MR enterography and MR enteroclysis findings in small bowel Crohn's disease: how to interpret them

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Learning objectives

- To describe the main imaging findings in MR Enterography and MR Enteroclysis in the various stages of Crohn's disease.

- To show a pictorial review of these findings.

- To outline the interpretation of these findings

Background

Crohn's disease is a chronic inflammatory process of the gastrointestinal tract that encompasses a spectrum of mucosal, transmural and mesenteric changes, which may prove challenging to diagnose with conventional endoscopic techniques, especially when confined to the small intestine. Furthermore, the typical relapsing/remitting course of Crohn's d. necessitates frequent imaging in order to stage the severity of disease and determine treatment response [1].

Conventional enteroclysis is highly accurate in the assessment of mucosal abnormalities but of limited value in evaluating extramural extension. Computed Tomography (CT)-based studies suffer from the inability to fluoroscopically monitor small bowel filling and from low soft tissue contrast. Additionally may incur high cumulative radiation doses to the relatively young patient population.

Currently, Magnetic Resonance (MR)-based techniques (Enterography/Enteroclysis) have emerged as the small bowel imaging modality of choice due to their excellent spatial resolution and soft tissue contrast, direct multiplanar capabilities, potential to provide functional information (motility, perfusion, diffusion) and lack of ionizing radiation exposure.

Using histological data as the golden standard, MR has been shown to achieve 85-94% sensitivity and 80% specificity in detecting the presence of disease, identifying its localization and delineating its extent. With regard to conventional enteroclysis, MR demonstrates comparable diagnostic accuracy in the depiction of ulcerations and strictures, but 24-70% higher sensitivity in the depiction of skip lesions, abscesses, lymphadenopathy and fibrofatty proliferation. Although video capsule endoscopy has been reported as superior in identifying early stage mucosal abnormalities, transmural
and extraluminal disease is better evaluated with MR. In addition it can be performed regardless of possible strictures.

MR documented features of Crohn's d. have been correlated with clinical biomarkers (CDAI-Crohn's Disease Activity Index), with deep ulcers, wall thickening and enhancing lymphadenopathy having the highest correlation to active disease among qualitative findings, whereas quantitative parameters, such as peak enhancement and enhancement ratio, may aid in the differentiation of active versus chronic stage.

MR has high accuracy in identifying complications of Crohn's d. High temporal resolution cinematic views to assess enteric peristalsis may indicate areas of stenosis/obstruction with up to 95% sensitivity and 72% specificity. The presence of stratified mural enhancement with thickening and mesenteric hyperemia may further characterize stenoses as acute inflammatory versus chronic fibrotic which influences the patient’s treatment.

In the detection of fistulae, the sensitivity and specificity of MR have been reported as 84% and 100% respectively. Detailed anatomical delineation of perianal fistulae is critical for appropriate surgical management.

Abscesses and inflammatory masses can be diagnosed at MR with an accuracy of 90-92%, with the application of Diffusion Weighted Imaging (DWI) potentially serving as an extra diagnostic tool in their detection and characterization.

Disease activity can be classified in four subtypes according to imaging findings as proposed by Maglinte and colleagues: active inflammatory, fistulating/penetrating, fibrostenotic and regenerative [2].

**Imaging findings OR Procedure details**

**Technique**

In our Department both MR Enterography and MR Enteroclysis are performed.

The preparation is the same for both and consists of a 6 hours preprocedural fasting time. Up to 1 hour prior to the examination they are allowed to receive fluids, excluding gas drinks and milk.
In both methods patients receive the same amount (1.5 to 2 liters) of water polyethylene glycol solution. MR Enterography patients are instructed to drink this amount in 50 minutes following a given time frame. MR Enteroclysis patients undergo nasojejunal intubation under fluoroscopic guidance. The tube is inserted just past the Treitz ligament to avoid reflux. The oral contrast is administered through the tube at a rate of about 100 ml/min. Bowel loop filling and distention is monitored with coronal T2-Haste Single Shot sequences (fig 1).

In our Department all examinations are performed with a Siemens Magnetom Avanto 1.5T scanner.

Patients are imaged in the prone position.

In both examination techniques 1 ml of Hyoscine-N-Butylbromide (Buscopan) is given intravenously just before the iv injection of the gadolinium contrast medium.

The MR Enterography and MR Enteroclysis protocol consists of the following sequences:

- Cor HASTE Single Shot images (only in MR enteroclysis to monitor bowel filling)
- Cor and Ax True FISP
- 1 slice cor True FISP (CINE) for bowel loop motility examination
- Cor HASTE FS
- Cor and ax VIBE after iv contrast administration
- Ax in/opp phase T1
- Ax Diffusion Weighted

**Findings**

1. **ACTIVE INFLAMMATORY DISEASE**

The findings in active inflammatory disease are increased enhancement and thickening of the bowel wall with layered appearance due to submucosal edema. Less often ulcers can also be seen. Findings from the mesentery are engorged mesenteric vessels, fat proliferation and lymphadenopathy [3-10].

MR of the small bowel is not sensitive in the demonstration of superficial ulcers. Sometimes they are seen as small irregularities of the mucosa or as small foci of high "signal" surrounded by thickened bowel wall (Fig 2). Longitudinal ulcers can be seen as linear high signal foci and are best depicted in HASTE images.
Mural thickening is easily seen in True FISP and T1 volumetric fat saturated contrast enhanced sequences. Proper distention of the small bowel adds confidence in recognizing milder thickening. The degree of mural thickening correlates with presence of inflammation and the degree of activity. As a rough guide, in a distended loop, thickness of 3 mm and above is suggestive of inflammation and thickness of 6 mm and above is suggestive of active disease (figs 3-5).

Increased mural enhancement is due to intestinal hyperemia. Sometimes it is the most prominent or even the only finding that indicates active disease. Comparison of the enhancement should be made with adjacent bowel loops. Suboptimal distended bowel loops especially of the jejunum may give the false impression of increased contrast enhancement (figs 4 and 5).

The stratified or layered appearance in active disease is produced by the contrast between the increased enhancement of the mucosa and muscle/serosa layers and the intermediate enhancement of the edematous submucosa. This gives the "target sign" on the axial T1 contrast enhanced images (figs 3 and 5). This layered appearance should be distinguished from a similar layered appearance in fibrostenotic disease due to submucosal fat. In the later case there is usually less enhancement and thickening of the bowel wall and there is no edema in the submucosa. Helpful in this differentiation is also the HASTE sequence, in which there is increased signal of the bowel wall in active disease due to edema (fig 6).

Increased enhancement in the delayed phase (8 minutes after contrast administration) is indicative of active disease especially when there is blurred enhancement which is seen in more severe active disease. (fig 7)

Diffusion weighted images can also help in recognizing the presence of active disease. Restricted diffusion of the bowel wall is seen in case of active disease but not in fibrostenotic disease. In addition DWI sequences sometimes can help depict inflamed bowel loops especially in cases of suboptimal distention and can also help in depiction of fistulas and small abscesses. (fig 8)

Mesenteric fat proliferation appears as bowel loop separation and is considered quite a specific finding of Crohn’s disease, but not specific of active disease. Engorgement of the mesenteric vessels, referred as "comb sign", is suggestive of active disease and is more obvious on the true FISP and contrast enhanced T1 FS images (figs 3 and 4).

Enlarged and enhancing lymph nodes can accompany active disease, but this finding is not specific.
Patients with active inflammatory disease are usually treated with medical therapy. The above described findings of active disease can be seen to subside in follow up examinations (fig 9). Note that the thickening of the bowel wall may persist.

2. PERFORATING AND FISTULA FORMING DISEASE

This subtype is characterized by deep penetrating ulcers leading to formation of sinus tracts, fistulas and abscesses.

Sinus tracts and fistulas are best visualized on the true FISP and thin T1 contrast enhanced images. The stellate appearance of multiple bowel loops converging to the same point "star sign" is suggestive of enteroenteric fistulas. (fig 10 and 11).

Penetration of the bowel wall can lead to phlegmon and abscess formation. Phlegmon is seen as an extra intestinal mass with mild to moderate increased signal on T2 images and contrast enhancement on T1 FS images. (fig 12).

Abscesses are seen as extraenteric fluid collections with enhancing wall on the T1 FS post-contrast images. Air may be present inside the abscess cavity. Some times such small collections of fluid are difficult to be distinguished from fluid filled bowel loops or pseudosacculations. In these cases careful examination of true FISP images reveals the nature of the fluid by looking for communication with the bowel lumen. DW images are very helpful in both identifying and differentiating abscesses as restricted diffusion is observed (figs 12 and 13).

3. FIBROSTENOTIC DISEASE AND REGENERATIVE DISEASE

The characteristic finding of fibrostenotic disease is fixed narrowing of the bowel with prestenotic dilatation (fig 15).

The bowel wall thickening is usually less pronounced than in active disease. There is less if any increased enhancement in comparison with active disease. This enhancement is due to fibrosis and is relatively homogenous without a stratified appearance (fig 14).

Sacculations or pseudodiverticula may also be seen and are produced by asymmetric thickening and dilatation of the affected bowel segments (fig 14).

Sometimes a layered appearance is seen due to submucosal fat and can be distinguished from the layered appearance in active disease as mentioned previously. Additionally the presence of submucosal fat may be recognized by the chemical shift artifact seen as a second "black line" in the inner part of the bowel wall (fig 16).
**Cine images** are useful to demonstrate the fixed nature of the narrowing. In this case the affected segment shows decreased or absent peristalsis compared to normal adjacent loops. (videos at figs 17 and 18)

In **regenerative disease** there is mucosal atrophy and regenerative polyps. There is no marked enhancement and no significant thickening and the findings resemble chronic disease. In contrast to fibrostenotic disease, stenosis and dilatation are not prominent findings.

**Images for this section:**

**Fig. 1:** MR enteroclysis monitoring of small bowel filling. Sequential single shot coronal HASTE FS images show progressive filling of the small bowel during a 10 minute interval. When the filling of the small bowel is adequate then the acquisition of diagnostic sequences starts.

**Fig. 2:** Ulcers. MR enterography in a 10 year old boy. True FISP coronal images. Note the mild thickening of the wall of jejunal loops and small linear foci of increased signal intensity representing ulcers (red arrows).
**Fig. 3:** Active disease findings. MR enterography in a 25 year old man with Crohn’s disease. Coronal true FISP and axial T1 FS contrast enhanced images. There is thickening of the bowel wall up to 11mm (red arrows) with a stratified pattern in the post-contrast images. The contrast enhancement is also increased compared to adjacent bowel loops. These findings are suggestive of active disease. Note the fibrofatty proliferation and comb sign (yellow arrows).

**Fig. 4:** Another example of active disease in a 58 year old woman. MR enterography coronal true FISP and axial T1 FS post-contrast images. There is mural thickening of the distal ileum wall (red arrows) with a layered appearance on the T1 post-contrast image. Note the avid mucosal enhancement and the lesser enhancement of the edematous submucosal. There is also fibrofatty proliferation and engorged vasa recta (yellow arrows).
**Fig. 5:** Bowel wall edema. MR enterography in a 62 year old woman. Axial T1 FS post-contrast image and coronal T1 FS post-contrast and HASTE images. There is active disease with thickened bowel wall up to 14mm, increased enhancement and layered appearance. Increased signal of the bowel wall in the HASTE image is consistent with bowel wall edema and is seen in active disease.

**Fig. 6:** Another example of bowel wall edema in HASTE images. MR enteroclysis in 22 year old male. Coronal T1 FS post-contrast image and coronal HASTE images. There is increased enhancement and layered appearance in the terminal ileum (red arrows). Restricted diffusion was also evident (not shown here). There is increased signal in the HASTE image due to edema in the terminal ileum. Compare with the more dark appearance of fibrostenotic lesions on HASTE images (yellow arrows). Note also prestenotic dilatation up to 5 cm (green arrows).
**Fig. 7:** Delayed enhancement in active disease. MR enterography in a 36 year old woman. Axial T1 FS image at 2 minutes and axial T1 out of phase image at 8 minutes after the i.v. administration of contrast. Increased enhancement and layered appearance of the thickened wall of the terminal ileum is seen in the first image. In the second image (delayed phase) there is increased blurred enhancement of the bowel wall, which is indicative of moderate to severe active disease.

**Fig. 8:** Diffusion imaging. MR enterography in a 45 year old patient. Axial T1 FS contrast enhanced image and axial diffusion and ADC map images. There is active disease with thickened (up to 13 mm) and avidly enhancing bowel wall with layered pattern (red arrows). Restricted diffusion of the bowel wall can be seen (green arrows). Fistulas coexist and are also well depicted in the diffusion image (yellow arrows).
**Fig. 9:** Response to medical therapy. MR enterography in a 25 year old male. T1 post-contrast fat sat coronal images acquired 7 months apart. There is less thickening and less contrast enhancement (yellow arrows) in the second image compared to the first, consistent with reduction in inflammation after medical therapy. Similar findings are present on a second loop (red arrows).

**Fig. 10:** Multiple fistulas. MR enterography in a 45 year old male. Coronal True FISP and T1 FS post-contrast images. Multiple enteroenteric (yellow arrows) and enterocolic (green arrows) fistulas are seen. Note the stellate appearance (star sign).
**Fig. 11:** Penetrating disease with fistulas and free fluid. Enterography in a 43 year old man. Coronal True FISP images and coronal T1 FS Post-contrast image. Multiple fistulas seen as linear lesions between bowel loops (red arrows). The stellate appearance is suggestive of multiple fistulas between small bowel loops. A small quantity of free fluid is seen adjacent to a bowel loop (yellow arrow).

**Fig. 12:** Phlegmon and abscess formation. MR enteroclysis in a 28 year old male. Coronal True FISP and T1 FS post-contrast images. An inflamed segment of the ileum is seen (green arrow) and just above this segment, a mesenteric lesion with contrast enhancement consistent with a phlegmon (yellow arrows) with foci of abscess formation (red arrows). Note also the edematous sigmoid just above the phlegmon (blue arrow).
**Fig. 13:** Enterocolic and enterovesical fistulas and abscess. MR enteroclysis in a 74 year old male. Coronal True FISP images and axial T1 FS post-contrast image. Enterocolic (yellow arrow) and enterovesical (green arrow) fistulas. The wall of the bladder is thickened due to inflammation and a small abscess is seen within it (red arrow). The sigmoid wall is also inflamed and thickened.

**Fig. 14:** Fibrostenotic disease and bowel dilatation. MR enterography in a 42 year old male. Coronal True FISP and coronal and axial T1 FS post-contrast images. Multiple skip lesions of bowel wall thickening (red arrows) and intervening segments of dilated small bowel with a diameter of up to 5.4 cm (yellow arrows). Pseudosacculations are also seen (green arrows). The enhancement of the thickened bowel wall is mild and homogenous without layering (red arrows in the T1 FS images). Compare with the avid enhancement with a layered pattern of active disease in figs 4 and 5.
**Fig. 15:** Fibrostenotic disease and bowel dilatation. MR enteroclysis in a 54 year old male. Coronal True FISP and T1 FS post-contrast images. A dilated loop of the ileum (green arrow) is seen proximal to a stenosis due to bowel wall thickening (red arrow). The dilated bowel has a diameter of 4.7 cm. The thickened bowel wall shows mild and homogenous enhancement. The dilated loop lacks peristalsis in the cine sequences (see video in fig. 17). The findings are consistent with fibrostenotic disease.
Fig. 16: Submucosal fat. MR enteroclysis in a 78 year old male. Coronal T1 FS Post-contrast image and axial True FISP and T1 in/out of phase images. There is slightly increased enhancement in the terminal ileum with a layered appearance (red arrow). In this case the layered appearance is due to submucosal fat and should not be misinterpreted for active disease. There is fat signal on the in phase image and signal drop on the out of phase image (green arrows). The second "black line" in the inner bowel wall on the True FISP image could also be related with submucosal fat (yellow arrows).
Fig. 17: Same patient as fig. 15. Note the absence of peristalsis of the thickened bowel segment and the dilated proximal bowel loop (See arrows in fig. 15).
**Fig. 18:** MR enterography, 28 year old male. Note the aperistaltic terminal ileum. There is also thickening of the bowel wall and pseudosacculations. The findings are consistent with fibrostenotic disease.
Conclusion

MR enteroclysis and MR enterography are well established techniques in the workup of Crohn's disease. The imaging findings help in detection of abnormal segments of the bowel wall and in the differentiation between active, perforating and fibrostenotic disease. Complications such as abscesses and fistulas can be recognized with good sensitivity and specificity.

References
