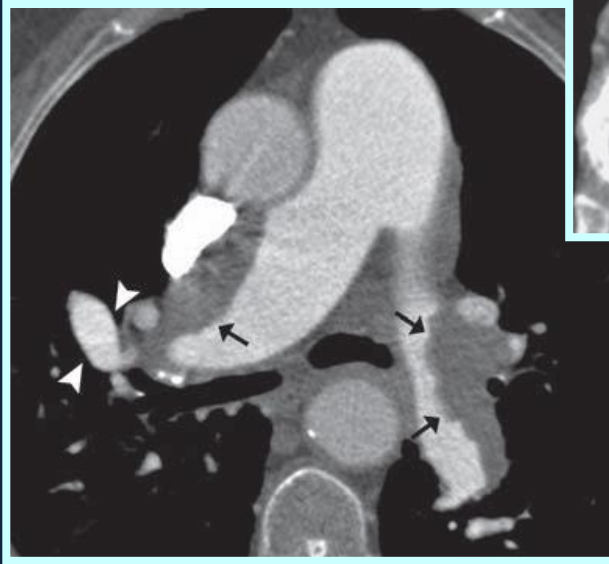
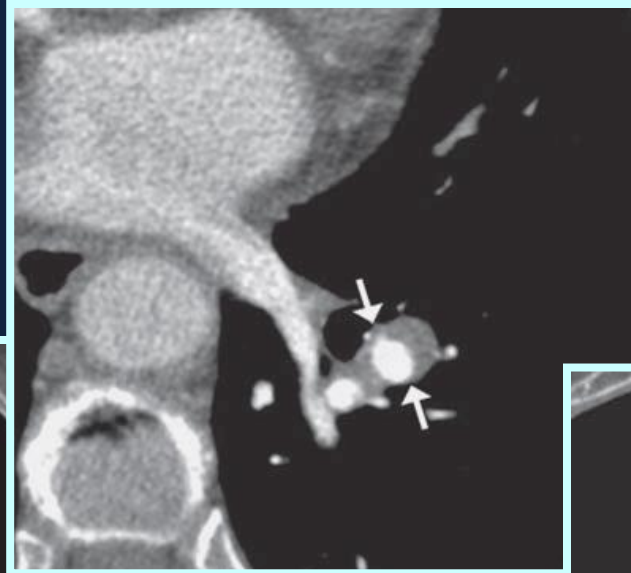
CT = computed tomography (pulmonary angiography and high resolution imaging of the lung for diagnosis of parenchymal lesions); CTEPH = chronic thromboembolic pulmonary hypertension; DSA = digital subtraction angiography; Echo = echocardiography; MRA = magnetic resonance angiography; TR = tricuspid regurgitation velocity; V/Q = ventilation-perfusion.

Algorithm for the diagnosis of chronic thromboembolic pulmonary hypertension



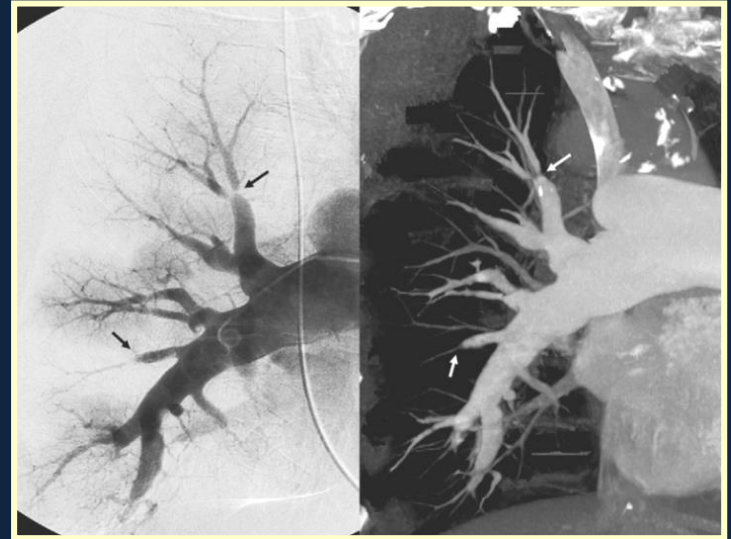
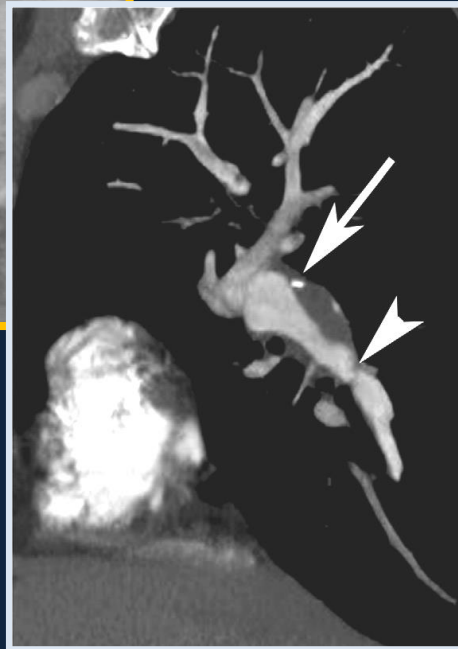
CTEPH

Vascular Signs



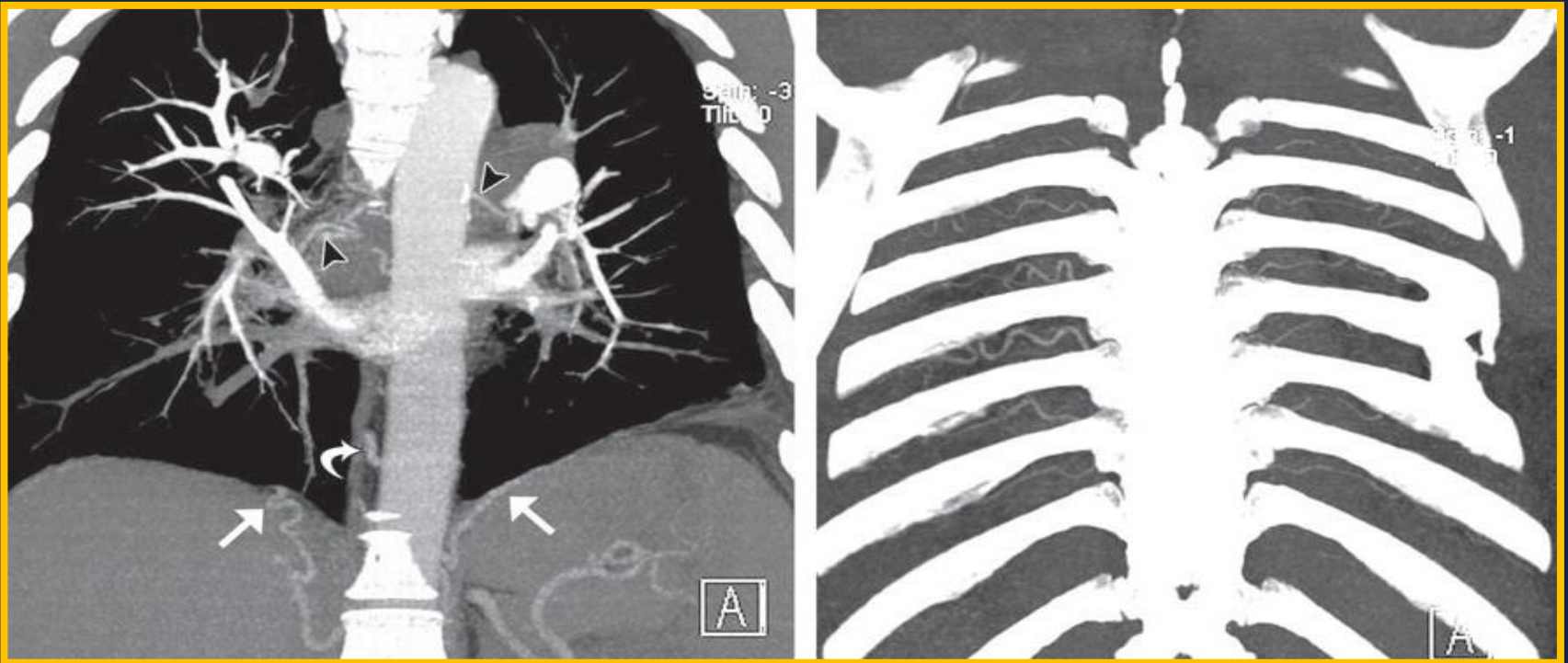
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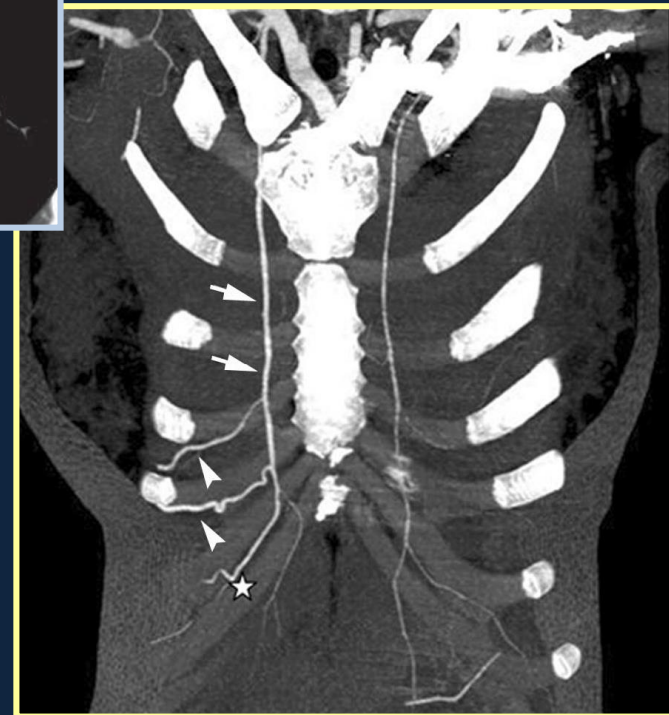
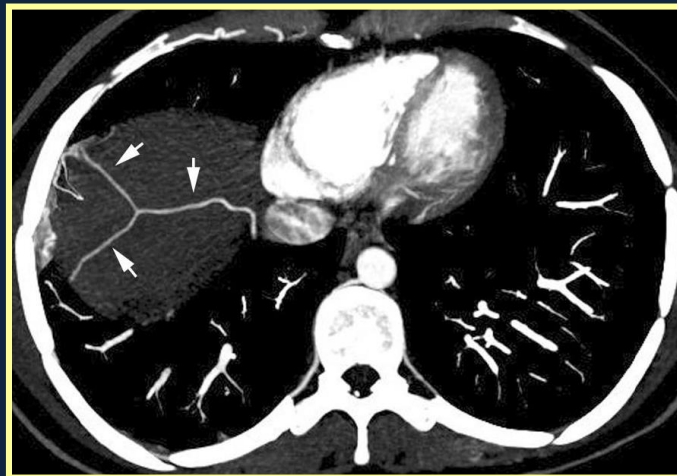
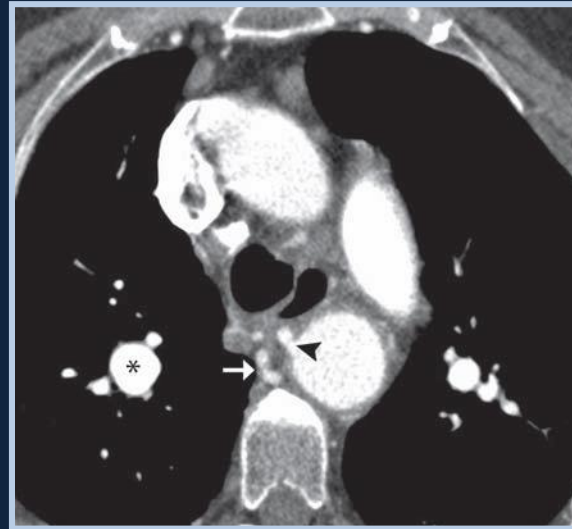
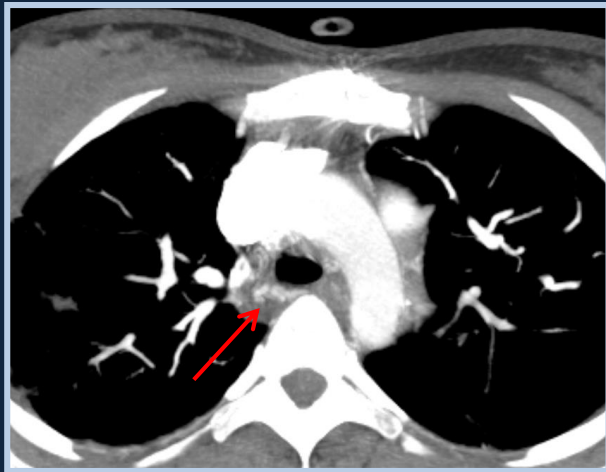
CTEPH

Vascular Signs Systemic collateral supply

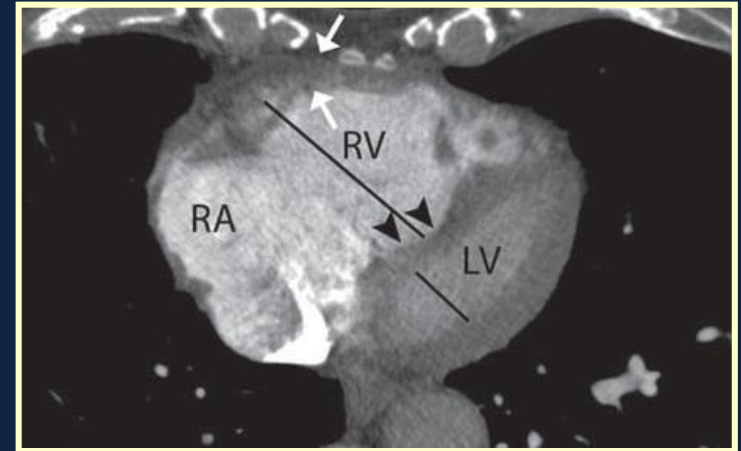
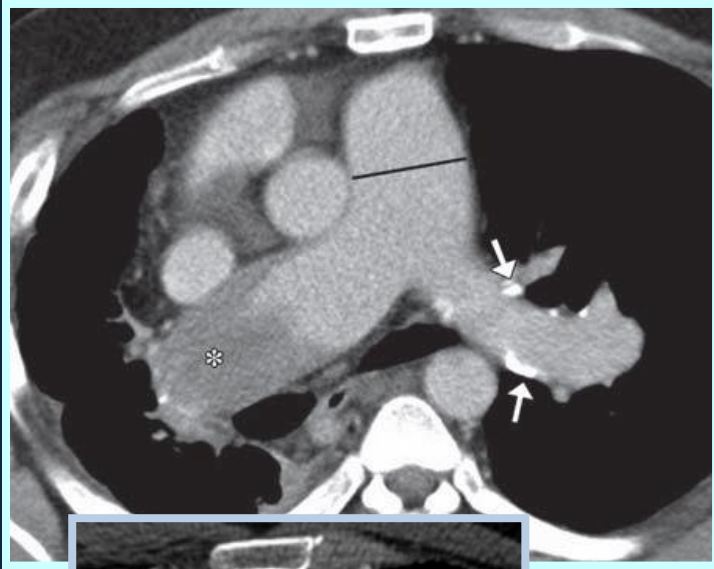


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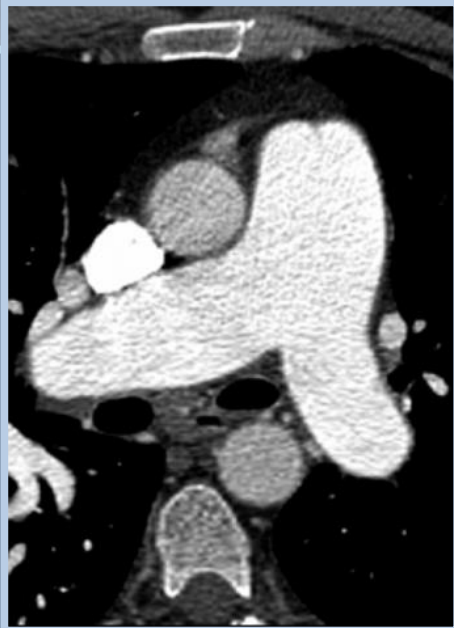


CTEPH



RV / LV > 1

Right ventr. myocardial thickness > 4 mm



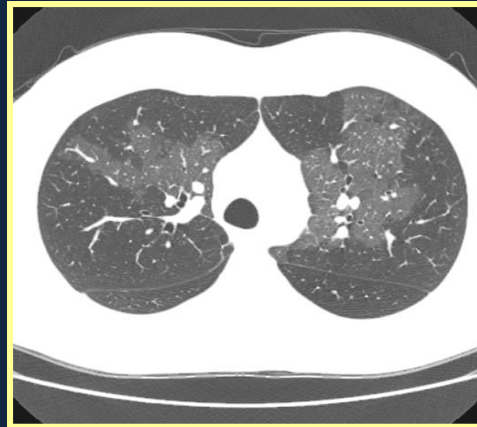
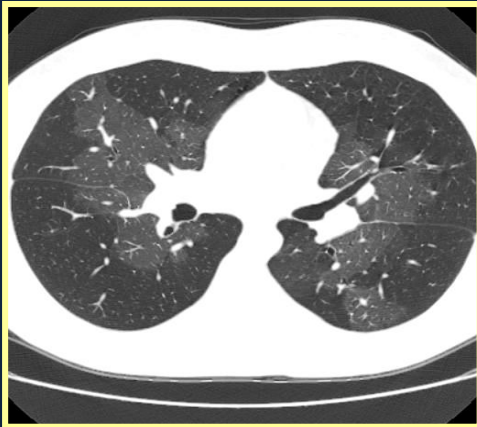
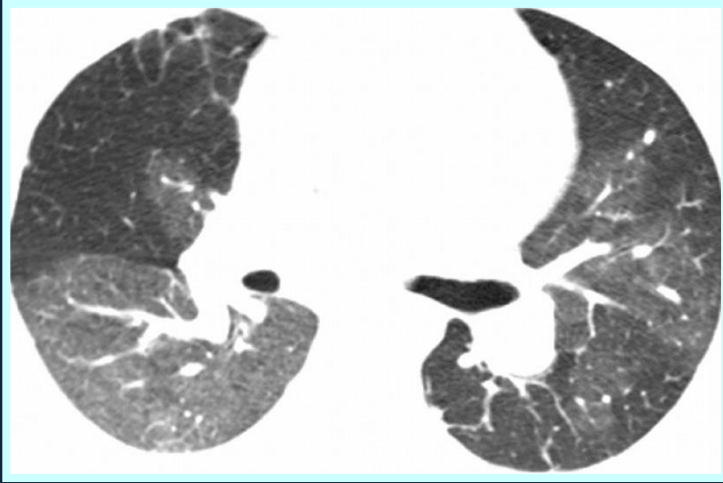
Διάμετρος ΠΑ > 29 mm

Διάμετρος ΠΑ > ΑΑ



CTEPH

Parenchymal signs



Mosaic perfusion

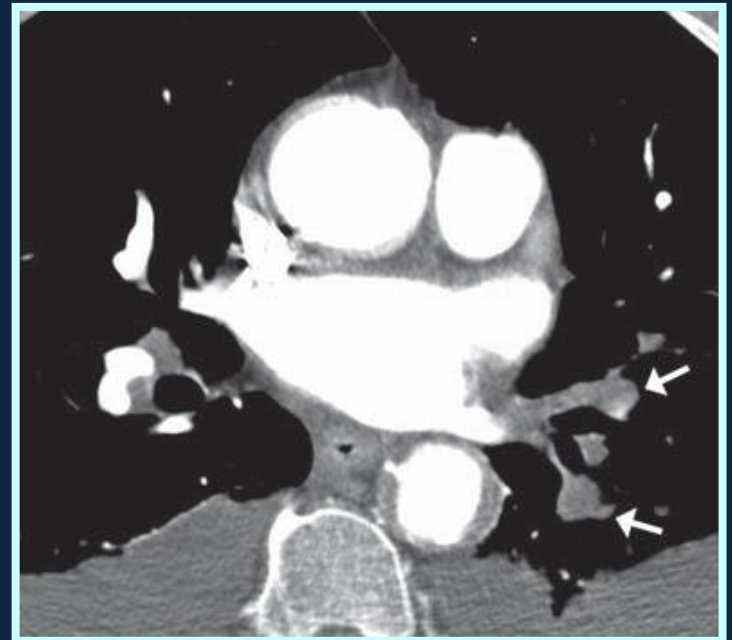
C: CTEPH Compared with Acute Pulmonary Embolism

CTEPH

Decrease in pulmonary artery diameter
Obtuse angle between embolus and vessel wall
Dilatation of bronchial arteries is common
Right ventricular dilatation and hypertrophy

Acute Pulmonary Embolism

Increase in pulmonary artery diameter
Acute angle between embolus and vessel wall
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Right ventricular dilatation (without hypertrophy) only : acute pulmonary arterial hypertension



RadioGraphics 2009; 29:31-53

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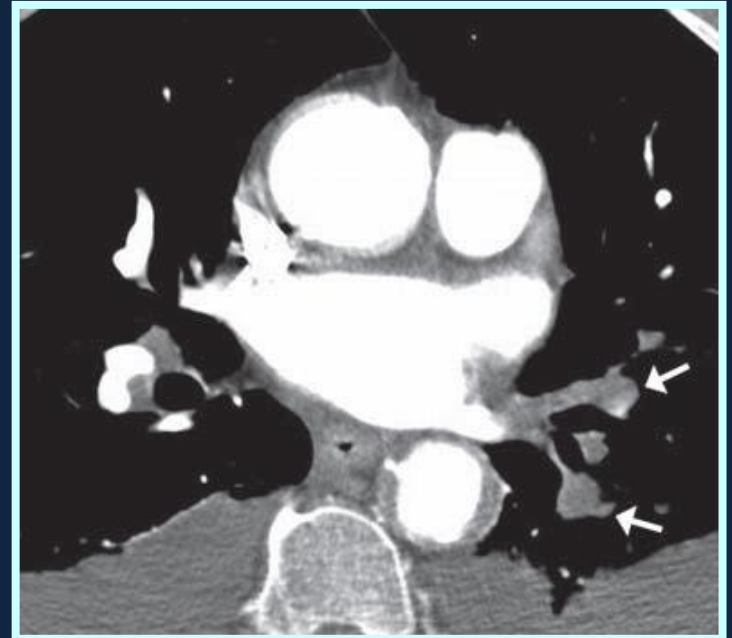
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RadioGraphics 2010; 30: 1753-1777



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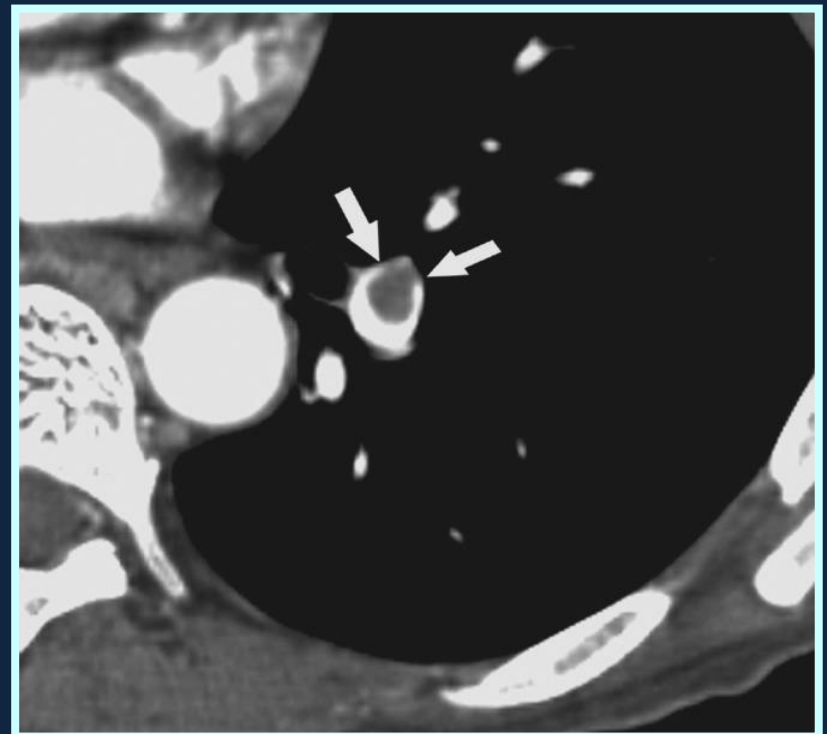
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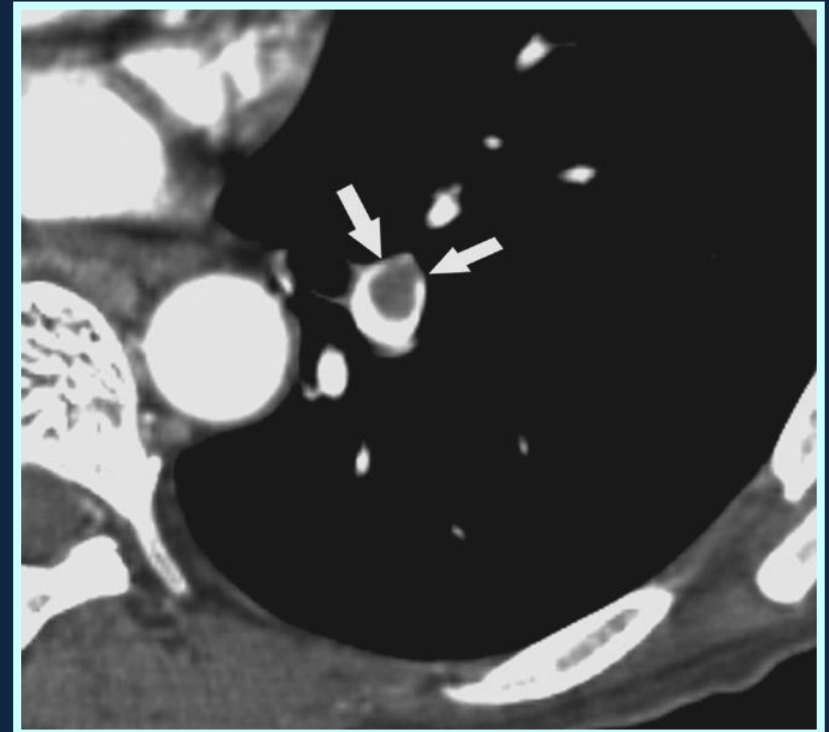
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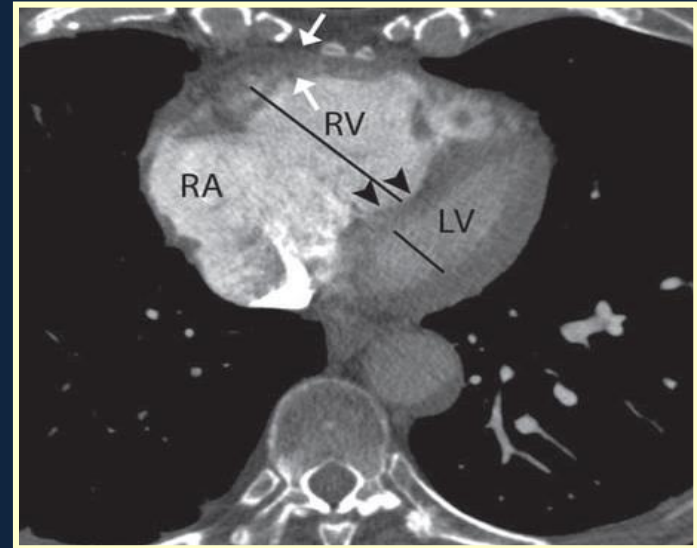
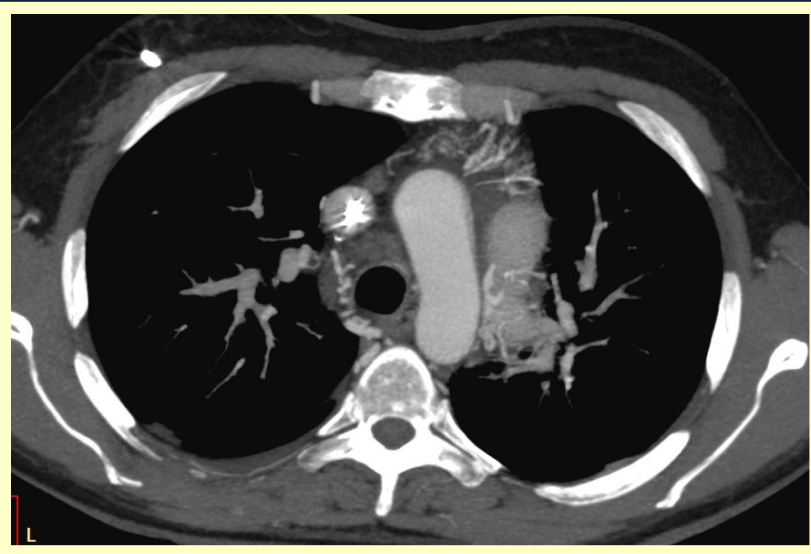
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Clinical classification of Pulmonary Hypertension (ESC/ERS guidelines 2015)

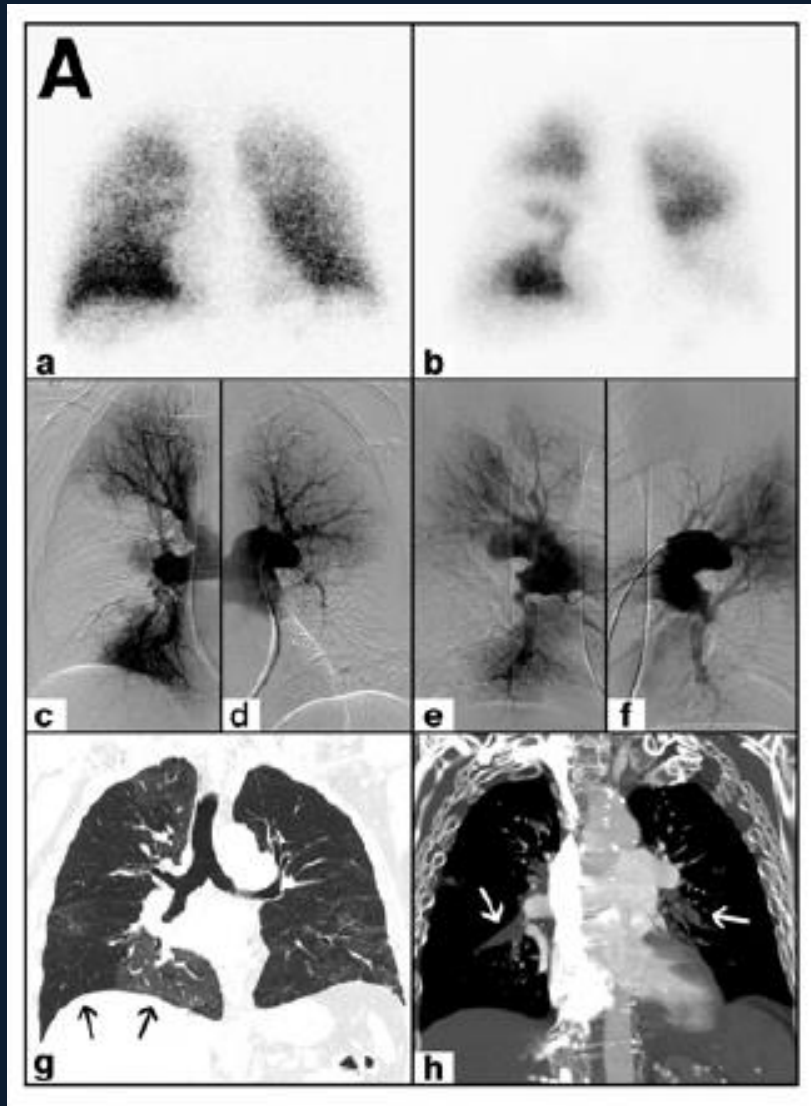
I. Pulmonary arterial hypertension
1.1 Idiopathic 1.2 Heritable 1.2.1 BMPR2 mutation 1.2.2 Other mutations 1.3 Drugs and toxins induced 1.4 Associated with: 1.4.1 Connective tissue disease 1.4.2 Human immunodeficiency virus (HIV) infection 1.4.3 Portal hypertension 1.4.4 Congenital heart disease (Table 6) 1.4.5 Schistosomiasis
I'. Pulmonary veno-occlusive disease and/or pulmonary capillary haemangiomatosis
1'.1 Idiopathic 1'.2 Heritable 1'.2.1 EIF2AK4 mutation 1'.2.2 Other mutations 1'.3 Drugs, toxins and radiation induced 1'.4 Associated with: 1'.4.1 Connective tissue disease 1'.4.2 HIV infection
I''. Persistent pulmonary hypertension of the newborn
2. Pulmonary hypertension due to left heart disease
2.1 Left ventricular systolic dysfunction 2.2 Left ventricular diastolic dysfunction 2.3 Valvular disease 2.4 Congenital / acquired left heart inflow/outflow tract obstruction and congenital cardiomyopathies 2.5 Congenital /acquired pulmonary veins stenosis

3. Pulmonary hypertension due to lung diseases and/or hypoxia
3.1 Chronic obstructive pulmonary disease 3.2 Interstitial lung disease 3.3 Other pulmonary diseases with mixed restrictive and obstructive pattern 3.4 Sleep-disordered breathing 3.5 Alveolar hypoventilation disorders 3.6 Chronic exposure to high altitude 3.7 Developmental lung diseases (Web Table III)
4. Chronic thromboembolic pulmonary hypertension and other pulmonary artery obstructions
4.1 Chronic thromboembolic pulmonary hypertension 4.2 Other pulmonary artery obstructions 4.2.1 Angiosarcoma 4.2.2 Other intravascular tumors 4.2.3 Arteritis 4.2.4 Congenital pulmonary arteries stenoses 4.2.5 Parasites (hydatidosis)
5. Pulmonary hypertension with unclear and/or multifactorial mechanisms
5.1 Haematological disorders: chronic haemolytic anaemia, myeloproliferative disorders, splenectomy 5.2 Systemic disorders, sarcoidosis, pulmonary histiocytosis, lymphangioleiomyomatosis 5.3 Metabolic disorders: glycogen storage disease, Gaucher disease, thyroid disorders 5.4 Others: pulmonary tumoral thrombotic microangiopathy, fibrosing mediastinitis, chronic renal failure (with/without dialysis), segmental pulmonary hypertension

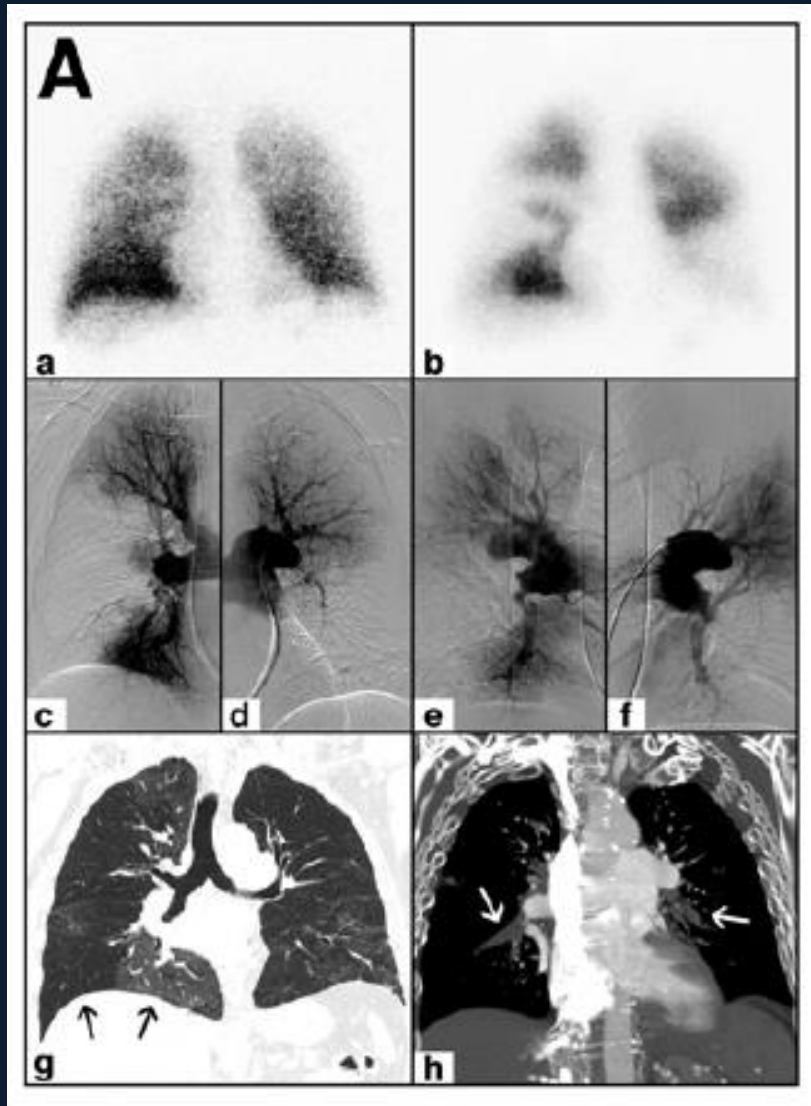
A: CTEPH Compared with Idiopathic Pulmonary Arterial Hypertension

CTEPH	Idiopathic Pulmonary Arterial Hypertension
Intraluminal thrombi, webs, and bands in central and peripheral pulmonary arteries	Apposition thrombus only in severe cases (localization in the central pulmonary arteries, associated with massive central pulmonary artery enlargement)
Dilatation of bronchial arteries is common (73% of patients)	Dilatation of bronchial arteries is uncommon (14% of patients)
Combination of mosaic lung attenuation and variation in the size of segmental vessels is common	Combination of mosaic lung attenuation and variation in the size of segmental vessels is uncommon
Segmental or subsegmental hypo- and hyper-attenuating lung areas (geographic mosaic perfusion)	Patchy heterogeneity of lung attenuation (patchy mosaic perfusion)

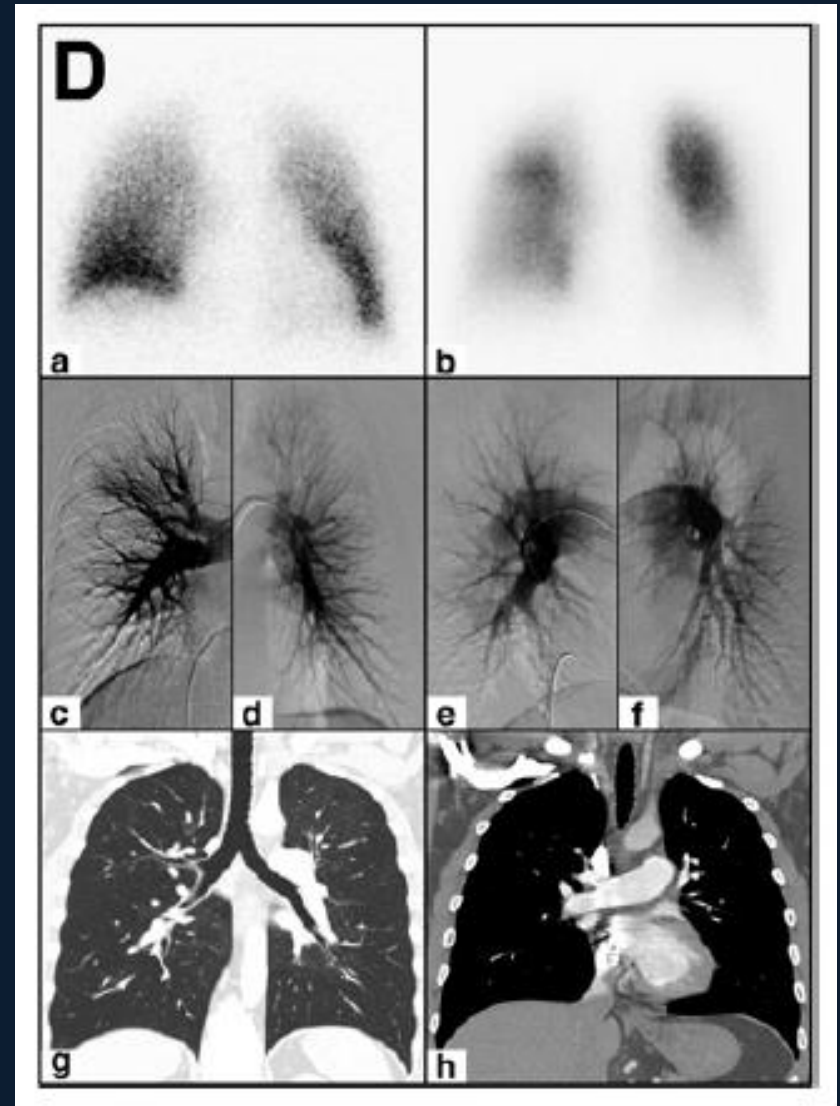
CTEPH



CTEPH



PAH





Imperial College
London



υπό την αιγίδα των
Ομάδων Εργασίας Ηλεκτροφυσιολογίας,
Απεικονιστικών Τεχνικών και
Ειδικής Αντιμέτωπος της
Ελληνικής Καρδιολογικής Εταιρείας

1ο ΣΥΝΕΔΡΙΟ ΚΑΡΔΙΑΓΓΕΙΑΚΗΣ ΑΠΕΙΚΟΝΙΣΗΣ ΣΤΗΝ ΚΛΙΝΙΚΗ ΠΡΑΞΗ

12-14 | 5 | 2016
HILTON, ΑΘΗΝΑ



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