tMRI Technique – SAR Crohn's DFP (1, 2)

MR Enterography Indications

Magnetic resonance enterography (MRE) is a well-established imaging technique that is commonly used for evaluating bowel disease. While MRE can be used to assess a number of bowel conditions, the most common reason to perform MRE is for the diagnosis, surveillance and detection of complications of inflammatory bowel disease (IBD) (Table 1) (3-10). MRE has several significant advantages over CT enterography (CTE) and traditional barium-based fluoroscopic exams (i.e. small bowel series and enteroclysis) in evaluating IBD. MRE does not use ionizing radiation which is important for IBD patients, many of which present earlier in life and may require multiple imaging exams during their lifetime to monitor treatment (3, 4, 6-12). MRE's higher contrast resolution and multiphasic post contrast sequences compared to CTE makes MRE more sensitive in identifying bowel wall hyperemia and fibrosis and able to provide insight into the severity of small bowel inflammation (4). MRE also offers small bowel motility evaluation with "cine" sequences, a feature not available with CTE, which can help identify bowel inflammation, strictures, adhesions and small bowel masses (4, 9, 12, 13). Finally, compared to CTE, MRE's higher contrast resolution provides better evaluation of the perianal region to identify perianal fistulas, which can occur in up to 25% of Crohn disease patients, along with possible associated abscesses (4).

Table 1: Indications for MR Enterography

MR Enterography Indications
Diagnosis of IBD- evaluate disease activity, extent and distribution
Follow up known IBD- evaluate disease activity and treatment response
Evaluating possible IBD-related complications such as stricture, obstruction or penetrating disease (e.g. fistula, sinus tract or inflammatory mass)
Small bowel masses
Non-IBD enteritis (e.g. infection, vasculitis or treatment-related enteritis)
Adhesive disease and intermittent or low-grade small bowel obstruction
Celiac disease

Abbreviations: IBD = Inflammatory Bowel Disease Note: Table modified, with permission, from reference (6).

(17)(17)(18)Enteric Contrast Agents

The primary goal of enteric contrast in bowel imaging is to distend the bowel and reduce susceptibility artifacts by displacing air. Collapsed bowel can mimic bowel wall thickening and lead to the over-diagnosis of bowel pathology, or conversely may hide polyps and other entities,

highlighting the indispensable role of oral contrast in MR enterography (19). Oral contrast markedly improves performance of the exam, notably in the diagnosis of active disease involving the terminal ileum (20). Though many oral contrast agents have been suggested in the literature (21-23), biphasic agents that are both T2 hyperintense (bright) and T1 hypointense (dark) have emerged as preferred agents for MRE to accentuate mucosal enhancement and bowel wall thickening. Commonly used biphasic agents include 0.1% low-density barium suspension (NeuLumEX, formerly VoLumen, Bracco Diagnostics, Princeton, New Jersey), mannitol, sorbitol, polyethelyene glycol (PEG) and methylcellulose. Water itself is well tolerated and also demonstrates biphasic properties, but rapid absorption in the stomach and duodenum limits its intended effect in the distal small bowel, where it matters most (14). Young, et al (24) found superior distension of the bowel with low-density barium suspension and PEG compared with water or methylcellulose, though PEG was the least tolerated of all agents due to diarrhea. Multiple recent studies have demonstrated similar distension efficacy of a sugar alcohol flavored beverage (Breeza; Beekley Corp., Bristol, CT) when compared with low-density barium suspension although with preferred palatability and texture profile (14, 25). These findings are reflected in a survey of academic radiology groups represented by members of the Society of Abdominal Radiology Crohn's Disease-Focused Panel (DFP) with over 80% of institutions using either a sugar alcohol flavored beverage or low-density barium suspension (15). Iron-based monophasic oral contrast darken the bowel lumen signal on both T1 and T2 weighted images and can improve visualization of bowel wall edema and tumors on T2 weighted images and bowel wall enhancement with intravenous contrast. Low patient tolerance, however, has limited the use of iron-based agents to date.

Whatever the agent, ingestion of a large volume of contrast is necessary to best distend the bowel. For typical assessment of the bowel, enteroclysis is unnecessary as patient-directed oral intake is much better tolerated with similar diagnostic accuracy and reproducibility (26, 27). Suggested ingestion volumes range from 1000-1500 mL, but can anecdotally vary widely based on patient willingness, tolerance, size, and history of bowel resection including the presence of an ileostomy. Timing of ingestion relative to the time of scanning is paramount but can be difficult to predict – scanning too soon after ingestion leads to inadequate distension of the distal small bowel while scanning too late after ingestion can result in a majority of the contrast passing completely through the small bowel, distending only the colon. At most institutions surveyed by the DFP, patients are instructed to drink the total volume in three divided aliquots over 30-60 minutes, as tolerated. An additional 250-500mL of water or contrast can be administered on the table just prior to imaging to distend the stomach and proximal small bowel.

Intravenous Contrast Agents

With Crohn disease, active inflammation increases blood flow to the bowel reflected in mural hyperenhancement after the administration of intravenous (IV) contrast. In numerous studies, bowel wall enhancement has been shown to correlate with disease activity and active inflammation (28-31). For this reason, IV contrast is recommended unless: a) intravenous access cannot be established; b) there is concern for a severe gadolinium allergy for which pre-medication is not possible or advisable; c) gadolinium is contraindicated (e.g., pregnancy); or d) risks of gadolinium-associated nephrogenic systemic fibrosis (NSF) outweigh the benefit in patients with chronic renal failure. Of the commercially available extracellular gadolinium-based contrast agents (Table 2), Gadobenate (MultiHance) is often cited as the agent of choice given its

superior T1 relaxivity profile. If a patient is to undergo multiple examinations requiring gadolinium, however, a more stable macrocyclic agent such as gadobutrol, gadoterate, or gadoteridol could be considered though the American College of Radiology classifies all four agents as risk Group II agents, which are associated with "few, if any" unconfounded cases of NSF (32, 33). The standard dose for all agents used for MR enterography is 0.1 mmol/kg administered at 2 mL/s, after which multiphase dynamic 3D fat-suppressed T1 gradient-echo images are acquired to evaluate temporal enhancement of the bowel wall, which peaks 45-50 seconds after injection. Images are typically acquired in the coronal plane, though some institutions also perform a delayed axial (up to eight minutes post-injection), which some authors have suggested improves lesion detection and disease grading (34). A recent published survey of member institutions of the Society of Abdominal Radiology Crohn's Disease Focused Panel revealed all but one institution regularly administered IV contrast for MR-enterography, routinely acquiring two to five (median four) post-contrast phases including subtraction images (15). (35)If gadolinium is contraindicated, at least one study has shown that T2-weighted sequences in conjunction with diffusion weighted images, without the use if IV contrast, was non-inferior to contrast-enhanced MRE in well-prepared patients that did not have penetrating complications of Crohn Disease (33).

Table 2: Gadolinium-based contrast agents

Generic Name	**Trade Name**	**ACR Class**	**Structure**	**T1 Relaxivity @ 1.5T (L/mmol-s)**	**Hepatobiliary Excretion (%)**
Gadoterate meglumine	Dotarem	II	Macrocyclic	+ (3.6)	0
Gadoteridol	ProHance	II	Macrocyclic	++ (4.1)	0
Gadopentetate dimeglumine	Magnevist	I	Linear	++ (4.1)	0
Gadoversetamide	Optimark	I	Linear	++ (4.3)	0
Gadobutrol	Gadavist	II	Macrocyclic	+++ (5.2)	0
Gadobenate dimeglumine	MutiHance	II	Linear	++++ (6.3)	3-5
	Eovist/Primovist	III	Linear	++++ (6.9)	50

Antiperistaltic agents

A key requisite for high-quality MR enterography (MRE) is the absence of bowel wall motion on acquired images. Peristalsis is usually increased due to the stimulatory effect of ingested oral contrast on the bowel, which may cause motion artifact, impeding interpretation. While diagnostic accuracy remains high without the use of antiperistaltic agents (36), international guidelines generally recommend routine administration of the antiperistaltic agent glucagon in the United States or hyoscine butylbromide outside the United States (4, 37). A recent survey of the Society of Abdominal Radiology Crohn's Disease-Focused Panel reported 13/16 (81%) of institutions routinely administered antiperistaltic agents, although there was variability in agent, dose, and timing of administration (15). While this partly reflects differences in regulatory

permissions between different countries, there are distinct pharmacokinetic differences between agents which may influence choice.

On average, subjective enteric MRE image quality is improved by administration of either glucagon (38) and hyoscine butylbromide (39) but volunteer studies reveal variability in time of onset, efficacy, and duration of effect (table 1). Gutzeit at al (40) compared the effect of intravenous (IV) and intramuscular (IM) glucagon and hyoscine butylbromide on bowel peristalsis in six volunteers using cine MRI sequences. They reported a slightly shorter time of onset for aperistalsis following 1 mg IV glucagon than 40mg IV hyoscine butyl bromide (mean 65 vs 85 seconds). Intramuscular administration delayed onset considerably for both agents, and was associated with increased variability of effect. Mean duration of action was slightly longer for IV glucagon than for IV hyoscine butylbromide. Froehlich et al reported similar findings after comparing 40mg IV hyoscine butylbromide with 1mg IV glucagon in 10 volunteers (41), although actual timings differed from those of Gutzeit et al (40), likely reflecting differences in methodology for evaluating bowel loops. Glucagon produced complete aperistalsis in all 10 volunteers versus 5/10 for hyoscine butylbromide.

Administered doses are typically 0.5-1mg for glucagon and 20-40mg for hyoscine butylbromide, with a minority of centers using a patient weight adjusted dose (15, 37). The optimal timing of administration and the potential benefit of splitting the dose remains unclear, with variation in clinical practice (15). The sensitivity of MRE sequences to peristaltic artifact influences the timing of administration. Pre and post gadolinium T1 weighted 3D gradient echo sequences (T1W GRE) are particularly susceptible, balanced steady state free procession sequences are relatively immune, while T2 weighted single shot fast spin echo (SSFSE) sequences are somewhere in between. Finally, the sensitivity of diffusion weighted imaging (DWI) for identifying active Crohn's disease is improved after administering antiperistaltic agents (42).

Administration of antiperistaltic agents before T1W GRE sequences either as a single dose or part of a split dose approach is common practice, and is effective in improving T1 weighted (T1W) image quality (38). Based on duration of action (table 1), it may be expected that an upfront single dose may "wear off" before the end of the MRE protocol, typically when DWI and T1W post contrast images are acquired. Recent work has confirmed the superiority of a split dose hyoscine butylbromide over a single dose technique (43) although the first 10mg dose was administered around 8 minutes prior to MRE acquisition. Antiperistaltic agents should be administered after cine motility sequences have been acquired.

A further consideration is the side effect profile of antiperistaltic agents. Glucagon may cause nausea in about 50% of patients (38), sometimes several hours after administration. This side effect can be reduced by injecting at a slower rate (44). Hyoscine butylbromide may temporarily cause dry mouth, tachycardia, and blurred vision, and although it has an excellent safely profile, is contraindicated in unstable cardiac conditions (45). Alternative antiperistaltic medications such as sublingual hyoscyamine sulfate are reported to be clinically ineffective (table 3) (46).

In conclusion, MRE is certainly feasible without antiperistaltic agents, but consensus guidelines generally recommend its use. Both glucagon and hyoscine butylbromide are effective and most reliable when administrated intravenously. Glucagon tends to have a slighter shorter time of

onset and longer duration of effect. Administration can either be as a single dose, often before T1W GRE sequences or as a split dose before other motion sensitive sequences such as T2W SSFSE and DWI.(38)

Table 3. Comparison of antiperistaltic agents based on cine motility MRI (40, 41, 46)

Agent	Route of administration	Typical dose	Typical time to onset	Typical duration of effect[b]	Quality of aperistalsis[b]	Common side effects	Cost
Glucagon	IM or IV[a]	0.5-1mg	½ to 1 minute (IV) 12 minutes (IM)	18 to 23 minutes (IV) 28 minutes (IM)	+++	Nausea, emesis	+++
Hyoscine Butylbromide	IM or IV[a]	20-40mg	½ to 1.5 minutes (IV) 5 minutes (IM)	7 to 21 minutes (IV) 17 minutes (IM)	++	Dry mouth, tachycardia, blurred vision	+
Hyoscyamine sulfate	Sublingual/oral	0.125-0.5mg	2-3 mins	4 to 6 hours	+	Dry mouth, blurred vision	++

Abbreviations: IM-intramuscular, IV-Intravenous
Notes:

[a]Intravenous administration produces a more reliable anti peristaltic effect that intramuscular.
[a]Based on direct data from MRI cine motility sequences.

Patient Preparation

Thoughtful preparation of the patient for MR enterography (MRE) can help the patient feel comfortable undergoing the exam and improve the quality of the acquired images. Patient education should include emphasis on the need for fasting and compliance with oral contrast drinking, information on the duration of the scan, and importance of lying still and following breathing instructions. It is critical to discuss with the patient the possibility of transient loose stool resulting from the oral contrast agent and the need for the patient to ensure access to a restroom for an hour or more after the scan (14).

Many practices advocate for a 4 to 6 hour fast, with the exception of clear liquids and regular medications, prior to the MRE exam. Fasting minimizes the presence of potentially confusing enteric contents. Fasting may also improve compliance with drinking the large volume of oral contrast material required for optimal bowel evaluation.

A second concern for MRE is high-T1-signal material that is commonly present in the colon and at times the distal small bowel, even after an overnight fast. Such bright T1 signal may interfere with the visualization of distal bowel wall hyper- and hypo-enhancement after intravenous gadolinium contrast administration. While bowel cleansing to remove high-T1-signal bowel contents is not currently in wide practice for MR enterography (15), cathartics may of value for patients with suspected colonic and rectal disease. In patients with uncleansed bowel, diffusion weighted images should be included to improve diagnostic accuracy (16).

A third consideration is gas in the bowel, which is of particular concern in the pediatric population. Large amounts of bowel gas may cause artifacts in the bowel and adjacent structures. While little has been published on gas reduction for MRE, approaches to this issue include avoiding foods that cause bloating for at least a day prior to the exam, keeping children calm to avoid crying which may result in increased swallowed air, and minimizing facemask bag ventilation which may force air into the bowel.

Patients who have claustrophobia may benefit from an anxiolytic which may be taken orally. Patients may take their own anxiolytic, or a short acting low dose benzodiazepine may be prescribed if needed.

MRE Protocol

There currently is no consensus on the appropriate MR enterography (MRE) protocol. However, there is general agreement on the main sequences which should be performed and other sequences which may be considered optional. There have been two publications by a panel of experts with recommendations on MRE technique (4, 37). These recommended and optional sequences will be reviewed in the subsequent paragraphs with a brief discussion on their utility, advantages, and limitations. Suggested parameters for the sequences are included in Table 4.

Patient Positioning

Patients can be scanned either supine or prone. The prone position has some theoretical advantages. Because of compression of bowel loops, the number of required images in the coronal plane can be reduced. Prone position may also reduce motion artifact from the anterior abdominal wall. Prone positioning allows the patient to look outside the bore of the magnet and may reduce claustrophobia. However, some patients may be more comfortable in the supine potion including those patients with ostomies.

T2-weighted and balanced steady-state free precession sequences (fluid-sensitive sequences)

There are two main types of fluid-sensitive sequences recommended for MRE (Fig. 1), T2-weighted single-shot fast spin echo (T2W SSFSE) and balanced steady-state free precession (BSSFP). These fast sequences can be performed during breath-holding and are not as susceptible to motion artifact as the other MRE sequences. Coronal and axial acquisitions should be performed to visualize the bowel in two planes, as certain abnormalities may be more perceptible in one plane. T2-weighted sequences are useful for evaluating bowel wall thickness and demonstrating the subtle inner luminal irregularities associated with ulcerations. They also provide an excellent overview of the entire abdomen (4, 10). BSSFP sequences are T2-like sequences which have combined T2- and to a lesser extent T1-weighting. These sequences provide a more homogenous appearance to the intraluminal fluid than T2W SSFSE which

frequently demonstrate multiple areas of flow void artifact secondary to bowel peristalsis. Therefore, these sequences may be more useful detecting intraluminal masses. BSSFP also provides improved visualization of mesenteric structures such as lymph nodes and blood vessels. BSSFP sequences can be added to supplement the T2W SSFSE sequences or as a replacement for one of the planes.

Fat-suppressed T2-weighted sequences

T2-weighted sequences with fat suppression (Fig 1B and 1D) are used to demonstrate intramural edema, a sign of active inflammation (4). Since the SSFSE sequence is more T2-weighted than BSSFP, most sites include a fat-suppressed SSFSE sequence in the protocol. Longer conventional T2-weighted sequences are usually not needed. Since the main purpose of these sequences is to evaluate for edema in the bowel wall and surrounding mesenteric fat, one acquisition plane is usually sufficient. Also, since the area covered during a coronal acquisition is significantly shorter than the axial plane, coronal sequences can be performed faster with less breath holds.

Contrast-enhanced sequences

Contrast enhancement is helpful to demonstrate bowel wall inflammation and penetrating disease, identification of abscesses and evaluation of the vasculature (4). While most experts currently recommend the administration of intravenous contrast there is no consensus on how this should be performed. In general, most institutions perform dynamic contrast-enhanced 3D GRE sequences in the coronal plane during breath holding and include 3 phases (Fig. 2A-C). Multiple phases are helpful as the rate of bowel wall enhancement may vary and some of the acquisitions may have motion artifacts. Following the dynamic coronal acquisition, an axial acquisition (Fig. 2D) should also be performed to evaluate the bowel in an additional plane and provide visualization of the anterior and posterior abdominal wall which can be excluded on the coronal dynamic coverage. Since the 3D sequences are susceptible to both respiratory motion and bowel peristalsis, breath-holding and spasmolytic agents should be utilized to reduce motion artifacts.

If high quality 3D GRE images cannot be obtained, 2D spoiled gradient recalled (SPGR) sequences can be performed. 2D SPGR sequences are long and may require multiple breath holds which may lead to respiratory mis-registration. Therefore, parameters should be adjusted to limit the number of breath holds.

Optional sequences

Diffusion-weighted Imaging (DWI)

Restricted diffusion, as shown by high signal on higher b value DWI in the range of 800-1000, has been shown to be associated with severe active inflammation (10, 47-49) (Fig 1E). However false positives are common and may be related to collapsed bowel or other difficult to define etiologies (48). Therefore, if performed, the DWI findings should be correlated with the conventional recommended sequences. DWI sequences are significantly longer than the other MRE sequences and therefore some sites acquire them in the coronal plane to reduce scan time. For example, a coronal acquisition can be performed in 2-3 minutes while an axial acquisition may take 8-9 minutes (Fig. 3A-B). However, coronal acquisitions are plagued by image

distortion which can be excessive on some scanners. If the distortion is too significant to allow interpretation, DWI should be performed in the axial plane. New technology such as simultaneous multi-slice (SMS) or multiband (Fig. 3C-D) excitation is becoming more widely available and allows acquisition of multiple slices at the same time, including DWI.

Cine Imaging

Multiphase BSSFP or SSFSE can be performed to visualize bowel peristalsis. Decreased peristalsis can be seen in areas of active inflammation or fibrosis and the presence of decreased peristalsis may increase a reader's level of confidence when visualizing subtle abnormalities on conventional images (13). Cine images should be performed before spasmolytics are administered as spasmolytics decrease bowel peristalsis. However, despite the administration of spasmolytics, some peristalsis is usually still visible. Cine images are usually performed in the coronal plane. These can be performed during breath-holding or free breathing. Breath holding provides improved image quality, however, requires longer scan times. Slice thickness can be acquired at 7-10 mm. Thinner slices require more acquisitions to cover the small bowel, however, may better demonstrate more subtle findings. To reduce scan time, the coverage should be limited to the small bowel.

Delayed imaging

Delayed GRE sequences can be performed at up to eight minutes post-injection (Fig. 2E) and may be helpful in identifying delayed bowel wall enhancement due to fibrosis (50) while potentially improving lesion detection and disease activity grading. These sequences should be acquired using similar parameters as the dynamic sequences so that adequate comparison can be performed.

Protocol Standardization

The MRE protocol is flexible and can be adjusted to individual institutional preferences or to overcome technology limitations that may be present. Despite the generalized agreement of the required sequences, a recent publication by the Society of Abdominal Radiology (SAR) Crohn's Disease-Focused Panel (DFP) showed variability in the sequences and acquisition planes performed by their member's institutions (15). Because of the current variability in protocols among the SAR Crohn's DFP members, the DFP is in the process of developing a more standardized protocol.

Protocol Organization Considerations

The total acquisition time of the MRE protocol should be less than 30 minutes (37). Historically, MRE has been performed with the T2-weighted sequences acquired at the beginning of the examination followed by the administration of intravenous spasmolytic agents and finally the contrast-enhanced sequences. However, reorganization of this approach can provide improved efficiency, decreased scan times, and perhaps improve image quality. An example of this alternative approach will be described in the following paragraphs.

Spasmolytics are helpful to reduce bowel peristalsis and decrease motion artifact on the contrast-enhanced 3D GRE sequences. IV administration of Glucagon provides rapid and reproducible effects and usually is injected immediately before the contrast-enhanced images. This requires pausing the exam, removing the patient from the bore of the magnet, slowly injecting the

Glucagon, and waiting 1-2 minutes to ensure that the patient does not develop nausea or vomiting before restarting the exam. At many institutions, nurses are required to inject the Glucagon which can lead to additional delays. If regulations allow a technologist to inject the Glucagon, this can help eliminate delays related to nursing. An alternative approach is to administer the Glucagon at the beginning of the examination when the patient is placed on the scanner table. This prevents the need to halt the exam in the middle, but may diminish cine quality.

If IV Glucagon is administered at the beginning of the exam, contrast-enhanced sequences should be performed earlier in the exam, closer to the Glucagon administration time, in order to achieve the maximum aperistaltic effect. Most fluid-sensitive sequences can be performed after IV contrast without negative impact although some should be performed before contrast to prevent any confounding appearances. For example, fat-suppressed BSSFP sequences which include both T2- and T1-weighting will show bowel wall enhancement simulating intramural edema. DWI sequences can be performed either before or after the gadolinium, although image quality may be better before administering contrast.

Another potential advantage of moving motion-sensitive contrast-enhanced 3D GRE sequences earlier in the exam is improved image quality. All MRE sequences are performed during breath holding. If the contrast-enhanced sequences are performed at the end of the exam the patient may be tired and not able to hold their breath adequately leading to significant motion artifact, image blurring and suboptimal image quality. This approach has been performed at the Mayo Clinic for the last 2-3 years with a significant decrease in scan times. This sample protocol is shown in Table 5.

There is a potential limitation of the above approach if using cine images for diagnostic purposes. The decreased peristalsis induced by the administration of Glucagon could potentially mimic areas of altered motility which can be seen with inflammation and fibrosis. Therefore, if cine images are performed these should probably be performed before Glucagon even though some peristalsis can still be visible after administration.

Table 4: Recommended MRE Parametersfor the Required and Optional MRE Pulse Squences

SEQUENCE	**PLANE**	**MAXIMUM SLICE THICKNESS/ GAP**	**COMMENT**
REQUIRED SEQUENCES			
SSFSE	coronal	5/0	
SSFSE with fat-suppression	coronal	5/0	
SSFSE	axial	6/0	Alternatively can perform BSSFP
3D T1 GRE with fat-suppression	coronal	4/0	Unenhanced followed by 3 dynamic post-contrast

			phases beginning with a 45 sec. scan delay Supplemental 2D FSPGR can be performed if 3D image quality is suboptimal
3D T1 GRE with fat-suppression	axial	6/0	Supplemental 2D FSPGR can be performed if 3D image quality is suboptimal
Optional Sequences			
DWI	coronal or axial	5-6/0	Coronal faster but more artifacts Axial longer but improved image quality B values of up to 800-1000 Consider SMS technology if available
Cine BSSFP or SSFSE	coronal	7-10/0	25-30 phases per slice location
3D T1 GRE with fat-suppression	coronal	4/0	5-7 minute delays to detect fibrosis

Abbreviations:
BSSFP= balanced steady-state free precession
DWI= diffusion-weighted images
GRE- gradient echo
SSFSE= single-shot fast spin echo

Table 5: Sample Time-Efficient Protocol

SEQUENCE	PLANE	T/G	MATRIX	COMMENT
				0.5 mg Glucagon IV
BSSFP with fat-suppression	axial	6/0	192x340	
DWI	coronal	5/0	80x128	B values of 0, 100 and 1000
3D T1 GRE with fat-suppression	coronal	4/0	320x320	Unenhanced followed by 3 dynamic post-contrast phases beginning with a 45 sec. scan delay
3D T1 GRE with fat-suppression	axial	5-6/0	256x192	
SSFSE	coronal	5/0	384x224	
SSFSE with fat-suppression	coronal	5/0	384x224	
BSSFP	coronal	5/0	192x340	

Abbreviations:
BSSFP= balanced steady-state free precession
DWI= diffusion-weighted images
GRE- gradient echo
SSFSE= single-shot fast spin echo
T/G = thickness/gap

Conclusion

MR enterography is a robust imaging tool for evaluating patients with inflammatory bowel disease without the harmful effects of radiation associated with CT enterography. Understanding the appropriate clinical indications for imaging and proper technique is essential to obtain high-quality images of the bowel for accurate evaluation and diagnosis of Crohn's disease. We hope this comprehensive review of MR enterography technique detailed above provides a state-of-the-art foundation for developing and optimizing MR enterography protocol at your institution.

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