ACR PRACTICE PARAMETER FOR PERFORMING AND INTERPRETING MAGNETIC RESONANCE IMAGING (MRI)

PREAMBLE

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care[1]. For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents 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 practitioner considering all the circumstances presented. Thus, an approach that differs from the guidance in this document, 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 this document when, in the reasonable judgment of the practitioner, such course of action is indicated by variables such as the condition of the patient, limitations of available resources, or advances in knowledge or technology after publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document may consider documenting in the patient record information sufficient to explain the approach taken.

The practice of medicine involves the science, and 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 the guidance in this document 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 purpose of this document is to assist practitioners in achieving this objective.

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1 *Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, 831 N.W.2d 826 (Iowa 2013) Iowa Supreme Court refuses to find that the "ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures (Revised 2008)" sets a national standard for who may perform fluoroscopic procedures in light of the standard's stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, Stanley v. McCarver, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that "published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation" even though ACR standards themselves do not establish the standard of care.*

I. INTRODUCTION

Magnetic resonance imaging (MRI) is a multiplanar imaging method based on an interaction between radiofrequency electromagnetic fields and certain nuclei in the body (usually hydrogen nuclei) after the body has been placed in a strong magnetic field[1]. MRI differentiates between normal and abnormal tissues, providing a sensitive examination to detect disease. This sensitivity is based on the high degree of inherent contrast due to variations in the magnetic relaxation properties of different tissues, both normal and diseased, and the dependence of the MRI signal on these tissue properties.

[1] See ACR Glossary of MR Terms, 5th edition, 2005

II. INDICATIONS AND CONTRAINDICATIONS

A. Indications

The currently accepted MRI techniques and indications for MRI specific to anatomic areas are discussed in various ACR practice parameter documents. It is important that any site offering MRI should have documented procedures, technical expertise, and appropriate equipment appropriate to examine each anatomic area. Because the clinical applications of MRI continue to expand, the techniques and indications enumerated in the reference documents may not be all inclusive.

Each site's procedures should be reviewed and updated at appropriate intervals. The final judgment regarding appropriateness of a given examination for a particular patient is the shared responsibility of the ordering physician or other appropriately licensed health care provider and the radiologist. The decision to use MRI to scan a particular segment of the human body depends on the available MRI software and hardware and the relative cost, efficacy and availability of alternative imaging methods. The examination should provide images with suitable contrast characteristics, spatial resolution, signal-to-noise ratio, and anatomic coverage appropriate to the specific clinical indications.

B. Contraindications

All patients should be screened for potential contraindications prior to MRI scanning [1,2]. Possible contraindications include, but are not limited to, the presence of certain cardiac pacemakers, ferromagnetic intracranial aneurysm clips, certain neurostimulators, certain cochlear implants, and certain other ferromagnetic foreign bodies or electronic devices [3-8]. Some implants (certain cardiac and vascular stents and gastrointestinal endoclips) may require a waiting period after insertion prior to MRI scanning. In addition, MRI conditional pacemaker and ICD devices are also in clinical use and can be scanned using the appropriate parameters. A large database inclusive of nearly all medical devices can be accessed at www.mrisafety.com [9]. Published test results and/or on-site testing of an identical device or foreign body may be helpful to determine whether a patient with a particular medical device, implant, or foreign body, such as a pacemaker, may be safely scanned. There is no known adverse effect of MRI on the fetus. The decision to scan during pregnancy should be made on an individual basis [11].

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

A. Physician

A physician must be responsible for all aspects of the study, including, but not limited to, reviewing indications for the examination, specifying the pulse sequences to be performed, interpreting images, generating official interpretations (final reports), and assuring the quality of the images and the interpretations. The physician should also be able to apply current knowledge about the gamut of MRI contrast agents, to include choice of agent, composition, risks and benefits, appropriate use, and dosing.

Physicians assuming these responsibilities for MR imaging of all anatomical areas, except for cardiac imaging, should meet one of the following criteria:

Certification in Radiology, Diagnostic Radiology, Interventional Radiology/Diagnostic Radiology (IR/DR), Nuclear Radiology, or Nuclear Medicine by one of the following organizations: the American Board of Radiology (ABR), the American Osteopathic Board of Radiology (AOBR), the Royal College of Physicians and Surgeons of Canada (Royal College), or the Collège des Médecins du Québec (CMQ), and involvement with the supervision, interpretation, and reporting of MRI examinations[1].

or

Completion of a diagnostic radiology residency program approved by the Accreditation Council for Graduate Medical Education (ACGME), the Royal College of Physicians and Surgeons of Canada (Royal College), the Collège des Médecins du Québec, or the American Osteopathic Association (AOA) to include active participation in the supervision, interpretation, and reporting of MRI examinations.

or

Physicians not board certified in radiology or not trained in a diagnostic radiology residency program who assume

the above responsibilities for MR imaging (excluding cardiac MRI) should limit themselves to the specific anatomic areas pertinent to their specialty practice and meet the following criteria: Completion of an ACGME approved residency program in the specialty practiced, plus Category I CME in MRI to include, but not limited to: MRI physics, recognition and correction of MRI artifacts, safety, instrumentation, and clinical applications of MRI in the relevant subspecialty. Additional criteria include the supervision, interpretation, and reporting of MRI cases in that specialty area in a supervised setting. For neurologic MRI, cases must include MR angiography (MRA) of the central nervous system.

Specific qualifications for physicians performing cardiac MRI are described in the ACR–NASCI–SPR Practice Parameter for the Performance and Interpretation of Cardiac MRI [12].

Maintenance of Competence

All physicians performing MRI examinations should demonstrate evidence of continuing competence in the interpretation and reporting of those examinations. Competence is assured primarily based on continuing experience, to maintain the physician's skills. Because a physician's practice or location may preclude this method, continued competency can also be assured through monitoring and evaluation that indicate appropriate protocols, acceptable technical success, and accuracy of interpretation.

Continuing Medical Education

The physician's continuing education should be in accordance with the ACR Practice Parameter for Continuing Medical Education (CME) [13] in MRI as is appropriate to the physician's practice needs.

[1] Board certification and completion of an accredited radiology residency in the past 24 months will be presumed to be satisfactory experience for the reporting and interpreting requirement.

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

B. Medical Physicist / MR Scientist

A Qualified Medical Physicist or a Qualified MR Scientist must be responsible for acceptance testing and monitoring of MRI equipment for the purposes of this practice parameter.

A Qualified Medical Physicist is an individual who is competent to practice independently one or more subfields in medical physics. The American College of Radiology (ACR) considers certification, continuing education, and experience in the appropriate subfield(s) to demonstrate that an individual is competent to practice in one or more subfields in medical physics, and to be a Qualified Medical Physicist. The ACR strongly recommends that the individual be certified in the appropriate subfield(s) by ABR, the Canadian College of Physics in Medicine, the American Board of Science in Nuclear Medicine (ABSNM), or the American Board of Medical Physics (ABMP).

The Qualified Medical Physicist should meet the ACR Practice Parameter for Continuing Medical Education (CME) [13].

The appropriate subfield of medical physics for this practice parameter is Diagnostic Medical Physics (previous medical physics certification categories including Radiological Physics, Diagnostic Radiological Physics, and Diagnostic Imaging Physics are also acceptable). (ACR Resolution 17, adopted in 1996 – revised in 2008, 2012, 2022, Resolution 41f)

Certification by the American Board of Medical Physicists (ABMP) or the Canadian College of Physics in Medicine (CCPM) in Magnetic Resonance Imaging Physics is also acceptable.

A Qualified MR Scientist is an individual who does not hold board certification in an appropriate subfield of medical physics but has obtained a graduate degree in a physical science or engineering field involving nuclear

magnetic resonance (NMR) or MRI and has documented experience in a clinical MRI environment [14].

Additional guidance on the initial qualifications, as well as continuing experience and education for the Qualified Medical Physicist or MR Scientist, is provided in the current document "ACR CT, MRI, Nuclear Medicine and PET Accreditation Program Requirements for Medical Physicists/MR Scientists," which can be found at https://www.acr.org/Clinical-Resources/Accreditation [14].

The Qualified Medical Physicist or MR scientist must maintain a thorough knowledge of the principles of MRI safety, physics, equipment, and relevant performance testing (see the ACR–AAPM Technical Standard for Diagnostics Medical Physics Performance Monitoring of Magnetic Resonance Imaging (MRI) Equipment) [15]. The Qualified Medical Physicist or MR scientist must have a working understanding of clinical imaging protocols and methods of image optimization. This proficiency must be maintained by participation in continuing education programs of sufficient frequency to ensure familiarity with current concepts, equipment, and procedures. All activities of the Qualified Medical Physicist or MR Scientist must be performed within the context of pertinent government regulations, including the Food and Drug Administration's guidance for MR diagnostic devices.

The Qualified Medical Physicist or MR scientist must be present during surveys and may be assisted in obtaining test data for performance monitoring by other properly trained individuals. These individuals must be properly trained and approved by the Qualified Medical Physicist or MR scientist in the techniques of performing the tests, the reason for a given test, the function and limitations of the imaging equipment and test instruments, the reason for the tests, and the importance of the test results. Supervision of these individuals should be in accordance with current American Association of Physicists in Medicine (AAPM) Professional Policy 18-B [16]. The Qualified Medical Physicist or MR Scientist must review and approve all measurements.

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

C. Non-Physician Radiology Provider (NPRP)

NPRPs are all Non-Physician Providers (eg, RRA, RPA, RA, PA, NP, ...) who assist with or participate in portions of the practice of a radiologist-led team (Radiologists = diagnostic, interventional, neurointerventional radiologists, radiation oncologists, and nuclear medicine physicians). The term "NPRP" does not include radiology, CT, US, NM MRI technologists, or radiation therapists who have specific training for radiology related tasks (eg, acquisition of images, operation of imaging and therapeutic equipment) that are not typically performed by radiologists.

The term 'radiologist-led team' is defined as a team supervised by a radiologist (ie, diagnostic, interventional, neurointerventional radiologist, radiation oncologist, and nuclear medicine physician) and consists of additional healthcare providers including RRAs, PAs, NPs, and other personnel critical to the provision of the highest quality of healthcare to patients. (ACR Resolution 8, adopted 2020).

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

D. Radiologic Technologist

The technologist should participate directly in assuring patient comfort and safety, preparing and positioning the patient for the MRI examination, and obtaining the MRI data in a manner suitable for interpretation by the physician. The technologist should also perform frequent quality control testing in accordance with the MRI manufacturer's recommendations.

The technologist performing MRI should:

1. Be certified by the American Registry of Radiologic Technologists (ARRT) or the American Registry of MRI Technologists (ARMRIT) in MRI, or the Canadian Association of Medical Radiation Technologists (CAMRT) as an MRI technologist (RTMR).
   or
2. Be certified by the ARRT in Radiography, Radiation Therapy, or Nuclear Medicine and/or have appropriate state licensure and have supervised clinical experience in MRI scanning

or

3. Have an associate's degree in an allied health field or a bachelor's degree and certification in another clinical imaging field and have supervised clinical MRI scanning experience.

To assure competence, the supervising physician should evaluate any technologist who began performing MRI prior to October 1996 and who does not meet the above criteria.

Any technologist practicing MRI scanning should be licensed in the jurisdiction in which he/she practices, if state licensure exists. To assure competence, all technologists must be evaluated by the supervising physician.

IV. SPECIFICATIONS OF THE EXAMINATION

The examination should be performed within parameters currently approved by the FDA. Examinations that use techniques not approved by the FDA may be considered when they are judged to be medically appropriate.

The written or electronic request for a MRI examination 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 – revised in 2016, Resolution 12-b)

Images should be labeled with the following: (1) patient identification, (2) facility identification, (3) examination date, and (4) image orientation indicated by unambiguous polarity symbols (eg, R, L, A, P, H, F). Study description, sequence name, parameters, image number, field-of-view (FOV) and slice thickness are recommended.

V. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [17].

High-quality patient care requires adequate documentation. There should be a permanent record of the full MRI examination in a suitable archival format. Images should remain retrievable within a reasonable period of time, whether for future clinical, facility, legal, or regulatory needs. Retention of the MRI examination should be consistent both with clinical need and with relevant legal and local health care facility requirements. If intravenous or intra-articular contrast material is administered during the MRI examination, the brand name, route of administration, and administered dose of the contrast agent should be recorded and included in the permanent record of the examination, as should injection of any other drugs (eg, glucagon, Lasix). An official interpretation (final report) of the MRI findings must be included in the patient's medical record.

VI. EQUIPMENT SPECIFICATIONS

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

Equipment monitoring should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Magnetic Resonance Imaging (MRI) Equipment [15].

VII. SAFETY GUIDELINES

Safety guidelines, practices, and policies must be written, enforced, and reviewed with documentation at least

annually by the supervising physician. These guidelines should take into consideration potential magnetic field interactions of ferromagnetic objects in the MRI environment [18,19]. They should also address potential hazards to the patient (eg, from magnetic field interactions, tissue heating, and induced electrical currents) and potential hazards posed by implanted objects or materials within the patient or other individuals in the MR environment [4,5].

A screening program should be implemented to assure appropriate and safe use of MR contrast material and to reduce the risk of nephrogenic systemic fibrosis (NSF) [20-22] unless a cyclic agent is used [23,24]. For further information on ACR screening recommendations see the ACR Manual on Contrast Media [25] and the ACR Manual on MR Safety [11]. Peer-reviewed literature pertaining to MR safety should be reviewed on a regular basis.

In pregnancy, gadolinium-based contrast agents (GBCAs) cross the placental barrier, enter the fetal circulation, and pass via the kidneys into the amniotic fluid. Although no definite adverse effects of GBCA administration on the human fetus have been documented, the potential bioeffects of fetal GBCA exposure are not well understood. GBCA administration should therefore be avoided during pregnancy unless no suitable alternative imaging is possible and the benefits of contrast administration outweigh the potential risk to the fetus (see the ACR–SPR Practice Parameter for the Safe and Optimal Performance of Fetal MRI [26]). If a gadolinium agent is used in pregnancy, a cyclic agent is recommended because of its extremely high kinetic stability [23,24].

Only a tiny fraction of a GBCA administered to a lactating patient is excreted into the breast milk, and only a similarly small portion of the excreted GBCA is actually absorbed by the infant gut. It is unlikely that the minute amount of GBCA absorbed by a nursing infant's gastrointestinal tract will be harmful. Moreover, intravenous administration of a GBCA to neonates and infants is considered safe and performed routinely in clinical practice. Given these observations and the fact that even temporary disruption of breastfeeding can be stressful for both mother and infant, no delay in resumption of breast feeding after MRI is necessary [27]. If a gadolinium agent is used while lactating, a cyclic agent is also recommended.

When contrast and**/**or sedation are necessary, they must be administered in accordance with institutional policy and state and federal law by a qualified practitioner with training in cardiopulmonary resuscitation [28] (see the ACR–SPR Practice Parameter for the Use of Intravascular Contrast Media [29] and the ACR-SIR Practice Parameter Minimal and/or Moderate Sedation/Analgesia [30]).

Appropriate emergency equipment and medications must be immediately available to treat adverse reactions associated with administered medications and should also be appropriate and comprehensive for the range of ages and sizes in the facility's patient population. Inventory and drug expiration dates must be monitored on a regular basis.

A documented quality control program must be maintained at the MR site. Quality control testing should be conducted by the technologist and/or service engineer with review at least annually by the supervising physician and/or a medical physicist**/**MR scientist [31-34].

VIII. QUALITY CONTROL AND IMPROVMENT, 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 Quality Control & Improvement, Safety, Infection Control*, *and Patient Education* on the ACR website (https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Quality-Control-and-Improvement).

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