Society of Nuclear Medicine Procedure Guideline for Hepatic and Splenic Imaging 3.0

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I. Purpose

The purpose of this guideline is to assist nuclear medicine practitioners in recommending, performing, interpreting, and reporting hepatic and splenic imaging studies.

II. Background Information and Definitions

A. Liver–spleen imaging is performed after the injection of a ^{99m}Tc-labeled colloid that has been rapidly phagocytized by the reticuloendothelial cells of the liver, spleen, and bone marrow.

B. Liver blood pool imaging is performed after the injection of ^{99m}Tc-labeled red blood cells for the detection of cavernous hemangiomas of the liver.

C. Hepatic perfusion studies are performed after the injection of ^{99m}Tc-macroaggregated albumin (MAA) through a hepatic artery catheter to determine that intra-arterially administered agents are delivered optimally.

D. Splenic imaging is performed after the injection of ^{99m}Tc-labeled heat-damaged red blood cells. Damaged red blood cells are taken up selectively by functioning splenic tissue.

III. Common Indications

A. Liver–Spleen Imaging
This study can be used for determining the size and shape of the liver and spleen as well as for detecting functional abnormalities of the reticuloendothelial cells of these organs. Specifically, these studies are occasionally performed:
1. For suspected focal nodular hyperplasia of the liver. These lesions often have normal or increased uptake on sulfur colloid imaging.
2. To assess the function of the reticuloendothelial system in patients with suspected liver disease. The decision to perform a liver biopsy or to continue treatment with a hepatotoxic agent may be influenced by the severity of liver disease that is seen on liver–spleen imaging.

B. Liver Blood Pool Imaging
This test is highly specific for cavernous hemangiomas of the liver. The sensitivity for detecting lesions of the liver (>2–3 cm) is also high. Hemangiomas as small as 0.5 cm may be detected with single-positron emission computed tomography (SPECT) using a multihead camera.

C. Hepatic Perfusion Imaging
This study is useful for demonstrating that hepatic artery catheters used to infuse chemotherapeutic or therapeutic radiolabeled microsphere agents are positioned optimally to perfuse liver tumors and to avoid perfusion of normal extrahepatic tissues (e.g., stomach).

D. Splenic Imaging
This study is used for detecting functional splenic tissue. This study is often performed:
1. In children to rule out congenital asplenia or polysplenia
2. In adults whose thrombocytopenia has been treated previously with splenectomy
3. For characterizing an incidentally noted mass as functional splenic tissue

IV. Procedure

A. Patient Preparation
No patient preparation is required.

B. Information Pertinent to Performing the Procedure
1. Relevant history and results of physical exam
2. The results of other anatomic imaging studies
3. The results of liver function tests
4. For splenic imaging, the results of a complete blood count and platelet count
5. For hepatic perfusion studies, the position of the hepatic artery catheter

C. Precautions

When red blood cells are labeled, strict adherence to a procedure designed to prevent the administration of one patient's labeled red blood cells into another patient is mandatory. Procedures and quality assurance for correct identification of patients and handling blood products are essential. See the Society of Nuclear Medicine *Procedure Guideline for Use of Radiopharmaceuticals*.

D. Radiopharmaceutical

1. Liver–spleen imaging

^{99m}Tc-sulfur colloid (SC) is preferred for liver–spleen imaging because the biodistribution and biokinetics of this agent are more reproducible than those of ^{99m}Tc-albumin colloid (AC). At the time of this revision, ^{99m}Tc-AC was no longer available in the United States.

2. Liver blood pool imaging

^{99m}Tc-labeled red blood cells can be labeled using in vitro, in vitro/in vivo, or in vivo methods. Methods with higher labeling efficiency (in vitro/in vivo or in vitro) may improve the results of imaging. Some experts recommend using only in vitro labeling.

3. Hepatic artery perfusion imaging

^{99m}Tc-MAA is injected slowly via the hepatic arterial catheter or infusion pump.

4. Splenic imaging

^{99m}Tc-labeled red blood cells typically are damaged by heating for 20 min in a waterbath at 49°–50°C.

E. Image Acquisition

1. Liver–spleen imaging

Imaging is begun 10–15 min or longer after the intravenous administration of ^{99m}Tc-colloid. Anterior, posterior, right lateral, right anterior oblique, and right posterior oblique images of the liver are commonly obtained. Left posterior oblique and left lateral views are added for evaluating the spleen. For small-field-of-view gamma cameras and standard amounts of administered activity, images are usually collected for a minimum of 300,000–500,000 counts. For large-field-of-view gamma cameras, an anterior image is

Radiation Dosimetry in Normal Adults

Radiopharmaceutical	Administered Activity MBq (mCi)	Organ Receiving the Largest Radiation Dose mGy/MBq (rad /mCi)	Effective Dose mSv /MBq (rem/mCi)
^{99m}Tc-colloid*	150–220 (4–6)	Spleen 0.074 (0.27)	0.014 (0.052)
^{99m}Tc-labeled red blood cells†	750–925 (20–25)	Heart 0.023 (0.085)	0.0085 (0.031)
^{99m}Tc-macroaggregated albumin	40–110 (1–3)	Liver Variable (Variable)	Variable (Variable)
^{99m}Tc–heat-damaged red blood cells‡	40–110 (1–3)	Spleen 0.56 (2.1)	0.041 (0.15)

*International Commission on Radiological Protection. *Radiation Dose to Patients from Radiopharmaceuticals.* ICRP report 53. London, UK: ICRP; 1988:180.

†International Commission on Radiological Protection. *Radiation Dose to Patients from Radiopharmaceuticals.* ICRP report 53. London, UK: ICRP; 1988:210.

‡International Commission on Radiological Protection. *Radiation Dose to Patients from Radiopharmaceuticals.* ICRP report 53. London, UK: ICRP; 1988:212.

Radiation Dosimetry in Children (5 Years Old)

Radiopharmaceutical	Administered Activity MBq/kg (mCi)	Organ Receiving the Largest Radiation Dose mGy/MBq (rad/mCi)	Effective Dose mSv/MBq (rem/mCi)
^{99m}Tc-colloid*	1.5–2.2 (0.04–0.06)	Spleen 0.25 (0.93)	0.041 (0.15)
^{99m}Tc-labeled red blood cells†	7.0–11.0 (0.2–0.3)	Heart 0.062 (0.23)	0.025 (0.093)
^{99m}Tc-macroaggregated albumin	1.5–2.2 (0.04–0.06)	Liver Variable (Variable)	Variable (Variable)
^{99m}Tc–heat-damaged red blood cells‡	0.7–1.5 (0.02–0.04)	Spleen 1.8 (6.7)	0.13 (0.48)

*International Commission on Radiological Protection. *Radiation Dose to Patients from Radiopharmaceuticals.* ICRP report 53. London, UK: ICRP; 1988:180.
†International Commission on Radiological Protection. *Radiation Dose to Patients from Radiopharmaceuticals.* ICRP report 53. London, UK: ICRP; 1988:210.
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usually acquired for 500,000–1 million counts. Subsequent images are then obtained for the same length of time as the anterior image. SPECT imaging may be helpful, particularly if focal disease is suspected.

Breath holding views may sometimes help clarify ambiguous findings by eliminating image degradation by respiratory motion. A size marker and a costal margin marker are needed for measuring liver and spleen size and for identifying anatomical landmarks.

2. Hepatic blood pool imaging

A rapid sequence of images (1 frame/s for 60 s) immediately after the injections may reveal useful information about regional variations in blood flow. This dynamic study should be performed in the view that is most likely to show the lesion. This view should be selected based on the location of the lesion of interest that usually has been documented on an earlier imaging study (i.e., computed tomography [CT], ultrasound, or magnetic resonance [MR] imaging). The initial flow study is optional.

Immediate blood pool images may be obtained in the view most likely to show the lesion, as well as anterior, posterior, and right lateral views. Generally these views are acquired for 1,000,000–2,000,000 counts. These immediate images are optional.

Delayed (45–180 min after injection) blood pool images are obtained in the view most likely to show the lesion, as well as anterior, posterior, and right lateral views. Generally these views are acquired for 1,000,000–2,000,000 counts. When the lesion is small (<2–3 cm) or if there are multiple lesions, SPECT imaging is recommended. If a high-quality delayed SPECT study is obtained, planar images are optional. SPECT facilitates comparison with CT and MR imaging.

3. Hepatic perfusion imaging

The radiopharmaceutical (^{99m}Tc-MAA) should be infused very slowly (<1 mL/min) at a measured rate through the hepatic perfusion catheter to avoid perturbing perfusion patterns that could result from streaming of the injectate. Imaging is performed immedi-

ately after the infusion of the agent. Anterior, posterior, and right lateral images of the liver containing 500,000–1,000,000 counts are typically acquired. Images of the lung are required to identify intrahepatic arteriovenous fistulas.

4. Splenic imaging
   Imaging may begin 30–120 min after the injection of the radiopharmaceutical. Anterior, posterior, and posterior oblique images of the expected location of the spleen should be acquired for 300,000–750,000 counts. If ectopic splenic tissue is a concern, the entire abdomen should be imaged. If the patient has had prior trauma that may have resulted in a diaphragmatic rupture, the chest also should be imaged. SPECT imaging facilitates comparison with CT and MR imaging.

F. Interventions
   None

G. Processing
   None

H. Interpretation Criteria

1. Liver–spleen imaging
   Most focal lesions in the liver will have less activity than the liver. Focal nodular hyperplasia may have activity equal to or greater than the surrounding liver in about 50% of patients. Finding normal activity or increased activity in a lesion is very suggestive of focal nodular hyperplasia.

   A relative radiocolloid "shift" (increased radionuclide deposition in the spleen and bone marrow relative to liver) may occur in hepatic dysfunction but also may be seen with portal hypertension, hypersplenism, marrow-active anemia as response to chemotherapy, and in some patients with malignant melanoma. Because of the variable particle size, colloid shift is more difficult to assess with ^{99m}Tc-AC than with ^{99m}Tc-SC.

2. Hepatic blood pool imaging
   The finding of markedly increased blood pool activity within a lesion is pathognomonic of a cavernous hemangioma of the liver. Hemangiomas typically have decreased or normal blood flow. Rarely, other tumors of the liver (e.g., angiosarcomas) have been reported to have increased blood pool on delayed images. However, they can usually be differentiated from cavernous hemangiomas by the fact that they also have increased blood flow.

   Cavernous hemangiomas that are 3 cm or greater in size almost always demonstrate markedly increased blood pool even on planar images. The sensitivity for detecting lesions <3 cm is improved by the use of SPECT imaging, particularly when multihead cameras are used. SPECT imaging is also helpful when there are multiple lesions in the liver and facilitates comparison with CT and MR imaging.

3. Hepatic perfusion imaging
   The images should be assessed for the presence of extrahepatic accumulation of activity (e.g. stomach, pancreas). Some lung activity may be seen with a properly positioned catheter as a result of arteriovenous fistulas in the liver. Significant lung uptake may preclude the administration of therapeutic radiolabeled microspheres. The presence of stomach or splenic activity indicates that the catheter is not optimally positioned.

4. Splenic imaging
   Functional splenic tissue is preferentially visualized when heat damaged blood cells are used.

I. Reporting

1. Liver–spleen imaging
   The size and shape of the liver and spleen and the relative amount of activity in the liver, spleen, and bone marrow should be noted. It is not always necessary to include measurements of liver or spleen size.

2. Hepatic blood pool imaging
   The report should include the results of other imaging studies when they are available. When multiple lesions have been noted on other imaging studies, the presence or absence of increased blood pool should be reported on a lesion-by-lesion basis when possible.

3. Hepatic perfusion imaging
   The approximate rate (mL / min) of the injection of the radiopharmaceutical should be included in the report. The presence of any extrahepatic activity should be noted. When indicated, the percentage of the activity in the lung should be reported.

4. Splenic imaging
   The time between injection and imaging should be reported, as well as the number, approximate size, and location of any functioning splenic tissue.

J. Quality Control
   None

K. Sources of Error

1. Liver–spleen imaging
   a. Anatomic variations
   b. Respiratory motion
   c. Colloid size: Small particles preferentially go to the bone marrow and large particles preferentially go to the spleen.

d. Artifacts resulting from radiation therapy
e. Breast attenuation artifact

2. Splenic imaging
   Degree of damage to the red blood cells

V. Issues Requiring Further Clarification

None

VI. Concise Bibliography

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VII. Disclaimer

The Society of Nuclear Medicine has written and approved guidelines to promote the cost-effective use of high-quality nuclear medicine procedures. These generic recommendations cannot be applied to all patients in all practice settings. The guidelines should not be deemed inclusive of all proper procedures or exclusive of other procedures reasonably directed to obtaining the same results. The spectrum of patients seen in a specialized practice setting may be quite different from the spectrum of patients seen in a more general practice setting. The appropriateness of a procedure will depend in part on the prevalence of disease in the patient population. In addition, the resources available to care for patients may vary greatly from one medical facility to another. For these reasons, guidelines cannot be rigidly applied.

Advances in medicine occur at a rapid rate. The date of a guideline should always be considered in determining its current applicability.