MR enterography: technique, indications and radiological findings in Crohn´s disease

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Learning objectives

1. Describing magnetic resonance enterography technique (MRE).

2. Reviewing the indications.

3. Describing the more important findings in Crohn’s disease.
Small bowel, because of its length and poor accessibility, is the most difficult part of the intestine to image. Radiology with oral contrast or through nasal intubation (enteroclysis), have traditionally been the techniques of choice in the small intestine examination. Their most remarkable characteristics are the excellent mucosal pattern visualization and the intestinal dynamic information. But the absence of extra-luminal information, the ionizing radiation and the potential damage with intubation have replaced these examinations with cross sectional techniques as computed tomography (CT) and magnetic resonance (MR) [1], which in addition allows intestinal movement visualization by fluoroscopy through of ultra-rapid sequences[2,3]. Ultrasonography is a good technique in the first evaluation of inflammatory intestinal disease and patient’s monitoring. Its limitations are the operator dependence, difficulty in evaluation of deep pelvic segments and less reproducibility and efficacy with intestinal gas than cross sectional techniques. CT, because of its great resolution and availability, is very much used in extraintestinal and intestinal disease, which means an increase of accumulate radiation dose in patients susceptible of having lots of radiologic images. It also involves an increasing risk to develop gastrointestinal and hepatobiliary neoplasms and intestinal lymphoma [4,5]. After appearance of MR sequences with big resolution, MRE is becoming very important in assessing intestinal problems such as tumours, celiac and inflammatory diseases and intestinal obstruction, because it doesn’t use ionizing radiation and due to its multiplanar capability and tisular differentiation, without the need of intubation, being in many cases the technique of choice and a complement of endoscopic biopsy [4,6-10]. In some series MRE with oral contrast has been compared with MR enteroclysis, although this has reached a larger bowel distention and good capability of superficial lesions detection. However, both have high accuracy and reproducibility [11]. Nevertheless, to be able to obtain high quality diagnostic images we may solve some problems like greater movement susceptibility or the greater time required.

**REMEMBER:** It’s important to get an optimal grade of bowel distention with the minimal damage and to reduce the examination timing to minimize motion artifacts.

**Our aim is optimizing the MRE technique describing the indications and the more usual findings in Crohn’s disease.**
Imaging findings OR Procedure details

Reaching a good intestinal distention (collapsed loops can hide or simulate pathologic conditions)[10,12], being the least aggressive possible, we must give a non-absorbible contrast media orally, with few side effects and signal characteristics that allow a bowel wall correct evaluation[1,9,13]. We have some substances that we can classify according to their MRI signal as:

- **Positive contrasts**: based in paramagnetic particles. They are hyperintense in T1 and T2-weighted images. They have been not very much recommended because they don’t allow bowel wall correct evaluation after i.v contrast administration due to poor signal differentiation between structures[4,8].

- **Negative contrasts**: based in superparamagnetic particles. They are hypointense in T1 and T2-weighted images, improving the contrast between bowel wall and intestinal lumen in intravenous contrast administration T1-weighted images and in T2-weighted images between wall edema and luminal contrast. They have a limited commercial availability[4,8,14].

- **Biphasic contrasts**: they are hypointense in T1-weighted imaged and hyperintense in T2-weighted images. They are the most used and safe with very few side effects[4,10,14,15].

**REMEMBER**: The most used oral contrasts are watery solutions of polialcohol (mannitol or sorbitol) or polyethyleneglycol (PEG). Water is non-desirable as a contrast because of its fast flow and early absorption that doesn’t provide enough luminal distention[4]. These non-absorbible substances remain into bowel lumen during the examination, keeping water properties improving, in fat saturated T2-weighted images, the evaluation of thickness and wall edema. Moreover, because of its T1 hypointensity, allow obtaining optimal contrast between bowel wall regarding mesenteric fat and intestinal lumen when intravenous gadolinium has been administered[4,8,14,16,17].

We ask patients to arrive to the hospital 1 hour before the appointment to drink 1-1.5 l of PEG or mannitol solution during 40-45 minutes, as it has been recommended by some authors[18]. Then, we ask patients to drink 2 glasses of water just before the MR examination. According to our experience, rectal contrast administration is not necessary if the sigmoid or left colonic pathology has not been suspected, given that, with this technique the right and transverse colon have already been filled up the antegrade way[8,16].

We often do the examination with phased-array coil and respiratory triggered, with the patient in supine position. Alternatively, in patients without stomas or recent scars in abdominal wall, we could acquire MRI in prone position, better for claustrophobic people,
and this way we achieve more separation between small bowel loops and we decrease number of slices in coronal plane[1,16,18].

It’s important to value three-planes scout images to replace coil if it was necessary. If the contrast has reached terminal ileum and right colon [7], an initial dose of glucagon (0,5 mg) intravenously is administered and we can start the examination. A second dose of glucagon (0,5 mg) is administered immediately before intravenous contrast infusion.

In our institution, MRI examinations are performed with a 1.5 T scanner with a 4 channel phased-array body coil and the following scan protocol:

- **before i.v contrast administration:**
  - Abdomen and pelvis axial fat saturated Fast Employing Steady State Acquisition (FIESTA) images (TR/TE 4/1,8 ms; TI 200 ms; slice thickness 6 mm; gap 1 mm; matrix 224x320).
  - Abdomen and pelvis axial FIESTA images (TR/TE 4/1,8 ms; TI 200 ms; slice thickness 6 mm; gap 1 mm; matrix 224x320).
  - Abdomen and pelvis coronal and axial Single Shot Fast Spin Echo T2-weighted images (SS FSE-T2) (TR/TE 604/86,2 ms); slice thickness 6 mm; gap 1 mm; matrix 320x224).
  - Abdomen and pelvis axial diffusion-weighted images with respiratory triggered (TR/TE 5455/70,9 ms; matrix 128x128; b=0,700).
  - Abdomen-pelvis axial Liver Acquisition Volume Acceleration images (LAVA) (TR/TE 4,1/1,9 ms; TI 1,7 ms; slice thickness 4,4 mm; matrix 320x192).

- **after i.v contrast administration:**
  - Abdomen-pelvis axial and coronal LAVA (TR/TE 4,1/1,9 ms; TI 1,7 ms; slice thickness 4,4 mm; matrix 320x192) 50 seconds after contrast administration (enteric phase)[14].
  - Abdomen-pelvis coronal fat saturated Gradient Echo T1-weighted images (TR/TE 170/1,4 ms; flip angle 80º; matrix 320x224) being optional a delayed acquisition.

In axial sequences, the abdomen and pelvis images are obtained separately. All sequences are obtained in expiratory apnea except diffusion-weighted images that it has been performed with respiratory triggered.

MRE examination is 20-25 minutes long which is well tolerated by patient; we have only seen autolimited nauseas after glucagon injection and diarrhea because of PEG. The bowel distention achieved depends on the volume and the timing of image acquisition after ingestion of the oral contrast[12].

**INDICATIONS**
**Crohn’s disease**: small bowel is the most involved site of the intestine and the least accessible with endoscopy[2]. It can course with ulcers, strictures and fistulas. A classification has been proposed in inflammatory, stenosing and fistulizing subtypes (some authors include reparative subtype)[1,3,19]. This classification is very useful in clinical practice due to having influence in the patient management. We don’t have a specific method for activity evaluation, which usually is performed by means of clinical index, laboratory data and imaging techniques; whereas endoscopy and small bowel follow-through or enteroclysis give limited information about bowel wall and extraluminal extension of disease, MRE is playing an increasing role to determine with accuracy the disease activity[9,20,21].

**REMEMBER**: MRE is indicated to evaluate the extension, activity and complications of Crohn’s disease, as well as treatment monitoring and the detection of recurrences after surgery[14,22-24]. Due to its safety, it’s indicated in nonspecific clinical settings too.

**Celiac disease** and its complications as intestinal lymphoma[25,26].

**Bowel obstruction** in patients which iodinated contrast administration is contraindicated. There are some studies that obtain high sensitivity in detecting obstructive lesions and in differentiation between benign (the most usual are adhesions) and malignant causes[27].

**Pediatric population** in which intestinal inflammatory disease are suspected as a minimal aggressive technique before endoscopy examination[28].

**REMEMBER** that in Crohn’s disease we can find:

-**Wall bowel thickening** (Fig. 1 and 2): a wall thickness more than 3 mm in a well-distended segment. It has often associated with high signal intensity because of edema. This finding is more conspicuous in fat saturated T2-weighted images due to a better contrast between mesenteric fat and inflamed wall[8,16,18]; however, thickening can persist in quiescent phases neither without inflammation nor associated edema.

-**Mucosal ulcerations** (Fig.3 and 4): aphthous ulcers (focal high signal intensity surrounded by edema), penetrating ulcers (deep fissures that break through mucosal into submucosal or deeper layers) and lineal ulcers (parallel course to bowel wall). (Fig.5) They are valuable in two planes and in enhanced or unenhanced images[8,16,18].

-**Stratified pathologic enhancement** (Fig.6 and 7): two-layered pattern with mucosal enhancement (high-signal in mucosa and low-signal in submucosa in T1-weighted images), or three-layered pattern with mucosal and serosal enhancement with edematous submucosa (high-signal in mucosa and serosa and low-signal in submucosa),
indicating inflammatory activity[2,7,8,15]. It has been described an homogeneous enhancement pattern more related to chronic disease than with inflammatory activity[14].

- **Strictures**: thickened bowel wall with luminal narrowing and proximal dilatation in an involved intestinal segment (Fig.8). Some studies have shown MRE useful to differentiate an inflammatory stricture (which is treated medically) from a fibrotic stricture (which is treated surgically) according to thickness wall, edema and enhancement (layered enhancement in inflammatory activity and homogeneous enhancement in fibrosis) [1,2,18].

- **Pseudodiverticula**: presence of sacculations in antimesenteric edge bowell that it is often not as involved as the mesenteric one which is more affected for inflammatory activity (Fig.9)[18].

- Increased mesenteric vascularity (Comb sign) (Fig.10): engorgement of vasa recta supplying the inflamed bowel segment[8,16]. In long term disease, this finding can be related with perivascular fibrosis, but with disease activity[29].

- **Fibro-fatty proliferation** of the mesentery around involved intestine that cause separation of bowel loops.

- **Phlegmon** as hyperenhanced, poor defined, inflammatory tissue (Fig.11); **abscesses** as fluid collections with an enhancing wall. Both can be localized in mesenteric fat, on abdominal wall, or side to an affected bowel loop (Fig. 12)[8,18].

- **Mesenteric lymph nodes** (Fig.13), frequently hyperenhanced, indicatives of inflammatory activity[8,16,29].

- **Sinus tracts**: anomalous tracts from the intestinal lumen to mesenteric fat[18].

- **Complex fistulas**: anomalous tracts that communicate two epitelized structures. In Cronh’s disease they are often localized between different intestinal loops (enteroenteric or enterosigmoid fistula) (Fig.14 and 15) or involving bladder (enterovesical fistula) (Fig.16)[8].

There have not been much studies that related the high signal in diffusion-weigthed images with intestinal inflammatory activity[4,30]. In our experience, the inflamed bowel segments have showed higher signal and decreased ADC values than non-affected segments, being a support sequence in our scan protocol at the moment (Fig. 17).
Fig. 1: Bowel wall thickening. A 29-year-old patient with active Crohn’s disease. Coronal FIESTA image demonstrates bowel wall thickening >3 mm of distal ileum (arrows) comparatively with the other loops.

**Fig. 2:** Bowel wall thickening. A 21-year-old patient with Crohn´s disease. Axial SS-FSE-T2 image that shows a stenotic segment in the distal ileum with wall thickening and high signal due to submucosal edema (arrow).

Fig. 3: Penetrating ulcer. A 35-year-old patient with active Crohn’s disease treated with biologic agents. Coronal FIESTA image showing focal irregularity that represents ulceration (black arrow) in a thickened segment of distal ileum with increased enhancement (white arrow).

Fig. 4: Penetrating ulcer. A 35-year-old patient with active Crohn’s disease treated with biologic agents. Coronal LAVA after i.v. gadolinium images showing focal irregularity represents ulceration (black arrow) in a thickened segment of distal ileum with increased enhancement (white arrow).

**Fig. 5:** Lineal ulcer. A 42-yr-old patient with Crohn’s disease. Axial SS FSE-T2 image showing a little ulcer with parallel course to bowel wall involved (arrow). This type of ulcers is typical in Crohn’s disease and it probably causes bowel wall fibrosis that produces strictures.

Fig. 6: Pathologic bowel wall enhancement. A 48-year-old patient with Crohn’s disease. Coronal LAVA after i.v. gadolinium image demonstrates ileal mucosal hyperenhancement (arrow) relatively submucosa and serosa.

**Fig. 7:** Stratified enhancement. A 31-year-old patient with Crohn’s disease with biological and clinical activity. Axial LAVA after i.v. gadolinium showing mucosal (white arrow) and serosal (empty arrow) hyperenhancement in a pelvic ileal segment with submucosal hypointensity. This pattern is considered, with the mucosal hyperenhancement pattern, more related with inflammatory activity.

**Fig. 8:** Short strictures. A 27-year-old-patient with Crohn’s disease. Axial LAVA after i.v gadolinium image showing two focal strictures in ileal loops (arrows) with mural enhancement and proximal dilatation. Discontinuous intestinal involving between non-affected segments is very typical in Crohn’s disease.

Fig. 9: Pseudodiverticula. A 46-year-old patient with long time Crohn’s disease. Coronal LAVA after i.v. gadolinium image shows a pseudodiverticular dilatation (empty arrow) in antimesenteric edge of distal ileum. This sacculation is often placed in this location due to the inflammatory changes and posterior fibrosis are more usual in mesenteric intestinal edge.

**Fig. 10:** Comb sign. A 30-year-old patient with Crohn’s disease. Coronal FIESTA image demonstrates vasa recta engorgement of the pathologic bowel segment (arrows). In chronic disease this finding can be due to perivascular fibrosis.

**Fig. 11:** Mesenteric phlegmon. A 35-year-old woman with lower right abdominal pain with unknown Crohn’s disease. Axial LAVA after i.v. gadolinium image showing fat mesenteric with increased enhancement (white arrow) next to affected bowel loop (empty arrow).

Fig. 12: Abscesses. A 26-year-old patient with Crohn’s disease with inflammatory activity. Axial LAVA after i.v. gadolinium showing two fluid collections with an enhancing wall on abdominal wall (white arrow) and lower right abdomen (empty arrow).

**Fig. 13:** Coronal contrast-enhanced fat-suppressed T1-weighted 2D gradient-echo image showing mesenteric lymphadenopathy with intense contrast uptake (arrow).

Fig. 14: Enteroenteric fistulas. A 36-year-old patient with penetrating Crohn’s disease. Axial fat-suppressed FIESTA shows small bowel loops interconnected by enteroenteric fistulas (arrows).

Fig. 15: Ileo-sigmoid fistula. A 51 year-old-patient with Crohn’s disease. Axial LAVA after i.v. gadolinium demonstrates sigmoid colon and ileal loop interconnected by fistulous tracts (empty arrow).

**Fig. 16:** Enterovesical fistula. A 38-year-old patient with Crohn’s disease. Coronal FIESTA image shows a fistulous tract between ileal pelvic loops and the bladder (arrow). The presence of bubble-gas into the bladder supports enterovesical fistula diagnostic.

**Fig. 17:** Diffusion-weighted image in a 28-year-old patient with Crohn’s disease. Thickened inflamed bowel wall with high signal in an axial diffusion-weighted image.

Conclusion

MRE is a well tolerated technique, without ionizing radiation, that is indicated in patients susceptible of having lots of radiologic controls as in Crohn’s disease. Due to its contrast tissue resolution and the ultra-rapid sequences availability, it allows having MRI to transmural and extramural accurate evaluation. It has influence in patient management. It is indicated too in suspected Crohn’s disease, in celiac disease, in intestinal evaluation in children and in suspicion of small bowel tumours or intestinal obstruction as an alternative to CT.
Personal Information

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