



# MR enterography: what is next after Crohn's disease?

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## Abstract

Within the gastrointestinal system, the small bowel represents the most difficult site to approach with imaging modalities. During the last decades, magnetic resonance enterography has reached an increasing interest, up to be considered an essential part in the diagnostic framework of Crohn's disease patients. Nevertheless, the distention of the intestinal loops provided by the administration of oral contrast medium, the possibility of a dynamic evaluation, and the lack of radiation exposure are huge advantages that can be exploited for the assessment of other clinical conditions affecting the small bowel. Physicians and radiologists should be aware of the possibilities offered by this technique, looking at it as a trustful alternative to the well-worn radiological examinations. In this respect, the purpose of this work is to show some uncommon clinical conditions that can be assessed with magnetic resonance enterography and that fall within the various differential diagnosis of the intestinal disorders.

**Keywords** MR enterography · Intestinal obstructions · Vasculitides · Amyloidosis

## Introduction

The length, tortuosity, and the different distension degree of the several loops have always represented the main obstacles in the modalities assessment of small bowel.

Conventional endoscopy or ileo-colonoscopy, with the exception of the most proximal or distal parts, is not able to evaluate the small-bowel loops, while video-capsule endoscopy, although accurate, is very expensive and focused on the mucosal layer [1].

On the radiological side, barium follows through is a worldwide spread imaging technique that, however, cannot directly provide parietal or extraintestinal information, while conventional CT scan or CT enterography, though more comprehensive, is impaired by radiation exposure [1].

On the other hand, conventional ultrasound (US), contrast-enhanced US (CEUS), and small-intestine contrast ultrasonography (SICUS) can reach a good level of accuracy, without using ionizing radiation. Nevertheless, this imaging

modality requires a good deal of time and an experienced operator [2].

MR enterography (MRE) is one of the few imaging modalities that can provide an accurate evaluation of the small-bowel loops as well as the whole abdominal cavity without any radiation exposure and at reasonable healthcare costs [1, 2].

Owing to the undoubted advantages, it is realistic to look now at MRE with a fresh eye, beyond the well-established role in the intestinal assessment of Crohn's disease (CD) patients.

In this sense, the aim of this work is to provide an overview of the possible clinical scenarios where MRE could be successfully applied.

## MRE technique

An optimal MRE assessment requires a good distention of the intestinal loops, obtained through the administration of an oral contrast agent.

In our department, the oral contrast medium used is Polyethilen Glycole (PEG) water solution (1500 ml for the adults, 80–1000 for pediatric patients) and its administration starts 45 min before the beginning of the exam.

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The MRE protocol consists of: coronal thick-section T2-weighted RARE acquisition; axial and coronal true-fast imaging with steady-state (True-Fisp; TR/TE: 4.20/2.10 ms, FA: 60°); half-Fourier acquisition single-shot turbo-spin-echo (HASTE; TR/TE: ∞/80 ms) with and without fat-suppression; axial diffusion-weighted imaging (DWI) sequences with a diffusion b factor fixed at 0, 400, and 800 s/mm<sup>2</sup>; ultrafast 3D T1-weighted gradient-echo fat-suppressed, obtained before and after the intravenous injection of Gadoterate Meglumine (Dotarem) at a dose of 0.2 ml/kg body-weight on the axial and/or coronal plane, followed by a bolus of 30 ml of normal saline.

All the MR examinations presented were performed using a 1.5 T MR Philips Gyroscan Intera (Philips Medical System, Best, Netherlands) and phased-array abdominal coils.

Although small differences can be found among different clinical centers, the sequences acquired are the ones generally included in the MRE protocol used for the evaluation of patients with CD [3].

The performance of this type of protocol has occasionally been reported in the assessment of gastrointestinal disorders other than CD [1].

## Clinical applications

### Intestinal obstructions

Small-bowel obstruction (SBO) is a severe clinical condition, whose mortality rate can range from 2 to 25% [4].

The leading causes are usually classified in intrinsic (such as neoplasms, intussusception, radiation enteritis, etc.), extrinsic (adhesion, hernias, and endometriosis), and intraluminal (gallstones, bezoar, or ingested foreign bodies), with post-surgical adhesions accounting for the majority of the cases (70%) [5, 6].

Abdominal plain radiography has a good sensitivity and it is usually considered the first step in the diagnostic framework of these patients; however, its accuracy dramatically decreases while evaluating early stages or low-grade obstructions.

Although oral contrast studies and US could also be performed to reach further information, CT scan plays a pivotal role in achieving the final diagnosis, due to the comprehensive evaluation and the rapid scan times.

Nowadays, MRI is not generally recommended for acute onset of intestinal obstruction, with the exception of patients at risk for radiation exposure, such as children and pregnant, or contrast medium injection, for instance, subjects with impaired renal function.

The signs of small-bowel obstruction are similar to those of CT scan, including: loops distention; presence of “transition points”, which separates the dilated segments from the

collapsed ones; “small-bowel feces sign”, a consequence of an absent peristalsis; and the “whirl sign”, consisting in a switch of the mesenteric vessels and usually indicating a volvulus [6].

Beyond the huge advantage of the lack of ionizing radiation, MRI has also significantly narrowed the gap with CT scan for the scanning times through the development of rapid acquisition sequences [6].

Moreover, MRE can add the advantage of a further intestinal distention with the administration of the oral contrast medium, which could be crucial in detecting intraluminal causes of obstruction or highlighting the presence of transition points [1] (Figs. 1, 2, 3, 4).

However, since the prolonged oral administration and acquisition scan times, MRE is not routinely performed in case of acute intestinal obstruction, but its use can be considered in patients with chronic abdominal discomfort and sub-occlusive episodes.

### Vasculitides

Systemic vasculitides are generally defined as autoimmune disorders that lead to inflammation of the vascular walls, with or without necrosis.

They can be classified on the basis of their etiology (direct infection, immunological, and unknown) or according to the size of vessel affected (small, medium, large, and variable) [7].

The GI tract is generally involved by small- and medium-size vessel vasculitides, especially Henoch–Schönlein purpura (50–85%), polyarteritis nodosa (14–65%), and ANCA-associated vasculitis (3–71%) [8].

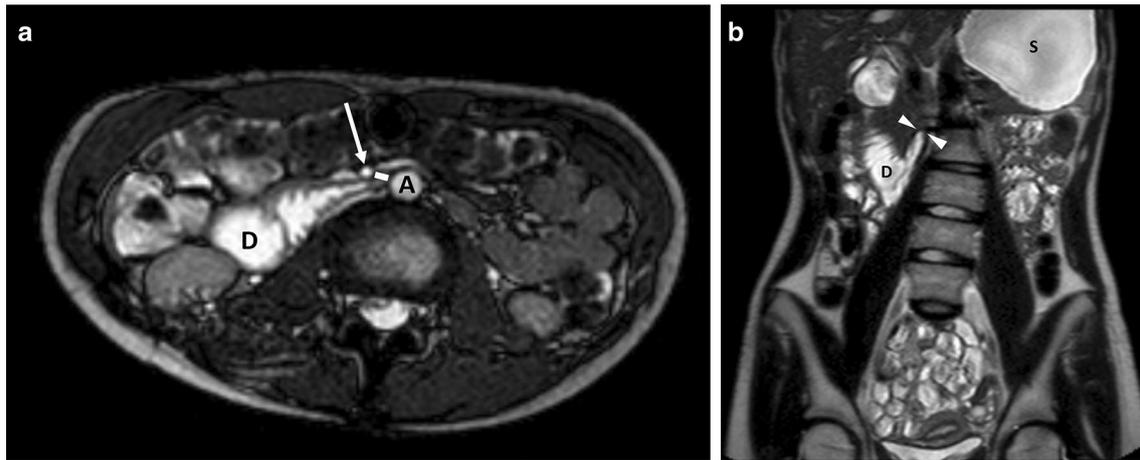
The typical clinical picture includes abdominal pain, nausea, vomiting, fever, and diarrhea, caused by a wide variety of gastrointestinal conditions, such as bowel ischemia, paralytic or mechanical ileus, gastrointestinal bleeding, and perforation as a possible complication [9, 10].

Imaging studies are necessary to detect the presence and to assess the entire extension of the disease.

As well as for CT scan, the main MRI signs of gastrointestinal involvement in vasculitis are the ones related to bowel ischemia, including dilatation of the loops, wall thickening, intramural gas, vascular engorgement, and mesenteric edema [1, 11–13].

After the administration of intravenous contrast agent, the affected loop generally shows poor or absent enhancement, although other patterns, such as delayed enhancement, cannot be completely ruled out (Figs. 5, 6).

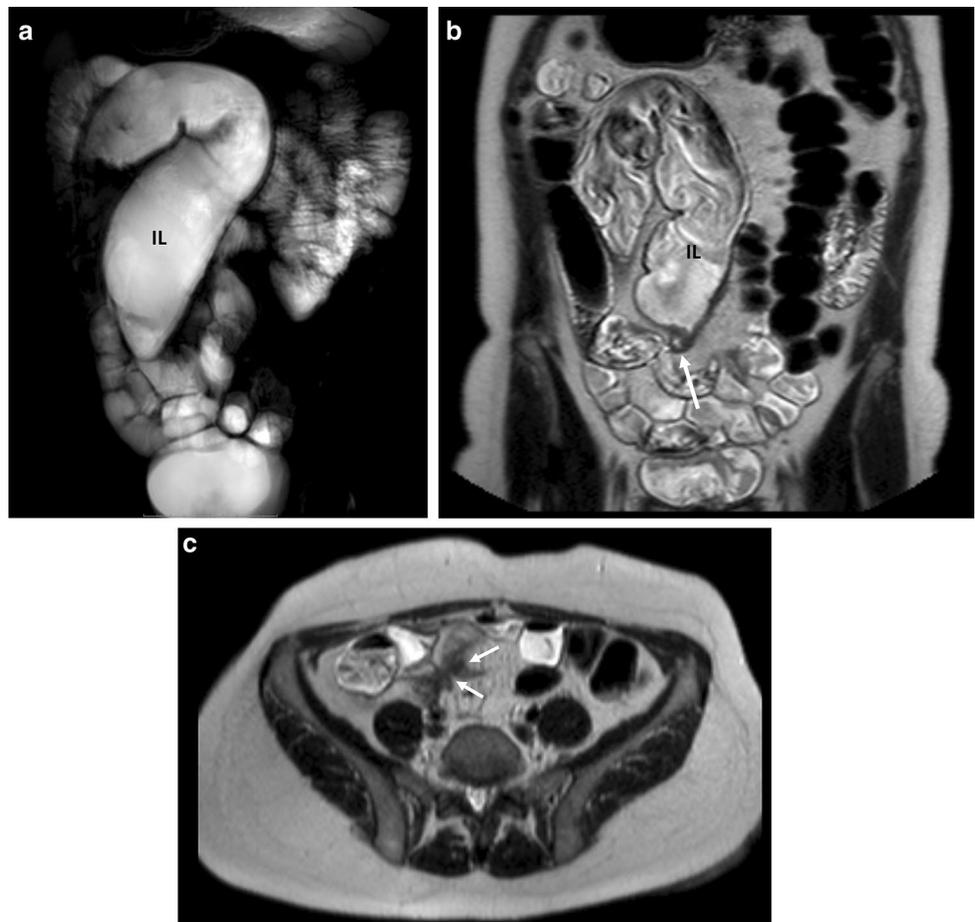
However, the differential diagnosis among vasculitides and with other clinical conditions is not usually possible basing only on the radiological findings. Therefore, an accurate clinical history collection, a good physical examination, and

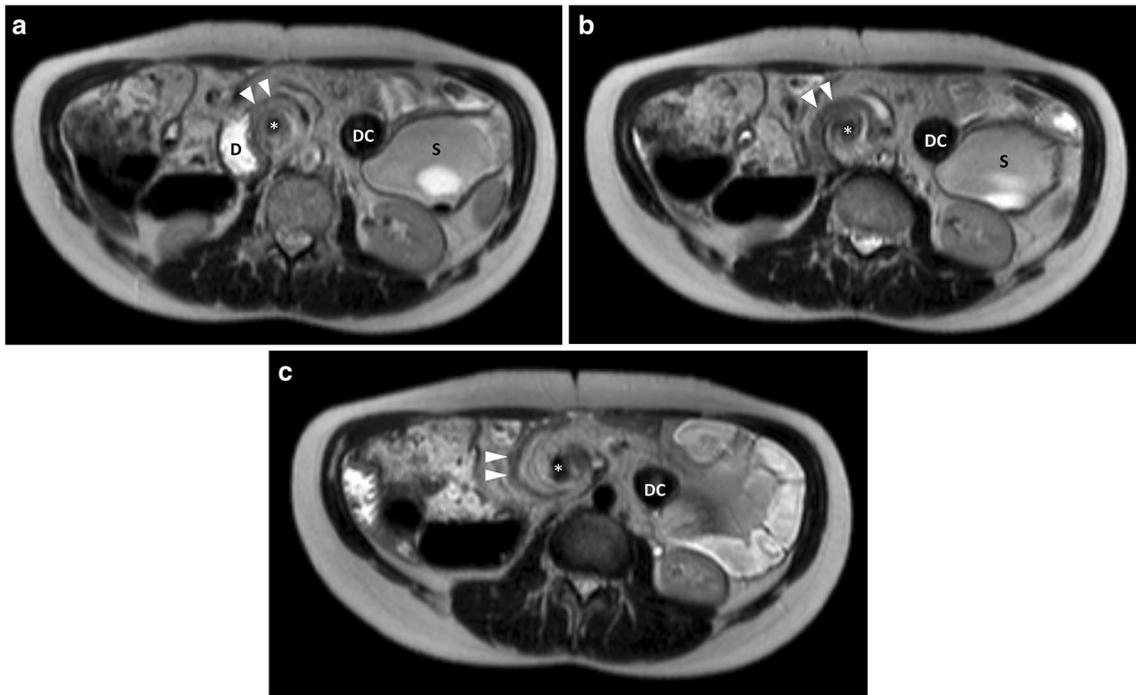


**Fig. 1** 15-years-old girl with abdominal pain, early satiety with nausea, vomiting, and a rapid weight-loss during the previous months. The axial T2-w True-Fisp (a) and the T2-w coronal HASTE (b) show a severe narrowing of the fourth duodenal portion (arrowheads), compressed between the superior mesenteric artery (arrow) and the abdominal aorta (A). A pathologic distance (line) between these two

vessels is also detectable (5 mm; normal: 10–20 mm), with a significant dilation of the stomach (S) and of the proximal duodenal segments (D), which persisted during all the phases of the examination. The radiological diagnosis of superior mesenteric artery syndrome (also known as Wilkie’s syndrome) was then endoscopically confirmed

**Fig. 2** 59-years-old female patient with a clinical history of histeroansectomy several years prior and chronic abdominal discomfort. The coronal T2-w RARE (a) and coronal T2-w HASTE (b) images demonstrate a huge distension of an ileal loop (IL) lying on the right abdominal quadrants. The dilation was caused by an adhesion band arising from an inhomogeneous fibrotic tissue (arrows), consequent to the previous histeroansectomy and better detectable on the axial T2-w HASTE sequence (c)

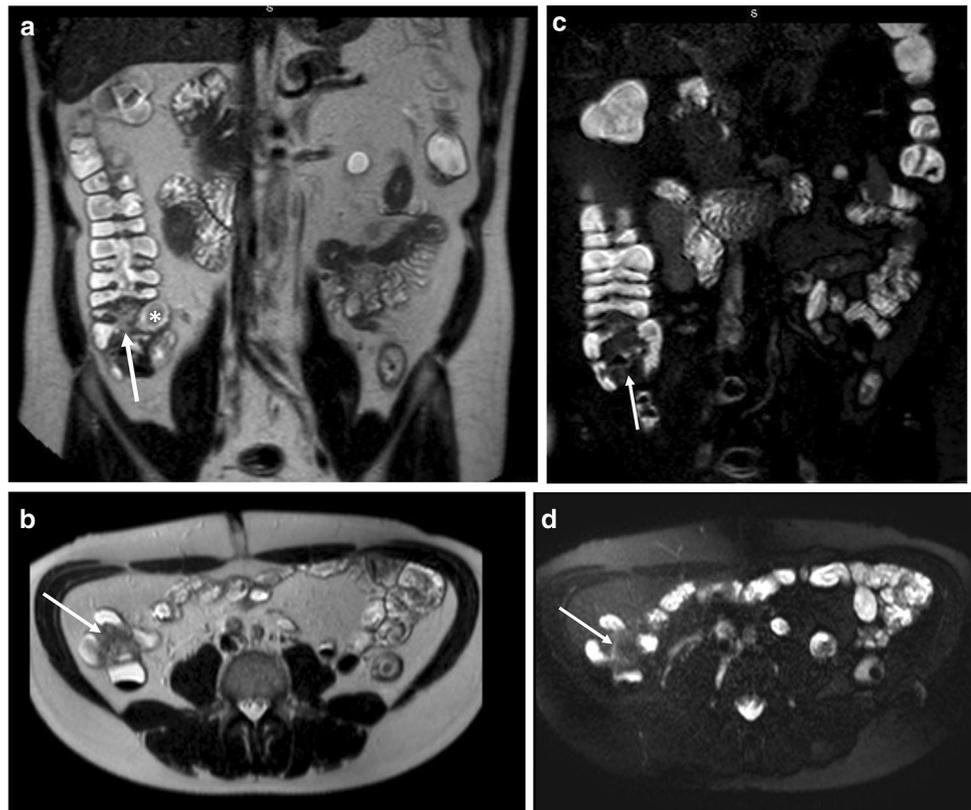


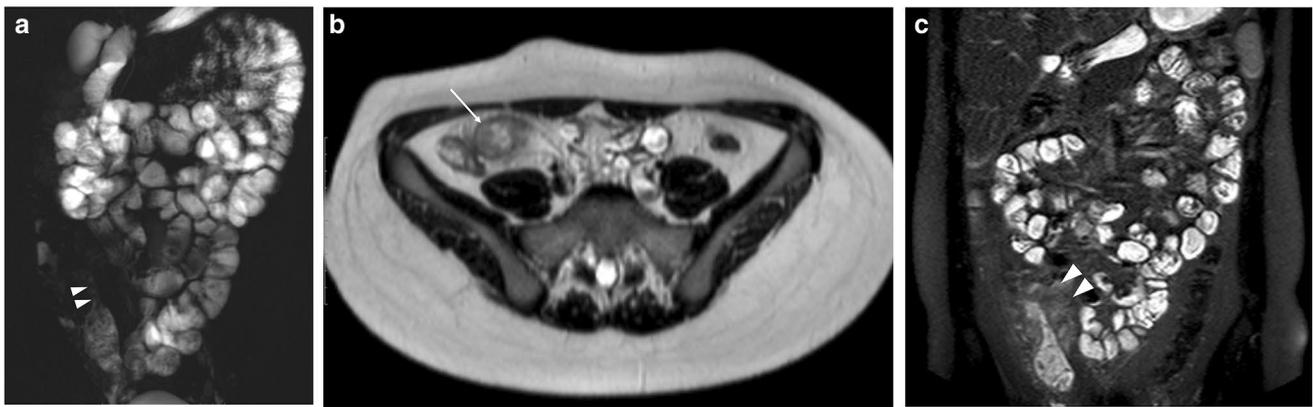


**Fig. 3** 45-years-old female patient with chronic abdominal pain and recurrent sub-occlusive episodes. On the three T2-w HASTE displayed in cranio-caudal order (a–c), it is possible to recognize a narrowing of the third-fourth portions of the duodenum (D) around the superior mesenteric artery axis (asterisk) resulting in the clockwise

«whirlpool sign» (arrowheads), typical of midgut volvulus. Dilation of the stomach (S) on the left flank. A «persistent descending mesocolon», an anatomical variant characterized by a medialization of the descending colon (DC), is also visible

**Fig. 4** 47-years-old male patient with a history of intermittent nonspecific abdominal pain, diarrhea, transient episodes of obstruction. Coronal (a) and axial (b) HASTE T2-w sequence show an intraluminal inhomogeneous lesion (arrow), at the level of the ileocecal valve (asterisk), protruding into the caecum. The coronal (c) and axial (d) T2-w HASTE images with fat-suppression, demonstrate a drop of the intensity signal within the lesion (arrow), allowing to put forward the suspicion of a lipoma of the ileocecal valve. The radiological diagnosis was then endoscopically confirmed

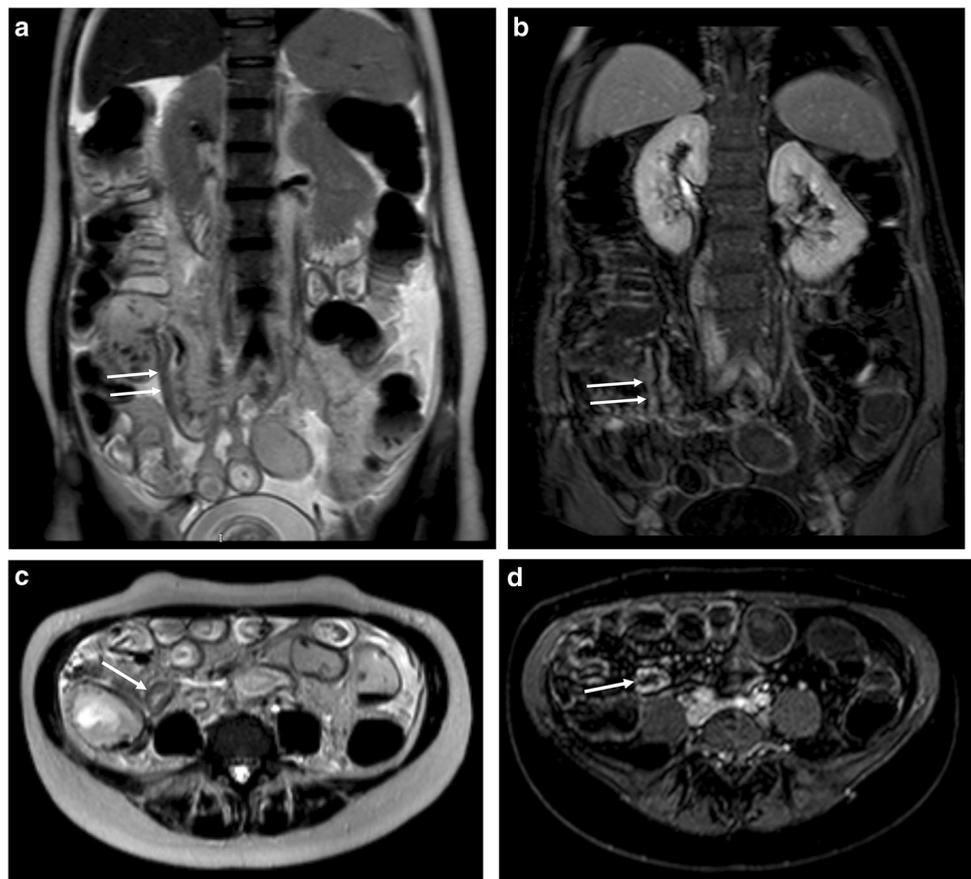




**Fig. 5** 13-year-old female patient with a known history of Behcet disease with neurological and gastrointestinal involvement. The coronal T2-w RARE sequence (a) shows a narrowing of the last ileal loop (arrowheads), caused by a severe wall thickening (arrow) with a polypoid appearance on the mucosal side appreciable on the axial T2-w

HASTE (b). The surrounding mesenteric fat appear hyperintense (arrowheads) on T2-w HASTE with fat saturation (c), as a sign of inflammatory reaction. Endoscopy confirmed the presence of edema, mucosal ulcers and erythema inside the pathological loop

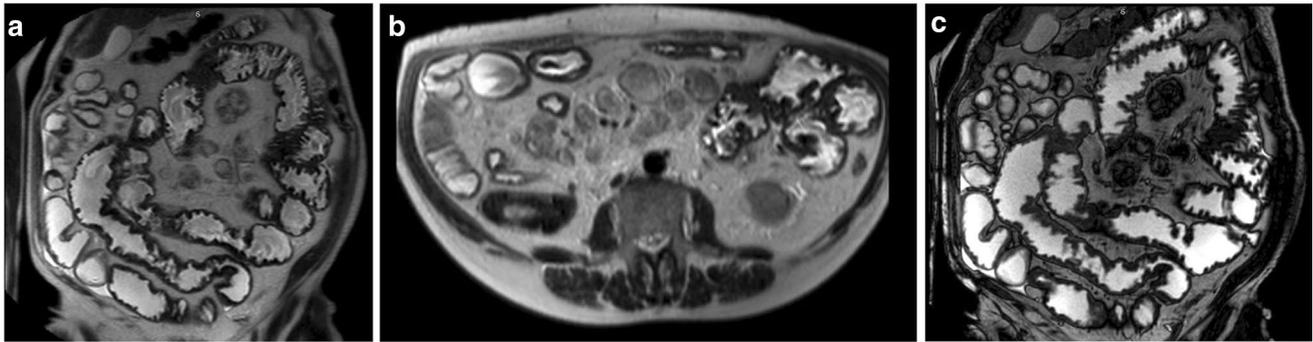
**Fig. 6** 22-years-old woman affected by Systemic Lupus Eritematosus, with an established ileal involvement, was referred to our hospital complaining for abdominal pain. Since an abdominal CT-scan was been already performed few months before, the patient underwent an MRE. On the coronal (a) and axial (b) T2-w HASTE acquisition it is possible to recognize a mild wall thickening of the last ileal loop (arrows), which shows only a mild enhancement at the coronal (c) and axial (d) T1-weighted THRIVE image with fat saturation (FS) after Gadolinium intravenous injection



appropriate laboratory tests are mandatory to achieve the final diagnosis [9, 14].

### Extracellular protein deposition diseases

The term amyloidosis refers to a group of disorders characterized by an abnormal extracellular deposit of protein or protein derivatives.



**Fig. 7** 67-years-old male patient with a well-known amyloidosis involvement of the heart and a history of chronic non-specific abdominal pain, nausea and constipation. The coronal (a) and axial T2-w HASTE (b) and the coronal True-Fisp (c) demonstrate a diffuse,

irregular thickening of the jejunal and ileal folds, related to the intramural deposition of amyloid fragments. Several lymphadenopathies, partly with a conglomerate appearance, are also visible within the mesenteric fat tissue

Excepting the inherited type, caused by the mutation of the Transthyretin protein, amyloidosis includes two different categories, according to the type of the accumulating protein [15, 16].

Primary amyloidosis is the most frequent and it is consequent to immunoglobulin light chains deposition, mainly in patients suffering from multiple myeloma, lymphoplasmacytic lymphoma, and Waldenstrom macroglobulinemia [16].

On the other hand, secondary amyloidosis is caused by the deposition of fragments of serum amyloid A proteins, essentially produced by the liver in response to inflammatory stimuli [16].

Amyloidosis can affect a large variety of tissues and organs, ranging from the nervous, to the cardiopulmonary, genitourinary, musculoskeletal, and gastrointestinal systems.

Within the latter one, the involvement of the small bowel is the most common, with abdominal pain, malabsorption, diarrhea, and weight loss as the most frequent symptoms.

The pathogenesis encompasses the infiltration and the resulting destruction of the muscularis layer and the Auerbach plexus by the amyloid deposit [15].

At oral contrast examinations or CT scan, the main radiological finding is the focal or diffuse wall thickening that can show a pseudo-nodular appearance [16].

Along with this, MRE is also able in highlighting the dilation of the intestinal loops and the mesenteric infiltration, detectable on T2-weighted sequences with fat-saturation as a high signal intensity area within the abdominal adipose tissue (Fig. 7).

The role of imaging, although very useful in the diagnostic evaluation and characterization of the whole involvement, is not definitive, with tissue biopsy still representing the gold standard for the final diagnosis.

## Conclusions

The safeness and the comprehensive evaluation of MRE ensure remarkable versatility to this imaging modality, allowing to consider its performance in several clinical conditions.

The cases presented demonstrate that MRE can represent a real alternative to CT scan, particularly in compliant patients with chronic abdominal discomfort.

Diagnostic radiologists should be familiar with this technique to achieve a correct interpretation of the findings and be aware of the possible different diagnosis.

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## Compliance with ethical standards

**Conflict of interest** The authors declare that and they have no conflict of interest.

**Ethical standards** This work was in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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