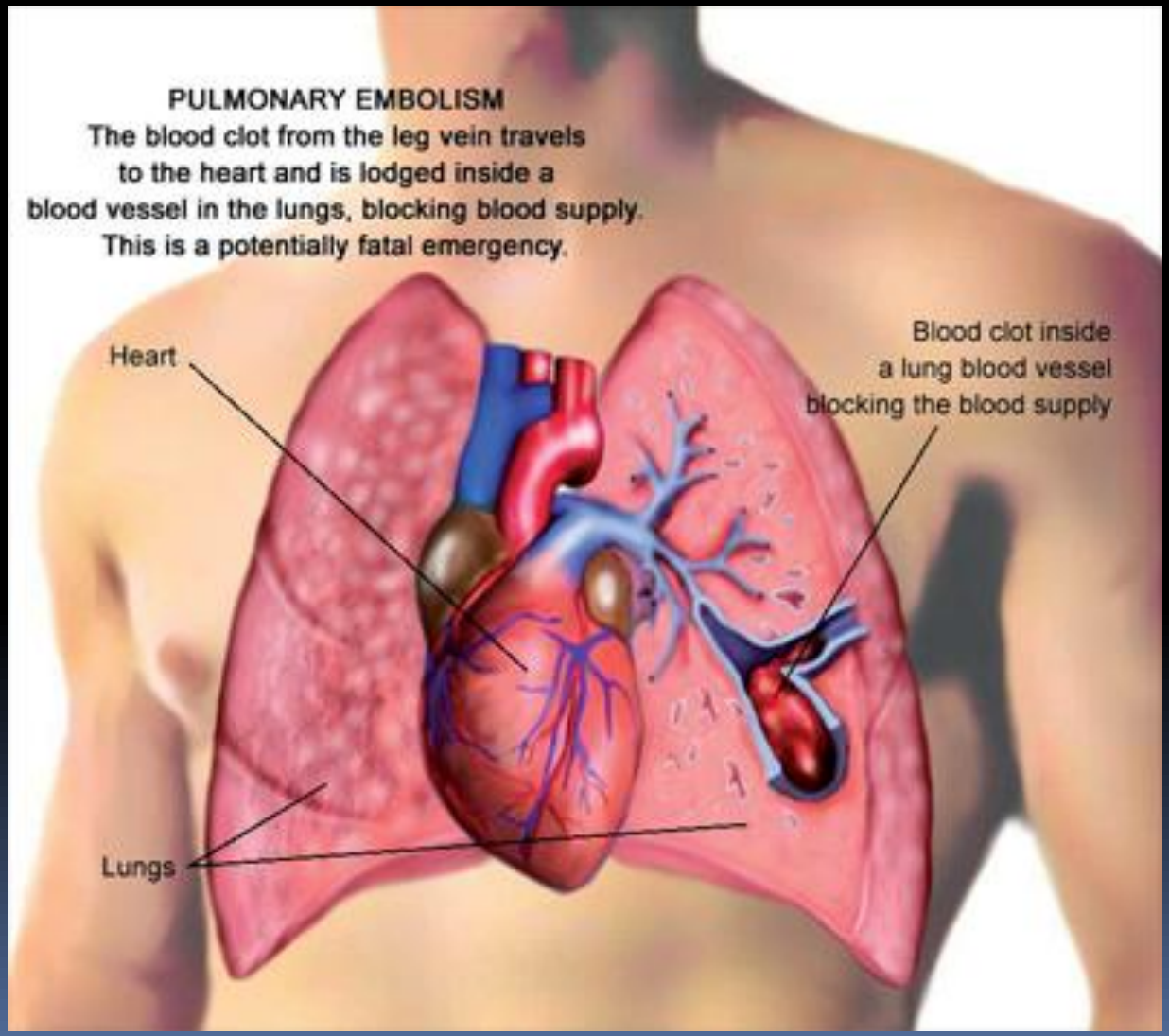
Chen Low
Specialist Registrar in Nuclear Medicine
City Hospital, Birmingham, UK

V/Q VERSUS THE REST. THE PLACE OF V/Q SCANS IN CLINICAL PATHWAYS

What is a Pulmonary Embolus?



Background

- Incidence estimated at 100 cases per 100,000 person years
- International Cooperative Embolism Registry showed the 3-month overall mortality rate was 15%
- Therefore, early diagnosis is required to reduce morbidity and mortality.

Bajc et al, EJNMMI 2009

Diagnosis

- Clinical signs, symptoms and routine laboratory tests do not allow the exclusion or confirmation of acute PE but increase the index of its suspicion.

- Clinical evaluation makes it possible to classify patients into probability categories corresponding to an increasing prevalence of PE.

ESC Guidelines 2008

Table 7 Clinical prediction rules for PE: the Wells score and the revised Geneva score

Revised Geneva score[64]	
Variable	**Points**
Predisposing factors	
Age >65 years	+1
Previous DVT or PE	+3
Surgery or fracture within 1 month	+2
Active malignancy	+2
Symptoms	
Unilateral lower limb pain	+3
Haemoptysis	+2
Clinical signs	
Heart rate	
75–94 beats/min	+3
≥95 beats/min	+5
Pain on lower limb deep vein at palpation and unilateral oedema	+4
Clinical probability	**Total**
Low	0–3
Intermediate	4–10
High	≥11

Wells score[65]	
Variable	**Points**
Predisposing factors	
Previous DVT or PE	+1.5
Recent surgery or immobilization	+1.5
Cancer	+1
Symptoms	
Haemoptysis	+1
Clinical signs	
Heart rate	
>100 beats/min	+1.5
Clinical signs of DVT	+3
Clinical judgement	
Alternative diagnosis less likely than PE	+3
Clinical probability (3 levels)	**Total**
Low	0–1
Intermediate	2–6
High	≥7
Clinical probability (2 levels)	
PE unlikely	0–4
PE likely	>4

Summary of recommendations

Clinical

- All patients with possible PE should have clinical probability assessed and documented. [C]
- An alternative clinical explanation should always be considered at presentation and sought when PE is excluded. [C]

D-dimer

- Blood D-dimer assay should only be considered following assessment of clinical probability. [B]
- D-dimer assay should not be performed in those with high clinical probability of PE. [B]
- A negative D-dimer test reliably excludes PE in patients with low (SimpliRED, Vidas, MDA) or intermediate (Vidas, MDA) clinical probability; such patients do not require imaging for VTE. [B]
- Each hospital should provide information on sensitivity and specificity of its D-dimer test. [C]

Imaging

- CTPA is now the recommended initial lung imaging modality for non-massive PE. [B]
- Patients with a good quality negative CTPA do not require further investigation or treatment for PE. [A]
- Isotope lung scanning may be considered as the initial imaging investigation providing (a) facilities are available on site, *and* (b) chest radiograph is normal, *and* (c) there is no significant symptomatic concurrent cardiopulmonary disease, *and* (d) standardised reporting criteria are used, *and* (e) a non-diagnostic result is always followed by further imaging. [B]
- Where isotope lung scanning is normal, PE is reliably excluded [B] but a significant minority of high probability results are false positive. [B]
- In patients with coexisting clinical DVT, leg ultrasound as the initial imaging test is often sufficient to confirm VTE. [B]
- A single normal leg ultrasound should not be relied on for exclusion of subclinical DVT. [B]

British Thoracic Society Standards of Care Committee Pulmonary Embolism Guideline Development Group*

Thorax 2003;**58**:470–484

- Heparin should be given to patients with intermediate or high clinical probability before imaging. [C]
- Unfractionated heparin (UFH) should be considered (a) as a first dose bolus, (b) in massive PE, or (c) where rapid reversal of effect may be needed. [C]
- Otherwise, low molecular weight heparin (LMWH) should be considered as preferable to UFH, having equal efficacy and safety and being easier to use. [A]
- Oral anticoagulation should only be commenced once VTE has been reliably confirmed. [C]
- The target INR should be 2.0–3.0; when this is achieved, heparin can be discontinued. [A]
- The standard duration of oral anticoagulation is: 4–6 weeks for temporary risk factors [A], 3 months for first idiopathic [A], and at least 6 months for other [C]; the risk of bleeding should be balanced with that of further VTE. [C]

Other

- Imaging should be performed within 1 hour in massive PE, and ideally within 24 hours in non-massive PE. [C]
- Testing for thrombophilia should be considered in patients aged under 50 with recurrent PE or in those with a strong family history of proven VTE. [C]
- Investigations for occult cancer are only indicated in idiopathic VTE when it is suspected clinically, on chest radiography, or on routine blood tests. [C]
- Current organisation for outpatient management of DVT should be extended to include stable patients with PE. [C]

A United Kingdom based survey of clinical practice in the diagnosis of suspected pulmonary embolism

Vidhiya Vinayakamoorthy, Susan Geary and Rakesh Ganatra

Nuclear Medicine Communications 2010, 31:112–120

- 101/249 (41%) responded

Table 2 Relative use of each imaging modality in the diagnosis of PE

Imaging modality used	V/Q >75%	V/Q and CTPA used between 25 and 75%	CTPA used >75%
Number of centres	17	54	17

CTPA, computed tomography pulmonary angiography; PE, pulmonary embolism; V/Q, ventilation/perfusion.

  - 2 Krypton and Technegas
  - 1 Krypton and DTPA aerosol

- 17 centres used only perfusion imaging

Vinayakamoorthy et al. 2010

Ventilation/Perfusion (V/Q) Scintigraphy

- Started with ^{131}I-labelled MAA about 4 decades ago.
- 1970s – ^{99m}Tc-labelled MAA with addition of ^{133}Xe.
- Subsequent introduction of ^{81m}Kr and ^{99m}Tc-DTPA aerosols for ventilation.

V/Q planar

- Normal or very low probability planar VQ scintigraphy effectively excludes PE
- High probability scans establishes the diagnosis of PE
- Well-validated from numerous studies including PIOPED II

Problems with Planar V/Q

- PIOPED criteria – indeterminate results and different probability classifications
- Limited by 2-D imaging
  - Overlap of anatomical segments
  - 'Shine-through' from underlying lung segments
  - Difficulties in visualising all lung segments
- Usually non-diagnostic when chest X-ray is abnormal
- Difficult to interpret in patients with chronic heart and lung disease

CTPA

- PIOPED II showed
  - Sensitivity = 83%
  - Specificity = 96%
  - PPV = 86%
    - Proximal – 97%
    - Segmental – 68%
    - Subsegmental – 25%
  - NPV = 95%
- Value of CTPA varied
  - High or intermediate clinical probability, PPV = 96%
  - Low clinical probability, 42% false positive rate

LeBlanc et al, 2010

SPECT V/Q - Accuracy

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 [illegible]	^{99m}Tc-DTPA	Not done	Not do	18/2		Consecutive suspected PE
Bajc (*30*)	CT angio	[illegible]	[illegible]	[illegible]	76 (			secutive suspected PE
Bajc (*30*)	Consensus, SPECT CT angio	[illegible] mismatch = PE	[illegible]	[illegible]	1,153/1			secutive 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, [illegible]	Reader A, 37/40 (93%) Reader 37/3		Yes	51 suspected PE 2 treated PE
Hata (*32*)	CT angio if high o inter SPECT	[illegible]	[illegible]	[illegible]	do	4/8 (5		creening after cancer surgery
Lemb (*31*)	SPECT better, new or normalized = SPECT unchang	[illegible]	Tec	[illegible]	9 (9			eferred for suspected PE

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

Sensitivities = 80-100%

Specificities = 93-100%

Stein et al, 2009

SPECT V/Q – Comparison with planar VQ

- SPECT VQ gave more precise information about the site and extent of disease.
- SPECT VQ showed mismatches, particularly sub-segmental mismatches more clearly
- SPECT VQ has a higher sensitivity

SPECT V/Q – Comparison with CTPA

- Reinazt et al and Gutte at al both showed better sensitivity for SPECT VQ while CTPA had greater specificity.
- SPECT VQ is more sensitive owing to the better visualisation of sub-segmental emboli.
- CTPA has a higher specificity due to direct visualisation of intraluminal clots and less prone to conditions that mimic embolism.

Strengths and Weaknesses

Table 1 Summary of Advantages and Limitations of CTPA and V/Q SPECT

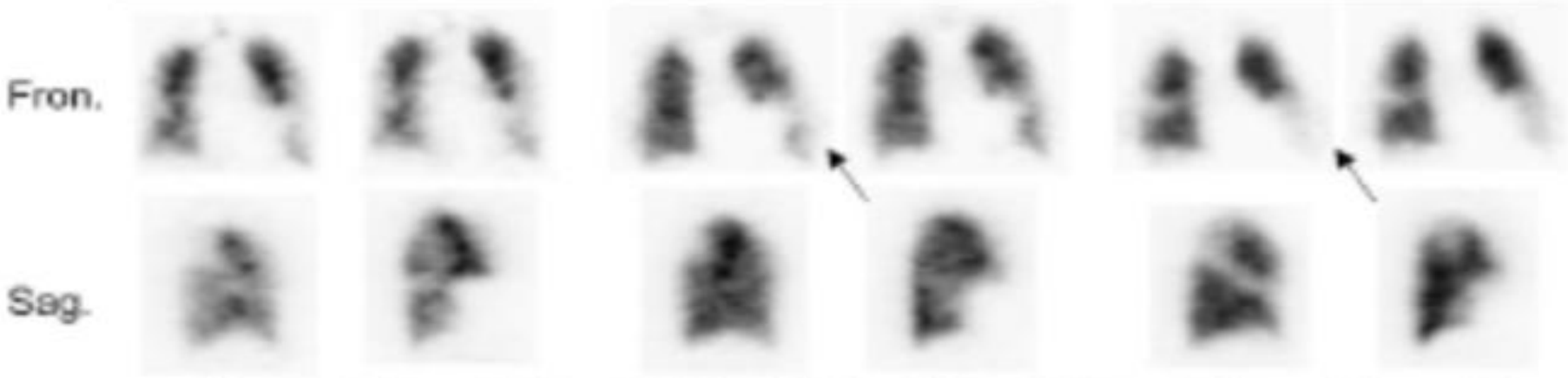
	CTPA	V/Q SPECT
Radiation dose	Higher	Lower
Availability	Better availability out of hours	Less available out of hours
Possible allergies	Yes	No
Contrast induced nephropathy	Yes	No
Useful alternate diagnosis	Yes, frequent	Infrequent
Nonrelated incidental findings requiring follow-up	Yes, frequent	Rare or nonexistent
Sensitivity	May be lower	May be higher
Specificity	May be higher	May be lower
Accuracy with abnormal X-ray	Unaffected	Affected in selected cases
Accuracy in pregnancy	Strongly affected	Unaffected
Accuracy in chronic PE	Low	High
Ease of follow-up	More difficult, with higher radiation dose	Easier, with lower radiation dose
Performance in COPD	Probably not affected	May be affected in very severe cases
Technical failure rate	Higher	Lower

COPD, chronic obstructive pulmonary disease; CTPA; computed tomography pulmonary angiography; PE, pulmonary embolism; V/Q SPECT, ventilation/perfusion single-photon emission computed tomography.

TABLE 3. Diagnostic Performance of the Imaging Modalities

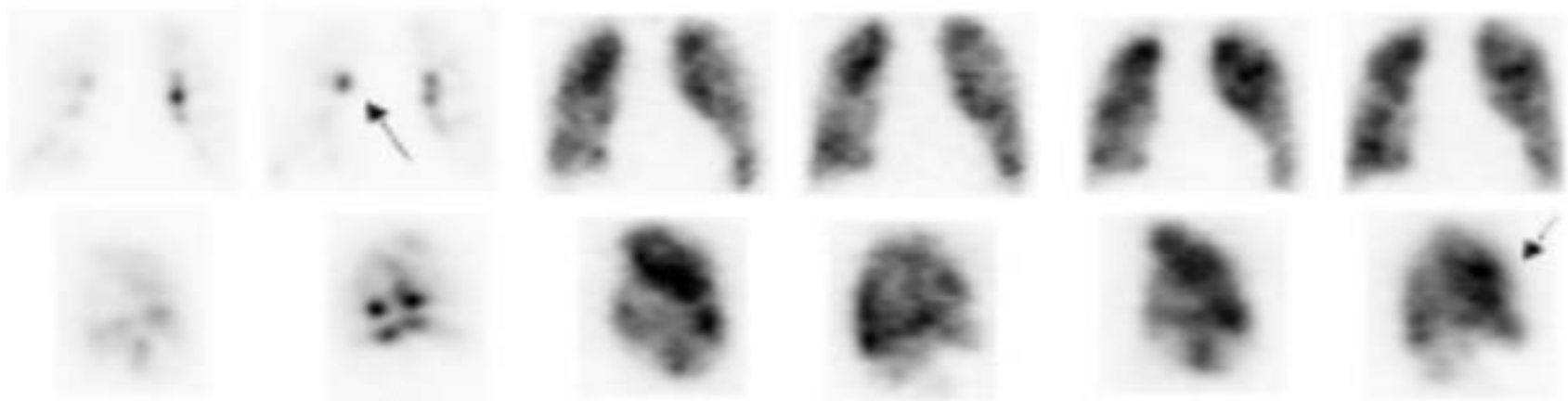
Modality	Performance
V/Q SPECT	
Sensitivity (%)	97 (82–100)
Specificity (%)	88 (75–95)
PPV (%)	82 (65–93)
NPV (%)	98 (88–100)
Accuracy (%)	91 (83–93)
Nondiagnostic rate (%)	5 (1–12)
V/Q SPECT plus low-dose CT	
Sensitivity (%)	97 (83–99)
Specificity (%)	100 (93–100)
PPV (%)	100 (88–100)
NPV (%)	98 (90–100)
Accuracy (%)	99 (93–100)
Nondiagnostic rate (%)	0 (0–4)
Perfusion SPECT plus low-dose CT	
Sensitivity (%)	93 (81–98)
Specificity (%)	51 (43–55)
PPV (%)	57 (49–60)
NPV (%)	91 (76–98)
Accuracy (%)	68 (58–72)
Nondiagnostic rate (%)	17 (10–28)
Pulmonary MDCT angiography	
Sensitivity (%)	68 (49–83)
Specificity (%)	100 (93–100)
PPV (%)	100 (84–100)
NPV (%)	83 (71–92)
Accuracy (%)	88 (78–94)
Nondiagnostic rate (%)	0 (0–4)

A



	Uneven (0-10 u)	C Dep (0-10 u)	FP Dep (0-10 u)	Tot Red (%)	Match (%)	Miam (%)	R Miam (%)	Obstr (degree)	PE (%)	HF (0/1)
DTPA	6.5	4	2	57.5	35	0	22.5	2.5	0	0
Techn	3	2.5	2	32.5	12.5	20	0	1	12.5	0

B



	Uneven (0-10 u)	C Dep (0-10 u)	FP Dep (0-10 u)	Tot Red (%)	Match (%)	Miam (%)	R Miam (%)	Obstr (degree)	PE (%)	HF (0/1)
DTPA	7.5	9.5	0	60	15	0	45	3	0 (?)	1
Techn	5	2.5	2	37.5	25	5	7.5	2	0	1

CLINICAL INVESTIGATIONS

Technegas Versus ^{81m}Kr Ventilation–Perfusion Scintigraphy: A Comparative Study in Patients with Suspected Acute Pulmonary Embolism

Ieneke J.C. Hartmann, Petronella J. Hagen, Marcel P.M. Stokkel, Otto S. Hoekstra, and Martin H. Prins for the ANTELOPE Study Group

- good agreement (k, 0.68) as well as comparable inter- and intraobserver variation.
- the use of technegas increases the number of nondiagnostic and technically inadequate V/Q lung scan results
- Technegas ventilation failed because of severe illness in 8 of 53 patients (15%) while ^{81m}Kr ventilation could not be performed in only one of these 8 patients.

Eur J Nucl Med Mol Imaging (2009) 36:1356–1370
DOI 10.1007/s00259-009-1170-5

GUIDELINES

EANM guidelines for ventilation/perfusion scintigraphy

Part 1. Pulmonary imaging with ventilation/perfusion single photon emission tomography

M. Bajc · J. B. Neilly · M. Miniati · C. Schuemichen · M. Meignan · B. Jonson

Eur J Nucl Med Mol Imaging (2009) 36:1528–1538
DOI 10.1007/s00259-009-1169-y

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EANM guidelines for ventilation/perfusion scintigraphy

Part 2. Algorithms and clinical considerations for diagnosis of pulmonary emboli with V/P_{SPECT} and MDCT

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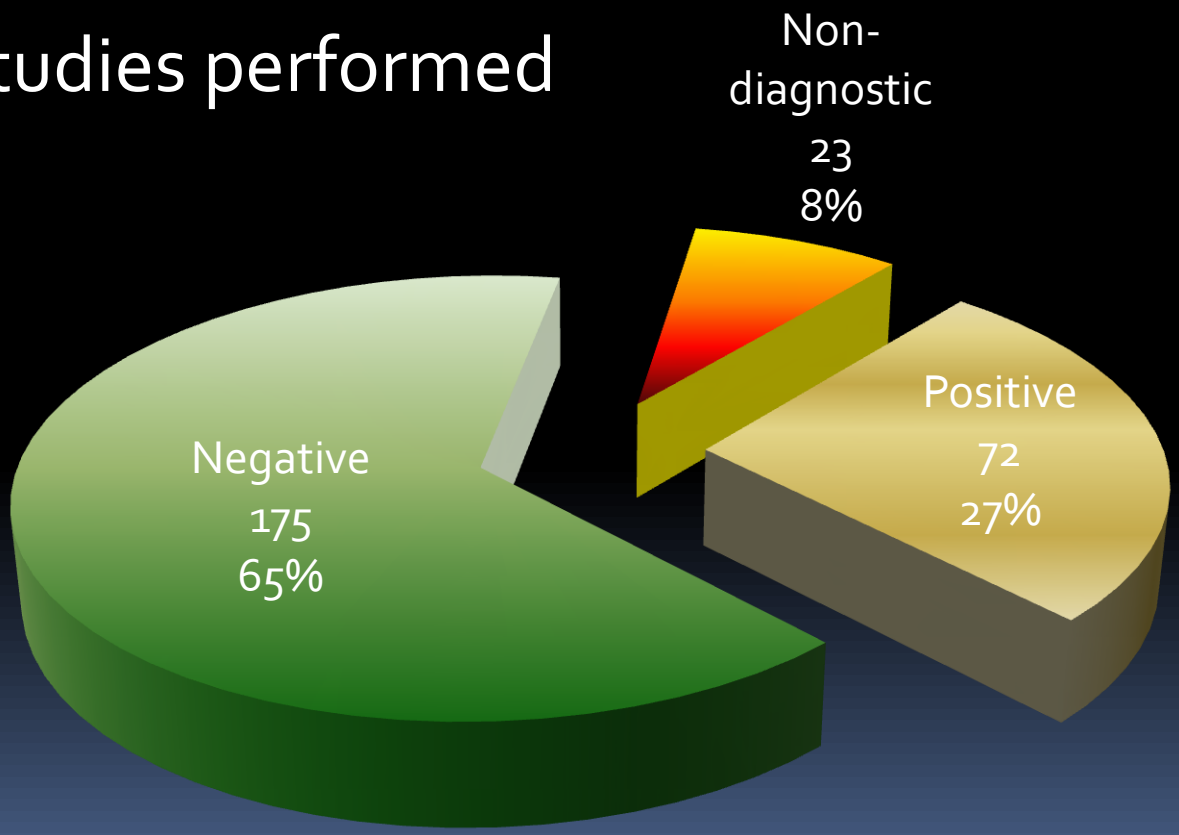
Table 6 Key recommendations for the use of ventilation scintigraphy in PE imaging

Recommendation	Level		Grade
A ventilation study should be done to support the perfusion scan in all patients with suspected PE, except during the first trimester of pregnancy	Ib		A
^{81m}Kr is t ^{81m}Kr is the radioactive gas of choice, when available, being a true gas and allowing simultaneous acquisition with the perfusion images	III	B	B
Radiolabelled aerosols with documented particle size and distribution pattern are recommended on the basis of their widespread availability	III		B
^{99m}Tc-Technegas is the agent of choice in the presence of obstructive lung disease	III		B
^{99m}Tc-DTPA aerosol is the agent of choice when ^{99m}Tc-Technegas is not available	III		B

SPECT VQ – Our Experience

- June 2010 – March 2011
- 270 studies performed



Non-Diagnostic SPECT VQ

- 4 had only SPECT perfusion as not able to tolerate ^{81m}Krypton gas
- 16/23 had CTPA
  - 14 had no PE
  - 2 had PE
- 6 patients did not have CTPA as a follow-up:
  - Main reason for not having CTPA is renal dysfunction.
  - 5/6 patients were treated with anticoagulation as high risk.
  - 1 patient was already on anticoagulation for atrial fibrillation
- 1 patient had no follow-up details as it was a external hospital referral.

Conclusion

- SPECT VQ with ^{81m}Kr is a fast and rapid technique as simultaneous dual acquisition is possible.
- SPECT VQ has proven to produce similar accuracy to CTPA.
- SPECT VQ should be recommended as the first line diagnostic investigation for suspected stable acute or chronic PE.