MR ENTEROGRAPHY FOR EVALUATION OF THE SMALL BOWEL

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Disclosures

- Nothing to disclose.
OUTLINE

• Introduction
• MRE advantages and limitations
• MRE vs. CTE
• Indications of MRE
• Technical aspects of MR enterography (MRE)
• Imaging findings
• Pitfalls of interpretation
• Conclusion
• References
• To review the **indications** for imaging of the small bowel with MR Enterography (MRE).
  • ACR appropriateness criteria

• **MRE vs. CTE**
  • Advantages and disadvantages

• To describe an optimal **protocol** for MRE.

• To review the **MRE findings of CD.**
  • Active vs chronic disease
  • Complications
    • Penetrating disease (fistulas, abscesses)
    • Fibrostenosing disease (strictures, SBO)

• To understand the **utility of MRE** for the evaluation of the small bowel.
INTRODUCTION

- Ability to provide cross-sectional information combined with a lack of ionizing radiation
  - MR imaging well suited for small-bowel imaging.

- Evaluation of both intraluminal and extraluminal small bowel disease.
  - Particularly in younger patients with Crohn disease.
  - Bowel wall contrast enhancement, wall thickening, and edema.
  - Depict lymphadenopathy, fistula and sinus formation, abscesses, and abnormal fold patterns.
ADVANTAGES

• Lack of ionizing radiation

• Superior contrast resolution

• Safety profile of IV contrast material

• May be done without IV contrast
  • Pregnant and low GFR pts

• Can assess temporal changes in bowel distention

• Assess progression of the small bowel disease, detect complications, and monitor the response to therapy.
LIMITATIONS

• Variability in examination quality
  • Related to patient cooperation and breath-holding ability

• Imager access

• Cost of the examination

• Lower spatial and temporal resolution than CT
### MRE VS. CTE

<table>
<thead>
<tr>
<th>MRE</th>
<th>CTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>No ionizing radiation</td>
<td>Ionizing radiation</td>
</tr>
<tr>
<td>Dynamic imaging</td>
<td>Static imaging</td>
</tr>
<tr>
<td>Better contrast resolution</td>
<td>Better spatial and temporal resolution</td>
</tr>
<tr>
<td>+/- Contrast</td>
<td>Contrast needed</td>
</tr>
<tr>
<td>Perianal eval in same exam</td>
<td>No perianal evaluation</td>
</tr>
<tr>
<td>Multiplanar capabilities</td>
<td>Multiplanar reformations</td>
</tr>
<tr>
<td>Expensive</td>
<td>Cost (cheaper)</td>
</tr>
<tr>
<td>Longer imaging time</td>
<td>Short imaging time</td>
</tr>
<tr>
<td>Less availability</td>
<td>Available</td>
</tr>
</tbody>
</table>
INDICATIONS

- **Crohn disease**
  - *Primary indication for MR imaging of the small bowel.*
    - Many patients present at a **young age** and require **multiple imaging tests** as a follow-up to therapy or to detect complications.
  
- Desmond et al (3) showed that certain subgroups of patients with Crohn disease may be exposed to **high lifetime doses of radiation**:
  
  - Pts diagnosed at an early age.
  - Pts with UGI tract inflammation or penetrating disease.
  - Pts who require therapy with IV steroids or infliximab.
    (an antibody that blocks the effects of tumor necrosis factor).
  - Pts who undergo multiple surgeries.
INDICATIONS

- **Crohn disease (CD)**
  
  - Some prefer to use **CT enterography as a baseline study** in most patients, although MR imaging may be used in young patients.
    - Follow-up MR imaging examinations may then be performed.
  
  - **MRE** can demonstrate complications of CD, including penetrating disease, bowel obstructions, and perianal fistulization.
    - It allows to evaluate **distensibility and peristalsis** of narrowed segments.
    - Provides the ability to monitor filling of the bowel, with **multiphasic sequences** applied at the levels of suspected narrowing.
Crohn disease with ileitis and transphincteric perianal fistula
INDICATIONS

- Pts with contraindications to CTE
  - Pregnancy
  - Contraindications to the use of iodinated contrast material

- Low grade bowel obstruction

- SB masses / Polyposis syndromes
  - Detection and surveillance of small-bowel polyps

- Chronic diarrhea

- Diffuse small bowel diseases
  - Celiac disease, radiation enteritis, scleroderma
Unknown Crohn disease in a young pregnant woman presenting with abdominal pain and diarrhea.
39 y/o F with previous appendectomy with recurrent abd pain.
### Variant 2: Suspected intermittent or low-grade SBO.

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT abdomen and pelvis with contrast (CT enteroclysis)</td>
<td>8</td>
<td>Other less invasive techniques may be considered first to avoid placing an enteric tube.</td>
<td>●●●●●</td>
</tr>
<tr>
<td>MRI abdomen and pelvis without and with contrast (MR enteroclysis)</td>
<td>8</td>
<td>MR enteroclysis may have sensitivity and specificity similar to those of CT enteroclysis and it avoids radiation risks. However, the choice of examination depends on institutional preferences and resources. See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>O</td>
</tr>
<tr>
<td>CT abdomen and pelvis with contrast (CT enterography)</td>
<td>8</td>
<td></td>
<td>●●●●●</td>
</tr>
<tr>
<td>MRI abdomen and pelvis without and with contrast (MR enterography)</td>
<td>7</td>
<td>See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>O</td>
</tr>
<tr>
<td>X-ray small bowel enteroclysis</td>
<td>7</td>
<td></td>
<td>●●●</td>
</tr>
<tr>
<td>CT abdomen and pelvis with contrast (routine)</td>
<td>5</td>
<td></td>
<td>●●●●</td>
</tr>
<tr>
<td>X-ray small bowel follow-through</td>
<td>5</td>
<td></td>
<td>●●●</td>
</tr>
<tr>
<td>MRI abdomen and pelvis with or without contrast (routine)</td>
<td>5</td>
<td>See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>O</td>
</tr>
<tr>
<td>X-ray abdomen and pelvis</td>
<td>4</td>
<td></td>
<td>●●●</td>
</tr>
<tr>
<td>US abdomen and pelvis</td>
<td>2</td>
<td></td>
<td>O</td>
</tr>
</tbody>
</table>

**Rating Scale:** 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

*Relative Radiation Level*
# Variant 2: Child or young adult. Initial presentation. Suspected Crohn disease.

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<td>CT abdomen and pelvis with contrast (CT enterography)</td>
<td>9</td>
<td>MR enterography may have sensitivity and specificity similar to CT enterography and avoids radiation risks. However, the choice of examination depends on institutional preferences and resources. MRI is the preferred modality for investigating perianal disease. See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>⭤✭✭✭</td>
</tr>
<tr>
<td>MRI abdomen and pelvis without and with contrast (MR enterography)</td>
<td>9</td>
<td></td>
<td>⭤</td>
</tr>
<tr>
<td>CT abdomen and pelvis with contrast (routine)</td>
<td>7</td>
<td>The RRL for the adult procedure is ⭤✭✭✭.</td>
<td>⭤✭✭✭</td>
</tr>
<tr>
<td>X-ray small-bowel follow-through</td>
<td>7</td>
<td></td>
<td>⭤✭✭✭</td>
</tr>
<tr>
<td>US abdomen and pelvis</td>
<td>6</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>X-ray contrast enema</td>
<td>5</td>
<td>The RRL for the adult procedure is ⭤✭✭✭.</td>
<td>⭤✭✭✭</td>
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<tr>
<td>X-ray abdomen</td>
<td>5</td>
<td>May be useful to exclude free air if perforated hollow viscus is suspected.</td>
<td>⭤✭✭✭</td>
</tr>
<tr>
<td>Tc-99m HMPAO leucoscintigraphy</td>
<td>3</td>
<td></td>
<td>O</td>
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<td>US pelvis endorectal</td>
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*Relative Radiation Level
**Variant 6:** Child or young adult with known Crohn disease; stable, mild symptoms and/or surveillance.

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<tr>
<td>US abdomen and pelvis</td>
<td>6</td>
<td>Consider dose reduction techniques. The higher spatial resolution obtained with CT is usually not required for surveillance of areas of known Crohn disease.</td>
</tr>
<tr>
<td>CT abdomen and pelvis with contrast (CT enterography)</td>
<td>6</td>
<td>The RRL for the adult procedure is ⚫⚫⚫⚫.</td>
</tr>
<tr>
<td>X-ray small-bowel follow-through</td>
<td>5</td>
<td>The RRL for the adult procedure is ⚫⚫⚫⚫.</td>
</tr>
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<td>⚫⚫⚫❼</td>
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*Relative Radiation Level*
TECHNIQUE - PROTOCOL

• Luminal distention is key.

• Large volume of oral contrast material
  • 1350–1500 mL
  • 40 - 60 min before the examination

• Contrast material may be administered via the rectum
  • To better distend the colon for assessment of colonic abnormalities.
  • Colonic abnormalities may be adequately demonstrated due to antegrade filling with contrast material.
Crohn ileocolitis
Crohn ileocolitis
**TECHNIQUE - PROTOCOL**

- **IV contrast material**
  - Useful for detecting areas of hyperenhancement suggestive of active inflammation in CD and hyperenhancing masses.
  - 0.2 mmol/kg gadolinium at a rate of 3 mL/sec
  - Begin imaging 50 - 70 seconds after initiation of the contrast material infusion.
  - Multiple acquisitions may be performed due to lack of ionizing radiation.

- **MRE may demonstrate pathologic findings even when IV contrast material is not administered.**
  - Evidence of increased perienteric vascularity and wall thickening on unenhanced images may be diagnostic of active inflammation.
Dynamic imaging
Active Crohn disease
Patients may be imaged in either supine or prone position.

- Use of the prone position may facilitate elevation and separation of small-bowel loops from the pelvis and reduce the area to be imaged.
  - However, improved distention may not translate into an improvement in the detection of abnormalities.

Spasmolytics (glucagon)

- Useful for reducing bowel peristalsis and motion artifacts.
  - Most important for fast gradient-echo sequences performed after the administration of IV contrast material and also may help reduce intraluminal flow artifacts on half-Fourier acquisition single-shot turbo spin-echo (HASTE) images.

- 0.2 - 0.5 mg/Kg every 12 - 15 min
TECHNIQUE - PHILIPS

- Coronal Haste
- Coronal balanced SSFP w/o FS
- Axial balanced SSFP w/o FS
- Axial balanced SSFP w FS
- Coronal balanced SSFP w FS (optional)
- Cine (bright blood seq for cardiac)
- Coronal 3D ultrafast GRE (precontrast)
- Coronal 2D ultrafast GRE (postcontrast)
- Coronal 3D ultrafast GRE (postcontrast)
- Axial 3D ultrafast GRE (postcontrast)
TECHNIQUE - GE

- Coronal T2 SSFSE
- Coronal 2D FIESTA w/o FS
- Axial T2 2D FIESTA w/o FS
- Axial T2 2D FIESTA w FS
- Cine (bright blood seq for cardiac)
- Axial T2 SSFSE (optional)
- Coronal 2D FIESTA w FS (optional)
- Coronal T1 LAVA FS (precontrast)
- Coronal T1 LAVA FS (postcontrast)
- Axial T1 LAVA FS (postcontrast)
TECHNIQUE - SIEMENS

- True fisp survey
- Coronal ss-TSE (upper, lower)
- Axial ss-TSE
- Coronal VIBE (upper, lower)
- Axial VIBE 2 sets (upper, lower)
- Cine (bright blood seq for cardiac)
- Axial VIBE dynamic arterial & venous (upper)
- Axial fat sat ss-TSE
- Axial VIBE 2 sets (upper, lower)
- Coronal VIBE
- Coronal 3D-MRCP upper and lower (done for bowel, not for bile ducts)
NORMAL MR ENTEROGRAPHY

- Mucosal enhancement
  - Homogeneous
  - Jejunum > ileum
    - Depends on degree of bowel distention
- Bowel wall thickness < 3 mm
  (distended)
  - If collapsed:
    - Jejunum - 7 mm
    - Ileum - 5 mm
- Small bowel luminal distention < 3 cm
IMAGING FINDINGS

• MRE may demonstrate changes of inflammatory disease.

• Active
  • **Mucosal hyperenhancement** (one of the earliest signs)
  • Wall **thickening** (> 3 mm)
    • Mural stratification ("bilaminar", "trilaminar" or "target")
    • Determined by luminal distention.
  • ↑ **mesenteric vascularity** ("comb sign")
  • ↑ **signal intensity** in the bowel wall (T2-W fat sat)
  • **Perienteric inflammation** (T2-W fat sat)
  • **Reactive adenopathy** (T2-W w/o fat sat)

• Complications
  • penetrating disease (fistulae, abscess) and bowel obstruction
Mural thickening
Mural stratification in patient with Crohn disease
Long segment ileitis
The “comb” sign
The “comb” sign
Mesenteric edema
Complex, stellate entero-colonic fistula
Ileoceleal fistula
Stellate entero-enteric fistula
Stellate entero-enteric fistula
Complex internal bowel fistula
CD with penetrating disease and mesenteric abscess
CD with penetrating disease and mesenteric abscess
CD with penetrating disease and mesenteric abscess
CD with mural abscesses
Abscess vs. SB loop ???
Ileitis with psoas abscess, stricture
Ileitis with psoas abscess, stricture
Ileitis with psoas abscess
Active stricture with partial bowel obstruction.
Crohn disease with bowel obstruction
Crohn disease with bowel obstruction.
IMAGING FINDINGS

- Chronic
  - Submucosal fat
  - Fibrosis (T2 images critical for fibrostenotic disease)
  - Fibrofatty proliferation
  - Pseudosacculations
Submucosal fat deposit resulting from chronic bowel inflammation

Fidler J L et al. Radiographics 2009;29:1811-1825
Fibrostenotic Crohn disease
Chronic fibrostenotic stricture with bowel obstruction
Crohn ileitis with ulcers and pseudosacculations
SMALL BOWEL MASSES

- **Limited data** regarding its sensitivity for detection of SB masses.

- MRE can generate images with different gradations of luminal contrast agents (not possible with CT).

- Small-bowel masses have varying enhancement patterns.
  - The use of biphasic enteric contrast agents at MRE may help overcome this limitation.

- **T2-WI**: SB masses display signal intensity lower than that of intraluminal fluid.
  - May help identify masses that don’t show substantial enhancement after IV contrast.
Polyposis syndrome in a patient with Cowden disease
**PITFALLS**

- **Suboptimal luminal distention**
  - Causes “pseudohyperenhancement” of the mucosa and apparent bowel wall thickening.

- **Suboptimal timing of contrast bolus**
  - Resultant poor enhancement of the bowel mucosa

- **Low-signal-intensity voids**
  - Can occur in the lumen because of peristalsis in T2-W imaging.
  - HASTE seq more susceptible than balanced SSFP seq.
  - Spasmolytics may help reduce the signal void artifact.
Low-signal-intensity artifacts
CONCLUSIONS

• MR imaging can provide exquisite anatomic, functional, and real-time information without the need for ionizing radiation.

• MRE should be the modality of choice for follow up patients with established CD.

• Implementation of MRE in clinical practice may benefit many patients, especially the young and those with chronic diseases that require surveillance to detect complications or monitor therapy, and it may help reduce their lifetime exposure to radiation.
• Grand DJ et al. MR enterography correlates highly with colonoscopy and histology for both distal ileal and colonic Crohn's disease in 310 patients. Eur J Radiol. 2012 Mar 23

• Ethan A. Smith et al. MR Enterography of Extraluminal Manifestations of Inflammatory Bowel Disease in Children and Adolescents: Moving Beyond the Bowel Wall. AJR January 2012 vol. 198 no. 1 W38-W45.

• Michael S. Gee et al. Prospective Evaluation of MR Enterography as the Primary Imaging Modality for Pediatric Crohn Disease Assessment. AJR July 2011 vol. 197 no. 1 224-231.


• Karin Horsthuis et al. Inflammatory Bowel Disease Diagnosed with US, MR, Scintigraphy, and CT: Meta-analysis of Prospective Studies. April 2008, Radiology, 247, 64-79.
THANK YOU!

Questions???

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