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The American College of Radiology will periodically define new practice guidelines and technical standards for radiologic practice to help advance the science of radiology and to improve the quality of service to patients throughout the United States. Existing practice guidelines and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

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.

Amended 2006 (Res. 35)\*

## **ACR PRACTICE GUIDELINE FOR THE PERFORMANCE OF MAGNETIC RESONANCE IMAGING (MRI) OF THE LIVER**

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### **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 on 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**

Magnetic resonance imaging (MRI) of the liver is a proven and useful tool for the evaluation, assessment of severity, and follow-up of diseases of the liver. While liver MRI is one of the most sensitive diagnostic tests for detection and characterization of hepatic lesions, findings may be misleading if not closely correlated with the results of previous imaging studies, clinical history, clinical examination, or physiologic tests. Adherence to the following guideline will enhance the probability of detecting such abnormalities.

### **II. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL**

See the [ACR Practice Guideline for Performing and Interpreting Magnetic Resonance Imaging \(MRI\)](#).

### **III. INDICATIONS**

Indications for MRI of liver include, but are not limited to:

#### **A. Primary Indications**

1. Detection of focal hepatic lesions.

2. Lesion characterization, i.e., cyst, focal fat, hemangioma, hepatocellular carcinoma, metastasis, focal nodular hyperplasia, hepatic adenoma.
3. Evaluation for known or suspected metastasis.
4. Evaluation of vascular patency.
5. Evaluation of diffuse liver disease such as hemochromatosis, hemosiderosis, fatty infiltration.
6. Evaluation of cirrhotic liver.
7. Clarification of findings from other imaging studies or laboratory abnormalities.

#### B. Extended Indications

1. Potential liver donor evaluation.
2. Evaluation of tumor response to treatment, e.g., imaged-guided liver interventions/tumor ablation, chemo embolization, or post-chemotherapy or surgery.
3. Evaluation of known or suspected congenital abnormalities.

### IV. SAFETY GUIDELINES AND POSSIBLE CONTRAINDICATIONS

See the [ACR Practice Guideline for Performing and Interpreting Magnetic Resonance Imaging \(MRI\)](#) and the ACR White Paper on Magnetic Resonance Safety<sup>1</sup>.

Peer-reviewed literature pertaining to MR safety should be reviewed on a regular basis [9,12].

### V. SPECIFICATIONS OF THE EXAMINATION

The supervising physician must have complete understanding of the indications, risks, and benefits of the examination, as well as alternative imaging procedures. The physician must be familiar with potential hazards associated with MRI, including potential adverse reactions to contrast media. The physician should be familiar with relevant ancillary studies that the patient may have undergone. The physician performing MRI interpretation must have a clear understanding and knowledge of the anatomy and pathophysiology relevant to the MRI examination.

The written or electronic request for MRI of the liver 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)

The supervising physician must also understand the pulse sequences to be employed and their effect on the appearance of the images, including the potential generation of image artifacts. Standard imaging protocols may be established and varied on a case-by-case basis when necessary. These protocols should be reviewed and updated periodically.

#### A. Patient Selection

The physician responsible for the examination shall supervise patient selection and preparation, and be available in person or by phone for consultation. Patients shall be screened and interviewed prior to the examination to exclude individuals who may be at risk by exposure to the MR environment.

Certain indications require administration of intravenous (IV) contrast media. IV contrast enhancement should be performed using appropriate injection protocols and in accordance with the institution's policy on IV contrast utilization. (See the [ACR Practice Guideline for the Use of Intravascular Contrast Media](#).)

Patients suffering from anxiety or claustrophobia may require sedation or additional assistance. Administration of moderate or "conscious" sedation may be needed to achieve a successful examination. If moderate sedation is necessary, refer to the [ACR Practice Guideline for Adult Sedation/Analgesia](#) or the [ACR Practice Guideline for Pediatric Sedation/Analgesia](#).

#### B. Facility Requirements

Appropriate emergency equipment and medications must be immediately available to treat adverse reactions associated with administered medications. The equipment and medications should be monitored for inventory and drug expiration dates on a regular basis. The equipment, medications, and other emergency support must also be

<sup>1</sup>In 2007 the following updated version was published: ACR Guidance Document for Safe MR Practices. AJR 2007; 188:1-27.

appropriate for the range of ages and/or sizes in the patient population.

### C. Examination Technique

A phased array surface coil should be used (1), unless precluded by patient body habitus. When possible, arms should be positioned overhead, out of the field of view. The field of view should be selected so that it is just large enough to include the entire liver.

An adequate MRI examination of the liver is typically performed in the axial plane, and coronal plane images are added as necessary to improve the visualization of the liver dome.

A satisfactory MRI of the liver should include an echo train T2-weighted sequence or short-time-inversion recovery (STIR) sequence in axial or coronal planes. T2-weighted images can be obtained using a breath-hold or non-breath-hold technique. When a non-breath-hold technique is used, every effort should be made to minimize the respiratory motion artifacts by using multiple signal averages and/or respiratory compensation. Alternatively STIR [3] or long-echo-train T2 sequence can be used as a breath-hold sequence. For effective T2-weighting, an echo time (TE) greater than 60 ms and preferably greater than 80 ms should be used. Optimally, slice thickness should approach 5 mm with an interslice gap of 10% and should not exceed 10 mm and a 30% gap.

In-phase and out-of-phase chemical shift imaging may be added for lesion characterization as this is a sensitive technique for hepatic steatosis.

Intravenous contrast enhancement with gadolinium chelates may be required for accurate diagnosis (4). Every attempt should be made to use intravenous contrast except when there is (a) no intravenous access, (b) known allergy to gadolinium chelates and the patient is not premedicated or, (c) relative contraindication to gadolinium chelates. Dynamic MR imaging should be performed after bolus administration of a gadolinium chelate contrast agent. T1-weighted images should be acquired before gadolinium contrast injection as well as during hepatic arterial, portal venous, and equilibrium phases [5] using a 2D or 3D technique. Additional delayed images may be added for further improvement of lesion characterization in the setting of certain lesions such as atypical hemangiomas [6,7] or cholangiocarcinoma [8]. Frequency selective fat saturation is preferable and is essential when using a 3D technique [9]. It is advantageous to acquire 3D data sets with isotropic and near isotropic resolution. When using a 2D technique, the slice thickness and interslice gap are not to exceed 10 mm and 3 mm, respectively.

## VI. DOCUMENTATION

Reporting should be in accordance with the [ACR Practice Guideline for Communication of Diagnostic Imaging Findings](#).

## VII. EQUIPMENT SPECIFICATIONS

The MRI equipment specifications and performance shall meet all state and federal requirements. The requirements include, but are not limited to, specifications of maximum static magnetic strength, maximum rate of change of magnetic field strength (dB/dt), maximum radiofrequency power deposition (specific absorption rate), and maximum acoustic noise levels.

## VIII. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION CONCERNS

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 Concerns appearing elsewhere in the ACR Practice Guidelines and Technical Standards book.

Specific policies and procedures related to MRI safety should be in place with documentation that is updated annually and compiled under the supervision and direction of the supervising MRI physician. Guidelines should be provided that deal with potential hazards associated with MRI examination of the patient as well as to others in the immediate area [9,11,12,13,16,17,19]. Screening forms must also be provided to detect those patients who may be at risk for adverse events associated with the MRI examination [9,13,16,17].

Equipment monitoring should be in accordance with the [ACR Technical Standard for Diagnostic Medical Physics Performance Monitoring of Magnetic Resonance Imaging \(MRI\) Equipment](#).

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This guideline was developed according to the process described in the ACR Practice Guidelines and Technical Standards book by the Guidelines and Standards Committee of the Commission on Neuroradiology.

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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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