Evaluation of transmural Crohn's disease complications with MRI/MRE

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Learning objectives

1. Define the role that imaging and MR-based modalities fulfill in the management of patients with Crohn disease.
2. Describe the MR Enterography (MRE) and MRI Pelvis protocols used at Boston University Medical Center (BUMC) and their application to gastrointestinal Crohn disease complications.
3. Explain the appearance of Crohn disease complications on MRI and MRE, providing example cases from our institution.
Background

Boston University Medical Center (BUMC) is the largest and busiest provider of trauma and emergency services in New England, serving a large population of patients with both acute and chronic manifestations of inflammatory bowel disease (IBD). Crohn disease is a chronic idiopathic inflammatory condition of the gastrointestinal (GI) tract that is characterized by recurrent acute exacerbations of disease activity. Diagnosis is commonly made during adolescence, and by the 3rd decade of life, cumulative inflammatory change to the bowel results in fibrostenotic and penetrating disease complications. Small bowel obstruction, fistula formation and abscess are among the commonly encountered complications, often requiring surgical intervention such as drainage, debridement or resection.

Imaging is crucial to Crohn disease patient management, providing clinicians with a non-invasive means to assess the extent of disease and to guide subsequent medical and surgical intervention. Traditional imaging techniques have included fluoroscopy, ultrasound, and computed tomography (CT). While fluoroscopy and ultrasound are still applicable today, CT has become the most common imaging modality to evaluate GI Crohn disease. However, due to the young age at diagnosis and the incurable nature of the disease, exposure to ionizing radiation is of increasingly greater concern. Many young adult patients are accumulating considerably high levels of ionizing radiation exposure, with over 1 in 10 young patients with Crohn disease exposed to greater than 50 mSv at some centers.

Recent advances have proven MRI to be a modality that is equal or superior to CT at characterizing IBD activity and extra-enteric complications. MR Enterography provides excellent visualization of the GI tract lumen and wall, as well as the abdominopelvic cavity through which extraluminal complications extend. The superior soft-tissue contrast offered by MRI allows a more detailed evaluation of the extra-enteric soft tissues, particularly within the pelvis, an anatomic region that is not assessed well with CT. While CT is more commonly used for the initial workup and emergent evaluation of patients with Crohn disease, MRI/MRE is the favored modality whenever feasible due to its lack of exposure to ionizing radiation.
Findings and procedure details

The primary section of this exhibit is divided into MRE and MRI Pelvis, which are the two primary MR-based studies used at Boston University Medical Center (BUMC) to evaluate gastrointestinal (GI) Crohn disease. The protocols for these exams are briefly discussed, followed by their application to Crohn disease imaging and the appearance of commonly arising complications. Case examples from BUMC are provided for further demonstration of characteristic imaging findings.

1) MR Enterography (MRE)

The superb soft tissue contrast that is inherent to MR-based techniques is augmented in MRE studies by the administration of both oral and intravenous contrast agents. These studies provide complete visualization of the bowel wall from mucosa to serosa, as well as the adjacent soft tissues and organs in multiple planes. The mucosal layer is well-defined by the presence of intraluminal contrast, which consists of 1L of low density barium sulfate (0.1% w/v) ingested orally 2 hours prior to the exam. Low density barium sulfate serves as a neutral oral contrast agent that prolongs signal on both T1 and T2-weighted sequences.

Further definition of the submucosal and deeper layers of the bowel wall is achieved with the intravenous administration of a gadolinium-based contrast agent. 3D volumetric ultrafast gradient echo sequences are acquired in the coronal plane before and at 3 time points after the intravenous administration of 10-20 mL of gadopentetate dimeglumine (Magnevist). Post-contrast THRIVE images typically correspond with the arterial, venous and equilibrium phases of bowel wall enhancement. (FIGURE 1).

The initial sequences acquired for the MRE protocol are triplanar T2-weighted half-fourier single-shot turbo spin-echo (SSTSE) sequences. The combination of multiplanar T2-weighted (T2WI) and T1-weighted images (T1WI) enhanced with both intraluminal and intravenous contrast agents provide a thorough three-dimensional assessment of the course and caliber of the small bowel. Focal abnormalities such as stricture or wall enhancement may not be apparent on all planes. "Troubleshooting" of questionably abnormal segments of bowel in the additional planes that are acquired aid in diagnosis. (FIGURE 2).

Triplanar balanced turbo field echo (bTFE) sequences provide high-contrast images with a relatively short acquisition time. Additionally, Sequential bTFE slices are used to create dynamic cine loops that portray bowel motility. These images are particularly useful for distinguishing abnormal segments of hypo- or hypermotile bowel from the usual peristaltic activity seen in normal bowel (FIGURE 3). Additionally, the faster acquisition time of
bTFE sequences offers a more forgiving means of assessment in the presence of patient motion, which may result in excessive artifact on other sequences.

The extra-enteric complications of Crohn disease within the abdomen and pelvis are readily detected on MRE. Sinus tracts originating from the bowel spread through the soft tissue of the abdominopelvic cavity, resulting in fluid collections, phlegmon and abscesses. Fistula formation occurs when an inflammatory tract penetrates the viscera of another hollow organ, forming a communication between the GI tract and any number of organs including the bladder, stomach, skin, or other segments of bowel (FIGURE 4).

Image subtraction sets created from post-contrast images further emphasize areas of enhancement seen within the bowel, soft tissue and other organs. Hyperintensity on subtracted images are the high signal remaining after the digital subtraction of the pre-contrast sequence from a post-contrast sequence (e.g., arterial, venous or equilibrium). Subtraction images are useful for identifying equivocal enhancement, or for further characterizing known regions of abnormal enhancement (FIGURE 5).

2) MRI Pelvis

The superior soft tissue contrast of MRI is most apparent within the pelvis, an anatomical region that is typically not well-visualized on CT. The MRI pelvic fistula protocol used at BUMC yields detailed T1W and T2W high-resolution images of the terminal GI tract and neighboring soft tissue.

Triplanar high-resolution SSTSE images provide a fluid-sensitive evaluation of the rectosigmoid colon and anus as well as the surrounding peri-rectal and peri-anal soft tissue. This sequence is useful for identifying the intraluminal contents of the native GI tract as well as abnormal fluid within a sinus tract, fistula or abscess. On T2WI, the usual intraluminal contents of the bowel appear hyperintense, while the abnormally thickened bowel wall appears iso- to hypointense. Further characterization of inflammation and edema is made in the presence of fat suppression, which is provided by a coronal T2 SPIR sequence.

Intravenous contrast affords the early identification of fibrostenosing complications such as stricture, as well as advanced penetrating processes such as abscess and fistula. Enhancement is demonstrated by 3D volumetric ultrafast gradient-echo sequences in the axial plane before and at three timepoints after the intravenous administration of 10-20 mL of gadobenate dimeglumine (Multihance). The final sequences acquired are high-resolution delayed THRIVE images in the axial, coronal and sagittal planes with subtraction images. These images provide transluminal visualization of the bowel wall as
well as extraluminal complications extending into the perianal and perirectal soft tissue (FIGURE 6).

Inflammation extending outside of the anus and rectum results in the formation of sinus tracts, fistulas, and abscesses. Irregular and thickened abscess walls demonstrate peripheral enhancement while the internal contents are heterogeneous or non-enhancing, reflecting inflammation and necrosis (FIGURES 7 and 8). In longstanding disease, complex intercommunicating networks of soft tissue inflammation begin to form. The characteritic fluid signal seen within fistulous tracts is readily identified on T1WI and T2WI. The irregular and thickened hyperemic walls demonstrate enhancement on post-gadolinium images (FIGURES 9 and 10).
**Fig. 1:** Coronal THRIVE a) pre-contrast and post-contrast b) arterial, c) venous and d) equilibrium phase images in a 36 year-old female patient with Crohn disease demonstrating focal and tapered narrowing (yellow) of the distal ileum with mildly dilated segments of interspersed bowel. There is wall thickening of the distal ileum (red), which demonstrates hyper-enhancement on post-contrast images (green).

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Fig. 2: Coronal post-contrast THRIVE image showing multiple strictures (yellow) and dilatation (red) of the post-operative bowel in a 70 year-old patient with Crohn disease who underwent colectomy after initially being diagnosed with ulcerative colitis.
Fig. 3: Sequential dynamic bTFE images from the same MRE study, demonstrating interval change in configuration of the bowel consistent with peristalsis (yellow), except for a focal narrowing of one segment (red) within the right hemi-abdomen, which persists through all dynamic timepoints, consistent with stricture.

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Fig. 4: Axial steady-state turbo spin-echo (SSTSE) image from a non-contrast MRE study performed in a 14-week pregnant female with Crohn disease, demonstrating a colonic sinus tract extending into the anterior abdominal wall.

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**Fig. 5:** Coronal post-contrast THRIVE arterial subtraction image in a 21 year-old female patient with Crohn disease demonstrating thickened hyperenhancing segments of bowel (yellow) with an enhancing fluid collection and superior sinus tract extension (red).

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Fig. 6: High-resolution postcontrast THRIVE image in a 25 year-old male patient demonstrating a fistulous tract (arrow) that extends from the terminal ileum to the sigmoid colon.

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**Fig. 7:** High-resolution post-contrast axial THRIVE sequence in a 44 year-old male with Crohn disease and prior colectomy, demonstrating fistulous tract extension into the iliorectal fossa on the left (arrow).

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**Fig. 8:** Axial post-contrast THRIVE image in a 29 year-old patient with Crohn disease demonstrating extension of a transphincteric fistulous tract (yellow) into the right gluteus maximus muscle, where there is a fluid collection with areas of non-enhancement, suggestive of abscess (red).

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**Fig. 9:** High-resolution post-contrast THRIVE sequence in the axial plane in a 25 year-old male with Crohn disease, demonstrating multiple intersphincteric and transphincteric perianal fistulous tracts (arrows).

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**Fig. 10:** High-resolution post-contrast sagittal THRIVE image of the same patient demonstrating the course of an intersphincteric tract that is only seen in its entirety in one plane.

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Conclusion

Crohn disease is a chronic idiopathic inflammatory disease of the GI tract that is often diagnosed in patients at a young age. Extra-enteric complications arise by the 3rd decade of life and include both fibrostenosing and penetrating disease. Imaging provides a non-invasive means to assess disease activity and to guide subsequent medical and surgical management. Cross-sectional techniques are critical to the clinical evaluation of acute symptoms and for monitoring complications that arise in longstanding disease.

CT and MRI are highly effective modalities used to visualize the GI tract, and both have associated advantages and disadvantages (e.g., ionizing radiation exposure, accessibility of scanner, duration of study) that must be taken into consideration with the patient and clinical presentation. The acute on chronic course of Crohn disease results in regular imaging for longterm monitoring and for the assessment of exacerbations. In order to prevent cumulative exposure to high levels of ionizing radiation, MR-based studies are preferred whenever clinically appropriate, particularly in young patients and for disease monitoring.

MRE and high-resolution pelvic MRI are the two MR-based studies most commonly used to evaluate GI Crohn disease at BUMC. MRE is useful for monitoring disease activity as early as at the time of diagnosis. Visualizing bowel wall thickness, enhancement and peristaltic activity in three planes permits accurate gauging of disease activity. High-resolution pelvic MRI studies provide images of the terminal GI tract and adjacent soft tissues in unprecedented detail. Extraluminal complications arising in multiple forms and with varying degrees of complexity are fully characterized using this high-contrast high-resolution imaging technique.
References


