MR enterography-our experience. Is it the future ?

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Learning objectives

Review our experience using enterography study (MRE) in patients with Crohn disease (CD). Make a brief review of the literature regarding the most common findings and MRE other indications.

Background

CD is a complex pathologic process with an unpredictable relapsing course. Despite the most common segment affected, the small bowel (SB) is the least accessible with endoscopic techniques (ET).

Findings and procedure details

We made 283 MRE during the last two years in our department. The most common indication and region affected were Crohn Disease staging (57 %), and terminal ileum (46 %) respectively. The prototype patient were young female patients.

Other common indications were indeterminate findings at ET, post-surgical, and low grade obstruction (LGO).

Unenhanced T2-weighted MR imaging and gadolinium-enhanced fat-suppressed T1-weighted MR are critical for characterizing wall thickening and identifying its cause. In a thickened bowel segment, a stratified enhancement pattern corresponding to the classic target sign is useful for excluding malignant conditions.

A pathognomic feature of CD is the presence of skip lesions.

MR imaging can demonstrate complications including penetrating disease, bowel obstructions, and perianal fistulization.

Maglinte and colleagues classify CD into four broad groups: active infammatory, perforating and fistulating, fibrostenotic, and reparative and regenerative.

Genetic susceptibilities that are important in the pathogenesis of IBD include genetic defects that result in gastrointestinal tract epithelial barrier function abnormalities and an abnormal immune response to a normal luminal micro- environment (1)

Endoscopy

Limitations

Cannot be used to assess extraintestinal abnormalities

Limited when strictures impede
the passage of the endoscope and thus prevent completion of the examination

Given the transmural inflammatory nature of CD and the resultant transmural extension ------ ***cross-sectional imaging is important for evaluating the extent and stage of CD.***

MR enterography :

ü MR enterography
is a valuable option with the **advantage** that it does not involve use of ionizing radiation----- mandatory consideration in young patients with IBD (4).

ü Helps to classify newly diagnosed IBD
in patients who have isolated colon disease or an indeterminate form of colitis

Example of a typical protocol

ü Ingestion a large volume of oral contrast material to achieve adequate distention of the small bowel, namely barium sulfate suspension with water (5).

ü A 0.5-mg dose of glucagon is administered intramuscularly before the image acquisition to reduce small-bowel peristalsis (6)

ü A second 0.5-mg dose of glucagon is administered intramuscularly before the intravenous administration of gadolinium-based contrast material

Sequences:

ü Dedicated phased- array torso coil: axial and coronal T2-weighted half-Fourier rapid acquisition with relaxation enhancement (RARE)

v RARE images----- T2 weighted

v Shows the presence of **mural edema and/**
or fat deposition; mucosal features are accentuated against a bright background that is created by ingested enteric contrast material (7)

ü T1-weighted volumetric interpolated breath-hold examination (VIBE)

v Useful for evaluating the degree of contrast enhancement and vascular features such as vasa recta engorgement;

ü Coronal and axial nonenhanced T2-weighted fat-saturated true fast imaging with steady-state precession (FISP)

ü Coronal and axial T1-weighted fat-saturated imaging

ü Coronal T1-weighted dynamic fat-saturated VIBE

Crohn Disease

CD is a relapsing-remitting chronic inflammatory disorder that manifests pathologically as **discontinuous transmural infammation** of the gastrointestinal tract (7,8)).

Peaks

Manifests During adolescence

1st peak- 20-30 years

2nd peak- 60-70 years

Classfication according to imaging features and endoscopic correlation

Active inflammatory

Fistulizing and perforating

Fibrostenotic

Reparative and regenerative disease

No stepwise progression between these disease phases

Various phases **may coexist** at the same time

A patient may have

ü Active inflammation superimposed on a fibrostenotic stricture

ü Different subtypes of the disease in different bowel segments in the same patient

ü CD can also be inactive- because of the natural history of the disease (8,9)

The histopathologic features of active infammatory CD include bowel segments with chronic focal inflammatory changes interspersed between disease-free intestinal segments (referred to as skip lesions).

Serosa

Muscularis externa

Submucosa

Mucosa

The inflammation can be transmural, but **it does not extend beyond the serosa**. Transmural inflammation tends to be **more severe within the mucosa and submucosa** (2-6).

The gross pathologic lesion seen earliest with CD is an **aphthous ulcer**

ü Shallow mucosal defect with peripheral erythema at endoscopy (8-10)

ü Initial lesion- microscopic evidence of epithelial necrosis (2-4)

Active inflammatory CD------ wall thickening is due to edema and inflammatory infiltrates, which **cause slightly increased signal intensity within thickened bowel segments on T2-weighted RARE images**.

Arterial phase

ü Intravenous contrast-enhanced **T1-weighted VIBE images** of these thickened bowel segments with active inflammation show hyperenhancement that progressively increases throughout all phases of contrast enhancement

ü Bowel wall hyperenhancement has been associated with active CD (15)

The relationship between degree of mural hyperenhancement and severity of inflammation is less well established

ü Bowel wall enhancement pattern has been shown to correlate with inflammation degree (16)

At qualitative assessment, contrast enhancement can be divided:

ü Mucosal (mucosa-submucosa region)

v The layered enhancement pattern results in **mucosa-submucosa and serosal enhancement**

v Correlates with the greatest degree of inflammation at histopathologic analysis

ü Homogeneous Layered

v The smallest degree of inflammation has been associated with the homogeneous pattern of mural enhancement (16-18).

Diffusion-weighted images show restricted diffusion in areas of active inflammation.

The luminal narrowing that results from bowel wall thickening in active inflammatory disease can result in proximal bowel dilatation and obstructive symptoms.

When reporting bowel obstruction in active inflammatory CD, it is important to determine and note whether the obstruction is due to active inflammation or fibrostenotic

WHY?

Treatments for these two disease phases differ

Luminal narrowing due to edema from active inflammation is managed with medication

Surgical resection is considered for bowel obstruction due to fibrostenotic disease.

Mural fibrosis

ü Feature of fibrostenotic disease

ü Mesenteric border also tends to have a higher degree of fibrosis and resultant retraction, **with relative sparing of the antimesenteric border** (18-20)

Consequently------**Antimesenteric border**

ü More stretchable and can expand to form sacculations

Cobblestoning

ü **Nodular mucosal protrusions** between areas of mucosal ulceration. These are best appreciated on **T2-weighted RARE images**, which accentuate the mucosal features against bright intestinal luminal contrast

Can be seen well on intravenous contrast-enhanced images

ü Owing to the nonenhancing crevasses between the cobblestones

ü **The MR enterographic findings correlate well with the cobblestone morphology seen at endoscopy**

A distinct advantage of MR enterography, as compared with endoscopic assessment--- enables evaluation of the mesentery.

Grading of Disease Severity-Categorization of the degree of inflammation

ü Mild, moderate, or severe

ü Can help guide therapy and is frequently used in CD research.

Radiologic-pathologic correlation data indicate

ü Associations between high T2 mural signal intensity, wall thickening, mucosal ulcerations, layered contrast enhancement, and severity of inflammation (20-22)

ü Multiple grading schemes based on varying combinations of MR enterographic features have been proposed for categorizing the degree of inflammation

Fistulizing and Perforating Disease

The transmural inflammation and deep penetrating ulcers involved with CD

ü May result in extension of inflammation through the serosa (23).

ü In nearly one-third of patients, transmural inflammation results in the formation of fissuring ulcers

Vertically oriented slitlike ulcers extending as far as the muscularis externa (22).

A fistula is an abnormal communication between two epithelialized surfaces ----Perianal fistulas are an example of fistulas commonly seen with CD

Sinus tract

ü Blind-ending abnormal connection with only one opening to an epithelialized surface

ü Sinus tracts leading to an intra- abdominal abscess are a common complication observed in patients with CD.

The **sensitivity of endoscopy** in appreciating the origin of the fistula or sinus tract may be based on the structure's size, and the ability to distinguish a sinus tract from a fistula is **limited because the distal aspect of the tract cannot be visualized**

These limitations can be overcome by using MR enterography

ü On MR enterographic images, fistulous tracts appear as **linear regions of T2 hyperintense signal arising from the serosal surface of the bowel and connecting to another organ cavity**, another bowel segment, or the skin surface;

ü Sinus tracts and fistulas may arise from bowel segments that have mural thickening and signs of active in ammation

ü **Abscesses appear as rim-enhancing fluid collections** in proximity to a fistula or sinus tract.

Fibrostenotic Disease

The results of long-term follow-up studies indicate that approximately 18%-27% of patients with CD develop fibrostenotic disease within 10-20 years after diagnosis (21-23)

Reparative and Regenerative Disease

The reparative and regenerative subtype of CD
is characterized by a lack of active inflammation and findings of mucosal atrophy and regenerative polyp formation (20).

ü There is no progressive mural fibrosis;

ü Submucosal fat deposition may be seen with prolonged inactive disease (14)

In addition to regenerative polyp formation

ü Intermediate signal intensity within the bowel wall, which could be related to fat deposition, may be seen on MR enterographic images

ü MR enterographic and endoscopic images will show no evidence of active inflammation

Cancer with CD

N

Indications

Crohn disease is the primary indication for MR imaging of the small bowel because **many patients present at a young age and require multiple imaging tests as a follow-up to therapy or to detect complications**.

A recent study by Desmond et al (3) showed that certain subgroups of patients with Crohn disease may be exposed to high lifetime doses of radiation, those:

ü Diagnosed at an early age;

ü Upper gastrointestinal tract inflammation or penetrating disease;

ü Requiring therapy with intravenous steroids or infliximab (an antibody that blocks the effects of tumor necrosis factor);

ü Multiple surgeries

The preference for performing enterography instead of enteroclysis is controversial:

ü Because of patient discomfort related to nasojejunal intubation, which is required for an enteroclysis examination

Several investigators have developed
a technique of administering large volumes of enteric contrast material orally, a method referred to as enterography (8,9).

ü Although superior distention is achieved with enteroclysis, this degree of distention may not be required to adequately assess the small bowel for certain disorders

Several enteric contrast agents may be used
for MR imaging

ü Classified according to the signal intensity they produce on T1- and T2- weighted images:

v Negative (low signal intensity)

v Positive (high signal intensity)

v Biphasic (low signal intensity on images of one type and high signal intensity on images of the other type)

Coronal T2-weighted fat-suppressed two-dimensional balanced SSFP MR image obtained with negative enteric contrast material

ü Shows an interloop abscess which is easily distinguished from the fluid- filled bowel

ü The bowel lumen is dark, and mural inflammation is seen in adjacent small- bowel loops

Several different types of contrast agents have been evaluated

ü Water, osmotic agents, nonosmotic bulking agents, sorbitol, and polyethylene glycol;

ü Several different dosing algorithms have been proposed and are determined by the agent used and the amount administered

ü In general, a large volume of contrast material (1350-2000 mL) is given during the hour before the examination.

Spasmolytics are useful for reducing bowel peristalsis and motion artifacts. Reduction of peristalsis is most important **for fast gradient- echo sequences** performed after the administration of intravenous contrast material

ü Also may help reduce intraluminal flow artifacts on half-Fourier acquisition single-shot turbo spin- echo (HASTE) images

Generally, T2- weighted and contrast-enhanced gradient-echo sequences usually are the most helpful

ü Specially with the use of biphasic enteric contrast agents;

ü T2-weighted sequences include HASTE and balanced SSFP

ü HASTE sequences are susceptible to intraluminal motion and often produce intraluminal low-signal-intensity artifacts

MR imaging may demonstrate changes of active Crohn disease

Increased mucosal enhancement

Wall thickening

Ulcerations

Increased mesenteric vascularity (the comb sign)

Perienteric inflammation

High signal intensity in the bowel wall

Reactive adenopathy

Associated complications such as penetrating disease and bowel obstruction.

MR Findings

MRI can be used to show the pathologic findings of and complications related to Crohn disease.

Maglinte and colleagues [1] proposed an imaging-based classification of Crohn disease, which they surmise could provide useful information when used in combination with clinical and laboratory data.

Advanced inflammation in Crohn disease manifests as deep ulcerations and a cobblestone mucosal appearance.

Deep transmural ulcers manifest

ü Linear, high-signal-intensity protrusions into the bowel wall on fast imaging with steady-state precession (FISP) and HASTE sequences

ü These linear protrusions are formed by enteral contrast material outlining deep ulcers

ü True FISP images have a black boundary artifact that may mask smaller transmural ulcers, and occasionally HASTE sequences may highlight transmural ulcers

ü Sensitivity values for the detection of bowel ulceration have been reported in the scientific literature to be between 75% and 90% [8-10].

Images for this section:

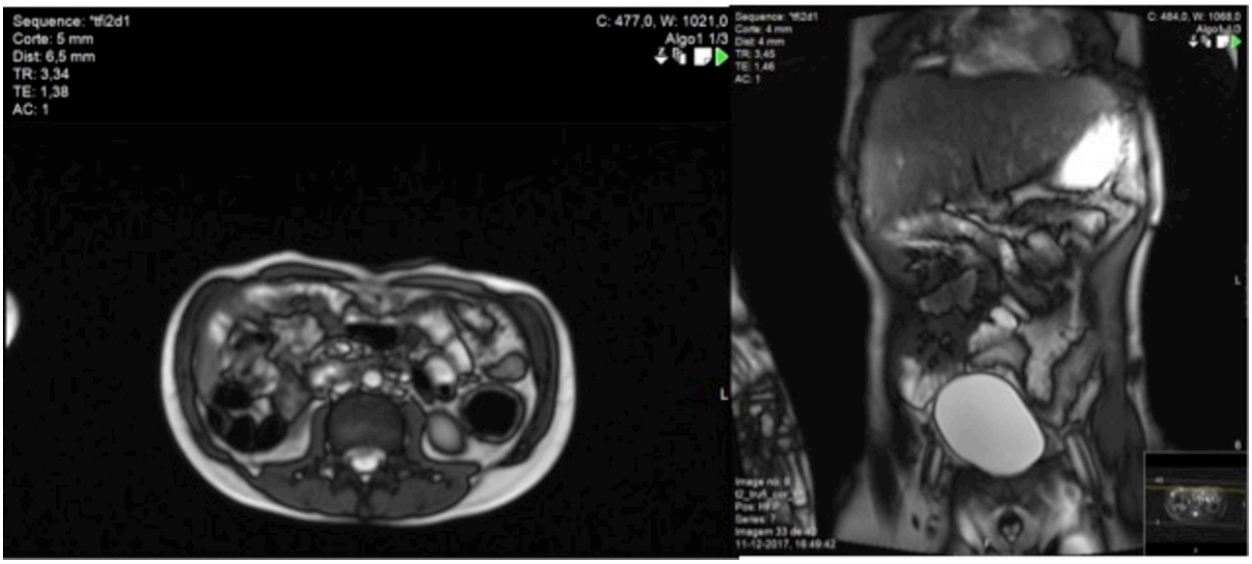

Fig. 1: Sigmoid and descending colon parietal thickening (6 mm) with mural homogeneous enhacement favoring inflamatory activity in Crohn context Lumitnal stenosis withou luminal upstream dilation

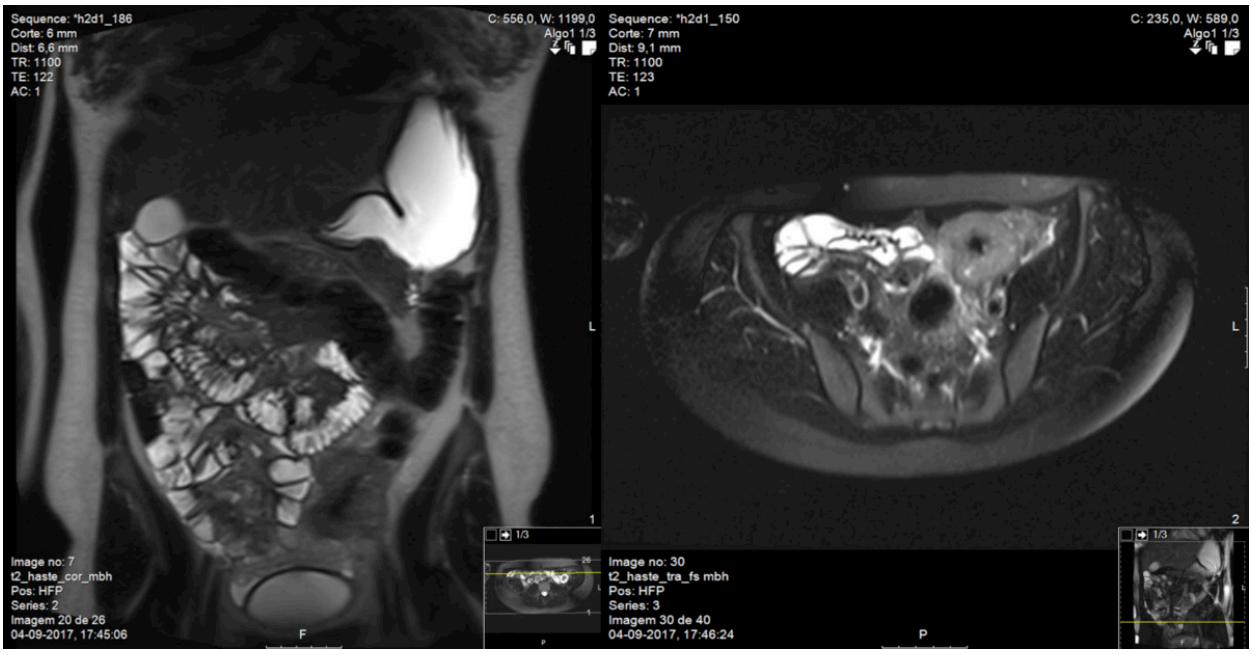

Fig. 2: Sigmoid pariteal concentric thickening (1,9mm) with an extension of 7 cm Mural edema and enhacement after contrast administration Left latero-aortic lymph node with 14 x 12 mm The findings favor the diagnosis of intstinal lymphoma

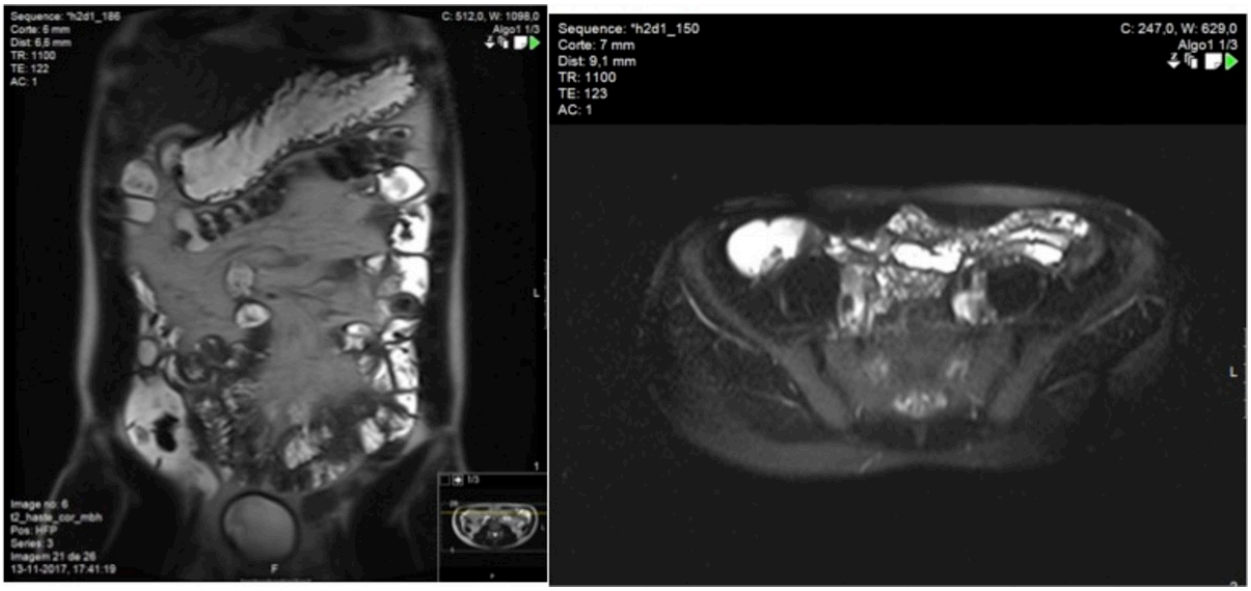

Fig. 3: Intestinal loops conglomerate in the hypgoastric region. No thickening enhacment or stenotic segments. No Crohn activity.

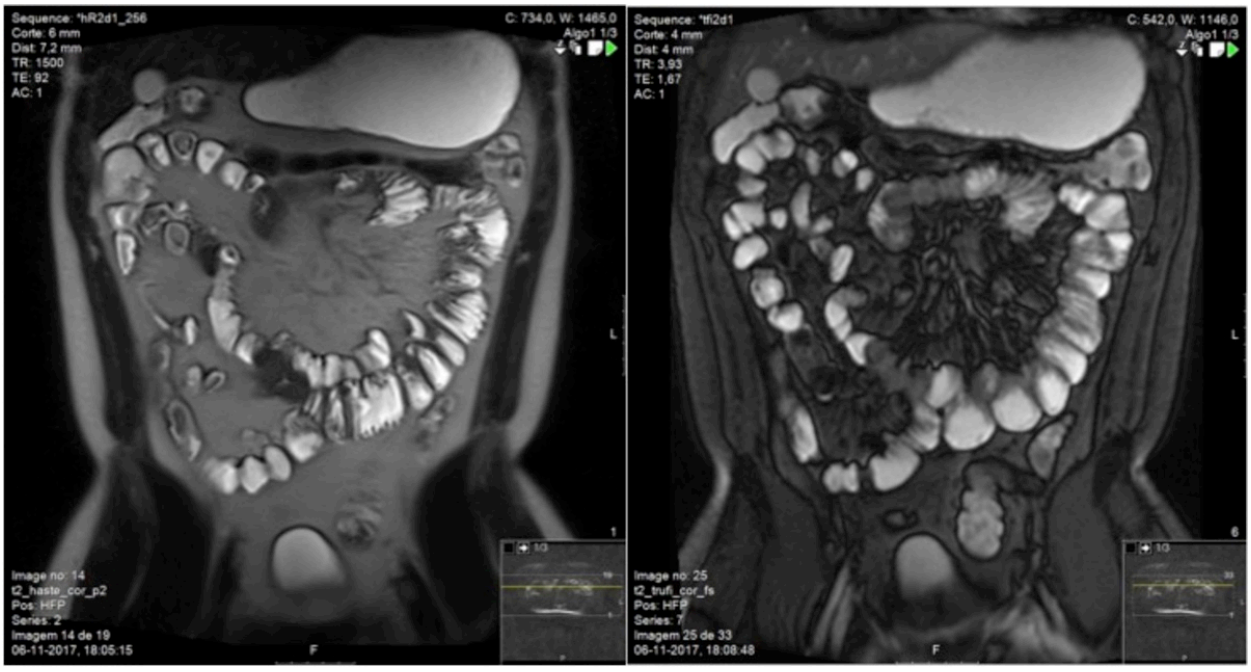

Fig. 4: Discrete mural thickening of the terminal ileum (4 mm) in a 4 cm extension Discrete restriction in diffusion. Parietal homogenous enhacement in the upstreal ileum. No fistula

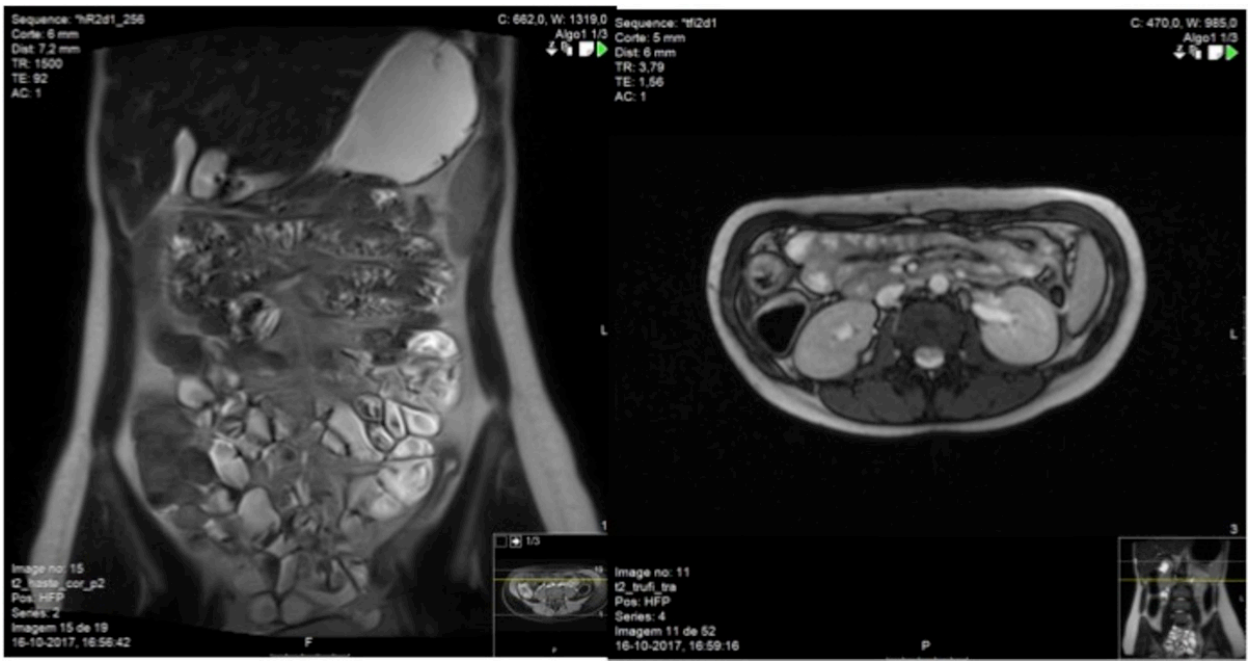

Fig. 5: Concentric parietal thickening involving the terminal ileum, ileo-cecal valve and cecum Maximal thickening of 6 mm Lymph nodes with 9 mm of maximal diameter

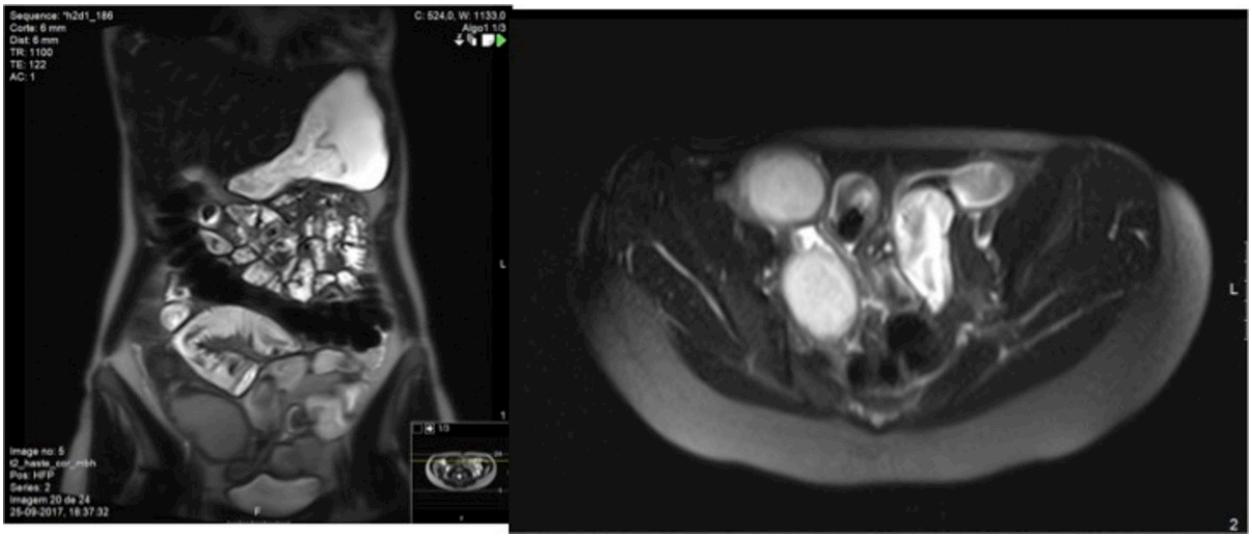

Fig. 6: Concentric parietal thickening involving the terminal ileum, ileo-cecal valve and cecum. Extension diameter of 5 cm. Terminal ileum stenosis Maximal thickening of 6mm Lymph nodes with 9 mm of maximal diameter

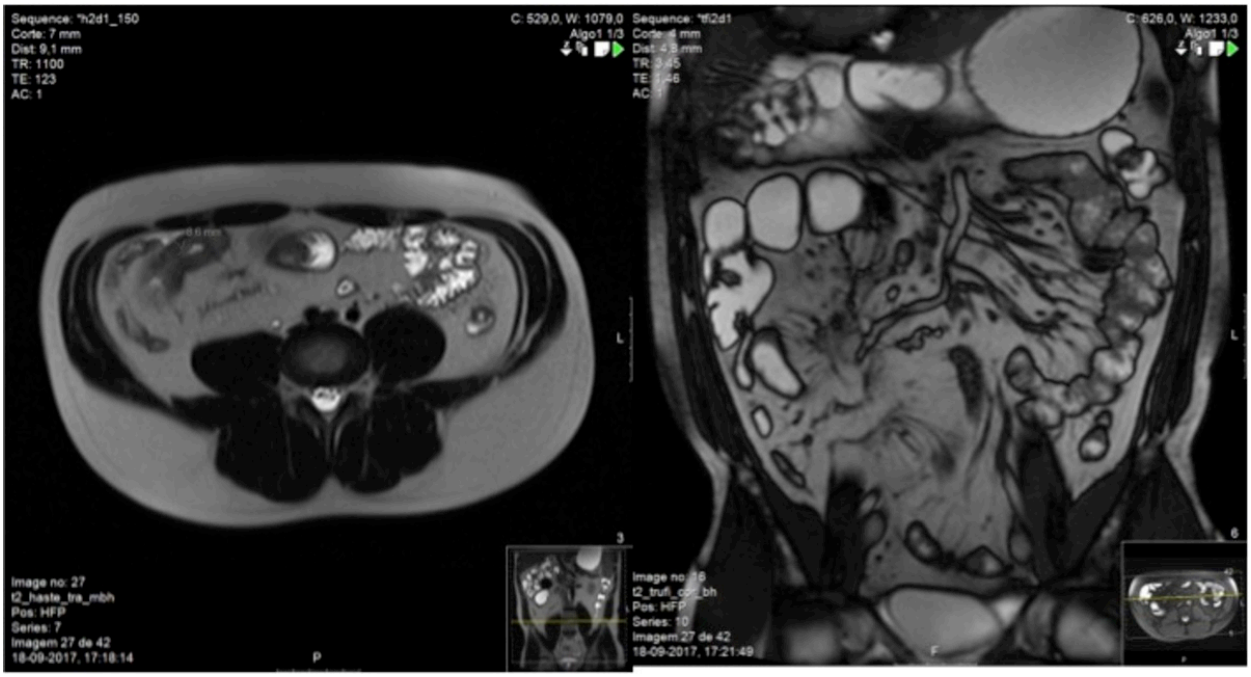

Fig. 7: Discontinuous segmental thickening of multiple ileal loops. Extension diameter of 9 cm. Comb sign Maximal thickening of 8 mm

Conclusion

MRE is an excellent resource for bowel study, with a definite aplication in inflammatory disease

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