

# Imaging in Crohns Disease:

## *MR Enterography*

SCBT/MR

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Scott B. Reeder, MD, PhD

Department of Radiology  
University of Wisconsin  
Madison, WI



# Disclosure

- Advisory boards of Bayer, GE Healthcare
- UW receives support from GE and Bracco
- Spouse is an employee of GE



# Off-Label Uses of Gadolinium

- Off-label uses of Gadolinium contrast
- Investigational Pulse Sequences



# Outline

- Need for cross sectional imaging of small bowel
  - Challenges in the diagnosis & treatment monitoring of Crohns disease
- Increasing concerns over radiation
- CT vs MR Enterography
- MR Enterography Protocol at UW
- Examples



# Crohn's Disease

- Inflammatory bowel disease (autoimmune)
- 700,000 Americans afflicted
- Young adults (20's and 30's)
- Any part of GI tract, esp. distal ileum
  - Complete small bowel coverage needed
  - Colon and esophagus accessible by other means
- Features
  - Transmural inflammation
  - Strictures
  - Fistulas, abscesses, etc
- Key question: *active vs quiescent disease*



# Crohns Disease

- Active disease treated with “*biologics*”
  - eg. infliximab (remicade)
  - Effective
  - Very expensive
  - Serious side effects, including lymphoma
- Burned out disease with strictures: *surgery*
- Imaging plays a central role
  - Small bowel follow through
  - CT enterography
  - *MR enterography*

*New opportunities: distinguish active from chronic disease*

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## Exposure to Low-Dose Ionizing Radiation from Medical Imaging Procedures

Reza Fazel, M.D., M.Sc., Harlan M. Krumholz, M.D., S.M., Yongfei Wang, M.S., Joseph S. Ross, M.D.,  
Jersey Chen, M.D., M.P.H., Henry H. Ting, M.D., M.B.A., Nilay D. Shah, Ph.D., Khurram Nasir, M.D., M.P.H.,  
Andrew J. Einstein, M.D., Ph.D., and Brahmajee K. Nallamothu, M.D., M.P.H.

952,420 non-elderly adults followed for three years  
655,613 underwent one or more imaging procedures  
 $2.4 \pm 6.0\text{mSv}$  ( $3\text{mSv}$  = background dose)  
82% from outpatient facilities (CT, nuclear scintigraphy)





2.5 year old boy for neck CT scan after falling off bed  
Inadvertent exposure to **151x** normal dose





# CTE Enterography:

## *Findings of Active Disease*

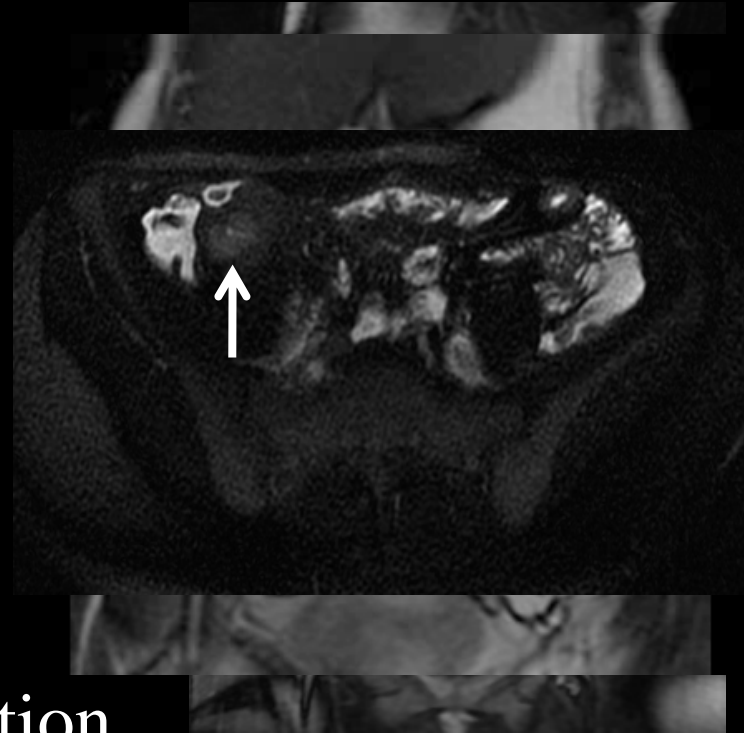
- Bowel wall thickening
  - $> 3\text{mm}$
  - Asymmetric involvement
    - mesenteric  $>$  antimesenteric
- Perienteric stranding
- Engorged vasa recta
  - “comb” sign
- Perienteric fibrofatty proliferation
  - Remains present in clinically quiescent disease



# MRE Enterography:

## *Findings of Active Disease*

- Bowel wall thickening
  - $> 3\text{mm}$
  - Asymmetric involvement
    - mesenteric  $>$  antimesenteric
- Perienteric stranding
- Engorged vasa recta
  - “comb” sign
- Perienteric fibrofatty proliferation
  - Remains present in clinically quiescent disease
- *High signal on T2 weighted imaging*
- *Decreased peristalsis on “real-time” imaging*



# MR vs CT Enterography



## Prospective Comparison of State-of-the-Art MR Enterography and CT Enterography in Small-Bowel Crohn's Disease

Hassan A. Siddiki<sup>1</sup>  
Jeff L. Fidler<sup>1</sup>  
Joel G. Fletcher<sup>1</sup>  
Sharon S. Burton<sup>1</sup>  
James E. Huprich<sup>1</sup>  
David M. Hough<sup>1</sup>  
C. Daniel Johnson<sup>1</sup>  
David H. Bruining<sup>2</sup>  
Edward V. Loftus, Jr.<sup>2</sup>  
William J. Sandborn<sup>2</sup>  
Darrell S. Pardi<sup>2</sup>  
Jayawant N. Mandrekar<sup>3</sup>

**OBJECTIVE.** The objective of our study was to prospectively obtain pilot data on the accuracy of MR enterography for detecting small-bowel Crohn's disease compared with CT enterography and with a clinical reference standard based on imaging, clinical information, and ileocolonoscopy.

**SUBJECTS AND METHODS.** The study group for this blinded prospective study was composed of 33 patients with suspected active Crohn's ileal inflammation who were scheduled for clinical CT enterography and ileocolonoscopy and had consented to also undergo MR enterography. The MR enterography and CT enterography examinations were each interpreted by two radiologists with disagreements resolved by consensus. The reports from ileocolonoscopy with or without mucosal biopsy were interpreted by a gastroenterologist. The reference standard for the presence of small-bowel Crohn's disease was based on the final clinical diagnosis by the referring gastroenterologist after reviewing all of the available information.

**RESULTS.** All 33 patients underwent CT enterography and ileocolonoscopy, 30 of whom also underwent MR enterography. The sensitivities of MR enterography and CT enterography for detecting active small-bowel Crohn's disease were similar (90.5% vs 95.2%, respectively;  $p = 0.32$ ). The image quality scores for MR enterography examinations were significantly lower than those for CT enterography ( $p = 0.005$ ). MR enterography and CT enterography identified eight cases (24%) with a final diagnosis of active small-bowel inflammation in which the ileal mucosa appeared normal at ileocolonoscopy. Furthermore, enterography provided the only available imaging in three additional patients who did not have ileal intubation.

**CONCLUSION.** MR enterography and CT enterography have similar sensitivities for detecting active small-bowel inflammation, but image quality across the study cohort was better with CT. Cross-sectional enterography provides complementary information to ileocolonoscopy.

In 2010, MRE and CTE have equivalent performance



# Accuracy of MRI

ORIGINAL RESEARCH ■ GASTROINTESTINAL IMAGING

Radiology

# Mural Inflammation in Crohn Disease: Location-Matched Histologic Validation of MR Imaging Features<sup>1</sup>

Shonit Punwani, MRCP, FRCR, PhD  
Manuel Rodriguez-Justo, FRCPath  
Alan Bainbridge, PhD  
Rebecca Greenhalgh, MRCS, FRCR  
Enrico De Vita, PhD  
Stuart Bloom, FRCR  
Richard Cohen, FRCS  
Alastair Windsor, FRCS  
Austin Obichere, FRCS  
Anika Hansmann, MRBS

**Purpose:** To validate proposed magnetic resonance (MR) imaging features of Crohn disease activity against a histopathologic reference.

**Materials and Methods:** Ethical permission was given by the University College London hospital ethics committee, and informed written consent was obtained from all participants. Preoperative MR imaging was performed in 18 consecutive patients with Crohn disease undergoing elective small-bowel resection. The Harvey-Bradshaw index, the C-reactive protein

**Conclusion:** Increasing mural thickness, high mural signal intensity on T2-weighted fat-saturated images, and a layered pattern of enhancement reflect histologic features of acute small-bowel inflammation in Crohn disease.

Accurate markers of acute inflammation:

- *increasing mural thickness*
- *high signal on T2*
- *mural enhancement NOT a feature*
- *layered enhancement*

# Complications

- Fistula
  - Enteroenteric
  - Enterocystic
  - Enterocutaneous (perianal fistulas common)
  - Enterovaginal
- Abscess
- Strictures (fibrostenosis)
- Small bowel obstruction

# Protocol: *Patient Preparation*

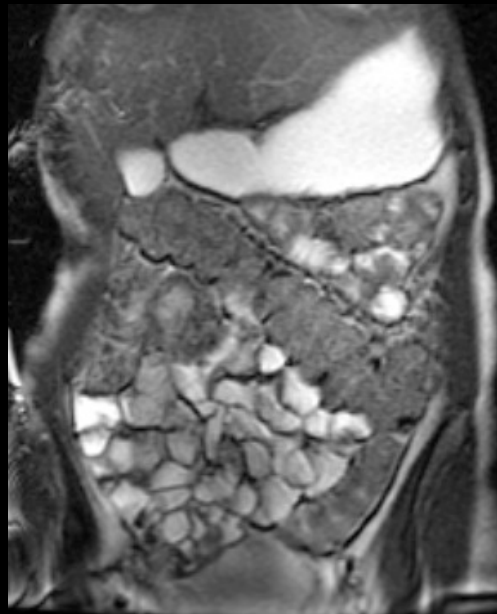
- Drink
- Prone position
  - minimize respiratory motion
  - Better co-localization between sequences
  - Splay out loops of small bowel
- Spasmolytic
  - Buscopan (Europe)
  - Glucagon (IM or IV)

# Drink

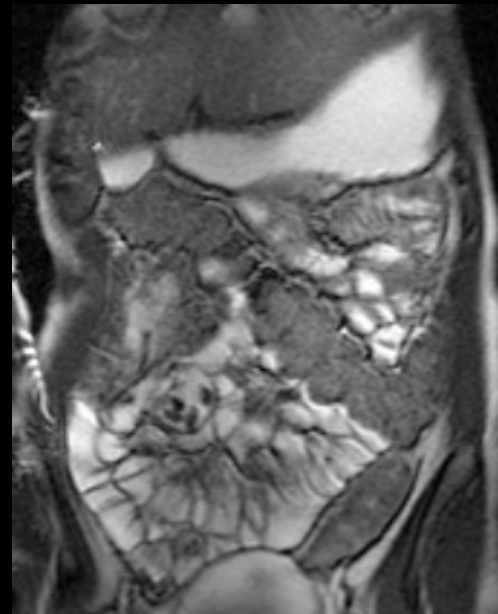
- Goal: distend small bowel, terminal ileum
- Variability in the literature
- Hyperosmolar agent to distend bowel
  - Mannitol
  - Locus bean gum
  - Sorbitol + Barium (Volumen)
- Volume
  - 1000-1500ml
- UW protocol
  - 900-1250ml Volumen in 2-3 boluses over 30-60minutes
  - 300 ml of water on table

# Glucagon: *IM or IV?*

- 1mg IM
  - Onset 1-3 min, 10-20 min duration
  - Efficacy is good but variable
- 0.3-0.5mg IV
  - Immediate onset, 5-7 minutes duration
  - Reliable cessation of peristalsis
  - Occasional nausea: *push slowly*





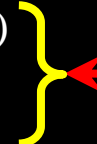
*No glucagon*



*1 minute after glucagon*



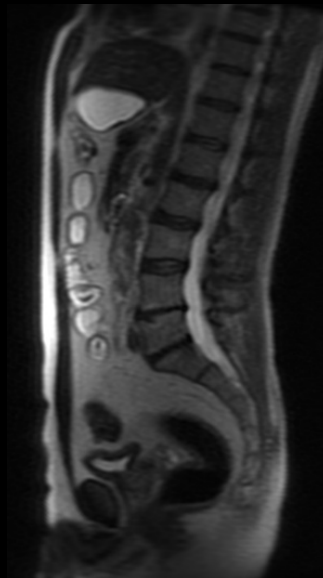
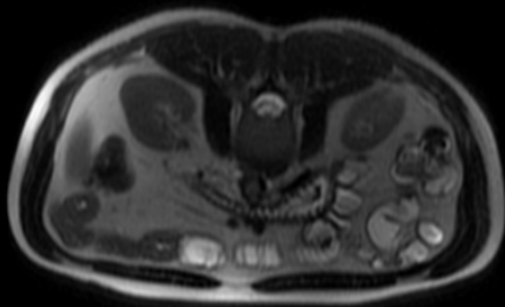
# Protocol: *Overview*

- Position prone on table
- Drink 300cc water on table
- Localizers
- Real time 2D-SSFP *before* Glucagon
- 0.3-0.5mg IV Glucagon
- Axial T2-SSFSE with fat-sat  \$\$ Money Shot \$\$
- Coronal T2-SSFSE without fat-sat  \$\$ Money Shot \$\$
- 3D-SSFP
- 0.3-0.5mg IV Glucagon
- T1W 3D-SPGR with fat-suppression
  - Pre-contrast (can perform before 2<sup>nd</sup> dose of glucagon)
  - Inject 0.1mmol/kg GBCA at 2.0ml/s, 25-50ml saline flush
  - 40 seconds (later arterial)
  - 2 minutes \$\$ Money Shot \$\$
- T1W 2D-SPGR with fat-suppression

*Total table time is 30 minutes*

# Protocol: *Localizers*

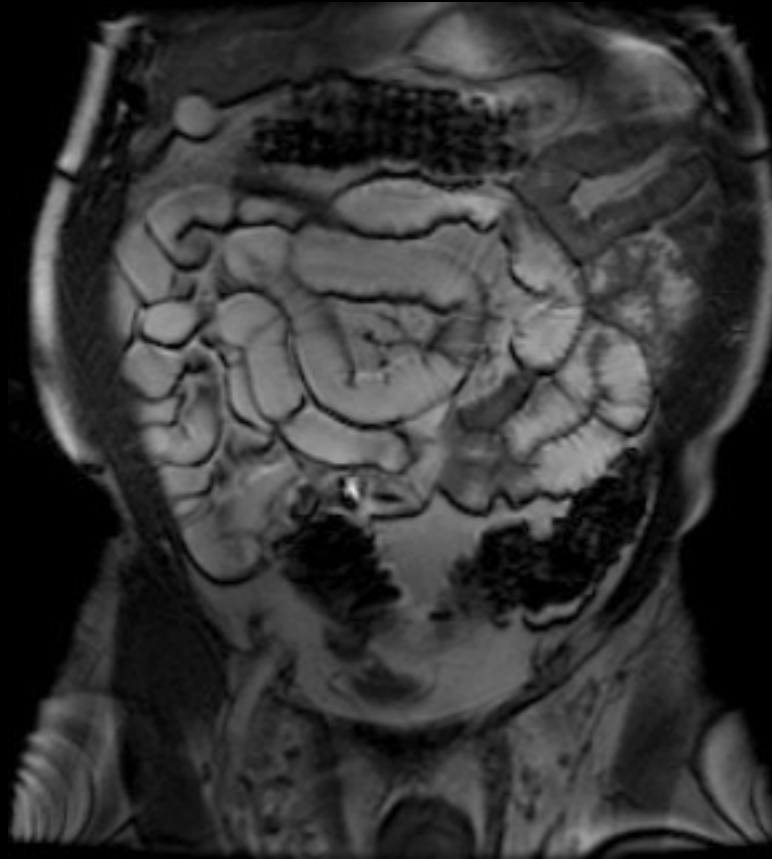
- 3-plane SSFSE no fat-saturation
- Large FOV body phased array
- Not critical to cover to dome of liver
- It is critical to cover through perineum
- Check coil sensitivity after this step
- Check bowel distension



# Protocol: *Real Time bSSFP*

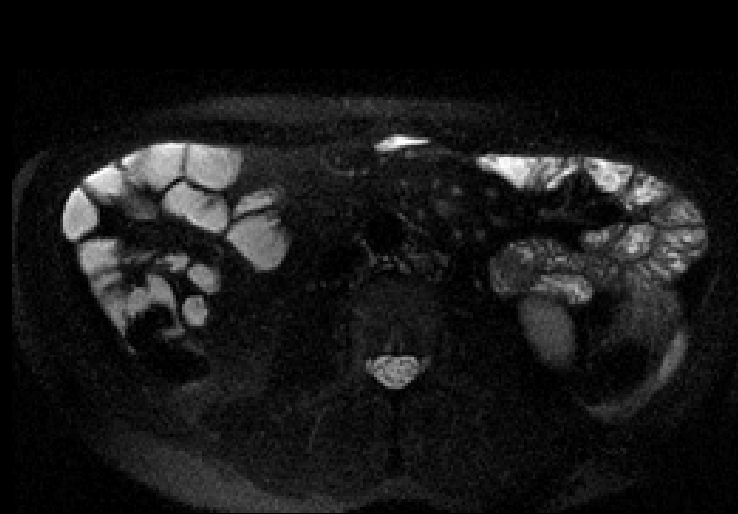
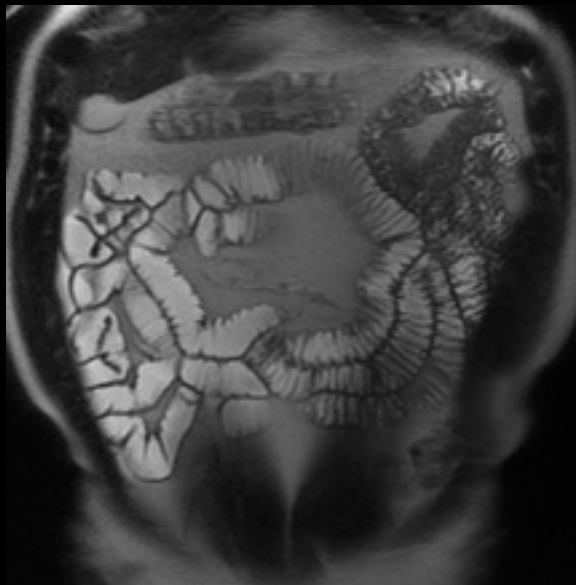
- Balanced steady-state free precession (SSFP, FIESTA, trueFISP, BFFE)
- Bright fluid
- “India-ink” artifact at water-fat interfaces
- 10-20 phases at each slice in 2D stack
- Free-breathing
- Fast, high SNR, available on all systems
- Perform *before* glucagon
- *Diseased segments have reduced motility*

# Protocol: *Real Time bSSFP*



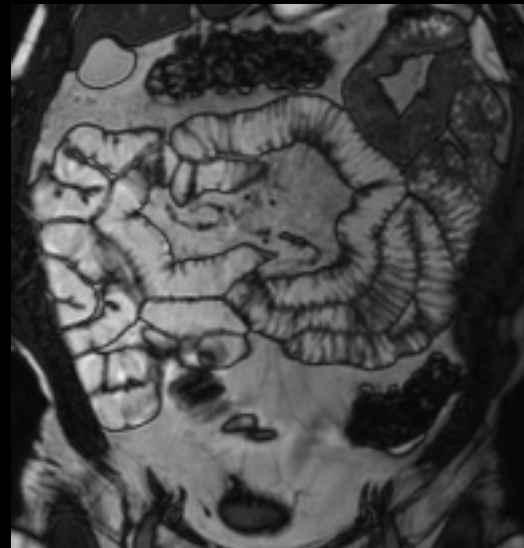
# Protocol: *T2 weighted imaging*

- SSFSE (HASTE): rapid, insensitive to motion
- Coronal T2-SSFSE *without* fat-sat: *anatomy*
- Axial T2-SSFSE *with* fat-sat: *disease activity*



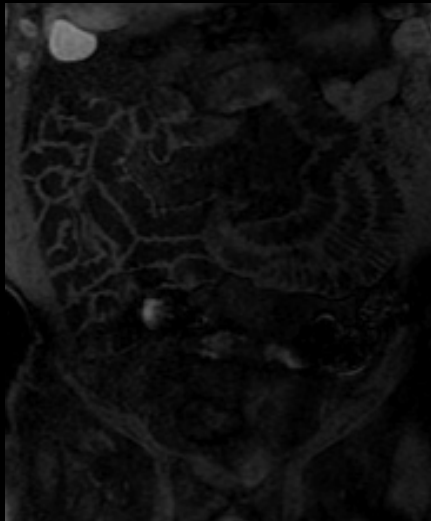
# Protocol: *3D-bSSFP*

- Anatomical overview with high resolution
- Isotropic spatial resolution for 3D reformats
- Bright fluid
- Water-fat interfaces black – etched appearance
- Banding artifacts
- Single breath-hold

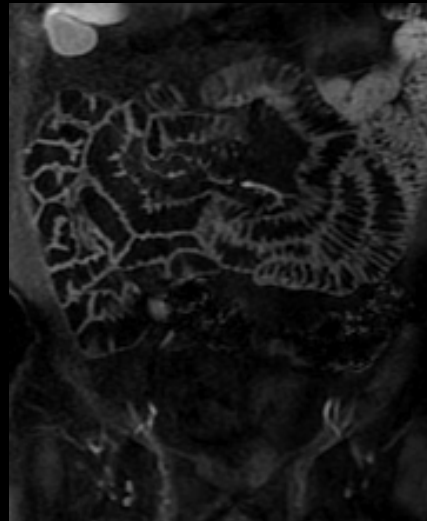


# Protocol: *Contrast Enhanced Imaging*

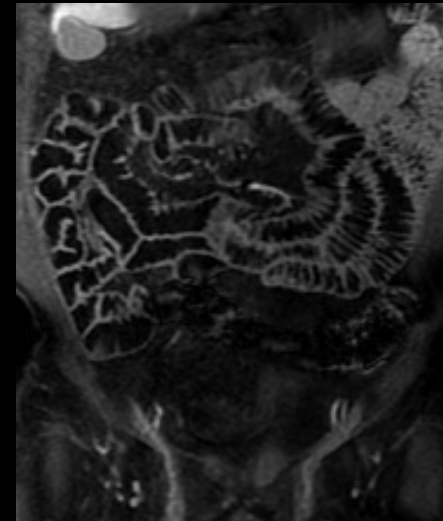
- T1 weighted 3D-SPGR with fat-saturation (LAVA, VIBE)
- 2D parallel imaging (ARC, GRAPPA) essential
  - Complete coverage of all small bowel
  - $1.5 \times 1.9 \times 2.0\text{mm}^3$  ( $0.9 \times 0.9 \times 1.0\text{mm}^3$ )



*Pre-contrast*

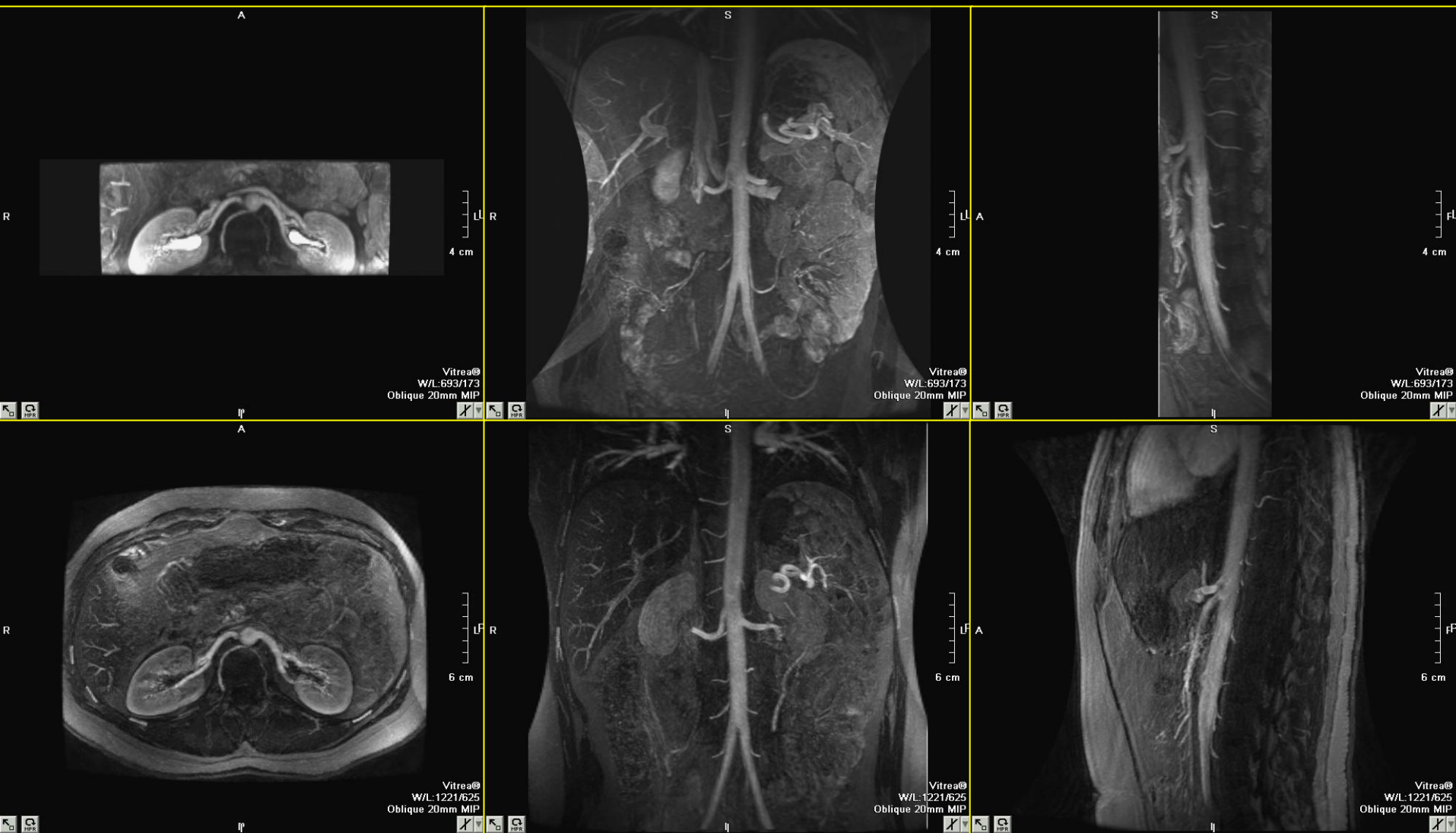


*Late Arterial (40s)*



*Delayed (2 minutes)*

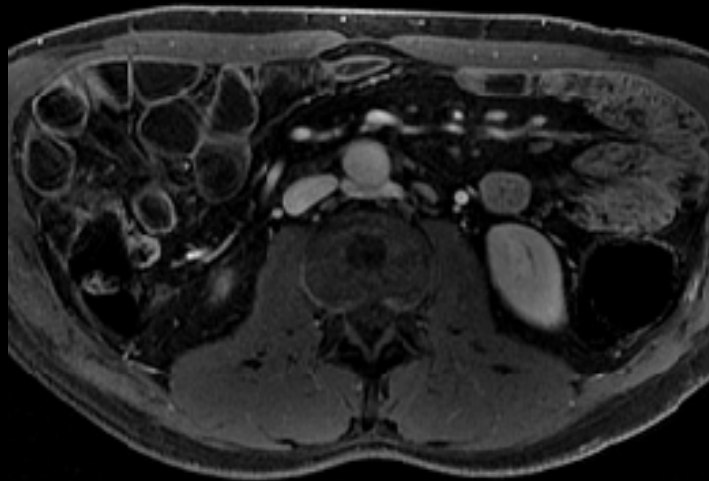
# 2D-ARC: Increased Coverage



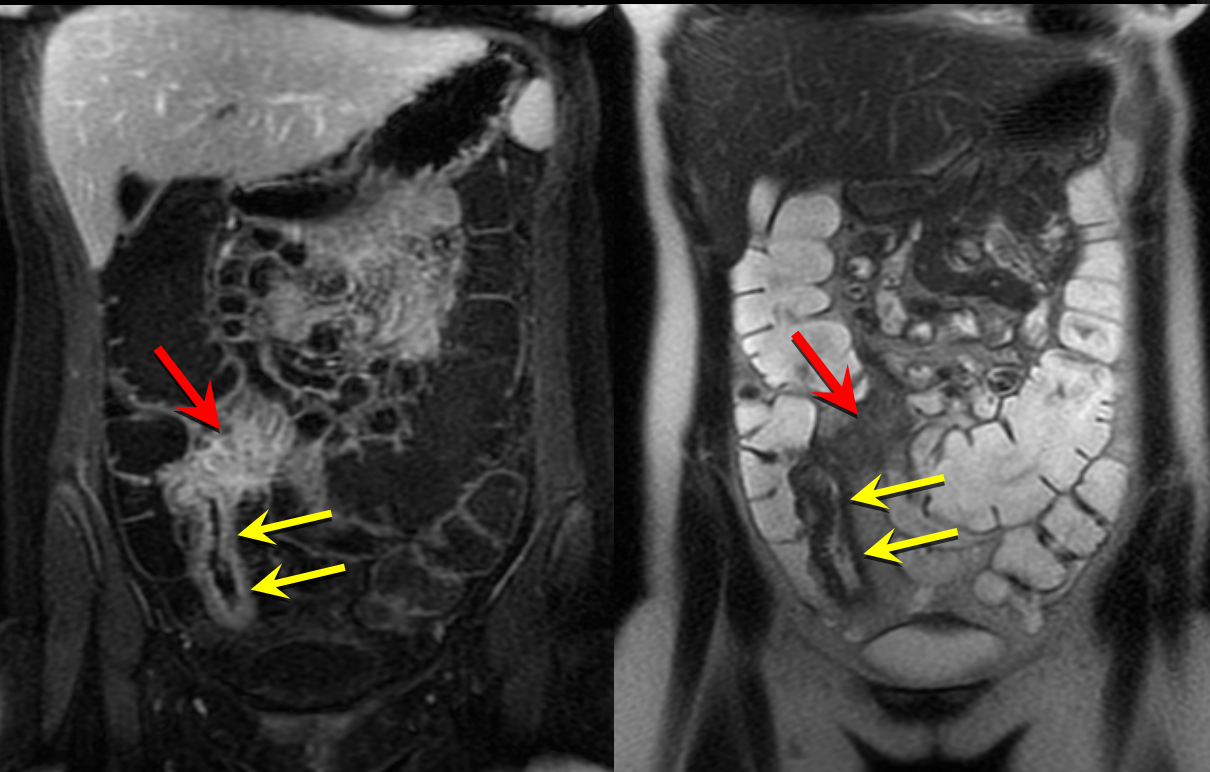


# Protocol: *Axial 2D T1W-SPGR*

- Second look with contrast
- Peri-anal fistulas
- Adenopathy



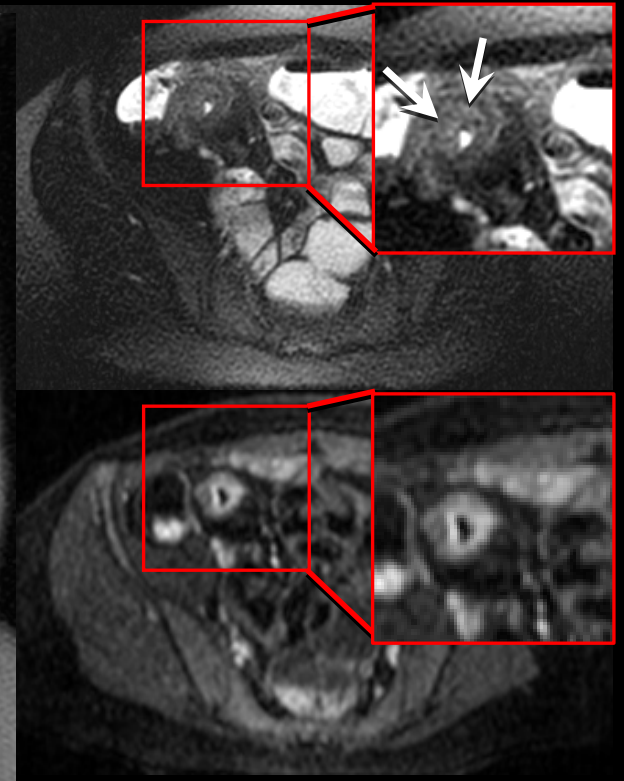
# Case: *16yo Girl with Crohns*



Coronal T<sub>1</sub> Weighted SPGR

Coronal T<sub>2</sub> Weighted SSFSE

Axial T<sub>2</sub> Weighted SSFSE

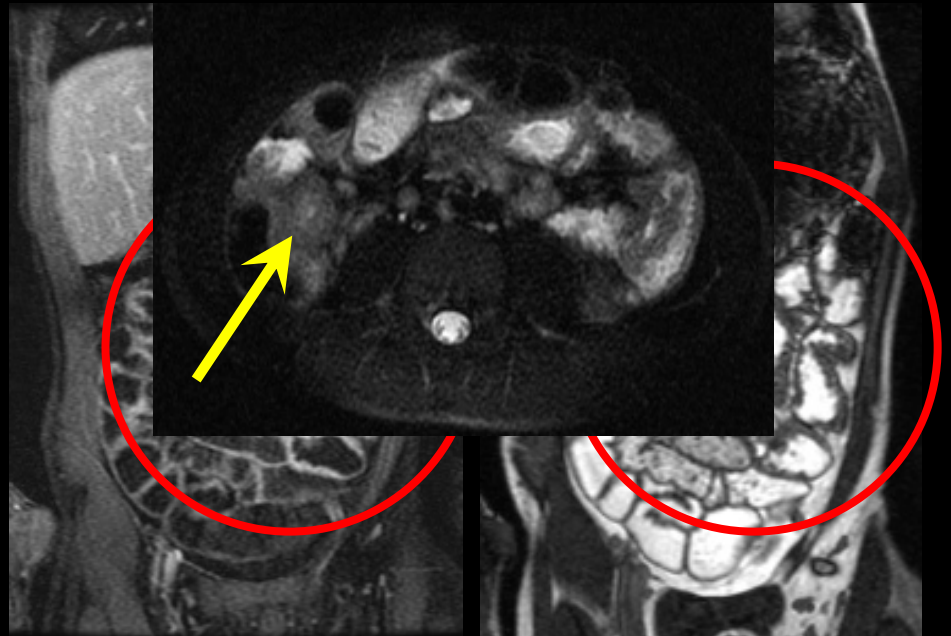
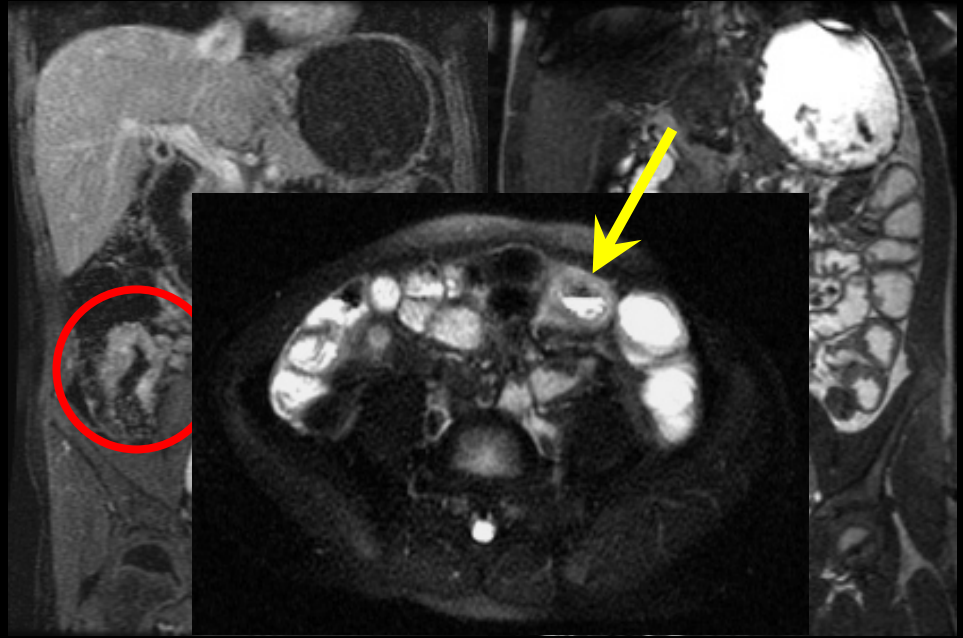


Axial Reformat T<sub>1</sub> Weighted SPGR



Case:

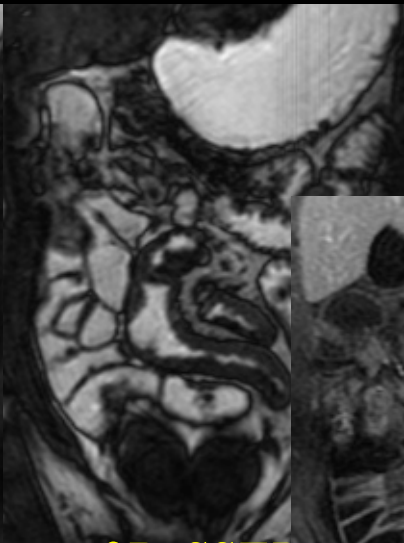
*9yo M with Crohn Dz*



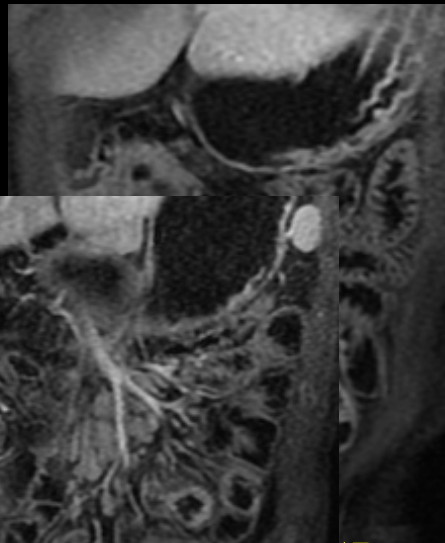
# Case: *Follow-up 1 year later*



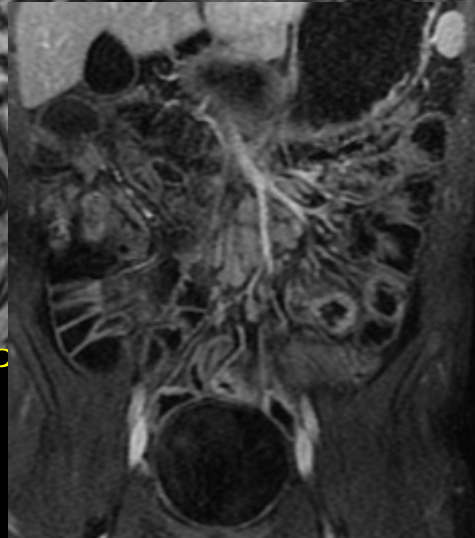
*SSFSE*



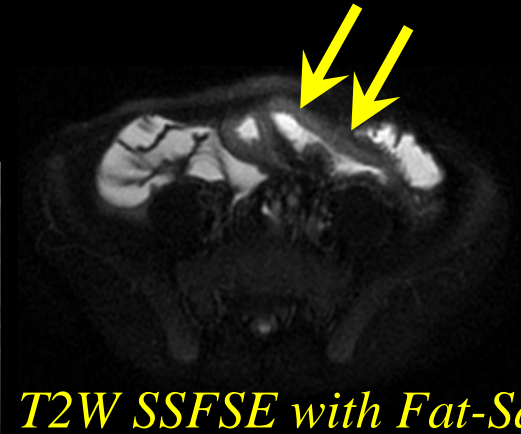
*3D-SSFP*



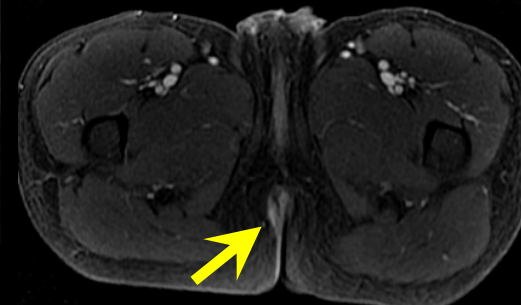
*MR*



Lymphadenopathy



*T2W SSFSE with Fat-Sat*



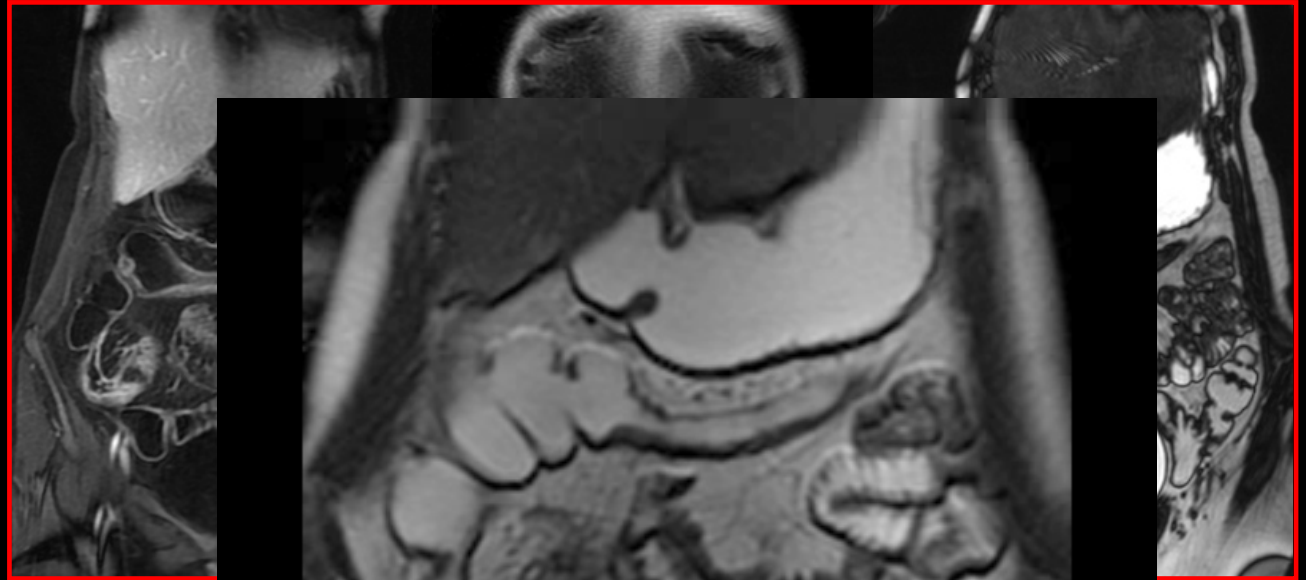
*T1W 2D-SPGR*

New lesions, high T2 signal: *Active Disease*

# Case: 24y woman with Crohns

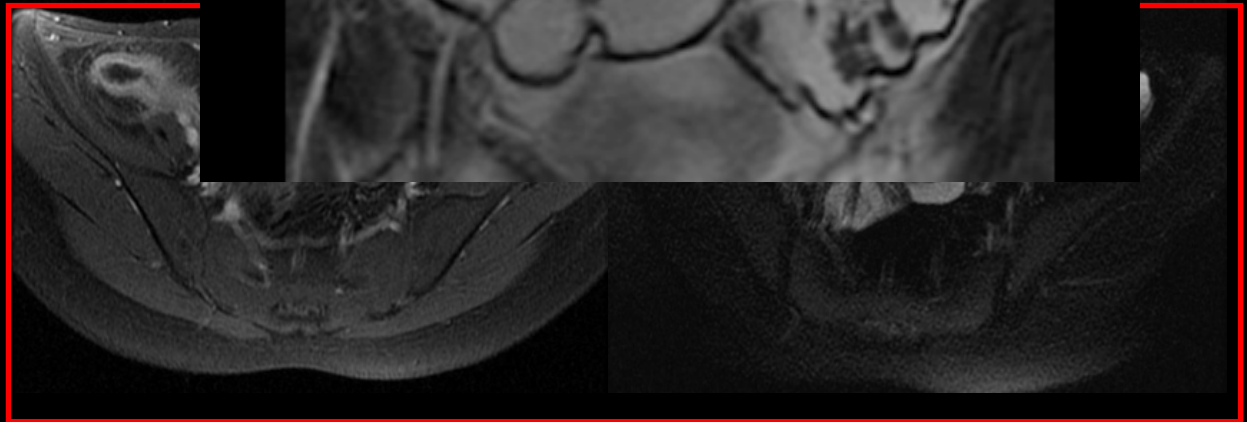


CT Enterography



T1W 3D-MDPR

P



T1W 2D-SPGR

T2 SSFSE with fat-sat



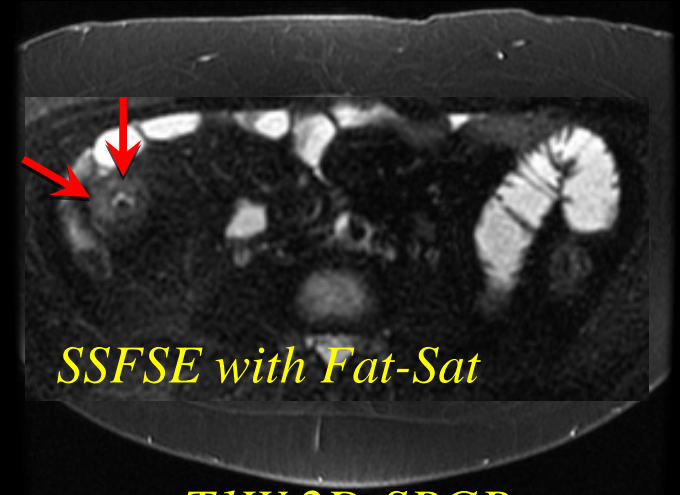
# Case: 27yo with abdominal pain



*SSFSE*

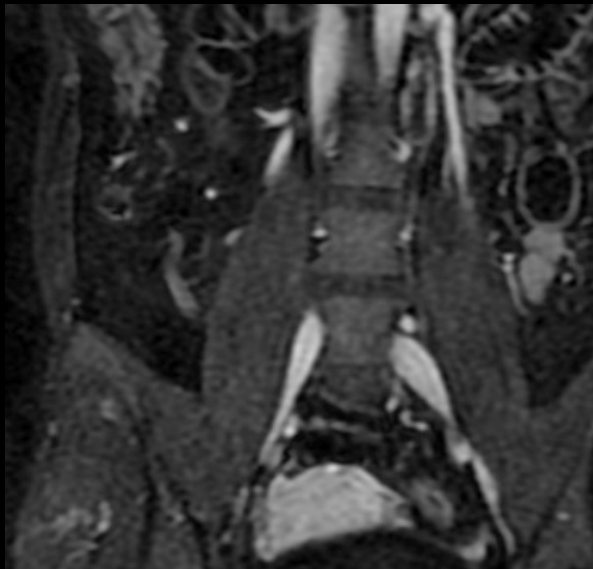


*T1W 3D-SPGR*



*SSFSE with Fat-Sat*

*T1W 2D-SPGR*

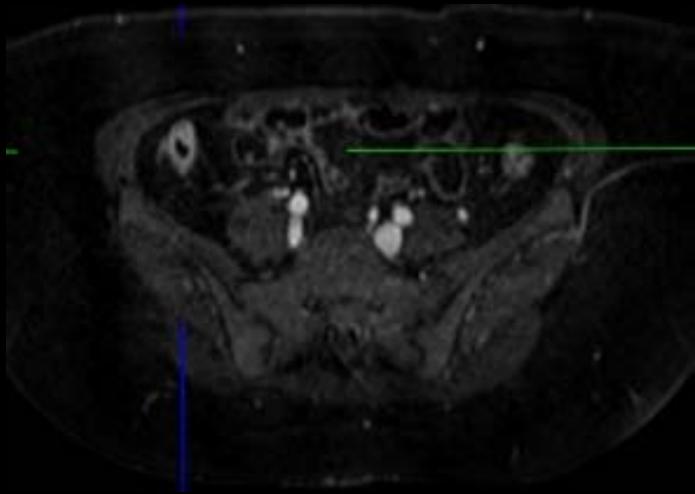


*T1W 3D-SPGR*

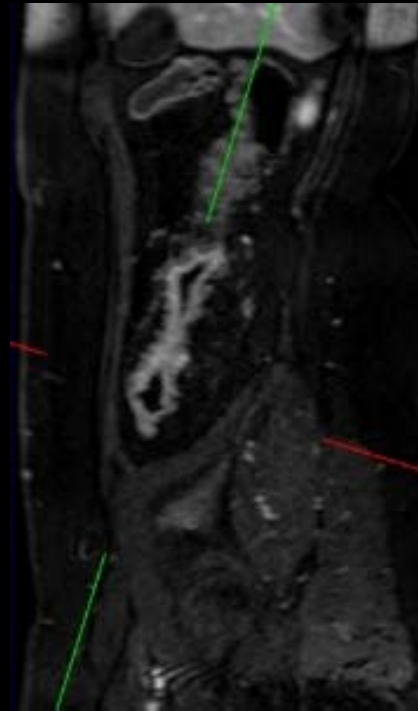


*CT*

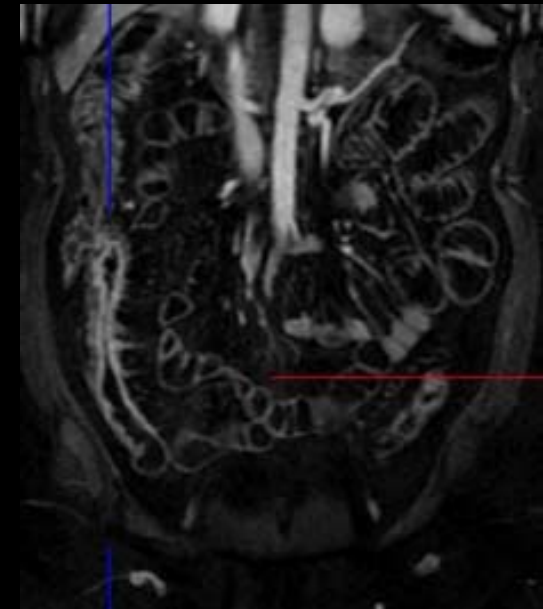
# 3D Multiplanar Reformats



*Axial*



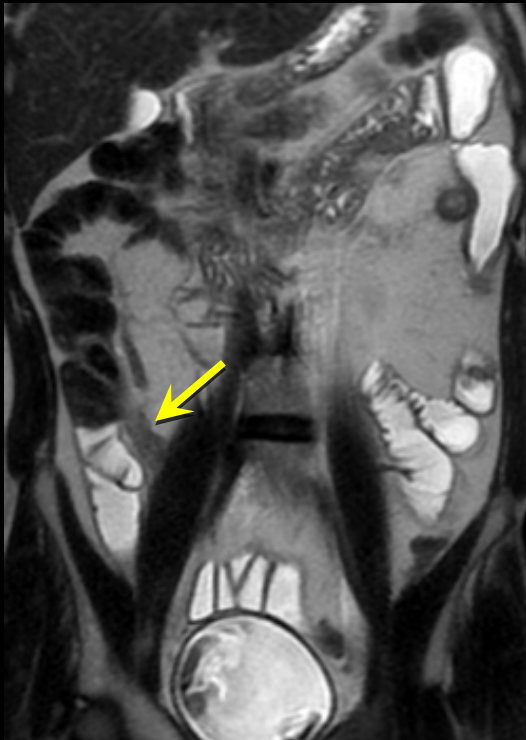
*Oblique  
Sagittal*



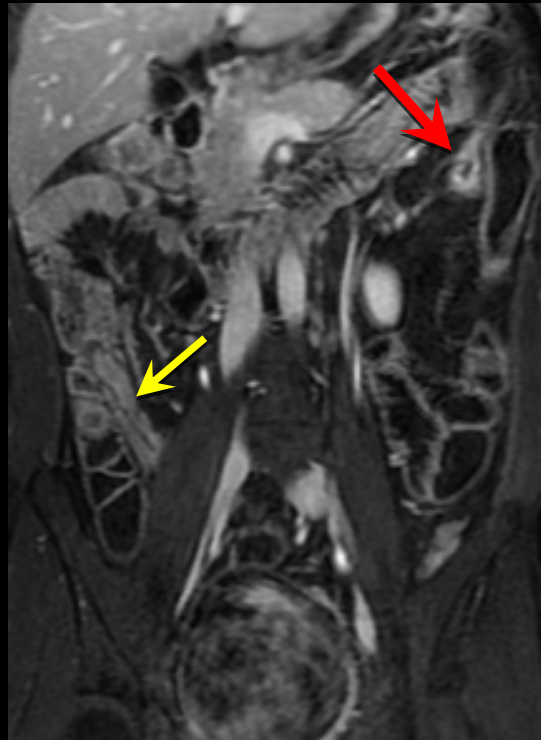
*Oblique  
Coronal*

*Pearl:* useful for referring  
surgeons - surgical planning

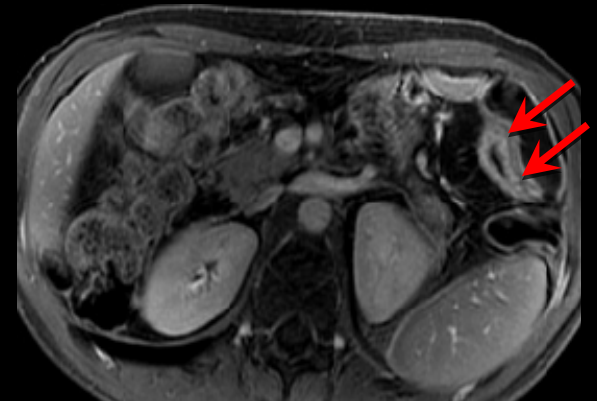
# Case: 33yo M with known h/o Crohns



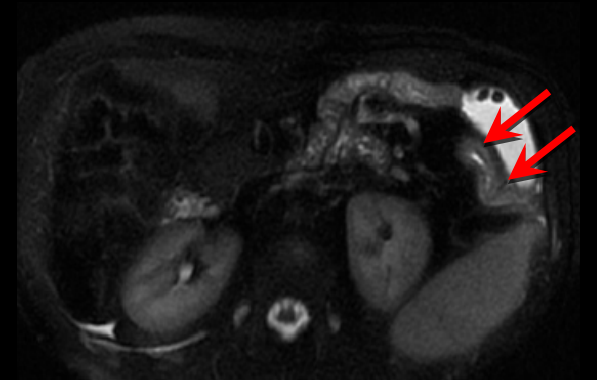
*SSFSE*



*T1W 3D-SPGR*



*T2W SSFSE with Fat-Sat*

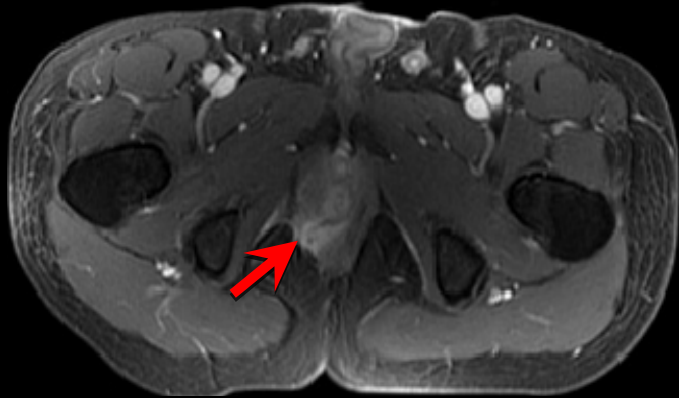


*T2W SSFSE with Fat-Sat*

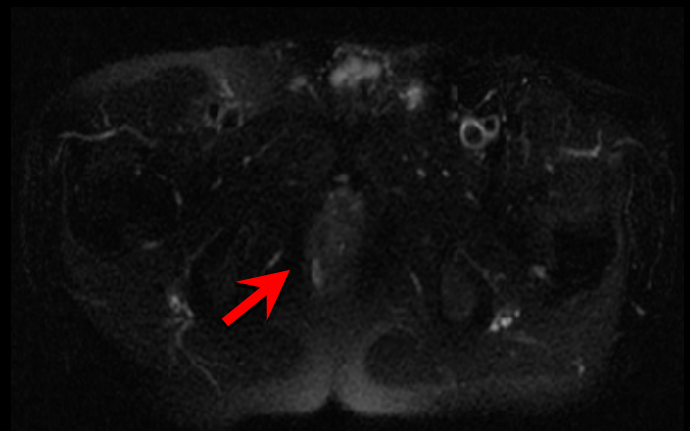
*Multiple Lesions of Varying Acuity*



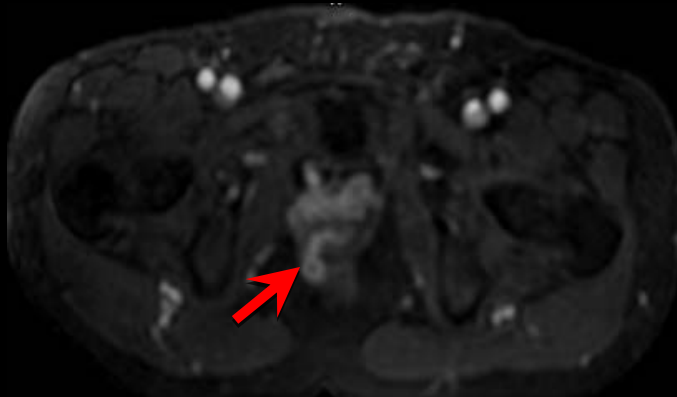
# Case: 33yo M with known h/o Crohns



*T1W 2D-SPGR*



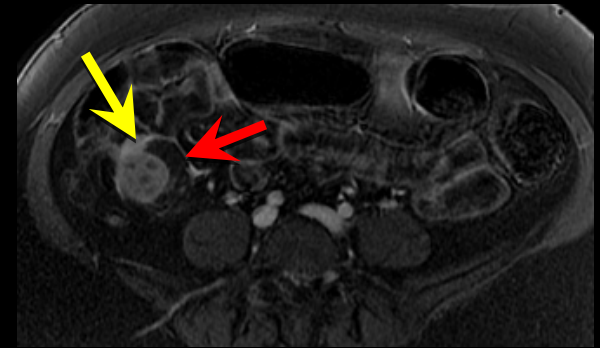
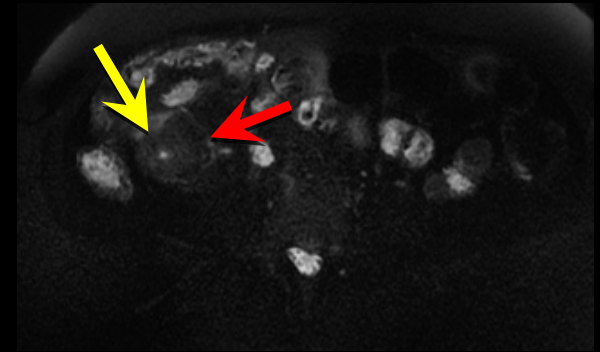
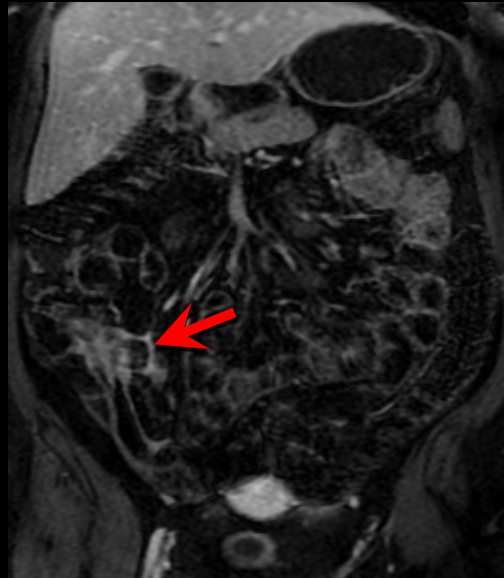
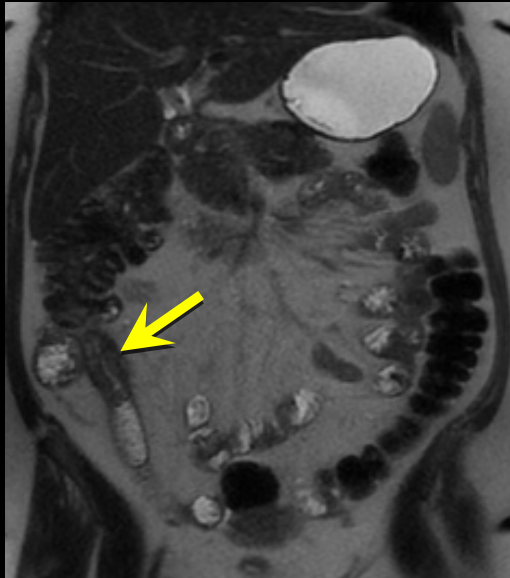
*T2W SSFSE with Fat-Sat*



*Oblique MPR 3D-SPGR*

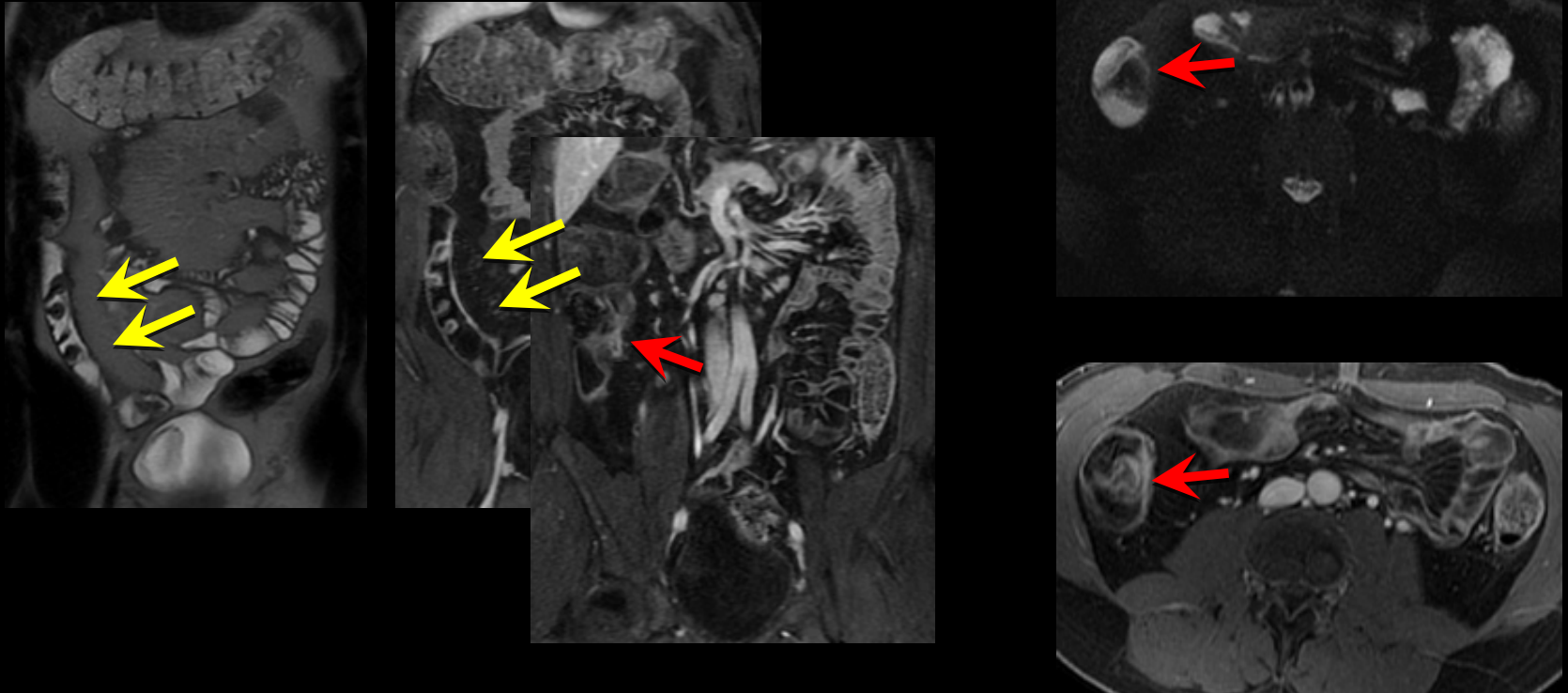
*Perianal Fistulas*

# Case: 30yo F, known Crohns Disease



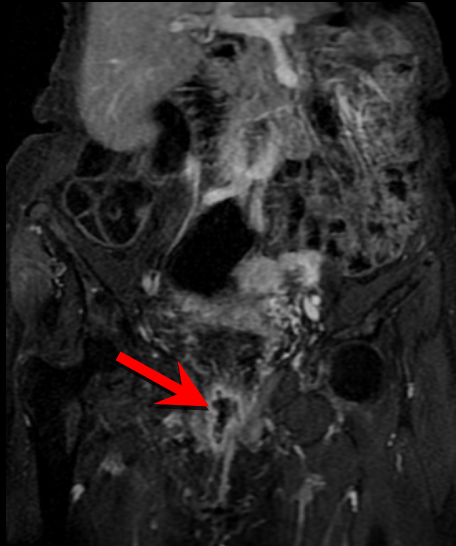
*Active disease with perienteric stranding and fistula formation*

*Case: 37 yo M with chronic  
disease and acute abdominal pain*

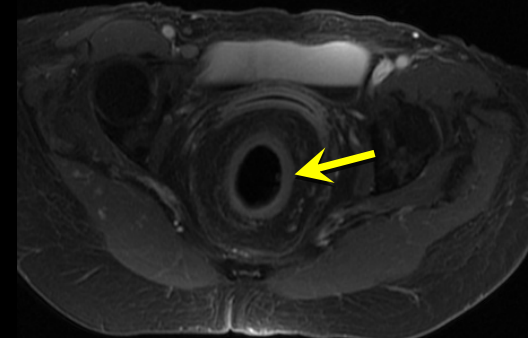


*Perienteric fatty proliferation (chronic)  
Enteroenteric fistula (active disease?)*

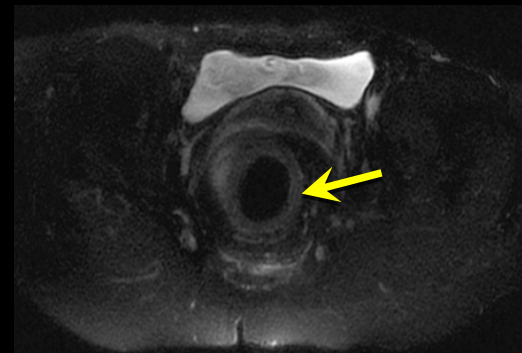
# Case: 69yo F with histology proven Crohns of the rectum



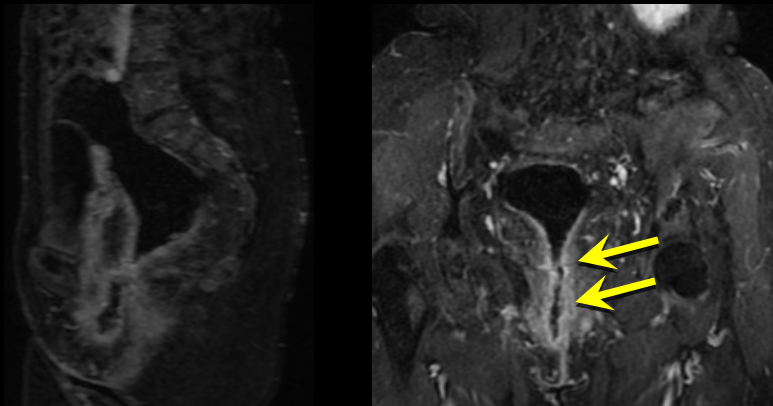
*T1W 3D-SPGR*



*T1W 2D-SPGR*



*T2W SSFSE with Fat-Sat*



*Oblique MPR 3D-SPGR*

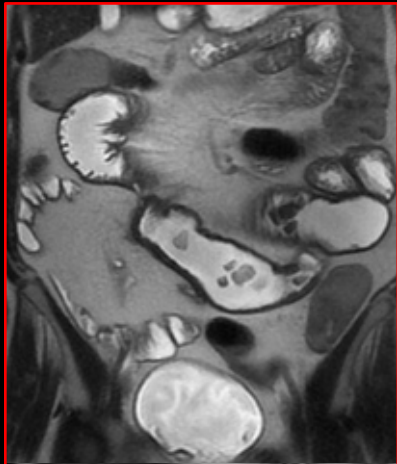
- *Active on chronic disease*

- *Bright T2 signal*
- *Perirectal fatty proliferation*

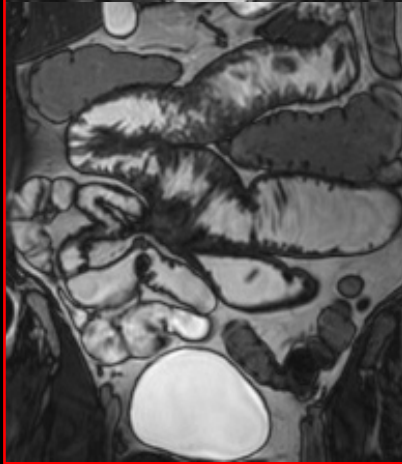
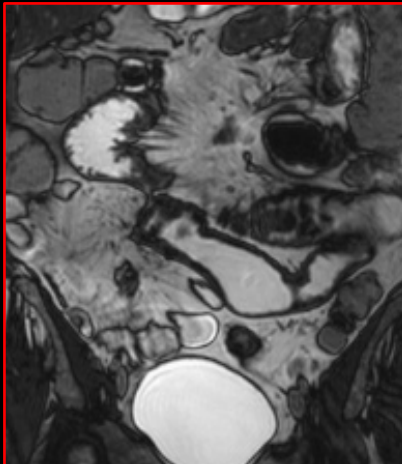
- *Rectal labial fistula*



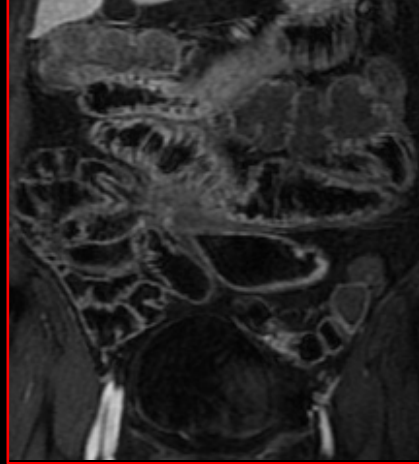
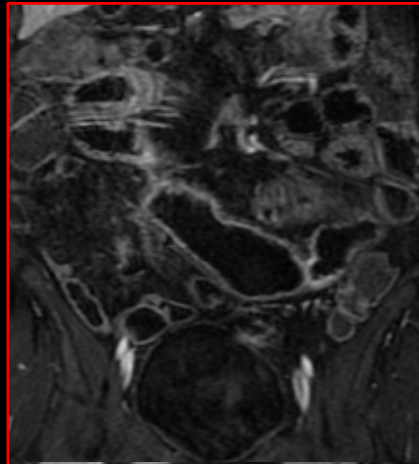
**Case:** 40yo M with long history of Crohns, presents with PSBO



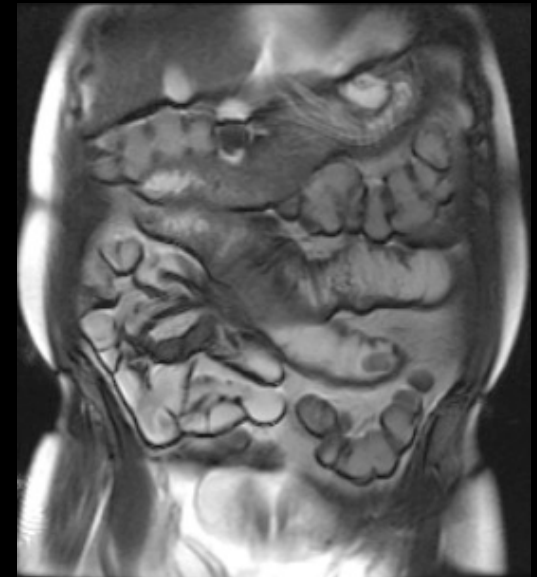
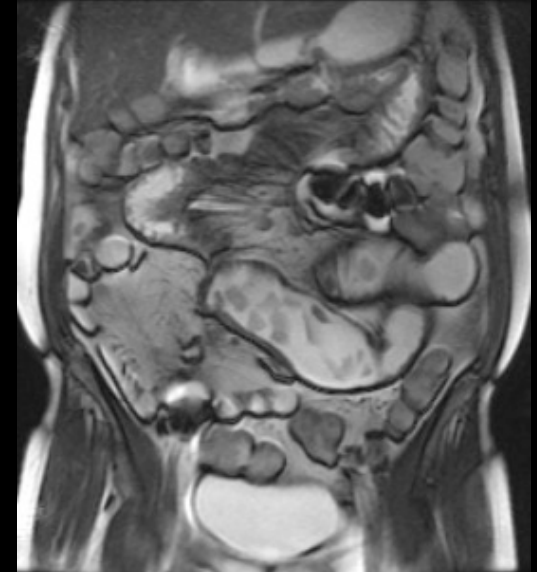
*SSFSE*



*3D-SSFP*



*T1W 3D-SPGR*



# Summary MR Enterography

- In 2010, MRE = CTE
- Moving target, with improved technology performance of MRE will exceed CTE
- MRE is an excellent modality to assess disease status and complications
- Additional information in the future ...
  - Assessment of active inflammation
  - Role for DWI, MT, DCE, BOLD, others?
  - Advanced real time applications



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