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Each practice guideline and technical standard, representing a policy statement by the College, has undergone a thorough consensus process in which it has been subjected to extensive review, requiring the approval of the Commission on Quality and Safety as well as the ACR Board of Chancellors, the ACR Council Steering Committee, and the ACR Council. The practice guidelines and technical standards recognize that the safe and effective use of diagnostic and therapeutic radiology requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the published practice guideline and technical standard by those entities not providing these services is not authorized.

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## **ACR–SNM–SPR PRACTICE GUIDELINE FOR THE PERFORMANCE OF LIVER AND SPLEEN SCINTIGRAPHY**

### **PREAMBLE**

These guidelines are an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, the American College of Radiology cautions against the use of these guidelines in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the physician or medical physicist in light of all the circumstances presented. Thus, an approach that differs from the guidelines, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in the guidelines when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of the guidelines. However, a practitioner who employs an approach substantially different from these guidelines is advised to document in the patient record information sufficient to explain the approach taken.

The practice of medicine involves not only the science, but also the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment.

Therefore, it should be recognized that adherence to these guidelines will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of these guidelines is to assist practitioners in achieving this objective.

### **I. INTRODUCTION**

This guideline was revised collaboratively by the American College of Radiology (ACR), the Society for Pediatric Radiology (SPR), and the Society of Nuclear Medicine (SNM).

This guideline is intended to assist interpreting physicians performing liver and spleen scintigraphy. Properly performed imaging with radiopharmaceuticals that localize in the reticuloendothelial system or in the blood pool of the liver and spleen can be used to assess certain disorders of the liver and spleen. Imaging of the hepatobiliary system is discussed in the ACR–SPR Practice Guideline for the Performance of Hepatobiliary Scintigraphy. Correlation of findings with clinical information and the results of other imaging modalities is frequently necessary to maximize the diagnostic yield.

Application of this guideline should be in accordance with the ACR Technical Standard for Diagnostic Procedures Using Radiopharmaceuticals.

## II. DEFINITION

Liver and spleen scintigraphy involves the intravascular administration of radiopharmaceuticals which localize in the reticuloendothelial cells or blood pool of the liver and/or spleen when given intravenously, or in the precapillary arterioles of the liver when injected through an arterial catheter into the hepatic artery. Imaging is performed with a gamma camera.

## III. GOAL

The goal of liver and spleen scintigraphy is to enable the interpreting physician to image hepatic and/or splenic tissue and to detect or characterize abnormalities of the liver and/or spleen by producing images of diagnostic quality.

## IV. INDICATIONS

The indications for liver and spleen scintigraphy include, but are not limited to:

1. Assessing the size, shape, and position of the liver and spleen.
2. Detecting, measuring, and monitoring masses of the liver and/or spleen.
3. Differentiating hepatic hemangiomas and focal nodular hyperplasia from other liver lesions.
4. Evaluating hepatic function in acute or chronic liver disease.
5. Confirming the patency of hepatic arterial perfusion catheters and evaluating the pattern of blood flow via these catheters, including aberrant perfusion and shunting.
6. Identifying functioning splenic tissue.
7. Evaluating suspected functional asplenia.

For the pregnant or potentially pregnant patient, see the ACR Practice Guideline for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation.

## V. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR Technical Standard for Diagnostic Procedures Using Radiopharmaceuticals.

## VI. RADIOPHARMACEUTICALS

### A. Technetium-99m Sulfur Colloid (SC)

Technetium-99m SC consists of particles composed of technetium-99m sulfide stabilized with gelatin. These particles average in size from 0.1 to 1.0  $\mu\text{m}$ . Given intravenously, they are phagocytized by the reticuloendothelial cells of the liver, spleen, and bone

marrow in proportion to relative blood flow, functional capacity of the phagocytic cells, and particle size. Maximum concentration in the liver and spleen occurs within 10 to 20 minutes, and the rate of biologic clearance from the reticuloendothelial cells is very slow. The usual administered activity is 111 to 222 MBq (3 to 6 mCi) for planar imaging in adults and up to 370 MBq (10 mCi) for single-photon-emission computed tomography (SPECT) imaging. Administered activity for children should be determined based on body weight and should be as low as reasonably achievable for diagnostic image quality.

### B. Technetium-99m-Labeled Red Blood Cells (RBCs) (Intravenous Administration)

See the ACR–SNM–SPR Practice Guideline for the Performance of Cardiac Scintigraphy and the ACR–SNM–SPR Practice Guideline for the Performance of Gastrointestinal Scintigraphy for RBC labeling techniques. See the ACR Technical Standard for Diagnostic Procedures Using Radiopharmaceuticals for handling of radiolabeled cells.

Hepatic hemangiomas are conspicuous with technetium-99m-radiolabeled RBC imaging because of their relatively greater blood volume than that of the surrounding liver parenchyma. They are typically identified when the radiolabeled RBCs reach equilibrium within the intravascular space of the hemangioma, which may be 30 to 60 minutes post injection or longer. Administered activity of up to 740 to 925 MBq (20 to 25 mCi) is commonly used. Procedures must be followed to ensure that the patient is injected with only autologous radiolabeled RBCs. Administered activity for children should be determined based on body weight and should be as low as reasonably achievable for diagnostic image quality.

### C. Technetium-99m Macroaggregated Albumin (MAA) (Intra-Arterial Administration)

See the ACR–SNM–SPR Practice Guideline for the Performance of Pulmonary Scintigraphy in Adults and Children. Technetium-99m MAA consists of particles of aggregated human serum albumin with a size range of 10 to 90  $\mu\text{m}$ . Given intra-arterially via a hepatic artery perfusion catheter, the MAA particles will localize within the liver in a distribution similar to that of the chemotherapeutic agent or therapeutic radiolabeled microspheres being introduced through the catheter. The usual adult administered activity is 37 to 185 MBq (1 to 5 mCi). Administered activity for children should be determined based on body weight and should be as low as reasonably achievable for diagnostic image quality.

#### D. Technetium-99m Heat-Damaged RBCs

Autologous RBCs are radiolabeled, preferably by the *in vitro* method, with an activity of 37 to 222 MBq (1 to 6 mCi) for planar imaging or 555 to 1,110 MBq (15 to 20 mCi) for SPECT imaging and heated for 15 minutes in a preheated water bath at 49.0 to 50.0 degrees C. After cooling to at least body temperature, the heat-damaged RBCs are administered intravenously, with imaging performed 20 to 30 minutes post injection. The heat-damaged RBCs will be preferentially sequestered by splenic tissue. The technique requires precision, as either insufficient or excessive damage to RBCs may produce variation in biologic distribution of the agent. See the ACR Technical Standard for Diagnostic Procedures Using Radiopharmaceuticals for handling of radiolabeled cells. Administered activity for children should be determined based on body weight and should be as low as reasonably achievable for diagnostic image quality.

### VII. SPECIFICATIONS OF THE EXAMINATION

The written or electronic request for liver and spleen scintigraphy should provide sufficient information to demonstrate the medical necessity of the examination and allow for its proper performance and interpretation.

Documentation that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). Additional information regarding the specific reason for the examination or a provisional diagnosis would be helpful and may at times be needed to allow for the proper performance and interpretation of the examination.

The request for the examination must be originated by a physician or other appropriately licensed health care provider. The accompanying clinical information should be provided by a physician or other appropriately licensed health care provider familiar with the patient's clinical problem or question and consistent with the state's scope of practice requirements. (ACR Resolution 35, adopted in 2006)

#### A. Planar Liver-Spleen Scan

Approximately 10 to 20 minutes after intravenous administration of technetium-99m SC, static planar images of the liver and spleen are obtained. Flow studies obtained during injection are occasionally useful. Anterior, posterior, right anterior oblique (RAO), left anterior oblique (LAO), right posterior oblique (RPO), and right lateral images should be acquired if possible. Additional views (left posterior oblique [LPO] and left lateral) may be indicated for more comprehensive evaluation of the spleen. Another anterior image may also

be acquired with a lead marker of known length to identify the right inferior costal margin and xyphoid process. This marker can also be used to calibrate the pixel size for organ size measurement. For small-field-of-view gamma cameras and standard administered activity, 300,000 counts per image is the usual minimum. For large-field-of-view gamma cameras, 500,000 to 1,000,000 counts per image are usually acquired in the anterior projection. Subsequent views may then be obtained for the same length of time as the first image.

#### B. SPECT Liver-Spleen Imaging

For a single-detector, large-field-of-view SPECT gamma camera, a 128 x 128 matrix, 6-degree angle of sampling (60 images in a 360-degree arc), and 20 to 30 seconds per image are appropriate parameters. For a multi-detector SPECT camera, a 128 x 128 matrix with a 3-degree angle of sampling (60 images per head for a dual-head camera or 40 images per head for a 3-head camera) can be used. SPECT/CT may be helpful for anatomic localization.

#### C. Radiolabeled RBC Hepatic Blood Pool Imaging (Intravenous Administration)

A rapid-sequence series of images (1 to 3 frames per second for 60 seconds) immediately upon injection may yield useful information about regional variations in blood flow. The projection should be chosen to optimally show the hepatic lesion (usually discovered during an earlier imaging study). Planar and SPECT imaging parameters are similar to those for sulfur colloid liver spleen images (as described above in sections A and B). When the lesion is small (less than 2 to 3 cm) or if there are multiple lesions, SPECT or SPECT/CT imaging may be helpful. Both early (0 to 30 minutes) and delayed (60 to 120 minutes) images are commonly acquired.

#### D. Perfusion of Hepatic Tumors

Technetium-99m MAA introduced into the hepatic arterial perfusion catheter should ideally be infused at a similar rate as the proposed therapeutic agent. Tracer distribution and shunting are assessed with static anterior and posterior images of the chest and abdomen. Additional static planar images and SPECT and SPECT/CT images can also be obtained as indicated. If SPECT/CT is not available, a useful alternative technique is to administer a separate intravenous injection of technetium-99m sulfur colloid 185 MBq (5mCi) which will localize throughout the entire liver, followed by a SPECT acquisition which may be coregistered to the MAA image using fusion software. This procedure will permit better characterization of the distribution of the MAA to the lobes or segments of the liver to which it was delivered. The pattern of activity helps to confirm the patency and desired position of the catheter. Pulmonary

shunting can be quantified and GI shunting detected for therapy planning.

#### E. Spleen (heat-damaged RBC) Imaging

The radiopharmaceutical, technetium-99m heat-damaged RBCs, is administered intravenously. Imaging of the abdomen may commence 30 minutes to 120 minutes later. Planar and SPECT or SPECT/CT imaging parameters are similar to those for liver-spleen imaging. If ectopic splenic tissue is being sought, the abdomen and pelvis should be imaged. If the patient has had prior trauma that might have ruptured the diaphragm, the chest should be imaged as well.

### VIII. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Guideline for Communication of Diagnostic Imaging Findings.

The report should include the radiopharmaceutical used and the dose and route of administration, as well as any other pharmaceuticals administered, also with dose and route of administration.

### IX. EQUIPMENT SPECIFICATIONS

A gamma camera with a low-energy all-purpose (LEAP) or low-energy high-resolution collimator may be used. SPECT or SPECT/CT may be used as indicated.

### X. RADIATION SAFETY

Radiologists, imaging technologists, and all supervising physicians have a responsibility to minimize radiation dose to individual patients, to staff, and to society as a whole, while maintaining the necessary diagnostic image quality. This concept is known as “as low as reasonably achievable (ALARA).”

Facilities, in consultation with the radiation safety officer, should have in place and should adhere to policies and procedures for the safe handling and administration of radiopharmaceuticals, in accordance with ALARA, and must comply with all applicable radiation safety regulations and conditions of licensure imposed by the Nuclear Regulatory Commission (NRC) and by state and/or other regulatory agencies. Quantities of radiopharmaceuticals should be tailored to the individual patient by prescription or protocol.

### XI. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION

Policies and procedures related to quality, patient education, infection control, and safety should be

developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education appearing under the heading *Position Statement on QC & Improvement, Safety, Infection Control, and Patient Education* on the ACR web page (<http://www.acr.org/guidelines>).

Equipment performance monitoring should be in accordance with the ACR Technical Standard for Medical Nuclear Physics Performance Monitoring of Gamma Cameras.

### ACKNOWLEDGEMENTS

This guideline was revised according to the process described under the heading *The Process for Developing ACR Practice Guidelines and Technical Standards* on the ACR web page (<http://www.acr.org/guidelines>) by the Guidelines and Standards Committee of the Commissions on Nuclear Medicine and Pediatric Radiology in collaboration with the SNM and the SPR.

#### Collaborative Committee

##### ACR

Darlene F. Metter, MD, Chair, FACR  
Lorraine M. Fig, MD, MB, ChB, MPH  
Michael J. Gelfand, MD  
Paul D. Shreve, MD

##### SPR

Larry A. Binkovitz, MD  
Massoud Majd, MD, FACR  
Marguerite T. Parisi, MD  
Stephanie E. Spottswood, MD

##### SNM

Helena R. Balon, MD  
Rachel A. Powsner, MD

#### ACR Guidelines and Standards Nuclear Medicine Committee

Jay A. Harolds, MD, FACR, Co-Chair  
Darlene F. Metter, MD, FACR, Co-Chair  
Richard K.J. Brown, MD  
Robert F. Carretta, MD  
Gary L. Dillehay, MD, FACR  
Mark F. Fisher, MD  
Lorraine M. Fig, MD, MB, ChB, MPH  
Leonie Gordon, MD  
Bennett S. Greenspan, MD, FACR  
Milton J. Guiberteau, MD, FACR  
Robert E. Henkin, MD, FACR  
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Eric M. Rohren, MD, PhD  
Henry D. Royal, MD

Paul D. Shreve, MD  
William G. Spies, MD, FACR  
Manuel L. Brown, MD, FACR, Chair, Commission

#### ACR Guidelines and Standards Pediatric Committee

Marta Hernanz-Schulman, MD, FACR, Chair  
Taylor Chung, MD  
Brian D. Coley, MD  
Seth Crapp, MD  
Kristin L. Crisci, MD  
Eric N. Faerber, MD, FACR  
Lynn A. Fordham, MD  
Lisa H. Lowe, MD  
Marguerite T. Parisi, MD  
Laureen M. Sena, MD  
Sudha P. Singh, MB, BS  
Donald P. Frush, MD, FACR, Chair, Commission

**Suggested Reading** (Additional articles that are not cited in the document but that the committee recommends for further reading on this topic)

1. Armas RR, Thakur ML, Gottschalk A. A simplified method of selective spleen scintigraphy with Tc-99m-labeled erythrocytes: clinical applications. Concise communication. *J Nucl Med* 1980;21:413-416.
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6. Treves ST, Jones AG. Liver and spleen. In: Treves S, ed. *Pediatric Nuclear Medicine*. 3rd edition New York: Springer-Verlag; 2007:209-238.
7. Zheng JG, Yao, ZM, Shu, CY, Zhang, Y, Zhang X. Role of SPECT/CT in diagnosis of hepatic hemangiomas. *World J Gastroenterol* 2005;11:5336-5341.
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\*Guidelines and standards are published annually with an effective date of October 1 in the year in which amended, revised or approved by the ACR Council. For guidelines and standards published before 1999, the effective date was January 1 following the year in which the guideline or standard was amended, revised, or approved by the ACR Council.

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