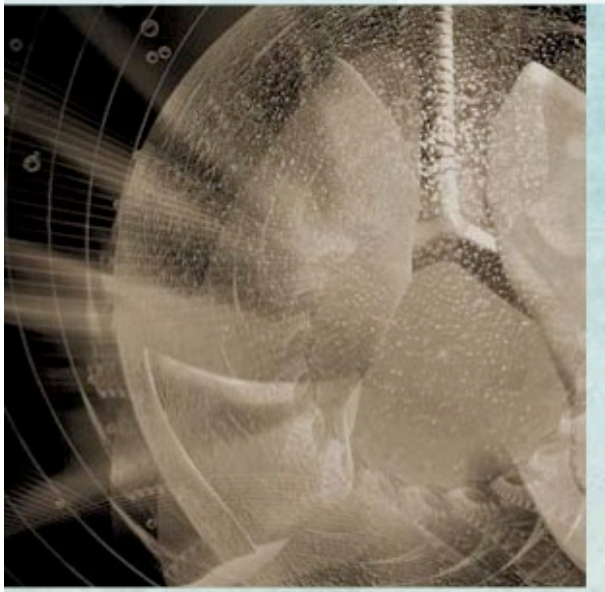
MORNING
EDUCATIONAL
SYMPOSIA

CHEST 2014



Diagnosis of Acute Pulmonary Embolism

Timothy A. Morris, MD FACCP
Professor of Medicine
Clinical Service Chief
Division of Pulmonary and Critical Care Medicine
University of California, San Diego

Disclosures

- Nothing to Disclose

Objectives

- Define a diagnostic strategy for the diagnosis of Venous Thromboembolism (VTE)

Questions

- Clinical decision rules to screen out PE
  - How do you use them? Are they any good? Which ones?
- D-dimer
  - Why use them? What is the best cut off value?
- PE imaging
  - CT or VQ? SPECT? Pregnancy?
- Risk Stratification
  - Does it work?

Questions

- Clinical decision rules to screen out PE
  - How do you use them? Are they any good? Which ones?
- D-dimer
  - Why use them? What is the best cut off value?
- PE imaging
  - CT or VQ? SPECT? Pregnancy?
- Risk Stratification
  - Does it work?

Clinical decision rules

Wells Score

- clinical signs /Sx DVT - 3.0 points
- HR > 100 beats/min - 1.5 points
- immobilization or surgery within 4 weeks, - 1.5 points
- previous objectively Dx'd DVT or PE - 1.5 points
- hemoptysis - 1.0 point
- malignancy within the past 6 months - 1.0 point
- PE at least as likely as alternative diagnosis - 3.0 points

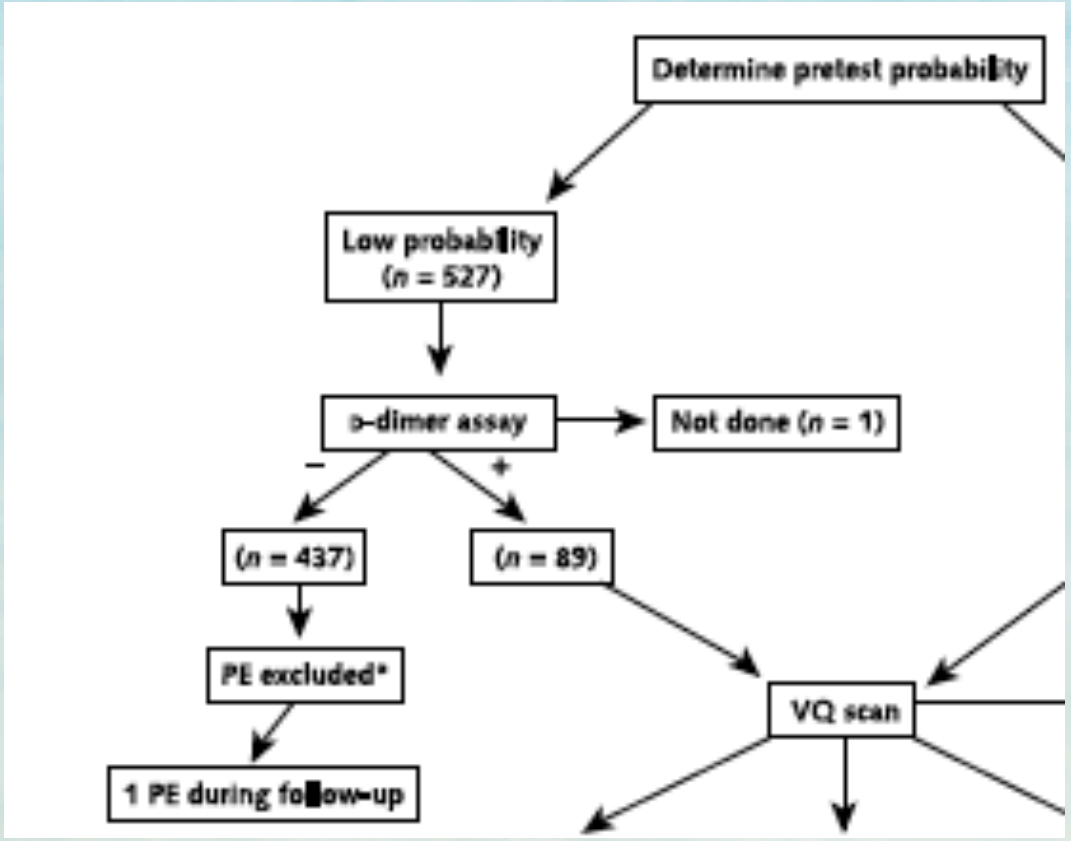
"Low prob" if score < 2

Screen is negative if "low prob" and D-dimeris "low"*

1. Wells PS, Anderson DR, Rodger M, Stiell I, Dreyer JF, Barnes D, Forgie M, Kovacs G, Ward J, Kovacs MJ. Excluding pulmonary embolism at the bedside without diagnostic imaging: management of patients with suspected pulmonary embolism presenting to the emergency department by using a simple clinical model and d-dimer. Ann Intern Med JID - 0372351. 2001;135(2):98-107

Wells: Low prob and D-dimer to r/o PE

- 1/437 (0.2%)



1. Wells PS, Anderson DR, Rodger M, Stiell I, Dreyer JF, Barnes D, Forgie M, Kovacs G, Ward J, Kovacs MJ. Excluding pulmonary embolism at the bedside without diagnostic imaging: management of patients with suspected pulmonary embolism presenting to the emergency department by using a simple clinical model and d-dimer. Ann Intern Med JID - 0372351. 2001;135(2):98-107

Why not just the score?

Score[1]	Patients with PE (n=86)	Patients without PE (n=844)	PE rate
High	24	40	38%
Intermediate	55	284	16%
Low	7	520	1%

Score[2]	Patients with PE (n=86)	Patients without PE (n=844)	PE rate
High	10	10	50%
Intermediate	24	104	19%
Low	2	97	2%

1. Wells PS, Anderson DR, Rodger M, Stiell I, Dreyer JF, Barnes D, Forgie M, Kovacs G, Ward J, Kovacs MJ. Excluding pulmonary embolism at the bedside without diagnostic imaging: management of patients with suspected pulmonary embolism presenting to the emergency department by using a simple clinical model and d-dimer. Ann Intern Med JID - 0372351. 2001;135(2):98-107
2. Wells PS, Anderson DR, Rodger M, Ginsberg JS, Kearon C, Gent M, Turpie AG, Bormanis J, Weitz J, Chamberlain M, Bowie D, Barnes D, Hirsh J. Derivation of a simple clinical model to categorize patients probability of pulmonary embolism: increasing the models utility with the SimpliRED D-dimer. *Thromb Haemost.* 2000;83(3):416-420.

Why not just the D-dimer?

D-dimer assay	Patients with PE (n=86)	Patients without PE (n=844)	PE rate
Positive	66	184	26%
Negative	18	657	3%
Not tested	2	3	

1. Wells PS, Anderson DR, Rodger M, Stiell I, Dreyer JF, Barnes D, Forgie M, Kovacs G, Ward J, Kovacs MJ. Excluding pulmonary embolism at the bedside without diagnostic imaging: management of patients with suspected pulmonary embolism presenting to the emergency department by using a simple clinical model and d-dimer. Ann Intern Med JID - 0372351. 2001;135(2):98-107

PE Rule-out Criteria (PERC)

- Is the patient older than 49 years of age?
- Is the pulse rate above 99 beats min^{-1}?
- Is room air pulse oximetry <95%?
- Is there a present history of hemoptysis?
- Is the patient taking exogenous estrogen?
- Does the patient have a prior diagnosis of VTE?
- Has the patient had recent surgery or trauma? (Requiring ETT or hospitalization in the previous 4 weeks.)
- Does the patient have unilateral leg swelling?

All have to be "no" for screen to be negative

1. Kline JA, Courtney DM, Kabrhel C, Moore CL, Smithline HA, Plewa MC, Richman PB, O'Neil BJ, Nordenholz K. Prospective multicenter evaluation of the pulmonary embolism rule-out criteria. J Thromb Haemost. 2008;6(5):772-780

Outcomes of PERC

	PERC(–)* (n = 1952)		
Outcome	n	%	95% CI
PE	19	1.0	0.6–1.5%
Any VTE	24	1.2	0.8–1.8%
VTE or death	25	1.3	0.8–1.9%

1. Kline JA, Courtney DM, Kabrhel C, Moore CL, Smithline HA, Plewa MC, Richman PB, O'Neil BJ, Nordenholz K. Prospective multicenter evaluation of the pulmonary embolism rule-out criteria. J Thromb Haemost. 2008;6(5):772-780

Clinical utility

- How many people in the room are PERC negative?

Clinical Likelihood Scores

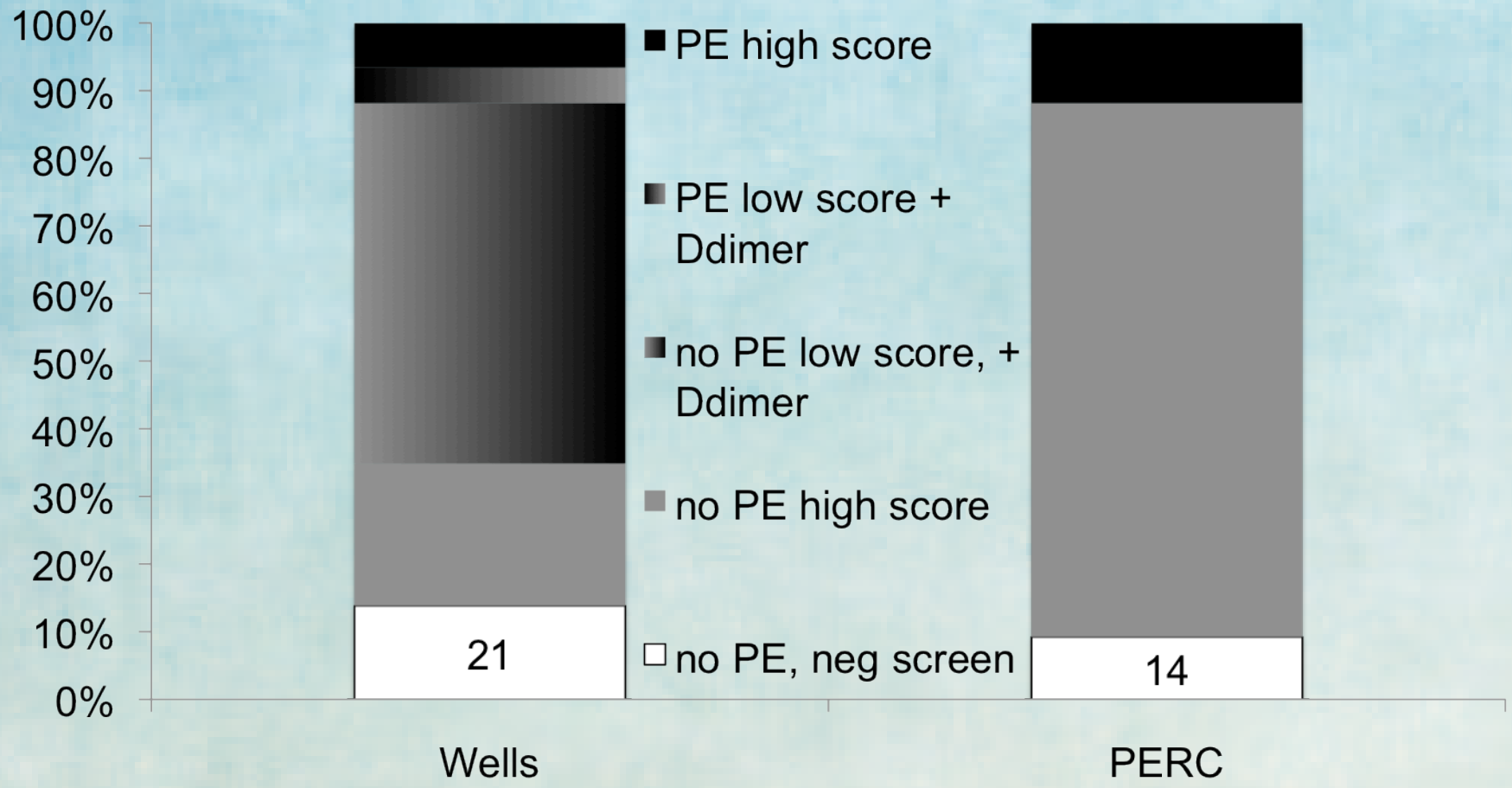
Wells Criteria

- Suspected DVT
- HR > 100
- Immobilization/surgery within 4 weeks
- Previous DVT/PE
- Hemoptysis
- *Alternative Dx less likely*
- *Malignancy in last 6 mo*

PERC Criteria

- Unilateral leg swelling
- HR > 99
- Surgery/trauma within 4 weeks
- Previous VTE
- Hemoptysis
- *RA pulse ox <95%*
- *Older than 49 years*
- *Taking estrogen*

Negative Screening in Pts Who Got CT Scans



1. Crichlow A, Cuker A, Mill AM. Overuse of computed tomography pulmonary angiography in the evaluation of patients with suspected pulmonary embolism in the emergency department. Acad Emerg Med 2012; 19:1220–1226

Bottom line about scores

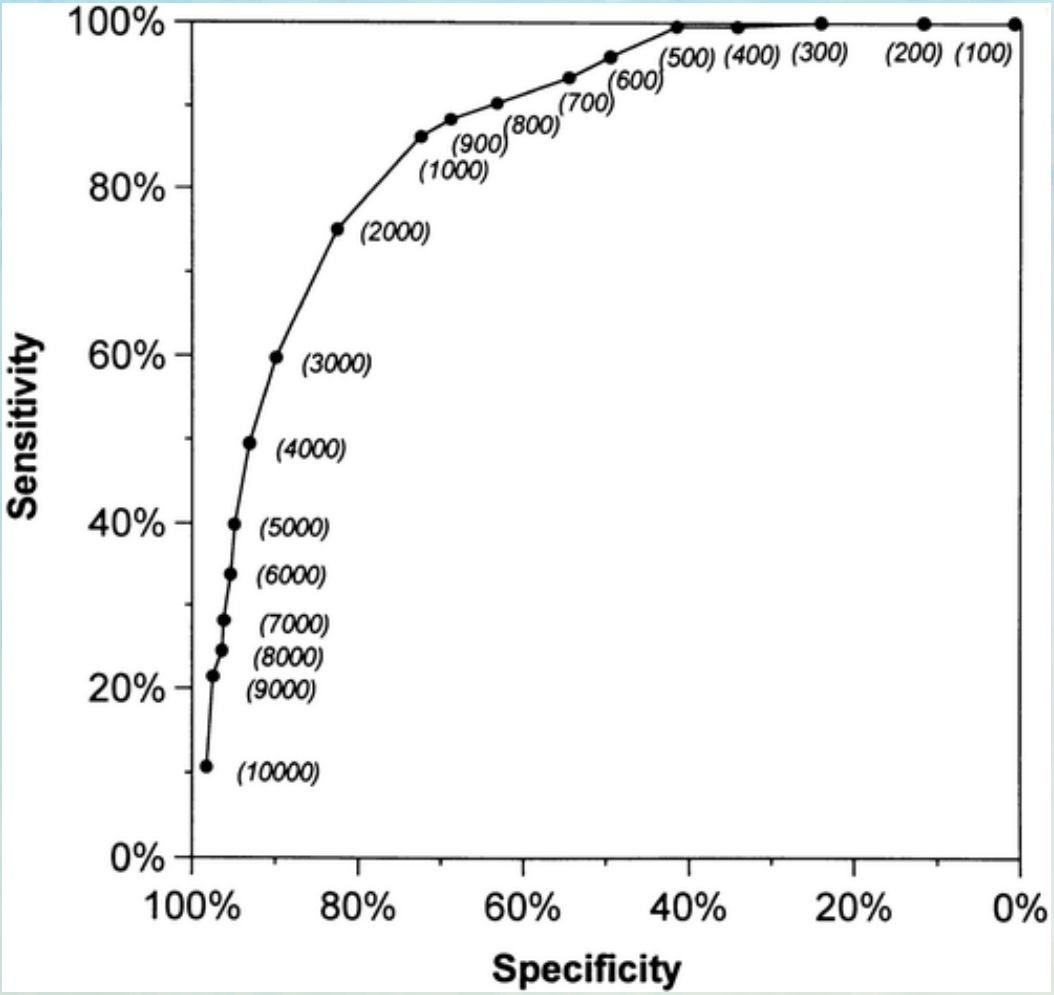
- Good if you already suspect PE
- Can distinguish b/w people with nothing and those that need work-up for PE
- Use your judgment

Questions

- Clinical decision rules to screen out PE
  - How do you use them? Are they any good? Which ones?
- D-dimer
  - Why use them? What is the best cut off value?
- PE imaging
  - CT or VQ? SPECT? Pregnancy?
- Risk Stratification
  - Does it work?

D-dimer

ROC Curve for D-dimer and PE



1. Perrier A, Desmarais S, Goehring C, de Moerloose P, Morabia A, Unger PF, Slosman D, Junod A, Bounameaux H. D-dimer testing for suspected pulmonary embolism in outpatients. Am J Respir Crit Care Med. 1997;156(2 Pt 1):492-496

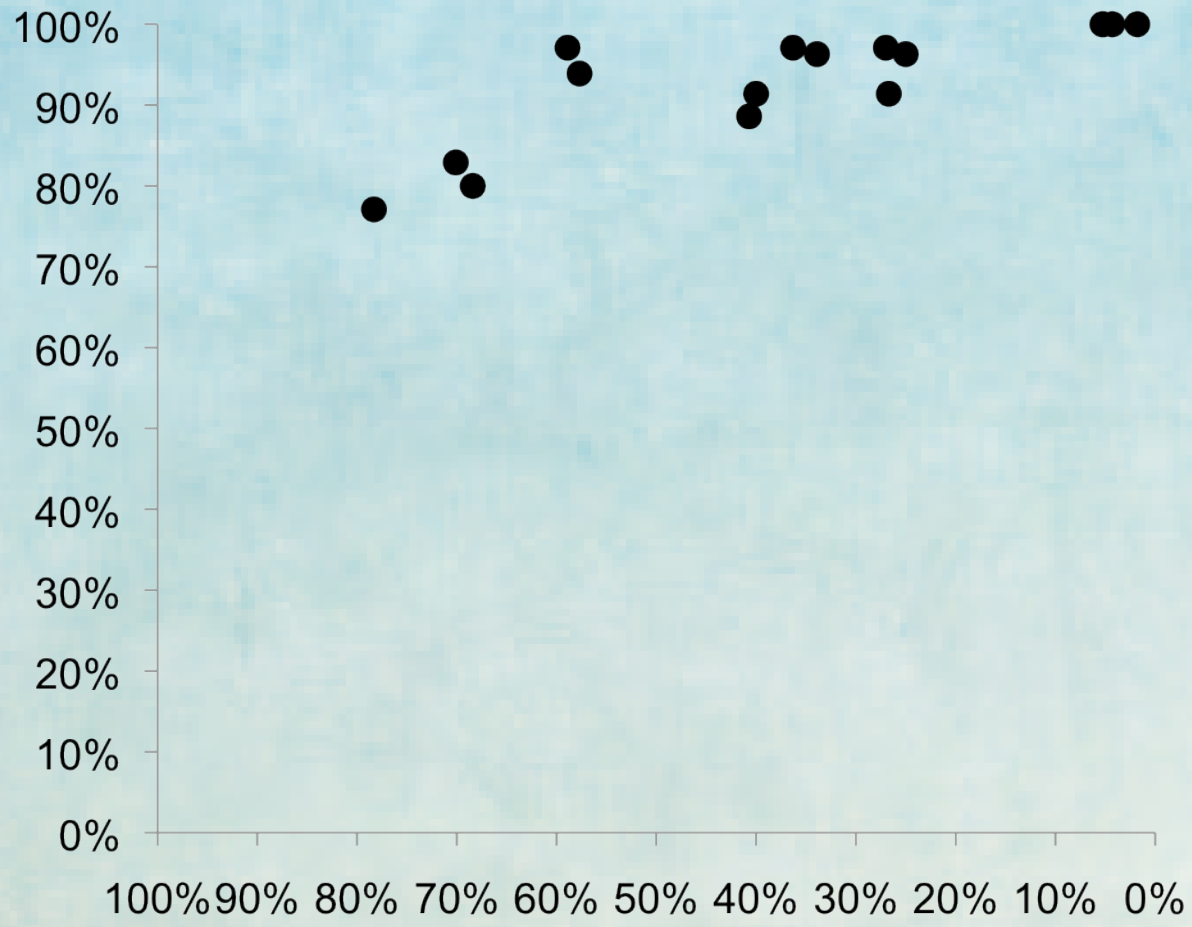
Cutoff values for D-dimer and VTE

Table 4 Sensitivity, specificity and negative predictive values (NPV) for D-dimer kits based on varying cut-off values

	D-dimer (µg/l)	Sensitivity (%) (95% CI)	Specificity (%) (95% CI)	NPV (%) (95% CI)
Dimertest Gold	< 200[a]	77.1 (63.2–91.0)	78.3 (70.8–85.8)	91.8 (86.4–97.2)
	< 120[b]	82.9 (70.1–95.7)	70.1 (61.5–78.7)	93.0 (87.8–100)
	< 100[c]	93.9 (85.9–100)	57.7 (48.7–66.6)	97.5 (94.0–100)
	< 6[d]	100 (98.8–100)	5.2 (1.1–9.3)	100 (99.7–100)
Asserachrome D-Di	< 500[a,b]	88.6 (77.8–99.4)	40.7 (31.5–49.9)	92.2 (84.8–100)
	< 400[c]	91.4 (82.1–100)	26.7 (18.6–34.8)	91.2 (86.0–96.4)
	< 200[d]	100 (98.8–100)	4.3 (0.6–8.0)	100 (99.7–100)
VIDAS D-Dimer	< 500[a,b]	91.4 (82.0–100)	40.0 (30.8–49.2)	93.9 (87.2–100)
	< 400[c]	97.1 (91.5–100)	27.0 (18.9–35.1)	96.9 (90.9–100)
	< 190[d]	100 (98.8–100)	4.3 (0.6–8.0)	100 (99.7–100)
MiniQuant D-Dimer	< 200[a,b]	96.3 (89.1–100)	33.9 (21.3–46.5)	96.8 (90.6–100)
	< 160[c]	96.3 (89.2–100)	25.0 (13.6–36.3)	93.3 (80.6–100)
	< 50[d]	100 (98.8–100)	1.8 (0–5.3)	100 (99.6–100)
Advanced D-Dimer	< 2000[a]	80.0 (66.7–93.2)	68.4 (59.9–76.9)	91.8 (86.0–97.6)
	< 1600[b]	97.1 (91.5–100)	58.9 (49.7–68.1)	98.5 (95.7–100)
	< 1200[c]	97.1 (91.5–100)	36.3 (27.5–45.1)	97.8 (93.5–102)
	< 500[d]	100 (98.8–100)	5.3 (1.2–9.4)	100 (99.7–100)

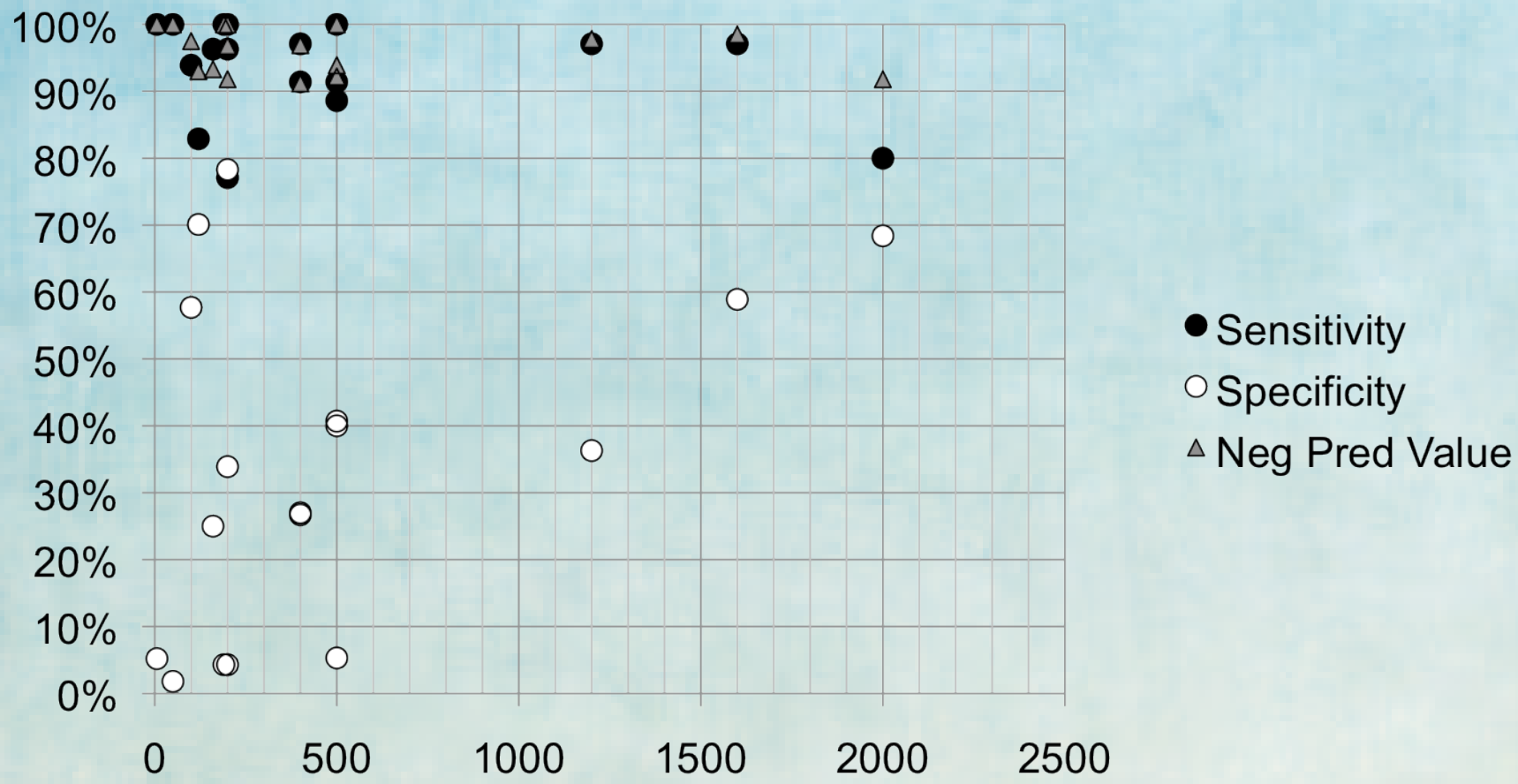
1. Gosselin RC, Owings JT, Kehoe J, Anderson JT, Dwyre DM, Jacoby RC, Utter G, Larkin EC. Comparison of six D-dimer methods in patients suspected of deep vein thrombosis. Blood Coagul Fibrinolysis. 2003;14(6):545-550

ROC for D-dimer and VTE



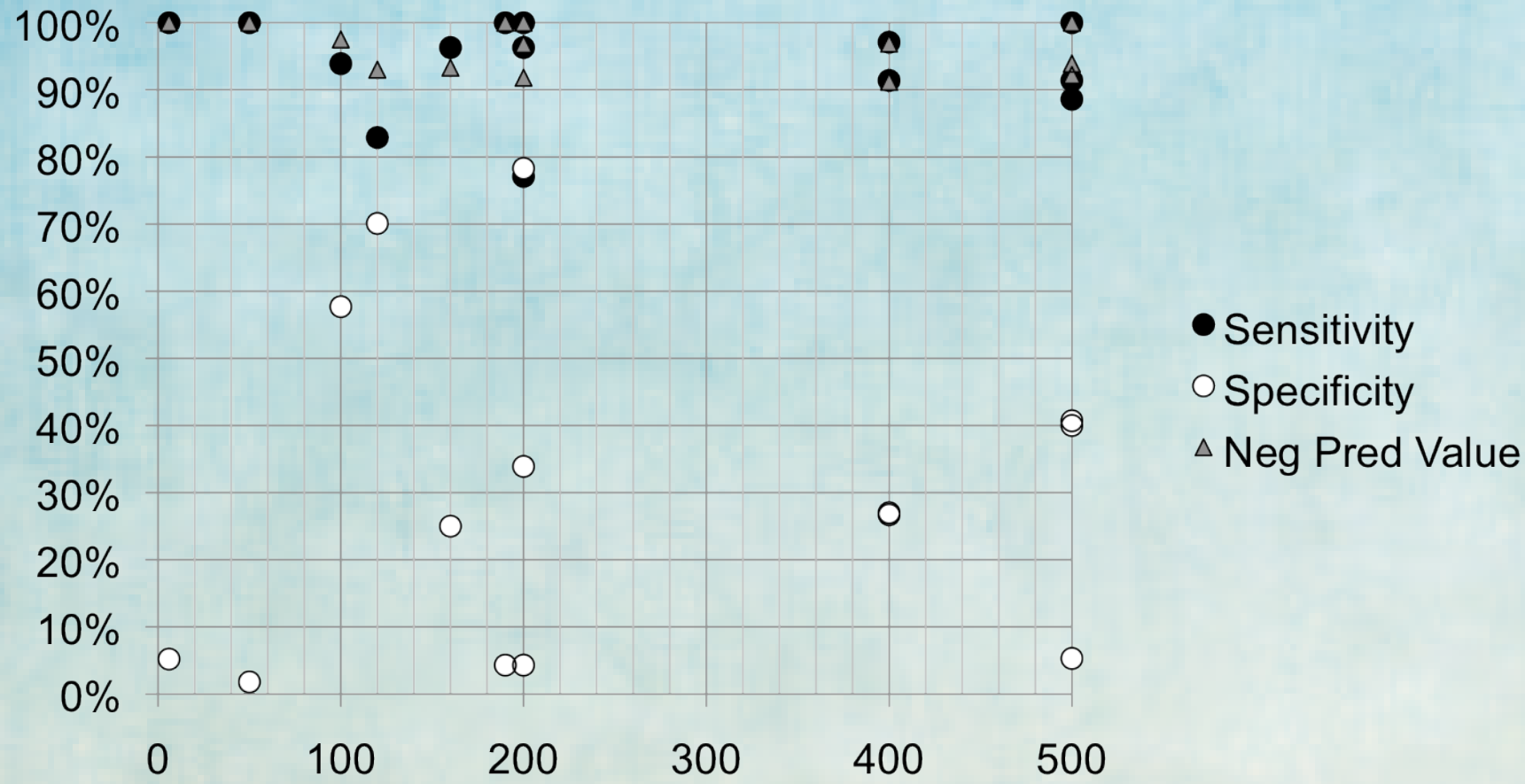
1. Gosselin RC, Owings JT, Kehoe J, Anderson JT, Dwyre DM, Jacoby RC, Utter G, Larkin EC. Comparison of six D-dimer methods in patients suspected of deep vein thrombosis. Blood Coagul Fibrinolysis. 2003;14(6):545-550

Cutoff values for D-dimer and VTE



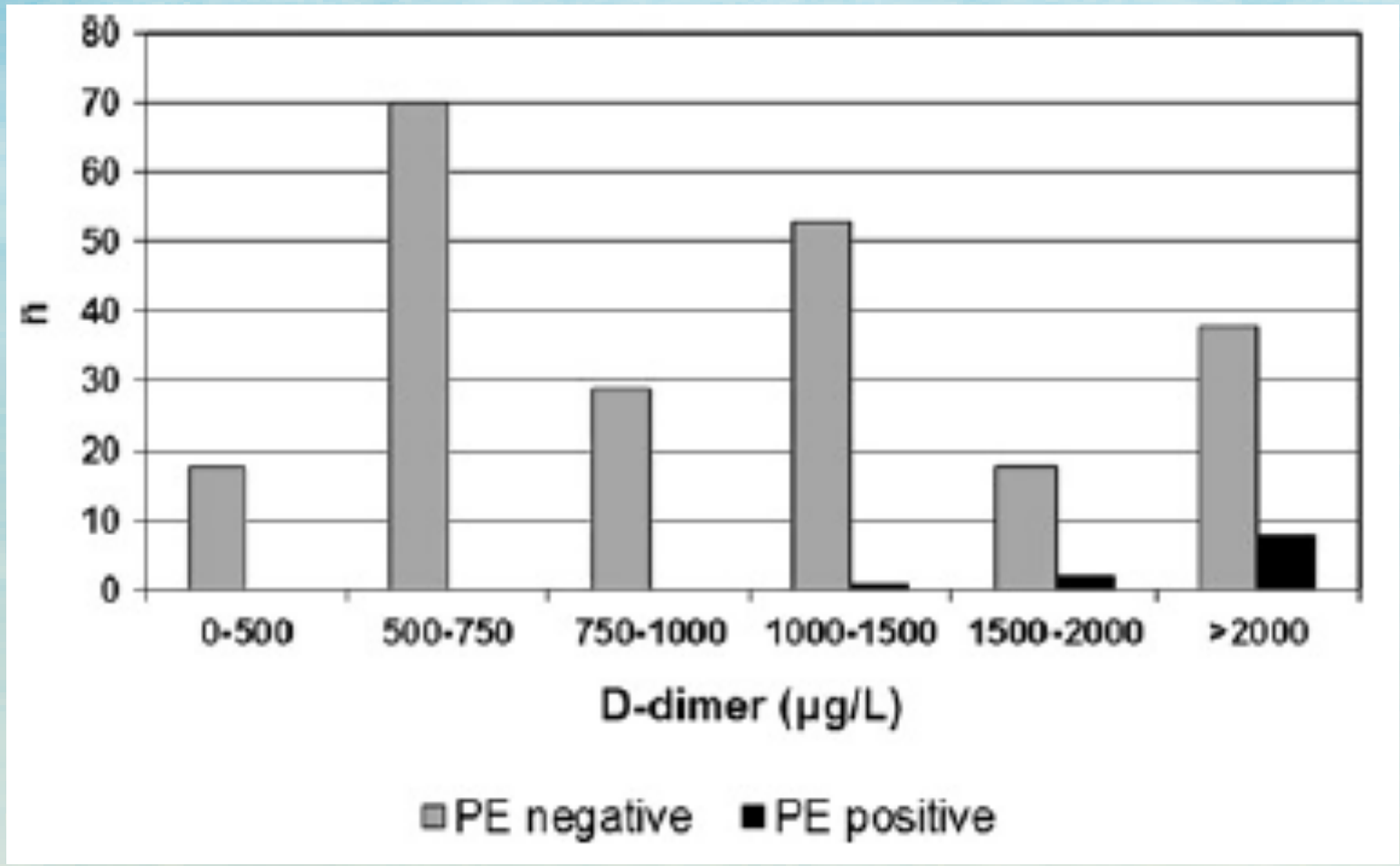
1. Gosselin RC, Owings JT, Kehoe J, Anderson JT, Dwyre DM, Jacoby RC, Utter G, Larkin EC. Comparison of six D-dimer methods in patients suspected of deep vein thrombosis. Blood Coagul Fibrinolysis. 2003;14(6):545-550

Small Cutoff Values?



1. Gosselin RC, Owings JT, Kehoe J, Anderson JT, Dwyre DM, Jacoby RC, Utter G, Larkin EC. Comparison of six D-dimer methods in patients suspected of deep vein thrombosis. Blood Coagul Fibrinolysis. 2003;14(6):545-550

Large Cutoff Values?



1. Vossen JA, Albrektson J, Sensarma A, Williams SC. Clinical usefulness of adjusted D-dimer cut-off values to exclude pulmonary embolism in a community hospital emergency department patient population. Acta Radiol. 2012;53(7):765-768

Bottom line about cutoff values

- It probably doesn't matter

Questions

- Clinical decision rules to screen out PE
  - How do you use them? Are they any good? Which ones?
- D-dimer
  - Why use them? What is the best cut off value?
- PE imaging
  - CT or VQ? SPECT? Pregnancy?
- Risk Stratification
  - Does it work?

Imaging

V/Q and CT

Computed Tomographic Pulmonary Angiography vs Ventilation-Perfusion Lung Scanning in Patients With Suspected Pulmonary Embolism

A Randomized Controlled Trial

David R. Anderson, MD
Susan R. Kahn, MD
Marc A. Rodger, MD
Michael J. Kovacs, MD
Tim Morris, MD
Andrew Hirsch, MD
Eddy Lang, MD
Ian Stiell, MD
George Kovacs, MD
Jon Dreyer, MD
Carol Dennie, MD
Yannick Cartier, MD
David Barnes, MD
Erica Burton, BSc
Susan Pleasance, BScN
Chris Skedgel, MSc
Keith O'Rouke, PhD
Philip S. Wells, MD

Context Ventilation-perfusion ($\dot{V}/\dot{Q}$) lung scanning and computed tomographic pulmonary angiography (CTPA) are widely used imaging procedures for the evaluation of patients with suspected pulmonary embolism. Ventilation-perfusion scanning has been largely replaced by CTPA in many centers despite limited comparative formal evaluations and concerns about CTPA's low sensitivity (ie, chance of missing clinically important pulmonary embuli).

Objectives To determine whether CTPA may be relied upon as a safe alternative to $\dot{V}/\dot{Q}$ scanning as the initial pulmonary imaging procedure for excluding the diagnosis of pulmonary embolism in acutely symptomatic patients.

Design, Setting, and Participants Randomized, single-blinded noninferiority clinical trial performed at 4 Canadian and 1 US tertiary care centers between May 2001 and April 2005 and involving 1417 patients considered likely to have acute pulmonary embolism based on a Wells clinical model score of 4.5 or greater or a positive D-dimer assay result.

Intervention Patients were randomized to undergo either $\dot{V}/\dot{Q}$ scanning or CTPA. Patients in whom pulmonary embolism was considered excluded did not receive antithrombotic therapy and were followed up for a 3-month period.

Main Outcome Measure The primary outcome was the subsequent development of symptomatic pulmonary embolism or proximal deep vein thrombosis in patients in whom pulmonary embolism had initially been excluded.

Results Seven hundred one patients were randomized to CTPA and 716 to $\dot{V}/\dot{Q}$ scanning. Of these, 133 patients (19.2%) in the CTPA group vs 101 (14.2%) in the $\dot{V}/\dot{Q}$ scan group were diagnosed as having pulmonary embolism in the initial evaluation period (difference, 5.0%; 95% confidence interval [CI], 1.1% to 8.9%) and were treated with anticoagulant therapy. Of those in whom pulmonary embolism was considered excluded, 2 of 561 patients (0.4%) randomized to CTPA vs 6 of 611 patients (1.0%) undergoing $\dot{V}/\dot{Q}$ scanning developed venous thromboembolism in follow-up (difference, –0.6%; 95% CI, –1.6% to 0.3%) including one patient with fatal pulmonary embolism in the $\dot{V}/\dot{Q}$ group.

Conclusions In this study, CTPA was not inferior to $\dot{V}/\dot{Q}$ scanning in ruling out pulmonary embolism. However, significantly more patients were diagnosed with pulmonary embolism using the CTPA approach. Further research is required to determine whether all pulmonary emboli detected by CTPA should be managed with anticoagulant therapy.

Trial Registration isrctn.org Identifier: ISRCTN65486961

JAMA. 2007;298(23):2743-2753 www.jama.com

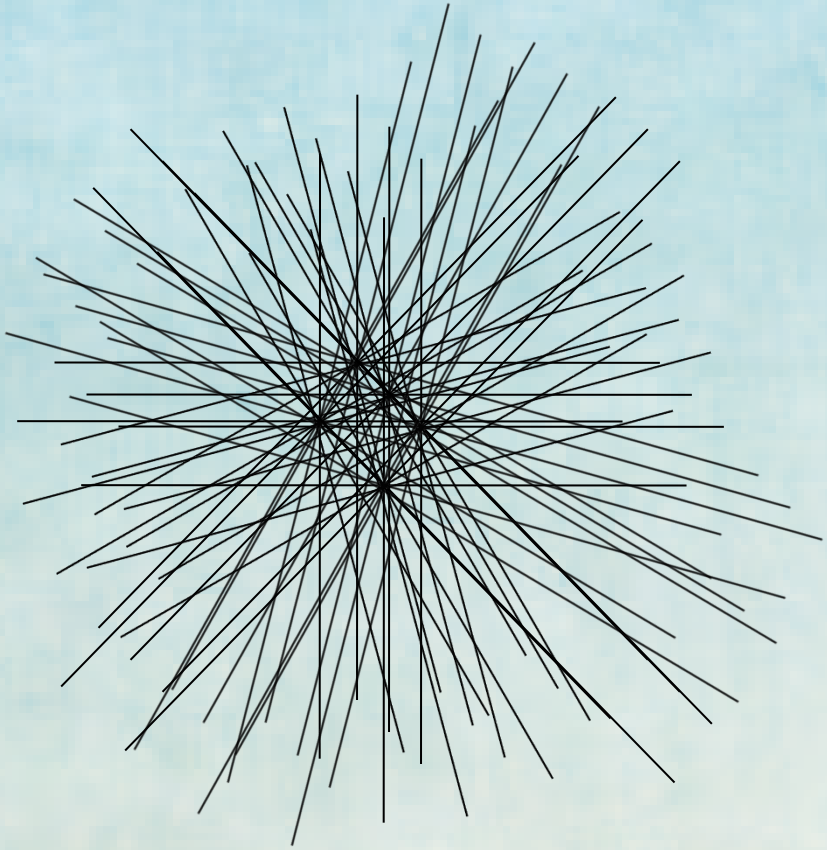
PULMONARY EMBOLISM IS A COMmon and serious medical condition leading to the hospitalization or death of more than 250 000 people in the United States each year.[1] It is the third leading cause of cardiovascular mortality and is estimated to result in 5% to 10% of all deaths in US hospitals.[2] Despite the potentially lethal nature of this condition, pulmonary embolism remains one

PEDS Trial: PE after a negative CTPA or VQ/CUS

	CTPA (n = 561)	V̇/Q̇ (n = 611)
PE total	2 (0.4)	4 (0.7)
Fatal PE	0	1 (0.2)
DVT	0	2 (0.3)
Total VTE[b]	2 (0.4)	6 (1.0)

Planar Perfusion Scan

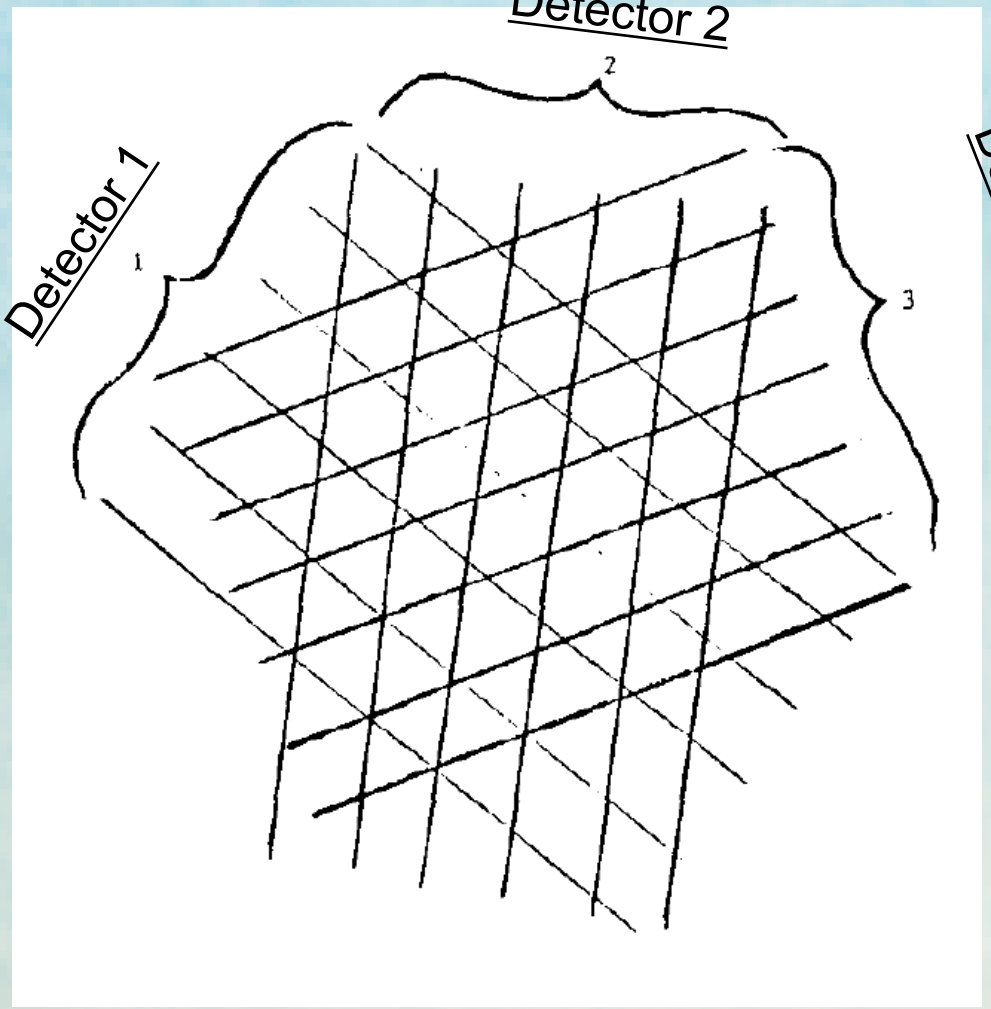
Detector



Who is this guy?

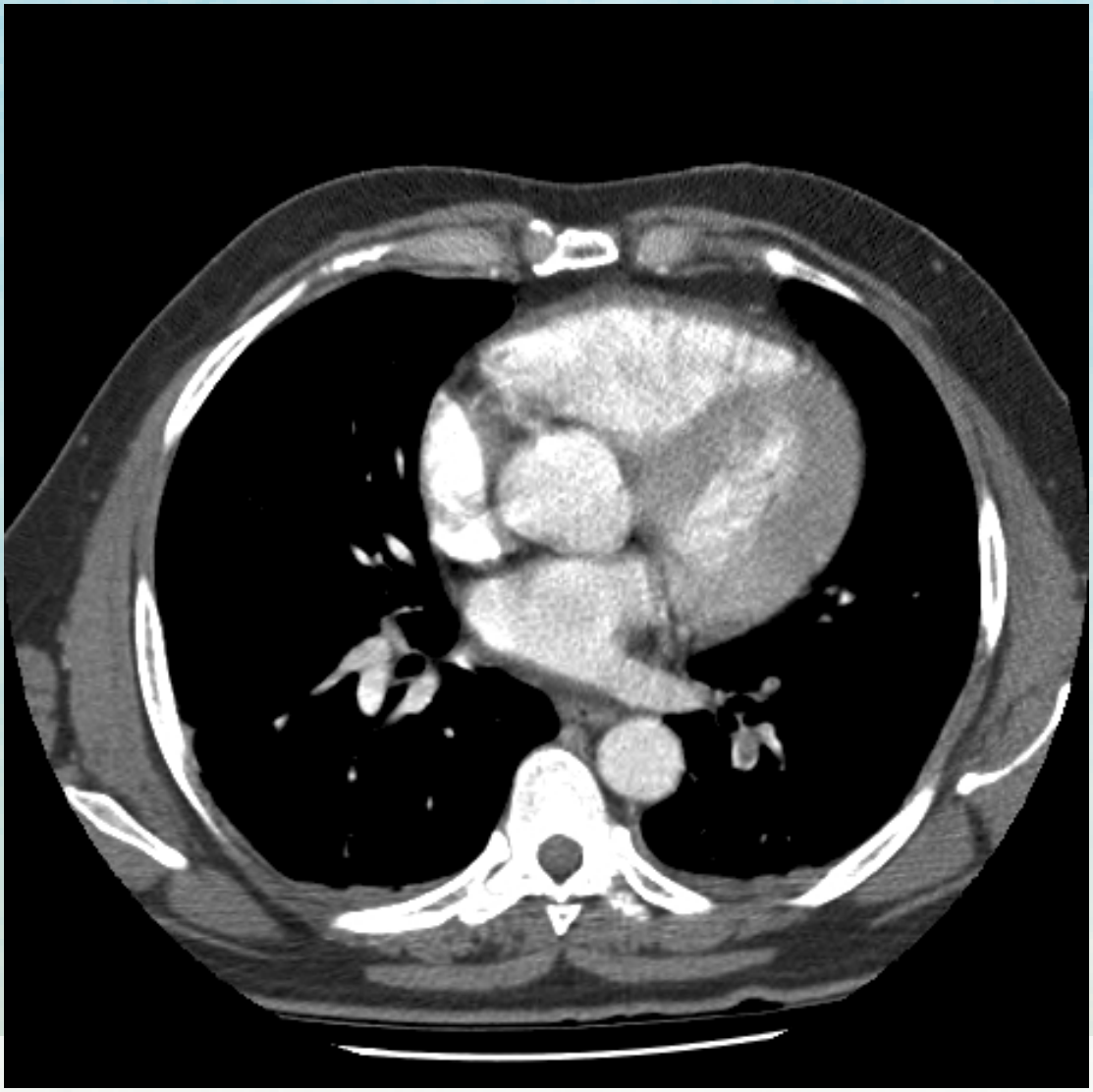
Godfrey N. Hounsfield. Computed Medical Imaging. Nobel Lecture, 8 December, 1979

CT data

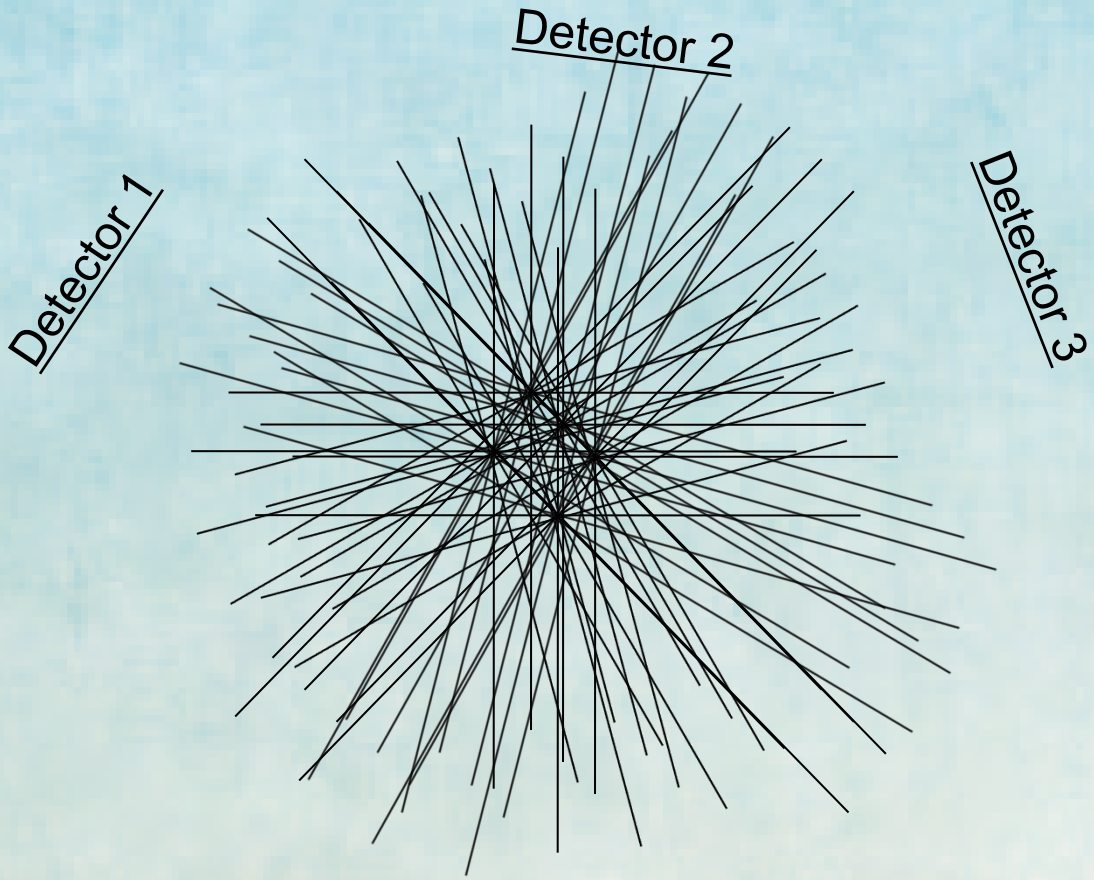


Godfrey N. Hounsfield. Computed Medical Imaging. Nobel Lecture, 8 December, 1979

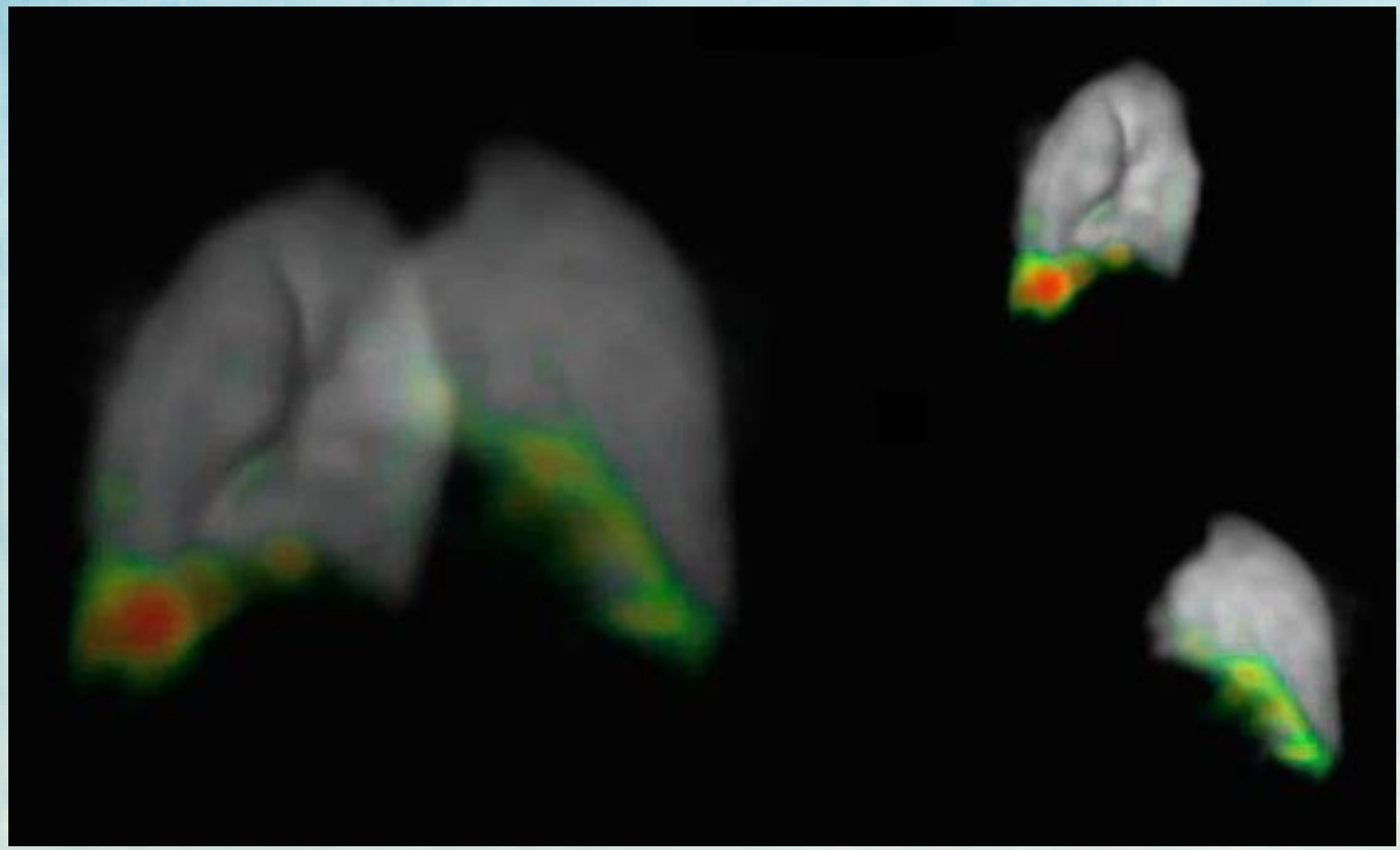
CT



SPECT Data

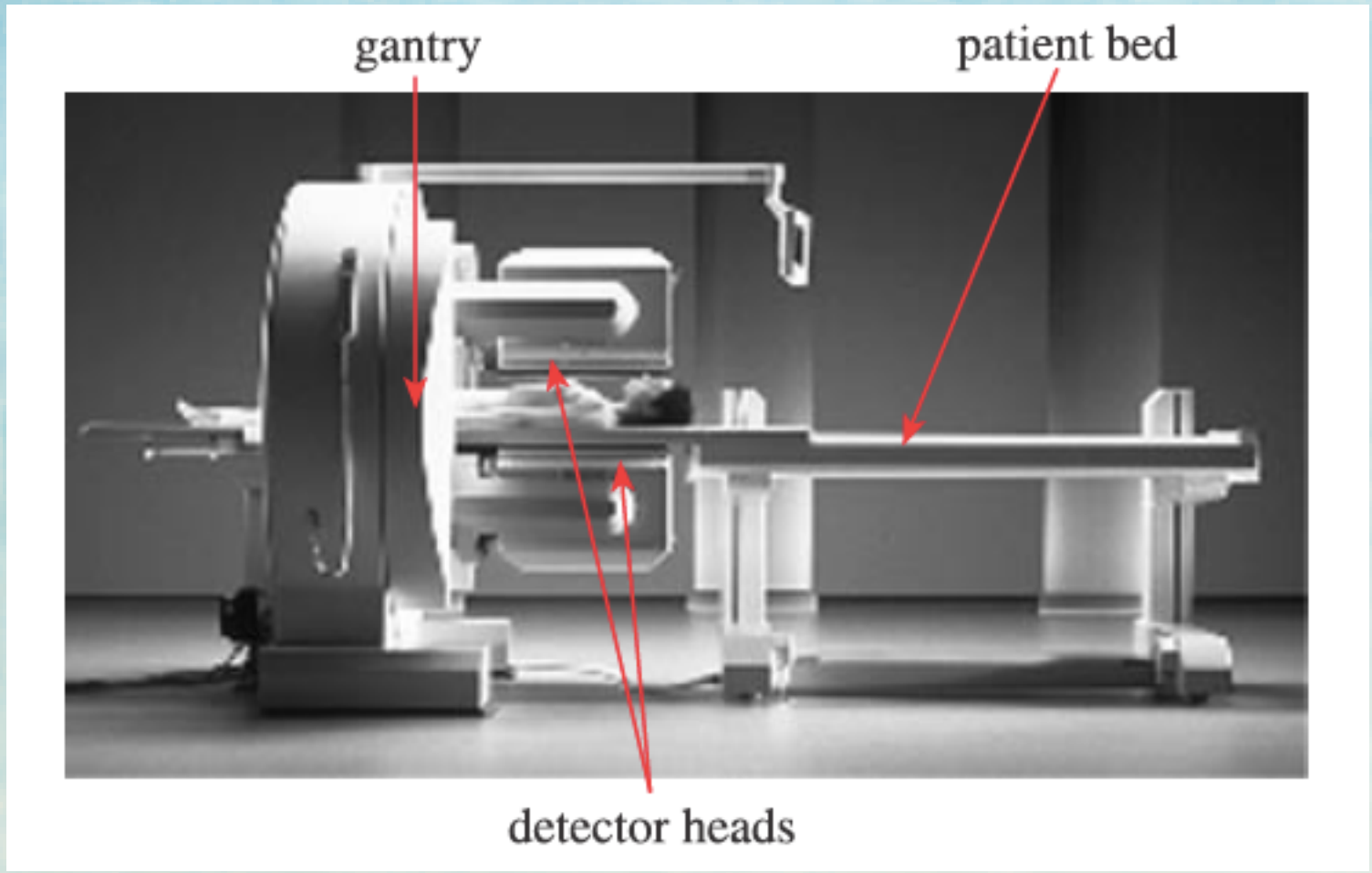


SPECT V/Q



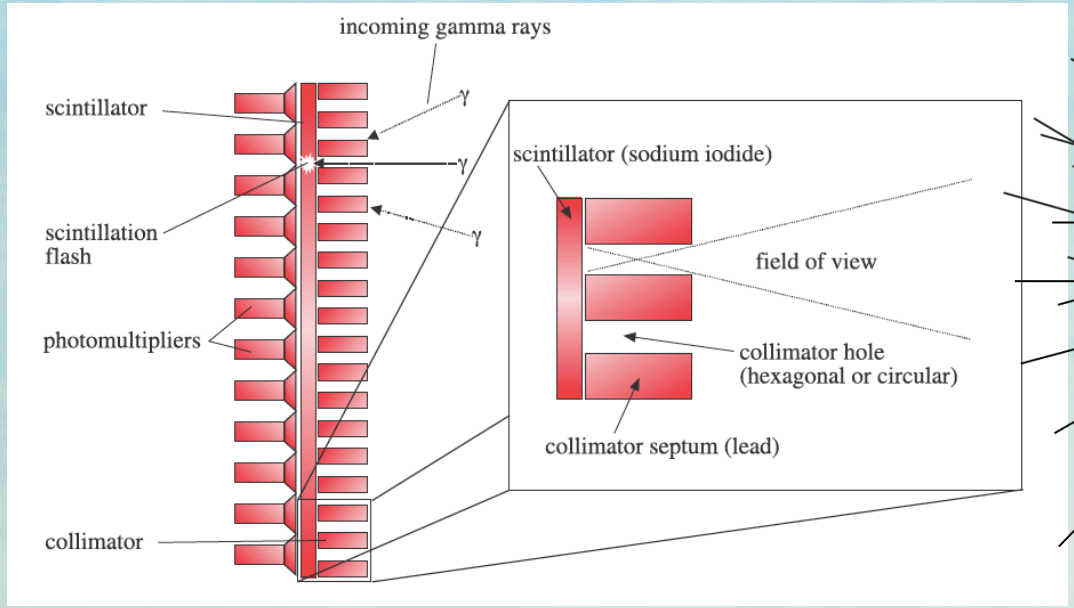
http://en.wikibooks.org/wiki/Basic_Physics_of_Nuclear_Medicine/Three-Dimensional_Visualization_Techniques

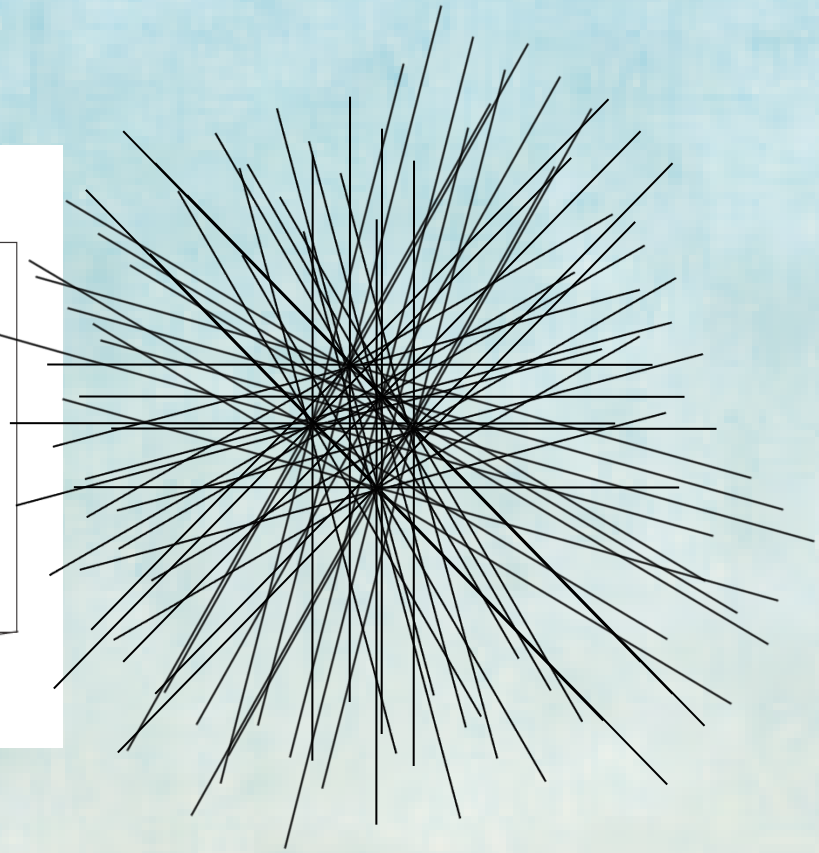
Nuclear Medicine Scanner



Ramsey D Badawi . Nuclear medicine. Physics Education. 36 452-459. 2001

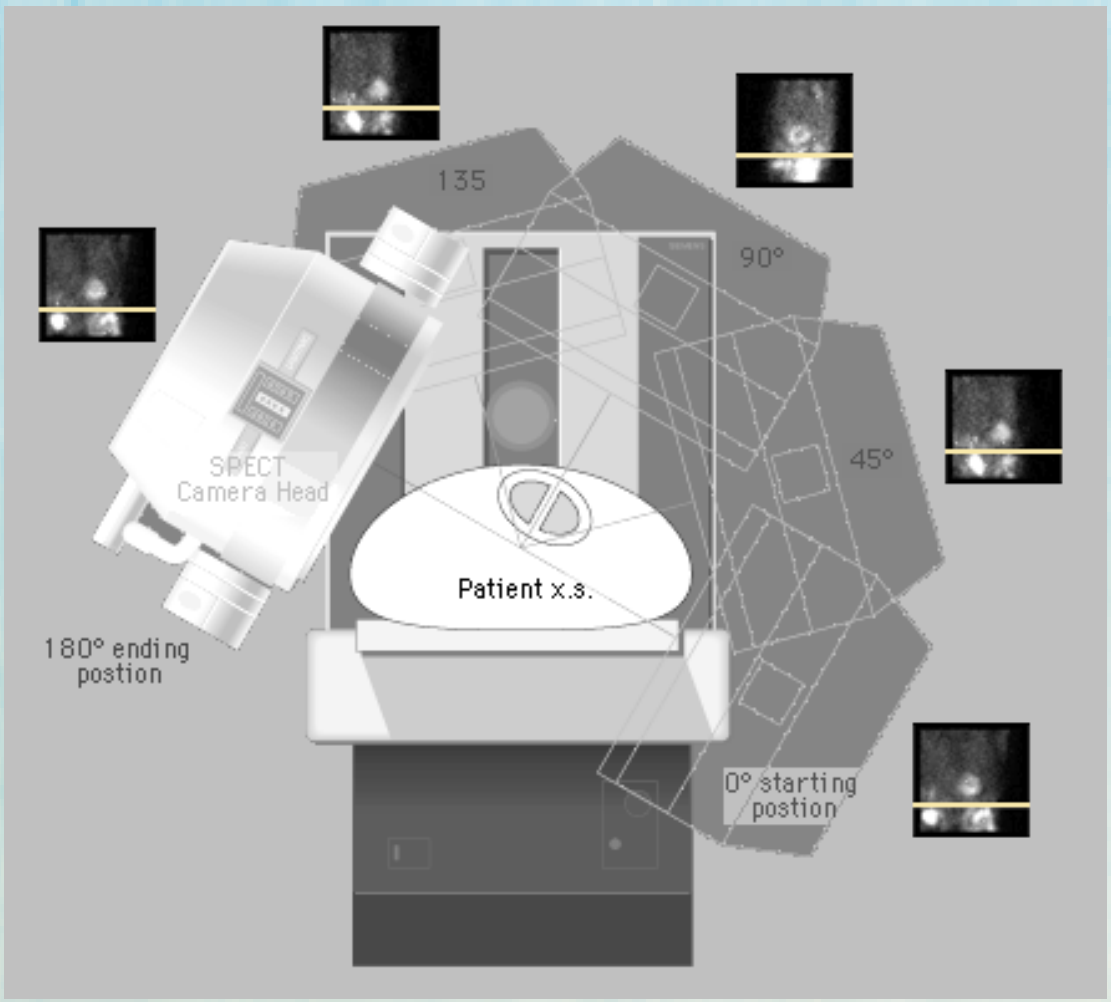
Nuclear Medicine Collimator





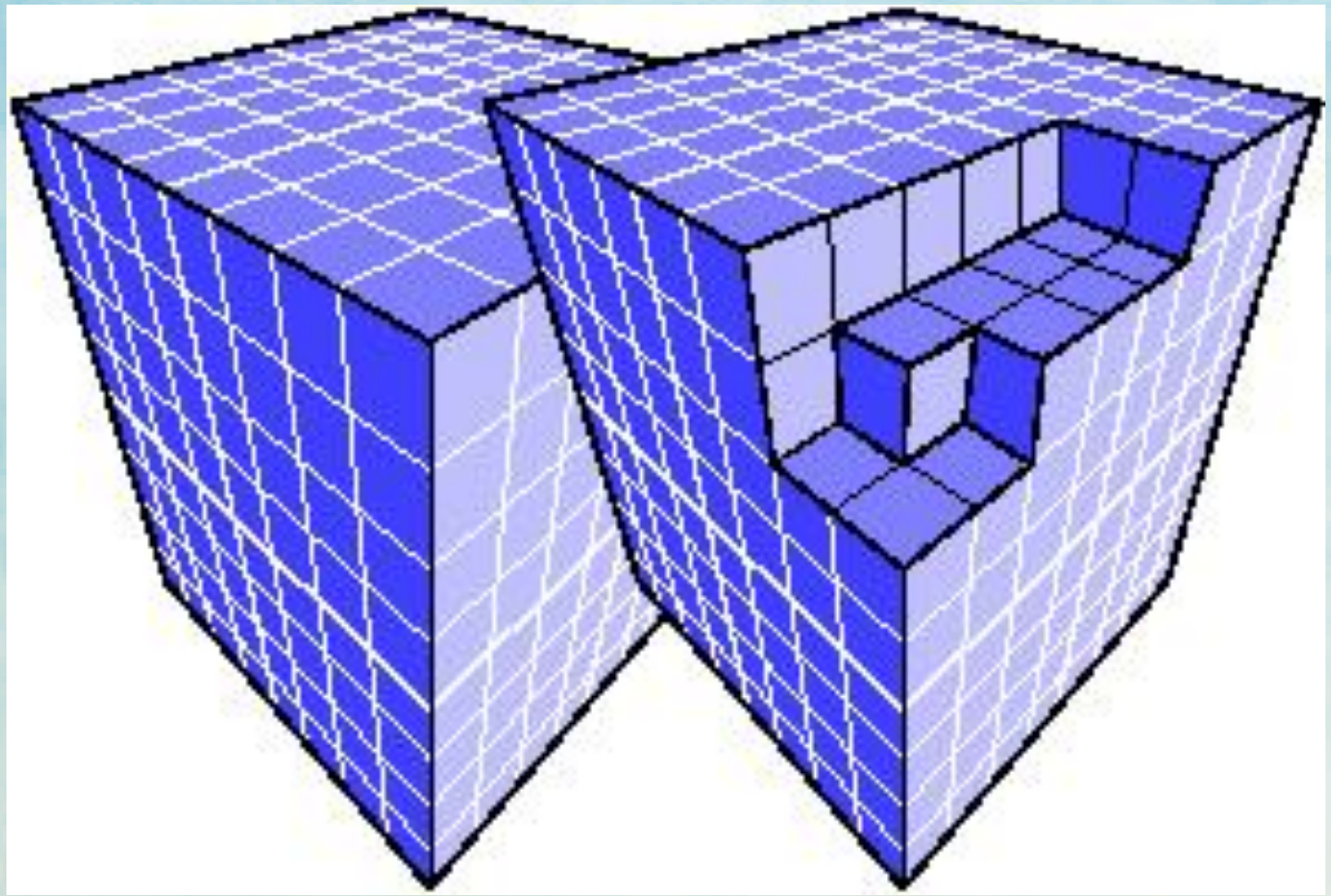
Ramsey D Badawi . Nuclear medicine. Physics Education. 36 452-459. 2001

SPECT Scanning



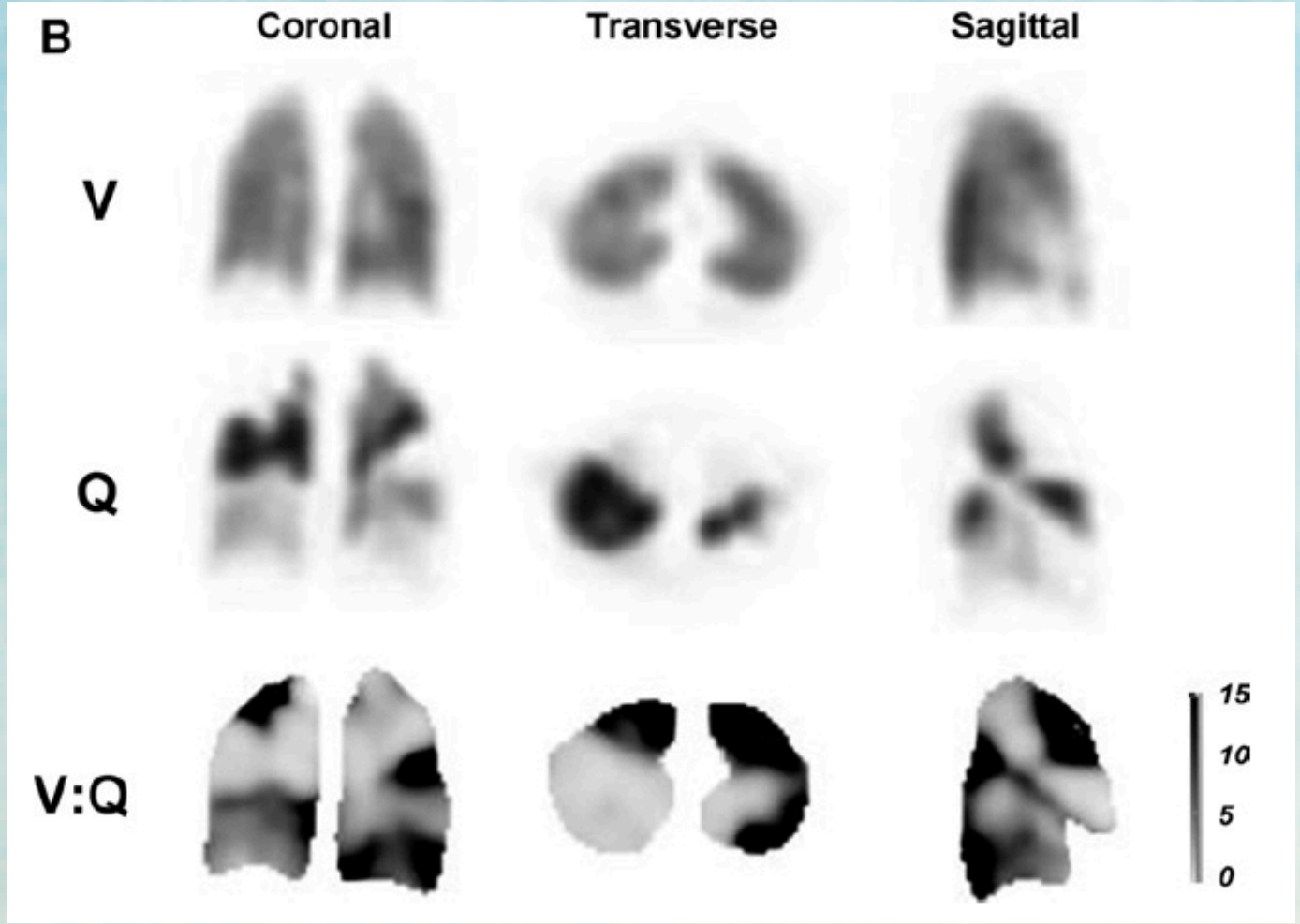
http://tomo3d-ea.gforge.inria.fr/tomo3d-ea.html

SPECT “Voxel” Dataset



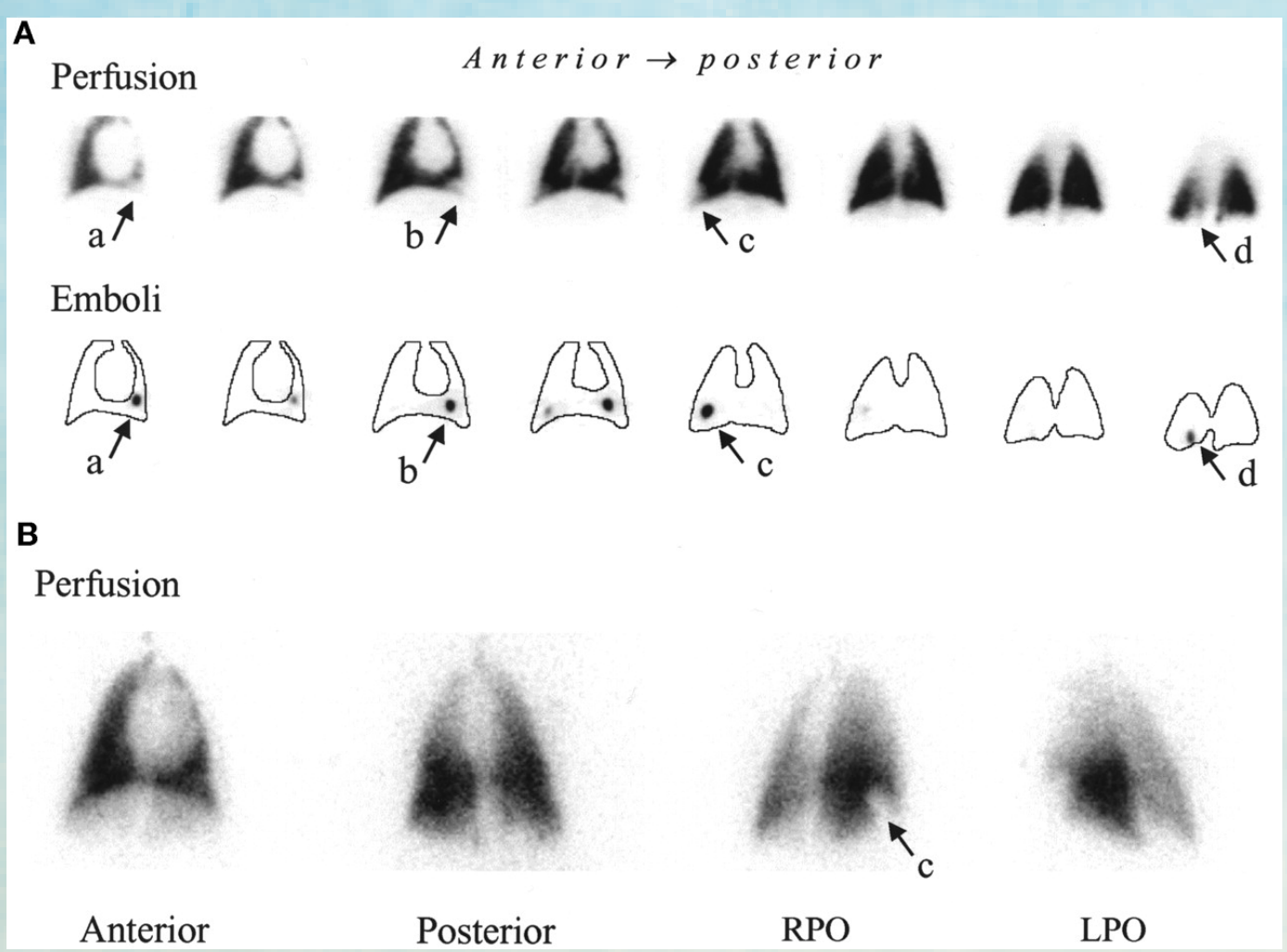
http://tomo3d-ea.gforge.inria.fr/tomo3d-ea.html

Digitally Compare V and Q



Roach PJ, Bailey DL, Harris BE. Enhancing lung scintigraphy with single-photon emission computed tomography. Semin Nucl Med 2008;38:441-9.

SPECT Q scan discloses emboli

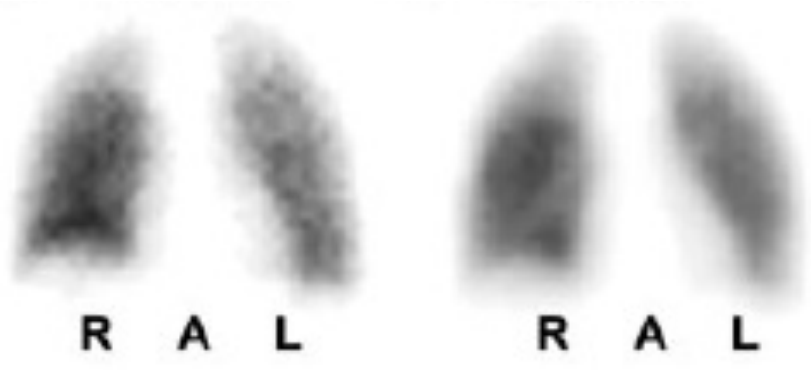


Bajc M, Bitzen U, Olsson B, Perez de Sa V, Palmer J, Jonson B. Lung ventilation/perfusion SPECT in the artificially embolized pig. J Nucl Med 2002;43:640-7.

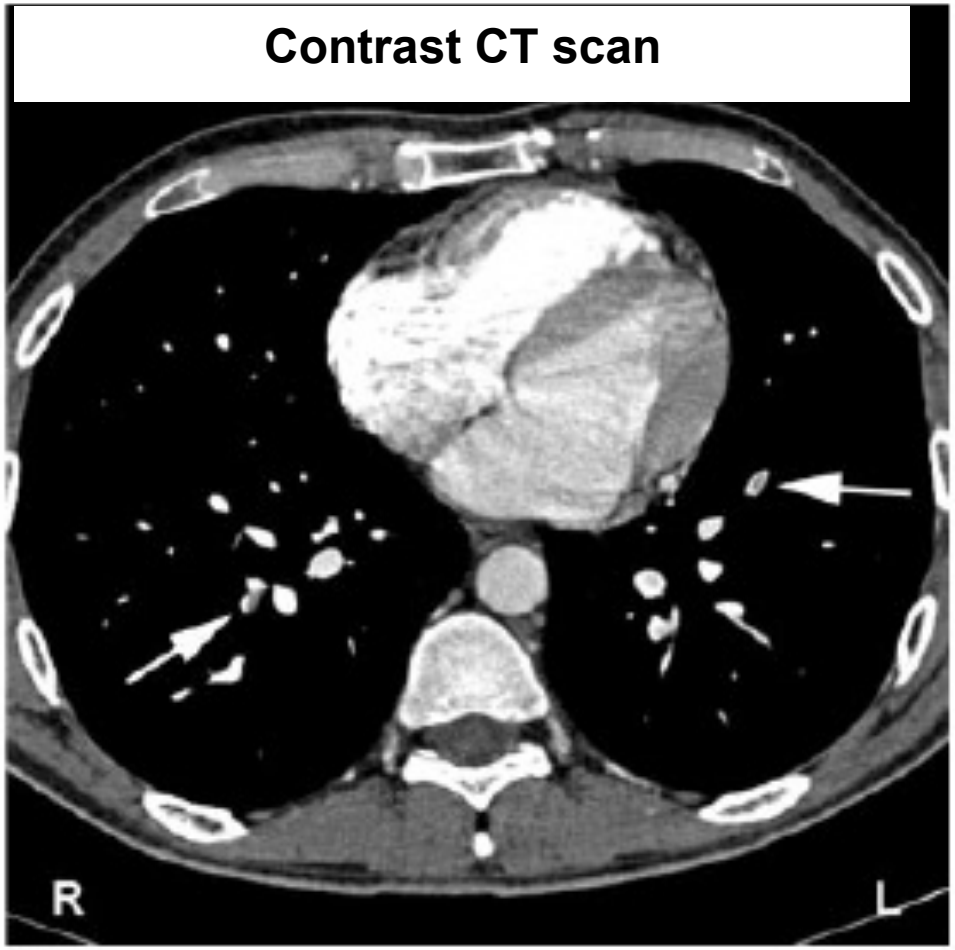
SPECT V/Q

SPECT V/Q scan

planar V/Q scan



Contrast CT scan



Reinartz P, Wildberger JE, Schaefer W, Nowak B, Mahnken AH, Buell U. Tomographic imaging in the diagnosis of pulmonary embolism: a comparison between V/Q lung scintigraphy in SPECT technique and multislice spiral CT. J Nucl Med. 2004;45(9):1501-8.

Accuracy Studies of SPECT VQ

TABLE 1. Accuracy Studies of SPECT

Study	Reference standard	SPECT criteria	Ventilation agent	SPECT sensitivity	SPECT specificity	SPECT PPV	Prospective	Patient characteristic
Corbus (*4*)	Conventional angio	Revised PIOPED: high or inter = PE; low or normal = no PE	^{99m}Tc-DTPA	Not done	Not done	18/29 (62%)	No	Consecutive suspected PE
Bajc (*30*)	CT angio	≥2 mismatches = PE; 1 mismatch = no PE	Technegas	24/26 (92%)	54/76 (71%)		No	Consecutive suspected PE
Bajc (*30*)	Consensus, SPECT, CT angio	≥2 mismatches = PE; 1 mismatch = no PE	Technegas	601/608 (99%)	1,153/1,177 (98%)		No	Consecutive suspected PE
Palla (*2*)	Conventional angio if planar V/Q perfusion defects	Defects in ≥ 1 segment	^{133}Xe	56/62 (90%)	75/118 (64%)		Yes	All referred for suspected PE, not consecutive
Collart (*20*)	Consensus V/Q, sonography, CT angio, D-dimer	Wedge-shaped defect	Not done	12/15 (80%)	49/51 (96%)		Yes	Consecutive suspected PE in emergency department
Reinartz (*22*)	Not stated	≥1 mismatch	Technegas	Reader 1, 96% Reader 2, 93% Reader 3, 89%	Reader 1, 96% Reader 2, 100% Reader 3, 100%		No	Consecutive suspected PE
Reinartz (*23*)	Consensus, including SPECT and CT angio	≥1 mismatch	Technegas	36/37 (97%)	42/46 (91%)		No	Suspected PE
Bajc (*19*)	Consensus, including SPECT and CT angio	≥2 seg or subseg mismatches = PE; 0 mismatch = no PE	^{99m}Tc-DTPA	Reader A, 13/13 (100%) Reader B, 13/13 (100%)	Reader A, 37/40 (93%) Reader B, 37/39 (95%)		Yes	51 suspected PE 2 treated PE
Hata (*32*)	CT angio if high or inter SPECT	Seg perfusion defect, 2 or 3 planes	Not done	Not done	Not done	4/8 (50%)	Yes	Screening after cancer surgery
Lemb (*31*)	SPECT better, new defects, or normalized = PE; SPECT unchanged = no PE	≥1 mismatch = PE; 0 mismatch = no PE	Technegas	44/46 (96%)	38/39 (97%)		No	All referred for suspected PE

PPV = positive predictive value; angio = angiography; inter = intermediate; seg = segmental; subseg = subsegmental.

Stein PD, Freeman LM, Sostman HD, et al. SPECT in Acute Pulmonary Embolism. J Nucl Med 2009;50:1999-2007.

SPECT VQ Compared to Planar VQ

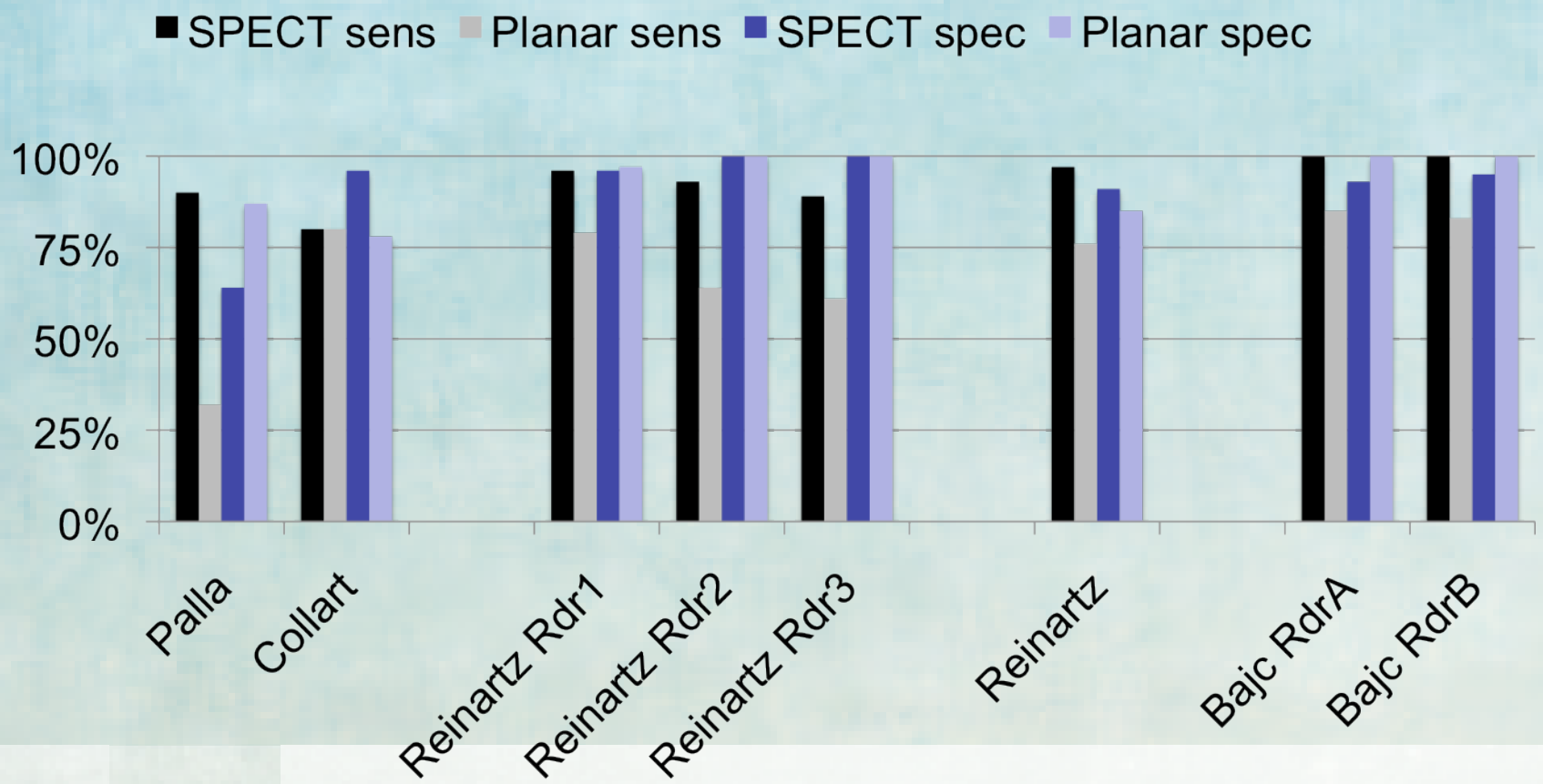
TABLE 2. Comparisons of SPECT with Planar V/Q Imaging

Study	Reference standard	SPECT criteria	Planar V/Q criteria	Ventilation agent	Planar V/Q method	SPECT sensitivity	SPECT specificity	Planar V/Q sensitivity	Planar V/Q specificity	Prospective	Patient characteristic
Palla (*2*)	Conventional angiogram if planar V/Q perfusion defects	≥1 mismatch	McNeil criteria	^{133}Xe	6-view conventional (ventilation only if no chest radiography abnormality matched perfusion)	56/62 (90%)	75/118 (64%)	20/62 (32%)	103/118 (87%)	Yes	All referred for suspected PE
Collart (*20*)	Consensus	Wedge-shaped defect	PISA-PED perfusion and revised PIOPED V/Q	Only planar ventilation was performed (^{81m}Kr)	6-view conventional	12/15 (80%)	49/51 (96%)	12/15 (80%)	40/51 (78%)	Yes	Consecutive suspected PE in emergency department
Reinartz (*22*)	Not stated	≥1 mismatch	≥1 mismatch	Technegas	Angular summed from SPECT	Reader 1, 96% Reader 2, 93% Reader 3, 89%	Reader 1, 96% Reader 2, 100% Reader 3, 100%	Reader 1, 79% Reader 2, 64% Reader 3, 61%	Reader 1, 97% Reader 2, 100% Reader 3, 100%	No	Consecutive suspected PE
Reinartz (*23*)	Consensus, including SPECT and CT angio	≥1 mismatch	≥1 mismatch	Technegas	Angular summed from SPECT	36/37 (97%)	42/46 (91%)	28/37 (76%)	39/46 (85%)	No	Suspected PE
Bajc (*19*)	Consensus, including SPECT and CT angio	≥2 seg or subseg mismatches = PE; 0 mismatch = no PE	≥2 seg or subseg mismatches = PE; 0 mismatch = no PE	^{99m}Tc-DTPA	4-view conventional	Reader A, 13/13 (100%) Reader B, 13/13 (100%)	Reader A, 37/40 (93%) Reader B, 37/39 (95%)	Reader A, 11/13 (85%) Reader B, 10/12 (83%)	Reader A, 40/40 (100%) Reader B, 40/40 (100%)	Yes	51 suspected PE 2 treated PE

Angio = angiography; seg = segmental; subseg = subsegmental.

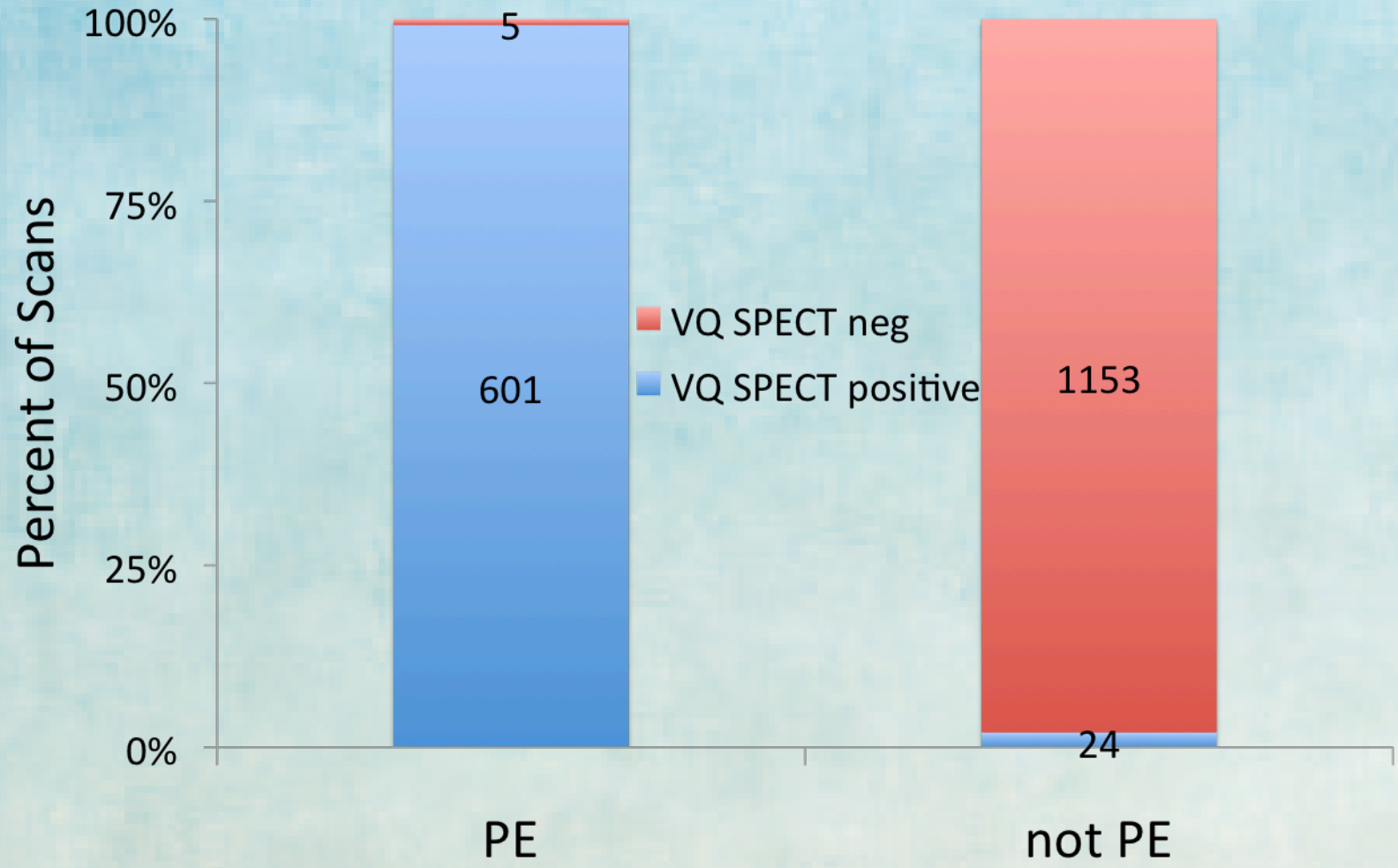
Stein PD, Freeman LM, Sostman HD, et al. SPECT in Acute Pulmonary Embolism. J Nucl Med 2009;50:1999-2007.

SPECT Compared to Planar VQ



Stein PD, Freeman LM, Sostman HD, et al. SPECT in Acute Pulmonary Embolism. J Nucl Med 2009;50:1999-2007.

Accuracy of SPECT VQ



Bajc M, Olsson B, Palmer J, Jonson B. Ventilation/Perfusion SPECT for diagnostics of pulmonary embolism in clinical practice. J Intern Med. 2008;264(4): 379-387.

Pregnancy

Pregnancy-Related Death

TABLE 3. Causes of pregnancy-related death, by outcome of pregnancy and pregnancy-related mortality ratios (PRMR*) — United States, 1991–1999

Cause of death	Outcome of pregnancy (% distribution)							All outcomes	
	Live birth (n = 2,519)	Stillbirth (n = 275)	Ectopic (n = 237)	Abortion† (n = 165)	Molar (n = 14)	Undelivered (n = 438)	Unknown (n = 552)	% (N = 4,200)	PRMR
Embolism	21.0	18.6	2.1	13.9	28.6	25.1	18.3	19.6	2.3
Hemorrhage	2.7	21.1	93.3	21.8	7.1	8.7	8.7	17.2	2.0
PIH§	19.3	20.0	0	0.6	0	12.3	11.8	15.7	1.8
Infection	11.7	18.9	2.5	33.9	14.3	11.0	12.9	12.6	1.5
Cardiomyopathy	10.1	5.1	0.4	1.8	0	3.4	11.2	8.3	1.0
CVA¶	5.7	0.7	0	1.2	0	3.9	8.5	5.0	0.6
Anesthesia	1.8	0.7	1.3	9.7	0	0	0.4	1.6	0.2
Other**	17.1	14.9	0.4	16.4	50.0	33.6	27.9	19.2	2.3
Unknown	0.6	0	0	0.6	0	2.1	0.4	0.7	0.1
Total††	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**11.8**

* Pregnancy-related deaths per 100,000 live births.
† Includes spontaneous and induced abortions.
§ Pregnancy-induced hypertension.
¶ Cerebrovascular accident.
** The majority of the other medical conditions were cardiovascular, pulmonary, and neurologic problems.
†† Percentages might not add to 100.0 because of rounding.

Chang J, Elam-Evans LD, Berg CJ, Herndon J, Flowers L, Seed KA, Syverson CJ. Pregnancy-related mortality surveillance--United States, 1991--1999. *MMWR Surveill Summ.* 2003;52(2):1-8.

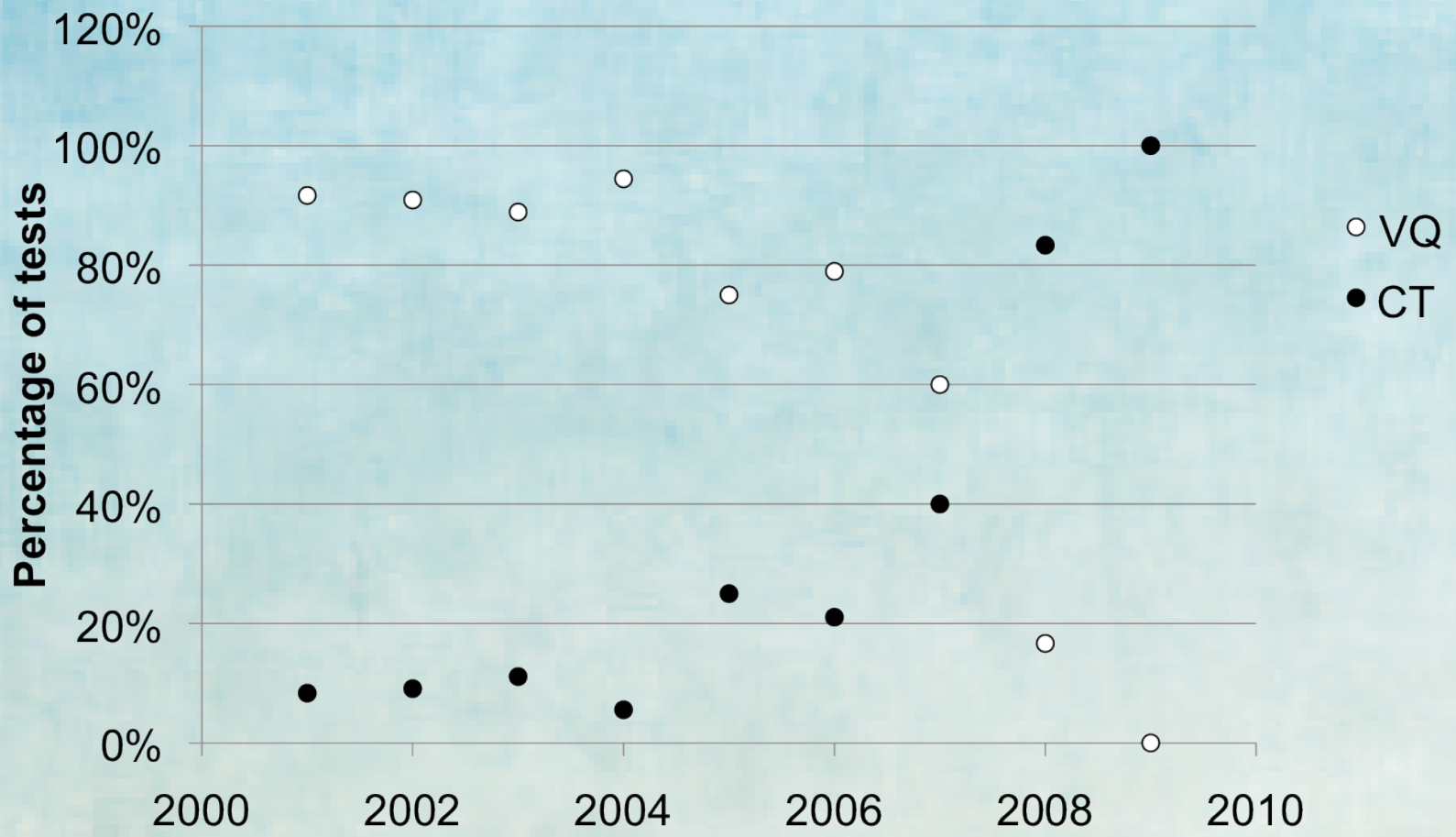
VTE Risk in Pregnancy and Post-partum

Table 2 Relative risk of venous thrombosis by different stages of pregnancy and postpartum

Status	Patients, *n* (%)	Control subjects, *n* (%)	OR*	95% CI
Neither	167 (60.9)	735 (87.2)	1	Ref.
1st and 2nd trimester	8 (2.9)	36 (4.3)	1.6	0.7–3.7
3rd trimester	28 (10.2)	22 (2.6)	8.8	4.5–17.3
1 to 6 weeks postpartum	66 (24.1)	6 (0.7)	84.0	31.7–222.6
7 weeks to 3rd month postpartum	3 (1.1)	4 (0.5)	8.9	1.7–48.1
4th month to 1 year postpartum	2 (0.8)	40 (4.7)	0.3	0.1–1.4

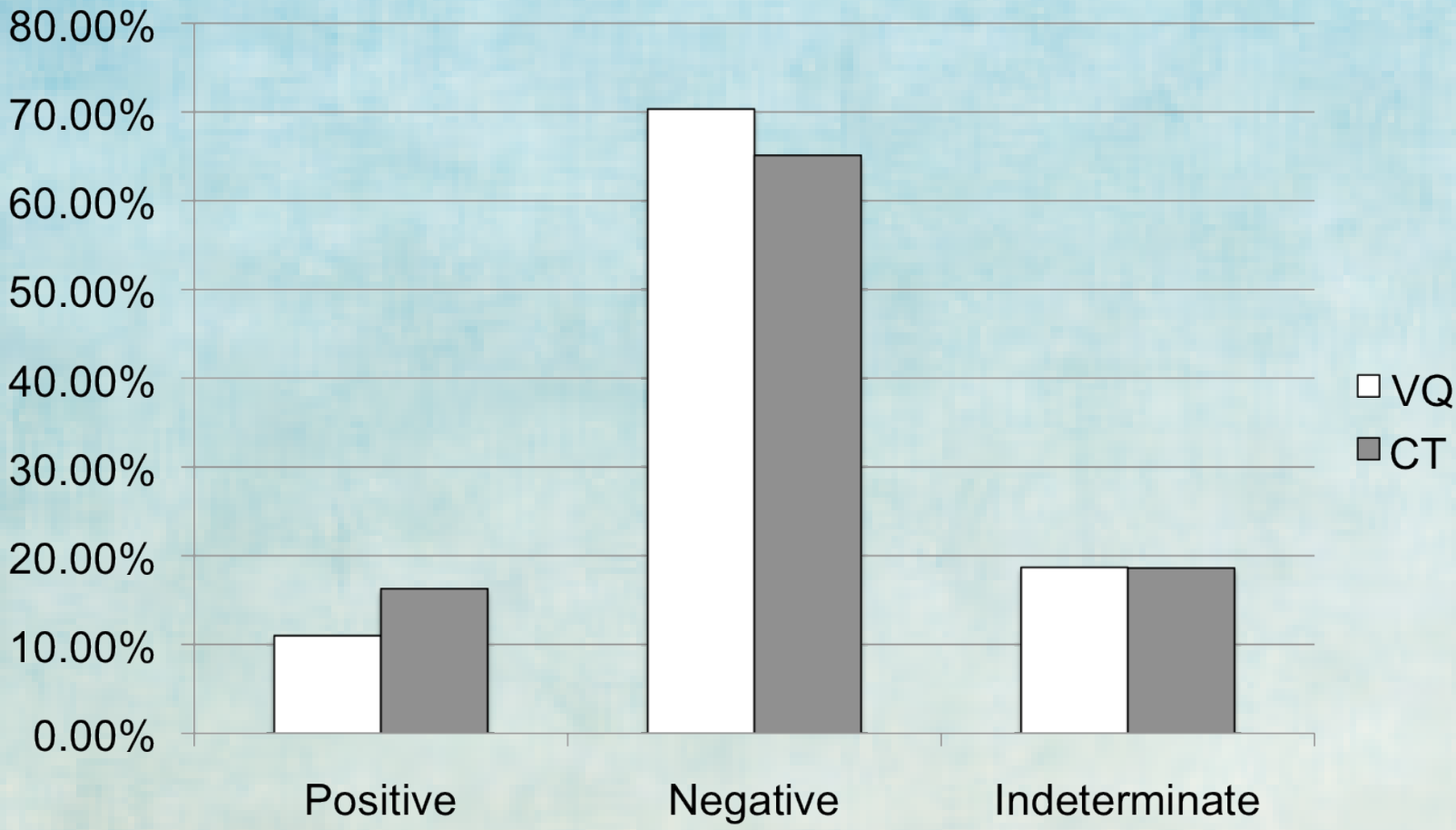
1. Pomp ER, Lenselink AM, Rosendaal FR, et al. Pregnancy, the postpartum period and prothrombotic defects: risk of venous thrombosis in the MEGA study. J Thromb Haemost 2008; 6: 632–7

Trend in CT vs VQ for Pregnant Patients



1. Revel M-P, Cohen S, Sanchez O, et al. Pulmonary embolism during pregnancy: diagnosis with lung scintigraphy or CT angiography. Radiology 2011;258:590-598

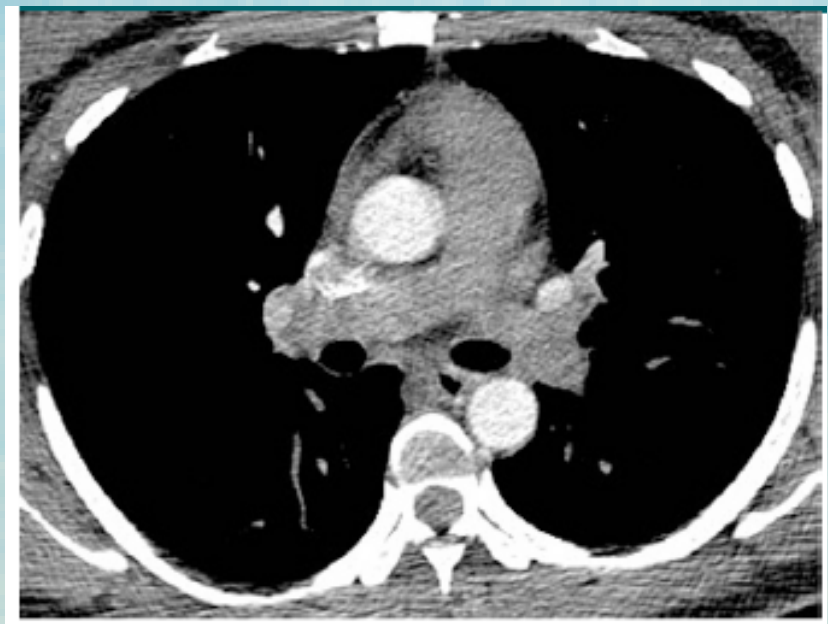
CT vs VQ in Pregnancy: Utility



1. Revel M-P, Cohen S, Sanchez O, et al. Pulmonary embolism during pregnancy: diagnosis with lung scintigraphy or CT angiography. Radiology 2011;258:590-598

Example of Indeterminate CT in Pregnant Woman

Bad



a.

- No contrast in PA
  - Smaller SVC (exhalation?)

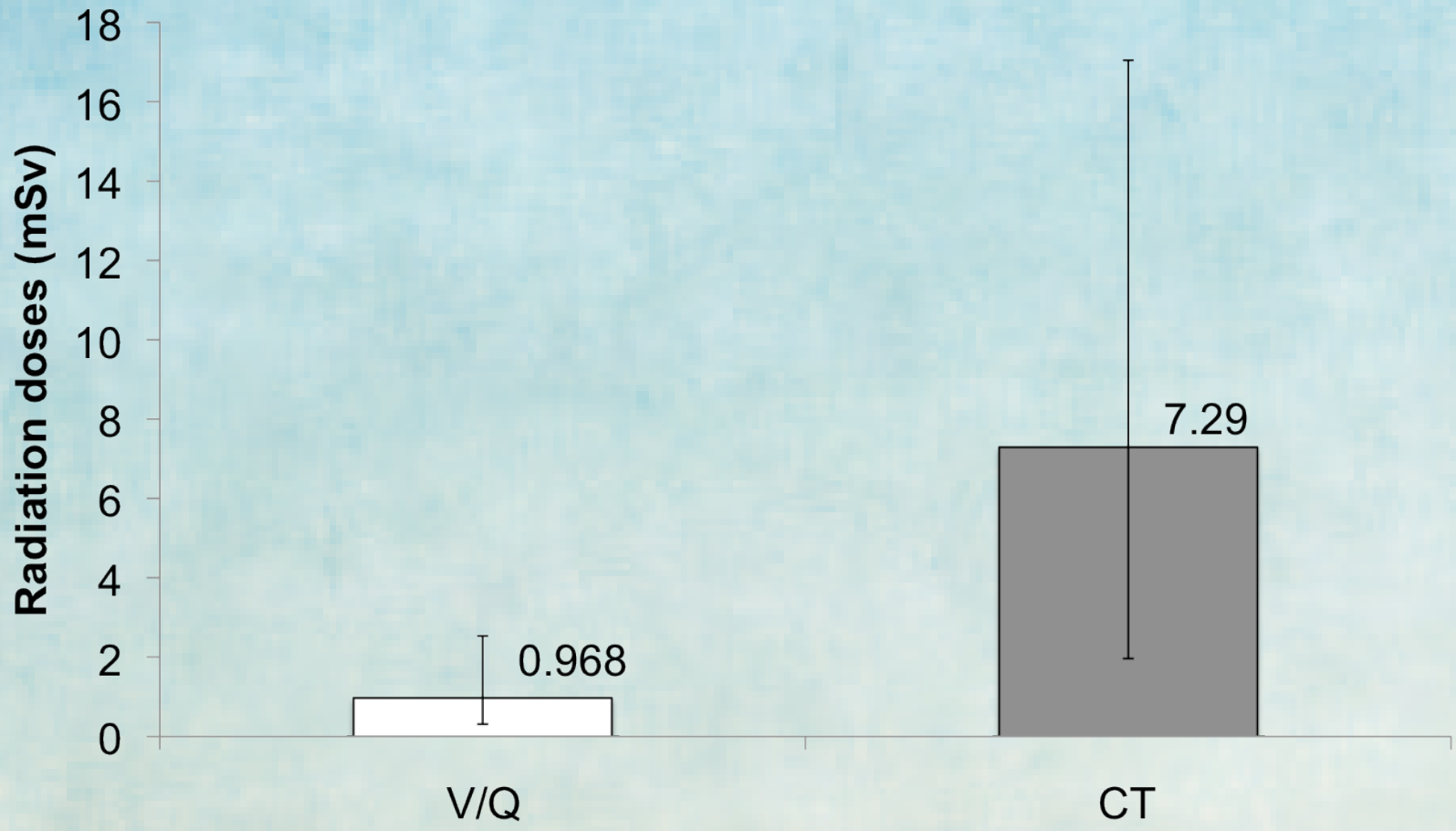
Good

b.

- Contrast in PA
  - Larger SVC (inhalation?)

1. Revel M-P, Cohen S, Sanchez O, et al. Pulmonary embolism during pregnancy: diagnosis with lung scintigraphy or CT angiography. Radiology 2011;258:590-598

CT vs VQ in Pregnant Women: Radiation



1. Revel M-P, Cohen S, Sanchez O, et al. Pulmonary embolism during pregnancy: diagnosis with lung scintigraphy or CT angiography. Radiology 2011;258:590-598

Questions

- Clinical decision rules to screen out PE
  - How do you use them? Are they any good? Which ones?
- D-dimer
  - Why use them? What is the best cut off value?
- PE imaging
  - CT or VQ? SPECT? Pregnancy?
- Risk Stratification
  - Does it work?

Risk stratification strategies

Pulmonary Embolism Severity Index

Predictors	Points assigned
Age, per year	**Age, in years**
Male sex	+10
History of cancer	+30
History of heart failure	+10
History of chronic lung disease	+10
Pulse ≥110/minute	+20
Systolic blood pressure < 100 mm Hg	+30
Respiratory rate ≥30/minute*	+20
Temperature < 36°C	+20
Altered mental status†	+60
Arterial oxygen saturation < 90%*	+20

Add age+points

Severity classes

I. ≤65

II. 66–85

III.86–10

IV.106–125

V. > 125

1. Donze J, Le Gal G, Fine MJ, Roy PM, Sanchez O, Verschuren F, Cornuz J, Meyer G, Perrier A, Righini M, Aujesky D. Prospective validation of the Pulmonary Embolism Severity Index. A clinical prognostic model for pulmonary embolism. Thromb Haemost. 2008;100(5):943-948

PESI Scores and Mortality

PESI Class	Mortality
I	0 - 1.6%
II	2.0% - 3.5%
III	6.5% - 7.7%
IV	10.4% - 12.2%
V	17.9% - 24.5%

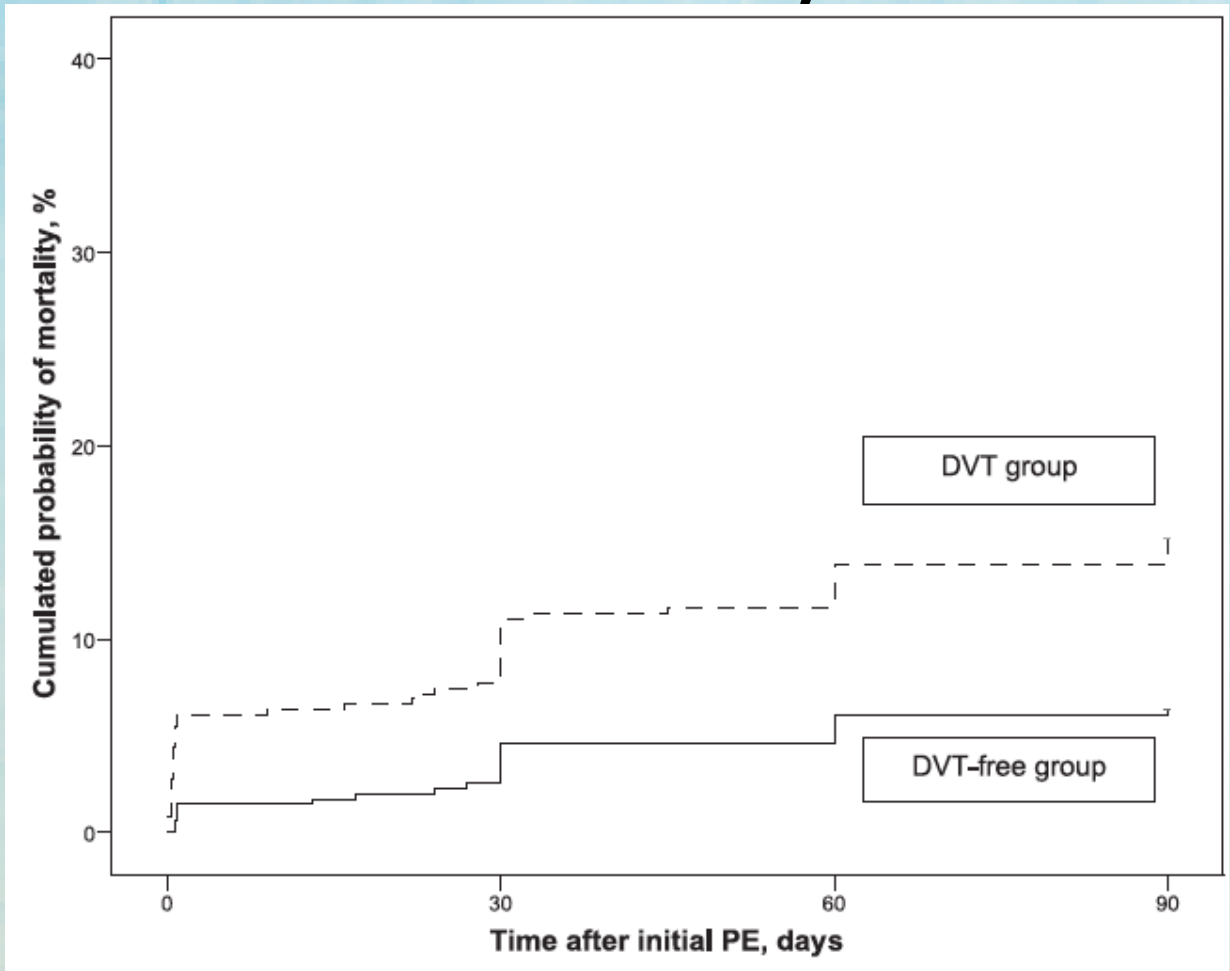
1. Donze J, Le Gal G, Fine MJ, Roy PM, Sanchez O, Verschuren F, Cornuz J, Meyer G, Perrier A, Righini M, Aujesky D. Prospective validation of the Pulmonary Embolism Severity Index. A clinical prognostic model for pulmonary embolism. Thromb Haemost. 2008;100(5):943-948

Other prognostic factors

- Co-existing DVT[1]
  - Positive US: hazard ratio of 2.0
- Right ventricular strain[2]
  - Echocardiography or CT: RR 2.4 (95% CI 1.3-4.4)
  - BNP: RR of 9.5 (95% CI 3.2-28.6)
  - Pro-BNP RR 5.7 (95% CI 2.2-15.1)
  - Troponin: RR 8.3 (95% CI 3.6-19.3)

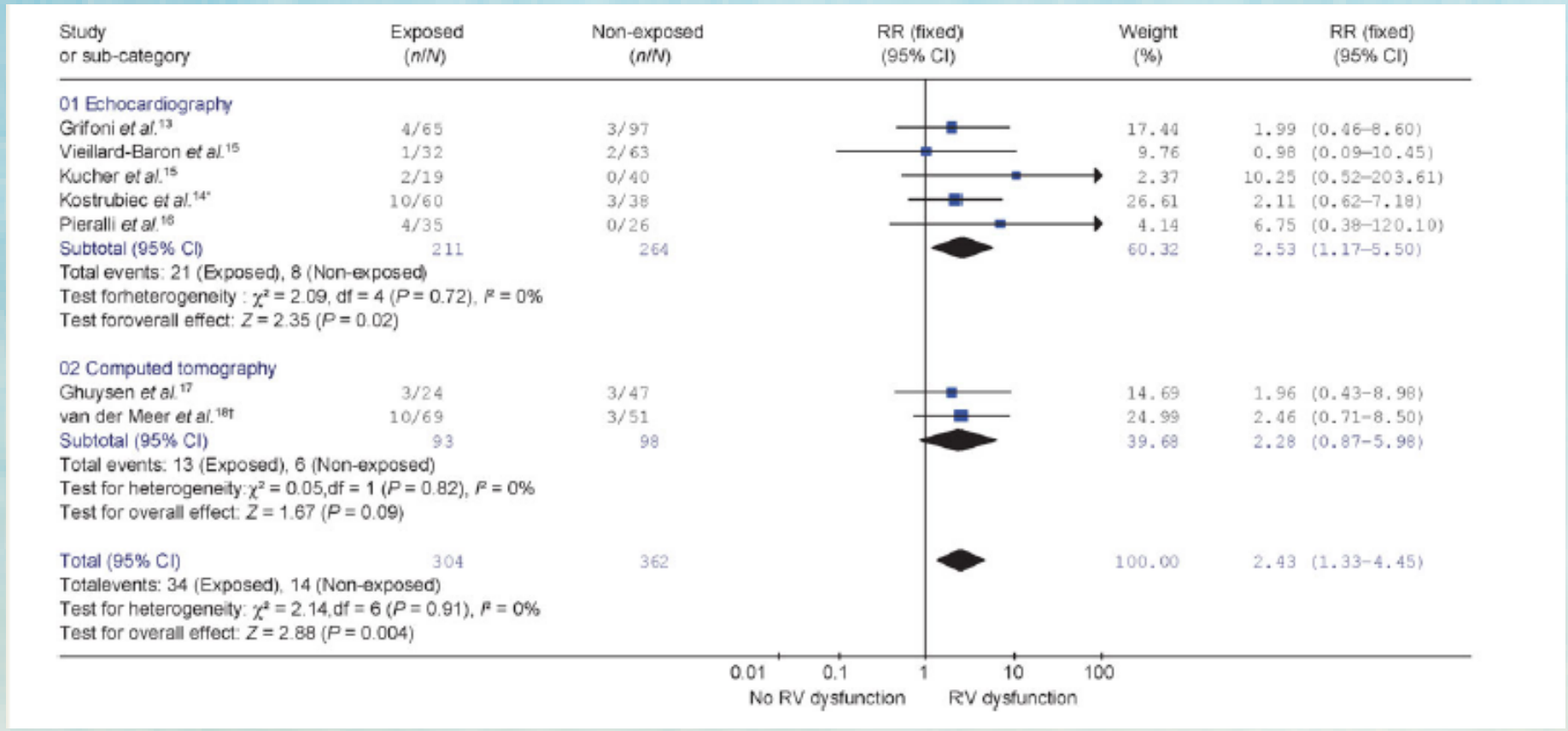
1. Jimenez D, Aujesky D, Diaz G, Monreal M, Otero R, Marti D, Marin E, Aracil E, Sueiro A, Yusen RD. Prognostic significance of deep vein thrombosis in patients presenting with acute symptomatic pulmonary embolism. *Am J Respir Crit Care Med.* 2010;181(9):983-991.
2. Sanchez O, Trinquart L, Colombet I, Durieux P, Huisman MV, Chatellier G, Meyer G. Prognostic value of right ventricular dysfunction in patients with haemodynamically stable pulmonary embolism: a systematic review. *Eur Heart J.* 2008;29(12): 1569-1577.

DVT increases mortality from acute PE



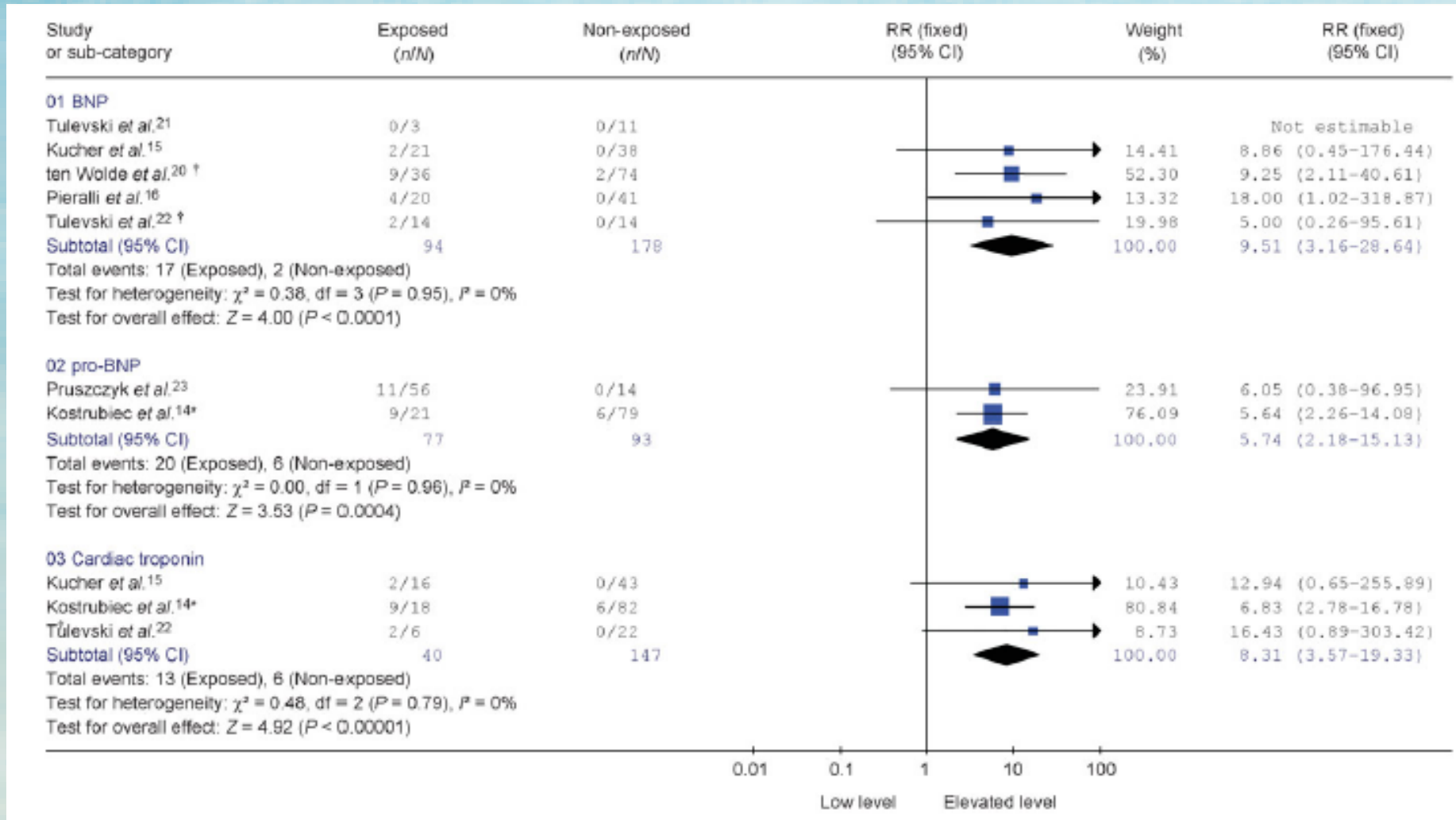
Jimenez D, Aujesky D, Diaz G, Monreal M, Otero R, Marti D, Marin E, Aracil E, Sueiro A, Yusen RD. Prognostic significance of deep vein thrombosis in patients presenting with acute symptomatic pulmonary embolism. *Am J Respir Crit Care Med.* 2010;181(9):983-991.

Large RV is associated with mortality



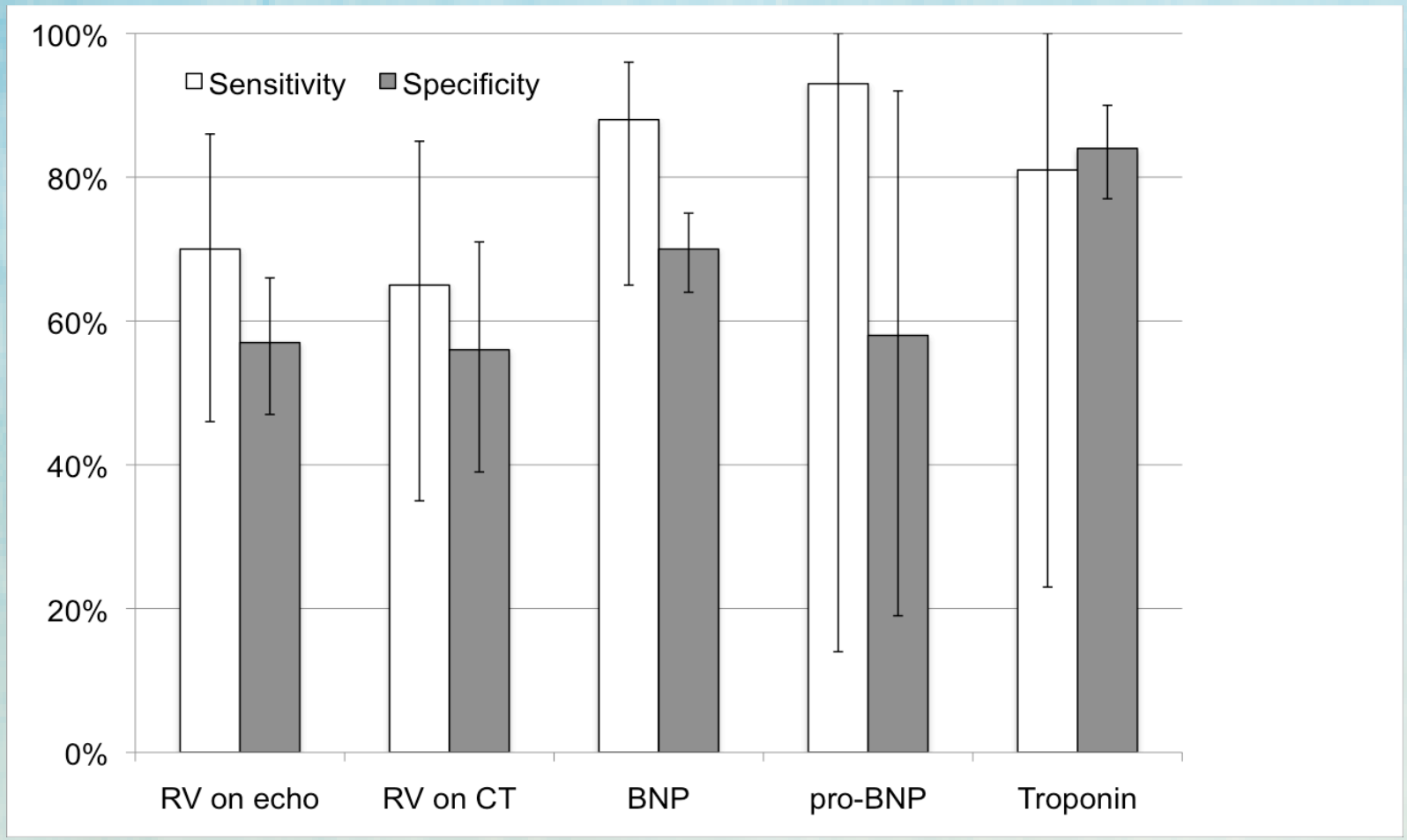
Sanchez O, Trinquart L, Colombet I, Durieux P, Huisman MV, Chatellier G, Meyer G. Prognostic value of right ventricular dysfunction in patients with haemodynamically stable pulmonary embolism: a systematic review. *Eur Heart J.* 2008;29(12):1569-1577.

Cardiac markers are associated with mortality



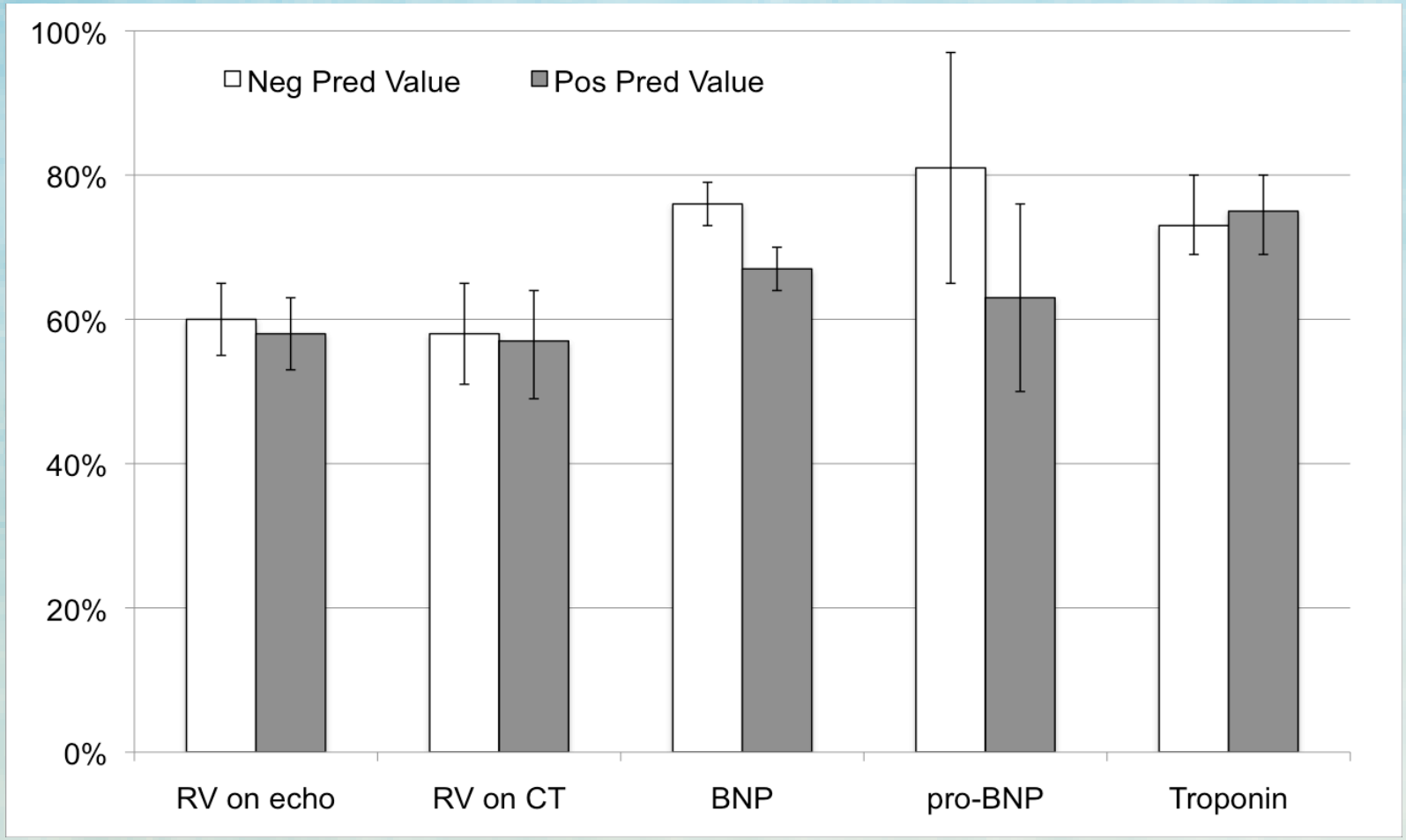
Sanchez O, Trinquart L, Colombet I, Durieux P, Huisman MV, Chatellier G, Meyer G. Prognostic value of right ventricular dysfunction in patients with haemodynamically stable pulmonary embolism: a systematic review. *Eur Heart J.* 2008;29(12):1569-1577.

Neither is that accurate



Sanchez O, Trinquart L, Colombet I, Durieux P, Huisman MV, Chatellier G, Meyer G. Prognostic value of right ventricular dysfunction in patients with haemodynamically stable pulmonary embolism: a systematic review. Eur Heart J. 2008;29(12):1569-1577.

Neither is that predictive



Sanchez O, Trinquart L, Colombet I, Durieux P, Huisman MV, Chatellier G, Meyer G. Prognostic value of right ventricular dysfunction in patients with haemodynamically stable pulmonary embolism: a systematic review. Eur Heart J. 2008;29(12):1569-1577.

Is that enough to change your therapy?

Summary

- Clinical decision rules to screen out “low prob” pts
- Low D-dimer adds sensitivity
- CTPA or VQ for Imaging
- Consider SPECT VQ
- Risk stratification can identify lower risk patients
- NONE OF THIS IS A SUBSTITUTE FOR GOOD JUDGEMENT