Revised 2008 (Resolution 21)*

ACR–ASNR PRACTICE GUIDELINE FOR THE PERFORMANCE AND INTERPRETATION OF MAGNETIC RESONANCE IMAGING (MRI) OF THE BRAIN

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) and the American Society of Neuroradiology (ASNR).

Magnetic resonance imaging (MRI) of the brain is a proven and well-established imaging modality in the evaluation and assessment of normal and abnormal conditions of the brain. MRI of the brain is the most sensitive technique available because of its high sensitivity in exploiting inherent contrast differences of tissues as a result of variable magnetic relaxation properties and magnetic susceptibilities. MRI is a rapidly changing technology, and ongoing technical improvements will continue to improve MRI diagnosis of brain disorders. This guideline outlines the principles for performing high-quality MRI of the brain.

II. INDICATIONS

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

A. Primary Indications
   1. Seizures

2. Cranial nerve dysfunction
3. Diplopia
4. Ataxia
5. Acute and chronic neurological deficits
6. Suspicion of neurodegenerative disease
7. Primary and secondary neoplasm
8. Aneurysm
9. Cortical dysplasia and other morphologic brain abnormalities
10. Vasculitis
11. Encephalitis
12. Brain maturation
13. Headache
14. Mental status change
15. Hydrocephalus
16. Ischemic disease and infarction
17. Suspected pituitary dysfunction
18. Inflammation or infection of the brain or meninges, or their complications
19. Postoperative evaluation
20. Demyelination and dysmyelination disorders
21. Vascular malformations
22. Arterial or venous/dural sinus abnormalities
23. Suspicion of nonaccidental trauma

B. Extended Indications

1. Suspicion of acute intracranial hemorrhage or evaluation of chronic hemorrhage
2. Neuroendocrine dysfunction
3. Functional imaging
4. Brain mapping
5. Blood flow and brain perfusion study
6. Image guidance for intervention or treatment planning
7. Spectroscopy (including evaluation of brain tumor, infectious processes, brain development and/or degeneration, and ischemic conditions)
8. Volumetry
9. Morphometry
10. Tractography
11. Post-traumatic conditions

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

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

IV. SAFETY GUIDELINES AND POSSIBLE CONTRAINDICATIONS

See the ACR Practice Guideline for Performing and Interpreting Magnetic Resonance Imaging (MRI) and the ACR Guidance Document for Safe MR Practices.

Peer-reviewed literature pertaining to MR safety should be reviewed on a regular basis.

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 clinical request form should be initiated by the referring physician or any appropriate allied health care professional acting within his or her scope of practice. It should contain pertinent information regarding the clinical indication for the procedure.

The written or electronic request for MRI of the brain 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 scope of practice requirements. (ACR Resolution 35, adopted in 2006)

The supervising physician must also understand the pulse sequences to be used 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 MRI 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–SPR Practice Guideline for the Use of Intravascular Contrast Media, the ACR Manual on Contrast Media, the ACR Guidance Document for Safe MR Practices, and the ACR Web site.)

Patients suffering from anxiety or claustrophobia may require sedation or additional assistance. Administration of moderate sedation may be needed to achieve a successful examination. If moderate sedation is necessary, refer to the ACR–SIR Practice Guideline for 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 appropriate for the range of ages and sizes in the patient population.

C. Examination Technique

MRI examination of the brain can be performed with a wide array of pulse sequences. This is a rapidly evolving field, and the appropriate pulse sequence**s** must be individualized and tailored to the clinical question at hand under the supervision of the MRI physician. The most commonly accepted basic imaging protocols for MRI of the brain currently include a T1-weighted sequence in the sagittal plane and T2-weighted fluid-attenuated inversion recovery (FLAIR) in the axial plane. If FLAIR is not available, proton density weighted sequences can be performed. A fast-spin-echo or turbo-spin-echo (or equivalent) technique can be substituted for these axial sequences. Under certain clinical circumstances, very rapid acquisitions such as echo planar imaging or single shot fast-spin-echo imaging can be performed to obtain T2 information. Diffusion imaging, if available, is helpful in many indications.

The recovery time (TR) and echo time (TE) required to optimize image quality depends on the field strength of the magnet. These parameters must therefore be adjusted by the supervising physician for image optimization. For example, lower field strength magnets may require lower TRs, while higher field strength magnets may require longer TRs for image optimization.

Slice thickness, spatial resolution, signal-to-noise ratio, acquisition time, and contrast are all interrelated. To optimize spatial resolution, imaging of the brain should be performed with a slice thickness of no greater than 5 mm and an interslice gap of no greater than 2.5 mm. Thinner slices (less than 5 mm) may be applied if clinical circumstances warrant.

Gadolinium chelates may be administered intravenously when there is suspicion of breakdown of the blood-brain barrier. Postcontrast images are obtained in the axial and/or coronal and/or sagittal planes with short TR and TE sequences (T1-weighted). Postcontrast T1-weighted images should be compared to precontrast images, although the precontrast images do not necessarily have to be performed in the same planes as the postcontrast images.

With the advent of high-performance gradient coil assemblies and amplifiers and other technical enhancements, advanced imaging applications are also an option when the appropriate hardware and software exist. Improvements in the receiver and data acquisition systems also allow for more rapid imaging. While a detailed discussion of all the evolving advanced imaging techniques is beyond the scope of this guideline, it should be noted that rapid pulse sequences and other advanced imaging techniques may provide added utility for MRI of the brain**.** These can include, but are not limited to: echo planar imaging, parallel imaging, diffusion weighted imaging, diffusion tensor imaging, rapid gradient-echo pulse sequences (capable of providing T1 or T2 information), susceptibility weighted imaging, functional imaging, perfusion imaging, and volumetric, morphometric, and other quantitative applications.

Certain clinical circumstances may warrant the use of proton MR spectroscopy as an adjunct to routine MR brain imaging (See the ACR–ASNR Practice Guideline for the Performance and Interpretation of Magnetic Resonance Spectroscopy of the Central Nervous System.) Additional techniques that may be useful under the appropriate clinical circumstances include 3-dimensional imaging techniques, neuronavigation and intraoperative MR, magnetization transfer imaging, cerebral spinal fluid (CSF) flow study using phase-contrast pulse sequences, and variations of single shot fast-spin-echo or turbo spin-echo imaging.

It is the responsibility of the supervising physician to determine whether additional pulse sequences or nonconventional pulse sequences and imaging techniques confer added benefit for the diagnosis and management of the patient. Generally MRI examination of the brain should be performed within parameters approved by the FDA. Examinations that use techniques not approved by the FDA can be considered when they are judged to be medically appropriate.

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

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).

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 the MRI examination of the patient as well as to others in the immediate area. Screening forms must also be provided to detect those patients who may be at risk for adverse events associated with the MRI examination.

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

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