

Clinicians' interpretation of ventilation/perfusion lung scan reports: Where are we today?

A Ismail,¹ MB BCh, FCNP (SA), MMed (Nucl Med) ; M Wong,² MB BCh, FCP (SA), FCCP, FRCP (Lond); S Dhooth,¹ MB BCh, FCNP (SA), MMed (Nucl Med); M D T Vangu,¹ MD, FCNP (SA), MMed (Nucl Med), MSc, PhD

¹ Department of Nuclear Medicine, Charlotte Maxeke Johannesburg Academic Hospital and Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

² Division of Pulmonology, Department of Internal Medicine, Chris Hani Baragwanath Hospital and Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

Corresponding author: A Ismail (draismail94@gmail.com)

Background. Clinicians' interpretation of lung scan reports will determine which further management decisions are taken when potentially fatal pulmonary embolism (PE) is suspected.

Objectives. To assess current referring clinicians' interpretation of the terminology used in ventilation/perfusion (V/Q) scan reports, whether this interpretation is affected by experience level, and how it affects clinical management decisions.

Methods. This was a questionnaire-based cross-sectional study. Between September 2020 and May 2021, 300 questionnaires were distributed among clinicians who refer patients for V/Q scans.

Results. Of the 162 clinicians who responded, 94% thought that there is >85% likelihood of PE or definitely PE present when a scan is reported as 'high probability of PE'; 87% interpreted 'low probability of PE' as <10% likelihood of PE or definitely no PE present. Overall, ≥70% of clinicians across all experience levels correctly interpreted the intended meaning of probability categories according to the Modified Prospective Investigation of Pulmonary Embolism Diagnosis (PIOPED) II criteria. Of the respondents, 77% agreed that clinically significant PE is ruled out by a normal scan. Further investigation for inconclusive findings, features of parenchymal lung disease and cardiomegaly were selected by 72%, 93% and 98% of clinicians, respectively.

Conclusion. The findings of this study regarding high-probability scan results were in line with existing literature on lung scan report interpretation. However, our findings regarding low-probability scan results and negative V/Q scan specificity contrasted with the findings in these articles, suggesting that clinicians are now more familiar with lung scan interpretation guidelines. Experience level did not significantly affect interpretation of reports. Although most clinicians agreed that a negative scan excludes clinically significant PE, two-thirds of them would still subject the patient to further unnecessary investigations to exclude PE.

Keywords. Pulmonary embolism, clinician's interpretation, lung scan.

Afr J Thoracic Crit Care Med 2023;29(2):e271. <https://doi.org/10.7196/AJTCCM.2023.v29i2.271>

Study synopsis

What the study adds. Our findings regarding a low-probability ventilation/perfusion (V/Q) scan and the specificity of a negative V/Q scan contrasted with previous articles on lung scan interpretation, suggesting that clinicians are now more familiar with lung scan interpretation guidelines.

Implications. Although most clinicians understood the negative predictive value of a V/Q scan, 20% would still investigate further with computed tomography pulmonary angiography or treat as confirmed pulmonary embolism. Education of clinicians about the negative predictive value of V/Q scans is important to avoid unnecessary radiation or anticoagulation.

Pulmonary embolism (PE) is responsible for 10% of deaths in hospitalised patients.^[1,2] Prompt diagnosis and treatment of PE are critical, as undiagnosed PE is associated with high rates of morbidity and mortality.^[1-4] Untreated PE results in morbidity from pulmonary hypertension, recurrent PE and right ventricular failure.^[1-4] Conversely, an inaccurate diagnosis of PE and resultant inappropriate anticoagulation places a patient at risk of bleeding, thrombocytopenia and drug-induced hypersensitivity reactions.^[1-4] Diagnostic lung imaging may include

computed tomography pulmonary angiography (CTPA) or ventilation/perfusion (V/Q) scintigraphy. The choice of investigation depends on several factors, including renal dysfunction, pregnancy, contrast allergy, radiation exposure, and the clinician's preference.^[2,3,5] An unambiguous conclusion on a V/Q scan report is essential for correct interpretation by clinicians and further patient treatment.

The choice of words in an imaging (nuclear medicine (NM)/radiology) report can influence the clinician's interpretation of it.

Variations in how a statement is worded or the actual words used can affect further decision-making.^[5-9] Articles on V/Q scan interpretation by Gray *et al.*^[6,7] and Siegel *et al.*^[10] showed that many clinicians have never fully understood the meaning of PE likelihood probabilities. A wide variation in the interpretation of probabilities by NM physicians themselves was also found.^[6,7]

The Modified Prospective Investigation of Pulmonary Embolism Diagnosis (PIOPED) II criteria developed in 2008^[5,11] have traditionally been used in our NM department for planar V/Q scan reporting. According to this system, a high probability of PE scan equates to >85% likelihood of PE.^[5] A very low probability of PE scan translates to <10% likelihood of PE.^[5] The likelihood of PE is reported as a linguistic probability (high, indeterminate, low or very low probability) and not numerical percentages.^[12] In the event of an abnormal chest radiograph, a V/Q single-photon emission computed tomography (SPECT) technique is used. Low-dose computed tomography (CT) can additionally be acquired for better visualisation of the lung fields. The interpretation criteria for V/Q SPECT include categories of 'PE present', 'PE absent' and 'non-diagnostic for PE', instead of using probabilities of PE.^[3] Use of the V/Q SPECT technique has become increasingly popular in the past decade. Planar V/Q imaging has a sensitivity of 67 - 85% and a specificity of 78 - 93%.^[2] The sensitivity and specificity of CT pulmonary angiography are similar, with values of 78 - 83% and 84 - 96%, respectively.^[5,11] V/Q SPECT has improved the sensitivity and specificity of V/Q scans to 96 - 99% and 91 - 98%, respectively,^[3,10] even in patients with abnormal chest radiographs and changes in lung parenchyma. Three-dimensional images have resulted in fewer inconclusive scans.^[2,3]

The greatest utility in the interpretation of lung scans is a normal V/Q scan, which essentially excludes clinically significant PE, irrespective of the pre-test probability.^[5,7,11] However, Gray *et al.*^[7] found that many clinicians still misunderstood the specificity of a normal V/Q scan. They reported that only 34% of 217 consultant physicians understood that a normal lung scan makes a diagnosis of PE highly unlikely. A normal report was interpreted to still mean an uncertain diagnosis by 31% of their respondents. Indeterminate V/Q reports are also frequently misinterpreted by clinicians as excluding PE.^[13] This misinterpretation is detrimental to patient care, as previous studies have shown that up to 30% of patients with indeterminate scans have proven pulmonary emboli on subsequent gold-standard imaging with angiography.^[13]

Our NM department has modified the acquisition of lung scans in certain cases (omitting the ventilation component) because of the COVID-19 pandemic. The modified acquisition of lung scans has resulted in a shift in our reporting style over the past 2 years. We use the Perfusion-only Modified PIOPED II system for patients who do not have a recent (<48 hours) negative COVID test. Perfusion images are compared with a recent (<24 hours) chest radiograph or a low-dose CT scan of the chest. Like V/Q SPECT-CT, this system includes categories of PE present, PE absent and non-diagnostic for PE, instead of using probabilities of PE.^[2,12]

Our NM department is based at two large academic tertiary hospitals affiliated to the University of the Witwatersrand, South Africa. They serve the city of Johannesburg and surrounding regions. Approximately 1 500 V/Q studies are performed annually. Interaction with referring physicians mainly occurs when a V/Q scan is requested. The discussion focuses on the pre-test probability

of PE. Interaction with the referring clinician after the scan has been performed is limited. The NM report is the primary method of communication with referring physicians. The department therefore has very little feedback with regard to how referring clinicians interpret our V/Q scan reports. From anecdotal reports in the department, very few clinicians have noticed or enquired about the differences in reporting systems so far.

Publication of the articles^[6,7,10] on lung scan interpretation in 1993 and 2004 took place after the initial 1983 PIOPED I study. Since then, criteria for a diagnosis of PE, scanning technology and technique have changed substantially. Although many articles have been written on radiology reports in the past three decades, little has been published on current clinicians' interpretation of V/Q scans. The main objective of this study was to assess the referring clinicians' interpretation of the terminology used in V/Q scan reports. In addition, we aimed to assess whether this interpretation is affected by experience level and how interpretation affects clinical management decisions.

Methods

A questionnaire-based study was conducted among clinicians who refer patients to the NM department. Medical students and short-term visiting doctors were excluded from the sample. This was an observational, cross-sectional study. There were 300 online and paper-based questionnaires distributed between September 2020 and May 2021. The questions related to demographic details, including experience level, understanding of terminology used in reports, and impact on management decisions (see Appendix A (available online at <https://www.samedical.org/file/2028>) and Appendix B (<https://www.samedical.org/file/2029>) for the study information sheet and questionnaire). Respondents worked in the internal medicine, surgery and obstetrics and gynaecology (O&G) departments. The sample included interns, medical officers, registrars (residents/specialists in training) and specialist consultants.

The questionnaire was first validated in a pilot study. The Microsoft Forms survey collection tool (version 16.30, Microsoft 365, 2019; Microsoft USA) was used for online questionnaires. Data analysis was performed using Microsoft Excel (version 16.30) and Microsoft Word (version 16.30). Descriptive statistics were used. Categorical variables were presented as frequencies, percentages and graphs.

Permission was obtained from the University of the Witwatersrand Human research Medical Ethics Committee prior to commencement of the study (ref. no. M200320).

Results

Three hundred questionnaires were distributed and 162 completed responses were received. The majority of the respondents were registrars, who provided 68 (42%) of the responses overall, 37 responses (23%) were from interns and 33 (20%) were from consultants, while the smallest number of responses ($n=25$; 15%) was received from the category of medical officer.

Years of experience were categorised as 1, 2 - 5, 6 - 10 and >10 years. Of the respondents, 134 (83%) had ≥ 2 years of working in clinical medicine. Almost a quarter of the respondents were senior clinicians with >10 years of experience. The largest number of responses was received from registrars with 2 - 5 years of experience.

The majority of the responses (67%) were from the internal medicine department. Smaller and similar numbers of responses (16 - 17%) were received from the O&G and surgery departments.

Clinicians' interpretation of terminology used in V/Q scan reports

When asked to interpret the meaning of a scan reported as 'high probability of PE', the majority of clinicians (94%) responded that there is >85% likelihood of PE or definitely PE present. Overall, 124 clinicians (76%) considered the likelihood of PE to be >85% when the report mentioned 'high probability of PE'. Fig. 1 shows the proportions of responses for each category of clinician.

Fig. 2 shows that when a scan was reported as 'low probability of PE', most clinicians (n=141; 87%) interpreted this as <10% likelihood of PE or definitely no PE present. Overall, 127 clinicians (78%) considered the likelihood of PE to be <10% when the report stated 'low probability of PE'. Only one registrar entered a qualitative response under the option of 'other' and considered a 'low probability of PE' to be <5% likelihood of PE.

Participants were asked what terminology they preferred for V/Q scan reports. The preferred terminology for 81 clinicians (50%) when there was no PE present was 'no convincing evidence of PE'. This was followed by 61 clinicians (38%) who preferred the phrase 'scan is negative for PE'. A minority of clinicians preferred the terms 'normal' and 'PE absent'. When PE was present, the preferred terminology for 86 clinicians (53%) was 'findings consistent with PE', followed by 'scan is positive for PE' for 59 clinicians (36%). The phrases 'PE present' and 'abnormal V/Q scan' were preferred by a minority. This pattern was consistent in the consultant, registrar, medical officer and intern subcategories.

For a non-diagnostic V/Q report, 111 clinicians (68%) preferred the term 'inconclusive', while 43 (27%) preferred 'indeterminate'. There were 8 clinicians (5%) who preferred the term 'non-diagnostic', all of whom worked in internal medicine.

Approximately two-thirds of the clinicians surveyed preferred the use of numerical rather than qualitatively described PE probability.

Effect of experience level on interpretation of V/Q scan reports

Fig. 3 shows that ≥80% of clinicians with an experience range of 2 - 5 and 6 - 10 years correctly interpreted the meaning of high probability of PE according to the Modified PLOPED II guidelines. Of clinicians with 1 or >10 years of experience, <80% had the interpretation correct. Fig. 4 illustrates that of clinicians with an experience range of 6 - 10 years, 88% had the interpretation of low probability of PE correct according to the guideline. For the rest of the experience categories, 72 - 79% of clinicians correctly interpreted the meaning of low probability of PE according to the Modified PLOPED II guidelines.

Effect of clinicians' interpretation of the presence or absence of venous thromboembolism on further clinical management

Table 1 illustrates the course of action the clinicians would take in response to specific findings on a V/Q scan report.

Fig. 5 shows that the majority of respondents agreed with the statement that clinically significant PE is ruled out by a normal V/Q scan.

The percentage of respondents for each category was similar, with 26 consultants (79%), 54 registrars (81%), 19 medical officers (76%) and 26 interns (70%). The total number of clinicians in agreement was 125 (77%), and the total number not in agreement was 37 (23%).

Of the clinicians, 60% admitted to rarely or never contacting the NM physician if a report was unclear. The majority of these clinicians did not offer a specific reason for this. Several junior clinicians mentioned that they would rely on their supervising registrar to clarify a report if necessary. A few clinicians also mentioned that it is too time consuming to contact the relevant person in the NM department. The remaining 40% of clinicians reported that they had contacted the NM physician at least once to clarify a report.

Suggestion of further management by NM physicians

Of the respondents, 108 (67%) thought that advice by the NM physician regarding further management would be useful for all reports, 51 (31%) thought that it was necessary for inconclusive scans only, and 3 (2%) did not want further management advice on the report. Clinicians from all categories, but registrars in particular, did appreciate further management advice.

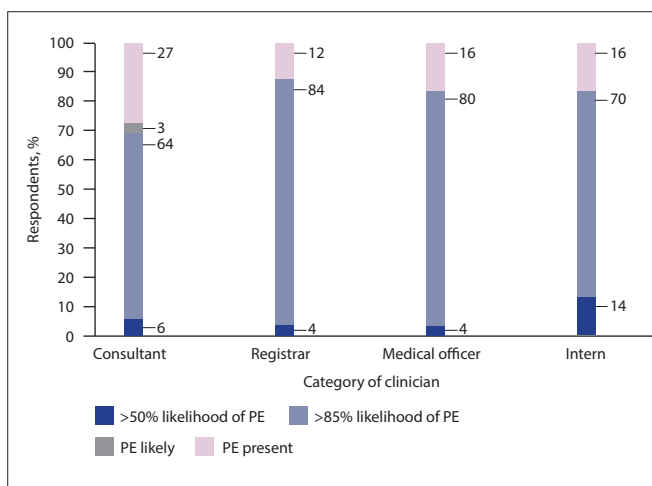


Fig. 1. Interpretation of V/Q scan reported as high probability for PE. (V/Q = ventilation/perfusion; PE = pulmonary embolism.)

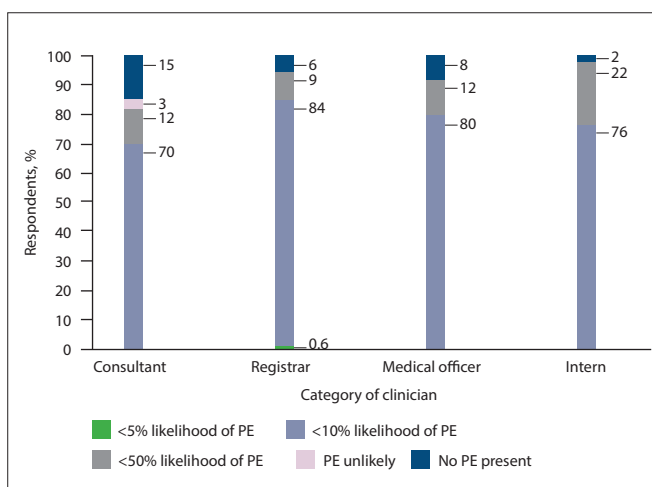


Fig. 2. Interpretation of V/Q scan reported as low probability for PE. (V/Q = ventilation/perfusion; PE = pulmonary embolism.)

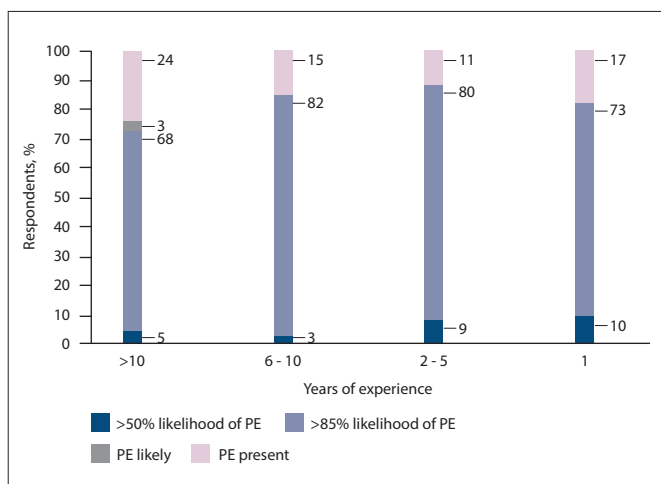


Fig. 3. Interpretation of V/Q scan reported as high probability for PE, by experience in years. (V/Q = ventilation/perfusion; PE = pulmonary embolism.)

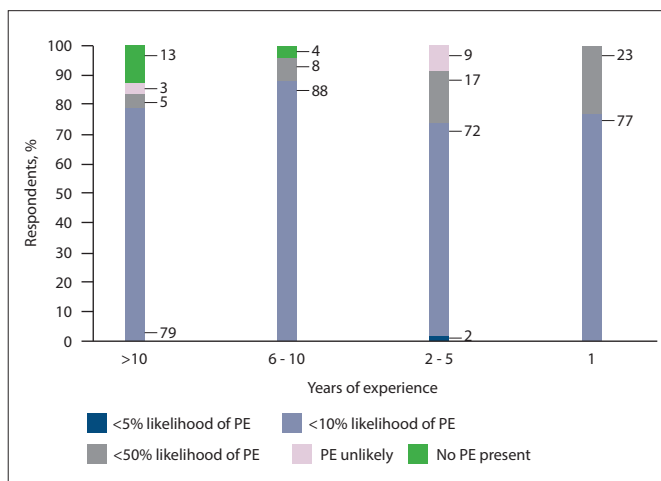


Fig. 4. Interpretation of V/Q scan reported as low probability for PE, by experience in years. (V/Q = ventilation/perfusion; PE = pulmonary embolism.)

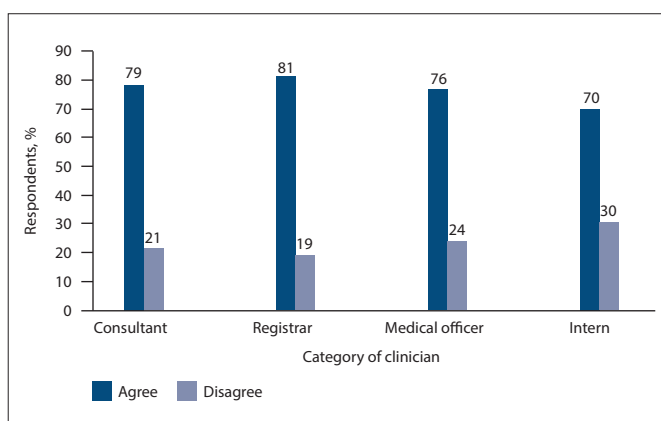


Fig. 5. Normal V/Q scan rules out PE. (V/Q = ventilation/perfusion; PE = pulmonary embolism.)

Discussion

The response rate to the questionnaire was relatively low at 54%.

Similar studies on V/Q scan interpretation^[6,7,10] had response rates of 44 - 64%. Data from a review of nine studies^[14] comparing online and paper-based questionnaires have shown the expected response rates to be 33% and 56%, respectively. Various specialties were therefore included in the present study in an attempt to increase the number of participants and ensure that responses were less biased in favour of those who are familiar with venous thromboembolism guidelines. The majority of responses were received from registrars. This is understandable, as they are the primary physicians at the bedside who review V/Q reports and treat patients accordingly. They also form the direct link between junior and senior doctors in academic institutions.

Clinicians' interpretation of terminology used in V/Q scan reports

Interpretation was assessed according to understanding and knowledge of terminology used in the Modified PIOPED II criteria. Use of the specific term 'PIOPED criteria' was omitted in the questionnaire, as many clinicians may not be familiar with this terminology.

Most clinicians correlated numerical likelihoods with phrases of probability correctly and understood the terms of the Modified PIOPED II criteria as intended. A high-probability scan was correctly interpreted by 94% of respondents, reflecting the finding by Gray *et al.*^[6] that 97% of clinicians understood the intended meaning of a high-probability scan. However, they found that for a low-probability scan, 43% of respondents would still have a working diagnosis of PE. In contrast, our study found that for a low-probability scan, only 13% of respondents would still consider a working diagnosis of PE. This was in line with a more recent study by Siegel *et al.*^[10] who had similar findings in 11% of their respondents. A reason for this difference may be that since the time of the article by Gray *et al.*^[6] the initial PIOPED criteria for low probability of PE (20% probability of PE) have been refined to increase the specificity.

Gray *et al.*^[6] found that only a third of consultant physicians understood that a normal lung scan makes a diagnosis of PE highly unlikely. A normal report still meant an uncertain diagnosis for a third of the physicians surveyed. This may have been due to the high negative predictive value of a normal V/Q scan not being well recognised outside the NM specialty at that time. If the clinician erroneously still considers the possibility of PE, it will result in either inappropriate anticoagulation therapy or unnecessary further investigations. In contrast, in our study, 77% of clinicians ($n=125$) agreed that a normal V/Q scan ruled out a clinically significant PE, and presumably would not use anticoagulation in these patients. Among consultant physicians, the proportion in agreement was 79%. This finding suggests that the high negative predictive value of a negative result for a V/Q scan is better appreciated today than at the time of publication of the previous articles.

Effect of experience level on interpretation of V/Q scan reports

Familiarity with PE investigation guidelines and commonly used phrases in reports is likely to differ depending on the frequency with which PE is encountered. When answers matching Modified PIOPED II groups correctly were broken down into each experience category, registrars and medical officers scored the highest. This is reassuring, as they are expected to make decisions regarding

Table 1. Clinical decisions in response to specific findings on a V/Q scan report

	Total, N (%)	Consultant, n (%)	Registrar, n (%)	Medical officer, n (%)	Intern, n (%)
Inconclusive V/Q scan					
Book CTPA if no contraindications	116 (72)	27 (82)	42 (63)	16 (64)	31 (84)
Therapeutic anticoagulation and repeat V/Q scan in 7 - 14 days	19 (12)	2 (6)	10 (15)	5 (20)	2 (5)
Use my clinical judgement and treat as PE	27 (16)	4 (12)	15 (22)	4 (16)	4 (11)
Features of parenchymal lung disease					
Treat as pneumonia	8 (5)	0	6 (9)	2 (8)	0
Investigate further	151 (93)	33 (100)	60 (90)	23 (92)	35 (95)
Ignore the comment	3 (2)	0	1 (1)	0	2 (5)
Cardiac outline enlarged					
Confirms cardiomegaly on CXR	72 (44)	13 (39)	30 (45)	14 (56)	15 (41)
Refer for cardiac review	88 (54)	19 (58)	36 (54)	11 (44)	22 (59)
Ignore the comment	2 (2)	1 (3)	1 (1)	0	0
High clinical suspicion for PE but scan is negative for PE					
Book CTPA if no contraindications	95 (59)	27 (82)	32 (48)	13 (52)	23 (62)
Consider another diagnosis	54 (33)	4 (12)	32 (48)	9 (36)	9 (24)
Trust my clinical judgement and treat as PE	13 (8)	2 (6)	3 (4)	3 (12)	5 (14)

V/Q = ventilation/perfusion; CTPA = computed tomography pulmonary angiography; PE = pulmonary embolism; CXR = chest radiograph.

anticoagulation and should be aware of the latest guidelines. The consultant (specialists) group scored the lowest for answering these questions correctly. This group was more likely than other groups to prefer the clearly stated options of 'PE present' or 'PE absent' instead of another likelihood option. This is in keeping with studies suggesting that experience level gives insight and confidence to commit to or rule out a diagnosis.^[9,15] Compared with the other groups, a slightly lower proportion of the intern group correctly interpreted the Modified PLOPED guidelines. The Royal College of Radiologists 2018 guidelines for reporting imaging investigations^[16] recommend that the report should be appropriate for the referrer. They suggest that the wording of a report should differ when written to a general practitioner as opposed to a specialist in a particular field. It is not always possible to do this in a hospital setting, but a clear report that is universally understood is achievable. Input from the referring clinician as the end user is important for guiding imaging physicians with regard to what clinicians want to see in reports.

Preferred terminology

The present study showed that only 4 - 9% of respondents preferred the conclusion of 'PE absent' or 'PE present', yet this is the terminology used in the guidelines for the Perfusion-only Modified PLOPED II system and V/Q SPECT-CT. All responses in our study were collected after the COVID-19 pandemic began, and our reporting style had changed in relevant cases. Radiology guidelines rarely consider preferences for reporting expressed by clinicians, and this may lead to confusion.^[8,17] The terms 'absent' and 'present' are straightforward to understand, and it is likely that clinicians prefer the other terms because of linguistic preference rather than clarity of meaning. Clinicians may also prefer probabilities or direct descriptions of 'scan is negative for PE' or 'scan is positive for PE', as this is the reporting

system that they have become accustomed to. While it is important to consider the clinicians' preferences, as they are the end users, it is also important to follow guidelines and standardise the use of terminology to avoid confusion.

The preference for terminology such as 'no convincing evidence of PE' and 'findings consistent with PE' found in the present study is in contrast to Hartung *et al.*,^[15] who suggest minimal use of terms of perception and avoiding redundancy. They are of the opinion that words such as 'is visualised' or 'there is evidence of' may be omitted without a change in meaning of the report.

For a non-diagnostic V/Q report, two-thirds of our respondents preferred the term 'inconclusive'. Only 5% of clinicians preferred the term 'non-diagnostic', which is used in the guidelines. These clinicians all worked in internal medicine and most were consultants. This finding suggests that preference for the term 'non-diagnostic' was not simply a random language preference but rather due to familiarity with the guidelines and terminology. No other specialties chose this unusual option. Unlike the words 'absent' and 'present', the term 'non-diagnostic' is not common language. In non-diagnostic cases, the use of an easily understood alternative term (such as 'inconclusive') may avoid confusion. Approximately two-thirds of clinicians would prefer the use of numerical instead of qualitatively described PE probability. These findings are in line with the literature, which advocates the use of numerical expression instead of technical language when describing the likelihood of PE to reduce confusion among clinicians.^[9,10,14,16,18]

Effect of clinicians' interpretation of the presence or absence of venous thromboembolism on further clinical management decisions

At our hospitals, CTPA is usually the investigation of choice when investigating PE. V/Q scans are usually requested in the presence

of contraindications to the use of contrast material, including renal dysfunction and allergy. V/Q scans are also predominantly used by the O&G department for pregnant patients in an attempt to decrease radiation exposure to the maternal breast tissue and fetus. There has been increased utilisation of V/Q scans for the investigation of chronic PE. An overloaded radiology department sometimes makes it more reasonable to choose a V/Q scan over CTPA, as an emergency scan may be obtained much sooner.

Inconclusive findings on a V/Q scan would lead the majority of the respondents (72%) to investigate further with CTPA, if there were no contraindications. However, if CTPA is contraindicated, another strategy needs to be employed. Very few respondents (12%) selected the option of treating with therapeutic doses of anticoagulation and repeating the perfusion-only scan in 7 - 14 days to assess for resolution of defects. This finding implies that clinicians are unaware of this option, which does not follow any specific guideline. Resolution of defects on subsequent V/Q imaging will indicate that fibrinolysis has occurred and a diagnosis of PE is likely. This is an option for further imaging that may be useful when CTPA is contraindicated.^[3] If CTPA is not absolutely contraindicated and the concern is more for avoiding radiation exposure (e.g. if the patient is a young woman with radiosensitive breast tissue), this approach may also be suitable.

The phrases 'features of parenchymal lung disease' and 'cardiac outline is enlarged' in the scan report would lead to further investigation and consideration of other diagnoses apart from PE by most respondents (93% and 98%, respectively). This is in agreement with Lukaszewicz *et al.*,^[9] who found that nearly all physicians felt obliged to further investigate abnormal findings mentioned in the report.

In the present study, most clinicians (77%) agreed that a normal V/Q scan ruled out a clinically significant PE. However, when asked about clinical management in response to a negative V/Q scan in the context of high clinical pre-test probability, only a third of clinicians would consider an alternative diagnosis. A significant proportion of clinicians (59%) would still investigate further with CTPA. This discrepancy is confusing to interpret, as we would expect 77% of clinicians to consider an alternative diagnosis once they had ruled out PE, and it suggests that many clinicians either do not trust or do not fully understand the negative predictive value of a V/Q scan. Clinicians may also be concerned about false-negative results. Dismissal of the negative predictive value of a V/Q scan potentially exposes the patient to unnecessary further radiation and anticoagulation. Education of clinicians about the negative predictive value of V/Q scans is therefore important. An efficient way to reach all clinicians reading the report may be to include a statement at the end of the report explaining the implication of a negative V/Q scan.

Two-thirds of our referring clinicians admitted to rarely or never contacting the NM physician if a report was unclear. This is concerning, as the NM department's location and telephone number together with the surnames of the reporting physicians (registrar and consultant) are clearly stated on all our reports. This finding highlights a need for the NM department to engage further with clinical departments to determine the reasons behind the lack of contact.

We found that most clinicians from all experience categories were in favour of receiving some advice on further management related to scan findings, which is similar to responses reported by

others.^[9,13] Lukaszewicz *et al.*^[9] found that a majority of physicians wanted specific recommendations on further imaging and follow-up and would appreciate a time frame. They also emphasised that the way in which recommendations are phrased determines whether the clinician follows them. They found that most clinicians would follow recommendations if they were stated outright. However, if terms such as 'if clinically indicated' were used, less than half of clinicians felt obliged to follow them.

Study limitations

A limitation of the present study is that the participants were clinicians from the two academic hospitals where the NM department is based. Clinicians from primary-, secondary- or other tertiary-level hospitals (not affiliated to the University of the Witwatersrand) were excluded, and this could have resulted in selection bias. The study findings may not be generalisable to all clinicians. Another limitation of the study was the low response rate of 54%. A future study including assessment of clinicians from academic-affiliated and non-affiliated hospitals throughout the country would be important to fully achieve the objectives of this study and increase the response rate. Expanding this study to include several countries would make the findings truly universal and unique.

The reasons for the preference for certain terminology by clinicians were not explored in the questionnaire used for this study. A qualitative future study exploring these reasons in detail would enable more definite conclusions.

Conclusion

This study found that the majority (77 - 78%) of respondents understood the Modified PLOPED and V/Q SPECT-CT interpretation guidelines as intended. We found that experience level did not significantly affect interpretation of reports. Clinicians' interpretation of the presence or absence of venous thromboembolism would result in further investigation by a majority of clinicians for scans with inconclusive findings, features of parenchymal lung disease and cardiomegaly. Although most clinicians agreed that a negative V/Q scan excludes clinically significant PE, not all of these clinicians would consider an alternative diagnosis.

The findings of this study regarding high-probability scan results were in line with the findings on lung scan interpretation reported by Gray *et al.*^[6,7] However, our findings regarding low-probability scan results and negative V/Q scan specificity contrasted with the findings in these articles, suggesting that clinicians are now more familiar with lung scan interpretation guidelines and the implications of findings in V/Q scan reports.

This study will help us to improve our reporting style to deliver reports with maximal clinical utility to our referring clinicians. It will assist in improving the management of a serious condition that often has an evasive diagnosis.

Declaration. MW is a member of the editorial board.

Acknowledgements. None.

Author contributions. AI: study conception and design, data acquisition, analysis and interpretation, drafting and editing of the manuscript, critical revision of important scientific content. MW: study conception and

interpretation of data, critical revision of important scientific content. SD: study design and interpretation of data, critical revision of important scientific content. MDTV: interpretation of data, critical revision of important scientific content. All authors approved the final manuscript for submission.

Funding. None.

Conflicts of interest. None.

1. Kearon C. Natural history of venous thromboembolism. *Circulation* 2003;107(23 Suppl 1):122-130. <https://doi.org/10.1161/01.CIR0000078464.82671.78>
2. Bajc M, Neilly JB, Miniati M, Schuemichen C, Meignan M, Jonson B. EANM guidelines for ventilation/perfusion scintigraphy: Part 1. Pulmonary imaging with ventilation/perfusion single photon emission tomography. *Eur J Nucl Med Mol Imaging* 2009;36(8):1356-1370. <https://doi.org/10.1007/s00259-009-1170-5>
3. Bajc M, Schümichen C, Grüning T, et al. EANM guideline for ventilation/perfusion single-photon emission computed tomography (SPECT) for diagnosis of pulmonary embolism and beyond. *Eur J Nucl Med Mol Imaging* 2019;46(12):2429-2451. <https://doi.org/10.1007/s00259-019-04450-0>
4. Jacobson BF, Louw S, Büller H, et al. Venous thromboembolism: Prophylactic and therapeutic practice guideline. *S Afr Med J* 2013;103(4 Pt 2):261-267. <https://doi.org/10.7196/SAMJ.6706>
5. Da Silva R, Shah M, Freeman L. Ventilation-perfusion (V/Q) lung scintigraphy: A long journey to a renewed position of prominence in diagnosing pulmonary embolism. *Clin Transl Imaging* 2014;2:369-378. <https://doi.org/10.1007/s40336-014-0077-8>
6. Gray HW, McKillop JH, Bessent RG. Lung scan reports: Interpretation by clinicians. *Nucl Med Commun* 1993;14(11):989-994. <https://doi.org/10.1097/00006231-199311000-00009>
7. Gray HW, McKillop JH, Bessent RG. Lung scan reporting language: What does it mean? *Nucl Med Commun* 1993;14(12):1084-1087. <https://doi.org/10.1097/00006231-199312000-00006>
8. Nickel B, Barratt A, Copp T, Moynihan R, McCaffery K. Words do matter: A systematic review on how different terminology for the same condition influences management preferences. *BMJ Open* 2017;7(7):e014129. <https://doi.org/10.1136/bmjopen-2016-014129>
9. Lukaszewicz A, Uricchio J, Gerasymchuk G. The art of the radiology report: Practical and stylistic guidelines for perfecting the conveyance of imaging findings. *Can Assoc Radiol J* 2016;67(4):318-321. <https://doi.org/10.1016/j.carj.2016.03.001>
10. Siegel A, Holtzman SR, Bettmann MA, Black WC. Clinicians' perceptions of the value of ventilation-perfusion scans. *Clin Nucl Med* 2004;29(7):419-425. <https://doi.org/10.1097/01.rlu.0000129122.44998.17>
11. Metter D, Tulchinsky M, Freeman LM. Current status of ventilation-perfusion scintigraphy for suspected pulmonary embolism. *AJR Am J Roentgenol* 2017;208(3):489-494. <https://doi.org/10.2214/AJR.16.17195>
12. Parker JA, Coleman RE, Grady E, et al. SNM practice guideline for lung scintigraphy 4.0. *J Nucl Med Technol* 2012;40(1):57-65. <https://doi.org/10.2967/jnmt.111.101386>
13. Kember PG, Euinton HA, Morcos SK. Clinicians' interpretation of the indeterminate ventilation-perfusion scan report. *Br J Radiol* 1997;70(839):1109-1111. <https://doi.org/10.1259/bjr.70.839.9536900>
14. Nulty DD. The adequacy of response rates to online and paper surveys: What can be done? *Assess Eval High Educ* 2008;33(3):301-314. <https://doi.org/10.1080/02602930701293231>
15. Hartung MP, Bickle IC, Gaillard F, Kanne JP. How to create a great radiology report. *Radiographics* 2020;40(6):1658-1670. <https://doi.org/10.1148/rg.2020200020>
16. Royal College of Radiologists. Standards for interpretation and reporting of imaging investigations: Second edition. 2018. <https://www.rcr.ac.uk>. <https://www.rcr.ac.uk/publication/standards-interpretation-and-reporting-imaging-investigations-second-edition> (accessed 31 July 2021).
17. Farmer CI, Bourne AM, O'Connor D, Jarvik JG, Buchbinder R. Enhancing clinician and patient understanding of radiology reports: A scoping review of international guidelines. *Insights Imaging* 2020;11:62. <https://doi.org/10.1186/s13244-020-00864-9>
18. Panicek DM, Hricak H. How sure are you, doctor? A standardised lexicon to describe the radiologist's level of certainty. *AJR Am J Roentgenol* 2016;207(1):2-3. <https://doi.org/10.2214/AJR.15.15895>

Submitted 12 August 2022. Accepted 2 May 2023. Published July 2023.