폐혈관 School 2021

Diagnosis and Risk Assessment for Suspected VTE

가천대학교 길병원
호흡기알레르기내과 황재준

Contents

- Introduction
- Epidemiology
- Diagnosis
  - Clinical decision rules
  - D-dimer
  - Imaging tools.
- Risk assessment

Introduction

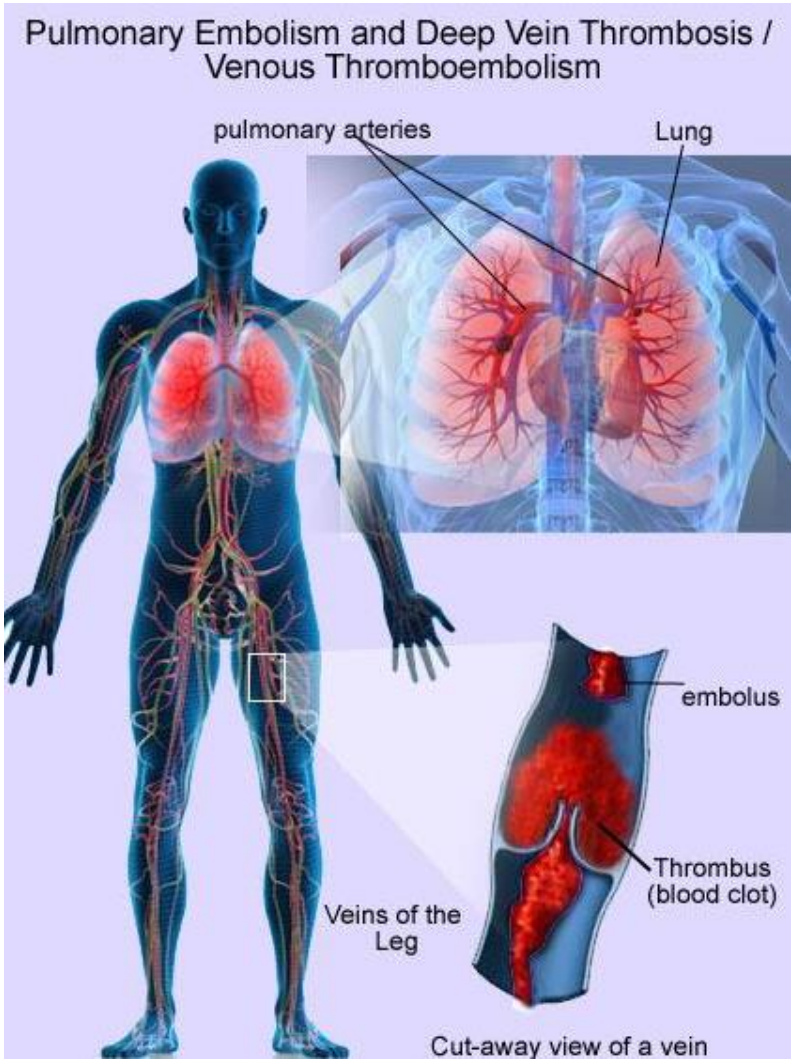
- Venous thromboembolism(VTE)
  - Deep vein thrombosis(DVT)
  - Pulmonary embolism(PE)
  - Common and potentially fatal disease.

Patient with suspected venous thromboembolism (VTE)

Symptoms of deep vein thrombosis (DVT):
unilateral leg pain, redness, swelling, warmth, and tenderness

Symptoms of pulmonary embolism (PE):
dyspnea, chest pain, hemoptysis, syncope, tachycardia, and hypotension

Introduction



- 4% from in the upper extremities
- 96% from in the lower extremities

- Almost all lower extremity DVTs arise from the calf veins and extend proximally

FJ Muñoz et Al. *Chest. 2008 Jan;133(1):143-8*

Predisposing factors

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

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 formulation)
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

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

Konstantinides, S. V. et Al. *European heart journal* 41.4 (2020): 543-603

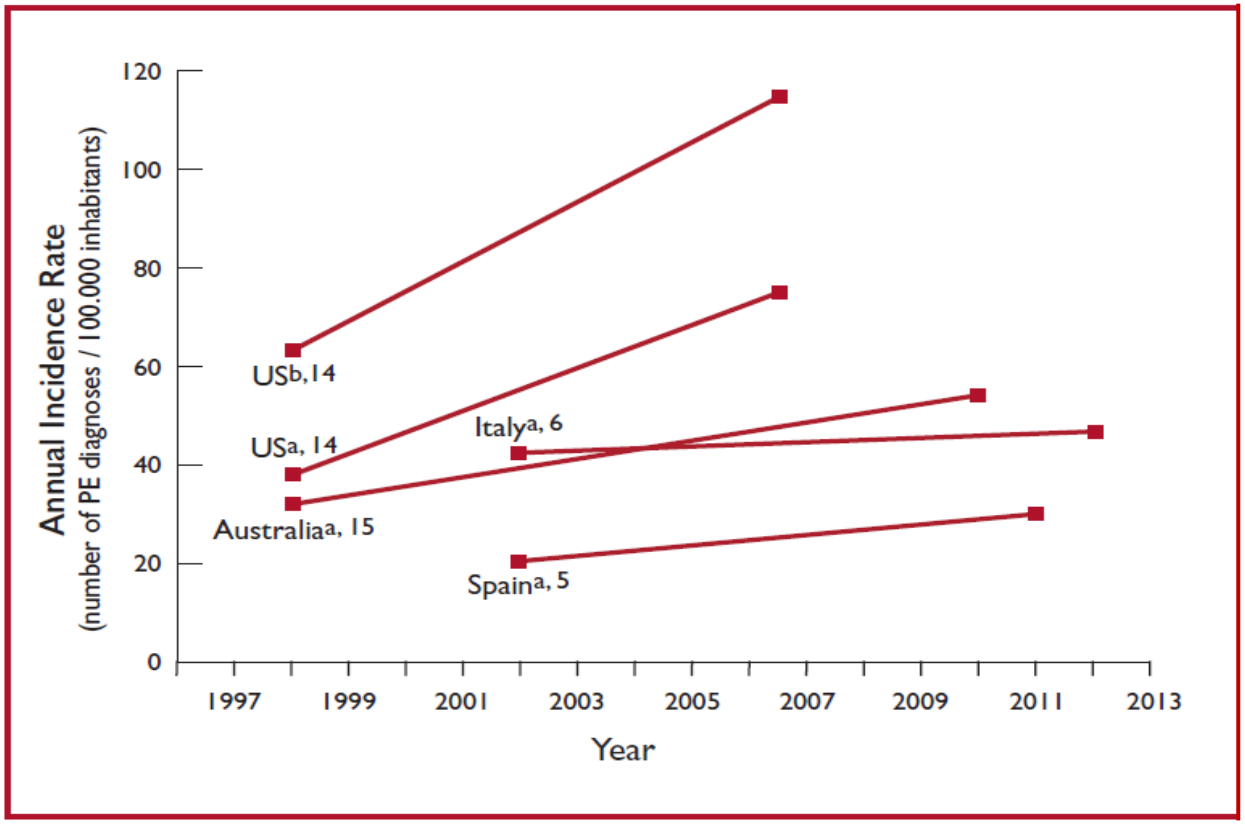
Epidemiology

Epidemiolgy

- Annual incidence rates of VTE
  - PE: 39-115 per 100,000 population.
  - DVT: 53-162 per 100,000 population.
  - Mostly observed in patients older than 55 years
- Incidence DVT
  - Constant over time.
- Hospital admissions for PE
  - Doubled over the last decade.

Wendelboe AM, et al. *Circ Res* 2016;118:13401347.
***Leller K, et al. Eur Heart J* 2020;41:522529**

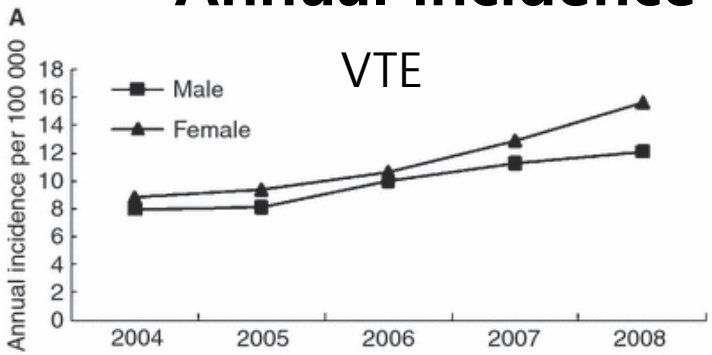
Epidemiology

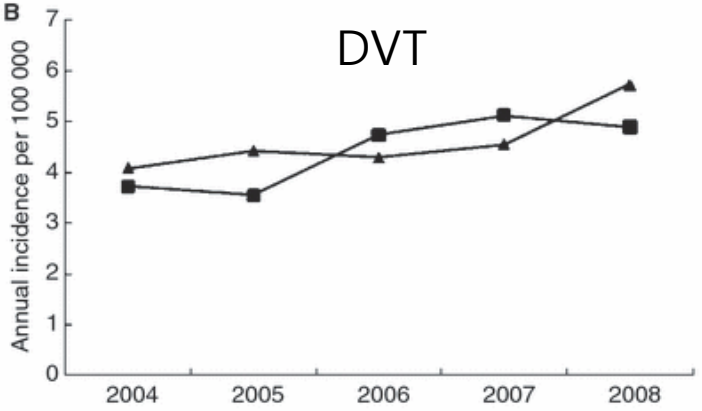


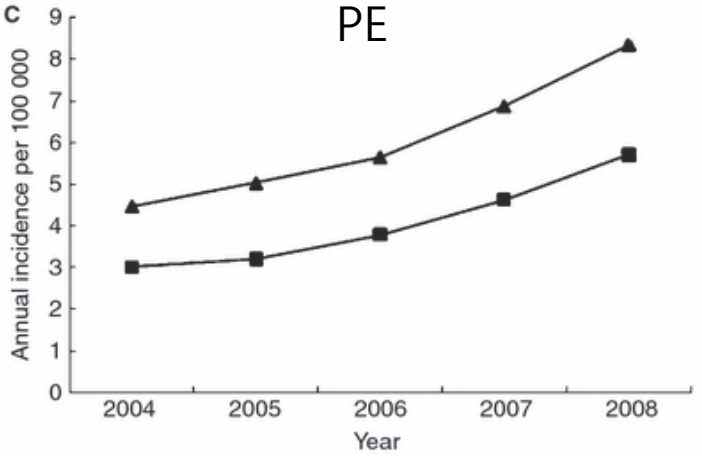
Annual incidence rate of PE

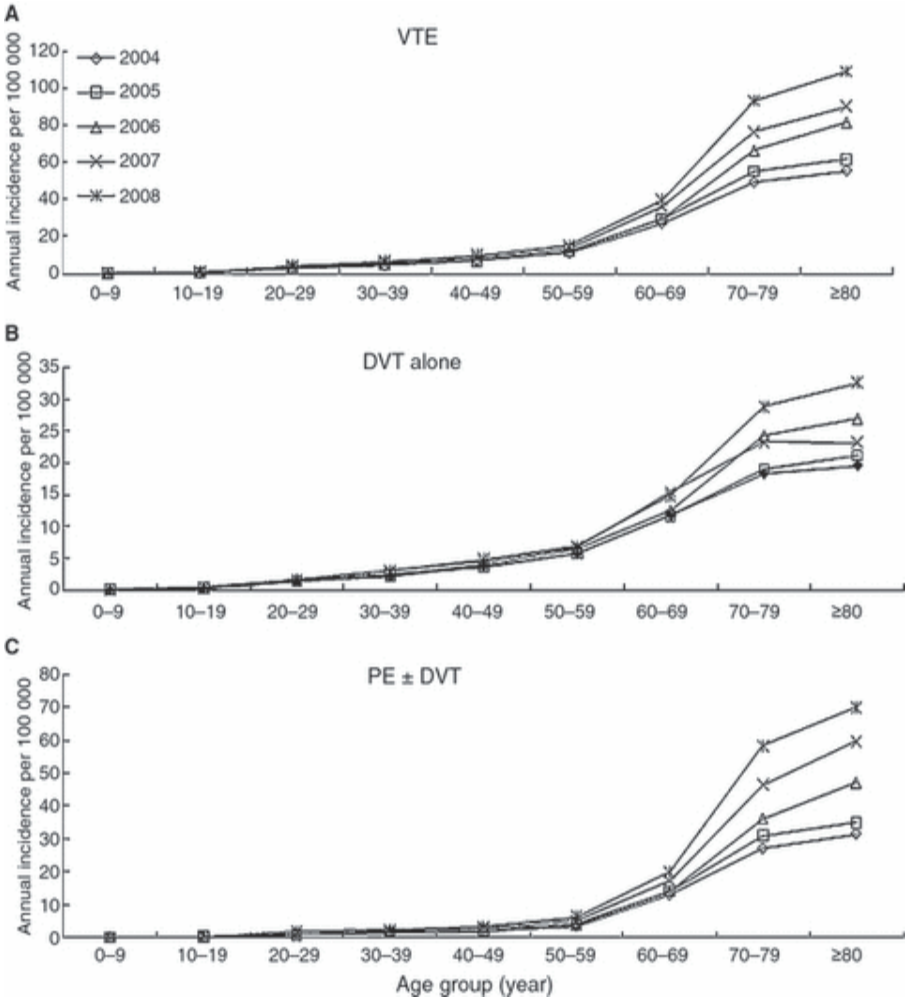
Konstantinides, S. V. et Al. *European heart journal* 41.4 (2020): 543-603

Annual incidence of VTE, DVT and PE In Korea







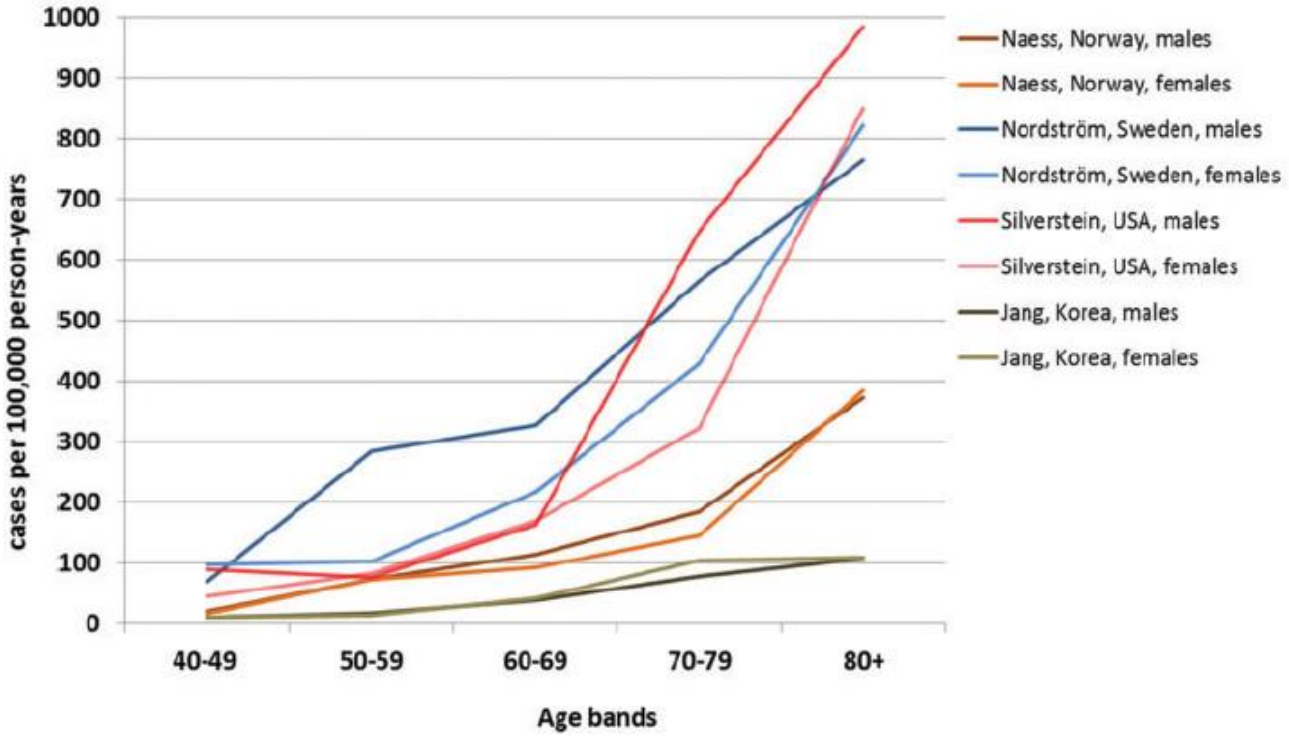


Jang, M.J et al. Journal of Thrombosis and Haemostasis **9.1 (2011): 85-91.)**

Epidemiolgy

- Incidence comparison (per 100, 000 individuals)

	VTE	PE	DVT
Massachusetts, US (2009)	113	65	68
Korea (2008)	13.8	5.31	7.01



Jang, M.J et al. Journal of Thrombosis and Haemostasis 9.1 (2011): 85-91.)
Mazzolai, Lucia, et al *European heart journal* (2017)

Epidemiology

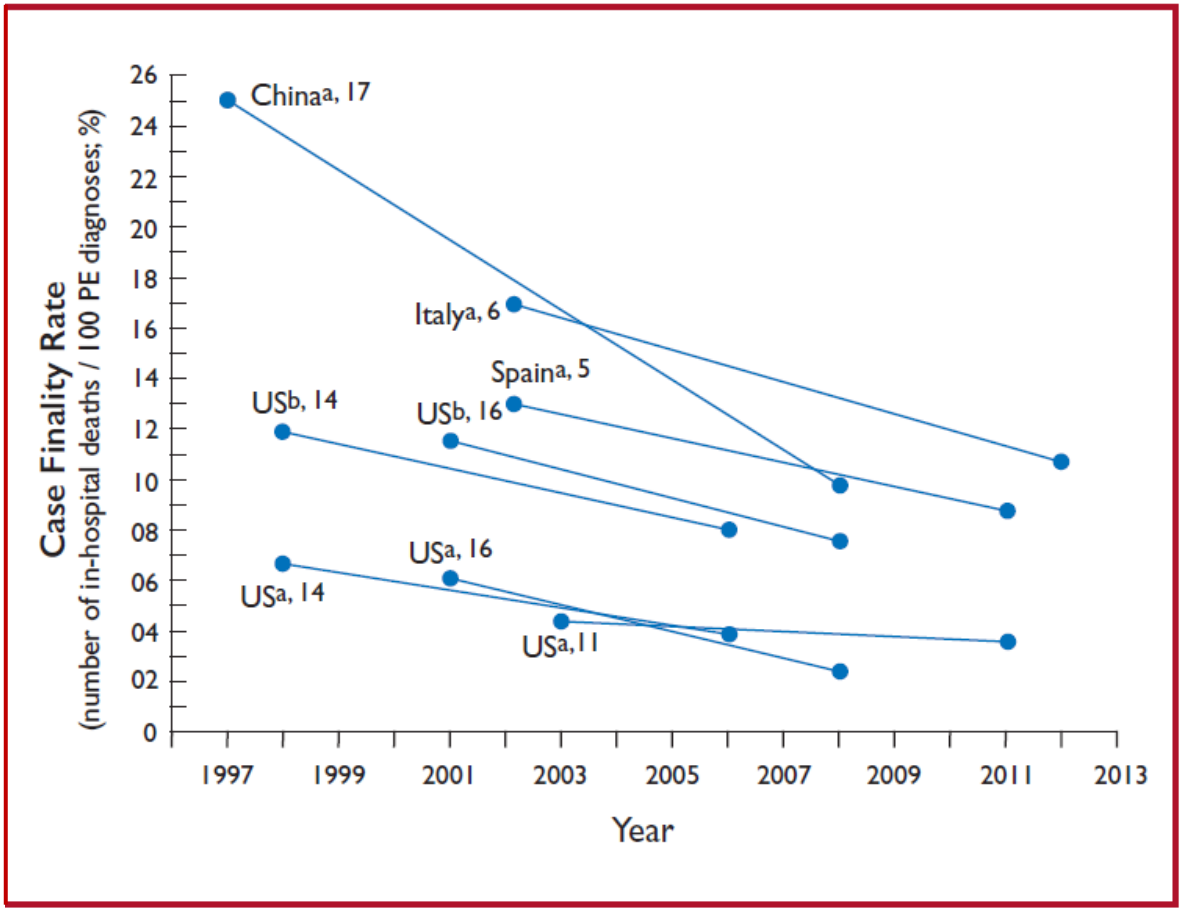
Table 5 Thirty-day and 1-year Case Fatality by Age Groups after First Definite Venous Thromboembolism

			Thirty Day			One Year		
	Age Group, y	Number at Risk	Number of Deaths	Case-fatality Rate (%)	95% CI	Number of Deaths	Case-fatality Rate (%)	95% CI
VTE	Overall	67,354	9497	14.10	13.84-14.36	19,672	29.21	28.86-29.55
	0-19	770	18	2.34	1.27-3.40	50	6.49	4.75-8.23
	20-29	2070	34	1.64	1.09-2.19	90	4.35	3.47-5.23
	30-39	3383	94	2.78	2.22-3.33	243	7.18	6.31-8.05
	40-49	6249	426	6.82	6.19-7.44	1031	16.50	15.58-17.42
	50-59	10,096	1118	11.07	10.46-11.69	2579	25.54	24.69-26.40
	60-69	13,440	1850	13.76	13.18-14.35	4078	30.34	29.57-31.12
	70-79	16,702	2762	16.54	15.97-17.10	5562	33.30	32.59-34.02
	≥80	14,644	3195	21.82	21.15-22.49	6039	41.24	40.44-42.04
DVT	Overall	39,138	3987	10.19	9.89-10.49	10,539	26.93	26.49-27.37
	0-19	572	13	2.27	1.05-3.49	41	7.17	5.05-9.28
	20-29	1171	17	1.45	0.77-2.14	58	4.95	3.71-6.20
	30-39	1991	33	1.66	1.10-2.22	129	6.48	5.40-7.56
	40-49	3547	184	5.19	4.46-5.92	572	16.13	14.92-17.34
	50-59	5780	479	8.29	7.58-9.00	1402	24.26	23.15-25.36
	60-69	7870	812	10.32	9.65-10.99	2249	28.58	27.58-29.58
	70-79	9712	1195	12.30	11.65-12.96	2966	30.54	29.62-31.46
	≥80	8495	1254	14.76	14.01-15.52	3122	36.75	35.73-37.78
PE	Overall	28,216	5510	19.53	19.07-19.99	9133	32.37	31.82-32.91
	0-19	198	5	2.53	0.34-4.71	9	4.55	1.64-7.45
	20-29	899	17	1.89	1.00-2.78	32	3.56	2.35-4.77
	30-39	1392	61	4.38	3.31-5.46	114	8.19	6.75-9.63
	40-49	2702	242	8.96	7.88-10.03	459	16.99	15.57-18.40
	50-59	4316	639	14.81	13.75-15.86	1177	27.27	25.94-28.60
	60-69	5570	1038	18.64	17.61-19.66	1829	32.84	31.60-34.07
	70-79	6990	1567	22.42	21.44-23.40	2596	37.14	36.01-38.27
	≥80	6149	1941	31.57	30.40-32.73	2917	47.44	46.19-48.69

CI = confidence interval; DVT = deep vein thrombosis; PE = pulmonary embolism; VTE = venous thromboembolism.

Tagalakis V, et al. *Am J Med*. 2013;126(9)

Epidemiology



Fatality rates of PE

Konstantinides, S. V. et Al. *European heart journal* 41.4 (2020): 543-603

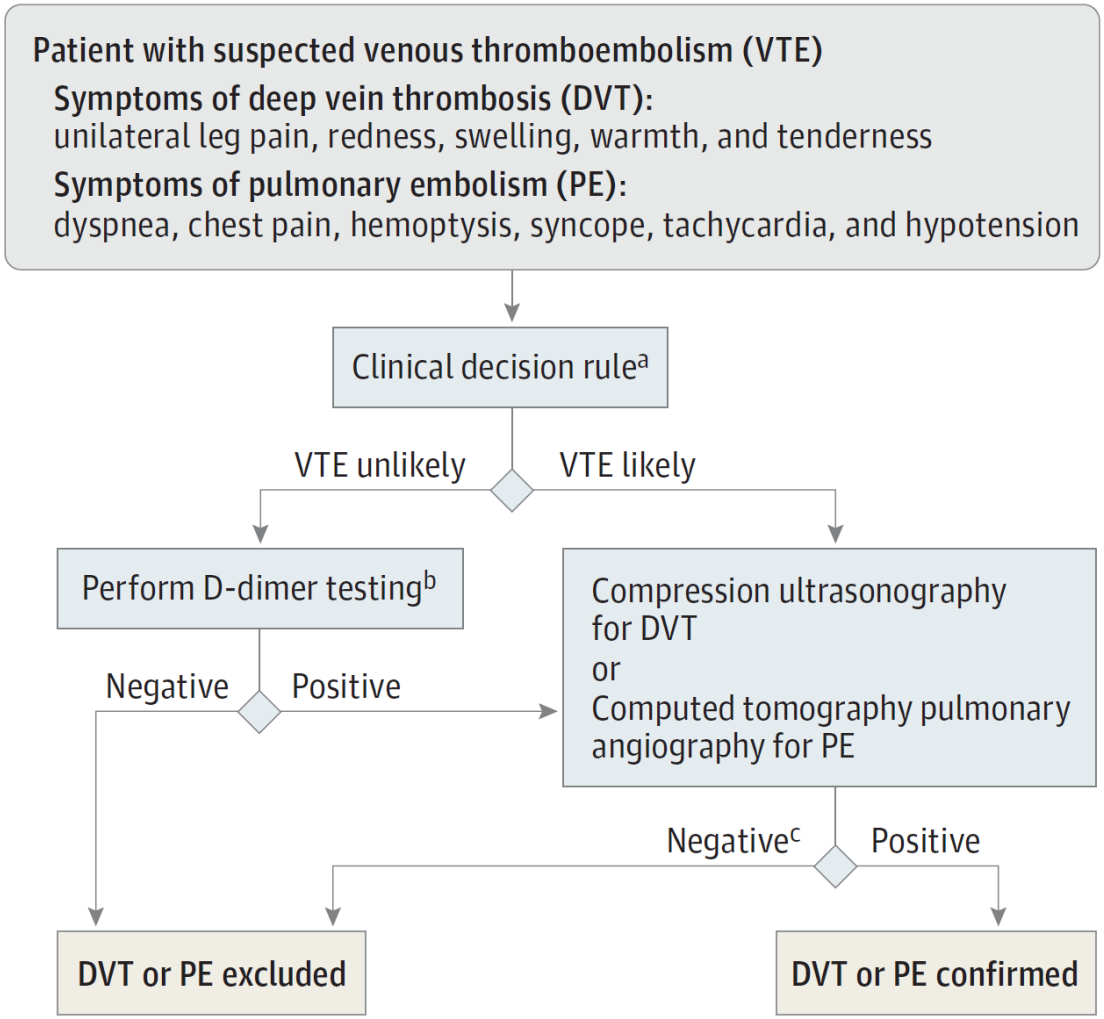
Diagnosis

Diagnosis

- Deep vein thrombosis and PE cannot be diagnosed based on signs and symptoms alone.

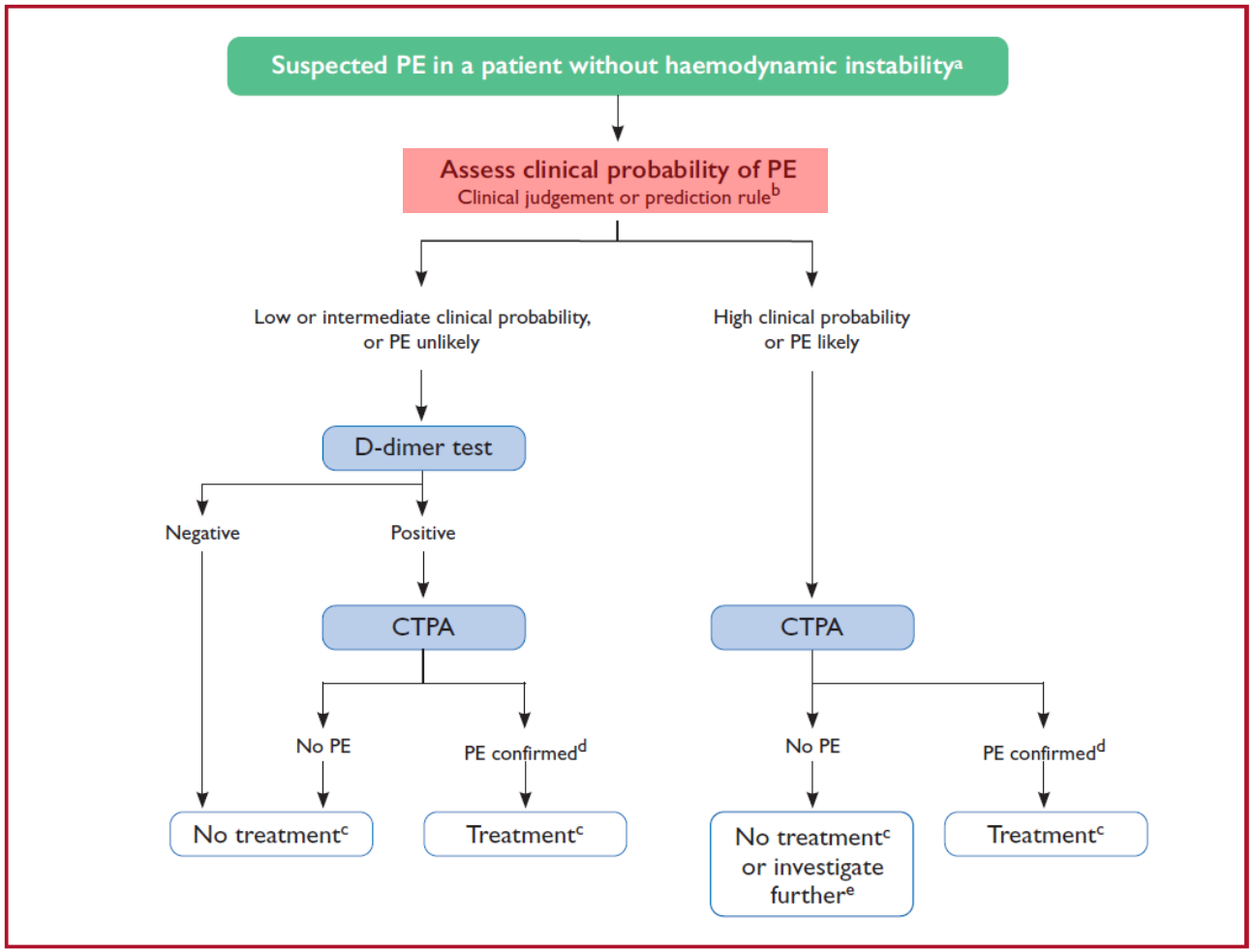
- Unnecessary diagnostic tests and anticoagulant therapy should be avoided.

Clinical decision rule



Tobias Tritschler et al. *JAMA*. 2018;320(15):1583-1594

Clinical decision rule



Clinical evaluation	Class	Level
It is recommended that the diagnostic strategy be based on clinical probability, assessed either by clinical judgement or by a validated prediction rule.[89,91,92,103,134,170–172]	I	A

Konstantinides, S. V. et Al. *European heart journal* 41.4 (2020): 543-603

Geneva	Points
Recent Surgery	3.0
Previous DVT or PE	2.0
Heart rate > 100 bpm	1.0
Age	
60–79 years old	1.0
≥ 80 years old	2.0
Chest Radiograph	
Atelectasis	1.0
Elevated hemidiaphram	1.0
PaO_2	
< 49 mm Hg (6.5 kPa)	4.0
49–59 mm Hg (6.5–7.99 kPa)	3.0
60–71 mm Hg (8–9.49 kPa)	2.0
72–82 mmHg (9.5–10.99 kPa)	1.0
$PaCO_2$	
< 36 mmHg (4.8 kPa)	2.0
36–38·9 mmHg (4.8–5.2 kPa)	1.0
Low	0–4
Intermediate	5–8
High	≥ 9

Revised Geneva	Points
Age > 65 years old	1.0
Previous history of PE or DVT	3.0
Surgery or fracture within 1 month	2.0
Active malignancy	2.0
Heart rate (bpm)	
75–94	3.0
≥ 95	5.0
Pain on leg venous palpation and unilateral edema	4.0
Unilateral leg pain	3.0
Hemoptysis	2.0
Low	0–3
Intermediate	4–10
High	≥ 11

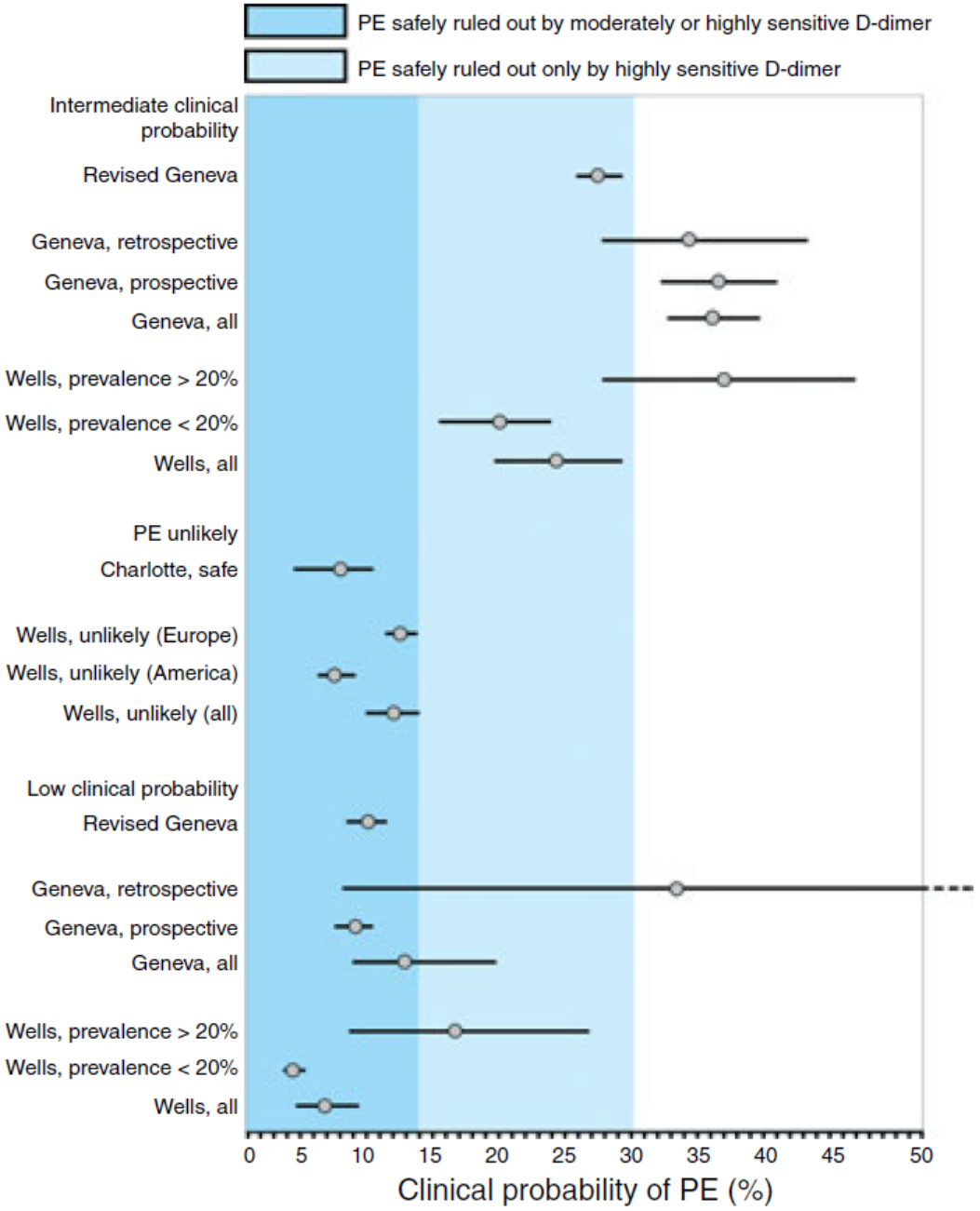
Wells	Points
Clinical signs of DVT	3.0
Recent surgery or immobilization	1.5
Heart rate > 100 bpm	1.5
Previous history of PE or DVT	1.5
Hemoptysis	1.0
Malignancy	1.0
Alternative diagnosis less likely than PE	3.0
3 levels	
Low	*< 2*
Intermediate	*2–6*
High	*> 6*
2 levels	
PE unlikely	*≤ 4*
PE likely	*> 4*

Charlotte Rule	
> 50 yers old	
Heart rate > systolic blood pressure	
Unexplained hypoxemia (O_2 < 95%)	
Recent surgery (previous 4 weeks)	
Hemoptysis	
Unilateral leg swelling	
Any of the previous present	*Unsafe*
All of the previous absent	Safe

Simp. Rev. Geneva	Points
Age > 65 years old	1.0
Previous history of PE or DVT	1.0
Surgery or fracture within 1 month	1.0
Active malignancy	1.0
Heart rate (bpm)	
75–94	1.0
≥ 95	1.0
Pain on leg deep vein palpation	1.0
Unilateral leg pain	1.0
Hemoptysis	1.0
Low	*0–1*
Intermediate	*2–4*
High	*≥ 5*

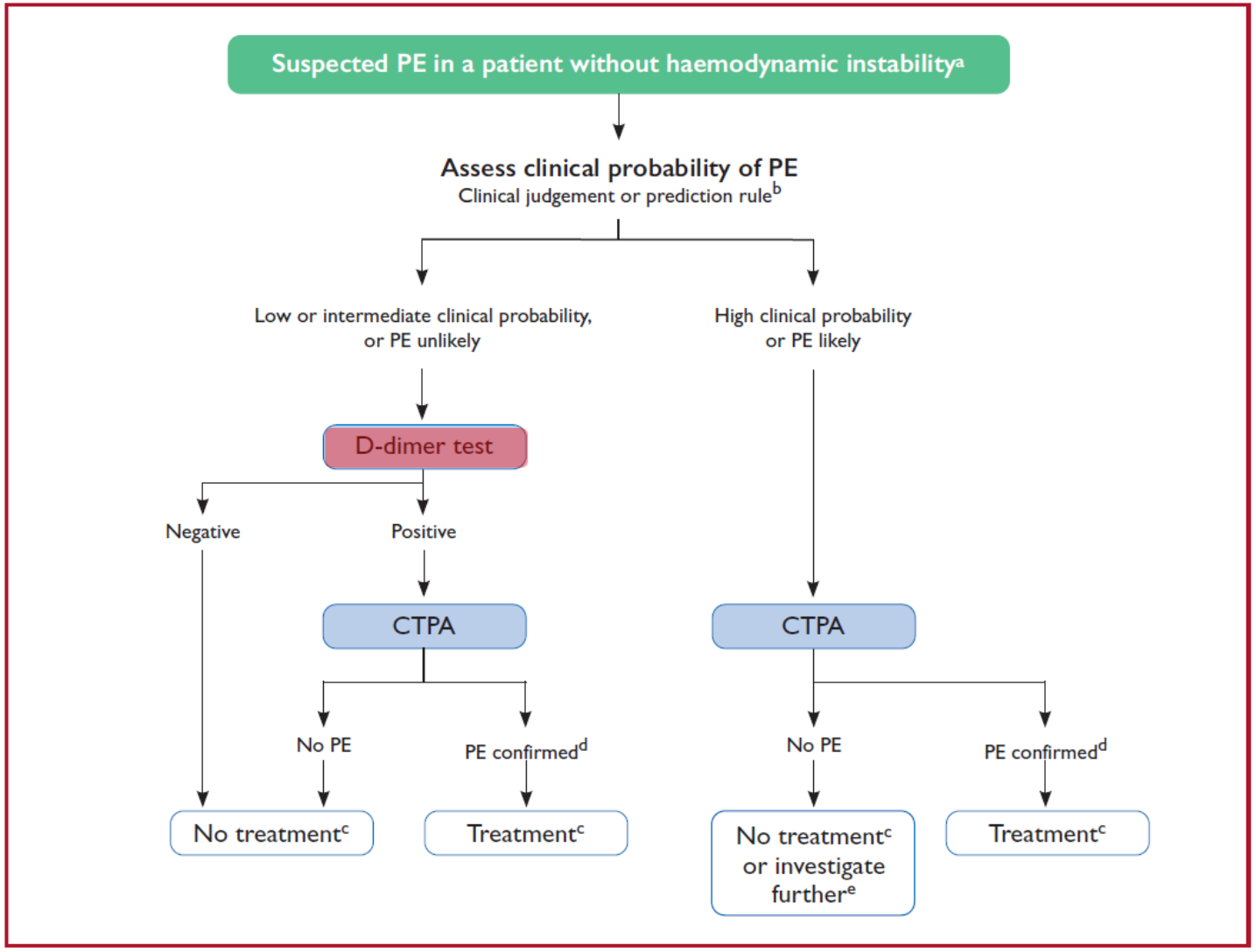
Simp. Wells	Points
Clinical signs of DVT	1.0
Recent surgery or immobilization	1.0
Heart rate > 100 beats per minutes	1.0
Previous history of PE or DVT	1.0
Hemoptysis	1.0
Malignancy	1.0
Alternative diagnosis less likely than PE	1.0
Unlikely	*≤ 1*
Likely	*> 1*

Ceriani, E. et al. *Journal of thrombosis and haemostasis*, 2010;*8*(5), 957-970.

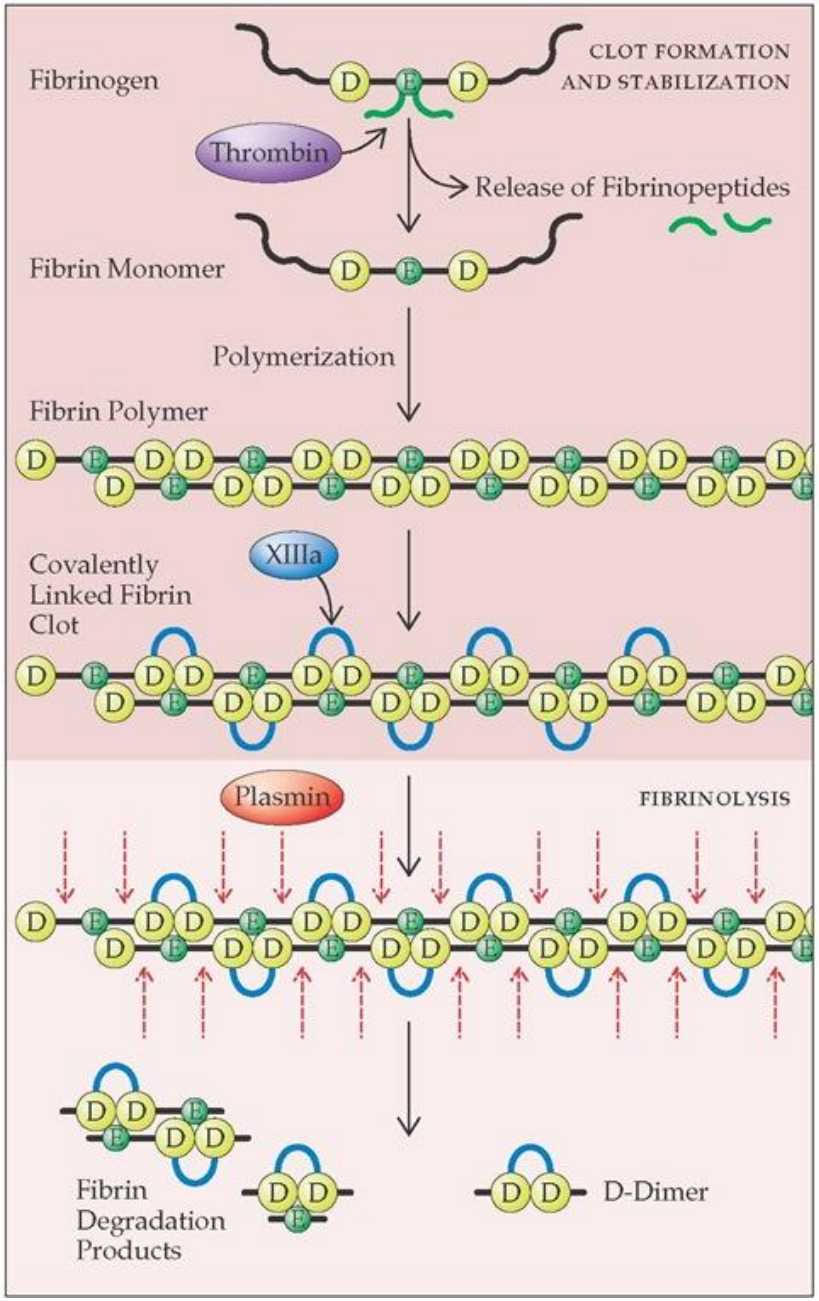


Ceriani, E. et al. *Journal of thrombosis and haemostasis*, 2010;*8*(5), 957-970.

D-dimer


Suspected PE in a patient without haemodynamic instability[a]
Assess clinical probability of PE
Clinical judgement or prediction rule[b]
Low or intermediate clinical probability, or PE unlikely
High clinical probability or PE likely
D-dimer test
Negative
Positive
CTPA
CTPA
No PE
PE confirmed[d]
No PE
PE confirmed[d]
No treatment[c]
Treatment[c]
No treatment[c] or investigate further[e]
Treatment[c]

- D-dimer


Fibrinogen
CLOT FORMATION AND STABILIZATION
Thrombin
Release of Fibrinopeptides
Fibrin Monomer
Polymerization
Fibrin Polymer
XIIIa
Covalently Linked Fibrin Clot
Plasmin
FIBRINOLYSIS
Fibrin Degradation Products
D-Dimer

D-dimer

- D-dimer
  - A sensitive(more than 95%) marker for VTE and excludes VTE without need for further testing among patients with a low clinical probability of PE.
  - Greater than 500 ng/mL suggest the presence of PE.
  - Age and renal function.

D-dimer	Class	Level
Plasma D-dimer measurement, preferably using a highly sensitive assay, is recommended in outpatients/emergency department patients with low or intermediate clinical probability, or those that are PE-unlikely, to reduce the need for unnecessary imaging and irradiation.[101–103,122,164,171,173,174]	I	A
As an alternative to the fixed D-dimer cut-off, a negative D-dimer test using an age-adjusted cut-off (age × 10 μg/L, in patients aged >50 years) should be considered for excluding PE in patients with low or intermediate clinical probability, or those that are PE-unlikely.[106]	IIa	B
As an alternative to the fixed or age-adjusted D-dimer cut-off, D-dimer levels adapted to clinical probability[c] should be considered to exclude PE.[107]	IIa	B
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.[175,176]	III	A

Konstantinides, S. V. et Al. *European heart journal* 41.4 (2020): 543-603

D-dimer

Renal function

Age

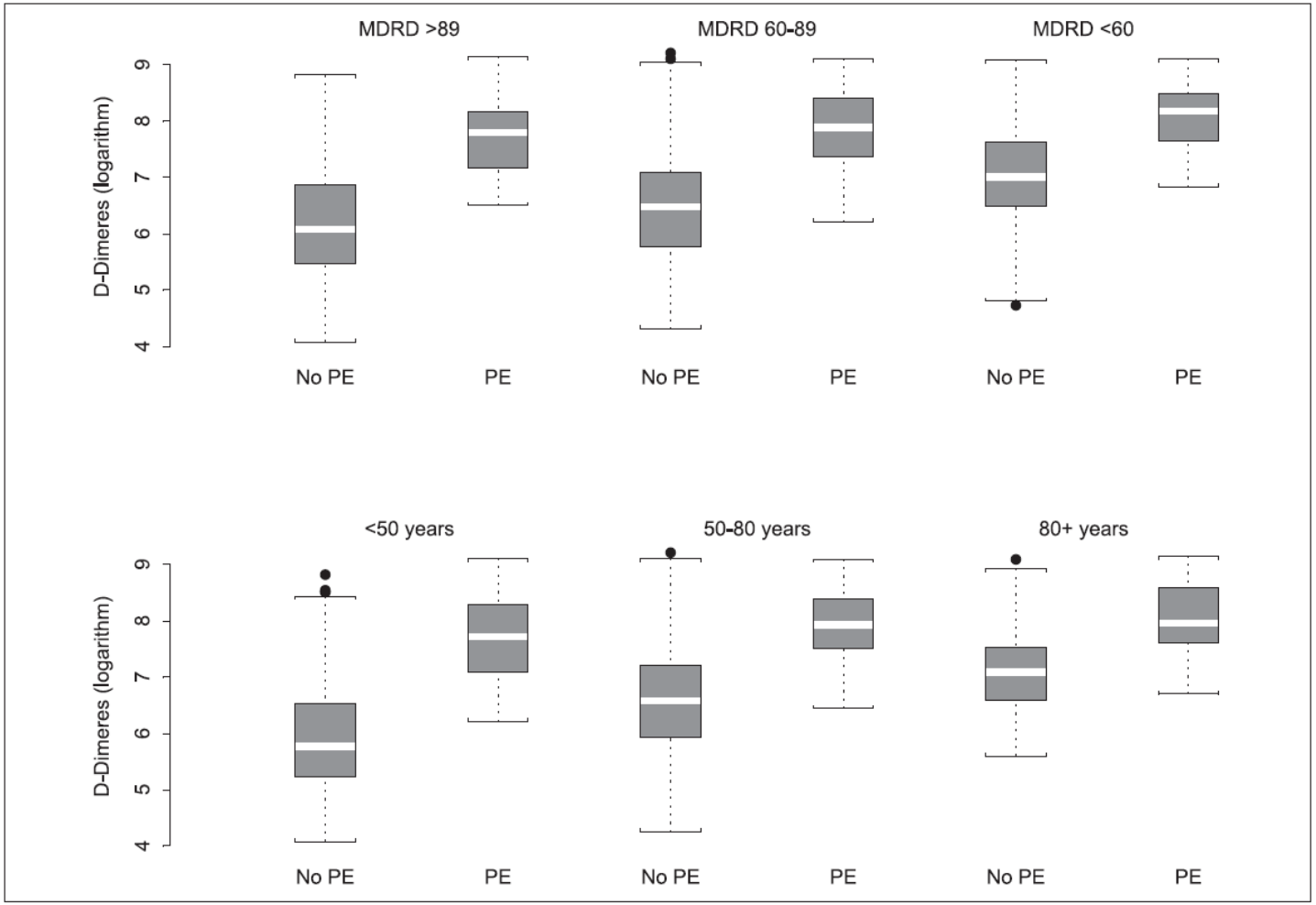


Figure 1: D-dimer levels according to creatinine clearance and age in patients with and without PE.

Bertoletti, L. et al. *Thrombosis and Haemostasis, 2014;112(09), 614–620.*

D-dimer

- Plasma concentration of D-dimer in a healthy population increases with age.
- 50% of those ≥70 years old had a positive D-dimer (>500 ng/mL FEU).
- Age-adjusted decision thresholds have sub-sequentially been recommended and validated (PE).

Age	Cut-off value
≤ 50 yrs	500 ng/mL
> 50 yrs	Age x 10 ng/mL

Haase C et al. *Thromb Res. 2013;132(6):676-80*
Douma RA et al. *BMJ. 2010;340:c1475*

$$GFR = 141 \times \min(Scr/\kappa, 1)^{\alpha} \times \max(Scr/\kappa, 1)^{1.209} \times Age^{0.0993} \times 1.018\ (\text{if woman}) \times 1.160\ (\text{if black})$$

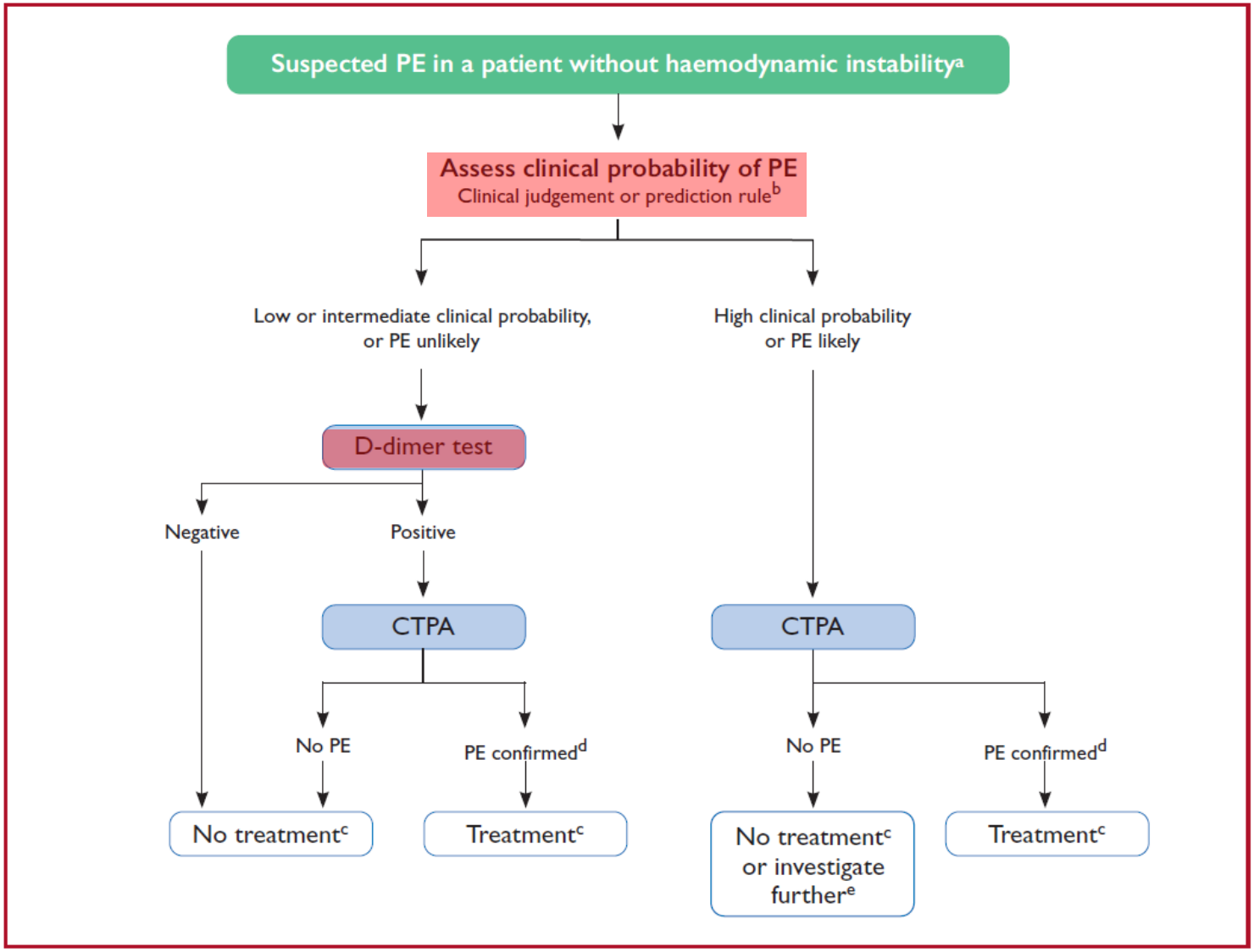
Patient population	D-Dimer cutoff (µg/L)	True positives (*n*)	True negatives (*n*)	False positives (*n*)	False negatives (*n*)	Sensitivity	Specificity	Positive predictive value	Negative predicitive value
All patients	<500	294	4305	5078	39	0.88	0.46	0.05	0.99
eGFR > 60 ml/min	<333	243	2679	4497	20	0.92	0.37	0.05	0.99
eGFR 30–60 ml/min	<1306	43	1047	663	6	0.88	0.61	0.06	0.99
eGFR < 30 ml/min	<1663	19	234	263	2	0.90	0.47	0.07	0.99

Renal Dysfunction/Renal Insufficiency Grade	Patients, *n* (%)	D-dimer <500 µg/L, *n* (%)	Thromboembolic events, *n* (%)
Renal function (mL/min)			
eGFR > 60	11 935 (82.4)	6,574 (55.1)	353 (3.0)
eGFR 30–60	1,919 (13.3)	477 (24.9)	94 (4.9)
eGFR < 30	623 (4.3)	73 (11.7)	53 (8.5)
Renal insufficiency			
Kidney failure, any type	1,364 (9.4)	191 (14.0)	123 (9.0)
Chronic kidney failure, any stage	1,253 (8.7)	176 (14.0)	113 (9.0)
Acute kidney failure, any stage	228 (1.6)	26 (11.4)	24 (10.5)
Acute on chronic, kidney failure	117 (0.8)	11 (9.4)	14 (11.9)

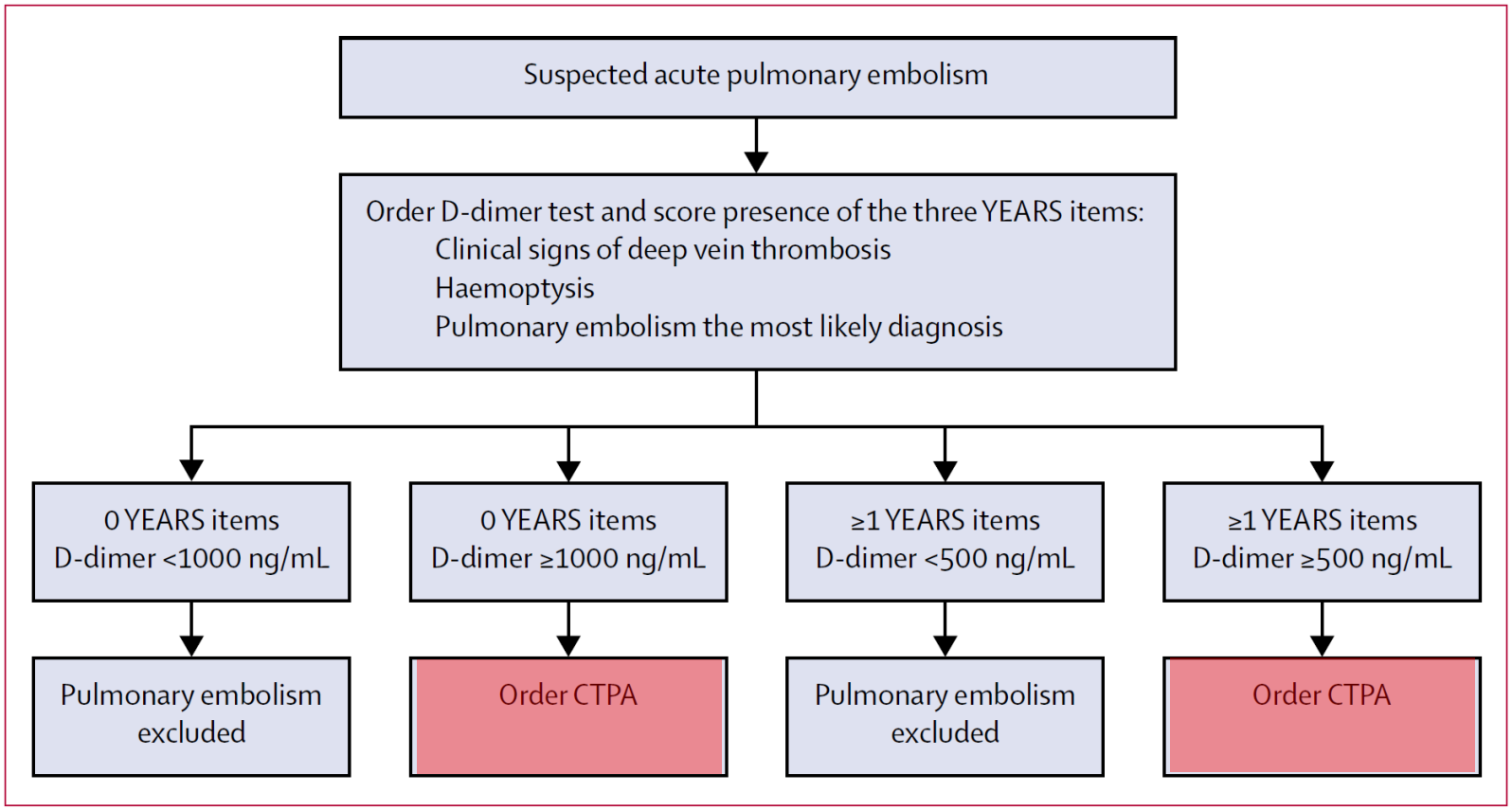
eGFR = estimated glomerular filtration rate.

Carmen A. et al. ***Intensive care medicine*****, 2017;43.3: 470.**
Joerg C. et al. ***Critical care medicine*****, 2020;48.4: e270-e276.**

Diagnosis

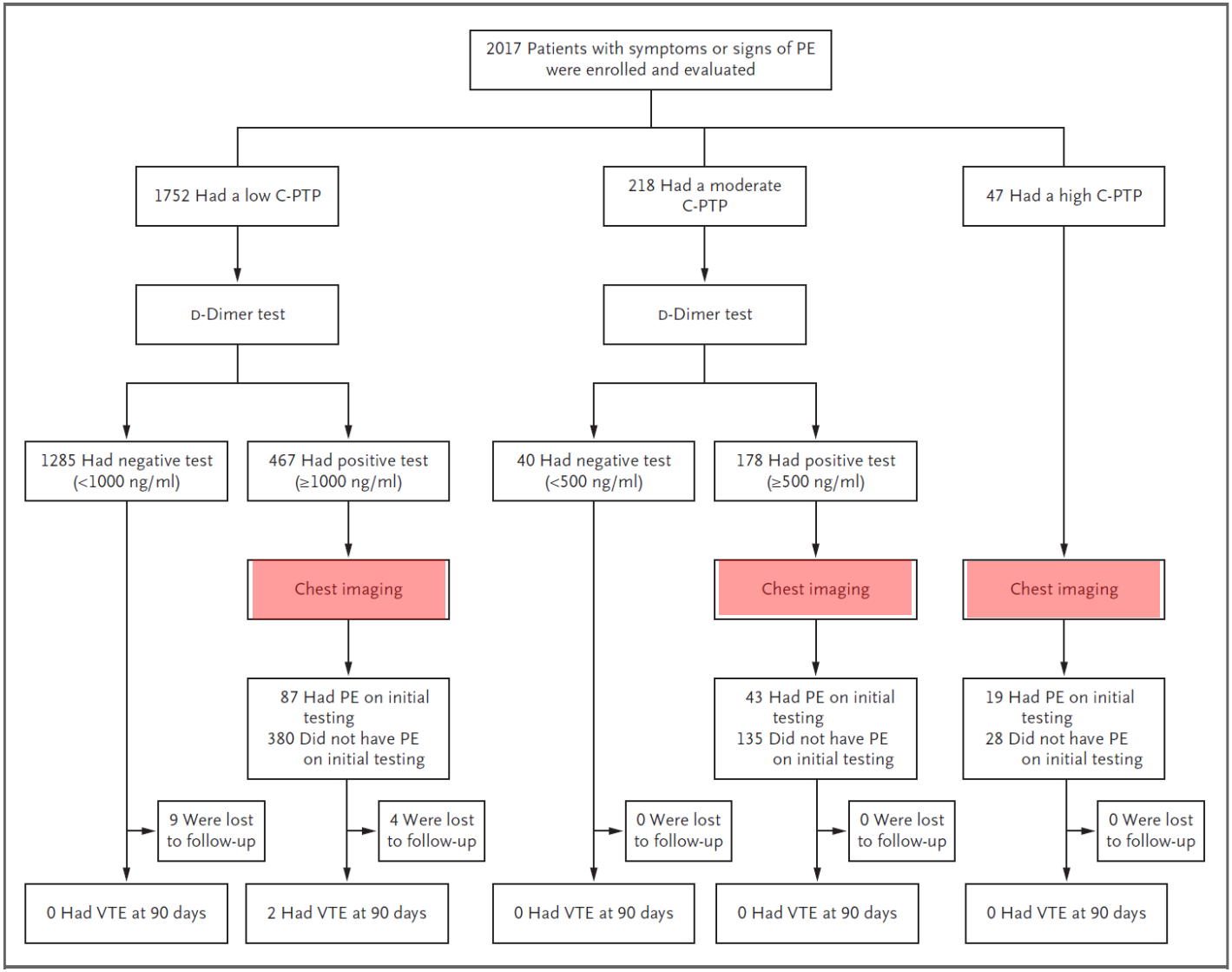

Suspected PE in a patient without haemodynamic instability[a]
Assess clinical probability of PE
Clinical judgement or prediction rule[b]
Low or intermediate clinical probability, or PE unlikely
High clinical probability or PE likely
D-dimer test
Negative
Positive
CTPA
CTPA
No PE
PE confirmed[d]
No PE
PE confirmed[d]
No treatment[c]
Treatment[c]
No treatment[c] or investigate further[e]
Treatment[c]

YEARS algorithm for PE



Tom van der Hulle et al. *Lancet* 2017; 390: 289–97

PEGeD study



Kearon, C. et al. *New England Journal of Medicine 2019;381*(22), 2125-2134.

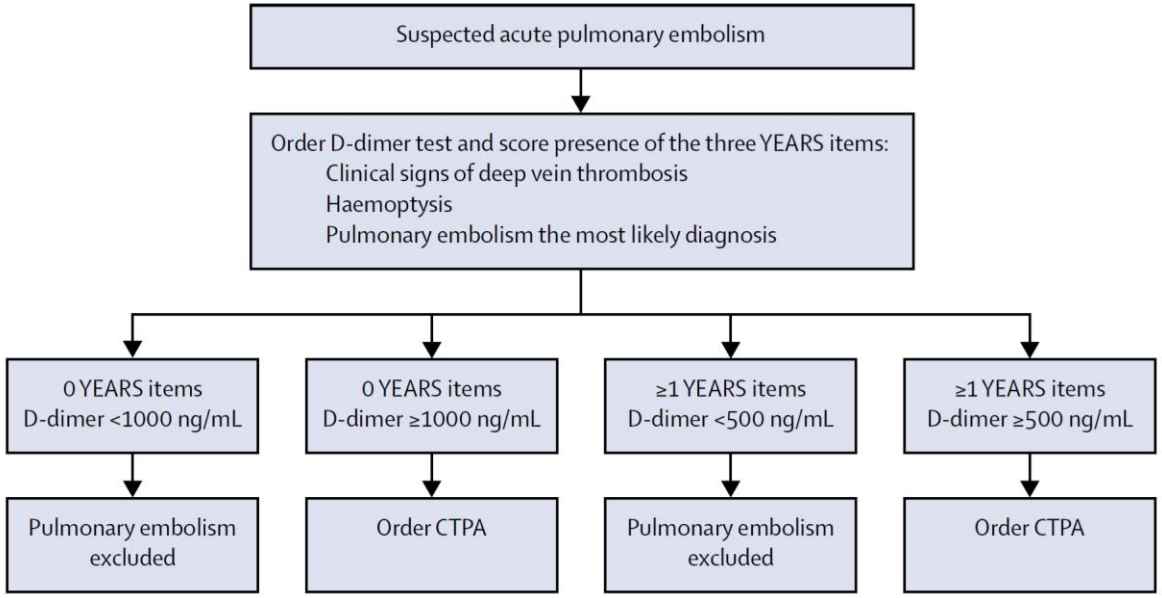
PEGeD Study

Table 3. Number of D-Dimer Tests and Chest Imaging Examinations with the PEGeD Strategy as Compared with Other Diagnostic Strategies.*

Diagnostic Strategy	Low C-PTP (N=1752)		Moderate C-PTP (N=218)		High C-PTP (N=47)		All Patients (N=2017)	
	D-Dimer Test	Chest Imaging†	D-Dimer Test	Chest Imaging†	D-Dimer Test	Chest Imaging†	D-Dimer Test	Chest Imaging†
PEGeD	1752	467	218	178	0	47	1970	692
Standard‡	1752	782	0	218	0	47	1752	1047
Difference: PEGeD – standard	0	–315	218	–40	—	0	218	–355
Age-adjusted§	1752	654	218	164	0	47	1970	865
Difference: PEGeD – age-adjusted	0	–187	0	14	—	0	0	–173
YEARS¶	1752	520	218	176	47	37	2017	733
Difference: PEGeD – YEARS	0	–53	0	2	–47	10	–47	–41

Kearon, C. et al. *New England Journal of Medicine, 2019;381*(22), 2125-2134.

YEARS study (2017)

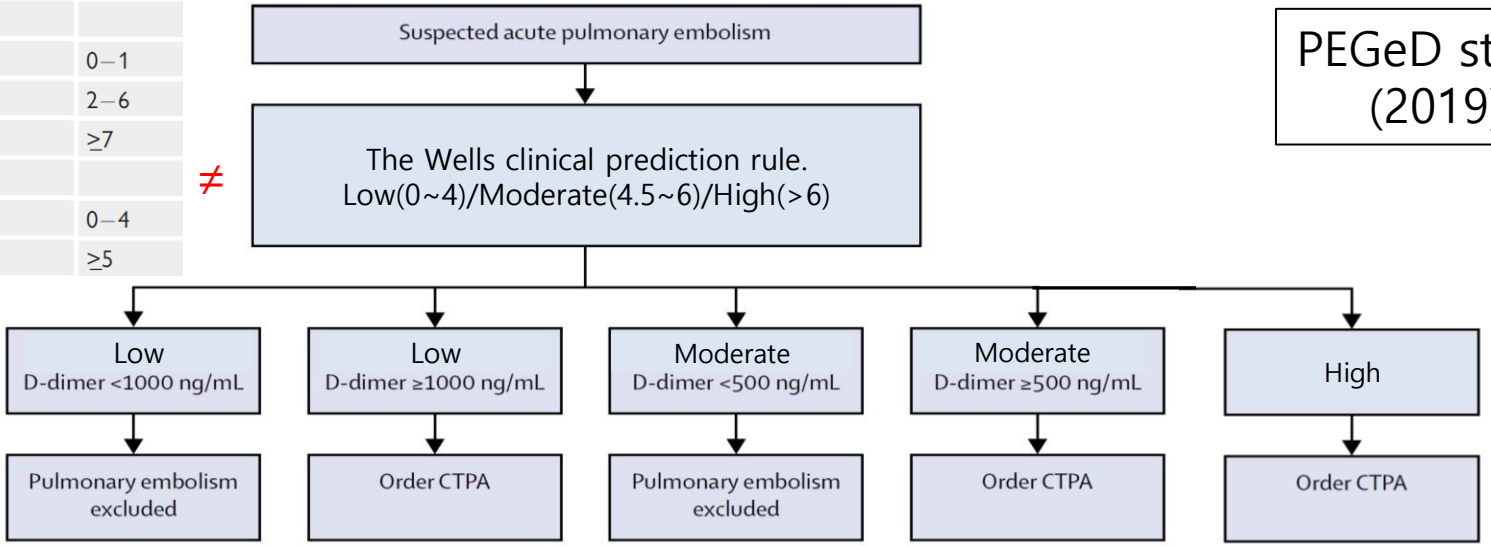


Original Well score

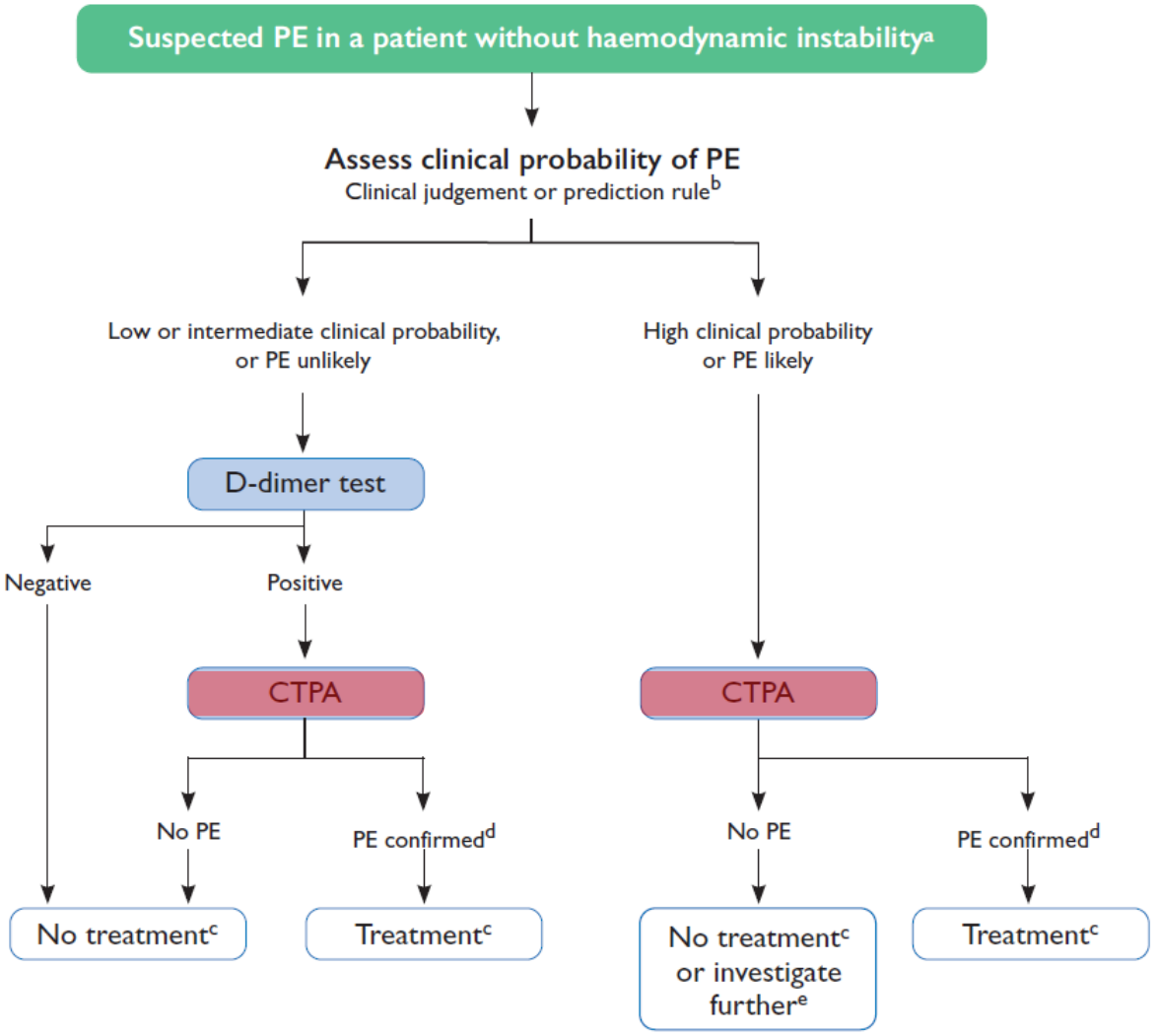
Clinical probability	
Three-level score	
Low	0–1
Intermediate	2–6
High	≥7
Two-level score	
PE unlikely	0–4
PE likely	≥5

≠

PEGeD study (2019)



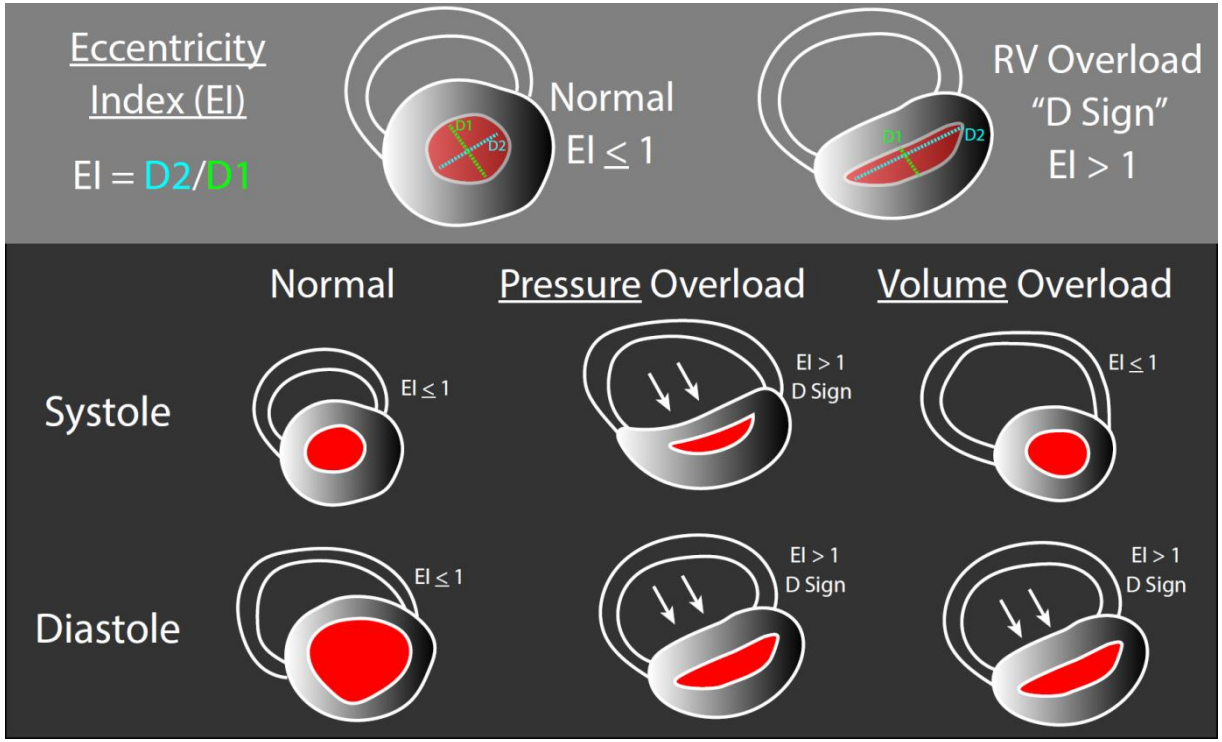
Diagnosis

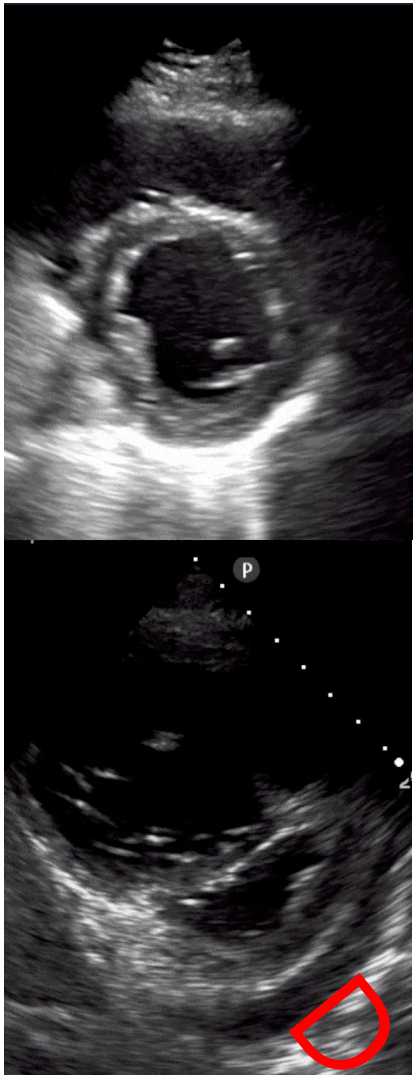

Suspected PE in a patient without haemodynamic instability[a]
Assess clinical probability of PE
Clinical judgement or prediction rule[b]
Low or intermediate clinical probability, or PE unlikely
High clinical probability or PE likely
D-dimer test
Negative
Positive
CTPA
CTPA
No PE
PE confirmed[d]
No PE
PE confirmed[d]
No treatment[c]
Treatment[c]
No treatment[c] or investigate further[e]
Treatment[c]

Imaging for Suspected PE

- Echocardiography
- Computed tomography pulmonary angiography
- Lung $\dot{V}/\dot{Q}$ Scintigraphy

Echocardiography





D-shape

Suspected PE with haemodynamic instability	Class	Level
In suspected high-risk PE, as indicated by the presence of haemodynamic instability, bedside echocardiography or emergency CTPA (depending on availability and clinical circumstances) is recommended for diagnosis.[169]	I	C

Suspected PE without haemodynamic instability	Class	Level
The use of validated criteria for diagnosing PE is recommended.[12]	I	B

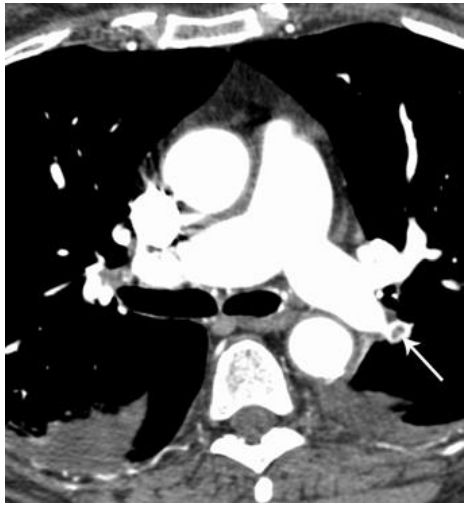
CTPA

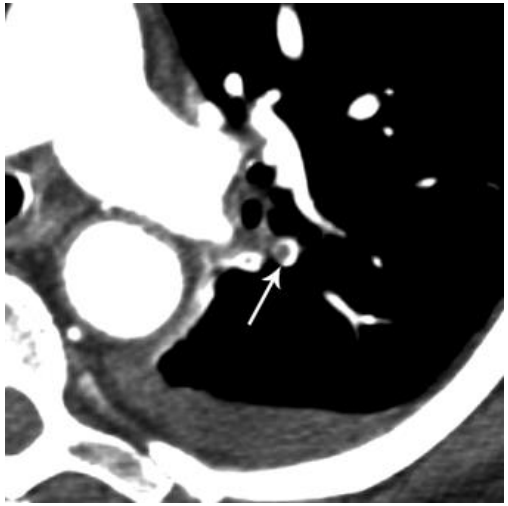
	Strengths	Weaknesses/limitations	Radiation issues[a]

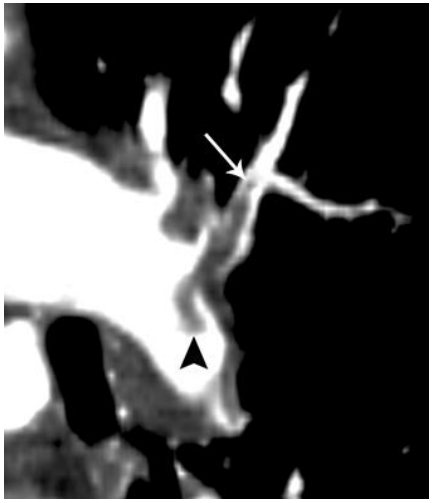
CTPA	• Readily available around the clock in most centres
	• Excellent accuracy
	• Strong validation in prospective management outcome studies
	• Low rate of inconclusive results (3–5%)
	• May provide alternative diagnosis if PE excluded
	• Short acquisition time
		• Radiation exposure
		• Exposure to iodine contrast:
		  ○ limited use in iodine allergy and hyperthyroidism
		  ○ risks in pregnant and breastfeeding women
		  ○ contraindicated in severe renal failure
		• Tendency to overuse because of easy accessibility
		• Clinical relevance of CTPA diagnosis of subsegmental PE unknown
			• Radiation effective dose 3–10 mSv[b]
			• Significant radiation exposure to young female breast tissue

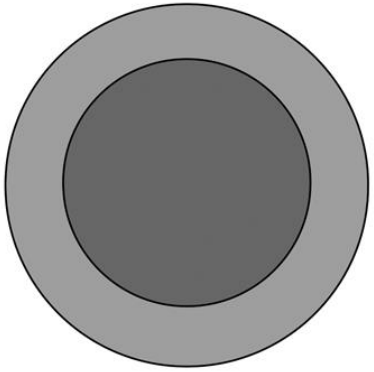
CTPA	Class	Level
It is recommended to reject the diagnosis of PE (without further testing) if CTPA is normal in a patient with low or intermediate clinical probability, or who is PE-unlikely.[101,122,164,171]	I	A
It is recommended to accept the diagnosis of PE (without further testing) if CTPA shows a segmental or more proximal filling defect in a patient with intermediate or high clinical probability.[115]	I	B
It should be considered to reject the diagnosis of PE (without further testing) if CTPA is normal in a patient with high clinical probability or who is PE-likely.[171]	IIa	B
Further imaging tests to confirm PE may be considered in cases of isolated subsegmental filling defects.[115]	IIb	C
CT venography is not recommended as an adjunct to CTPA.[115,164]	III	B

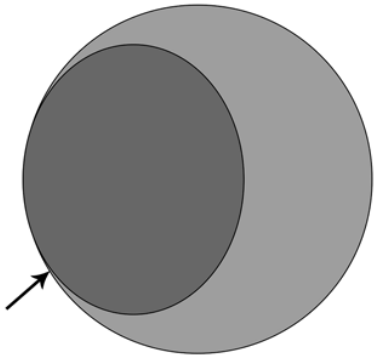
CTPA - Acute PTE

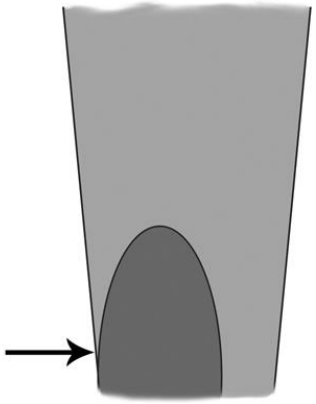






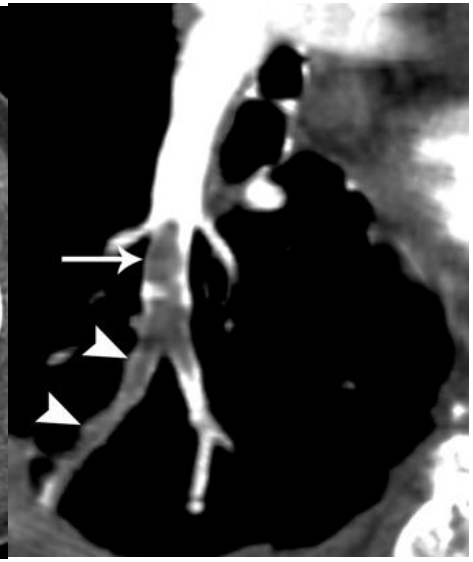


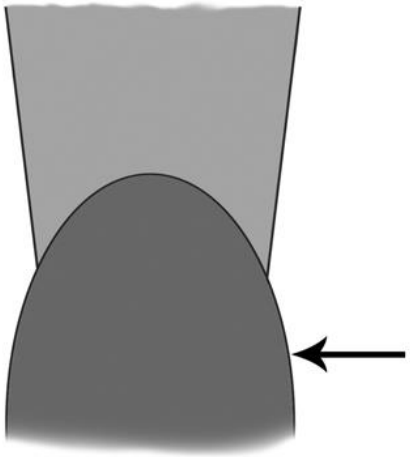




Wittram, Conrad, et al. *American Journal of Roentgenology* 186.6(2006): S421-S429.

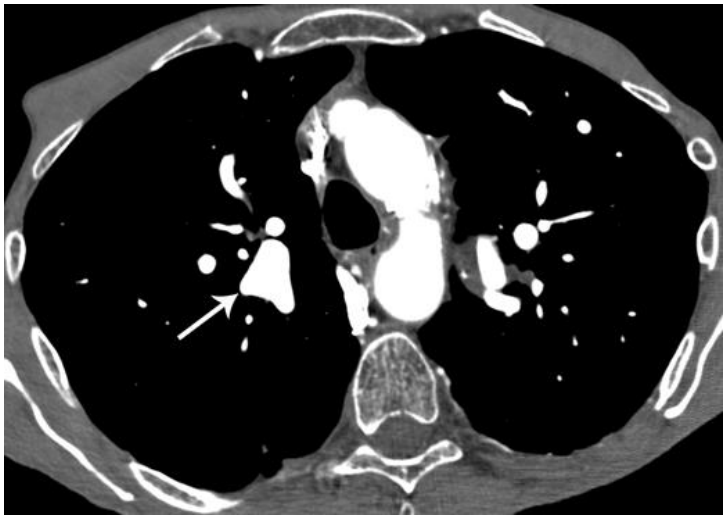
CTPA - Acute PTE

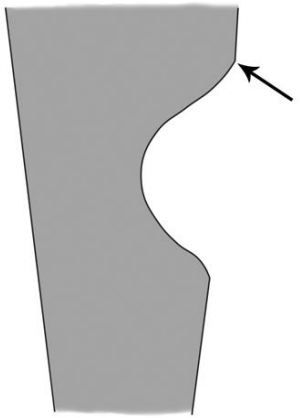




Wittram, Conrad, et al. *American Journal of Roentgenology* 186.6(2006): S421-S429.

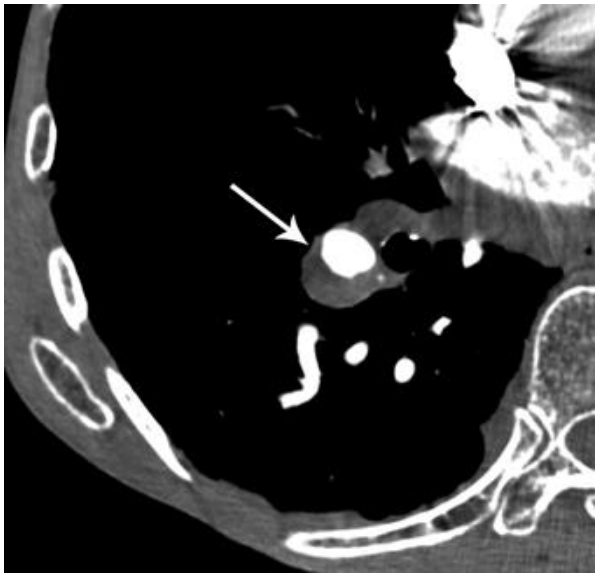
CTPA - Chronic PTE

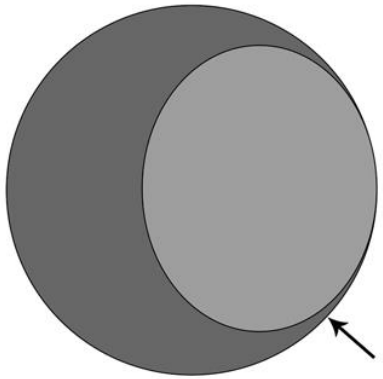


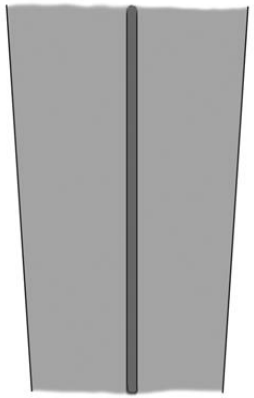


Wittram, Conrad, et al. *American Journal of Roentgenology* 186.6(2006): S421-S429.

CTPA - Chronic PTE

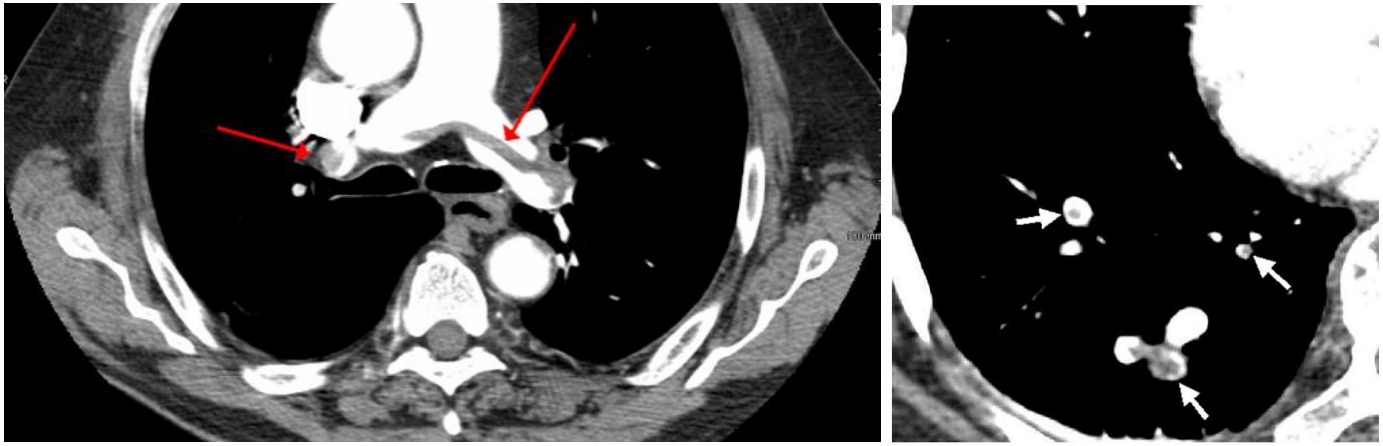




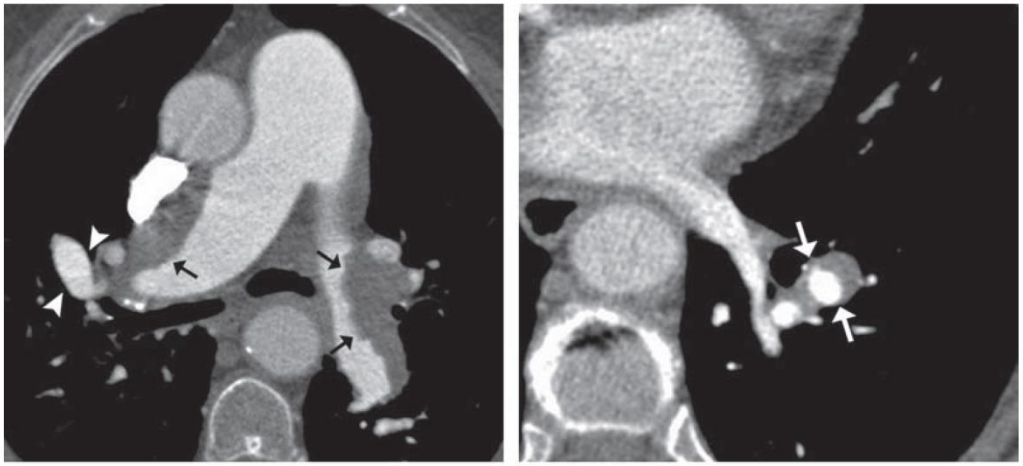


Wittram, Conrad, et al. *American Journal of Roentgenology* 186.6(2006): S421-S429.

CTPA, PTE



Acute PTE

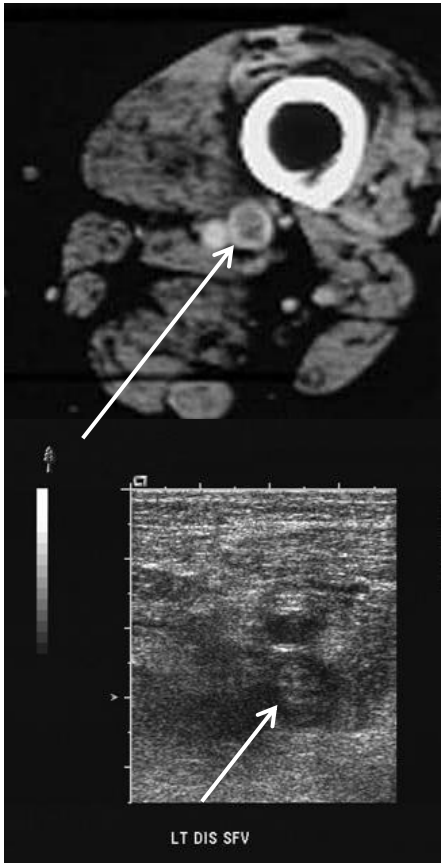


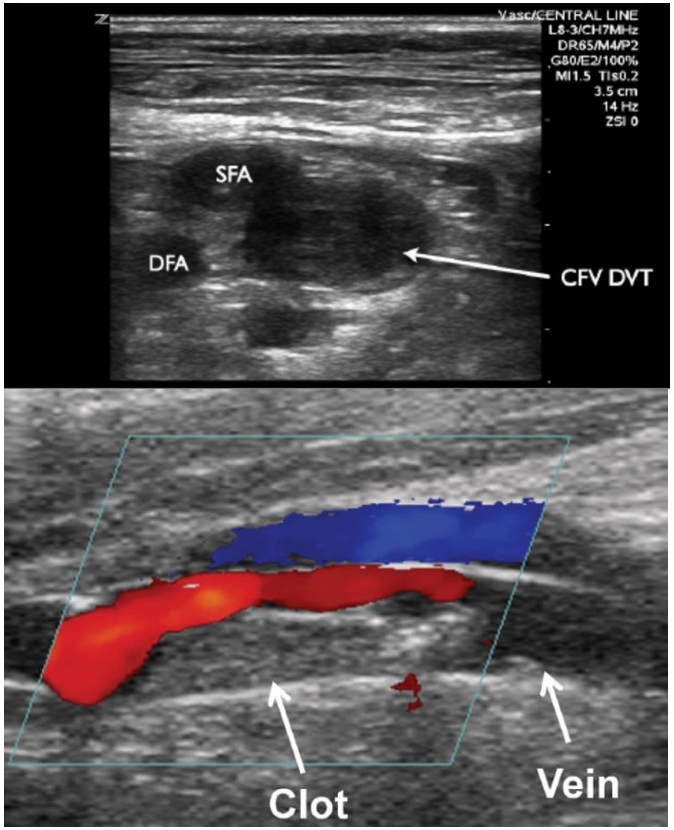
Chronic PTE

Imaging for Suspected DVT

- Ultra-sonogrphy
  - 24-hour available
  - The proximal veins
    - Within 15 minutes
    - Good overall diagnostic accuracy
    - Sensitivity: 96%, Specificity: 97% for DVT diagnosis
  - Diagnostic accuracy is operator dependent.

Lower-limb CUS





Lower-limb CUS	Class	Level
It is recommended to accept the diagnosis of VTE (and PE) if a CUS shows a proximal DVT in a patient with clinical suspicion of PE.[164,165]	I	A
If CUS shows only a distal DVT, further testing should be considered to confirm PE.[177]	IIa	B
If a positive proximal CUS is used to confirm PE, assessment of PE severity should be considered to permit risk-adjusted management.[178,179]	IIa	C

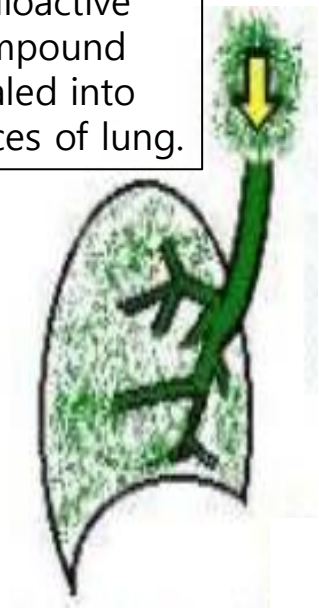
V/Q scintigraphy

	Strengths	Weaknesses/limitations	Radiation issues[a]
Planar V/Q scan	• Almost no contraindications • Relatively inexpensive • Strong validation in prospective management outcome studies	• Not readily available in all centres • Interobserver variability in interpretation • Results reported as likelihood ratios • Inconclusive in 50% of cases • Cannot provide alternative diagnosis if PE excluded	• Lower radiation than CTPA, effective dose ~2 mSv[b]

V/Q scintigraphy	Class	Level
It is recommended to reject the diagnosis of PE (without further testing) if the perfusion lung scan is normal.[75,122,134,174]	I	A
It should be considered to accept that the diagnosis of PE (without further testing) if the V/Q scan yields high probability for PE.[134]	IIa	B
A non-diagnostic V/Q scan should be considered as exclusion of PE when combined with a negative proximal CUS in patients with low clinical probability, or who are PE-unlikely.[75,122,174]	IIa	B

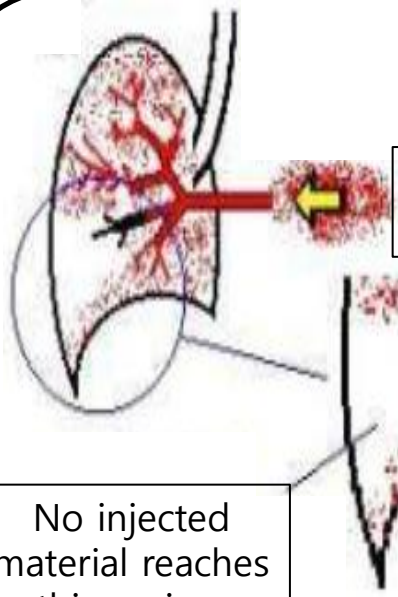
Lung perfusion

Radioactive compound inhaled into airspaces of lung.



≠

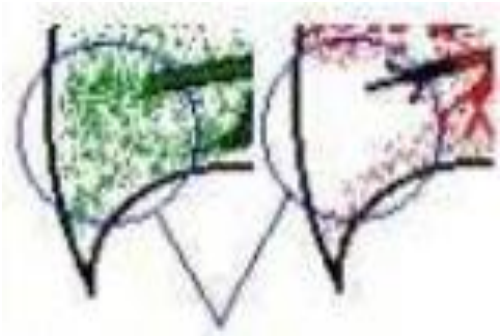
Blood distribution



Radioactive compound injected into vein.

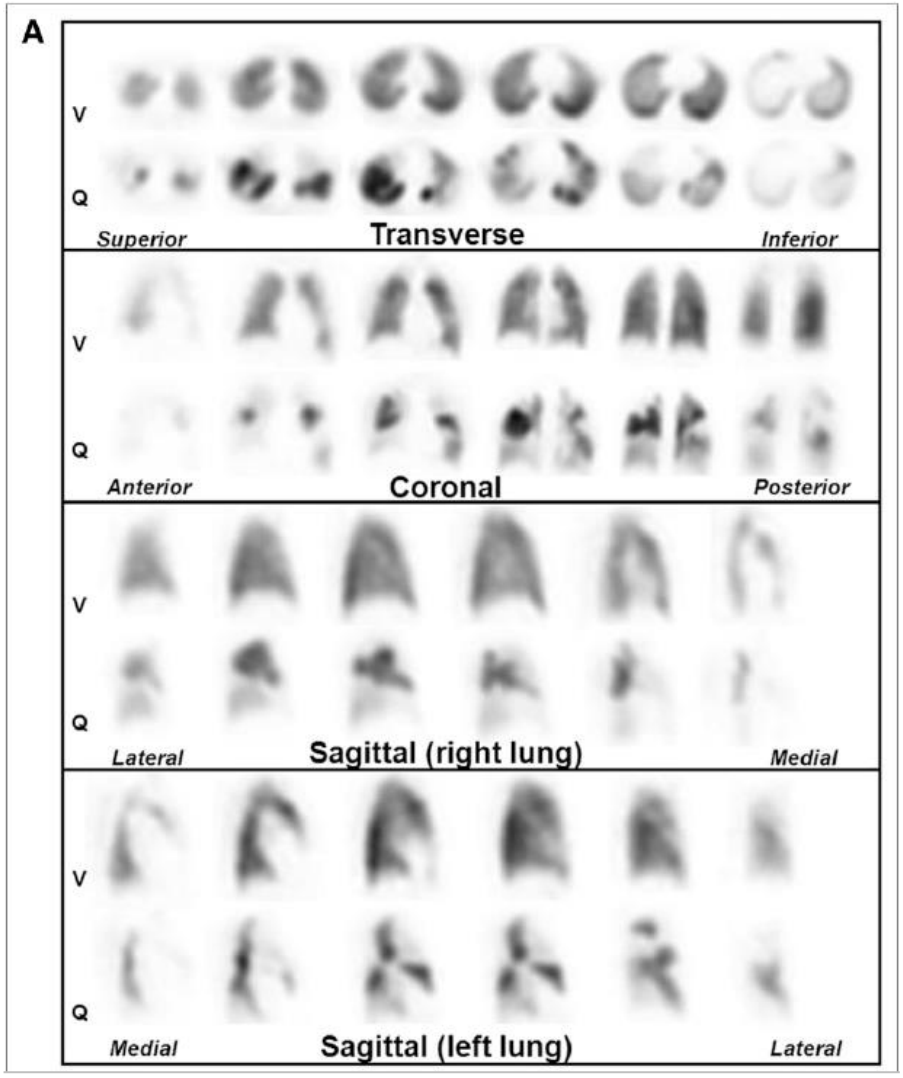
No injected material reaches this region.

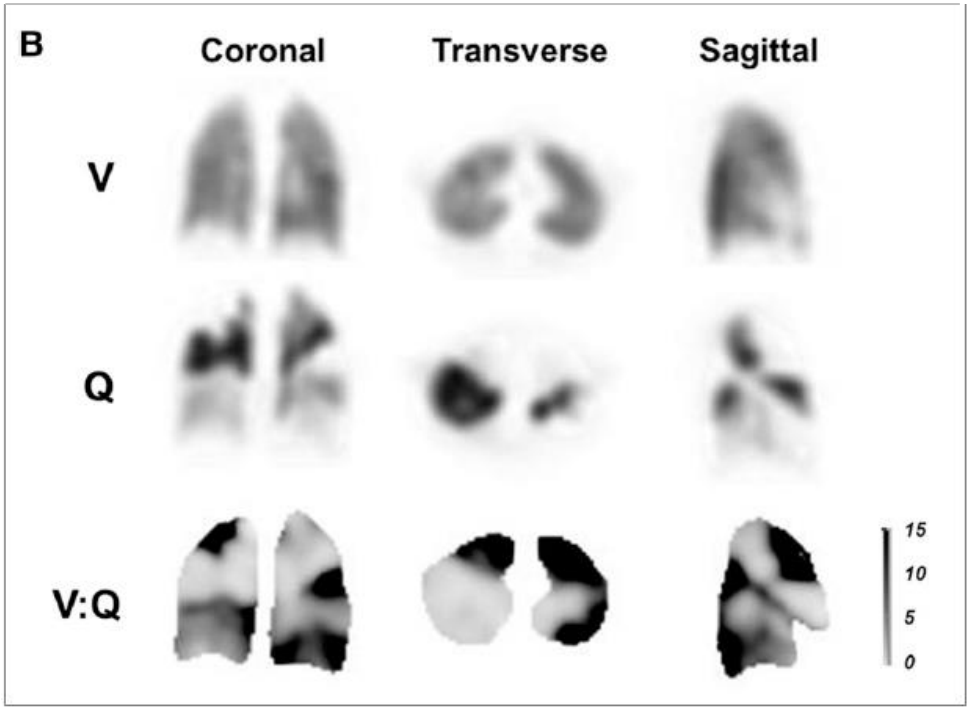
Embolus in pulmonary artery



"**Mismatch**" of inhaled and injected compounds.

V/S scintigraphy



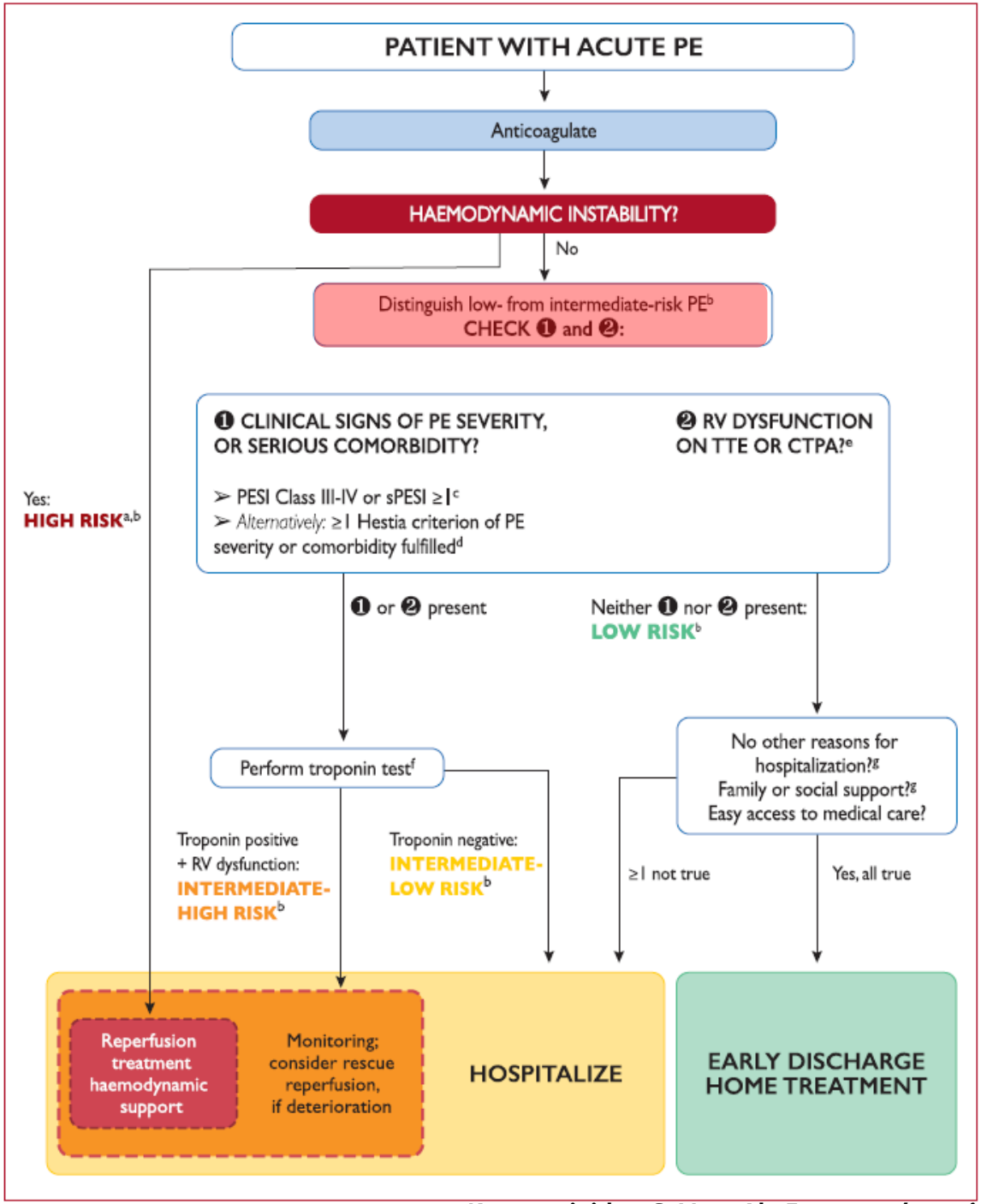


Risk assessment

Risk assessment

- Mandatory for determining the appropriate therapeutic management approach.
- Based on clinical symptoms and signs of hemodynamic instability.
- Clinical, imaging, and laboratory indicators of PE severity.
- Presence of comorbidity and any other aggravating condition.

Recommendations	Class[a]	Level[b]
Initial risk stratification of suspected or confirmed PE, based on the presence of haemodynamic instability, is recommended to identify patients at high risk of early mortality.[218,219,235]	I	B
In patients without haemodynamic instability, further stratification of patients with acute PE into intermediate- and low-risk categories is recommended.[179,218,219,235]	I	B
In patients without haemodynamic instability, use of clinical prediction rules integrating PE severity and comorbidity, preferably the PESI or sPESI, should be considered for risk assessment in the acute phase of PE.[178,226,229]	IIa	B
Assessment of the RV by imaging methods[c] or laboratory biomarkers[d] should be considered, even in the presence of a low PESI or a negative sPESI.[234]	IIa	B
In patients without haemodynamic instability, use of validated scores combining clinical, imaging, and laboratory PE-related prognostic factors may be considered to further stratify the severity of the acute PE episode.[218–223]	IIb	C



Konstantinides, S. V. et Al. *European heart journal* 41.4 (2020): 543-603

Risk assessment

Early mortality risk		Indicators of risk			
		Haemodynamic instability[a]	Clinical parameters of PE severity and/or comorbidity: PESI class III–V or sPESI ≥I	RV dysfunction on TTE or CTPA[b]	Elevated cardiac troponin levels[c]
High		+	(+)[d]	+	(+)
Intermediate	Intermediate–high	-	+[e]	+	+
	Intermediate–low	-	+[e]	One (or none) positive	
Low		-	-	-	Assesment optional; if assessed, negative

Konstantinides, S. V. et Al. *European heart journal* 41.4 (2020): 543-603

Hemodynamic instability

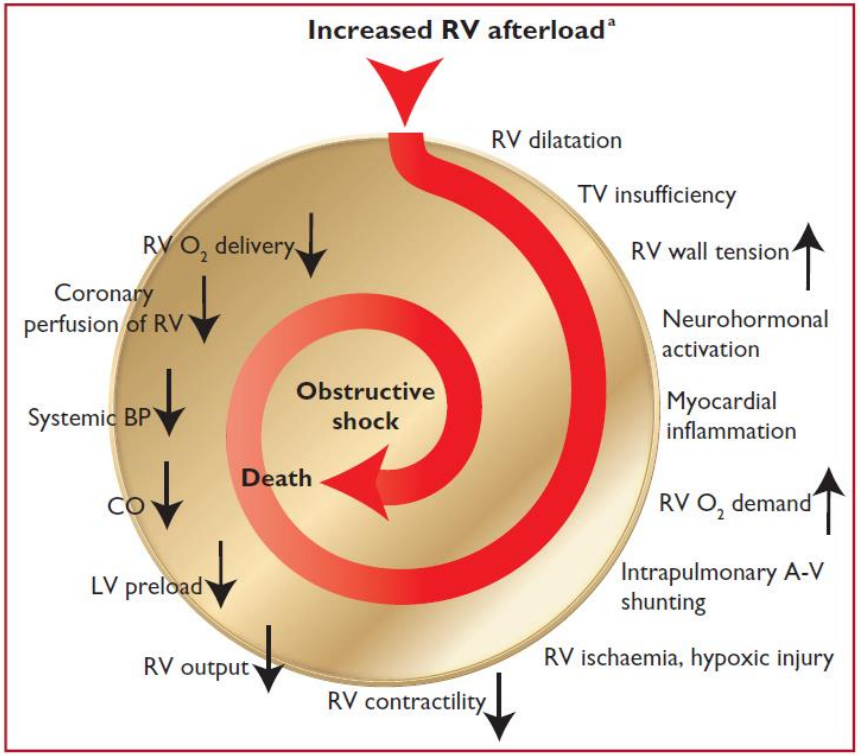


Table 4 **Definition of haemodynamic instability, which delineates acute high-risk pulmonary embolism (one of the following clinical manifestations at presentation)**

(1) Cardiac arrest	(2) Obstructive shock[68–70]	(3) Persistent hypotension
Need for cardiopulmonary resuscitation	Systolic BP < 90 mmHg or vasopressors required to achieve a BP ≥90 mmHg despite adequate filling status	Systolic BP < 90 mmHg or systolic BP drop ≥40 mmHg, lasting longer than 15 min and not caused by new-onset arrhythmia, hypovolaemia, or sepsis
	And	
	End-organ hypoperfusion (altered mental status; cold, clammy skin; oliguria/anuria; increased serum lactate)	

Pulmonary Embolism Severity Index

Parameter	Original version[226]	Simplified version[229]
Age	Age in years	1 point (if age >80 years)
Male sex	+10 points	–
Cancer	+30 points	1 point
Chronic heart failure	+10 points	1 point
Chronic pulmonary disease	+10 points	
Pulse rate ≥110 b.p.m.	+20 points	1 point
Systolic BP <100 mmHg	+30 points	1 point
Respiratory rate >30 breaths per min	+20 points	–
Temperature <36°C	+20 points	–
Altered mental status	+60 points	–
Arterial oxyhaemoglobin saturation <90%	+20 points	1 point

Parameter	Original version[226]	Simplified version[229]
	Risk strata[a]	
	Class I: ≤65 points very low 30 day mortality risk (0–1.6%) **Class II: 66–85 points** low mortality risk (1.7–3.5%)	**0 points** = 30 day mortality risk 1.0% (95% CI 0.0–2.1%)
	Class III: 86–105 points moderate mortality risk (3.2–7.1%) **Class IV: 106–125 points** high mortality risk (4.0–11.4%) **Class V: >125 points** very high mortality risk (10.0–24.5%)	**≥1 point(s)** = 30 day mortality risk 10.9% (95% CI 8.5–13.2%)

Konstantinides, S. V. et Al. *European heart journal* 41.4 (2020): 543-603

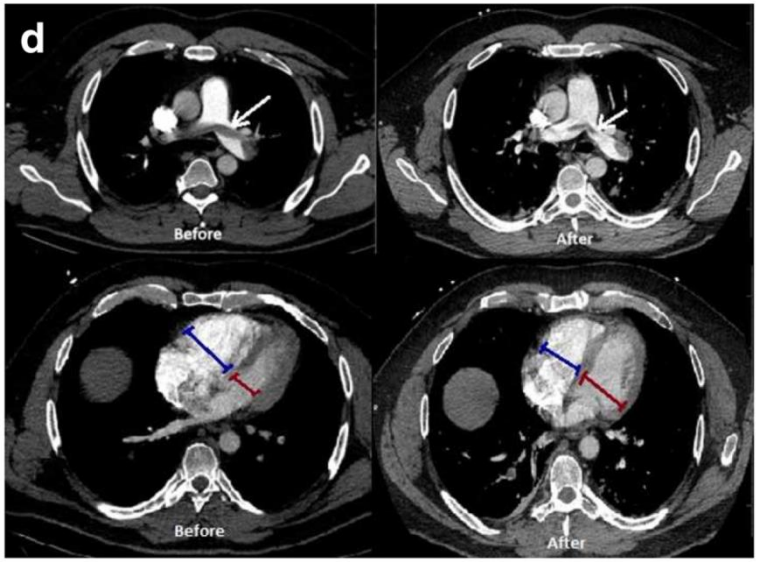
Risk assessment

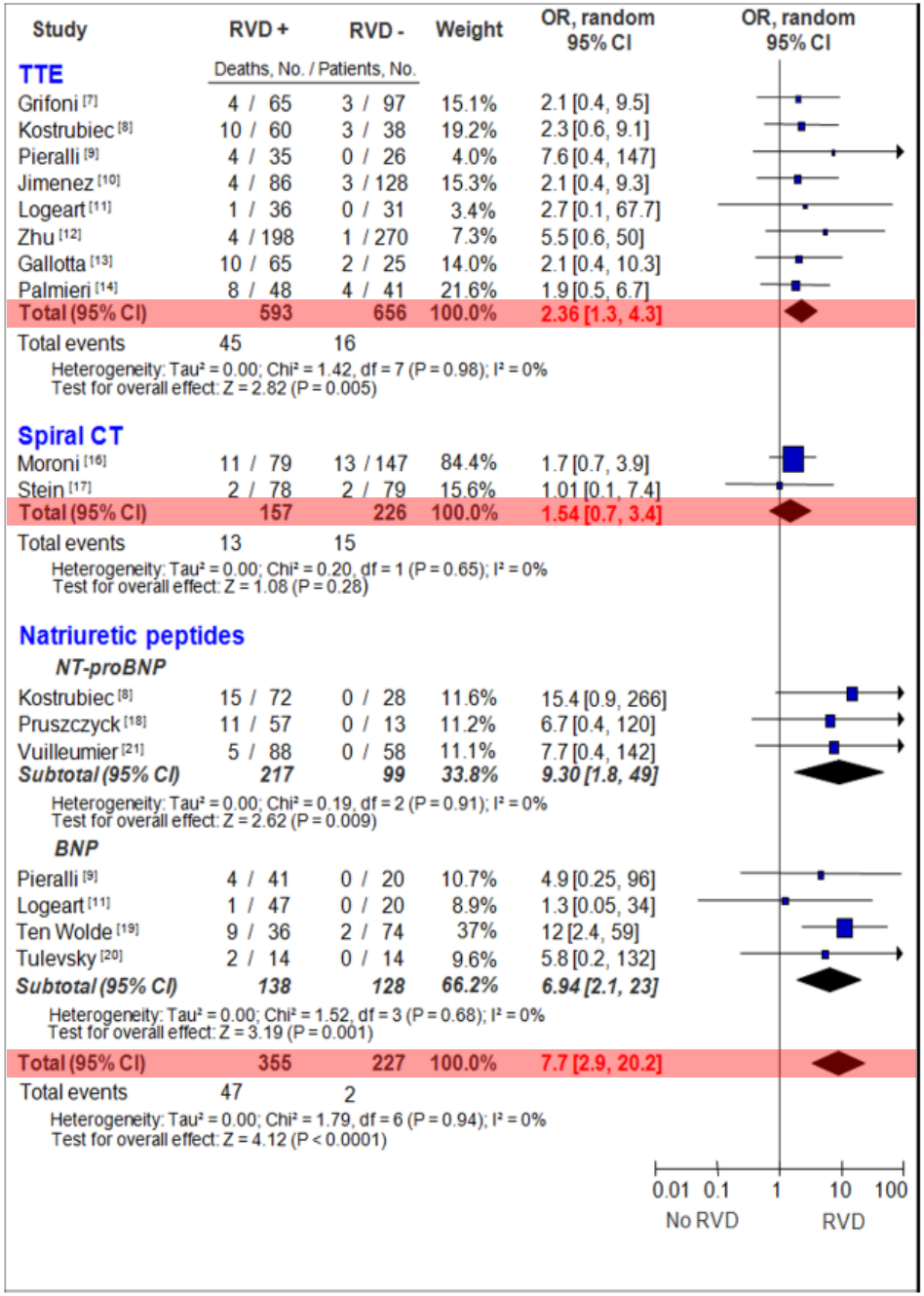
Table 2. Pulmonary Embolism Risk Scores and Associated 7- and 30-Day Mortality

Risk score	All patients, No.	Death within 7 d			Death within 30 d		
		Patients, No. (%)	*P* value	AUC (95% CI)	Patients, No. (%)	*P* value	AUC (95% CI)
European Society of Cardiology risk score							
Low	64	1 (1.6)	.02	0.638 (0.598-0.679)	5 (7.8)	.02	0.592 (0.563-0.621)
Intermediate-low	109	5 (4.6)			13 (11.9)		
Intermediate-high	146	7 (4.8)			15 (10.3)		
High	51	8 (15.7)			12 (23.5)		
Unable to assess[a]	46	4 (8.7)			6 (13.0)		
Pulmonary Embolism Severity Index							
Class I	39	1 (2.6)	.02	0.652 (0.629-0.675)	1 (2.6)	<.001	0.694 (0.677-0.710)
Class II	55	1 (1.8)			4 (7.3)		
Class III	65	3 (4.6)			5 (7.7)		
Class IV	56	0			2 (3.6)		
Class V	99	12 (12.1)			26 (26.3)		
Unable to assess[a]	102	8 (7.8)			13 (12.7)		
Simplified Pulmonary Embolism Severity Index							
Low risk	78	1 (1.3)	.004	0.666 (0.640-0.693)	3 (3.8)	<.001	0.657 (0.644-0.671)
Not low risk	257	18 (7.0)			37 (14.4)		
Unable to assess[a]	81	6 (7.4)			11 (13.6)		
Bova							
Class I	128	4 (3.1)	.01	0.639 (0.603-0.675)	13 (10.2)	.06	0.567 (0.540-0.594)
Class II	99	5 (5.1)			9 (9.1)		
Class III	78	4 (5.1)			9 (11.5)		
Systolic blood pressure <90 mm Hg	43	7 (16.3)			11 (25.6)		
Class III and systolic blood pressure <90 mm Hg[b]	121	11 (9.1)	.05	0.616 (0.581-0.651)	20 (16.5)	.24	0.550 (0.526-0.575)
Unable to assess[a]	68	5 (5.1)			9 (13.2)		

Barnes, Geoffrey D., et al. *JAMA network open* 3.8 (2020): e2010779-e2010779.

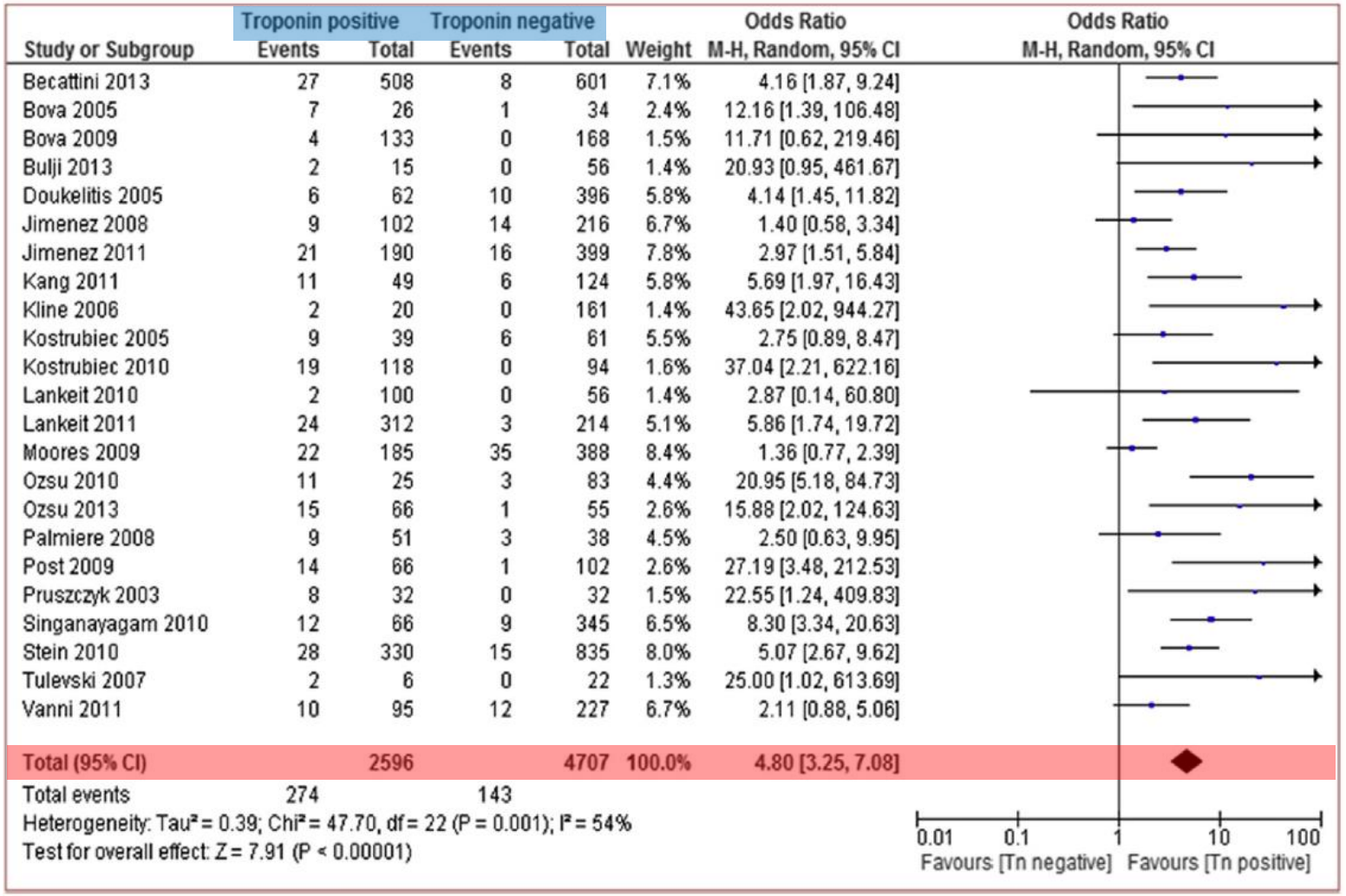
- RV dysfunction
  - RV/LV diameter ratio ≥ 1.0
  - TAPSE < 16mm





Coutance et al. *Critical Care* 2011, 15:R103
Bryce et al. *Insights into Imaging* 2019, 10:18

Troponin



Study or Subgroup	Troponin positive Events	Total	Troponin negative Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Becattini 2013	27	508	8	601	7.1%	4.16 [1.87, 9.24]
Bova 2005	7	26	1	34	2.4%	12.16 [1.39, 106.48]
Bova 2009	4	133	0	168	1.5%	11.71 [0.62, 219.46]
Bulji 2013	2	15	0	56	1.4%	20.93 [0.95, 461.67]
Doukelitis 2005	6	62	10	396	5.8%	4.14 [1.45, 11.82]
Jimenez 2008	9	102	14	216	6.7%	1.40 [0.58, 3.34]
Jimenez 2011	21	190	16	399	7.8%	2.97 [1.51, 5.84]
Kang 2011	11	49	6	124	5.8%	5.69 [1.97, 16.43]
Kline 2006	2	20	0	161	1.4%	43.65 [2.02, 944.27]
Kostrubiec 2005	9	39	6	61	5.5%	2.75 [0.89, 8.47]
Kostrubiec 2010	19	118	0	94	1.6%	37.04 [2.21, 622.16]
Lankeit 2010	2	100	0	56	1.4%	2.87 [0.14, 60.80]
Lankeit 2011	24	312	3	214	5.1%	5.86 [1.74, 19.72]
Moores 2009	22	185	35	388	8.4%	1.36 [0.77, 2.39]
Ozsu 2010	11	25	3	83	4.4%	20.95 [5.18, 84.73]
Ozsu 2013	15	66	1	55	2.6%	15.88 [2.02, 124.63]
Palmiere 2008	9	51	3	38	4.5%	2.50 [0.63, 9.95]
Post 2009	14	66	1	102	2.6%	27.19 [3.48, 212.53]
Pruszczyk 2003	8	32	0	32	1.5%	22.55 [1.24, 409.83]
Singanayagam 2010	12	66	9	345	6.5%	8.30 [3.34, 20.63]
Stein 2010	28	330	15	835	8.0%	5.07 [2.67, 9.62]
Tulevski 2007	2	6	0	22	1.3%	25.00 [1.02, 613.69]
Vanni 2011	10	95	12	227	6.7%	2.11 [0.88, 5.06]
Total (95% CI)		2596		4707	100.0%	4.80 [3.25, 7.08]
Total events	274		143			

Heterogeneity: $Tau^2 = 0.39$; $Chi^2 = 47.70$, $df = 22$ ($P = 0.001$); $I^2 = 54\%$

Test for overall effect: $Z = 7.91$ ($P < 0.00001$)

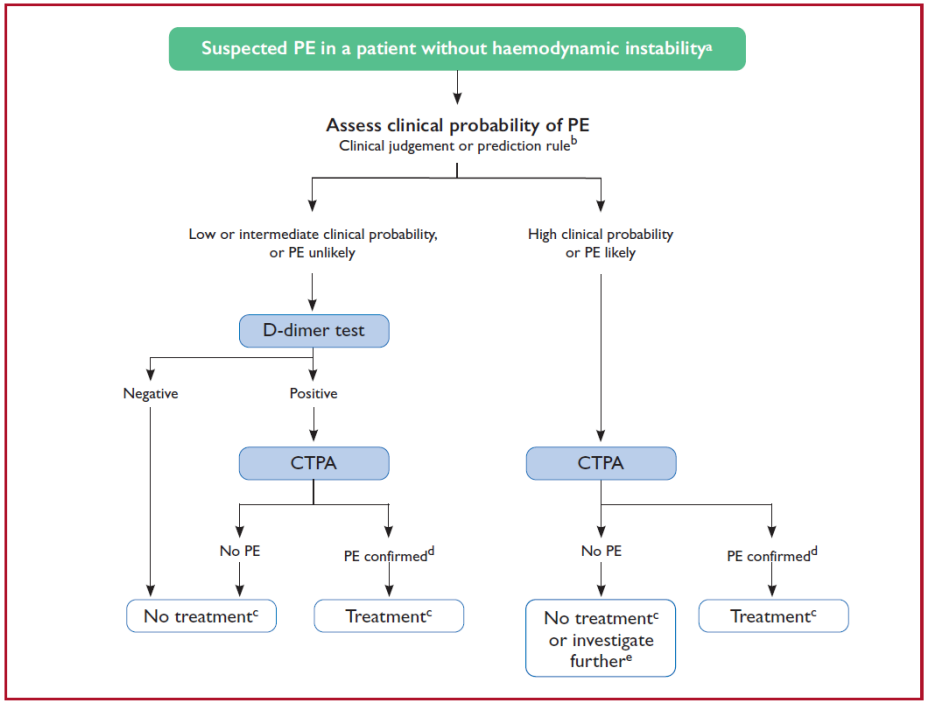
Bajaj, Anurag, et al. *Heart & Lung* 44.4 (2015): 327-334.

Risk assessment

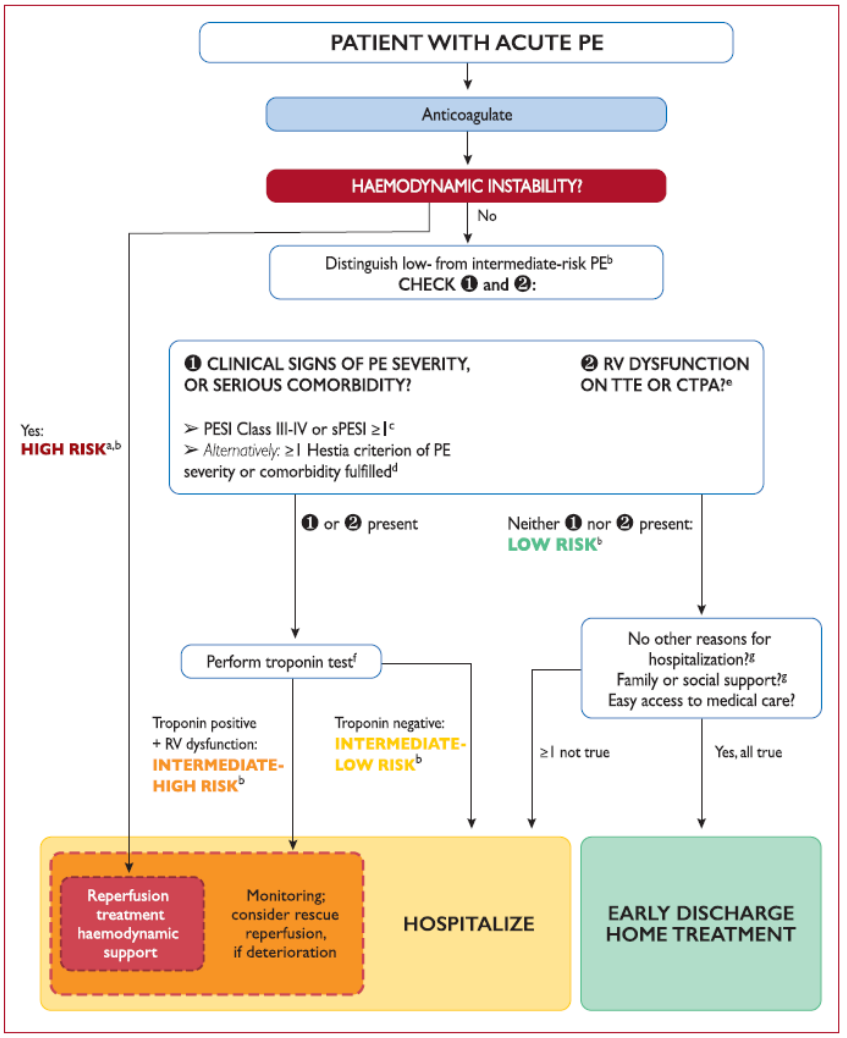
Early mortality risk		Indicators of risk			
		Haemodynamic instability[a]	Clinical parameters of PE severity and/or comorbidity: PESI class III–V or sPESI ≥I	RV dysfunction on TTE or CTPA[b]	Elevated cardiac troponin levels[c]
High		+	(+)[d]	+	(+)
Intermediate	Intermediate–high	-	+[e]	+	+
	Intermediate–low	-	+[e]	One (or none) positive	
Low		-	-	-	Assesment optional; if assessed, negative

Konstantinides, S. V. et Al. *European heart journal* 41.4 (2020): 543-603

Summary



Diagnosis



Risk assessment

Take home massage

- Reduce the number of unnecessary imaging examinations.

- Precise risk assessment for proper management.