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

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

This practice parameter was developed and written collaboratively by the American College of Radiology (ACR), the Society for Advanced Body Imaging (SABI), the Society of Abdominal Radiology (SAR), and the Society for Pediatric Radiology (SPR).

Magnetic Resonance enterography (MRE) is an MR examination optimized for evaluation of the small bowel that usually includes the administration of oral contrast agents, intravenous (IV) contrast and spasmolytics to reduce

motion artifacts. However may be modified in certain clinical scenarios. MRE is a is a proven and useful tool for the diagnosis, assessment of severity and complications, and follow-up of small-bowel disease [1-10]. MRE is especially useful and is most widely used in patients with inflammatory bowel disease (IBD), particularly Crohn disease. MRE is a noninvasive imaging test that does not employ ionizing radiation. For these reasons MRE 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 MRE include, but are not limited to, the following:

1. Diagnosis of IBD, including assessment of disease activity, extent, and distribution.
2. Surveillance of known IBD, including assessment of disease activity and response to therapeutic intervention.
3. Evaluation of suspected IBD-related complications, such as stricture, obstruction and internal penetrating disease (eg, fistula, sinus tract, inflammatory mass, or abscess). High-resolution pelvic MRI sequences may be added to the routine MRE or obtained as a separate examination for dedicated evaluation of perianal disease.
4. Differentiation of Crohn Disease from ulcerative colitis in patients with "indeterminate colitis,"
5. Nonemergent evaluation of suspected bowel disease with previous negative computed tomography (CT) examination and/or endoscopy, or in place of these other tests. Suspected small-bowel disease may include a variety of processes, such as subacute bowel obstruction or non-IBD enteritis (eg, due to infection, celiac disease, vasculitis, or neoplasms, etc).
6. To further evaluate suspected small-bowel wall thickening or small-bowel pathology on routine CT examinations.

Contraindications

1. Contraindication to MRI in general including incompatible implanted devices/foreign bodies
2. Patient size/body habitus that may prevent scanning
3. Suspected bowel perforation excluding internal penetrating disease.

MRE protocols are specifically tailored to allow detailed assessment of the small intestine [13]. However, in some patients with IBD, additional evaluation of IBD-related diseases or conditions may be desired at the time of MRE. Variations in MRE 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 MRE 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) [14].

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 MRE 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 advantages and limitations of 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.

IV. SPECIFICATIONS OF THE EXAMINATION

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 before the examination to exclude individuals who may have contraindications to MRI, including retained capsule endoscopy camera, in which the potential risks may outweigh the potential benefits.

The majority of MRE examinations require the administration of intravenous (IV) gadolinium-based contrast media (GBCA) [15, 16]. 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 [17]). Noncontrast examinations may be considered in select cases in which the presence/absence of active bowel inflammation or surveillance of luminal narrowing/stricturing 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) [18-20]. Noncontrast examinations may also be considered in patients with contraindications to IV GBCA administration, such as during pregnancy.

IV. SPECIFICATIONS OF THE EXAMINATION

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 [21], as well as the management of contrast reactions.

IV. SPECIFICATIONS OF THE EXAMINATION

C. Patient Preparation

Techniques to optimize imaging of the bowel are generally regarded as helpful for improving the diagnostic performance of MRE [22-25]. The goal is to 1) achieve maximal distension of small 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.

Unless contraindicated, oral contrast should be administered to patients prior to MRE to improve small-bowel distension. Patients should be fasting 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 [26-

28]. 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. If the patient is unable to drink commercially available oral contrast agents, water can be administered however will provide less optimal small bowel distension. If optimized small bowel distension is necessary a small feeding tube can be placed into the stomach and the oral contrast administered via the tube. 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. In general, oral contrast should be administered in divided doses over one hour preceding the exam to ensure consistent bowel distension. Water is often administered just before the scan acquisition in an attempt to distend the stomach and duodenum. If possible, monitoring of patients may be helpful with compliance.

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 [29]. Administration of glucagon as a spasmolytic agent is a commonly employed method to reduce bowel motion artifact . 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 [30]. 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 [24]. Though enteroclysis may provide increased small-bowel distension more reliably compared with routine oral contrast administration , the impact on clinical decision-making pathways has not been well documented [31]. For this reason, enteroclysis is not required for routine applications of MRE. Dedicated colon cleansing and administration of rectal contrast is another potential patient preparation step that may be considered on a case-by-case basis.

In younger pediatric patients who cannot cooperate to allow performance of MRE, general anesthesia (GA) may be required. Institutions should develop policies and procedures in collaboration with the Department of Anesthesiology if they perform MRE under general anesthesia. There is no consensus on the appropriate technique, however some guidelines have been suggested [32]. Patients should be kept nothing by mouth for 6 hours before the exam. Patients should be assessed by anesthesiology upon arrival for the examination. If GA is indicated, the anesthesiology team should be responsible for the induction of GA and monitoring during the examination. A cuffed endotracheal tube is utilized to reduce the risk of aspiration. After the airway has been protected a nasogastric or orogastric tube is placed and oral contrast administered according to institutional guidelines. Spasmolytics can be omitted to reduce the exacerbation of ileus. Routine pulse sequences can be performed for those patients under GA. At the conclusion of the exam residual fluid is removed from the stomach via the gastric tube.

IV. SPECIFICATIONS OF THE EXAMINATION

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 decrease motion artifacts and improve 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.

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.

Adequate performance of MRE requires imaging in both the axial and coronal planes. Imaging in the coronal plane is a key feature of MRE, allowing for maximum visualization and inclusion of small bowel loops in each slice, optimum display of the terminal ileum, and shorter breath holds as compared with axial imaging. Axial images provide orthogonal views of the small bowel which can be helpful to identify abnormalities that are more conspicuous in the axial plane and allows more complete visualization of soft tissues anterior and posterior to the field-of-view (typically excluded on coronal acquisitions). For most applications, MRE should include T1W, T2W, and, if available, DWI [9, 15, 18, 33, 34].

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 MRE for identifying bowel wall edema 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 [20].

T1W imaging should 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.

IV contrast enhancement with GBCAs is an important component of a comprehensive MRE examination, especially for the accurate diagnosis and detection of bowel wall inflammation, fistulas, abscesses, and perianal fistulas. 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 MRE examination. The standard MRE examination will include multiple dynamic postcontrast phases, ideally 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, 35-38]. Similarly, late enhancement is a feature of fibrotic adhesions that may be associated with tethered bowel loops or fistula [39]. In select patients with previous enterography examinations for comparisons, noncontrast MRE could be considered to assess treatment response or follow-up of luminal narrowing [40].

DWI can be an important component of MRE examination and should be performed if possible. DWI evaluates for abnormal water mobility in tissues. 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. Additional optional lower b-values can be used to identify edema and fluid. DWI sequences may be helpful in MRE examinations in which IV GBCAs cannot be administered, in fat-suppressed T2W imaging (which is essential for the detection of edema and inflammation) 31785602, 32080107.

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 [41-44]. 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 narrowing. A quantitative perfusion sequence is an additional MRI technique that can be performed for bowel imaging [18, 45-49]. 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 [50].

The 2018 SAR/American Gastroenterogical Association (AGA)/SPR consensus document recommends that a templated, standardized reporting method be used for MRE in Crohn's disease [10]. Others recommend this as well [51-56]. Systematic reporting using a template and standardized terms for the findings and conclusions will facilitate communication and allow for outcomes measures. Findings on computed tomography enterography and MRE are increasingly important in directing both medical and surgical management [57-61]; therefore, consistency in reporting is critical. The report should specifically indicate that the abdomen and pelvis MR with oral and IV contrast was a MRE examination utilizing oral contrast media. Additionally, every effort should be made to use the standardized terms for radiographic findings of Crohn's disease as well as the accepted impressions summarizing those findings [10].

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) [14], the ACR Manual on MR Safety [21], and the ACR Manual on Contrast Media [51].

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 [17].

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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