

Liver and Spleen Scintigraphy

MWJ Versleijen, Antoni van Leeuwenhoek, Amsterdam

1. Introduction

After intravenous administration of ^{99m}Tc labelled albumin or sulphur colloid, phagocytosis takes place in the cells of the reticuloendothelial system (RES), 85% of which is found in the liver (Kupffer cells), 5-10% in the spleen and 5-10% in the bone marrow and lungs. RES cells are distributed homogeneously in the liver and the spleen, which results in homogeneous uptake of an injected quantity of radioactive colloid. The various kits result in different liver-to-spleen uptake ratios. The identification of the preparation should therefore be stated clearly in the report, to avoid errors in comparing with previous scintigrams.

Accumulation in the liver depends on:

- a. RES function.
- b. The manner in which the colloid reaches the liver as a result of the hepatic-arterial to portal-venous blood flow ratio, the pressure and flow direction in the portal system, and any collateral flow in the case of large vein occlusion.
- c. Properties of the colloid, such as particle size, charge and serum factors (opsonins).

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. Semi-quantitative assessment of RES function and functional distribution between the liver, spleen and bone marrow, e.g. when parenchymal liver disease (cirrhosis, portal hypertension, hepatitis) is suspected.
- b. Demonstrating splenic infarction, accessory spleen localisation or to rule out congenital asplenia. In the later, labelled denatured erythrocytes are more useful since there is no (disturbing) liver uptake.
- c. Differentiation between focal nodular hyperplasia (FNH), haemangioma and liver adenoma. Given the risk of complications, an adenoma is resected if it exceeds 5 cm. A FNH lesion is resected only if symptomatic. A haemangioma is resected only if it causes symptoms or complications.
- d. Since the advent of (dynamic) PET or PET/CT, liver scintigraphy for diagnosis of liver metastases has become obsolete.

4. Relation to other diagnostic procedures

Ultrasound, multiple-phase CT and MRI are the examinations of choice for detecting and identifying most liver abnormalities. Differentiation between adenoma and FNH can also be performed by ^{18}F -fluoromethylcholine PET/CT. A haemangioma shows typical uptake on a haemangioma scintigraphy (Hepatic Haemangioma Scintigraphy, pag 327)

Combining liver and spleen scintigraphy, cholescintigraphy and erythrocyte (RBC) scintigraphy for discrimination between FNH, adenoma and haemangioma is possible but nowadays only very rarely used (see the table below). In addition to CT, MRI and ultrasound, PET/CT is frequently used for the detection of liver metastases. Different PET-tracers, depending on the characteristics of the primary tumour, are used for this indication. The liver-spleen scintigram is more suitable for measuring RES function than other techniques are.

	Liver-Spleen (colloid) scintigraphy	Cholescintigraphy	RBC scintigraphy	¹⁸F-fluoromethylcholine PET/CT
Adenoma	Focal defect. Low uptake possible.	Mostly no uptake. Possibly low uptake, without excretion	Normal uptake, sometimes slightly increased uptake.	Decreased or iso-intense uptake
FNH	Normal (60%) Cold (30%) Hot (10%)	Increased flow, normal uptake in relation to surrounding tissue, delayed excretion.	Normal uptake, sometimes slightly increased uptake.	Increased uptake
Haemangioma	Focal defect	Focal defect	Hypoperfusion, hot spot on late images.	

5. Medical information necessary for planning

- Clinical information: tentative or probable clinical diagnosis. Knowledge of the exact size and localisation of the suspect lesion is required for optimal interpretation of the investigation.
- Results of other relevant investigations (ultrasound, CT or MRI), if performed.

6. Radiopharmaceutical

Tracer: ^{99m}Tc tin colloid
 Nuclide: Technetium-99m
 Activity: 80 MBq
 Administration: Intravenous

7. Radiation safety

- Pregnancy:*
 The external radiation dose received by the foetus after oral administration of the radiopharmaceutical to the mother is approximately 0,152 mGy (0,0019 mGy/MBq).

Foetal risk is therefore low for this investigation. Nevertheless, the investigation should be postponed till after parturition whenever possible.

b. *Lactation*

According to ICRP 106 there is no need to interrupt breastfeeding, but due to possible free ^{99m}Tc pertechnetate it is advisable to interrupt the feeding for 4 h

c. *Effective dose (mSv/MBq)*

0,050; 0,028; 0,018; 0,012 and 0,0094 for respectively a 1-yr-, 5-yr-, 10-yr-, 15-yr old and an adult patient with a normal biological functioning.

8. Patient preparation/essentials for the procedure

Patient preparation

Preferably no barium investigation of the gastrointestinal tract due to possible barium accumulation in the hepatic flexure.

Essentials for the procedure:

none.

9. Acquisition and processing

- Dynamic investigation: information about the various perfusion phases (arterial phase via hepatic artery; 25% of the total blood flow and venous phase via the portal vein; 75%) are obtained using frames of 1 s/frame for 60 sec.
- Static images: 15-30 min after injection, anterior, posterior, left-lateral and right-lateral images are taken. Oblique images may sometimes also be necessary.
- It is recommended that SPECT images of the liver and spleen region are made, if possible combined with CT for attenuation correction and localisation. The SPECT or combined SPECT/CT images can be used to demonstrate small space occupying lesions in the liver with a considerably higher sensitivity than planar scintigraphy can achieve.
- Camera settings and processing:

Energy:	^{99m}Tc setting, 140 keV
Window:	15-20%
Collimator:	LEHR
Counting time:	Dynamic (perfusion phase); 1sec/frame for 1 min, Planar; 5 min per image or 500.000 counts per view
SPECT:	60 views 20 sec in a dual-head system, 120 views 20 sec in a single-head, non-circular orbit
Computer:	matrix 128×128 for planar images; 64×64 for SPECT images.

10. Interpretation and pitfalls

- When interpreting the results, it is important to remember that the half-value thickness of 140 keV gamma radiation in tissue is approximately 5 cm. This means, an accumulation defect located at a depth of approximately 20 cm in the right lobe of the liver visualised on an anterior image may not always be found on the posterior image.
- SPECT and SPECT/CT images increase the sensitivity of the liver and spleen investigation and can provide better insight into the localisation and progression of an

abnormality.

- c. The scintigram only visualises the RES in the liver, and not the hepatocytes. Diffuse parenchymal liver damage leads to a decrease in RES tissue in the liver, which results in increased/more intense splenic uptake of the colloid. The bone marrow will become clearly visible at a later stage.
- d. The liver-to-spleen uptake ratio should be assessed on the posterior image and depends on the radiopharmaceutical chosen. Comparing images made after the administration of different radiopharmaceuticals can therefore lead to incorrect interpretations.
- e. Areas of decreased uptake (cold spots) or inhomogeneous uptake are of little specificity. Pathological liver tissue, abscesses, cysts and an intrahepatic gall bladder do not contain RES tissue and are depicted as accumulation defects on the scintigram.
- f. A liver adenoma leads to a focal defect, sometimes with limited accumulation.
- g. FNH can show normal uptake (60%), decreased (30%) or increased uptake (10%). A hepatoma shows a focal defect.
- h. Thrombosis of the hepatic vein (Budd Chiari syndrome) shows decreased and irregular liver uptake, while uptake in the caudate lobe of the liver remains relatively normal.
- i. Insufficient quality of the radiopharmaceutical can result in flocculation and lung trapping after the injection.
- j. Determining liver and spleen volume by including two point sources (^{57}Co) 10 cm apart has become obsolete because these volumes can now be calculated from the digital CT and MRI images.

11. Report

Describe the relative uptake differences between the liver and spleen, the shape of both organs, outlines, configuration, homogeneity, any focal defects present and the extent of radiopharmaceutical uptake by the spleen, bone marrow and lungs. In the case of liver dysfunction, the bone marrow and spleen assume the RES function.

12. Literature

- Adekile AD, Owunwanne A, Al-Za'abi K, et al. Temporal sequence of splenic dysfunction in sickle cell disease. *Am J Hematol* 2002;69:23-7.
- De Carlis L, Pirota V, Rondinara GF, et al. Hepatic adenoma and focal nodular hyperplasia: diagnosis and criteria for treatment. *Liver Transpl Surg* 1997;3:160-5.
- Guze BH, Hawkins R. The utility of SPECT liver-spleen imaging in the evaluation of a possible accessory spleen. *Clin Nucl Med* 1988;13:496-7.
- Herman P, Pugliese V, Machado MA, et al. Hepatic adenoma and focal nodular hyperplasia: differential diagnosis and treatment. *World J Surg* 2000;24:372-6.
- Kim C.K., Worsley D.F. Radionuclide Imaging of Hepatic Function. In: Eli PJ, Gambhir SS, eds. *Nuclear Medicine in Clinical Diagnosis and Treatment*, 3rd ed. Edinburgh: Churchill Livingstone; 2004;15-22.
- Zuckerman E, Slobodin G, Sabo E. Quantitative liver-spleen scan using single photon emission computerized tomography (SPECT) for assessment of hepatic function in cirrhotic patients. *J Hepatol* 2003;39:326-32.
- Bieze M, Bennink RJ, El-Massoudi Y, et al. The use of 18F-fluoromethylcholine PET/CT in differentiating focal nodular hyperplasia from hepatocellular adenoma: a prospective study of diagnostic accuracy. *Nucl Med Commun*; 2013; 34(2):146-54.