Ventilation / Perfusion Imaging for Pulmonary Embolic Disease

1. Purpose
This guideline must be read in conjunction with the BNMS Generic Guidelines. The purpose of this guideline is to assist specialists in Nuclear medicine and Radionuclide Radiology in recommending, performing, interpreting and reporting the results of lung scintigraphy for pulmonary embolism. This guideline will assist individual departments in the development and formulation of their own local protocols.

2. Background
Ventilation and perfusion lung imaging is an accurate, non-invasive way of evaluating ventilation and perfusion. Ventilation and perfusion to broncho-pulmonary segments is matched in a healthy individual. In pulmonary embolic disease, segmental reduction in perfusion occurs with maintenance of normal ventilation. This leads to the mismatch of perfusion and ventilation in the broncho-pulmonary segment. In parenchymal lung disease matched ventilation and perfusion defects occur. In acute infection the ventilation defect may exceed the perfusion defect.

3. Common Indications

3.1 To determine the probability of pulmonary emboli
3.2 To monitor the degree of resolution of change in ventilation and perfusion following an episode of pulmonary emboli

Contraindications

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<tr>
<th>Type</th>
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<tbody>
<tr>
<td>Absolute</td>
<td>none</td>
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<tr>
<td>Relative</td>
<td>pregnant and breastfeeding patients</td>
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<td>patients with pulmonary hypertension</td>
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<td>patients with right to left shunts</td>
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4. Procedure

4.1 Patient Preparation
The study should be performed within 1 working day of receipt of the request form.
Ventilation and perfusion imaging should be performed as part of a single study. If, for logistical reasons, a perfusion-only study is performed which is abnormal, both ventilation and perfusion imaging should be undertaken when the opportunity for ventilation imaging occurs, as a perfusion defect can alter within a 24 hour period.
A chest x-ray performed within 24 hours should be reviewed before undertaking the study.
The pre-test probability of pulmonary embolic disease should be determined.
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If previous ventilation/perfusion studies have been performed, these should be available at the time of reporting.

4.2 Injection Technique

The $^{99}$Tc$^{m}$ MAA$^1$ vial should be agitated prior to withdrawing the dose. Immediately prior to injection, the syringe should be gently inverted a few times to ensure re-suspension of the particles. The radiopharmaceutical should be injected with patient supine. Patient should breath deeply during the injection. Blood must not be drawn back into the syringe.

4.3 Special Precautions

Patients who are breastfeeding should be advised to discontinue breastfeeding in accordance with ARSAC guidelines for nine hours following administration of radiopharmaceuticals. Consideration should be given to reducing the administered activity of both perfusion and ventilation agents when studying patients who are pregnant. Care should be taken to ensure that an equivalent number of particles are administered to these patients compared to those receiving the full activity.

5. Radiopharmaceutical

5.1 Perfusion Study

The radiopharmaceutical most commonly used for perfusion imaging is $^{99}$Tc$^{m}$ MAA.

ARSAC recommended diagnostic reference level is 100 MBq.

The usual paediatric administered activity is adjusted as per ARSAC 'Notes for Guidance' Dec 1998 p20.

The number of particles injected may range from a minimum of 60,000 to a maximum of 700,000; with the recommended average being 200,000. This latter statement particularly applies to patients with significant pulmonary hypertension.

5.2 Ventilation Study

Manufacturers' instructions for ventilation equipment must be followed with regard to single use instructions.

5.2.1 Aerosol
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\(^{99}\text{Tc}^m\text{DTPA}\) is administered via a nebuliser of which the patient should receive an administered activity not exceeding 80MBq in the lungs. The amount of administered activity should be reduced if the perfusion study is to be performed immediately after ventilation study. As both agents are labelled with \(^{99}\text{Tc}^m\) the count rate of the second study must be at least four times the count rate of the first study. The aerosol should be administered supine.

5.2.2 \(^{99}\text{Tc}^m\text{Technegas}\)

Technetium-labelled carbon particles are generated using a dedicated piece of equipment. Faulty operation of equipment may lead to large particles being produced, which will significantly impair the quality of the image. Diagnostic reference activity is 40MBq. Technegas should be administered with patient supine.

5.2.3 \(^{81}\text{Kr}^m\text{Krypton}\)

\(^{81}\text{Kr}^m\) is obtained from a \(^{81}\text{Rb}\) Rubidium/ \(^{81}\text{Kr}^m\) Krypton generator. Diagnostic reference activity is 6000MBq.

5.2.4 \(^{133}\text{Xe}\text{Xenon}\)

Diagnostic reference activity is 400MBq.

6. Image Acquisition

6.1 Camera / Collimator

The study is performed using a LFOV camera with a general purpose collimator. If \(^{99}\text{Tc}^m\) aerosols are used the ventilation study should be performed prior to the perfusion study. The \(^{81}\text{Kr}^m\) ventilation study may be performed after or simultaneously with the acquisition of the perfusion images. If using \(^{81}\text{Kr}^m\), the collimator should be selected to ensure no significant septal penetration occurs.

6.2 Patient position

The patient should be imaged, if possible, in the same position for both ventilation and perfusion imaging, unless the patient’s clinical condition prevents this.

6.3 Views

Ventilation and perfusion imaging should be performed in the following projections: anterior, posterior, left posterior oblique, right posterior oblique. Right lateral and left lateral views and right anterior and left anterior oblique.
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views may also be obtained. If ventilation with $^{133}$Xe Xenon is undertaken images will be acquired in the posterior view to include inspiratory, equilibrium and expiratory images.

6.4 Computer acquisition

A 128 x 128 or 256 x 256 matrix should be used or a pixel size between 2 – 4mm.

For lung perfusion 500K counts per view should be obtained. For lung ventilation using $^{99}$Tc$^{m}$ DTPA aerosol 100K counts per view. For $^{81}$Krypton gas ventilation imaging 300K counts per view.

6.5 Interventions

Nil.

7. Data Analysis

Not usually performed when V/Q performed for embolus detection.

8. INTERPRETATION & REPORTING

The following should be assessed and described in the report as appropriate:-

Homogeneity of tracer uptake

Presence of clumping of aerosol and central airways deposition

Perfusion and/or ventilation defects to include location, size and number

The interpretation should include an overall assessment of the likelihood of pulmonary embolism based on the scintigraphic findings. Modified PIOPED criteria may be used to provide probability information within the report. The report should include an assessment of the post-test probability of pulmonary embolism based on both the pre-test probability and the result of lung scintigraphy. The report should also contain advice to repeat the ventilation/perfusion lung scan at the end of the period of anti-coagulation where the study has been abnormal. Consideration should be given to the urgent transmission of the report if the results are likely to urgently affect patient management. This is essential when a large perfusion defect has been identified.

9. Discussion

9.1 Pitfalls

9.1.1 Hot spots on the perfusion image if clotting of blood occurs within the
9.1.2. Central airways deposition of aerosol or technegas. This may be due to chronic obstructive airways disease with central airways narrowing or poor technical quality. Poor peripheral penetration of aerosol will reduce the sensitivity of detecting mismatch for peripheral lesions.

9.1.3. Injection of $^{99}$Tc$^{m}$-MAA through a central line may result in particle adherence to the cannula and may also result in inadequate mixing in the pulmonary artery and lead to uneven distribution throughout the pulmonary artery territories. If the ventilation and perfusion imaging is not acquired with the patient in the same position mismatched patterns may be recorded which are not clinically significant. The position of the patient during imaging should be noted.

9.1.4. If the ventilation/perfusion imaging is not acquired with the patient in the same position mismatched patterns may be recorded which are not clinically significant.

9.1.5. Oesophageal activity may affect the interpretation of the images.

9.1.6. Previous pulmonary emboli may lead to persisting perfusion defects reducing the specificity of the test.

10. Controversies

10.1. There is debate in the literature about the optimum number of particles to be injected.

10.2. The use of the lateral and anterior oblique views.

10.3. Use of PIOPED reporting criteria

10.4. Role of CT and pulmonary angiography

11. References


Fazio F, Lavender PJ, Steiner RE (1978). $^{81}$mKrypton ventilation and $^{99}$mTc
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12. **Date Agreed/Approved**
April 2001

13. **Date for Review/Update**
April 2005

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These guidelines do not constitute a formal protocol but highlight the aspects of a study where variation in practice may significantly affect the quality of outcome the study.