

Regional Cerebral Blood Perfusion Scintigraphy

HS Broekhuizen-de Gast, University Medical Centre Utrecht (Retired)

1. Introduction

The intravenously administered radiopharmaceutical crosses the intact blood-brain barrier and is completely absorbed into the brain tissue via different routes. The regional accumulation of the radiopharmaceutical is directly related to the regional blood flow. Peak activity is reached within 2 min of i.v. injection. Suitable radiopharmaceuticals are ^{99m}Tc -HMPAO and ^{99m}Tc -ECD. These compounds have a lipophilic character. Fixation in the brain occurs through specific and non-specific binding and/or transformation into a hydrophilic compound, which can no longer leave the cell. It is likely that binding occurs both to neurons and glial cells. SPECT is essential for imaging. Planar images are not useful except for the diagnosis of brain death.

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

- a. Detection of cerebral ischaemia in the first 24 h.
- b. Prognosis with regard to survival after stroke.
- c. Focus localisation in complex partial epilepsy.
- d. Differential diagnosis in dementia: Alzheimer's, multi-infarct or fronto-temporal dementia.
- e. Vasospasm after subarachnoid haemorrhage.
- f. Detection of brain death.
- g. Brain trauma.

4. Relation to other diagnostic procedures

Ultrasound, diffusion-weighted MRI and/or MRA (angiography) also provide information on cerebral vascularisation.

5. Medical information necessary for planning

- a. Neurological history.
- b. Recent CT and/or MRI investigation.
- c. Neuropsychological examination data.
- d. EEG investigation.

6. Radiopharmaceutical :

Tracer: ^{99m}Tc -exametazime (HMPAO), ^{99m}Tc -ethyl cysteinyl dimer (ECD)
 Nuclide: Technetium-99m
 Dosage: 500 MBq
 Administration: Intravenous

7. Radiation safety

See radiation dosimetry pag. 745

8. Patient preparation

- Cerebral activity affects the regional blood flow. Environmental factors during the injection, such as light and sound, should be standardised as much as possible.
- Patient lies in a quiet and comfortable room.
- Patient keeps eyes open but may not speak or read.
- I.v. cannulation occurs well in advance of the administration of the radiopharmaceutical
- No interaction with the patient is allowed before, during and for 5 min after administration.
- On the day of the investigation caffeine, alcohol and medication that influence cerebral perfusion must be avoided.
- Concurrent administration of sedatives influences the distribution of the radiopharmaceutical. If sedation is necessary, administration should occur at least 5 min after that of the radiopharmaceutical.

9. Acquisition and processing

- a. Patient:

Appropriate head restraint should be applied. Analogous to CT, slices are usually made parallel to the canthomeatal line. Thus, the head should be positioned with the cantomeatal line perpendicular to the axis of rotation of the gamma camera.
- b. Gamma camera and computer

Energy: ^{99m}Tc -setting, 140 keV.
 Window: 15-20%.
 Collimator: LEHR. The track around the head should be as small as possible. For proper image formation, the rotation radius should be no greater than 20 cm.
 Counting time: See computer.
 Computer: For computer reconstruction of SPECT see also the general section, 128x128 matrix, at least 60-64 acquisitions of 30 sec during one rotation of 360°.
- c. Recording can start 2 min after administration. However, acquisition up to 45 min post injection has no influence on the quality of the images.
- d. Processing of data: It is important to choose an appropriate filter that eliminates noise on the one hand and on the other hand allows structures such as the basal ganglia to remain visible. Attenuation correction should take place, with the exact attenuation coefficient to be determined experimentally using a homogeneously filled phantom for the relevant radionuclide.
- e. Check whether the slices obtained are perpendicular to the coronal and the transverse plane. If not, phantom images can easily arise.
- f. Images of transverse, coronal and sagittal sections of approximately 1 cm thickness are required. Coronal sections are particularly informative in the assessment of the temporal lobes.

10. Interpretation and pitfalls

- a. The head should be fixed in an appropriate restraint as a tilt of the head can cause apparent perfusion defects especially of the temporal lobe.
- b. Between 5 days and 3 weeks after a cerebrovascular accident, local hyperactivity can be found at the site of initial perfusion deficiency. This corresponds with contrast enhancement of the infarcted area on CT and is thought to be caused by permeability of the blood brain barrier. As such it has no particular significance with regard to the prognosis. After a few weeks, this area will once more show a defect. Thus, there is potential masking of a perfusion defect during this phase.
Crossed and uncrossed diaschisis is a frequently occurring functional phenomenon. Cortical infarction with contralateral hypoactivity in the cerebellum is often observed. This phenomenon can be maintained for weeks to months. Infarction of the thalamus can produce functional hypoactivity in the overlying cerebral cortex.
- c. Tumours can produce very variable images. Meningiomas are often hyperactive.
- d. A dilated ventricular system (e.g. normal -pressure hydrocephalus), in particular the posterior horn can produce a pseudo - dementia image. In this case quantification of regional activity usually produces normal values.

11. Report

- a. Mention the quality of the images. In practice this is strongly dependent on the amount of activity in cerebrum. It may be useful to evaluate the raw data on the contrast of brain versus facial and skull musculature.
- b. Describe the uptake in the cerebellum, the brainstem, the basal nuclei, the frontal, parietal, temporal and occipital cortex. Pay attention to asymmetry and less active areas. Any perfusion defects should be described with regards to the arterial basin, where possible (arteria cerebri media, anterior, posterior).
- c. The quantitative data are stated and compared to reference values.

12. Literature

- SNM Guidelines July 1, 2009: Procedure Guideline for Brain Perfusion SPECT Using 99mTc Radiopharmaceuticals 3.0*.
- Gerda Thomsen et al. Required timedelay from 99m TC-HMPAO injection to SPECT data acquisition: healthy subjects and patients with rCBF pattern. *Eur J Nucl Med Mol Imaging*.2008;35(12):2212-9.
- Duncan R. SPECT in focal epilepsies. *Behav Neurol* 2000;12:69-75.
- Henry TR, Van Heertum RL. Positron emission tomography and single photon emission computed tomography in epilepsy care. *Semin Nucl Med* 2003;33:88-104.
- Inoue K, Nakagawa M, Goto R, et al. Regional differences between 99mTc-ECD and 99mTc-HMPAO SPET in perfusion changes with age and gender in healthy adults. *Eur J Nucl Med Mol Imaging* 2003;30:1489-97.
- Kaneko K, Kuwabara Y, Sasaki M, et al. Posterior cingulate hypoperfusion in Alzheimer's disease, senile dementia of Alzheimer type, and other dementias evaluated by threedimensional stereotactic surface projections using Tc-99m HMPAO SPECT. *Clin Nucl Med* 2004;29:362-6.
- Kemp PM, Holmes C, Hoffmann SM, et al. Alzheimer's disease: differences in technetium-99m HMPAO SPECT scan findings between early onset and late onset dementia. *J Neurol Neurosurg Psychiatry* 2003;74:715-9.
- Kinuya K, Kakuda K, Nobata K, et al. Role of brain perfusion single-photon emission tomography in

traumatic head injury. Nucl Med Commun 2004;25:333-7.

- Lee DS, Lee SK, Kim YK, et al. The usefulness of repeated ictal SPET for the localization of epileptogenic zones in intractable epilepsy. Eur J Nucl Med Mol Imaging 2002;29:607-14.
- Lu G, Shih WJ, Ryo UY. Findings on Tc-99m HMPAO brain imaging in brain death. Clin Nucl Med 1996;21:891-3.
- Schaefer PW, Hassankhani A, Putman C, et al. Characterization and evolution of diffusion MR imaging abnormalities in stroke patients undergoing intra-arterial thrombolysis. Am J Neuroradiol 2004;25:951-7.
- Takasawa M, Watanabe M, Yamamoto S, et al. Prognostic value of subacute crossed cerebellar diaschisis: single-photon emission CT study in patients with middle cerebral artery territory infarct. Am J Neuroradiol 2002;23:189-193.
- Varma AR, Adams W, Lloyd JJ, et al. Diagnostic patterns of regional atrophy on MRI and regional cerebral blood flow change on SPECT in young onset patients with Alzheimer's disease, frontotemporal dementia and vascular dementia. Acta Neurol Scand 2002;105:261-9.