Reporting Guidelines For V/Q Studies

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Disclosure

None

Acknowledgments

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Educational Objectives

- To review and understand recommendations of national and international groups
- To understand the nature of communication between nuclear medicine physicians and clinicians with respect to lung scanning
- To appreciate the limitations of probabalistic interpretation of lung scanning

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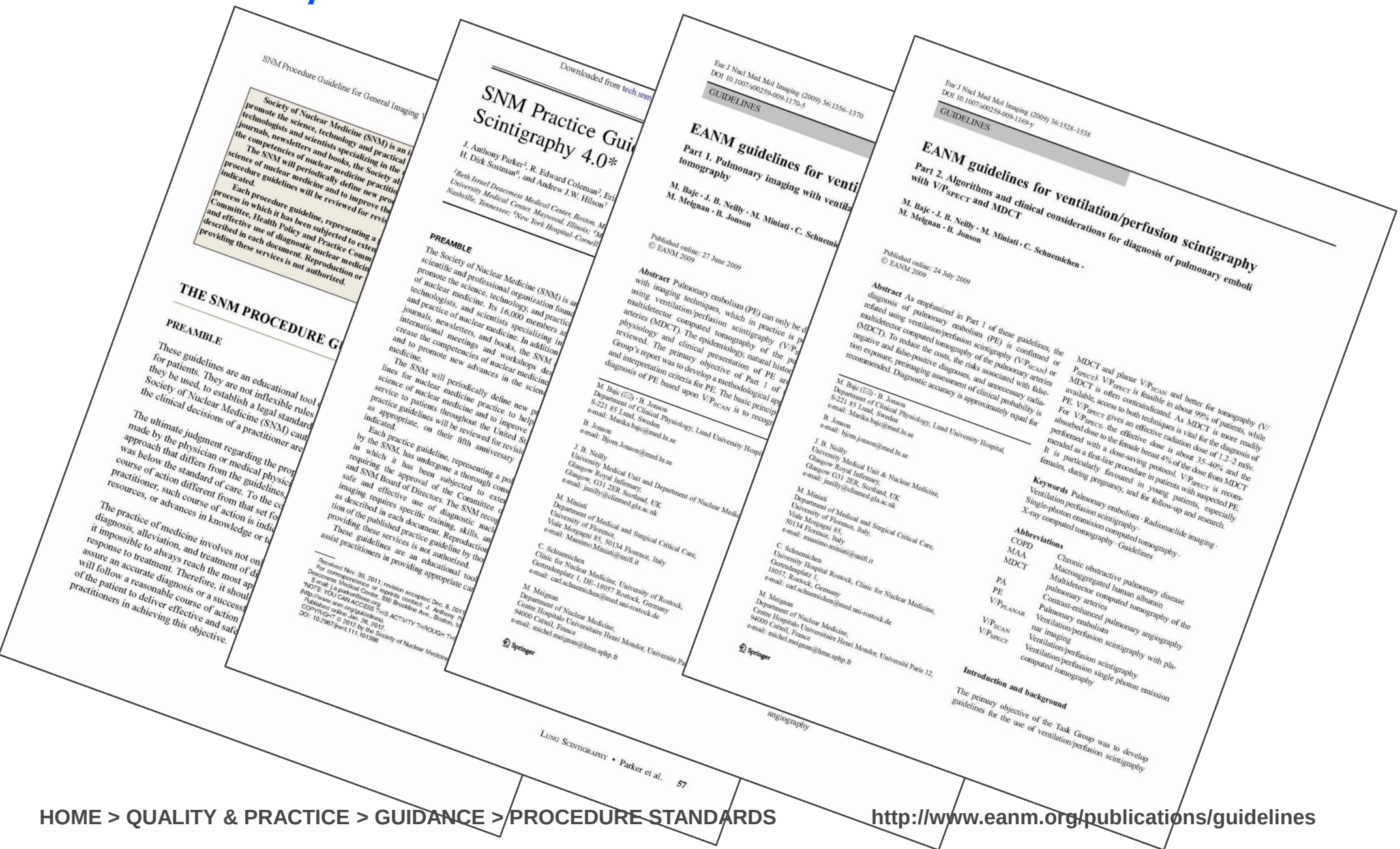
SNM/EANM Practice Guidelines



SNM Procedure Guideline for General Imaging

THE SNM PROCEDURE G

PREAMBLE

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SNM Practice Guid
Scintigraphy 4.0*

PREAMBLE

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

GUIDELINES

EANM guidelines for venti

Part 1. Pulmonary imaging with ventila
tomography

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

GUIDELINES

EANM guidelines for ventilation/perfusion scintigraphy

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

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

Published online: 24 July 2009
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Abstract As emphasized in Part 1 of these guidelines, the diagnosis of pulmonary embolism (PE) is confirmed or refuted using ventilation/perfusion scintigraphy (V/P$_{SCAN}$) or multidetector computed tomography of the pulmonary arteries (MDCT). To reduce the costs, the risks associated with false-negative and false-positive diagnoses, and unnecessary radiation exposure, preimaging assessment of clinical probability is recommended. Diagnostic accuracy is approximately equal for MDCT and planar V/P$_{SCAN}$ and better for tomography (V/P$_{SPECT}$). V/P$_{SPECT}$ is feasible in about 99% of patients, while MDCT is often contraindicated. As MDCT is more readily available, access to both techniques is vital for the diagnosis of PE. V/P$_{SPECT}$ gives an effective radiation dose of 1.2–2 mSv. For V/P$_{SPECT}$ the effective dose is about 35–40% and the absorbed dose to the female breast 4% of the dose from MDCT performed with a dose-saving protocol. V/P$_{SPECT}$ is recommended as a first-line procedure in patients with suspected PE. It is particularly favoured in young patients, especially females, during pregnancy, and for follow-up and research.

Keywords Pulmonary embolism · Radionuclide imaging · Ventilation perfusion scintigraphy · Single-photon emmision computed tomography · X-ray computed tomography · Guidelines

Abbreviations

COPD	Chronic obstructive pulmonary disease
MAA	Macroaggregated human albumin
MDCT	Multidetector computed tomography of the pulmonary arteries
PA	Contrast-enhanced pulmonary angiography
PE	Pulmonary embolism
V/P$_{PLANAR}$	Ventilation/perfusion scintigraphy with planar imaging
V/P$_{SCAN}$	Ventilation/perfusion scintigraphy
V/P$_{SPECT}$	Ventilation/perfusion single photon emission computed tomography

Introduction and background

The primary objective of the Task Group was to develop guidelines for the use of ventilation/perfusion scintigraphy

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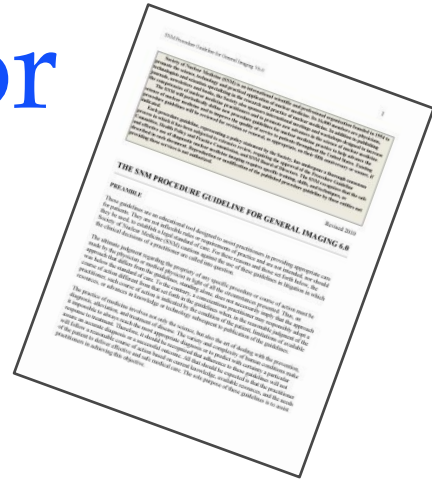

Goals of a Nuclear Medicine Report

- Provide the referring physician with a timely answer to the clinical question within the limits of the test
- Document the appropriateness, necessity and performance of the procedure
- Expedite and assure correct billing

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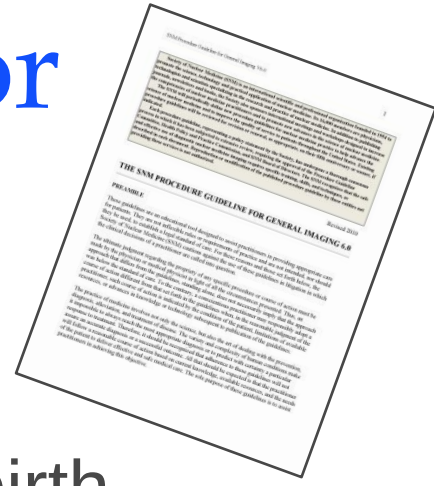

Study Identification

- Patient name and identifiers: gender, date of birth, medical record number, or universal patient code
- Health care providers such as the primary care physician
- Type of study
- Date of study; Time of study, if relevant
- Study accession number
- Completion dates and times

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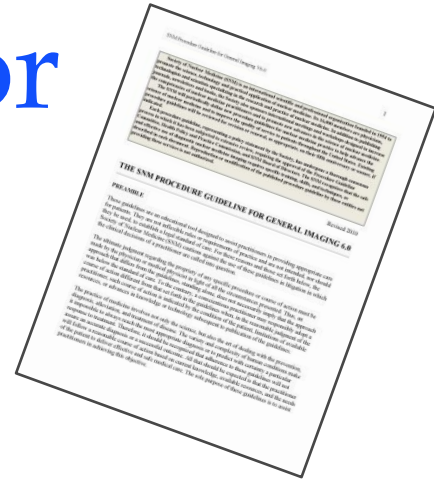

Clinical information

- Indication
- Other relevant history
- Information needed for billing
  - Insurance carriers may not accept phrases such as “rule out” or “possible.”
  - Diagnosis to the highest level of specificity known at the time of billing, or the pertinent symptom or sign

JNMT 40:57-65, 2012

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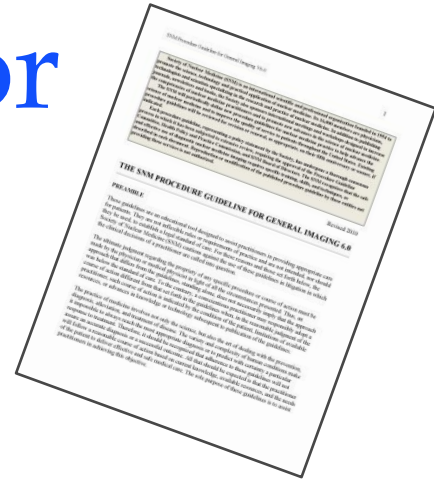

Procedure Description

- Radiopharmaceutical
- Administered dose; route of administration
- Timing of imaging relative to radiopharmaceutical administration
- Other drugs used
- Catheters or devices used
- Imaging technique, including alteration in normal procedure
- Complications or patient reactions

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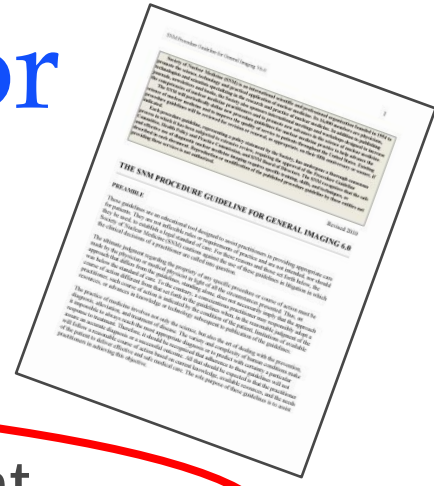
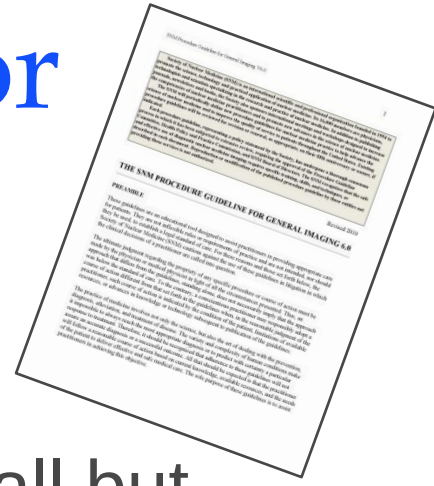


Description of findings

- Significant positive findings as well as pertinent negative findings should be mentioned.
- Image quality or other causes of study limitations
- Reference range may be useful for quantitative values.
- Correlation with other imaging studies should be documented; If other studies are not available for correlation, this should be mentioned in written report.
- See individual guidelines for specifics.

JNMT 40:57-65, 2012

SNM Practice Guideline for General Imaging 6.0



Impression

- A separate impression should be included for all but the shortest reports.
- The impression should address the clinical indication for the scan.
- Diagnoses, differential diagnoses and judgments about the significance of the pertinent findings may be included in the impression.

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SNM Practice Guideline for Lung Scintigraphy 4.0

SNM Practice Guideline for Lung Scintigraphy 4.0*

- The report may include an assessment of the post-test probability of PE based on the results of lung scintigraphy and an estimate of the prior probability of disease
- Many experts believe limiting reporting to 3 categories – PE present, PE absent and non-Dx – facilitates communication
- Some believe more accurate categorization provides more information to referring MDs.

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SNM Practice Guideline for Lung Scintigraphy 4.0

- Modified PIOPED criteria derived from retrospective analysis of PIOPED database, prospectively tested and better than original PIOPED criteria
- PIOPED II criteria modified using fewer categories in attempt to reduce non-Dx studies
- PIOPED II and PISAPED using information from CXR and perfusion scan equivalent to paradigms with ventilation scintigraphy, with fewer non-diagnostic studies.

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SNM Practice Guideline for Lung Scintigraphy 4.0

Ventilation, Perfusion, and Radiographic Interpretive Criteria for Pulmonary Embolism

PIOPED
High LR
>2 large mismatched (V:Q) segmental defects*
Borderline high LR
2 large mismatched (V:Q) segmental defects*
Intermediate LR
2 moderate or 1 large mismatched (V:Q) defect*
Difficult to categorize as high or low
Borderline low LR
1 matched (V:Q) defect, CXR-negative
Low LR
Nonsegmental perfusion defects†
Q defect substantially < CXR defect
Matched (V:Q) defects, CXR-negative
Any number of small Q defects*
Normal
No Q defects

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SNM Practice Guideline for Lung Scintigraphy 4.0

- The experienced NM physician may be able to provide a more accurate interpretation of VQ study than that provided by criteria alone.

- The physician's opinion is usually informed by detailed knowledge of stated criteria.

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EANM Guideline for Ventilation/ Perfusion Scintigraphy

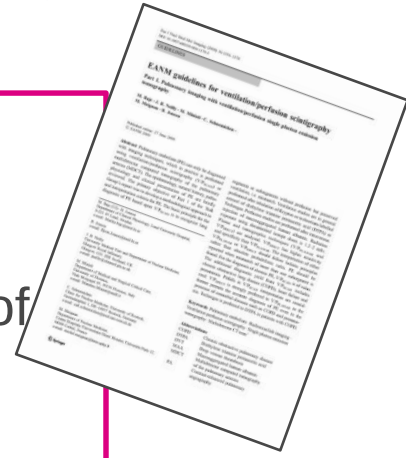
EANM guidelines for ventilation/perfusion scintigraphy

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

- SPECT preferred
- Basic criteria for reading the images
- Knowledge and experience of the interpreter i.e. ‘gestalt’
- Pretest probability in accordance with the principle of Holistic interpretation
- Probabalistic interpretation ‘impracticable’

EJNMMI 36:1356-70,2009

SPECT Interpretation Criteria



EANM Criteria

No PE is reported if there is (are):

- Normal perfusion pattern conforming to the anatomic boundaries of the lungs
- Matched or reversed mismatch V/P defects of any size, shape or number in the absence of mismatch
- Mismatch that does not have a lobar, segmental or subsegmental pattern

PE is reported if there is:

- V/P mismatch of at least one segment or two subsegments that conforms to the pulmonary vascular anatomy

Nondiagnostic for PE is reported if there are:

- Multiple V/P abnormalities not typical of specific diseases.

EJNMMI 36:1356-70,2009

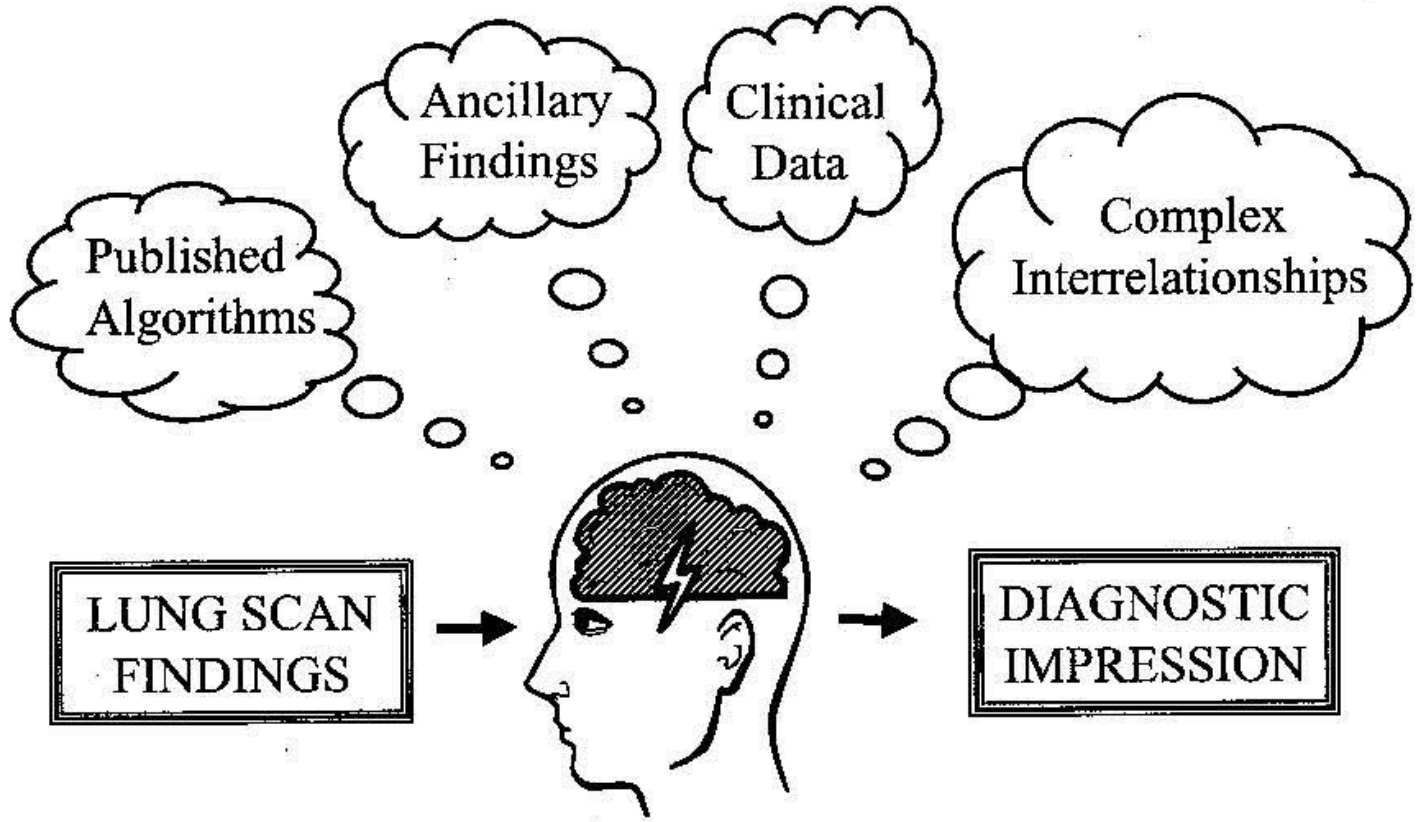
Gestalt interpretation

- Gestalt refers to the German school of psychology that describes perceptions as "...a system of phenomena so integrated as to constitute a functional unit with properties not derivable from its parts. “

- Gestalt interpretation refers to the expert‘s ability to successfully interpret lung scans exceeding the best accuracy achievable by algorithms, which, by definition, are distillations of decision making into finite linear steps.

Freeman, Krynyckyi & Zuckier
Seminars in Nuclear Medicine,31:143-157,2001

Gestalt interpretation

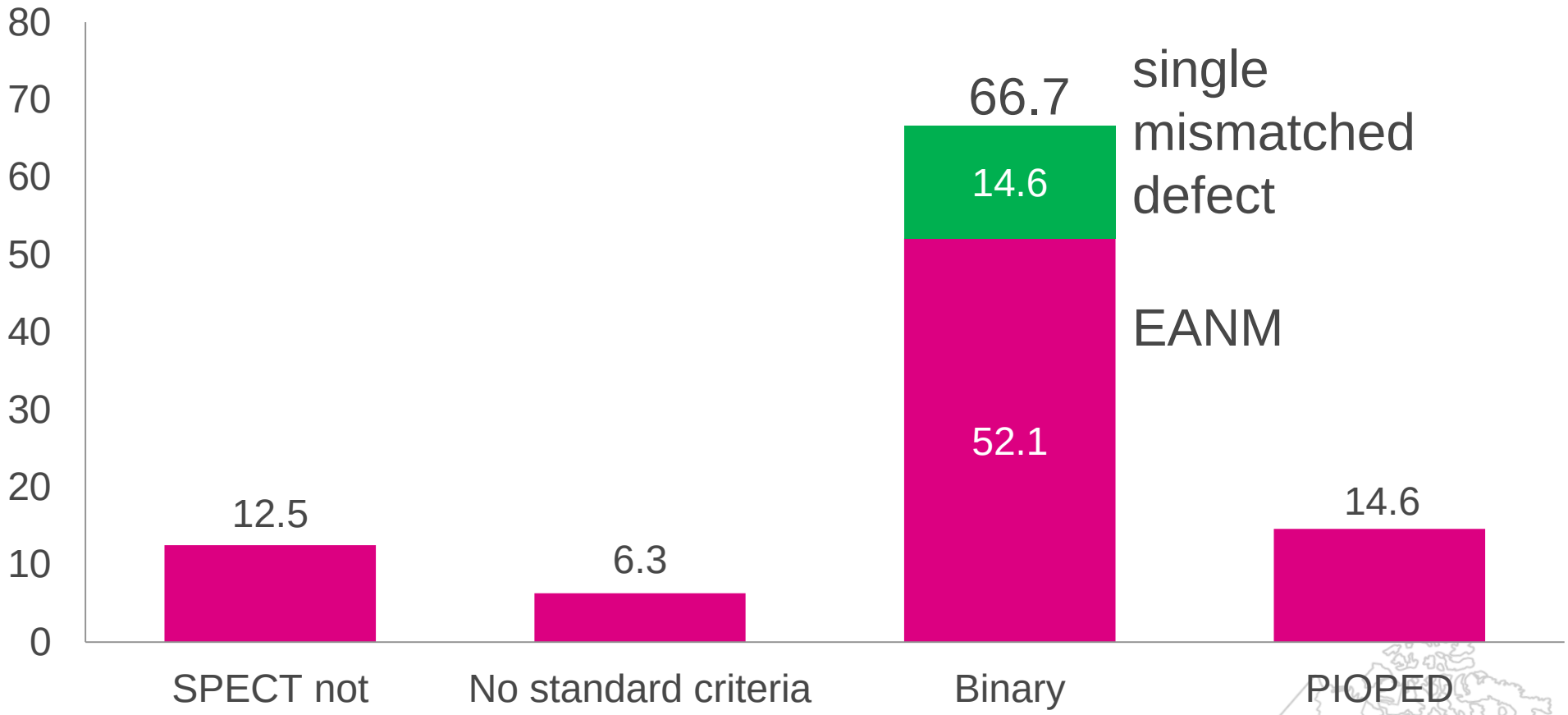


Freeman, Krynyckyi & Zuckier
Seminars in Nuclear Medicine,31:143-157,2001

What ventilation/perfusion SPECT diagnostic criteria do you use for suspicion of acute pulmonary embolism?

Matthieu Pelletier-Galarneau, MD MSc
University of Ottawa

SPECT Interpretation Criteria



Matthieu Pelletier-Galarneau, MD MSc
University of Ottawa

What ventilation/perfusion PLANAR scintigraphy diagnostic criteria do you use for suspicion of acute pulmonary embolism?

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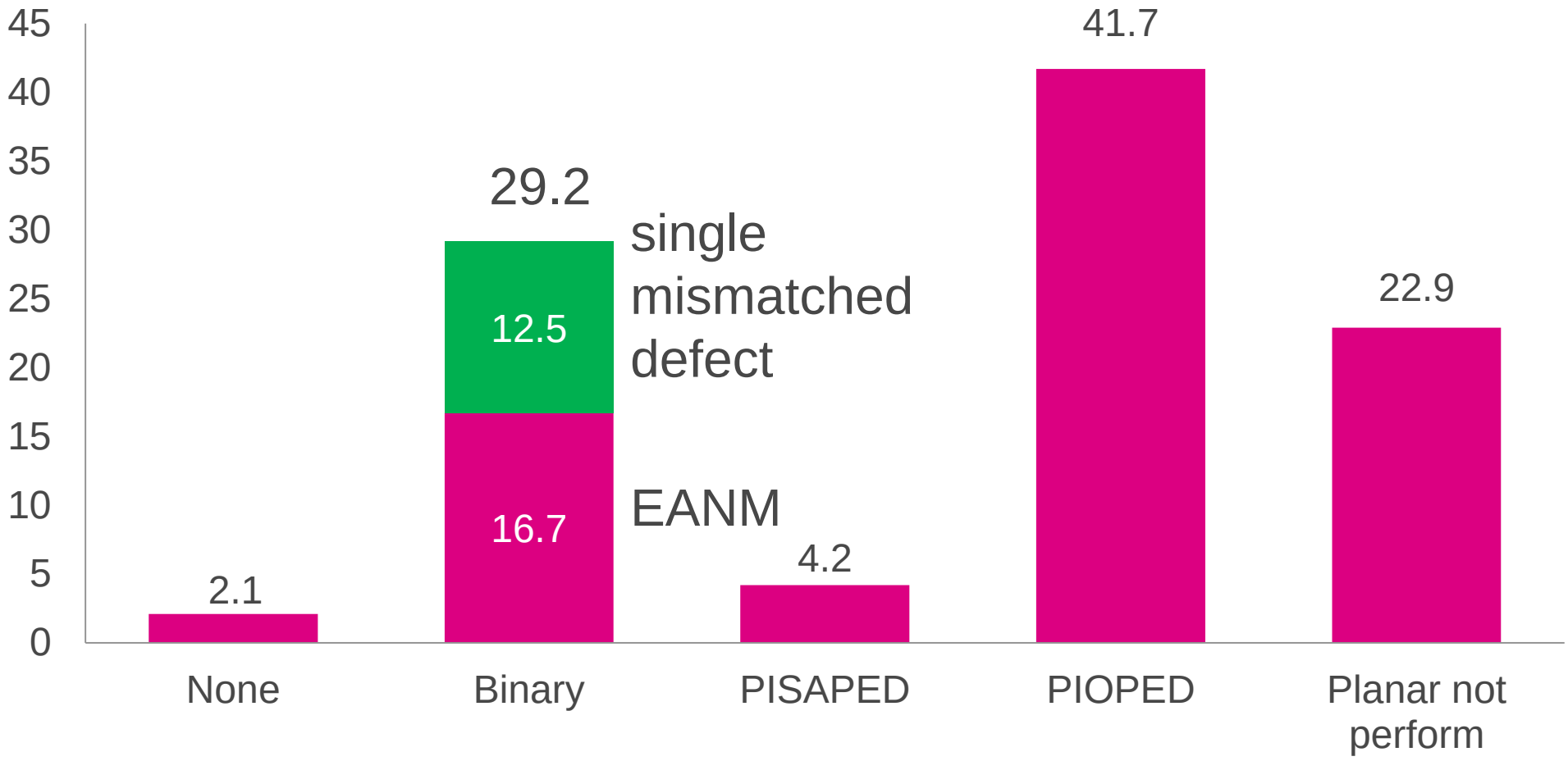
University of Ottawa

Planar Criteria



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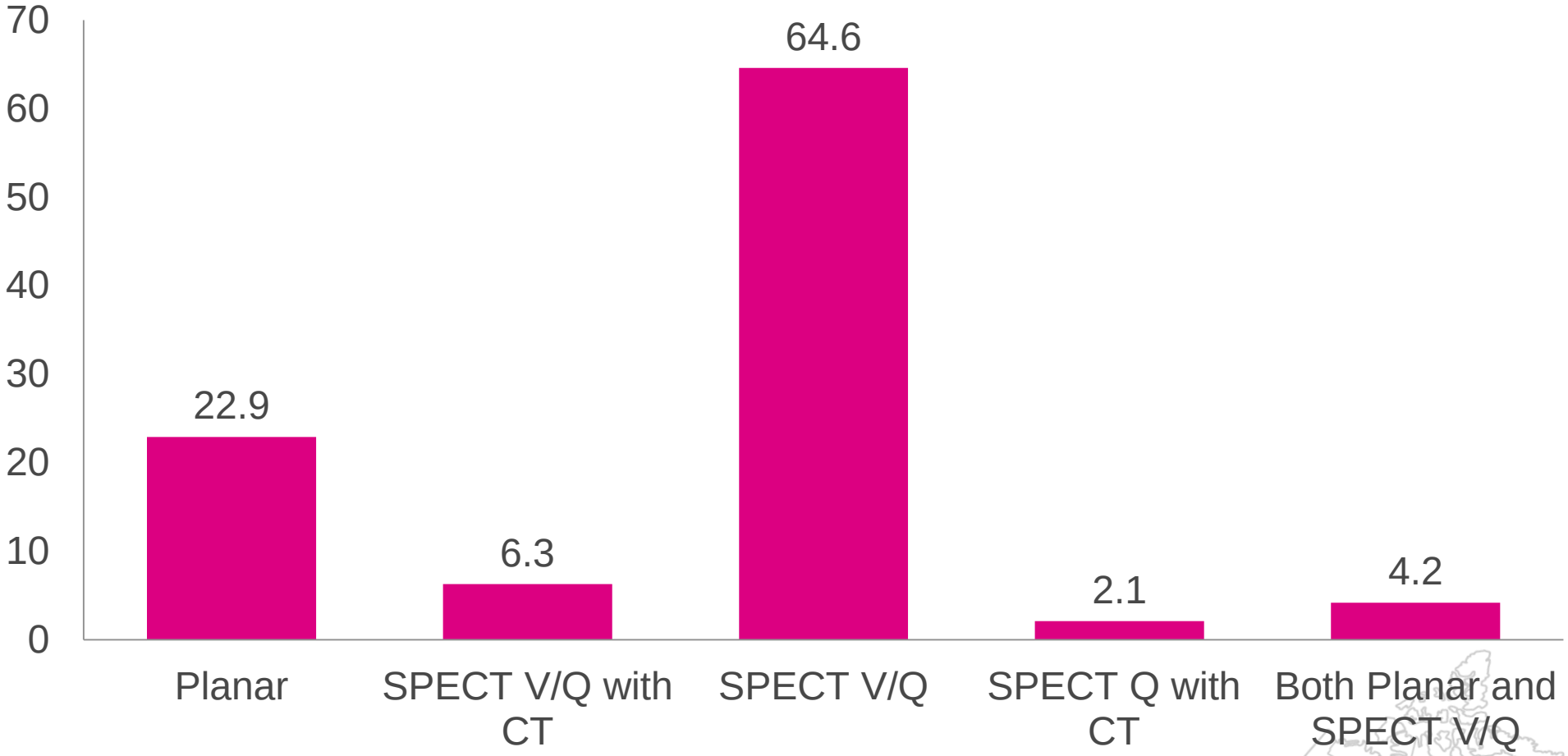
Routine exam for all centers



Matthieu Pelletier-Galarneau, MD MSc
University of Ottawa

What imaging technique should be used for suspicion of acute pulmonary embolism? Planar vs. SPECT

Proceed catiously

Related to question of subclinical disease

Educational Objectives

- To review and understand recommendations of national and international groups
- To understand the nature of communication between nuclear medicine physicians and clinicians with respect to lung scanning
- To appreciate the limitations of probabalistic interpretation of lung scanning

Nuclear Medicine Communications (1993) **14**, 989–994

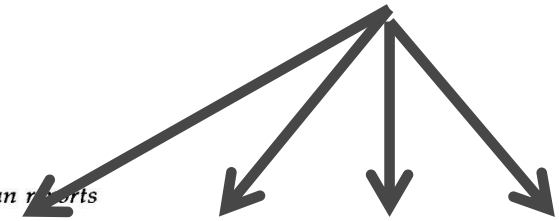
Nuclear Medicine Communications

Lung scan reports: interpretation by clinicians

H.W. GRAY, J.H. McKILLOP and R.G. BESSENT

Departments of Nuclear Medicine and Medicine, The Royal Infirmary, Glasgow, UK

Which one or more of these groups best described your interpretation of each of 4 lung scan reports?



Physician interpretation of lung scan reports	*Lung scan reports*			
	Normal	*Low probability*	*Indeterminate*	*High probability*
PE highly unlikely – group 1 only				
PE unlikely – group 2				
PE uncertain – group 3				
PE likely – group 4 only				
Totals				

Nuclear Medicine Communications (1993) **14**, 989–994

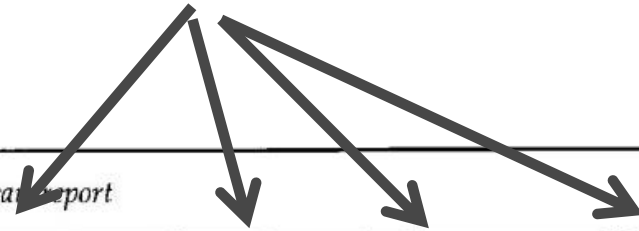
Nuclear Medicine Communications

Lung scan reports: interpretation by clinicians

H.W. GRAY, J.H. McKILLOP and R.G. BESSENT

Departments of Nuclear Medicine and Medicine, The Royal Infirmary, Glasgow, UK

What decision would you enact if you were caring for a middle aged patient with no risk factors or history of peptic ulceration but with a suspicious clinical history??



	Lung scan report			
Post-test diagnosis	*Normal*	*Low probability*	*Indeterminate*	*High probability*
PE excluded				
Working diagnosis of no				
Diagnosis uncertain				
Working diagnosis of PE				
PE likely				
Total selections				

Nuclear Medicine Communications (1993) **14**, 989–994

Nuclear Medicine Communications

Lung scan reports: interpretation by clinicians

H.W. GRAY, J.H. McKILLOP and R.G. BESSENT

Departments of Nuclear Medicine and Medicine, The Royal Infirmary, Glasgow, UK

- Misunderstanding by clinicians of risks of normal and low probability reports
- Underlines need for reporting MDs to provide informed guidance
- May point to need for a more easily understood style of reporting
- Could it be that misinterpretation of lung scans by some clinicians is a direct result of the verbal or probability style of reporting?

Nuclear Medicine Communications (1993) **14**, 1084–1087

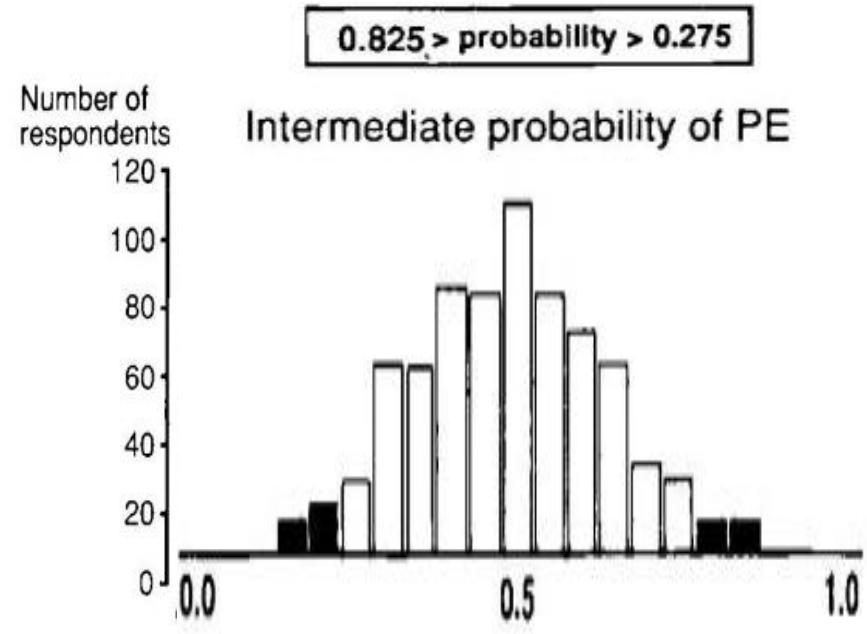
Nuclear Medicine Communications

Lung scan reporting language: what does it mean?

H.W. GRAY, J.H. McKILLOP and R.G. BESSENT

Departments of Nuclear Medicine and Medicine, The Royal Infirmary, Glasgow G31 2ER, UK

Estimate probability of PE suggested by each of a series of expressions



Nuclear Medicine Communications (1993) **14**, 1084–1087

Nuclear Medicine Communications

Lung scan reporting language: what does it mean?

H.W. GRAY, J.H. McKILLOP and R.G. BESSENT

Departments of Nuclear Medicine and Medicine, The Royal Infirmary, Glasgow G31 2ER, UK

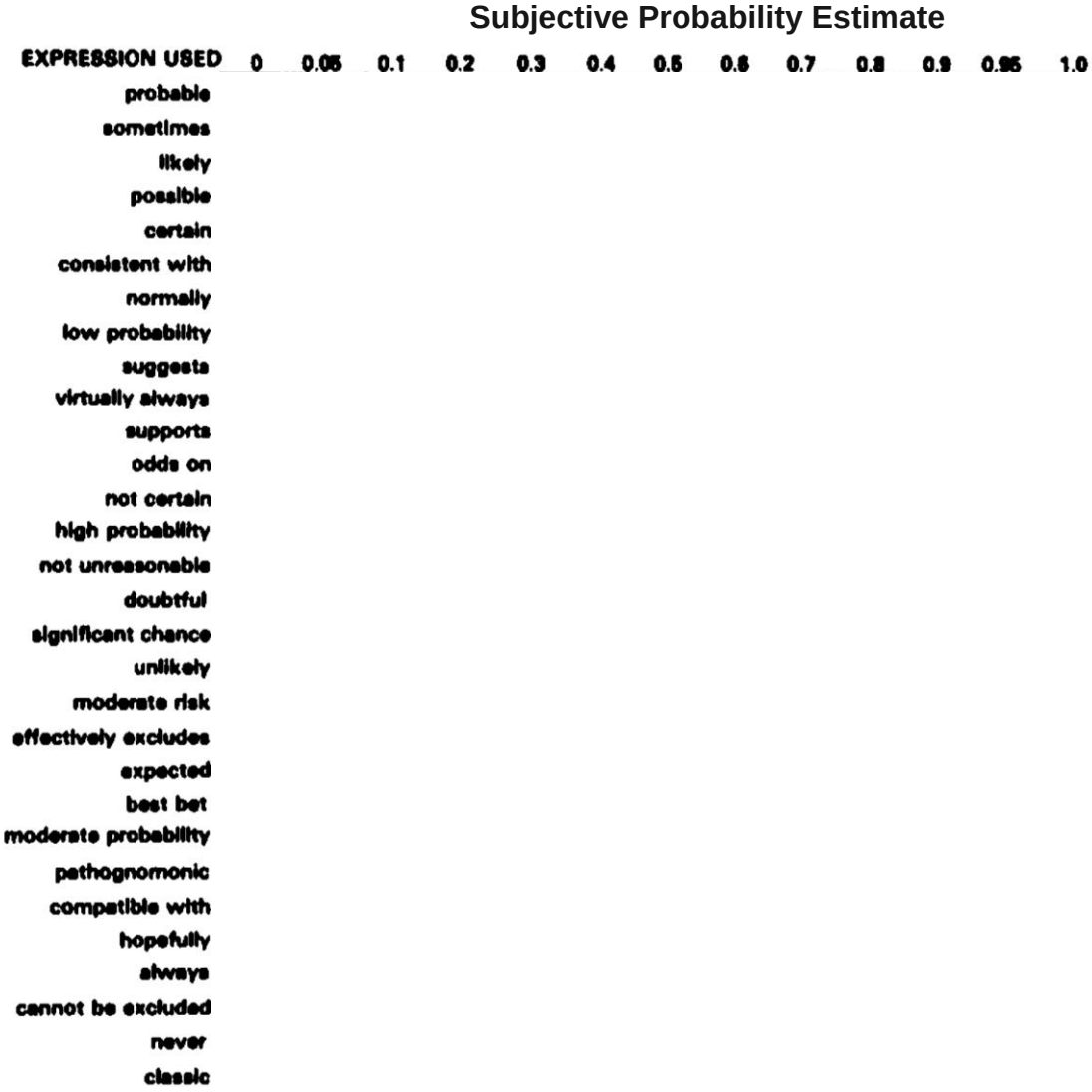
- There is a wide variation in interpretation of lung scan reports in the verbal probability style
- Variable training or experience or even different hospital protocols may have influenced the result
- Use of verbal probability language complicates the communication of PE risk

Why is there difficulty with
the probabalistic terminology?

? Generic issue

Expressions of probability: Words and Numbers

- 16 physicians, done twice
- Mean, SD, range
- Intra-MD agreement excellent
- Inter-MD agreement poor: Only 9 expressions with range <0.5



Bryant & Norman, NEJM 302:411,1980

THE NEW ENGLAND JOURNAL OF MEDICINE Sept. 18, 1986

SPECIAL ARTICLE

HOW MEDICAL PROFESSIONALS EVALUATE EXPRESSIONS OF PROBABILITY

AUGUSTINE KONG, A.M., G. OCTO BARNETT, M.D., FREDERICK MOSTELLER, PH.D., AND CLEO YOUTZ, M.S.

- Assigned percentage value to 12 common expressions in hypothetical patient with unspecified disease
- Compared MDs, med. students and other professionals

SPECIAL ARTICLE

HOW MEDICAL PROFESSIONALS EVALUATE EXPRESSIONS OF PROBABILITY

AUGUSTINE KONG, A.M., G. OCTO BARNETT, M.D., FREDERICK MOSTELLER, PH.D., AND CLEO YOUTZ, M.S.

Table 2. Percentage Values Assigned to Expressions of Probability by All Respondents and by Different Groups.*

FORMAT	EXPRESSION	ALL RESPONDENTS			RESPONSE GROUP			RANGE OF GROUP MEDIANS
		MEAN	MEDIAN	IQR	PHYSICIANS	MEDICAL STUDENTS	OTHERS	
					median value (no. in sample)			
HP	Certain	95	99	5	99 (33)	99 (79)	99 (39)	0
HP	Almost certain	90	94	8	93 (38)	94 (68)	95 (28)	2
US	Almost certain	82	87	12	86 (24)	88 (91)	86 (30)	2
FC	Almost certain	78	90	19	90 (53)	85 (67)	90 (50)	5
HP	Very likely	85	89	16	93 (37)	88 (65)	91 (32)	5
US	Probable	65	70	21	69 (23)	70 (38)	70 (20)	1
FC	Probable	64	70	25	70 (55)	70 (63)	70 (47)	0
US	Likely	63	67	21	65 (20)	64 (21)	68 (34)	4
FC	Likely	63	70	25	70 (33)	70 (92)	75 (50)	5
US	Frequent	56	62	25	57 (49)	63 (83)	66 (51)	9
US	Not unreasonable	32	26	32	36 (27)	23 (80)	31 (40)	13
US	Possible	27	20	23	21 (46)	21 (59)	19 (50)	2
US	Unlikely	14	11	11	10 (43)	12 (64)	12 (43)	2
US	Improbable	13	10	8	10 (28)	10 (78)	10 (28)	0
LP	Almost never	2	1	1	1 (39)	1 (64)	2 (38)	1
LP	Never	3	0	1	0 (47)	0 (63)	1 (37)	1

*HP denotes high-probability scale, LP low-probability scale, US uniform scale, FC free choice, and IQR interquartile range.

SPECIAL ARTICLE

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Table 3. Comparison of Means of Numerical Probabilities Assigned by Physicians to Expressions of Probability in Two Studies.*

EXPRESSION	KONG ET AL.	BRYANT AND NORMAN
	percent (scale)	
Certain	93 (HP)	95
Probable	64 (FC)	77
Likely	60 (FC)	73
Not unreasonable	36 (US)	47
Possible	26 (US)	43
Unlikely	12 (US)	20
Never	3 (LP)	33†

*Data are for the present study (Kong et al.) and that by Bryant and Norman, in which two estimates were made by each of 16 physicians, on different days. Percentage values are estimated from the diagram in Bryant and Norman.[2] HP denotes high-probability scale, FC free choice, US uniform scale, and LP low-probability scale.

†The authors suggested that this anomalous value resulted from a misinterpretation of the instructions.

Why is there difficulty with
the probabalistic terminology?

? Specific problem

Educational Objectives

- To review and understand recommendations of national and international groups
- To understand the nature of communication between nuclear medicine physicians and clinicians with respect to lung scanning
- To appreciate the limitations of probabalistic interpretation of lung scanning

Oversimplification in Basic Nuclear Medicine Textbooks has Introduced Conceptual and Mathematical Errors

Matthieu Pelletier-Galarneau, Lionel S. Zuckier

Division of Nuclear Medicine, Department of Medicine, University of Ottawa

Abstract

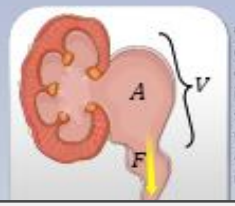
Objective: In the effort to simplify physiologic and epidemiologic concepts, we note that basic textbooks have promulgated 2 mathematical non sequiturs which often have become standard teaching. We therefore wish to review the mathematical underpinnings of the interpretation of diuretic renography and V/Q lung scanning and contrast them to the simplified rules of interpretation.

Findings: Published interpretation of obstruction on diuretic renography relies on fixed washout cutoff times (typically <10, 10-20 and > 20 min) to differentiate obstructed from non-obstructed renal units. We note that half-time of washout is actually dependent on the ratio of renal flow to renal pelvic volume; use of a fixed cutoff in the cas… mo… ma… will… and… Our… rep… low… non… and… pro… the… con… **Con**… und… sca… phy… exa…

In th… con… overlooked or simplified 2 mathematical concepts. We therefore wish to review the mathematical foundations of the interpretation of diuretic renography and V/Q lung scanning and contrast them to the simplified rules of interpretation.

Diuretic Renography

Diuretic renography is use to differentiate tracer retention in a dilated non-obstructed system from retention due to a true obstruction. In a non-obstructed system, diuretic will cause increased urine flow allowing the retained tracer to wash out. Typically, interpretation of a diuretic renography relies on the clearance half-time (<10, 10-20 and > 20 minutes). Let's review the clearance half-time calculation.



Once all the activity has been excreted by the kidney, the concentration of activity (A) in the renal pelvis at time t is function of the renal pelvi… volume (V) and urine f… of the pelvis int… (F) is given …

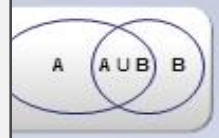
stipulates that A_0 is a constant, meaning that all the tracer has been excreted at time of diuretic imaging. In cases of interstitial injection, dehydration, and poor renal function, the kidneys might still be excreting tracer at time of diuretic imaging, increasing the clearance time.

V/Q Scan

V/Q scintigraphy is used to diagnose pulmonary embolism (PE). The interpretation relies on the assumption that in a lung segment affected by a PE, the perfusion is reduced and the ventilation is preserved. Such findings are referred as perfusion/ventilation (V/Q) mismatches.

In an effort to improve V/Q scintigraphy specificity, Biello et al. (1979) retrospectively analyzed images of patients with suspected PE who underwent both pulmonary angiography and V/Q scan. They described different imaging pat… and allot them a probability for PE (high, indet… …ow and normal). Since, the probabilistic …een used by the vast majority of publications …s to report scintigraphic findings.

…tunate labeling does not take into account the …probability, therefore ignoring the Bayes theorem. …y understand the matter, let's review Bayes …m. Bayes theorem stipulates that the probability of



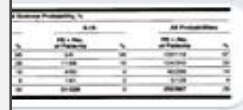
…ability of PE, P(D⁺), given …m the VQ scintigraphy.

$$\frac{\ldots P(VQ|D^{+})}{\ldots P(VQ)}$$

… given the scintigraphic

$$\ldots rob. \times sensitivity \ldots graphic\ Prob.$$

…act. In PIOPED I, a table



…ation, used without …obability, is a conceptual non-sense. It ignores valuable and available information. For example, if a patient has a high clinical probability and a low probability pattern on the scintigraphy, should one give it a low probability for PE knowing that P(D⁺|VQ) is in fact close to 40%?

Conclusion

Review of fundamental mathematical underpinnings different nuclear medicine imaging techniques is essential to gain superior understanding of these examinations.

In the case of diuretic renography, it allows the nuclear medicine physician to understand possible causes of false positive studies. More specifically, in cases of severely dilated collecting system, the typical cut off time to diagnose obstruction is no longer reliable.

In the case of perfusion/ventilation scintigraphy, the use of probabilistic labeling ignores pre test probability, hence disregarding Bayes theorem.

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In an effort to improve V/Q scintigraphy specificity, Biello et al. (1979) retrospectively analyzed images of patients with suspected PE who underwent both pulmonary angiography and V/Q scan. They described different imaging patterns and alloted them a probability for PE (high, indeterminate, low and normal). Since then, the probabilistic labeling has been used by the vast majority of publications and physicians to report scintigraphic findings.

This unfortunate labeling does not take into account the pre-test probability, therefore ignoring the Bayes theorem.

Michelangelo

Ventilation-Perfusion Studies in Suspected Pulmonary Embolism

Daniel R. Biello[1]
Adel G. Mattar
Robert C. McKnight
Barry A. Siegel

TABLE 4: **Scheme for Interpretation of V-Q Imaging**

Interpretation	Pattern	Frequency of Pulmonary Embolism (%)
Normal	Normal perfusion	0*
Probability of pulmonary embolism:		
Low	Small V-Q mismatches	0
	Focal V-Q matches with no corresponding radiographic abnormalities	4.8
	Perfusion defects substantially smaller than radiographic abnormalities	7.7
Intermediate	Diffuse, severe airway obstruction	20
	Matched perfusion defects and radiographic abnormalities	27
	Single moderate V-Q mismatch without corresponding radiographic abnormality	33
High	Perfusion defects substantially larger than radiographic abnormalities	87
	1 or more large, or 2 or more moderate-sized V-Q mismatches with no corresponding radiographic abnormalities	92

* From [4, 6, 7].

AJR 133:1033-7,1979

- You can’t fit a round peg into a square hole
- One cannot assign an accurate clinical probability based on an examination finding
- Because posterior probability depends on prior probability, there is a wide range of interpretation based on this ambiguity.

Lung scan probability

- A *posterior* probability, based on lung scan interpretation, cannot be offered unless *prior* or *pretest* probability is taken into account
- This truism is governed by Bayes' Theorem
- Therefore makes no sense to assign a probability to a scan pattern if one does not factor in *prior* probability

Thomas Bayes

- Born 1702; Died 1761
- English mathematician and theologian
- Work published posthumously in 1763

Bayes Theorem

- Every medical test has a **sensitivity** (accuracy in subjects with disease) and **specificity** (accuracy in normal subjects)
- When you encounter a positive test result, you do not know if it is a **true positive** (in subject with disease) or a **false positive** (in subject without disease).
- The ratio of subjects with disease in your group to those with no disease in your group will determine liklihood of a positive test being true or false

BAYES THEOREM
Relates PVPT and PVNT to sens, spec, prev

$$P(D+|T+) = \frac{P(T+|D+)p(D+)}{P(T+|D+)p(D+) + p(T+|D-)p(D-)}$$

$$P(D-|T-) = \frac{P(T-|D-)p(D-)}{P(T-|D-)p(D-) + p(T-|D+)p(D+)}$$

Population A (Disease prev 30%)
Test A (sens = .95; spec = .98)

	Disease present (D+)	Disease absent (D-)	
Test Abnormal (T+)	285	14	299
Test Normal (T-)	15	686	701
	300	700	1000

Accuracy .97; PVPT .95; PVNT .98

Population B (Disease prev 5%)
Test A (sens = .95; spec = .98)

	Disease present (D+)	Disease absent (D-)	
Test Abnormal (T+)	48	19	67
Test Normal (T-)	2	931	933
	50	950	1000

Accuracy .98; PVPT .72; PVNT .998

Ventilation-Perfusion Studies and the Diagnosis of Pulmonary Embolism: Concise Communication

Barbara J. McNeil

Harvard Medical School and the Peter Bent Brigham Hospital, Boston, Massachusetts

JNM 21:319-23,1980

TABLE 4. PROBABILISTIC ESTIMATES OF PULMONARY EMBOLISM, P(PE+|S_i), IN THREE CLINICAL SITUATIONS ASSOCIATED WITH SELECTED SCINTIGRAPHIC OUTCOMES

Scan pattern	Posterior probabilities for clinical chances of pulmonary embolism		
	Low	Average	High
Indeterminate	0.04	0.13	0.47*
Many perfusion defects, no ventilation study			
Subsegmental	0.01	0.02	0.09
Segmental	0.10*	0.27*	0.68*
Lobar	0.26*	0.54*	0.87
Many perfusion defects, V/Q mismatch			
Lobar/segmental	0.54*	0.80	0.96
Subsegmental	0.01	0.03	0.17
Many perfusion defects, any size and V/Q match	0	0	0

* Probabilistic estimates in intermediate range.

Value of the Ventilation/Perfusion Scan in Acute Pulmonary Embolism

Results of the Prospective Investigation of Pulmonary Embolism Diagnosis (PIOPED)

The PIOPED Investigators

	Clinical Science Probability, %							
	80-100		20-79		0-19		All Probabilities	
Scan Category	PE + /No. of Patients	%	PE + /No. of Patients	%	PE + /No. of Patients	%	PE + /No. of Patients	%
High probability	28/29	96	70/80	88	5/9	56	103/118	87
Intermediate probability	27/41	66	66/236	28	11/68	16	104/345	30
Low probability	6/15	40	30/191	16	4/90	4	40/296	14
Near normal/normal	0/5	0	4/62	6	1/61	2	5/128	4
Total	**61/90**	68	**170/569**	30	**21/228**	9	**252/887**	28

PIOPED I, JAMA 263(20): 2753-2759, 1990

Clinical probability
Clinical decision rules

Wells' score for PE

History of DVT or PE	**+ 1,5**
Immobilization or surgery (< 4 weeks)	**+ 1,5**
Cancer	**+ 1**
An alternative diagnosis is less likely	**+ 3**
Hemoptysis	**+ 1**
Heart rate > 100/min	**+ 1,5**
Signs of DVT	**+ 3**

Low 0-1; intermediate 2-6; high: ≥ 7

Unlikely ≤ 4; likely > 4

Revised Geneva score

Age > 65 years	**+1**
History of DVT or PE	**+3**
Surgery or fracture (<1 month)	**+2**
Cancer	**+2**
Unilateral leg pain	**+3**
Hemoptysis	**+2**
Heart rate	
75 - 94 / minute	**+3**
≥ 95 / minute	**+5**
Pain at calf palpation and swelling	**+4**

Low 0-3 ; intermediate 4-10 ; high ≥ 11+

Wells, Thromb Haemost 2001 ; Le Gal, Ann Intern Med 2006

General Diagnostic Imaging question:

To what extent does the imager delve into a final diagnosis?

Interaction between clinical and imaging findings

- Clinical management of patients with suspected embolism in influenced not only by the scan results, but also by the prior probability of embolism
- Should we take this prior probability into account when reporting scans?
- Do we see ourselves as being in the best position to get the diagnosis right in these patients, or wish to concentrate only on imaging criteria and leave final integration of all diagnostic data to our clinical colleagues?

P.J. Robinson, Clinical Radiology 40:557,1989

Probabalistic Interpretation

- If dealing with savvy clinicians, provide scan patterns to acknowledge reality of Bayes theorem
- If dealing with non-savvy clinicians, provide “radiology-like” trinary interpretations

Educational Objectives

- To review and understand recommendations of national and international groups
- To understand the nature of communication between nuclear medicine physicians and clinicians with respect to lung scanning
- To appreciate the limitations of probabalistic interpretation of lung scanning

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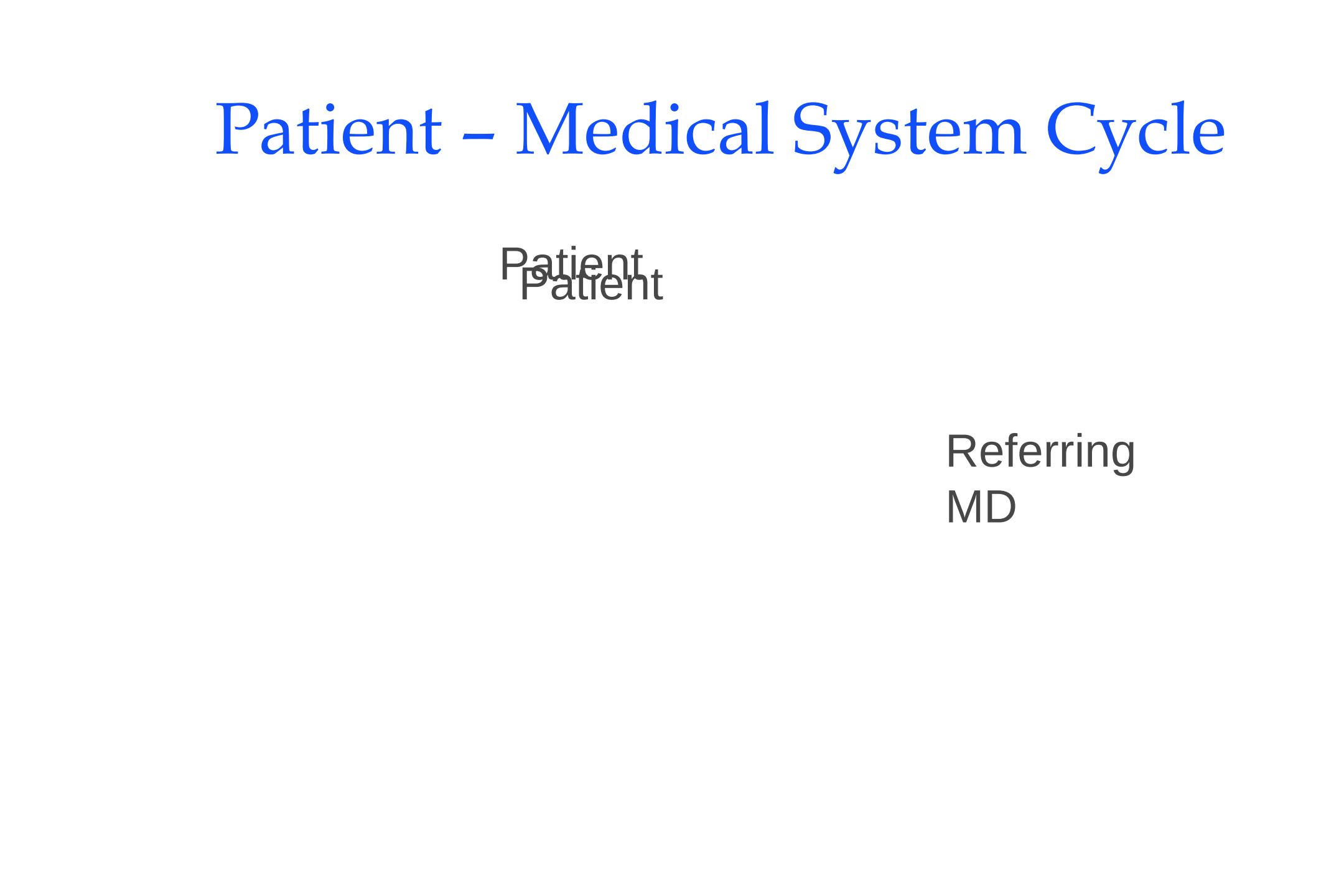
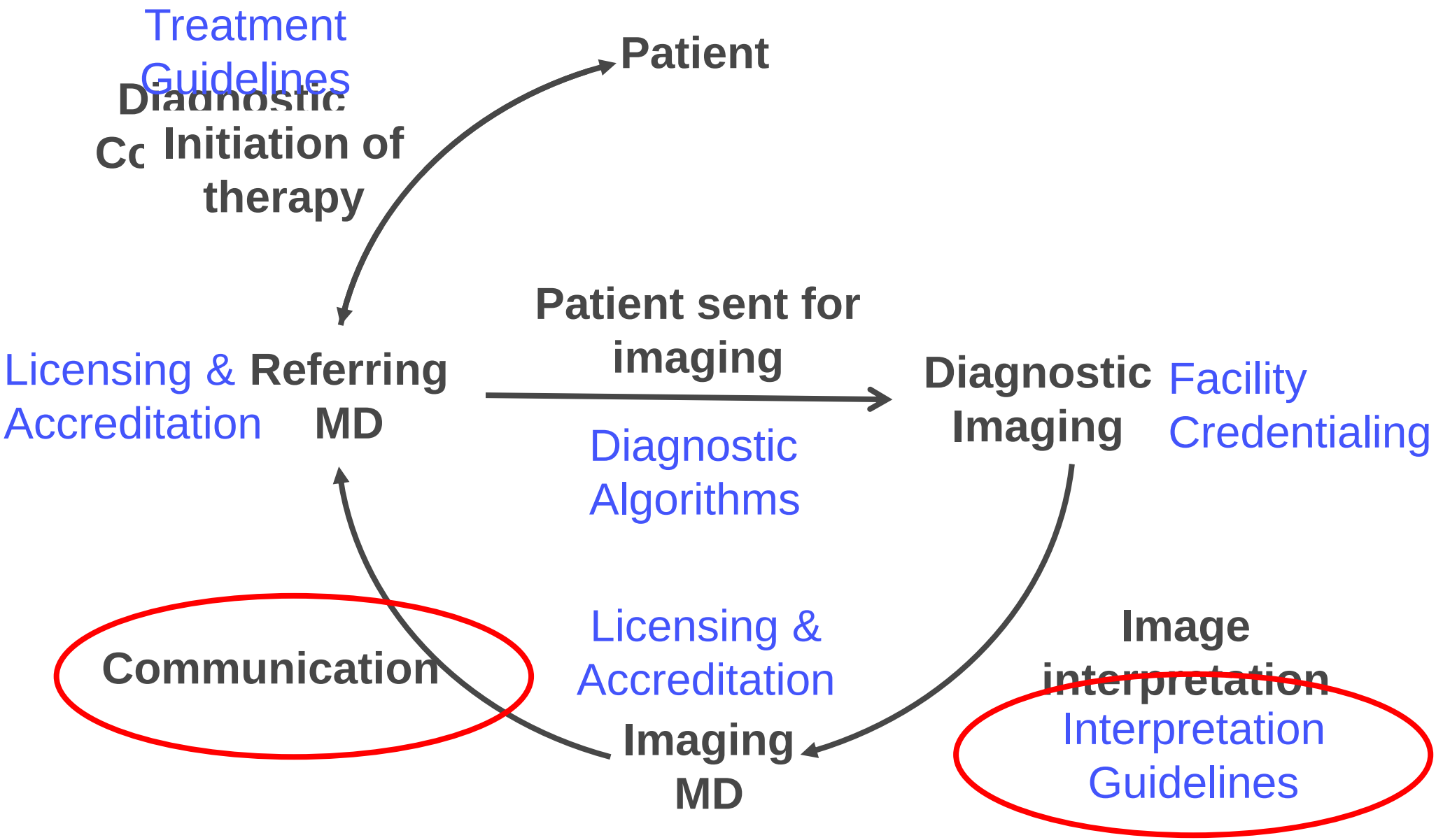
Thank you for your attention

Merci!

Patient – Medical System Cycle




Treatment Guidelines
Patient
Diagnostic Cc
Initiation of therapy
Licensing & Accreditation
Referring MD
Patient sent for imaging
Diagnostic Algorithms
Diagnostic Imaging
Facility Credentialing
Communication
Licensing & Accreditation
Image interpretation
Imaging MD
Interpretation Guidelines

Radiology

Lawrence R. Goodman, MD

Radiology 234 :654-658, 2005

Small Pulmonary Emboli: What Do We Know?[1]

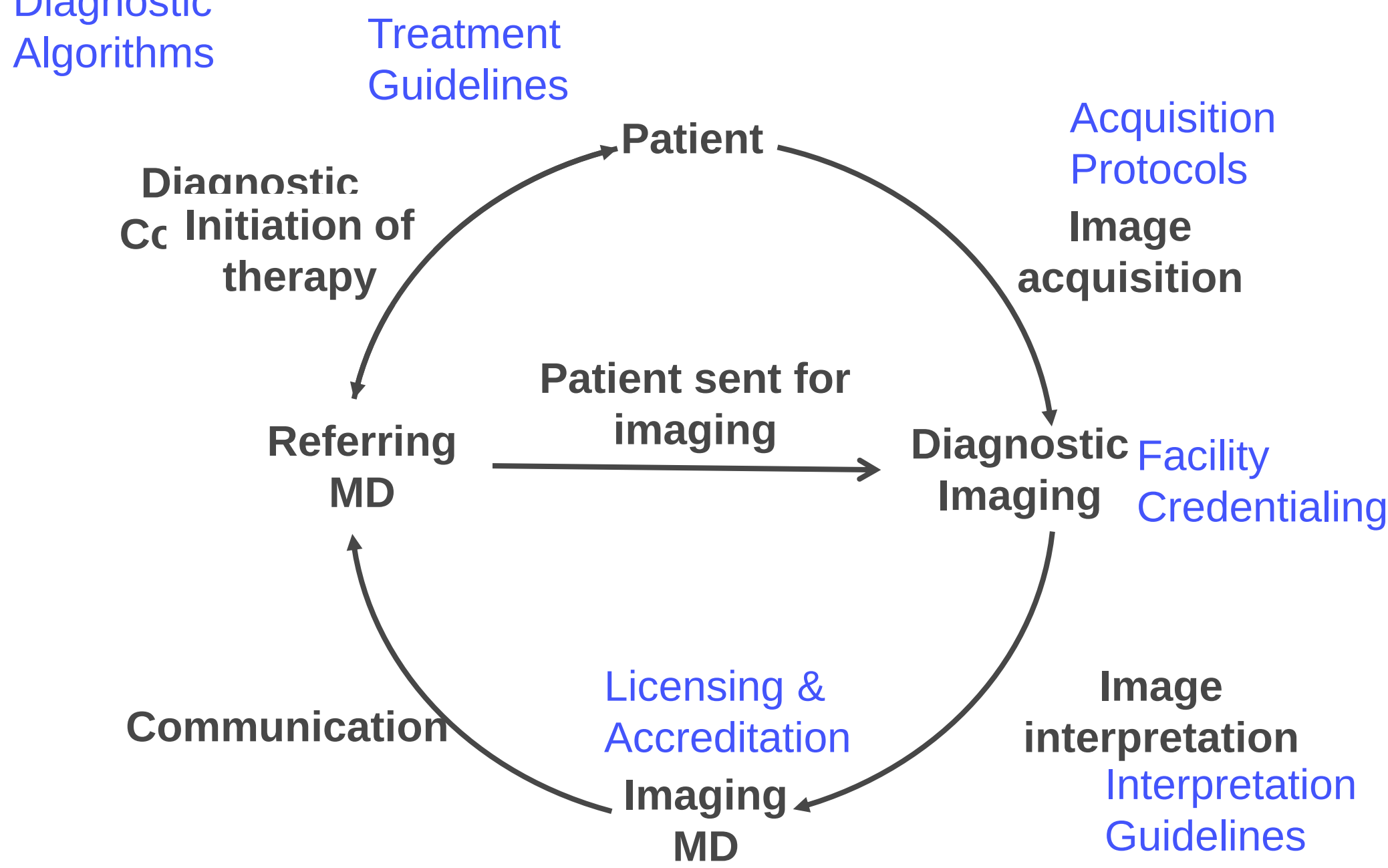
There are 3 scenarios where even small PE require treatment

A—patients with inadequate cardiopulmonary reserve

B---patients with coexisting DVT

C---patients with recurrent small PE to prevent chronic PE and pulmonary arterial hypertension

Dr. Goodman also points outs (quoting Gurney) that there is considerable belief by many that healthy people often pass small clots from the legs to the lungs, and the lung capillary bed traps the emboli thereby protecting the systemic circulation


Diagnostic Algorithms
Treatment Guidelines
Patient
Acquisition Protocols
Diagnostic
Cc
Initiation of therapy
Image acquisition
Patient sent for imaging
Referring MD
Diagnostic Imaging
Facility Credentialing
Licensing & Accreditation
Communication
Image interpretation
Imaging MD
Interpretation Guidelines

Clinical probability – Wells' score

Clinical variable		Points
Active cancer		+1
Hemoptysis		+1
Recent immobilization or surgery		+1.5
Heart rate > 100 / min		+1.5
Prior DVT or PE		+1.5
Signs orsymptoms of DVT		+3
No alternative diagnosis as or more likely than PE		+3
Number of points	**Clinical proability**	**Prevalence of DVT**
≤ 4	Unlikely	6 – 11%
> 4	Likely	29 – 40%

Why have we witnessed such a proliferation in the use of CT Angiography for the diagnosis of Pulmonary Embolism?

1.Lack of knowledge concerning excessive radiation risk; particularly to the breasts of young women

2.Availability of CTA as well as the relative lack of availability of V/Q after hours and on weekends

3. Radiologist's lack of familiarity and comfort with V/Q interpretation

4. Clinician's lack of familiarity and/or misconceptions about the relative accuracy of V/Q and CTA imaging

5. Biased interpretation of PIOPED II results

Estimating Risk of Cancer Associated With Radiation Exposure From 64-Slice Computed Tomography Coronary Angiography

Andrew J. Einstein, MD, PhD
Milena J. Henzlova, MD, PhD
Sanjay Rajagopalan, MD

Context Computed tomography coronary angiography (CTCA) has become a common diagnostic test, yet there are little data on its associated cancer risk. The recent Biological Effects of Ionizing Radiation (BEIR) VII Phase 2 report provides a framework for estimating lifetime attributable risk (LAR) of cancer incidence associated with ra-

REVIEW ARTICLE

CURRENT CONCEPTS

Computed Tomography — An Increasing Source of Radiation Exposure

David J. Brenner, Ph.D., D.Sc., and Eric J. Hall, D.Phil., D.Sc.

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 AUGUST 27, 2009 VOL. 361 NO. 9

Exposure to Low-Dose Ionizing Radiation from Medical Imaging Procedures

Reza Fazel, M.D., M.Sc., Harlan M. Krumholz, M.D., S.M., Yongfei Wang, M.S., Joseph S. Ross, M.D., Jersey Chen, M.D., M.P.H., Henry H. Ting, M.D., M.B.A., Nilay D. Shah, Ph.D., Khurram Nasir, M.D., M.P.H., Andrew J. Einstein, M.D., Ph.D., and Brahmajee K. Nallamothu, M.D., M.P.H.

Table 7
Radiation Exposure of Various Imaging Examinations Performed for Pulmonary Embolism

Examination	Effective Whole-Body Dose (mSv)	Fetal Dose (mGy)	Effective Dose per Breast (mGy)
PA/lateral CXR	0.06–0.25	0.01	…
Low-dose perfusion scintigraphy	0.6–1.0	0.1–0.37	0.11–0.3
V/Q scintigraphy	1.2–6.8	0.1–0.8	0.22–0.28
CTPA	2–20	0.01–0.66*	10–70
Low-dose CTPA	2.7	…	…
Pulmonary DSA	3.2–30.1	0.5	…
Evaluation of background radiation	2.5	1.1–2.5	…

Note.—Variation in reported doses is largely related to CT settings, number of CT detectors, trimester, patient age, body mass index, and method of dose calculation. CTPA = CT pulmonary angiography, CXR = chest radiography, DSA = digital subtraction angiography, PA = posteroanterior.
*Data from Winer-Muram et al (3) not included due to outdated CT parameters and generation of CT scanner used in their study.

Radiation Exposure of V/Q Scintigraphy vs. MDCTA

The bottom line is that the radiation exposure to the breasts of women in the child bearing age group from MDCTA is somewhere between 65-250 times greater than that from V/Q scintigraphy. Most quotes are in the 70-100 X range.

Additionally, the estimated radiation exposure from a standard 2 view mammogram is associated with 3-4.4 mSv which makes the MDCTA radiation dose approximately 10-20 times greater.

The Pregnant Patient with Suspected Pulmonary Embolism

Estimates of Fetal Radiation exposure suggest that V/Q scintigraphy is associated with 0.2-0.4 mSv while the exposure from CTA is 0.96 mSv. Other references have suggested that the exposure from both procedures is similar. However, the excessive radiation dose to the breast remains the major factor in avoiding CTA.

At Montefiore, our approach has, for the past 15-20 years, been to use a low dose (1 mCi) perfusion only study in association with a plain chest radiograph. Although actual numbers have not been collected, we have likely performed more than 200 such studies. The overwhelming majority (probably >95%) are perfectly normal.

American Thoracic Society Documents

An Official American Thoracic Society/Society of Thoracic Radiology Clinical Practice Guideline: Evaluation of Suspected Pulmonary Embolism In Pregnancy

Ann N. Leung, Todd M. Bull, Roman Jaeschke, Charles J. Lockwood, Phillip M. Boiselle, Lynne M. Hurwitz, Andra H. James, Laurence B. McCullough, Yusuf Menda, Michael J. Paidas, Henry D. Royal, Victor F. Tapson, Helen T. Winer-Muram, Frank A. Chervenak, Dianna D. Cody, Michael F. McNitt-Gray, Christopher D. Stave, and Brandi D. Tuttle, on behalf of the ATS/STR Committee on Pulmonary Embolism in Pregnancy

THIS OFFICIAL CLINICAL PRACTICE GUIDELINE OF THE AMERICAN THORACIC SOCIETY (ATS) AND THE SOCIETY OF THORACIC RADIOLOGY (STR) WAS APPROVED BY THE ATS BOARD OF DIRECTORS, MARCH 2011 AND BY THE STR, MAY 2011

THIS CLINICAL PRACTICE GUIEDLINE HAS BEEN FORMALLY ENDORSED BY THE AMERICAN COLLEGE OF OBSTETRICIANS AND GYNECOLOGISTS

Am J Respir Crit Care Med 2011;184:1200-1208

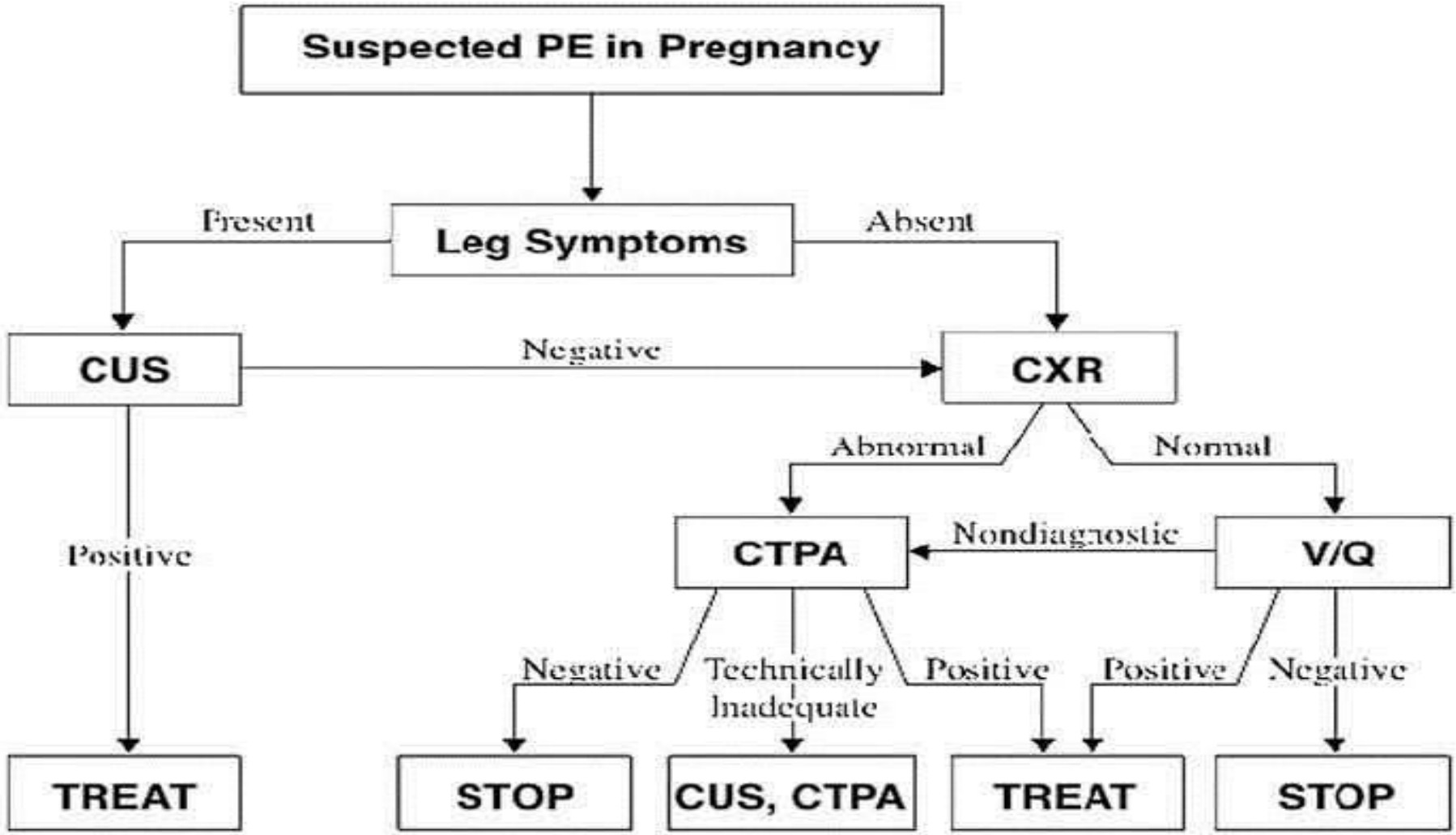


Figure 1. Diagnostic algorithm for suspected PE in pregnancy.

Results in Pregnant Women

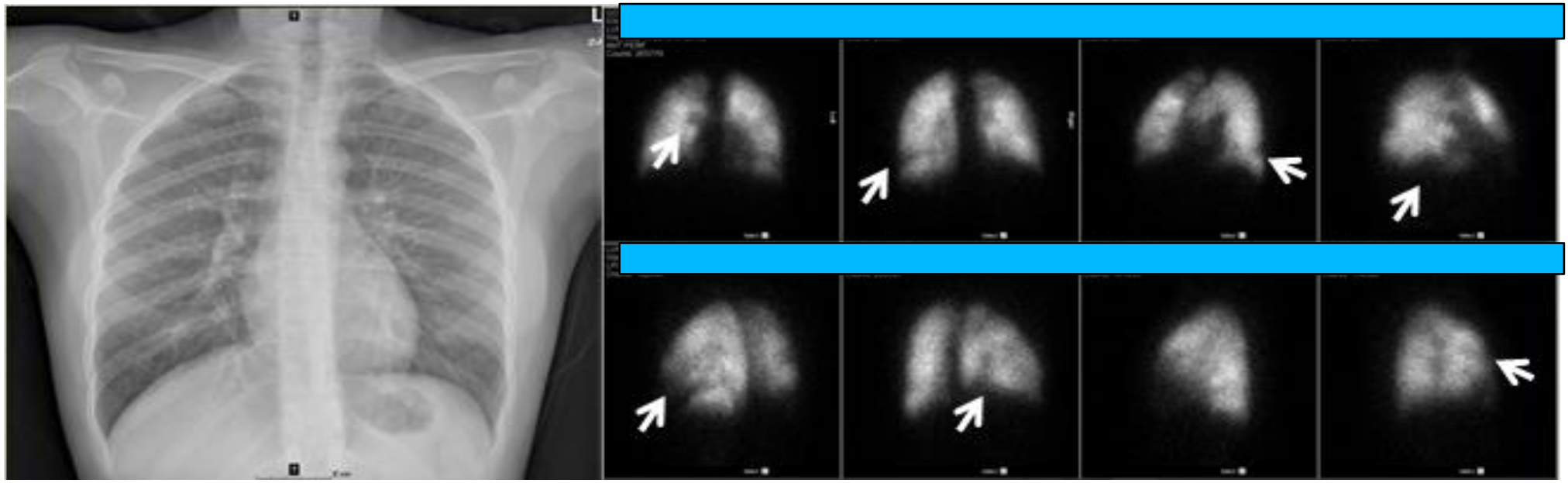
Total 324 patients, 17 patients had both perfusion and CT scan

	Positive	Indeterminant	Negative
Perfusion scan	6/229 (2.6%)	23/229 (10%)	200/229 (87.3%)
CT scan	7/112 (6.2%)	12/112 (10.7%)	93/112 (83%)

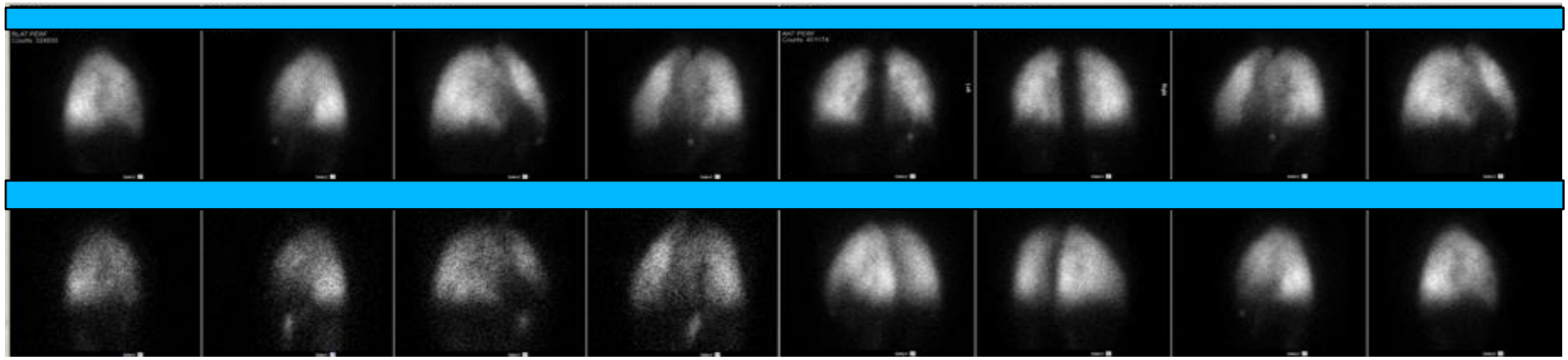
17 patients had both perfusion and CT scan

	Perfusion Positive	Perfusion indeterminant	Perfusion negative
CT positive	1	2	0
CT indeterminant	0	2	0
CT negative	2	7	3

19 y/o pregnant woman came to the ED actively wheezing



15 hours later, repeat V/Q scan following broncho-dilator Rx was negative



Success of a Safe and Simple Algorithm to Reduce Utilization of CT Pulmonary Angiography in the Emergency Department

- Evan G Stein, MD, PhD, Linda B Haramati, MD, MS, Murthy Chamarthy, MD, Seymour Sprayregen, MD Michelle M Davitt, MD, Leonard M Freeman, MD

Departments of Radiology, Nuclear Medicine, and Emergency Medicine, Albert Einstein College of Medicine, Montefiore Medical Center
Bronx, NY

Stable ED patient PE suspected

CXR

(-) Pleural or Parenchymal Disease

V/Q Scan

EQUIVOCAL RESULTS OR DDISCORDANT WITH CLINICAL

(+) Pleural or Parenchymal Disease

CTPA

FACT

The Language of Lung Scan Interpretation has always been poorly understood and confusing to the Clinician requesting the study and receiving the “probability” based report

Our Premise

Reporting CTA and V/Q studies

V/Q studies and CTA should both be reported with similar terminology.

For either procedure, the interpretation should be:

1—**findings consistent with PE**. If this finding is discordant with objective clinical assessment, further investigation is warranted.

2**---no evidence of PE on this study**. If this finding is discordant with objective clinical assessment, further investigation is warranted

3—**non diagnostic study.** Further study with V/Q (CTA) may be helpful

3 Month Follow Up on Negative CTPA studies and V/Q studies interpreted as Normal ,Very Low or Low Probability (or PE Negative from 2009 to present)

	CTPA	V/Q
# of cases	1799	3039
False Negatives	16 (0.9 %)	37 (1.2 %)
	10 / 16 PE 6 / 16 DVT	14 / 37 PE 23 / 37 DVT
FN for PE alone	10 / 1799 = 0.6 %	14 / 3039 = 0.5 %

Data from the Moses Division of Montefiore Medical Center

3 Month Follow Up on Negative CTPA studies and V/Q studies interpreted as Normal ,Very Low or Low Probability (or PE Negative from 2009 to present)

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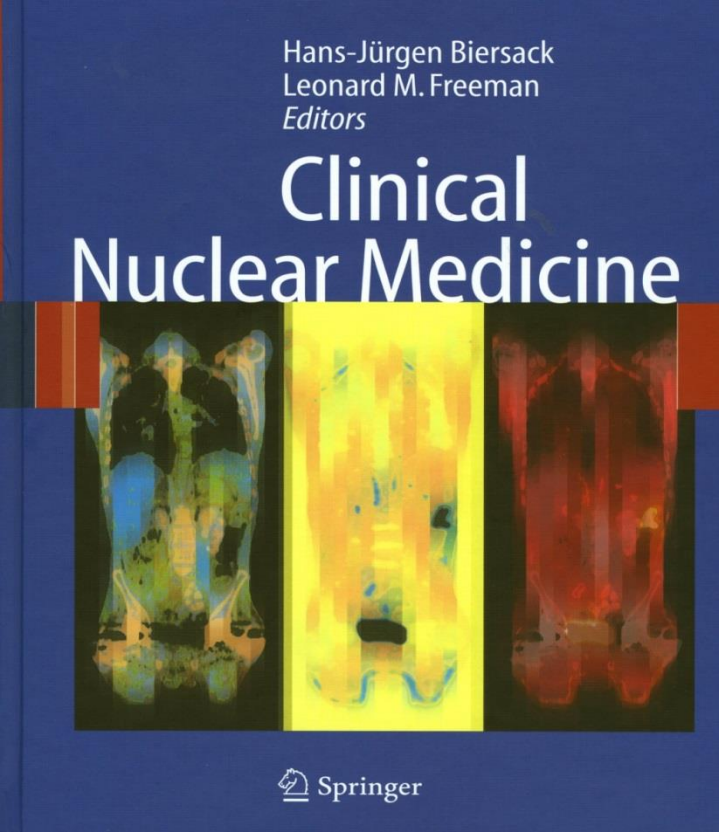
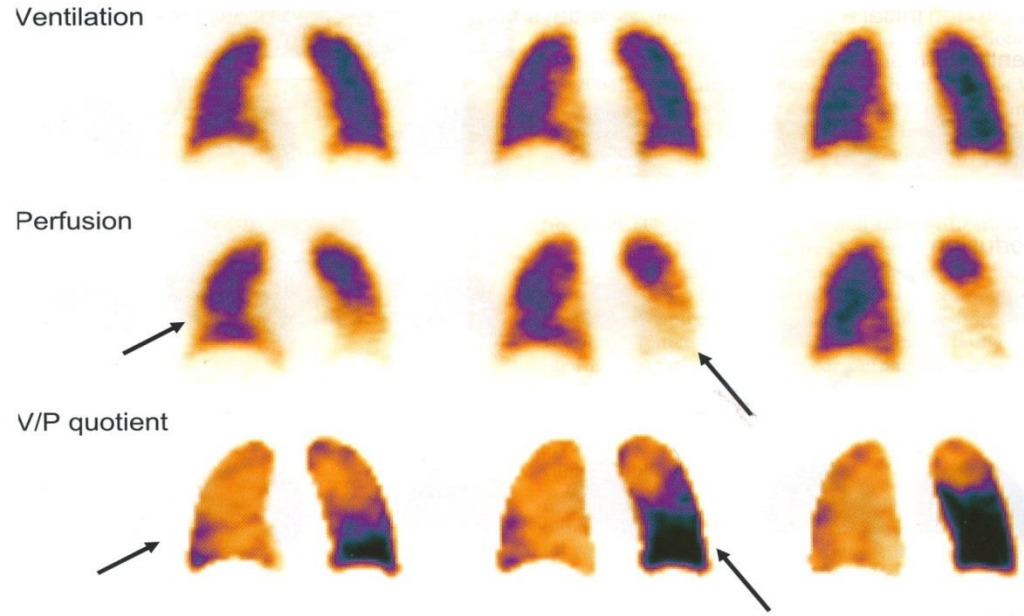


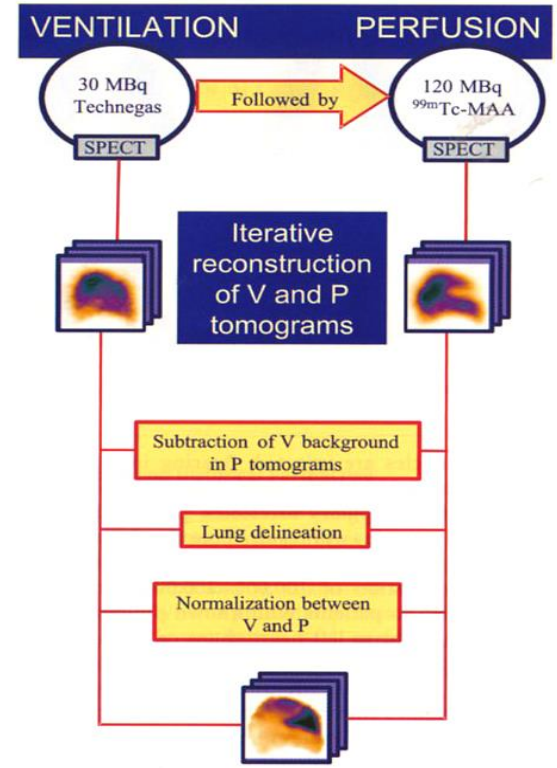
5 Lung

M. Bajc, B. Jonson, H.C. Steinert

5.1 Conventional and SPECT Lung Imaging

M. Bajc, B. Jonson





V/Q Scans in Canada; Results of Survey

Matthieu Pelletier-Galarneau, MD MSc
PGY 4 Nuclear Medicine
University of Ottawa

CANM 2015
Montréal, Québec

Acknowledgments

- Lionel S. Zuckier, The Ottawa Hospital
- Grégoire Le Gal, The Ottawa Hospital
- Pierre-Yves Le Roux, Brest, France
- Pierre-Yves Salaün, Brest, France
- CANM, Hélène Samson, Jean-Luc Urbain

- No disclosure

Probabalistic Language

- EANM:

The Ottawa Experience

- One of the goal of using SPECT is to reduce the number of indeterminate results
- Clinicians are hesitant to move toward SPECT due to lack of outcome data
  - » Does SPECT over diagnose small subsegmental PE?
  - » What is the clinical significance of a small mismatched perfusion defect?
- Are other Canadian centers performing SPECT?
- How are SPECT VQ interpreted in other centers?

CURRENT PRACTICES IN CANADA

National Survey

- National survey to answers some of these questions

- Part of an international survey
  - » France
  - » Australia
  - » Canada

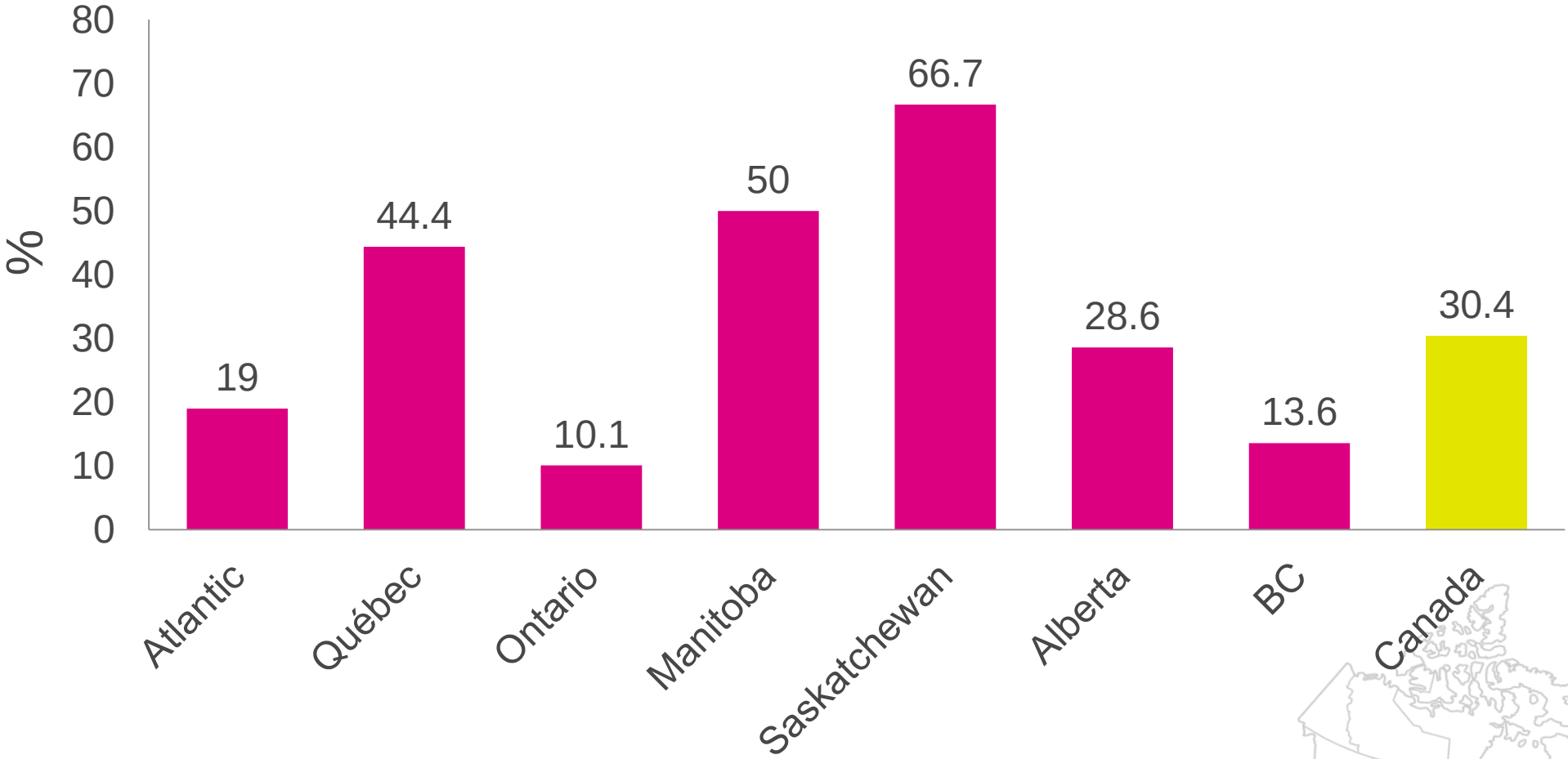
National Survey - Methods

- Research Ethic Board (REB) approval was obtained
- Physicians were contacted by email - 2 emails were sent through CANM mailing list
- 158 centers in Canada according to our list
- Survey included 10 questions

National Survey

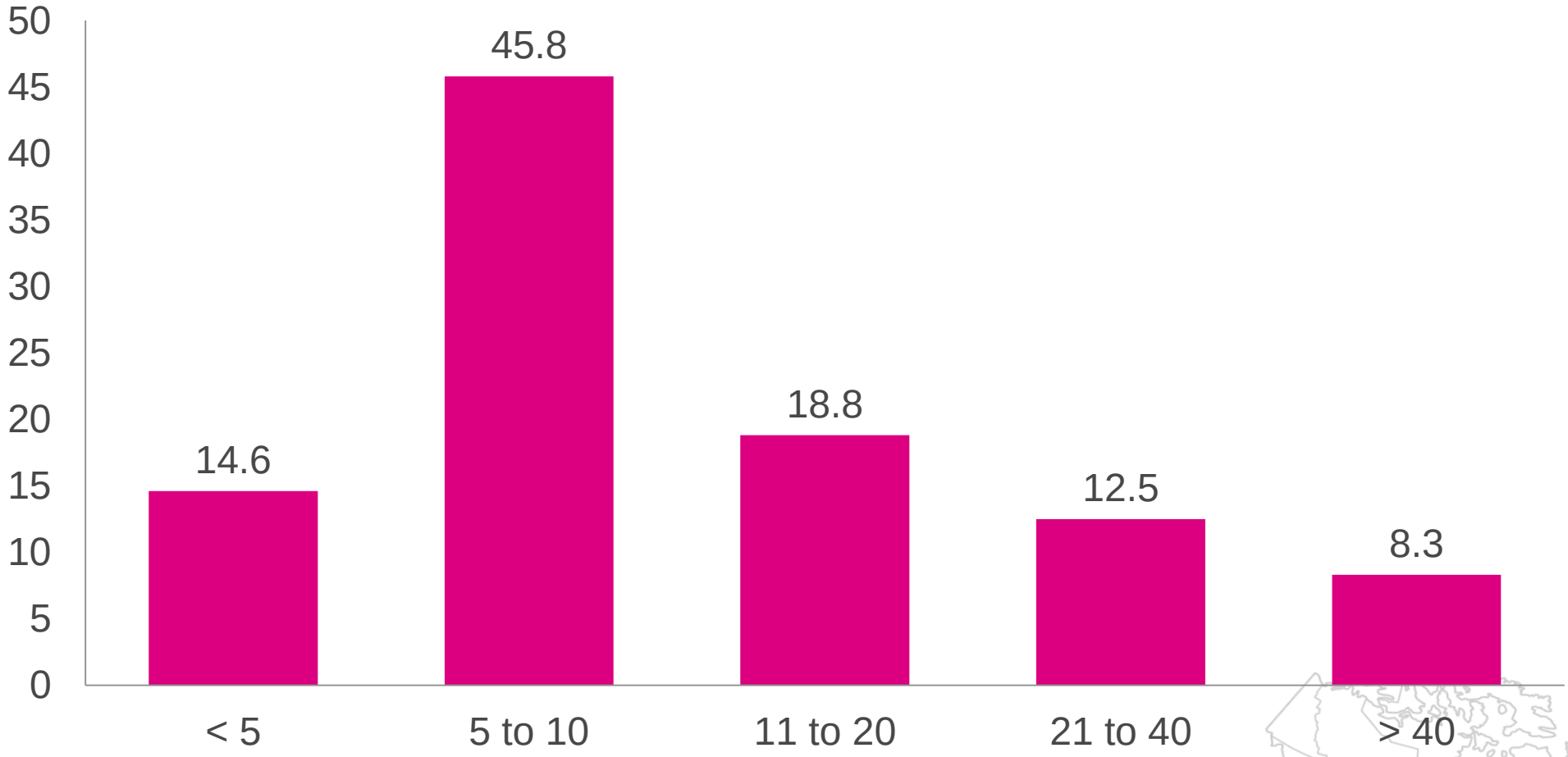
- A total of 75 responses
  - » From 48 different centers
  - » 27 excluded due to duplicate
- Of the 48 unique responses
  - » 36 responses after the 1st email
  - » 12 responses after the 2nd email
- Response rate of 30.4%

Response Rates (%)



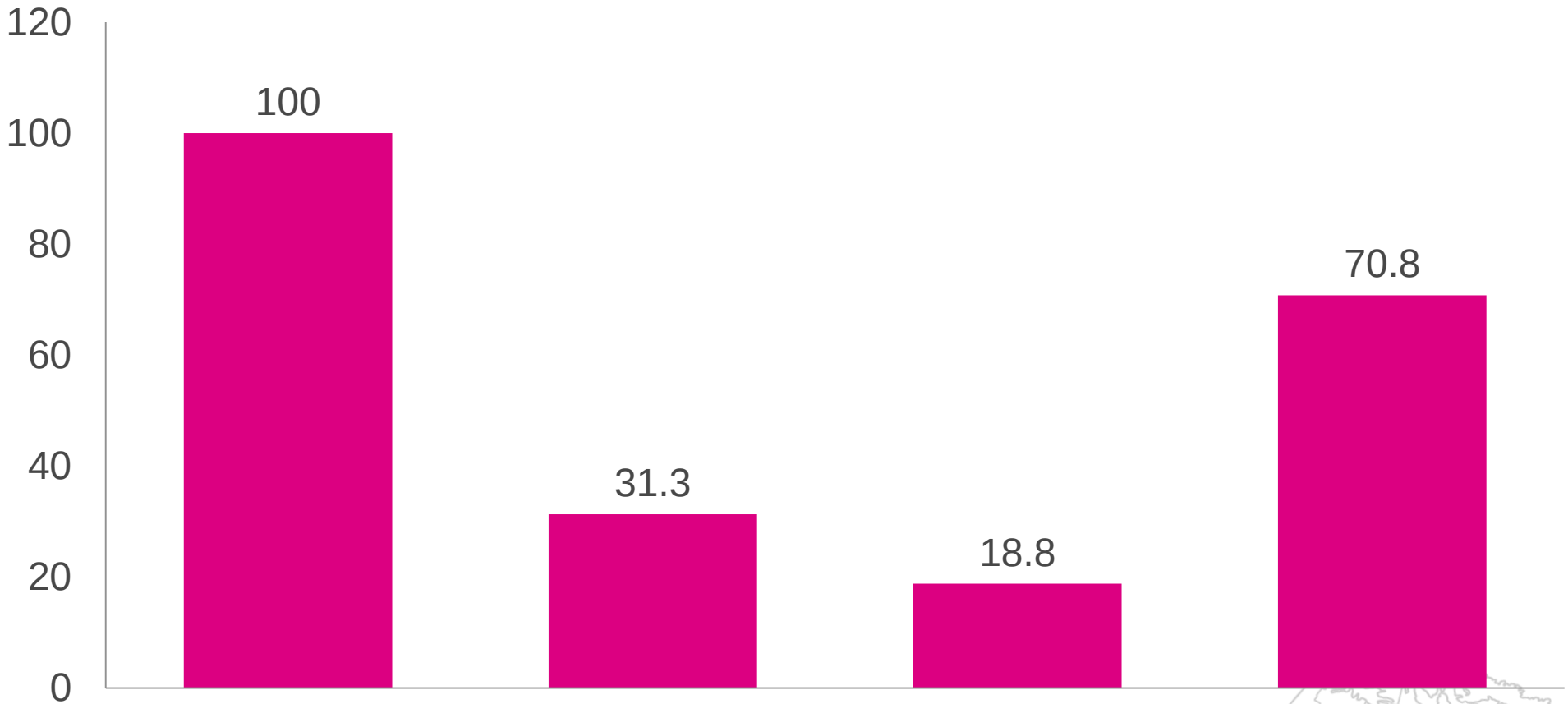
Approximately how many cases of ventilation/perfusion (V/Q) scintigraphy are performed per week at your campus?

Number of scans per week



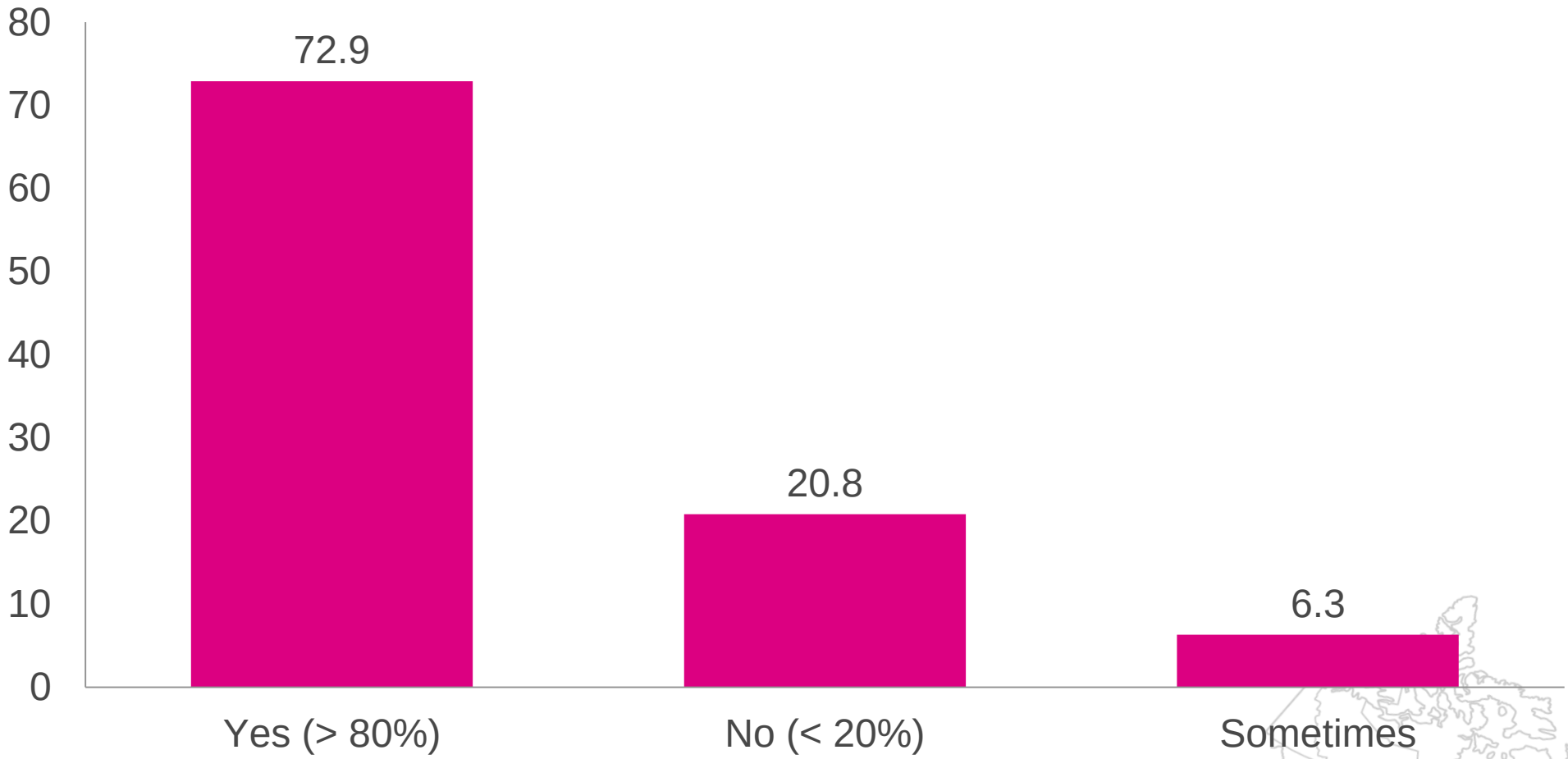
What is the availability of ventilation/perfusion scintigraphy at your center?

Availability of V/Q scans

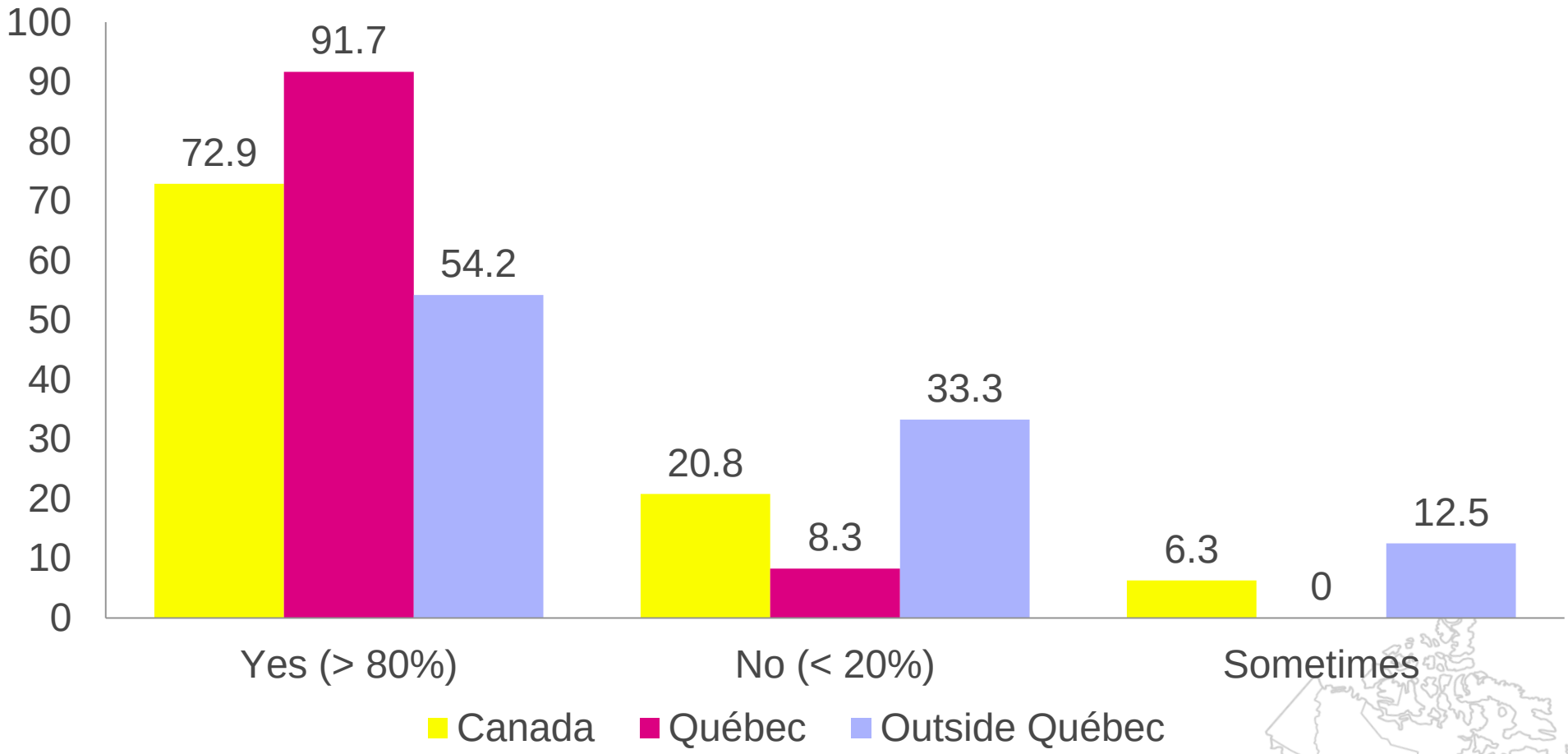


Do you routinely use ventilation/perfusion SPECT (rather than planar scintigraphy) at your campus for suspicion of acute pulmonary embolism?

Do you routinely use ventilation/perfusion SPECT

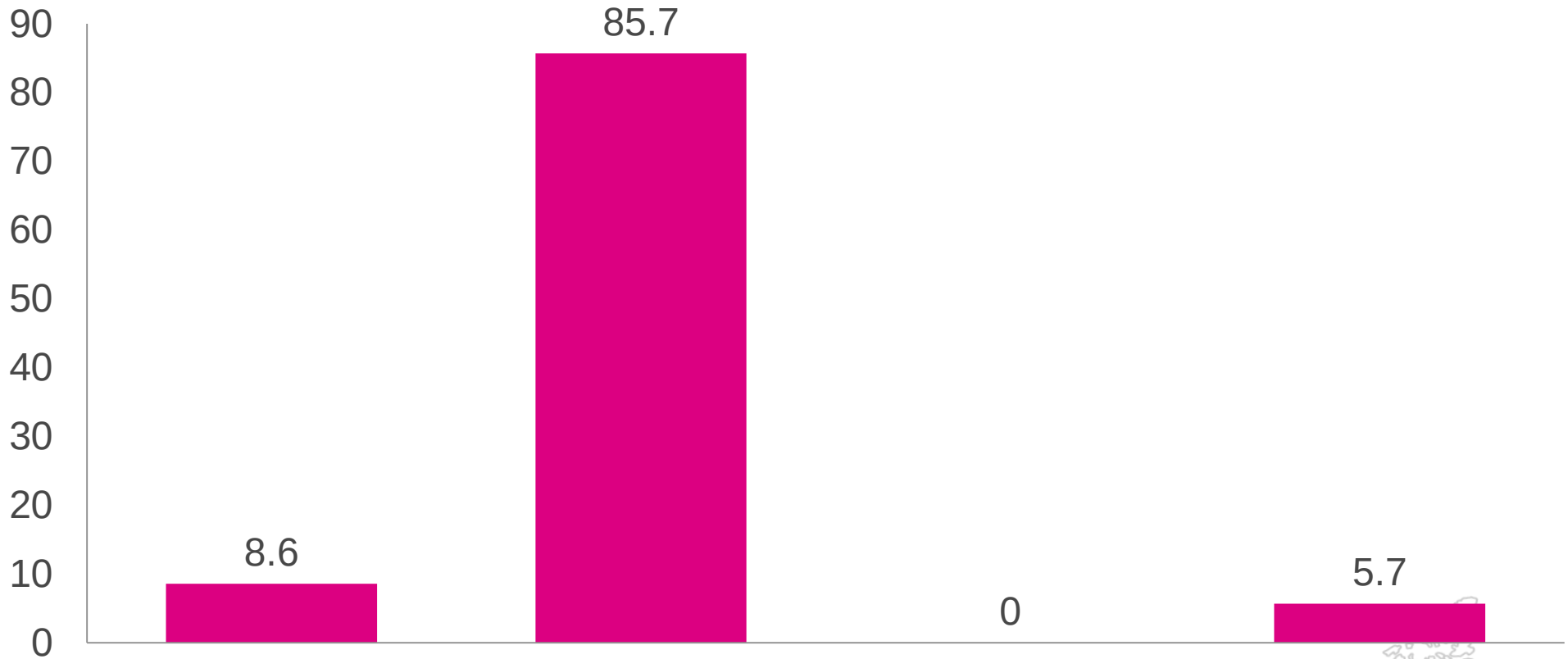


Do you routinely use ventilation/perfusion SPECT



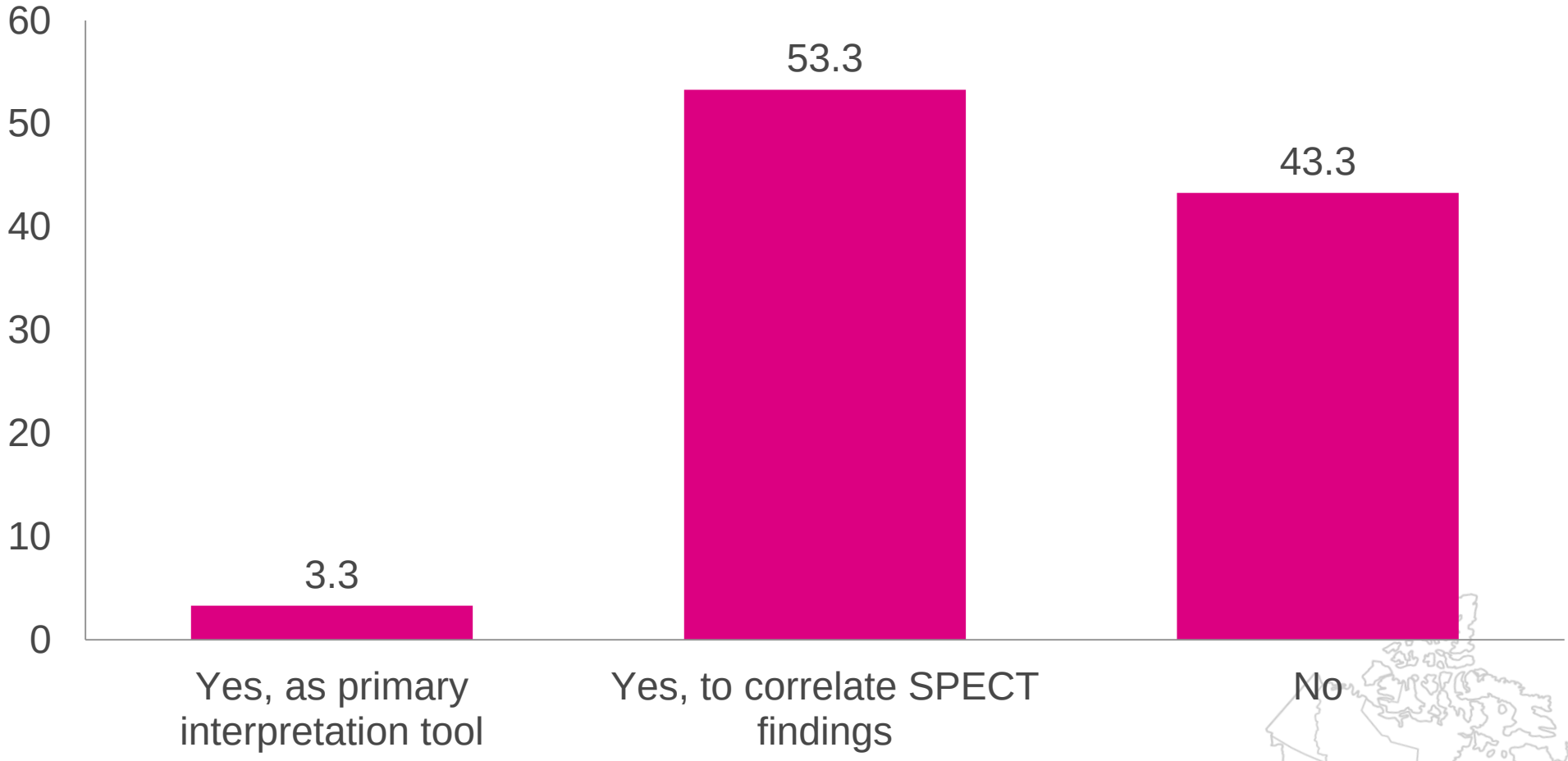
What is your routine exam for suspicion of acute pulmonary embolism?

Routine exam for centers performing routine SPECT



Do you use pseudoplanar images generated from SPECT data (not actually acquired, but generated from SPECT data)?

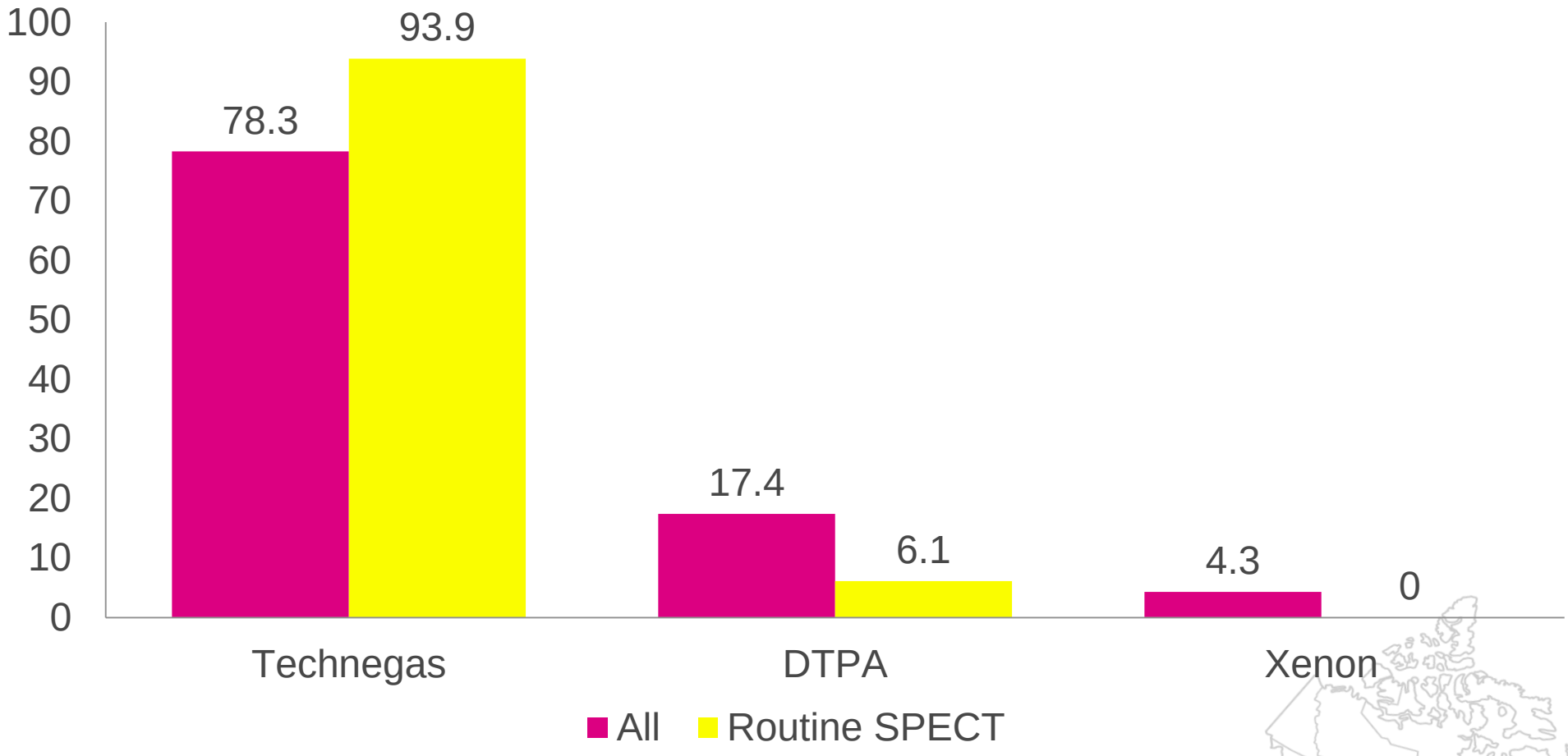
Use of Pseudoplanar Images*



*For those who perform SPECT

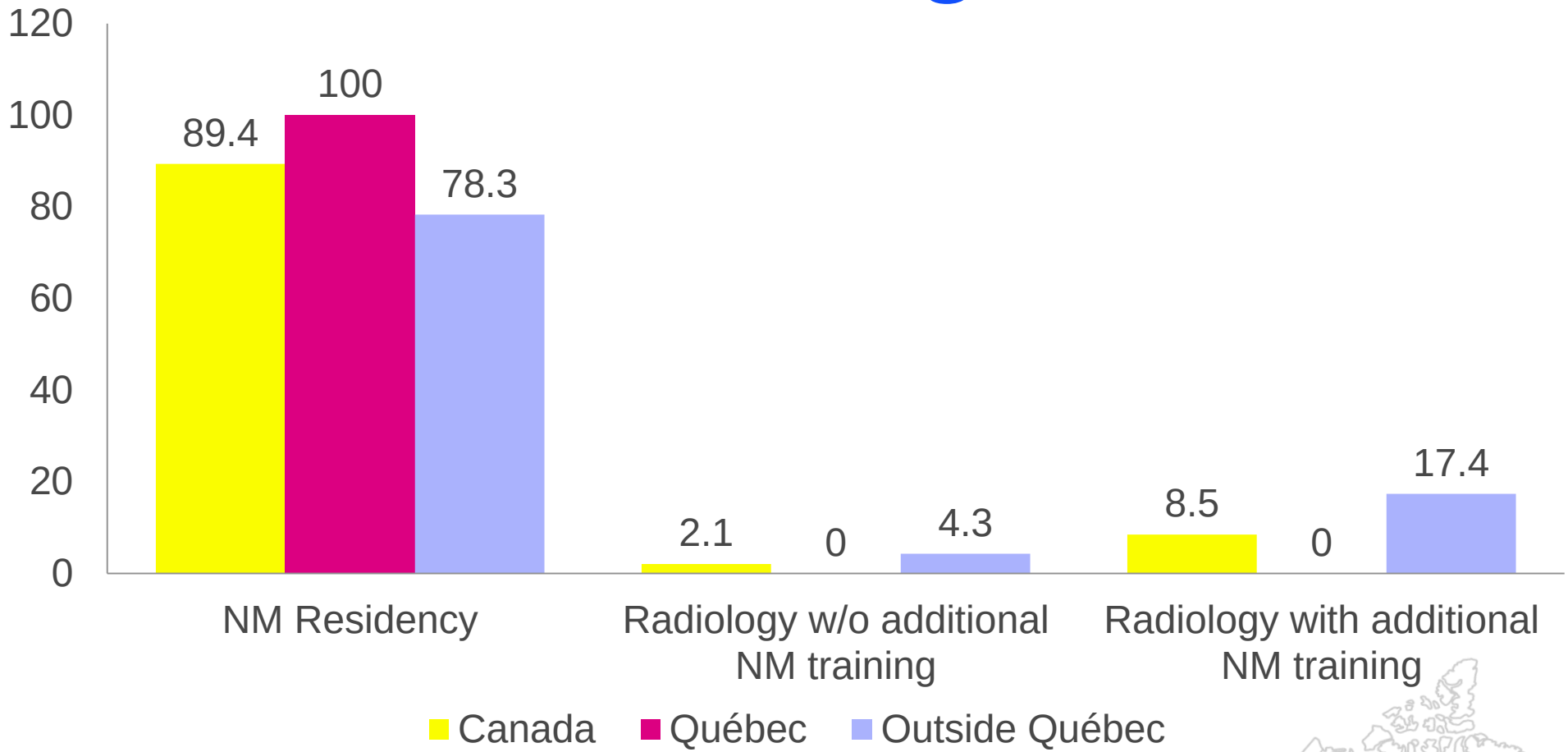
Which radiotracer do you usually use for ventilation imaging?

Ventilation Tracer



At your center, what is the training of the attendings reading ventilation/perfusion scintigraphy? Select all that applies

Training


120
100
80
60
40
20
0
89.4
100
78.3
2.1
0
4.3
8.5
0
17.4
NM Residency
Radiology w/o additional NM training
Radiology with additional NM training
Canada
Québec
Outside Québec

CONCLUSION

Ottawa experience with V/Q scans

- Most V/Q scans are ordered by physicians from the Thrombosis Clinic
- Reflects different patient care
- ED physicians are ordering V/Q scans when there is a contra-indication to contrast

Ottawa experience with V/Q scans

- 1/3 of patients with intermediate probability of PE on planar V/Q will receive anti-coagulation therapy within 3 months

- SPECT is not performed because our clinicians feel that there is a lack of good prospective data and overall good performance of planar V/Q scintigraphy

Current practices in Canada

- NM physician contacted by email
- A total of 75 responses were obtained
- 48 unique responses were used
- Response rate of 30.4%

Current practices in Canada

- 73% of Canadian centers are routinely using SPECT
  - » 92% in Québec
  - » 54% outside Québec

- Of those centers, the vast majority (86%) are using SPECT ventilation-perfusion imaging alone, without planar images or SPECT-CT

Merci!

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