



# MRI ENTEROGRAPHY OF CROHN'S DISEASE: WHAT EVERY RESIDENT SHOULD KNOW

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# Learning Objectives

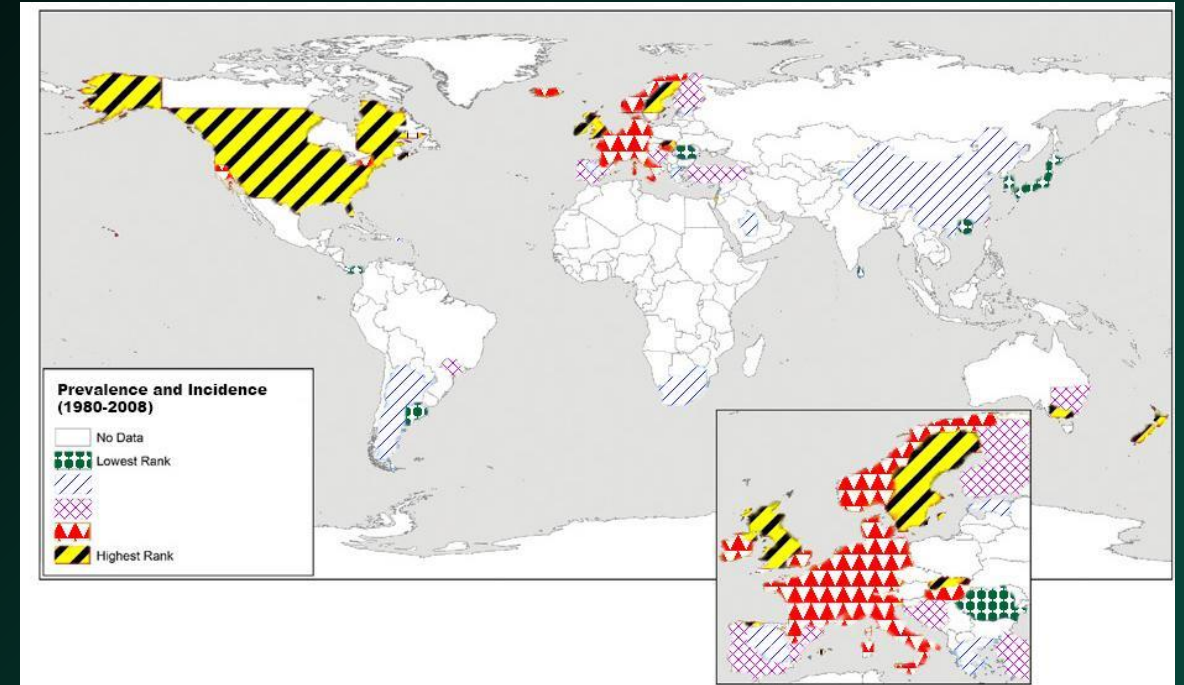
- to know the best MR enterography (MRE) protocols for Crohn's disease (CD);
- to know all the phenotypes MRI finding of CD;
- to know the complications of CD, including malignant transformation;
- to evaluate the response to biological treatment.

# Background

**Crohn disease** (CD) is an idiopathic chronic inflammatory bowel disease characterised by transmural inflammation, that may involve the entire gastrointestinal tract, from mouth to the anus.

A systematic review demonstrated an incidence of:

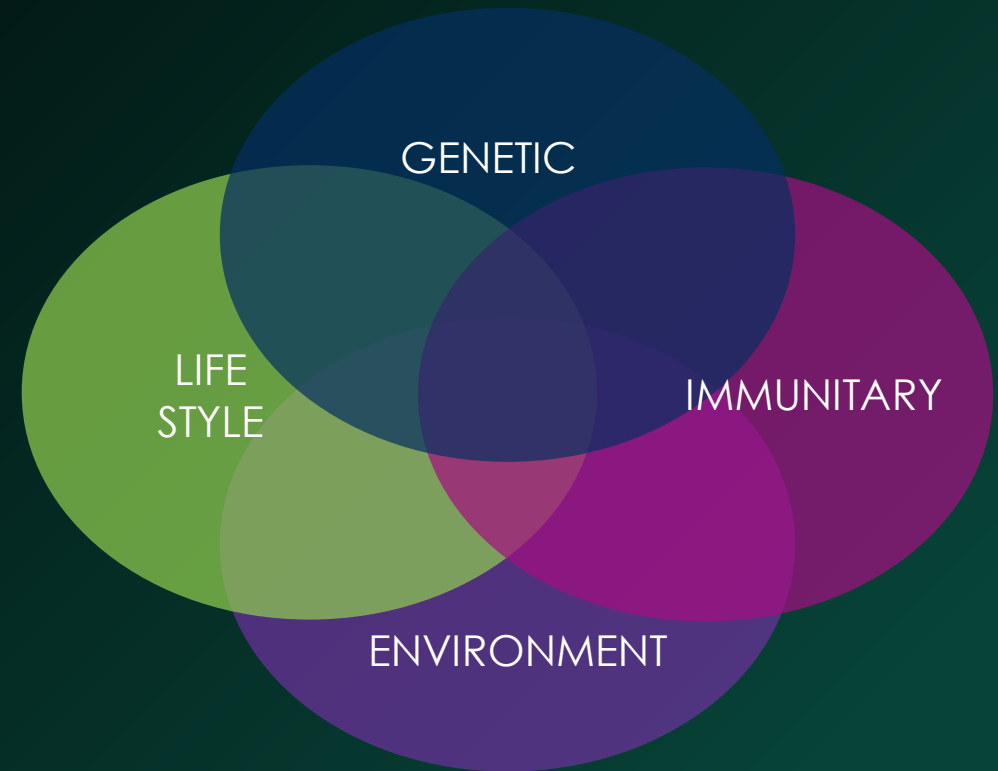
- 12,7 per 100,000 person-years in Europe;
- 5,0 per 100,000 person-years in Asia and the Middle East;
- 20,2 per 100,000 person-years in North America.



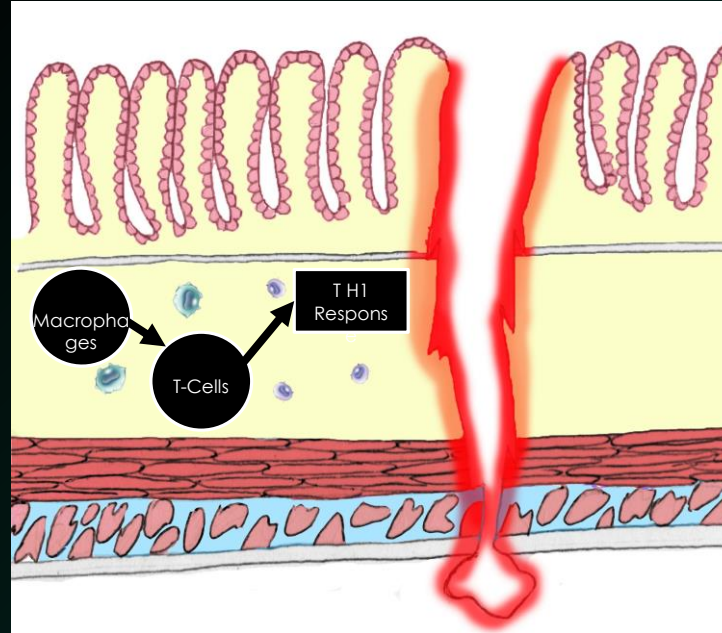
# Background

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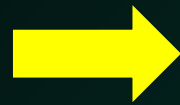
Although the exact aetiology is unknown, it has been postulated that combined effects of **genetic**, **environmental**, **life style** and/or epithelial barrier dysfunction cause activation of mucosal **immune responses**, which in turn lead to inflammatory response.



# Background



Initially, the disease is limited to the mucosa → neutrophilic cryptitis, lymphoid hyperplasia, lymphoedema and shallow aphthoid ulceration.



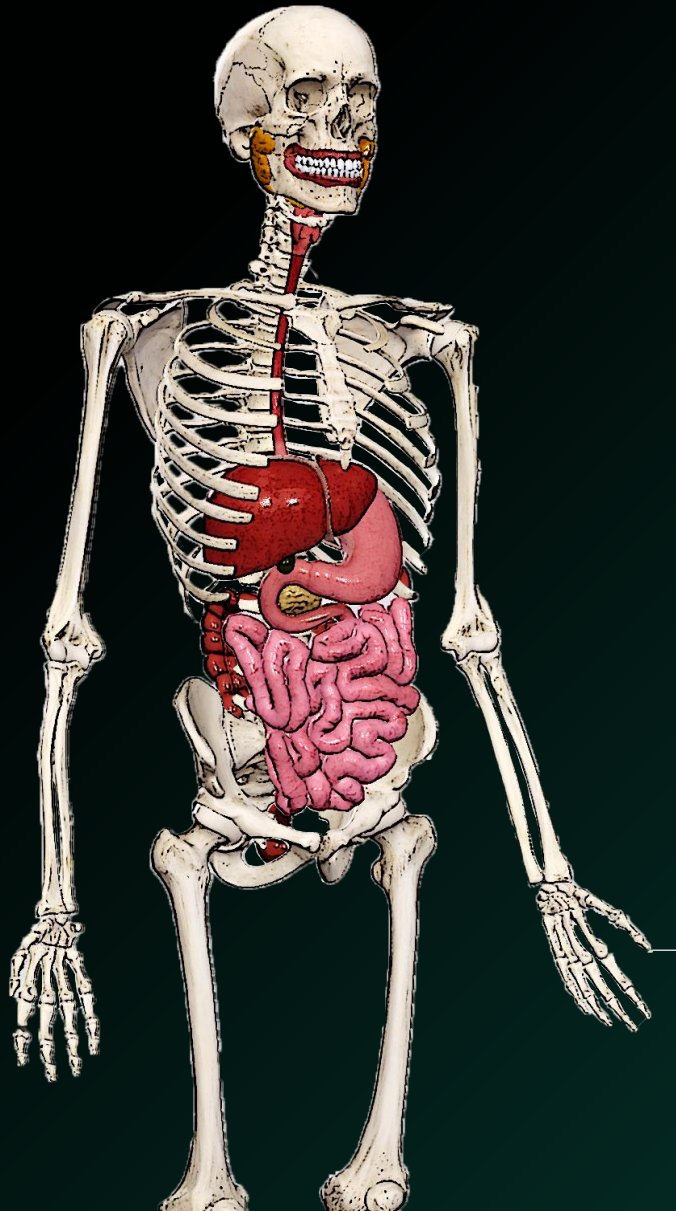
As the disease progresses → the entire bowel wall becomes involved, with linear longitudinal and circumferential ulcers extending deep into the bowel wall, predisposing to fistulae.



Inflammation also extends into the mesentery and over time leads to chronic fibrotic change, and stricture formation.



# Background



- ~ 80% of patients → have **small bowel involvement**, usually in the distal ileum (with one-third of patients having ileitis exclusively);
- ~ 50% of patients → have **ileocolitis** (which refers to involvement of both the ileum and colon);
- ~ 20% of patients → have disease limited to the **colon**. In contrast to rectal involvement in patients with ulcerative colitis, one-half of CD patients with colitis have sparing of the rectum;
- ~ 1/3 of patients have **perianal disease**.

# Background

## CD Subtypes (Montreal classification):



### **B1. Non stricturing, non penetrating (active inflammation):**

aphthoid and deep ulceration, wall thickening, intramural and mesenteric oedema, increased mesenteric vascularity

**B2. Stricturing:** chronic inflammation progress towards fibrostenotic complications → bowel strictures and obstruction

**B3. Penetrating (Fistulizing/perforating):** deep penetrating ulcers → sinus tract, fistulas and/or abscess

**P. Perianal disease modifier:** anal fissures, perirectal abscesses, and anorectal fistulas.

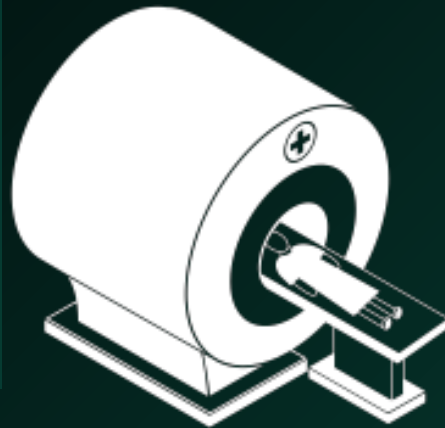
The Montreal classification is an easy, assessable and widely accepted PROGNOSTIC and THERAPEUTIC parameter; it includes the age at diagnosis and the location and behavior of disease.

# Background

CT enterography (CTE) and MR enterography (MRE) are cross-sectional imaging techniques optimized for the small bowel imaging.

MRE advantages:

- **not radiation** exposure;
- **superior soft tissue contrast**; some abnormalities and enhancing areas may be more conspicuous;
- **multiple** different **pulse sequences**;
- **multiphasic** imaging demonstrating bowel peristalsis and physiology;
- more informative than CTE when intravenous contrast cannot be administered.



CTE advantages:

- **higher spatial resolution** (improvement in detection of small subtle abnormalities);
- **widely available and fast** → images of the entire abdomen and pelvis obtained in one breath hold (better patient tolerance with less motion artefact).





# Background

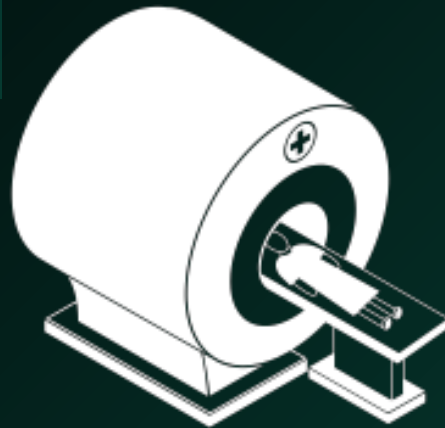
CT enterography (CTE) and MR enterography (MRE) are cross-sectional imaging techniques optimized for the small bowel imaging.

MRE limitations:

- access and costs;
- long time examinations and multiple breath holds (motion artefacts and suboptimal image quality);
- imaging of other organs such may not be possible in a single examination.

CTE limitation:

- radiation exposure.



# Background

CT enterography (CTE) and MR enterography (MRE) are cross-sectional imaging techniques optimized for the small bowel imaging.



Same sensitivity (CTE 83%, MRE 86%) and specificity (CTE 88%, MRE 87%)

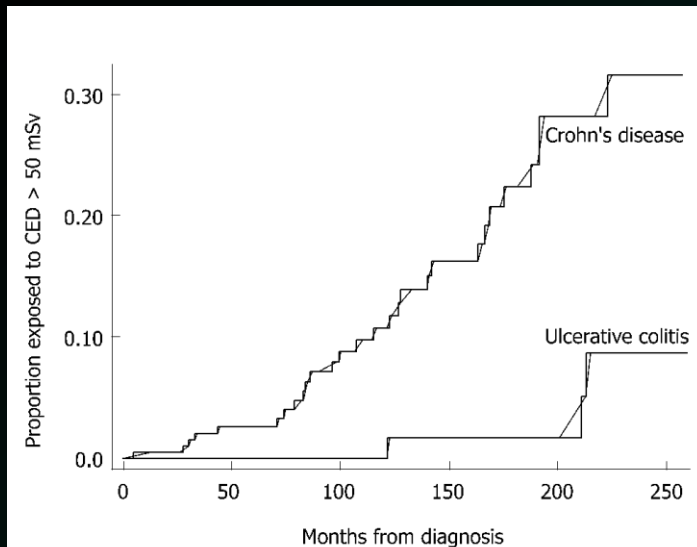


Figure 1 Kaplan Meier analysis showing the cumulative probability of being exposed to cumulative effective dose > 50 mSv from diagnosis according to inflammatory bowel disease type (Chatu *et al*<sup>[14]</sup>, 2013).

Due to radiation exposure

CTE in Emergency

MRE in Follow-up  
and young patients

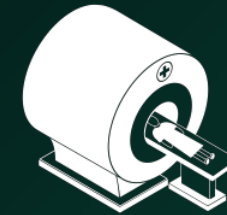
# Background

CT enterography (CTE) and MR enterography (MRE) are cross-sectional imaging techniques optimized for the small bowel imaging.



## Consider CTE

- Concern for sepsis, or suspect complex intra-abdominal penetrating disease
- Older patient (over 35 y.o.)
- To rule out other disease
- When low dose CT is available
- Absolute contraindication to MRE
- Local imaging access and expertise

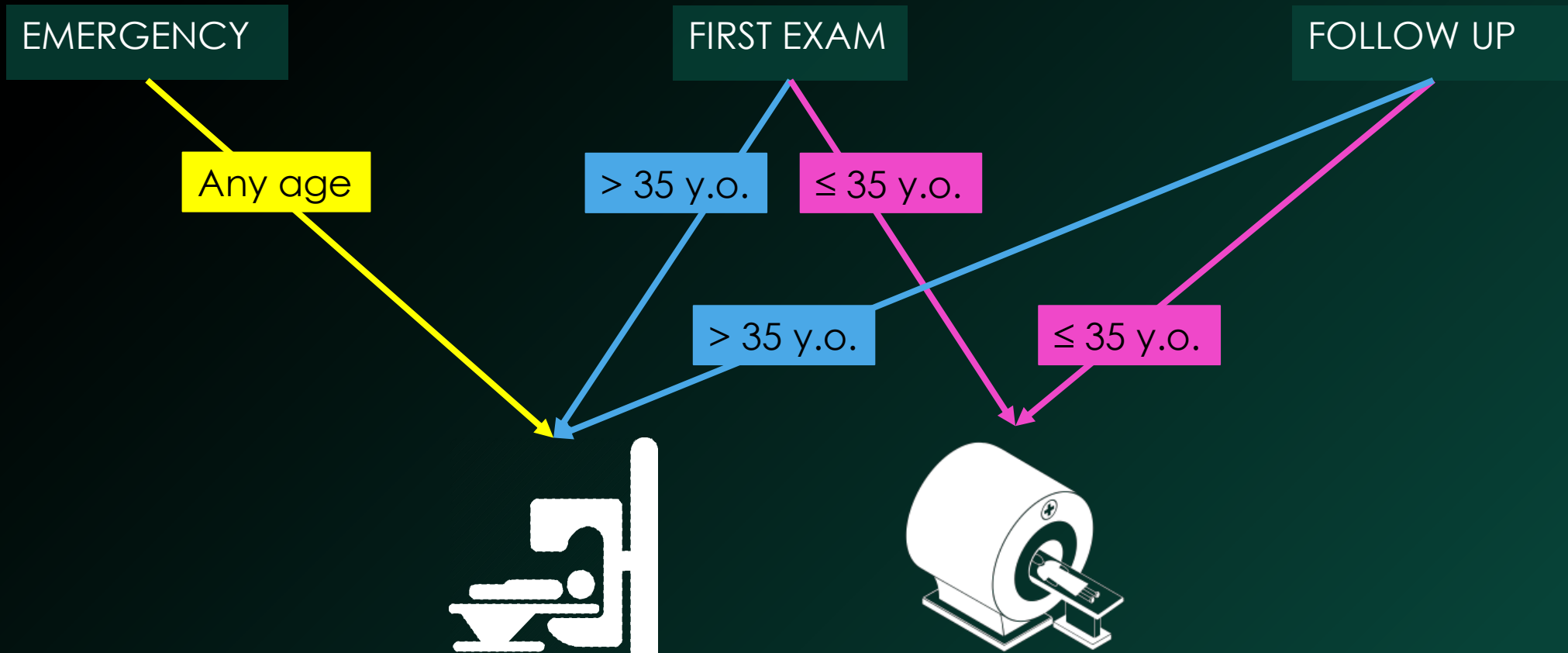


## Consider MRE

- Prior CTE
- Young patient (under 35 y.o.)
- To evaluate not acutely CD or to assess response to therapy
- Known perianal fistula or sepsis
- Contraindication to CTE (pregnancy allergy)
- Local imaging access and expertise

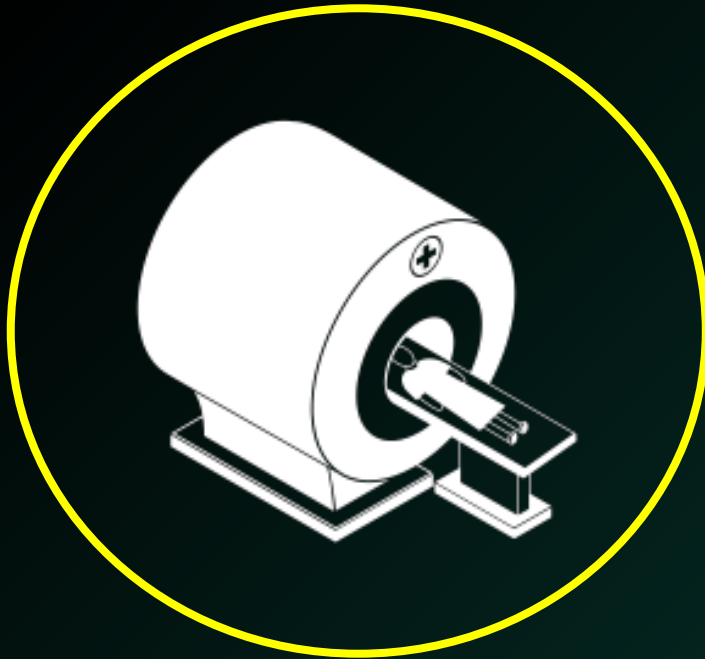
# Background

CT enterography (CTE) and MR enterography (MRE) are cross-sectional imaging techniques optimized for the small bowel imaging.



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CT enterography (CTE) and MR enterography (MRE) are cross-sectional imaging techniques optimized for the small bowel imaging.



Today we will talk  
about MRI  
enterography



# Imaging findings – MRE Protocols



## General patient preparation:

### Oral contrast:

- Hyperosmolar solution (mannitol, PEG, sorbitol);
- Optimal volume 1000-1500 ml(not less than 450 ml);
- 45-60 min prior to the examination (patient without bowel resection);
- 30 min prior to the examination (patient with bowel resection);
- Patients should not eat any solid food for 4-6 h;
- Patients should not drink any fluid for 4-6 h → non-sparkling water is permissible;
- In patients with a stoma, the stoma should be plugged before oral contrast ingestion;
- Routine medications should not be stopped.

Good evidence

Strong evidence

# Imaging findings – MRE Protocols



## MRE technique:

### Spasmolytic somministration:

- Spasmolytic agents administered during MRE and MR enteroclysis;
- Recommended dose of i.v. hyoscine butylbromide → 20 mg;
- Spasmolytics should be administered before motion sensitive sequences (FSE T2W sequence and post contrast T1W images);
- Recommended first line spasmolytic agent → i.v. hyoscine butylbromide;
- Second line spasmolytic agent (i.v. glucagon 1 mg) recommended if the first line agent cannot be given.

Poor evidence

Good evidence

Strong evidence

# Imaging findings – MRE Protocols

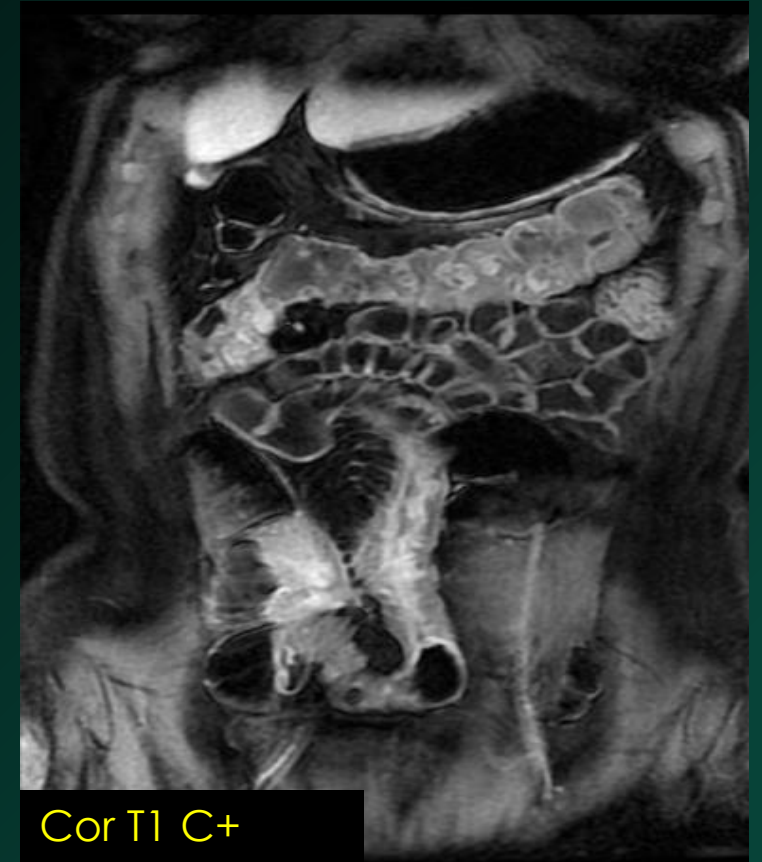
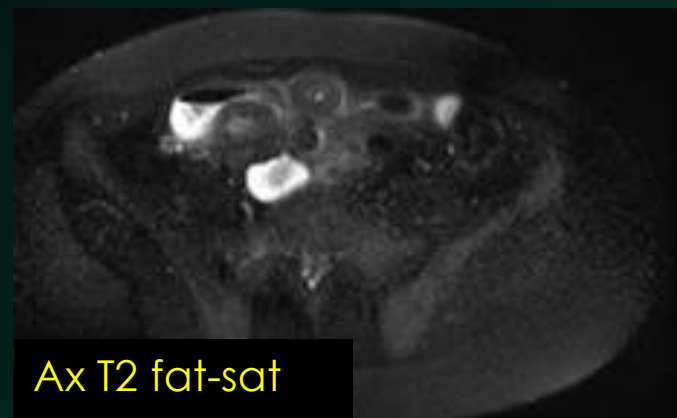
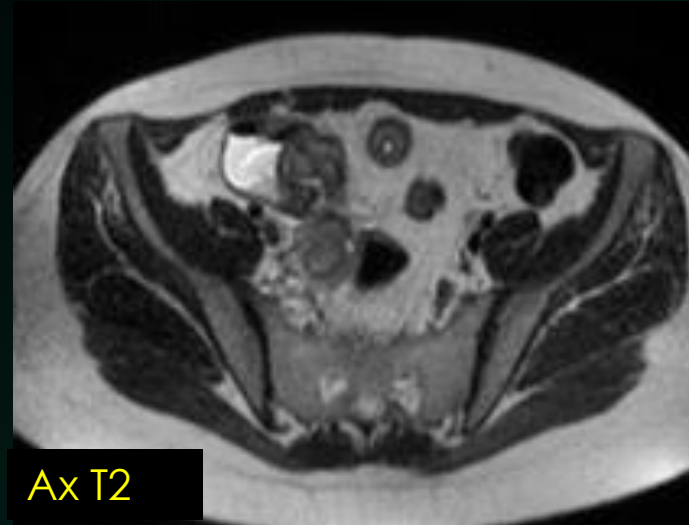


## MRE technique: SEQUENCES

Type of sequences	Plane	Comments
<ul style="list-style-type: none"><li>• TSE-T2W +/- Fat sat</li><li>• SSFP GE not Fat sat (also CINE)</li><li>• SSFSE</li></ul>	<ul style="list-style-type: none"><li>• Axial</li><li>• Coronal</li></ul>	<ul style="list-style-type: none"><li>• +/- Fat sat</li><li>• Assess mural inflammation and changes in peri-enteric fat</li><li>• Max slice thickness 5 mm</li><li>• 2D (preferred) or 3D</li><li>• CINE sequences for bowel motility</li></ul>
<ul style="list-style-type: none"><li>• T1W FSPGR</li></ul>	<ul style="list-style-type: none"><li>• Coronal (pre-post CE)</li><li>• Axial (post CE)</li></ul>	<ul style="list-style-type: none"><li>• In patient with suspected chronic GI bleeding:<ul style="list-style-type: none"><li>• Arterial 30 s</li><li>• Enteric 45 s</li><li>• Portal 70 s</li></ul></li><li>• i.v. gadolinium 2 ml/sec (0,1-0,2 mmol/kg)</li><li>• Max slice thickness 3 mm</li><li>• Preferred 3D</li></ul>
<ul style="list-style-type: none"><li>• DWI</li></ul>	<ul style="list-style-type: none"><li>• Axial</li></ul>	<ul style="list-style-type: none"><li>• Free breathing</li><li>• Lower b 0-50</li><li>• Highest b 600-900</li><li>• Max slice thickness 5 mm</li></ul>

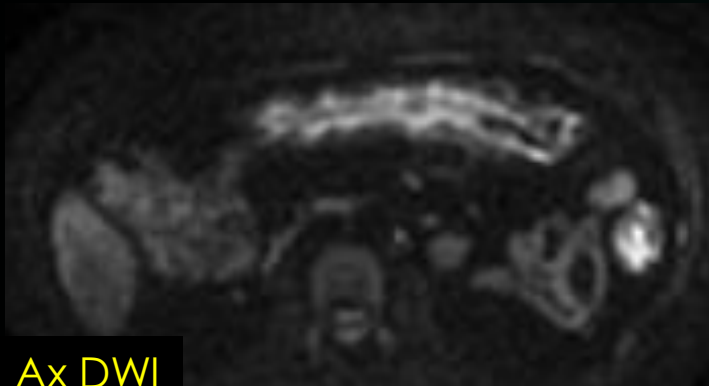
# Imaging findings – MRE Protocols - SEQUENCES

From standard....

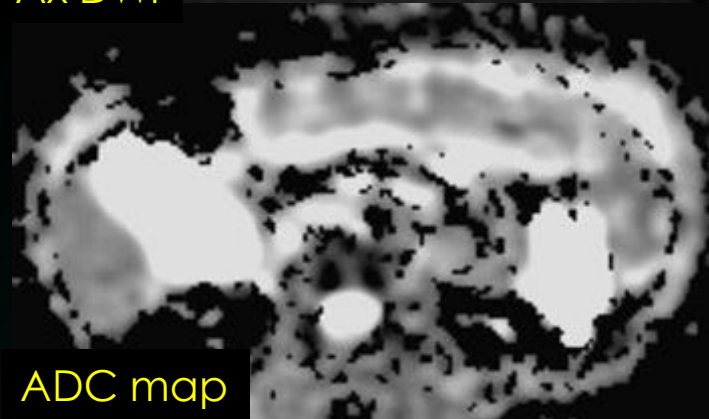


# Imaging findings – MRE Protocols - SEQUENCES

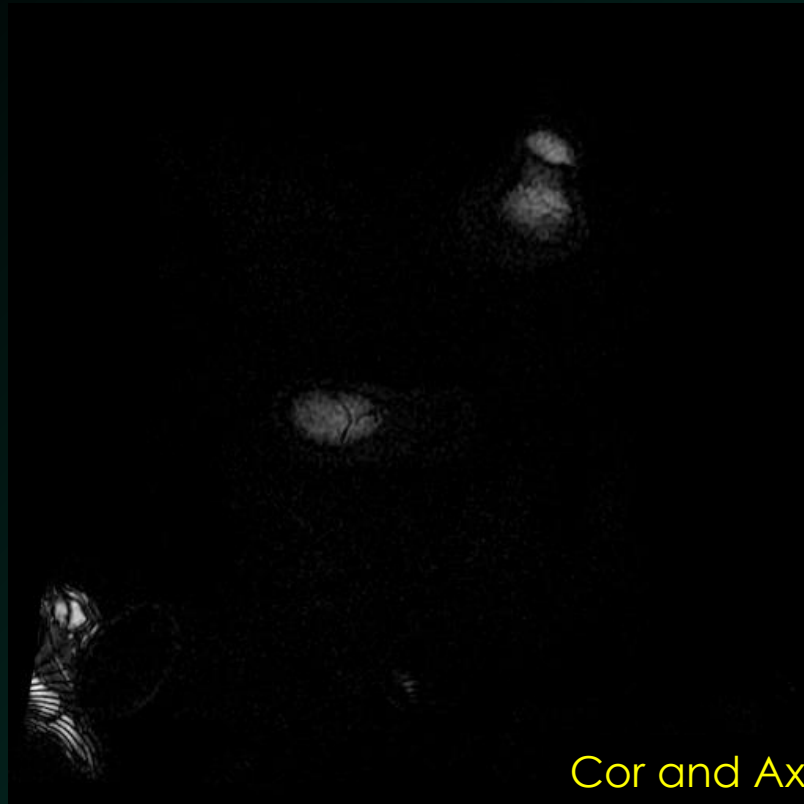
...to advanced protocols



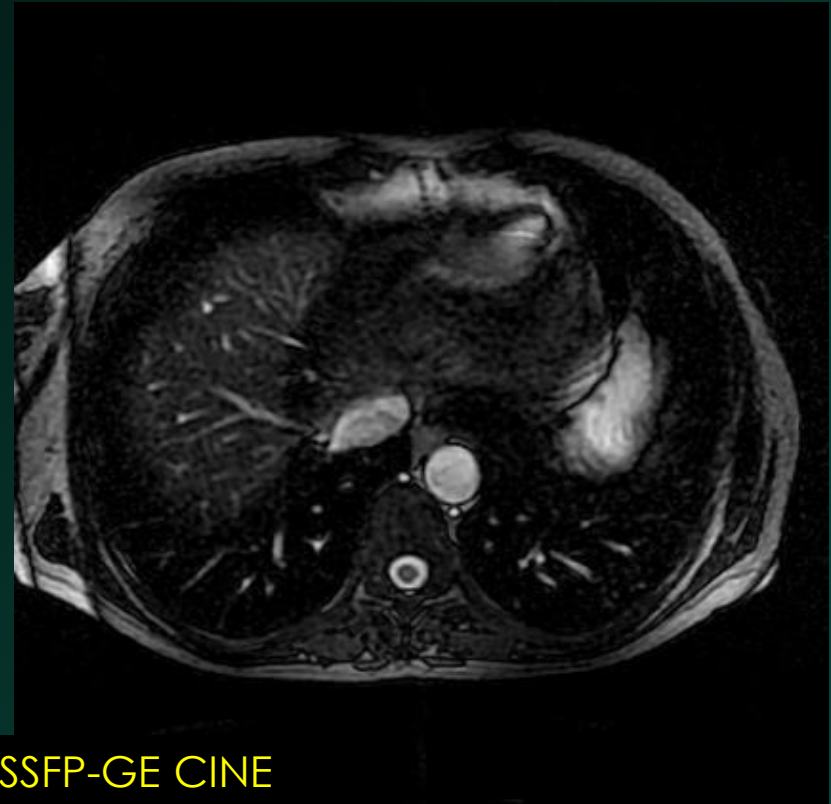
Ax DWI



ADC map



Cor and Ax SSFP-GE CINE



CINE sequences are useful to show pathologic dilatations of bowel loop otherwise not visible on static images.



# Imaging findings – MRE Protocols

MRE technique:

Scan coverage and duration:

- Scan coverage should include at least the small bowel and colon extended to include the perineum;
- Total acquisition time for should be equal to or less than 30min.

Strong evidence



# Imaging findings – MRE Signs

WALL THICKENING

ULCERATION

FOLD THICKENING

MESENTERIC EDEMA

ACUTE WALL EDEMA

COMB SIGN

LYMPH NODES

WALL ENHANCEMENT

ACTIVE INFLAMMATORY

FISTULIZING/PERFORATING  
AND  
STRICTURING

FATTY INFILTRATION

FAT WRAPPING

STRICTURE

PSEUDODIVERTICULUM

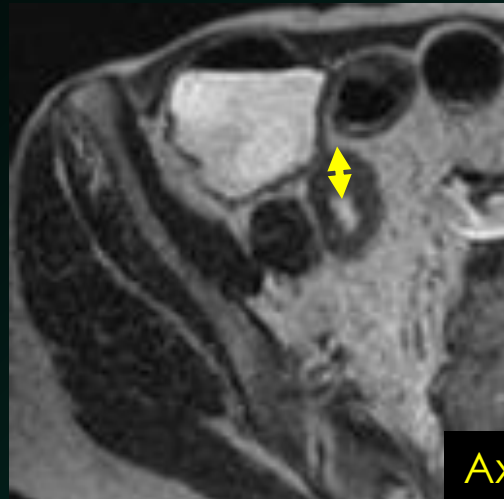
FISTULAS

# Imaging findings – Active inflammatory

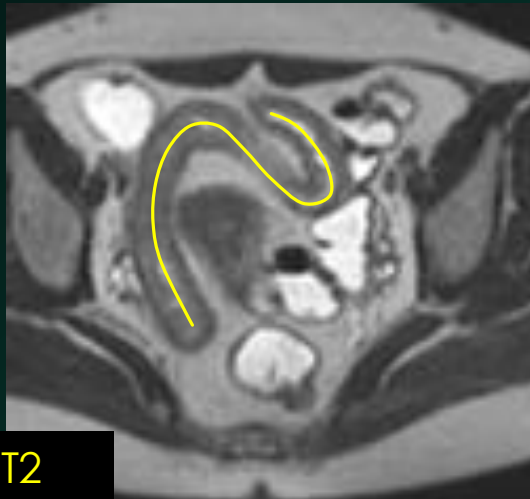
## WALL THICKENING

- Distended small bowel → wall > 3 mm ABNORMAL;
- Crohn's Disease → 5-10 mm;
- No edema → low to moderate signal (true FISP, HASTE);
- HASTE > true FISP (chemical shift artifact can complicate assessment).

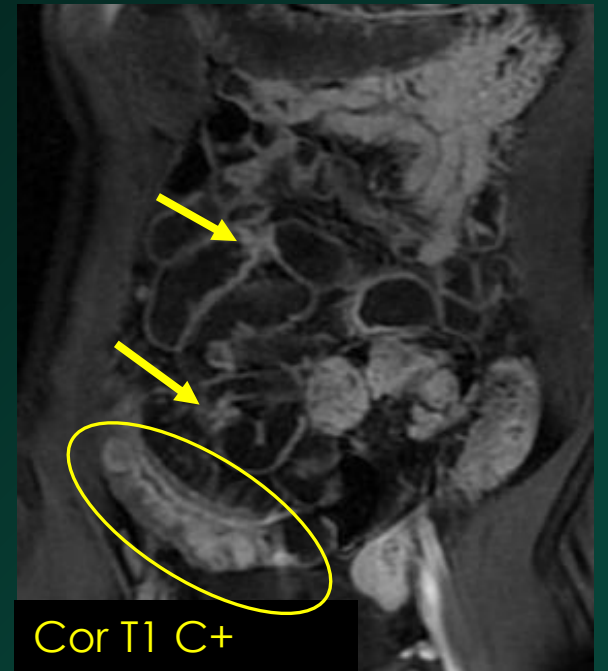
Transversal and longitudinal measure of wall thickening



Ax T2



Bowel loop thickening and skip lesions (arrow)

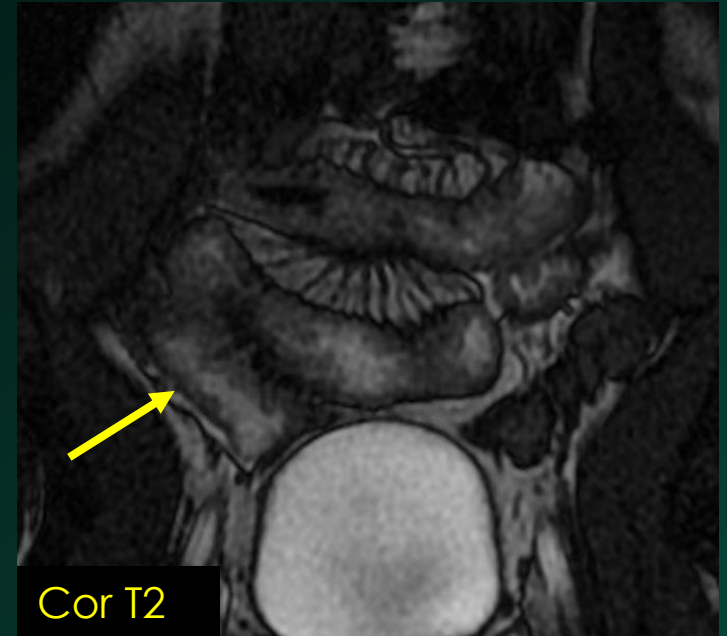


Cor T1 C+

# Imaging findings – Active inflammatory

## FOLD THICKENING

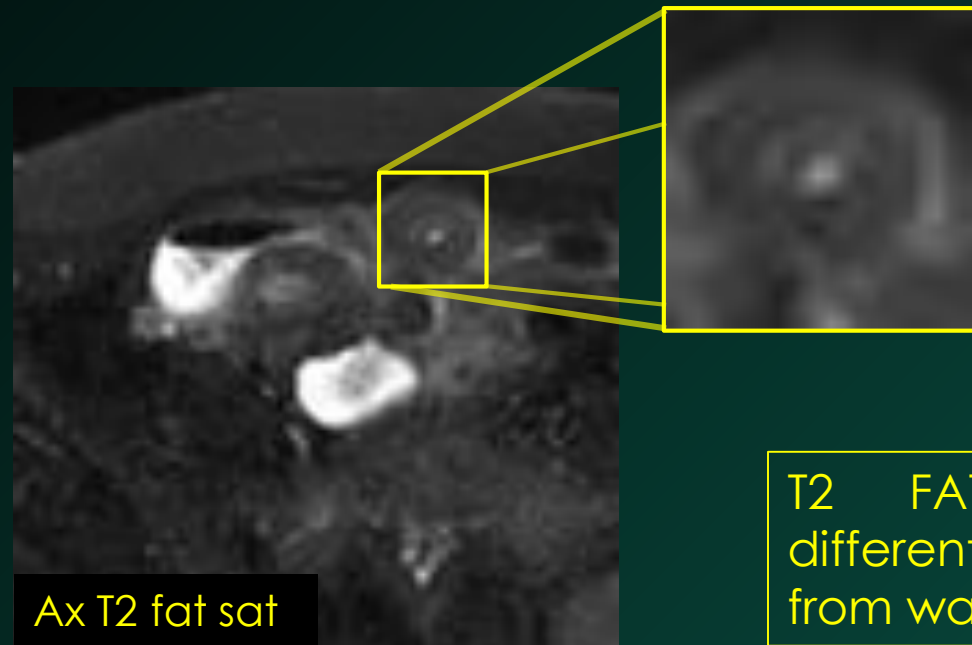
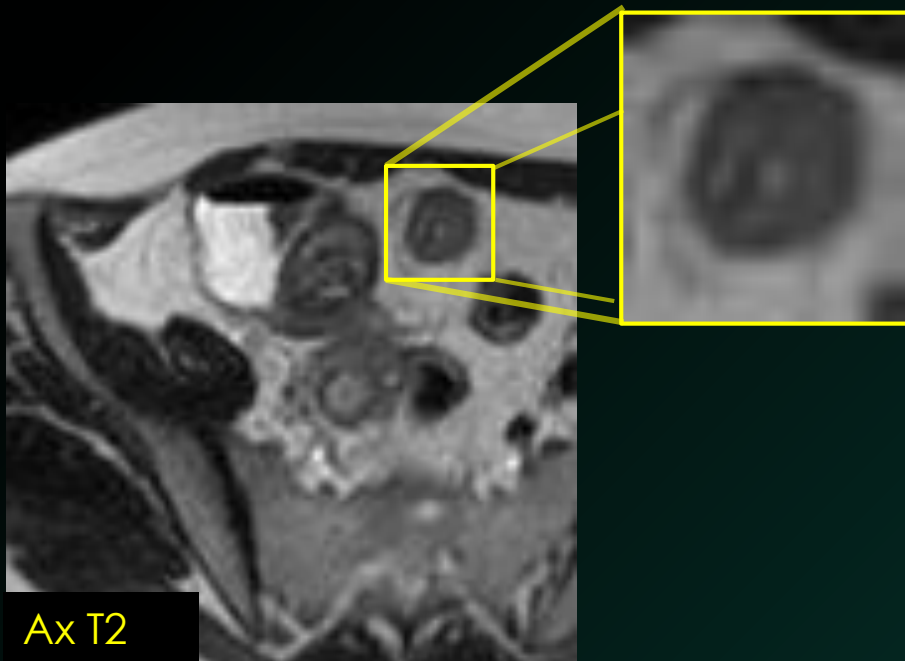
- Diffuse thickened folds (picket fence);
- Reduction/distortion folds;
- Cobblestoning;
- True FISP;
- Common pitfall → incomplete luminal distension.



# Imaging findings – Active inflammatory

## ACUTE WALL EDEMA

- ↑ T2 signal intensity within thickened bowel wall;
- Best seen in Fat saturated SSFSE;
- DD: fibrotic wall thickened (low-to-moderate T2 signal).



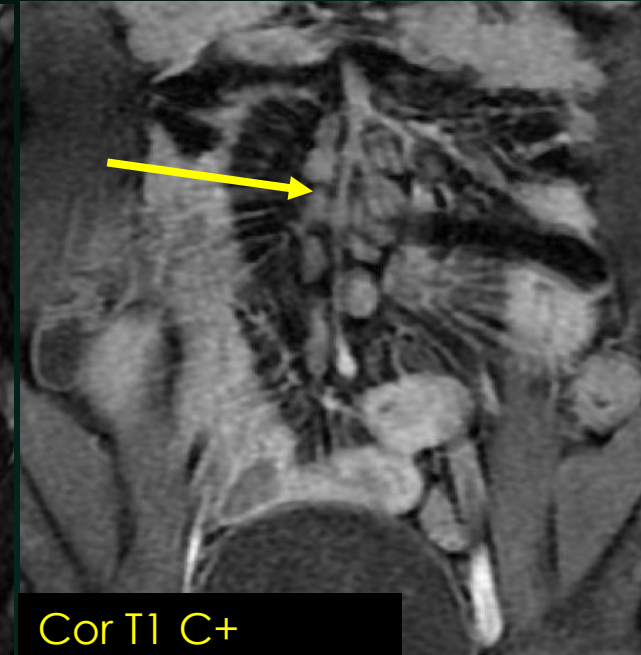
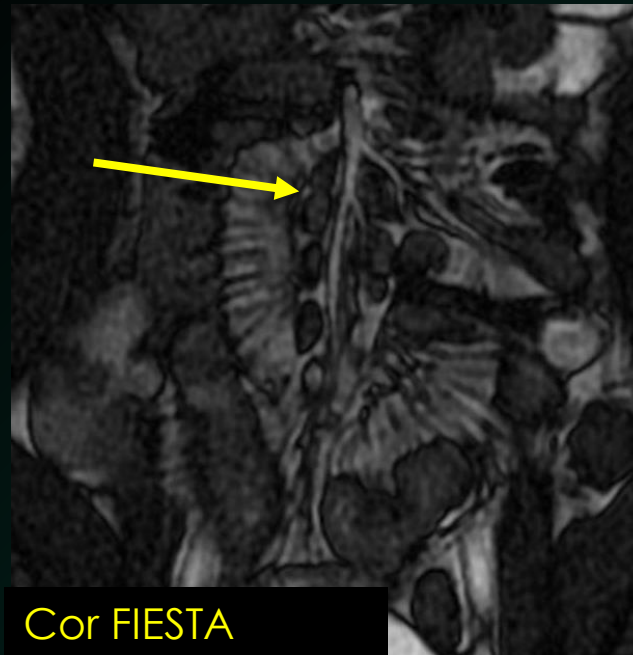
T2 FAT SAT helps in differentiate fat infiltration from wall oedema.



# Imaging findings – Active inflammatory

## LYMPH NODES

- Hyperenhancement;
- Enlargement;
- Oedema;
- Typically along the vascular supply of the affected segment;
- Best seen on T2W SSFP and T1C+.

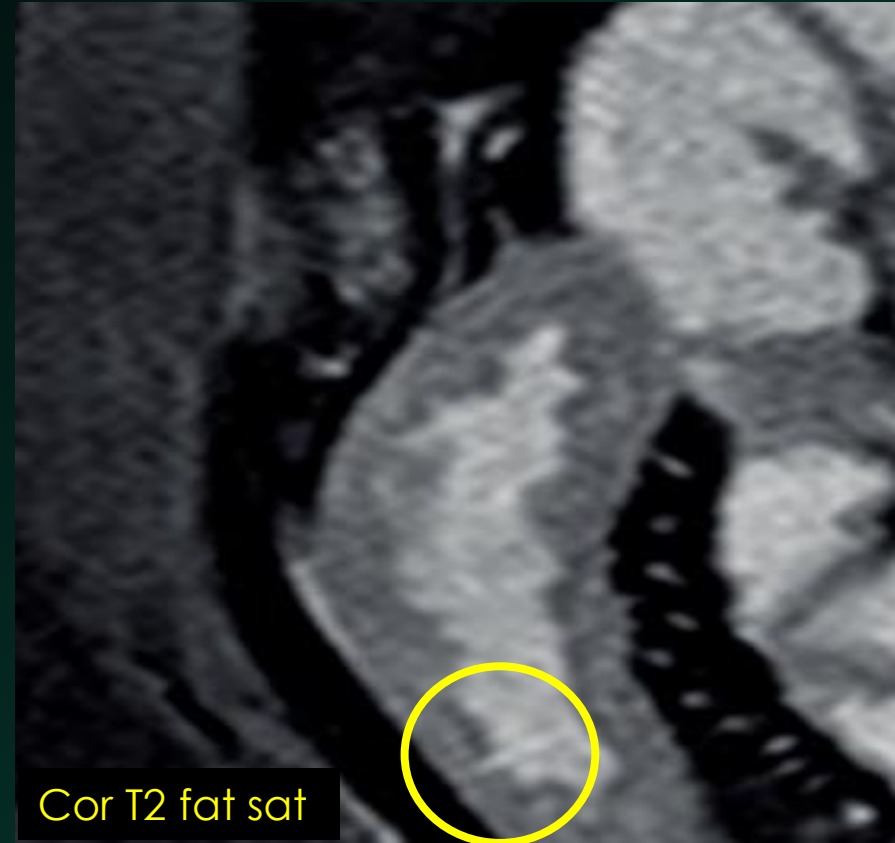


Bunch of grapes sign

# Imaging findings – Active inflammatory

## ULCERATION

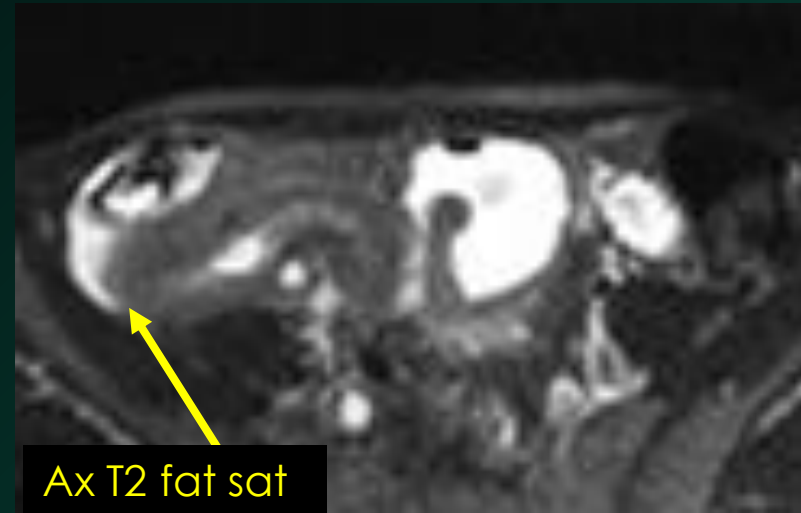
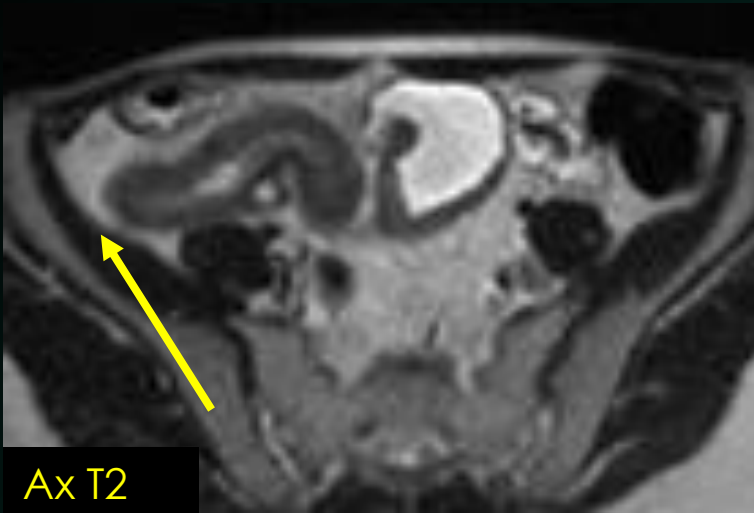
- Thin lines of high signal oriented longitudinally or transversally within the thickened wall;
- Dependent on the quality of luminal distension;
- Best seen on SSFSE.



# Imaging findings – Active inflammatory

## MESENTERIC EDEMA

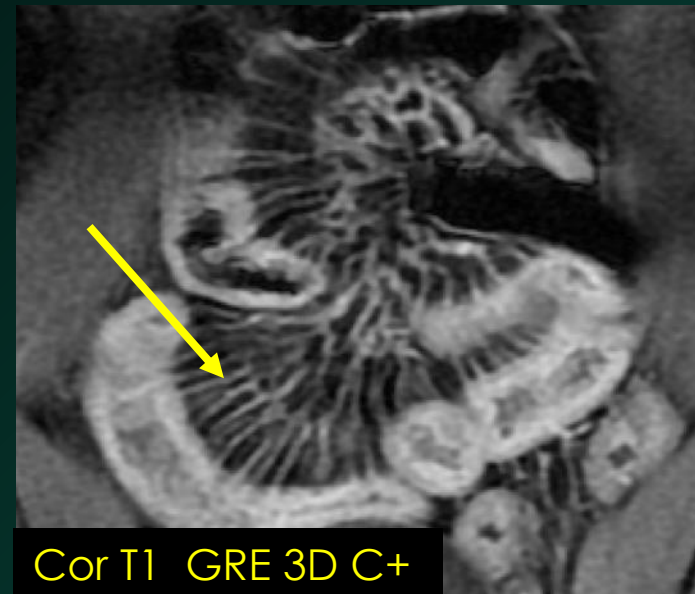
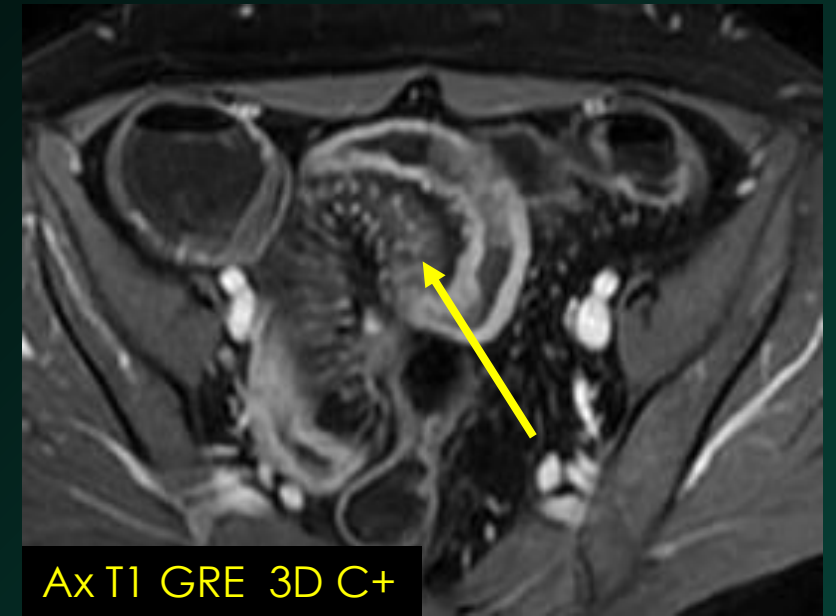
- Not always present;
- It tracks along the adjacent mesentery from an inflamed bowel loop.



# Imaging findings – Active inflammatory

## COMB SIGN

- Increased mesenteric vascularity;
- High-signal intensity parallel lines on contrast enhanced sequences;
- Short low-signal intensity parallel lines on steady state sequences.



MIP reconstruction may enhance the comb sign



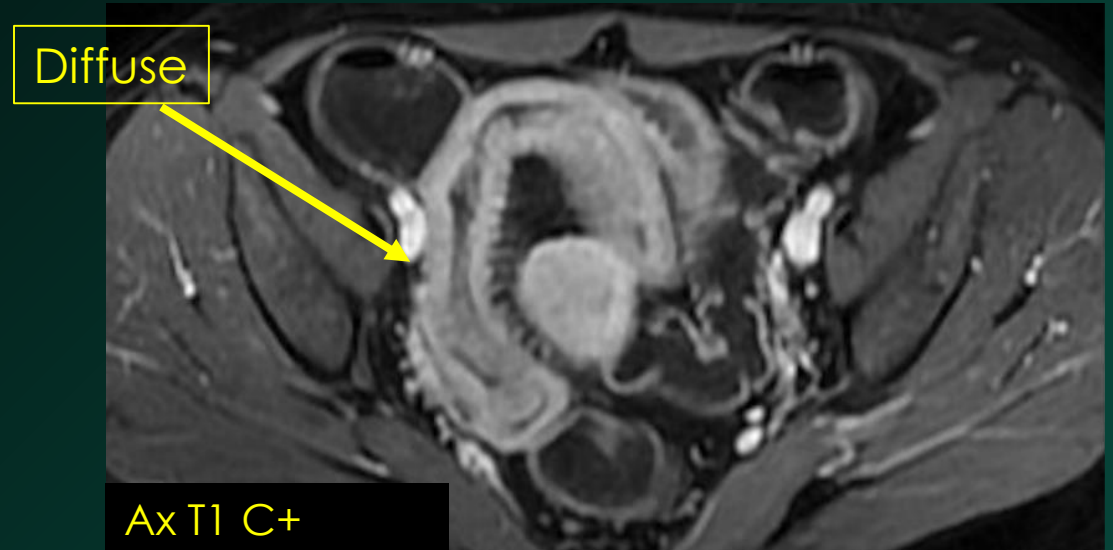
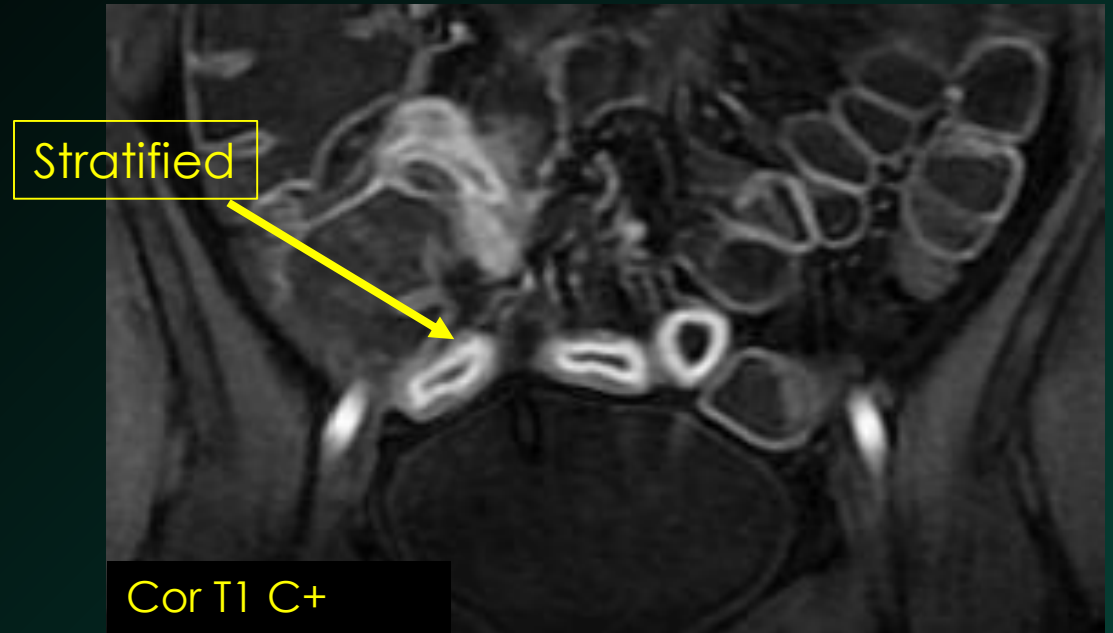
# Imaging findings – Active inflammatory

## WALL ENHANCEMENT

- Stratified enhancement → ↑ enhancement mucosa; ↓ enhancement submucosa; ↑ submucosal edema;
- Diffuse enhancement → homogeneous enhancement of the entire wall thickness.

Best assessing:

- Abnormal bowel with adjacent normal loops;
- Bowel loops at similar distance from the centre of FOV → mitigate field inhomogeneity.

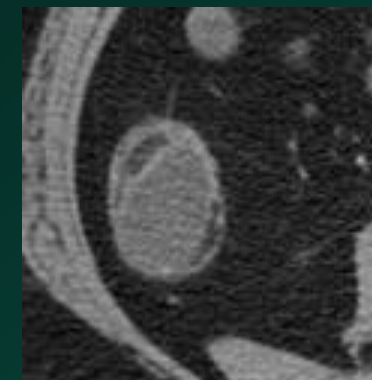
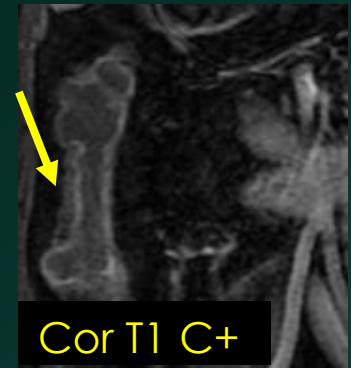
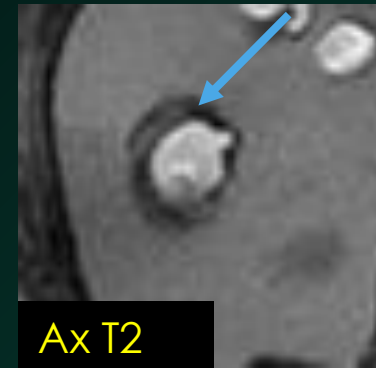
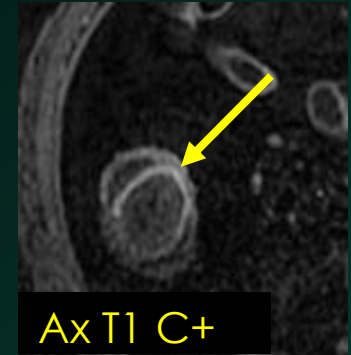
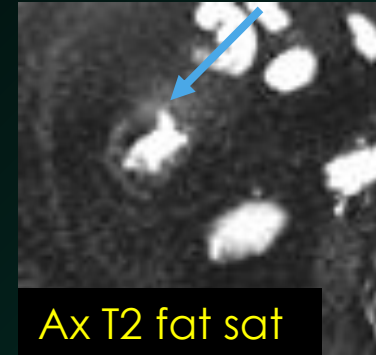




# Imaging findings – Fistulizing/perforating and stricturing

## FATTY INFILTRATION

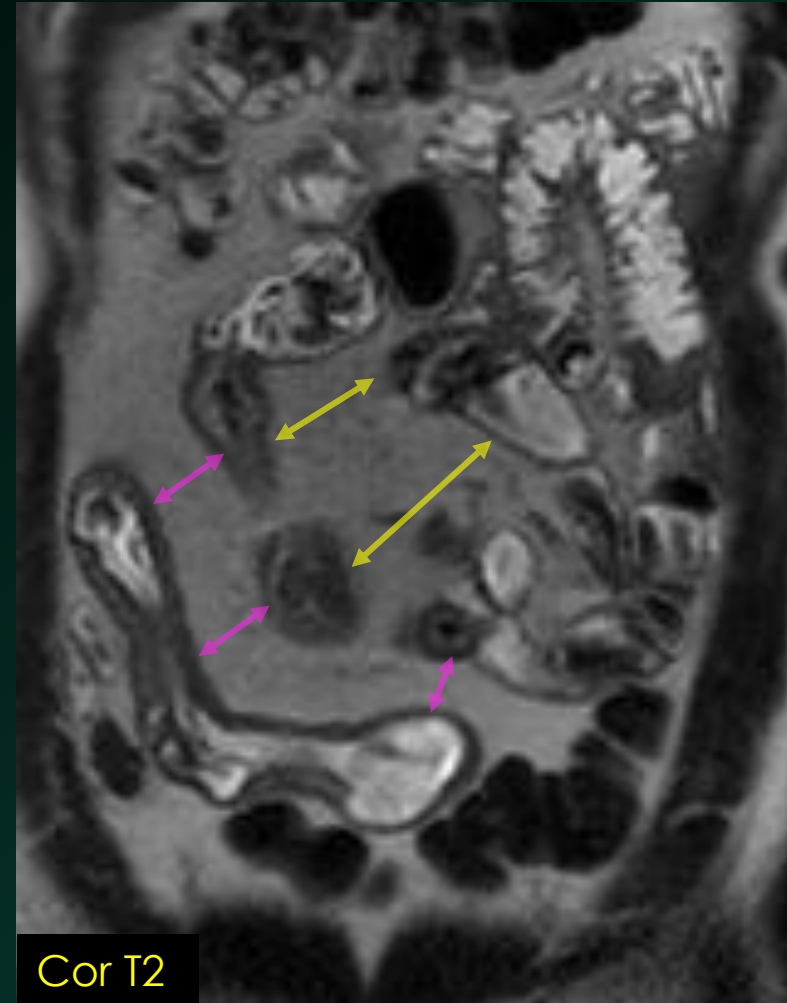
- May occur in chronic CD;
- **Halo sign** → ↑ signal inner (mucosa) and outer (muscularis propria and serosa); ↓ signal middle layer (submucosa);
- DD: **target sign** (due to submucosal oedema);
- It may also occur in healthy individuals → obesity;
- It should consider in context of clinical presentation;
- SSFSE +/- FAT-SAT: differentiate fat from wall oedema.



# Imaging findings – Fistulizing/perforating and stricturing

## FAT WRAPPING

- Increased mesentery fat producing a mass effect;
- Frequently asymmetric;
- Often encircling involved bowel loop.



Loop separation seen with mesenteric fat wrapping

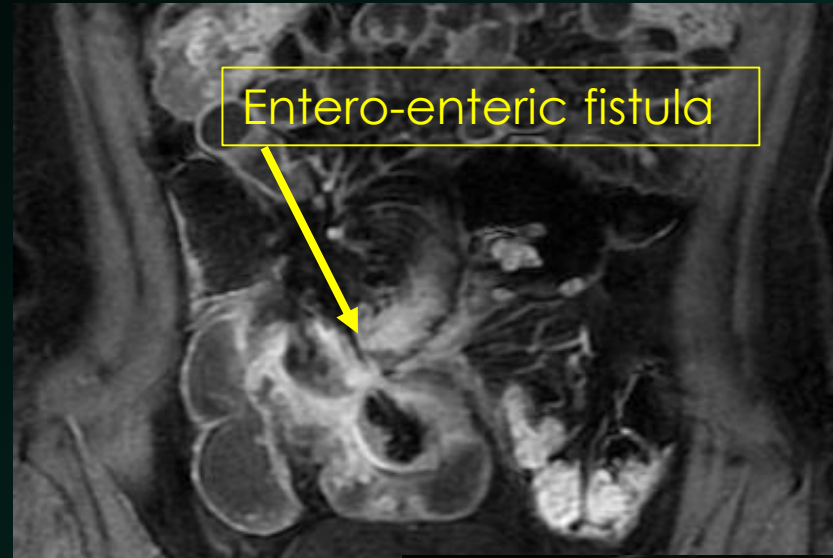
# Imaging findings – Fistulizing/perforating and stricturing

## FISTULAS

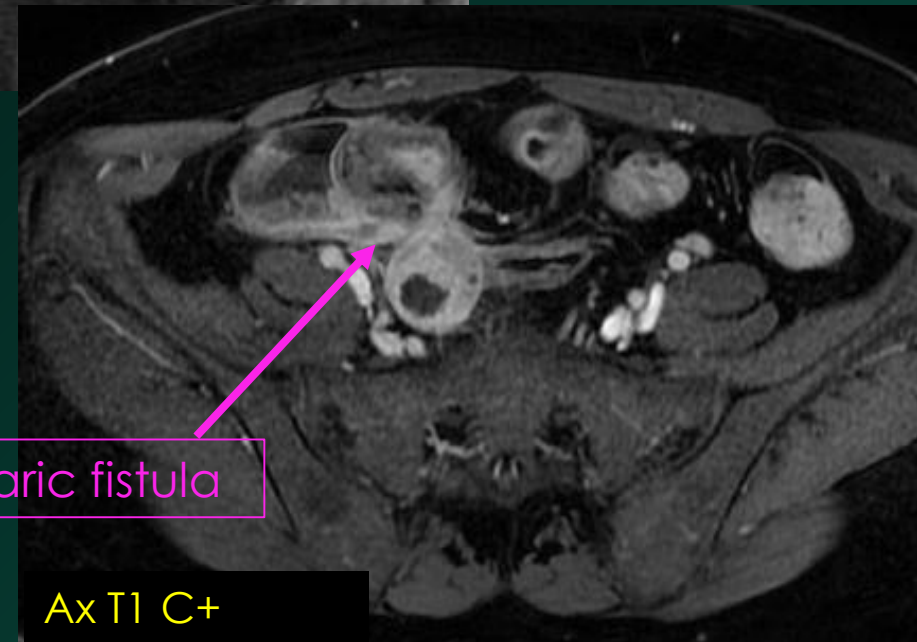
- Transmural ulcers that communicate with adjacent epithelial surface;
- High-signal-intensity tracts on T2W images;
- High-contrast enhanced.

## SINUSES

- Blind-ending tracts arising from bowel, that doesn't reach other epithelial surface.



Cor T1 C+

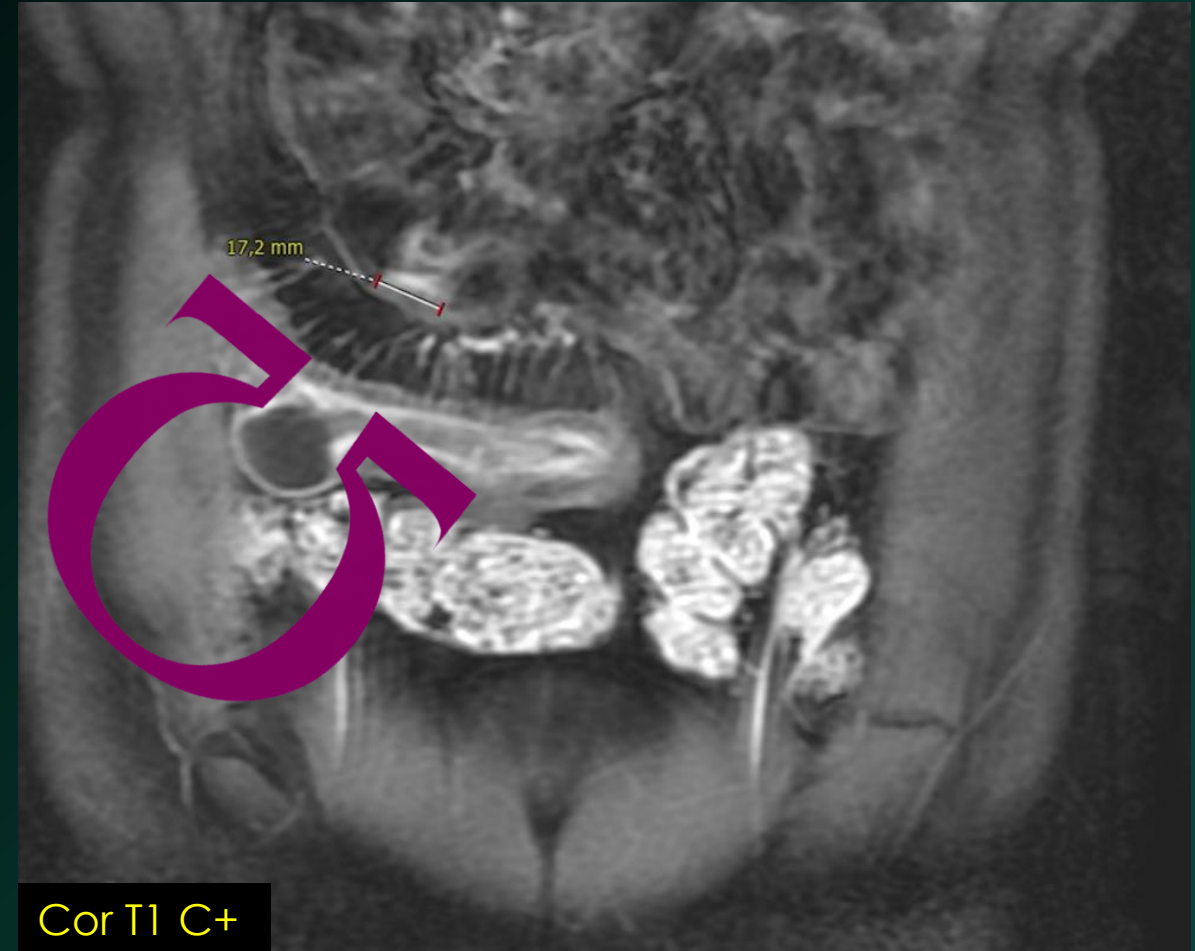
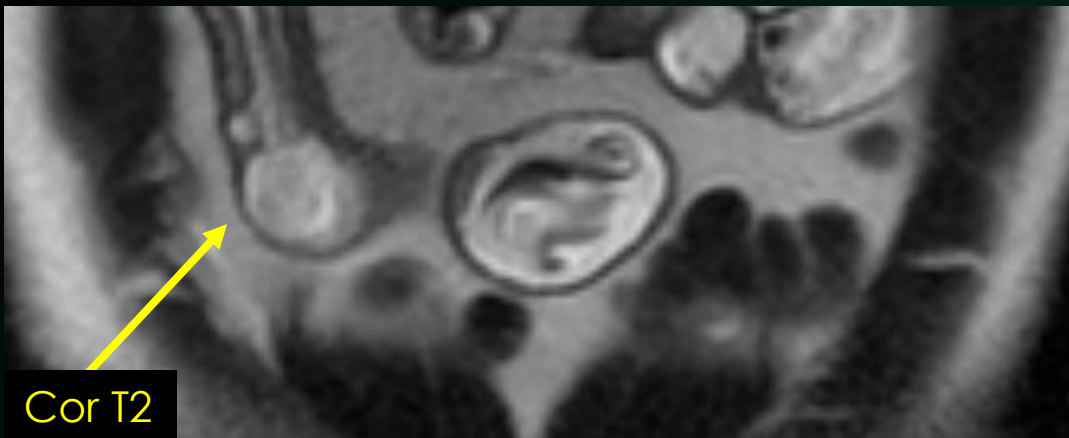


Ax T1 C+

# Imaging findings – Fistulizing/perforating and stricturing

## PSEUDODIVERTICULUM

- Consequence of relative sparing of the antimesenteric border within an affected bowel segment;
- Fibrosis and shortening of the diseased mesenteric wall lead to apparent dilatation of the opposing normal bowel wall.



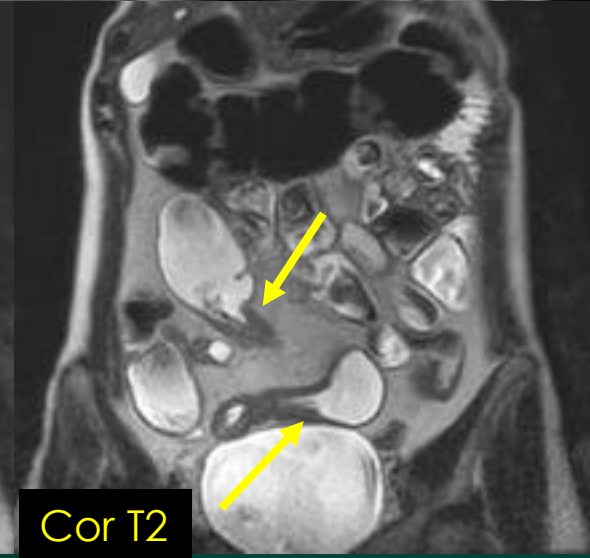
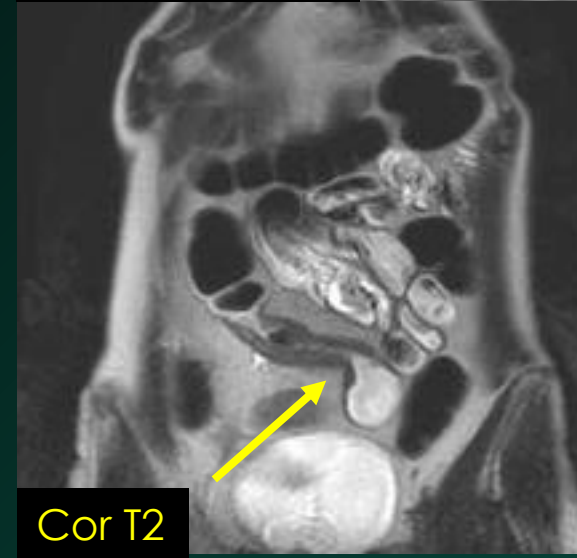
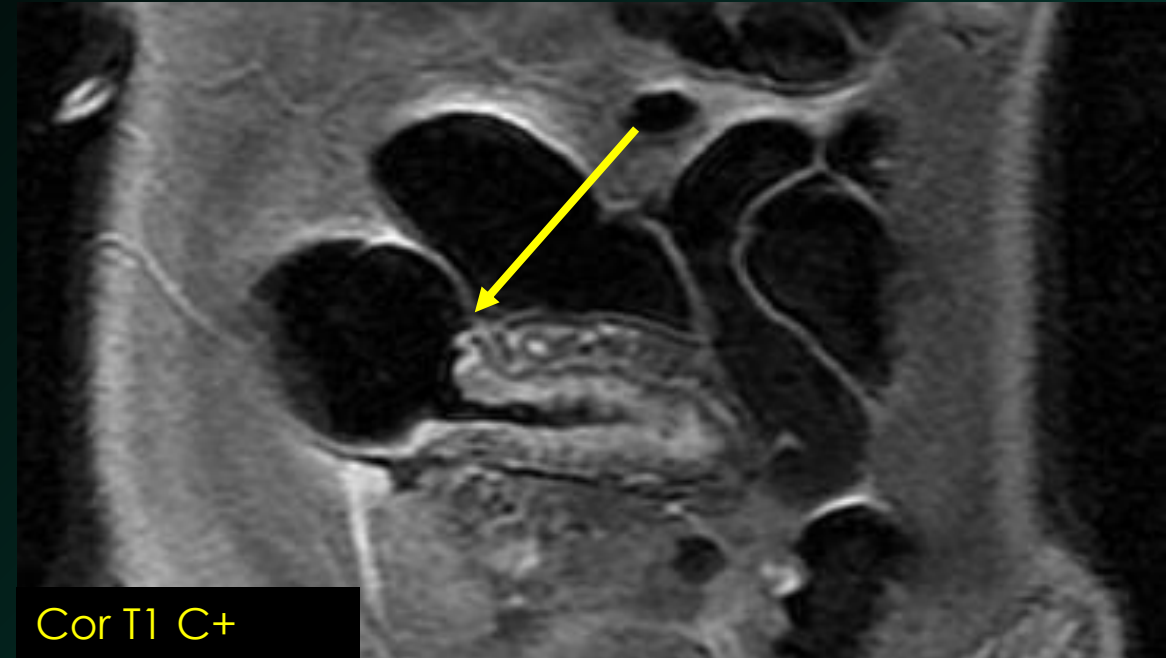
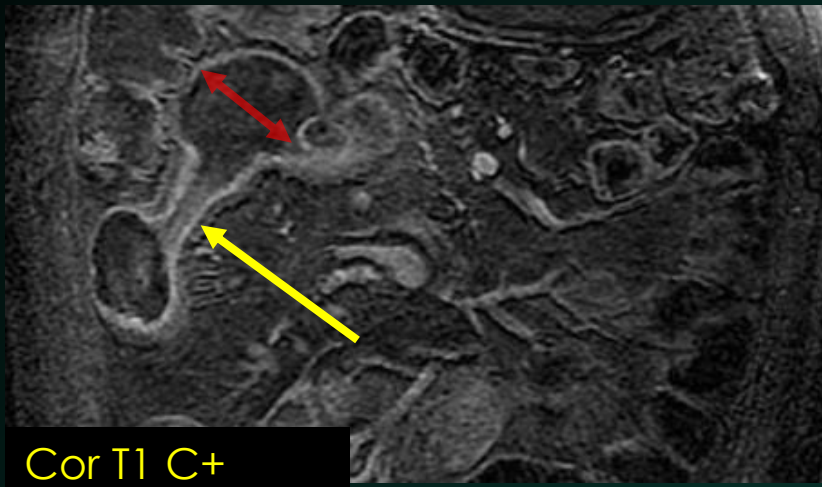
“Omega” sign



# Imaging findings – Fistulizing/perforating and stricturing

## STRICTURE

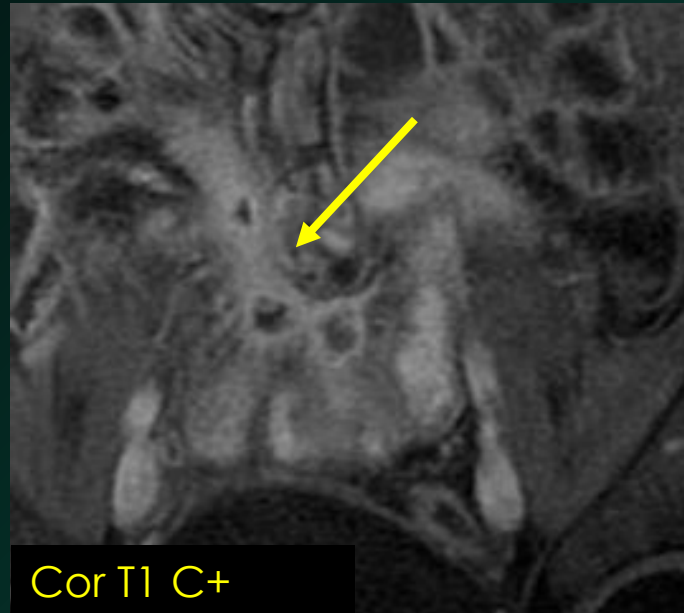
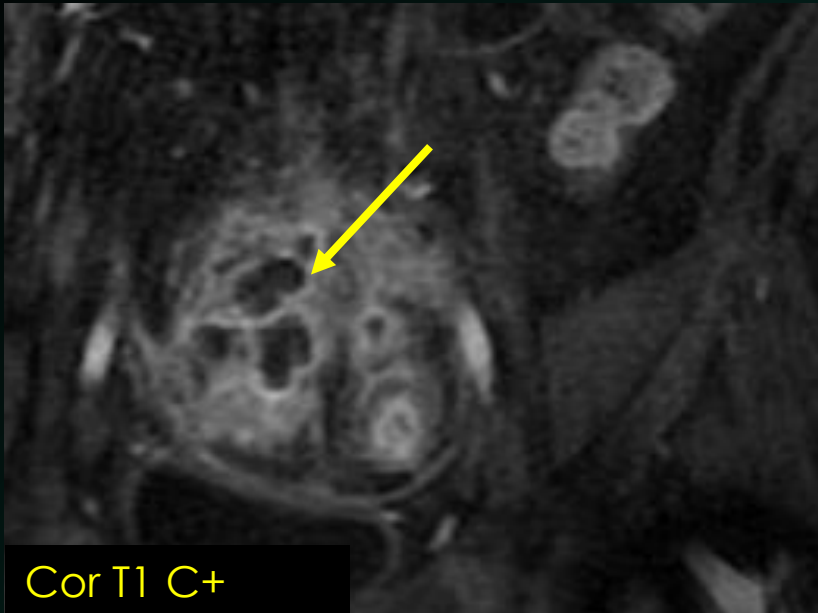
- Well demonstrated with MRE;
- Functionally significant → upstream bowel lumen > 30 mm;
- Nonfunctionally significant → narrowing > 10% in absence of dilatation;
- Invariably associated with thick-walled bowel.



# Imaging findings - Complications

## ABSCESS

- Often seen in patients with severe active CD;
- Rim enhancement on post contrast T1W images;
- Central ↑ signal on T2W images;
- Frequently surrounded by fat stranding.





# Imaging findings - Complications

## BOWEL OBSTRUCTION

- caused by acute inflammatory narrowing or fibrostenosing disease;
- High grade BO → CT;
- Mural thickening and stratification, mucosal hyperaemia, engorgement of the adjacent mesenteric vessel and mesenteric inflammatory stranding.



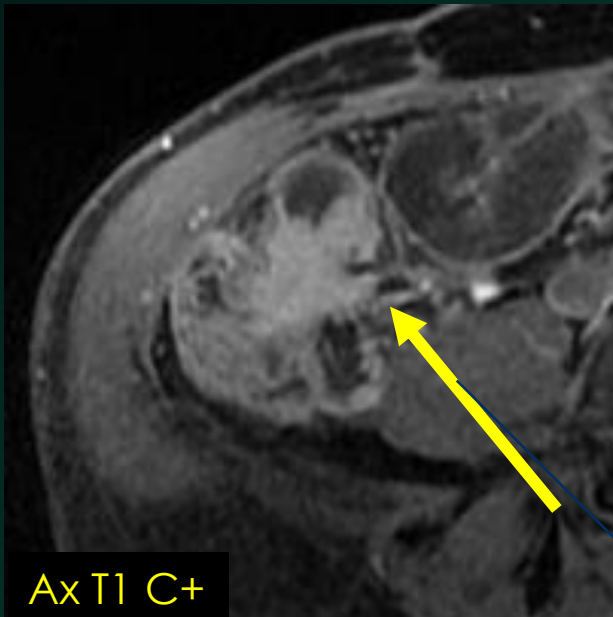
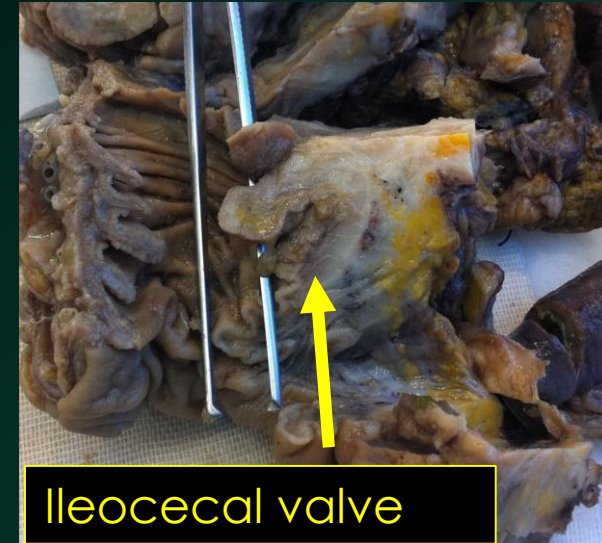
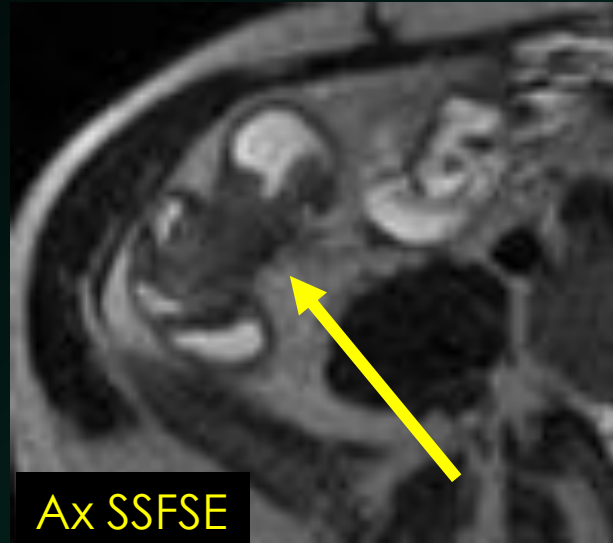
Acute SBO caused by wall thickening and stricture resolved with corticosteroid therapy → CT is preferred in acute obstruction.



# Imaging findings - Complications

## MALIGNANT LESIONS

- In the general population SB adenocarcinoma is rare; in patients with CD risk of SB adenocarcinoma is 20 to 30 times higher;
- Typical arises in the ileal lesion of patient with CD more than 8 years after diagnosis;
- Findings of MRE can be suggestive of the diagnosis of SB adenocarcinoma but most cases are diagnosed incidentally during laparotomy performed for SBO or perforation.



Adenocarcinoma on Crohn disease in distal ileum, involving ileocecal valve.

# Imaging findings – Active inflammation VS fibrosis

Assess fibrosis → crucial to quantify efficacy of anti-fibrotic drugs

Continue with anti-fibrotic drugs or undergo surgery

Endoscopic biopsy → do not reflect the transmural fibrosis

MRI → inconsistent and discordant data

Punwani et al. → mural stratification after gadolinium

Zappa et al. → mural thickness after gadolinium with no stratification

**Fibrosis and active inflammation often coexist in strictured bowel**

Superimposed active disease can obscure underlining fibrosis on imaging

# Imaging findings – Active inflammation VS fibrosis

Assess fibrosis → crucial to quantify efficacy of anti-fibrotic drugs



**New concept** (Rimola et al) → enhancement gain between early (70 sec) and late (7 min) phase after gadolinium



**Rationale**

Fibrotic lesion typically show late enhancement (cholangiocarcinoma, myocardial scar)

The wall signal intensity (WSI) correspond to the average of two WSI measurements in each segment

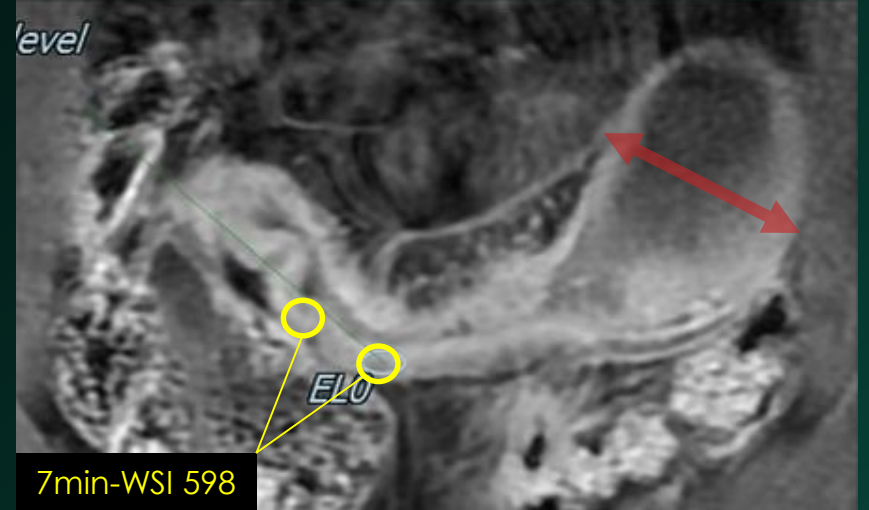
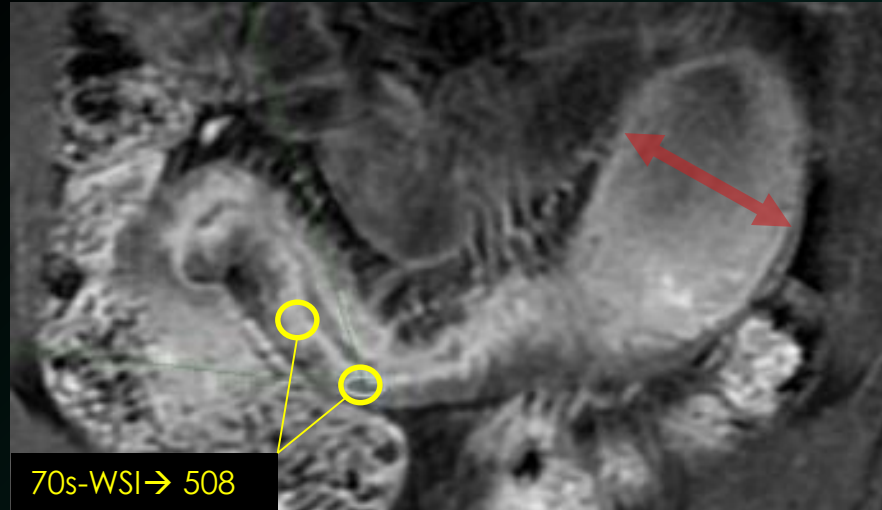
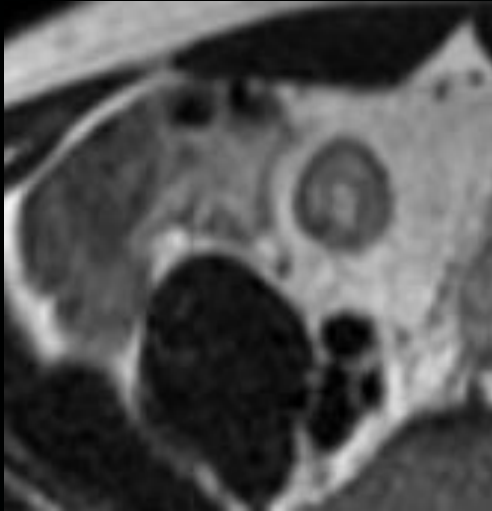
	≤24% of enhancement gain 70s-7min	>24% of enhancement gain 70s-7min
Normal signal on T2-W	<ul style="list-style-type: none"><li>• ↓ inflammation</li><li>• ↓ fibrosis</li></ul>	<ul style="list-style-type: none"><li>• ↓ inflammation</li><li>• ↑ fibrosis</li></ul>
High signal on T2-W	<ul style="list-style-type: none"><li>• ↓ fibrosis</li><li>• ↑ Inflammation</li></ul>	<ul style="list-style-type: none"><li>• ↑ fibrosis</li><li>• ↑ Inflammation</li></ul>

$$\% \text{ Gain} = [(WSI \text{ 7 min} - WSI \text{ 70 s}) / (WSI \text{ 70 s})] * 100$$

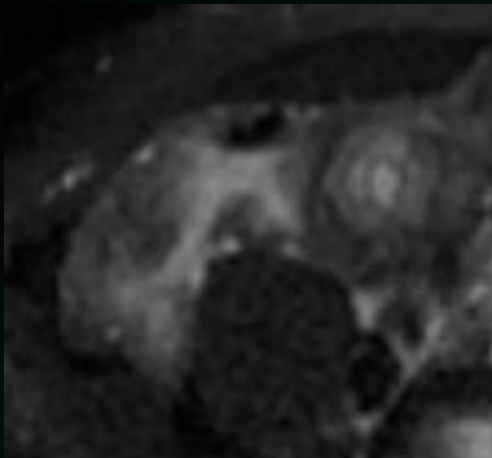


# Imaging findings – Active inflammation VS fibrosis

Young man (23 y.o.) with abdominal pain and subocclusion: MRE demonstrate stenosis of distal ileum; not responsive to drugs.



$$\% \text{ Gain} = [(598 - 508) / (508)] * 100 = 17\%$$



↑ T2 signal

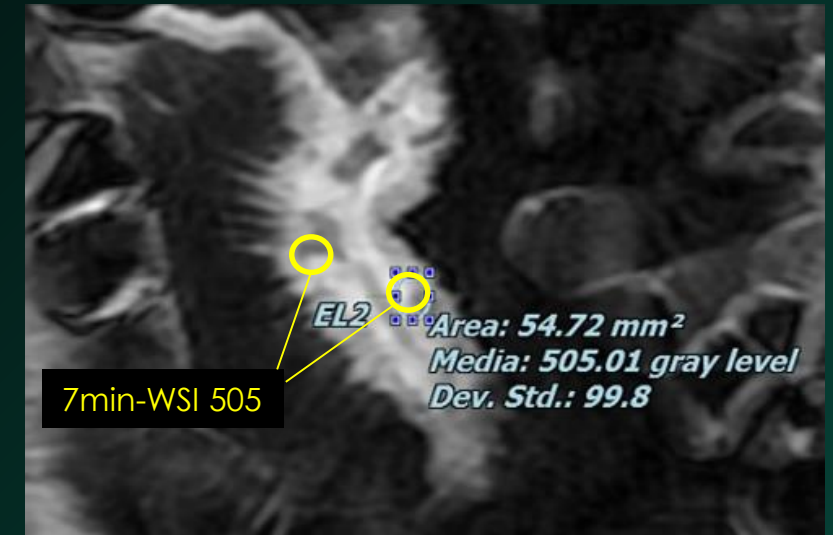
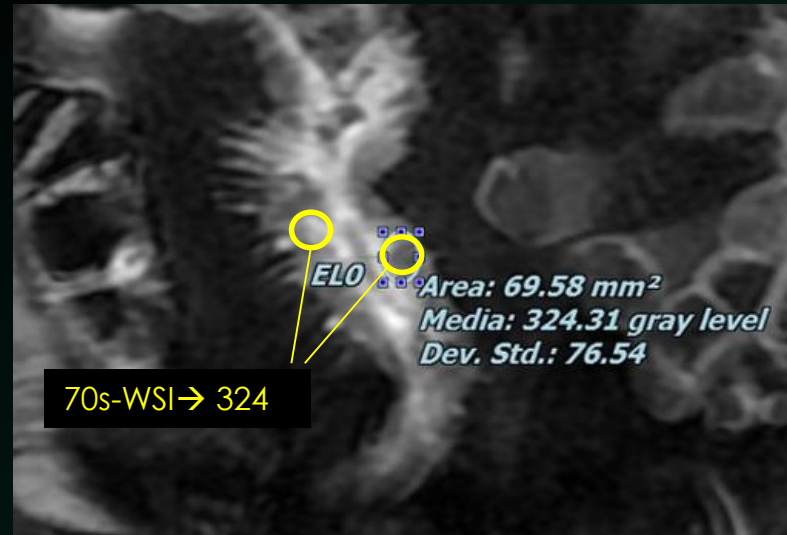
% Gain=17%  
High signal on T2-W

↓ fibrosis  
↑ inflammation

Confirmed after surgery

# Imaging findings – Active inflammation VS fibrosis

Man (65 y.o.) with symptomatic stenosis of distal ileum



$$\% \text{ Gain} = [(505 - 324) / (324)] * 100 = 56\%$$

↑ T2 signal

% Gain=56%  
High signal on T2-W

↑ fibrosis  
↑ inflammation

Confirmed after surgery



# Imaging findings- Wall healing

Symptoms do not correlate with objective measures of disease activities



Currently endoscopic evaluation  
→ gold standard for CD treatment response assessment

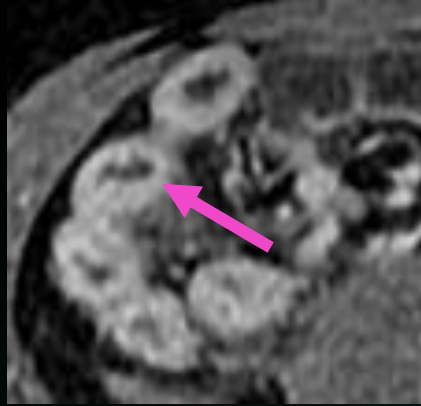
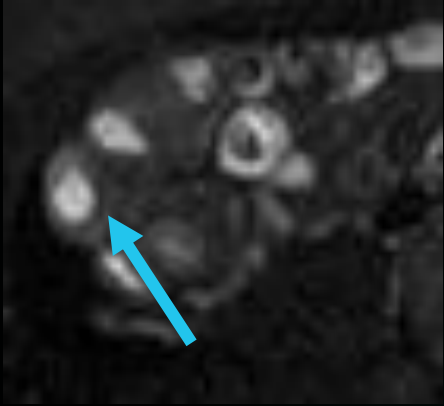


But it is invasive and it is unable to explore all the small bowel

MRE is able to detect mucosal healing:

- 90% accuracy mural healing;
- 84% accuracy endoscopic remission.

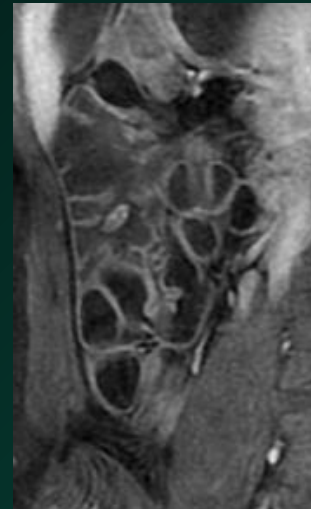
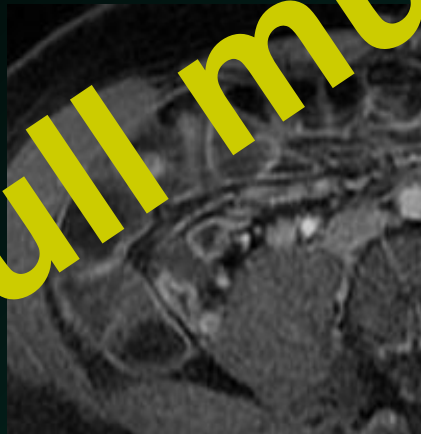
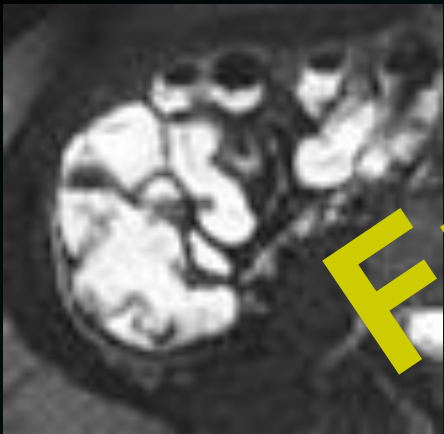
# Imaging findings- Wall healing



January 2016: wall thickening of a long small bowel loop, with wall edema and intense enhancement



After therapy



April 2016: the same small bowel loop appears to be normal

Full mural healing!!!

# Conclusions

- MR enterography is a reliable and important tool in Crohn's disease evaluation (for diagnosis, staging and follow-up);
- It is an excellent modality to assess complication and response to therapy;
- MR images have an important role in the management of the disease (medical or surgical treatment).

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