Lung Perfusion Scintigraphy

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1. Introduction

Perfusion scintigraphy is a diagnostic imaging procedure that records the distribution of the pulmonary arterial blood flow. Each, in principal conical, bronchopulmonary segment is supplied by a single artery. A thrombus affecting an individual pulmonary artery therefore results in a characteristic lobar, segmental or subsegmental peripheral wedge-shaped defect with the base projecting to the lung periphery. The basic principle of the perfusion scintigraphy is based on an intravenous injection of technetium ^{99m}Tc labelled macro aggregated albumin particles. A pulmonary embolism will block a small fraction of pulmonary capillaries and thereby enable scintigraphic assessment of lung perfusion at the tissue level. Where there is an occlusion of pulmonary arterial branches, the peripheral capillary bed will not receive the radioactive particles, rendering the area 'cold' on subsequent images.

2. Methodology

This guideline is based on available scientific literature on the subject, the previous guideline (Aanbevelingen Nucleaire Geneeskunde 2007), international guidelines from EANM and/or SNMMI if available and applicable to the Dutch situation.

3. Indications

- Determination of the likelihood of pulmonary embolism
- To document the degree of resolution of pulmonary embolism
- Quantification of regional pulmonary function before oncological pulmonary surgery, lung volume reduction surgery and lung transplantation surgery
- Evaluation of congenital heart disease such as cardiac shunts, pulmonary arterial stenosis and arteriovenous fistulae and there treatment
- Evaluation of the cause of pulmonary hypertension

4. Relation to other diagnostic procedures

The introduction of the Multidetector CT angiography (MDCT) with high spatial and temporal resolution and good quality of arterial opacification has made this technology the method of choice for imaging pulmonary vasculature in lots of hospitals. It allows adequate visualisation of the pulmonary arteries up to at least segmental level. Another advantage of MDCT is the finding of an alternative diagnosis.
Pulmonary angiography was used as the gold standard from the late 1960s onwards. The era of digital subtraction angiography has improved image quality. It is a reliable but invasive imaging test which is currently useful when the results of non-invasive imaging tests are equivocal.

5. Medical information necessary for planning

- History (onset of complaints, history of VTE)

- Results of a D-dimer test
- Determination of the pretest probability of pulmonary embolism by for example the Wells-score
- A recent (within 24 h) chest X-ray
- Prior lung scintigraphy findings

6. Radiopharmaceutical

Tracer:	^{99m}Tc-MAA
Nuclide:	Technetium-99m
Activity:	80-120 MBq (the number of particles should be in the range of 100.000 - 250.000)
Administration:	Labelled MAA particles will settle at the bottom of the vial with time. Contents of vials should be mixed before a dose is withdrawn and the syringe should be inverted before injection

7. Radiation safety

In patients who are pregnant consider reducing the administered activity of technetium ^{99m}Tc- labelled macroaggregated albumin particles. Usually half of the normal dose will be sufficient.
Breast feeding should be interrupted for 12 h according to ICRP 106.
Adult Perfusion radiation dose: 0,8-1,4mSv
Perfusion SPECT-CT: 1,2-4mSv (dependent of the tissue density of the scanning area).

8. Patient preparation/essentials for procedure

Patient preparation

- A chest X-ray should be obtained before lung scinitgraphy for pulmonary embolism. A chest X-ray obtained in both the posterior-anterior and lateral projections is preferred. A anterior-posterior chest X-ray is acceptable only if the patient cannot tolerate a standard chest X-ray.
- Before intravenous administration of the ^{99m}Tc labelled macroaggragated particles the patient should be instructed to cough and to take several deep breaths. The injection should be with the patient in supine position, or in case of orthopnea as close to supine as possible. During the injection the patient should take several deep breaths.

Procedure

- Perfusion scintigraphy should be performed in combination with ventilation imaging as part of a single study. If, for logistical reasons, a perfusion-only study is performed and it is abnormal, ventilation imaging should be performed whitin 24 h.
- SPECT (with or without CT) may be useful in defining the size and location of the perfusion defects in individual segments. In several studies it is suggested in order to increase the diagnostic accuracy and to reduce the number of nondiagnostic scan results.

9. Acquisition and processing

Planar images

Energy:	^{99m}Tc setting, 140 keV
Window:	15%-20%
Collimator:	LEAP collimator

Counts: 500K counts per view
Computer: 128x128 or 256x256 matrix
Imaging can be performed immediately after the injection of the macroaggregated particles. Perfusion imaging should be performed in the following directions: anterior, posterior, right posterior oblique and left posterior oblique. Upon indication right lateral, left lateral,right anterior oblique and left anterior oblique views may be obtained.
Imaging is preferably performed in the upright position to increase chest cavity size and to minimize diaphragmatic motion. If necassary, images can be obtained in the supine position.

SPECT
Energy: ^{99m}Tc setting, 140 keV
Window: 15%-20%
Collimator: LEAP collimator
Counts Perfusion: 10-20s per projection
Computer: 128x128 or 64x64 matrix
For (preoperative) lungscan quantification each lung is divided into 3 equal rectangular regions of interest in anterior and posterior views. The activity in the 6 regions of interest is reported for the perfusion as well as for the ventialtion scintigraphy.

10. Interpretation
The interpretation should include an overall assessment of the likelihood of pulmonary embolism based on the scintigraphy findings. Most frequently used criteria for lung scan interpretation are the Modified PIOPED criteria or the PISAPED criteria. Normal perfusion scintigraphy rules out pulmonary embolism (>90%), two or more segmental perfusion defects indicate a high probability of PE (>90%).
The experienced nuclear medicine physician might be able to provide a more accurate interpretation of the lung scintigraph than is provided by criteria alone, by using a Gestalt interpretation. Such interpretation is usually based on detailed knowledge of the various, well known, lung image interpretive criteria.

A stripe sign (activity at the periphery of a perfusion defect) lowers the chance of pulmonary embolism in the zone of the perfusion defect that shows the stripe. Perfusion defects can have other causes than acute pulmonary embolism alone: old pulmonary embolism, obstruction of an artery by tumour or post radiation therapy. In the group of high risk patients the report can advise repetition of the lung scintigraphy at the end of the period of anti-coagulation therapy to evaluate the response. Low count ratios in the apex of the lungs may be caused by a patient's inability to take deep breaths. Extra pulmonary activity may be due to either right-to-left shunt or free ^{99m}Tc pertechnetate. An image of the head can differentiate free pertechnetate from a right-to-left shunt. Interpretation of preoperative lung scintigraphy should give the percentage of perfusion in the rectangular lung regions or more frequently in the left and right lung.

9. Report
The report should include the following findings:
- Homogeneity of tracer uptake

- Presence of hot spots due to accumilation of aggregates
- Perfusion defect including location, size and number
- Finaly the perfusion defect should be correlated to the ventilation study and described as matched defects (perfusion and ventilation defect are exactly the same), mismatched defects (preserved ventilation with abnormal perfusion), reversed mismatch (ventilation is more severely affected than perfusion) or the combination.
- The report should give an overall assesment of the likelihood of pulmonary embolism based on both the pre-test probability and the result of the lung scintigraphy.

10. Literature

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