ACR–SAR–SPR PRACTICE PARAMETER FOR THE PERFORMANCE OF MAGNETIC RESONANCE (MR) ENTEROGRAPHY

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The American College of Radiology will periodically define new practice parameters 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 parameters and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

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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 enterography (MREnt) is a proven and useful tool for the diagnosis, assessment of severity and complications, and follow-up of small-bowel disease [1-10]. MREnt is especially useful and is most widely used in patients with inflammatory bowel disease (IBD), particularly Crohn's disease (CD). MREnt is a noninvasive imaging test that does not employ ionizing radiation. For these reasons MREnt may be considered a primary imaging modality for patients, especially for pediatric and young adult patients with IBD who require repeated imaging for disease assessment and therapeutic monitoring [11,12].

II. INDICATIONS

Indications for MREnt include, but are not limited to, the following:

1. Diagnosis of IBD, including assessment of disease activity, extent, and distribution.
2. Follow-up of known IBD, including assessment of disease activity and response to therapeutic intervention.
3. Evaluation of suspected IBD-related complications, such as stricture and obstruction or penetrating disease (eg, fistula, sinus tract, or abscess). High-resolution pelvic MRI sequences may be added to the routine MREnt or obtained as a separate examination for dedicated evaluation of perianal disease.
4. Differentiation of CD from ulcerative colitis in children with "indeterminate colitis," searching for features that are more characteristic for CD, which include transmural and periserosal disease, terminal ileal or other small-bowel involvement, asymmetric involvement of the mesenteric border of the small bowel, associated penetrating complications (eg, fistulas or sinus tracts), lack of involvement of the rectum and distal large bowel, or skip lesions.
5. Nonemergent evaluation of suspected bowel disease with prior negative computed tomography (CT) examination and/or endoscopy, or in place of these other tests, including a variety of disease processes, such as subacute bowel obstruction or non-IBD enteritis (eg, due to infection or vasculitis)

MREnt protocols are specifically tailored to allow detailed assessment of the small intestine. However, in some IBD patients, additional evaluation of IBD-related diseases or conditions may be desired at the time of MREnt. Variations in MREnt scanning protocols, usually requiring added pulse sequences, can allow for concurrent appraisal of the pancreaticobiliary tree (eg, in the setting of a known or suspected sclerosing cholangitis), perianal/perineal region (eg, in the setting of known or suspected perianal fistula or abscess), and sacroiliac joints. Although additional imaging will lengthen the MREnt examination and increase the likelihood of motion-related artifacts due to patient discomfort and/or pain, this approach may be desired when imaging is to be performed under sedation or general anesthesia (eg, in the pediatric population). However, combined studies should be performed in a manner that does not adversely affect image quality or overall diagnostic performance of either examination.

III. QUALIFICATIONS AND RESPONSIBILITES OF PERSONNEL

See the ACR Practice Parameter for Performing and Interpreting Magnetic Resonance Imaging (MRI) [13].

IV. SPECIFICATIONS OF THE EXAMINATION

The supervising physician must understand 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 prior ancillary studies. The physician performing the MRI interpretation must be knowledgeable about the relevant anatomy and pathophysiology.

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

Documentation that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). The provision of 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)

The supervising physician must also understand the pulse sequences that are used and their imaging appearance, including the appearance of image artifacts. Standardized imaging protocols should be established but may be 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 should supervise patient selection and preparation and be available for consultation by direct communication. Patients must be screened and interviewed prior to the examination to exclude individuals who may have contraindications to MRI, in which the risks may outweigh the benefits.

The majority of MREnt examinations require the administration of intravenous (IV) gadolinium-based contrast media (GBCA) [14,15]. IV GBCA administration should be performed using appropriate injection protocols and in accordance with the institution's policy on IV contrast utilization (see the ACR-SPR Practice Parameter for the Use of Intravascular Contrast Media [16]). Noncontrast examinations may be considered in select cases in which the presence/absence of active bowel inflammation is the only clinical question and it is felt that the clinical question may be resolved with T2-weighted (T2W) fat-suppressed sequences and/or diffusion-weighted imaging (DWI) [17-19]. Noncontrast examinations may also be considered in patients with contraindications to IV GBCA administration, such as during pregnancy.

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. Physicians working in or near the MRI area must have current training in MRI safety, preferably Level 2 training [20], as well as the management of contrast reactions.

C. Patient Preparation

Bowel preparation is generally regarded as helpful for improving the diagnostic performance of MREnt [21-24]. The goal of bowel preparation is to 1) achieve maximal distension of bowel loops to minimize false-positive instances of bowel-wall thickening, 2) improve the visibility of mural postcontrast enhancement, 3) reduce bowel peristaltic activity to improve the diagnostic quality of motion-sensitive MR sequences, and 4) displace air within bowel loops that can cause susceptibility artifacts.

Oral contrast may be administered to patients prior to MREnt to improve small-bowel distension. Patients may be asked to fast 4 to 6 hours prior to the examination to improve compliance with ingestion of enteric contrast preparations and minimize filling defects within the small bowel. Though the types and volumes of enteric contrast may vary across centers, oral contrast agents should provide some osmotic effect to prevent water absorption by the gut, and a viscosity agent to promote distension. In addition, the generally favored contrast agents should be biphasic, demonstrating bright signal on T2W images and dark signal on T1-weighted (T1W) images, to achieve maximum contrast with the bowel wall. This is especially important on T1W postcontrast sequences in which the bowel wall will enhance and the distended lumen will remain low signal [25-27]. Patient compliance with enteric contrast (especially pediatric patients) can be improved by contrast refrigeration and flavor additives, although caution should be employed with color additives if contemporaneous endoscopy is planned. A defined time delay from administration of oral contrast to imaging allows for adequate distal passage of contrast to the terminal ileum prior to image acquisition. The

amount of contrast and the specified time delay may vary according to center-specific experience. A recommendation is to follow prescriptions as used for CT oral contrast administration at the corresponding imaging facility.

Antiperistalsis medications may also be administered prior to and during the imaging examination. An oral, over-the-counter liquid anticholinergic agent may be mixed with the patient's enteric contrast to reduce bowel motility [28-31]. Administration of IV glucagon as a spasmolytic agent is a commonly employed method to reduce bowel motion artifact [31]. However, because of the short-acting half-life of glucagon, it is recommended that it be administered immediately prior to motion-sensitive sequences (typically T1W dynamic contrast-enhanced sequences), which may require interruption of image acquisition; both intramuscular (IM) and IV routes of administration are available. IM administration is longer lasting but less reliable [32]. Evaluation for any potential contraindications or drug interactions should be investigated prior to administration.

Enteroclysis is an invasive method for improving small-bowel distension through intubation of the jejunum with a nasojejunal feeding tube and direct administration of enteric contrast through the tube [23,33]. Though enteroclysis may provide increased small-bowel distension more reliably compared with routine oral contrast administration [33], the impact on clinical decision-making pathways has not been well documented [34]. For this reason, enteroclysis is not considered an absolute requirement for routine applications of MREnt. Furthermore, dedicated colon cleansing and administration of rectal contrast is another potential patient preparation step that may be considered on a case-by-case basis [35,36].

D. Examination Technique

A phased array surface coil should be used unless precluded by patient body habitus. The field of view should be selected to cover as much of the bowel as possible, ensuring the inclusion of the anal region while providing the highest possible signal-to-noise ratio with adequate spatial resolution. The patient may be imaged prone or supine. Although some centers have found prone imaging to improve bowel motion artifacts and bowel separation, there is no consensus on this point, and there are patients who will prefer supine positioning for comfort. Prone positioning may also be uncomfortable for patients with a stoma device and should be avoided in these instances. Adequate performance of MREnt requires imaging in both the axial and coronal planes; imaging in the coronal plane is a key feature of MREnt, allowing for maximum visualization and inclusion of bowel loops in each slice, with optimum display of the terminal ileum. For most applications, MREnt should include T1W, T2W, and, if available, DWI [9,14,17,37-40].

Given the motion effects of a contracting bowel that cannot be corrected with breath-holding or triggering techniques, motion-insensitive fast spin-echo (FSE) T2W imaging with acquisition of all necessary phase lines in one repetition time (TR) interval ("single shot" technique) is the most reliable method for T2W imaging of the bowel. Slice thickness is typically 4 – 7 mm, and the interslice gap should not exceed 10% of the slice thickness.

T2W imaging is a fluid-sensitive sequence that is used for identifying fluid collections, edema, fluid-filled fistulas and sinus tracts. T2W imaging with fat suppression is a key component of MREnt for identifying bowel wall and mesenteric edema, which are signs of active inflammation. Fat suppression may be accomplished through a variety of techniques, including short tau inversion recovery (STIR), chemically selective fat saturation, water excitation, or Dixon-based methods. Spectral adiabatic inversion recovery (SPAIR) fat suppression is a technique that combines elements of both inversion recovery and chemical fat suppression techniques to provide a very reliable and robust degree of fat suppression while continuing to preserve water signal [19,41,42].

T1W imaging may be performed using a 3-D accelerated gradient-echo with fat suppression. Use of surface coils is important for improved signal. T1W 3-D gradient-echo acquisitions have the advantage of rapid acquisitions within a breath-hold, reducing breathing-motion artifact without the need for time-consuming respiratory navigation and triggering techniques. These acquisitions should be no longer than 15-19 seconds. However, antiperistaltic agents, administered prior to T1W 3-D imaging, are recommended to reduce bowel peristalsis and bowel wall motion artifacts. Radial acquisition methods, such as radial 3-D gradient-echo (GRE) sequences, are less sensitive to image deterioration from bowel peristalsis and breathing motion and may be used in patients unable to hold their breath [43,44].

IV contrast enhancement with GBCAs is an important component of a comprehensive MREnt examination, especially for the accurate diagnosis and detection of bowel wall inflammation, fistulas, abscesses, and perianal fistulas. Standard extracellular GBCAs should be used because there is no benefit in using a liver-uptake GBCA or blood pool agent. Attempts should be made to use IV contrast material except when there is 1) no IV access, 2) history of prior allergic-type reactions to GBCAs and the patient has not been premedicated, 3) relative contraindication to gadolinium chelates (such as pregnancy), or 4) known or suspected nephrogenic systemic fibrosis (NSF) or particular concerns regarding NSF risk that may outweigh the benefits of a contrast-enhanced MREnt examination. The standard MREnt examination will include multiple dynamic postcontrast phases, which ideally would include a late arterial or enteric phase and portal venous phase usually obtained in the coronal plane. Axial and coronal delayed phase postcontrast images obtained at least 2 minutes or up to several minutes after the start of the injection can be the key sequences to depict fibrosis within the bowel wall, which will appear thickened and will retain contrast [1,3,45-48]. Similarly, late enhancement is a feature of fibrotic adhesions that may be associated with tethered bowel loops or fistula [49].

DWI can be an important component of an MREnt examination and should be performed if possible. DWI evaluates for abnormal water mobility in tissues. With DWI, ideally, multiple b-values (eg, b-values of 0, 20, and 800 s/mm^2) are obtained, having varying degrees of diffusion weighting as well as an apparent diffusion coefficient (ADC) map. Low b-value images (eg, 20 s/mm^2) can be used to identify edema and fluid. High b-value images of at least 500 s/mm^2 can be used to identify bowel wall inflammation, abscesses, and lymph nodes that will have high signal intensity on high b-value images and low signal on the ADC map. DWI sequences may be additionally helpful in MREnt examinations in which IV GBCAs cannot be administered, in addition to fat-suppressed T2W imaging (which is essential for the detection of edema and inflammation).

Additional MR sequences, although considered optional, may provide added value to bowel imaging. Dynamic, real-time cine MRI of the bowel may be obtained by a single-shot balanced steady-state free-precession sequence or a heavily T2W coronal slab centered over a region of interest [50-52]. Repeated image acquisitions over time with these techniques may be used to produce real-time cine imaging of the bowel to evaluate bowel motility and also aid in evaluating the potential functional significance of fibrotic strictures and fixed luminal narrowing. However, even in the absence of real-time cine images, comparison of different sequences that are acquired at different time points during the study acquisition or over multiple examinations is helpful to discern bowel peristalsis from a fixed fibrotic stricture. A quantitative perfusion sequence is an additional MRI technique that can be performed for bowel imaging [17,53-57]. Quantitative perfusion may be able to help discriminate between inflammation or fibrosis in a region of abnormally thickened bowel wall, where inflammation leads to increased vascularity and accelerated contrast arterial phase enhancement.

V. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [58].

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

See the ACR Practice Parameter for Performing and Interpreting Magnetic Resonance Imaging (MRI) [13], the ACR Guidance Document on MR Safe Practices 2020 [20], and the ACR Manual on Contrast Media [59].

VI. EQUIPMENT SPECIFICATIONS

Equipment monitoring should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Magnetic Resonance (MR) Imaging Equipment [16].

The MRI equipment specifications and performance must 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. Additional considerations include the use of surface coils that can provide coverage of the entire abdomen and pelvis. In addition, it may be necessary to use at least 2 fields of view (FOV) to capture the entire abdomen and pelvis. Acquisition and postprocessing of these images may be facilitated by systems with specific software that allows merging of at least 2 imaging fields.

VII. 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 *ACR Position Statement on Quality Control and 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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