MR Enterography in Crohn’s Disease

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Financial Disclosure

Grant support: Bayer
Burrill Crohn (1884 –1983)

- Trained in pathology and gastroenterology at Mount Sinai
- Named Chief of Mount Sinai’s Gastroenterology Clinic in 1923
- Associated with Mount Sinai for over 60y
- One of the first to describe CD as “Regional ileitis; a pathologic and clinical entity”. JAMA 1932 (14 cases of granulomatous inflammation of the distal ileum)
Crohn’s disease (CD)

- Chronic IBD with variable clinical features and disease course
- Can involve any location of the GI tract, frequently affects distal SB
- All bowel layers may be involved, with skip areas
- Fatigue, persistent diarrhea, cramping abdominal pain, fever, rectal bleeding, loss of appetite, weight loss
- Extra-digestive symptoms: joints, eyes, skin, PSC
- Complications: SBO, GI ulcers, perianal fistulas, protein loss, vitamin insufficiency, superinfection
- Increased risk of SB, colorectal cancer, lymphoma and carcinoid tumors
Crohn’s disease (CD)

- Disease behavior based on the presence/absence of complications such as stricture, fistula, and abscesses
- Biologic therapy: immune modifiers (azathioprine, 6-MP, methotrexate), antibiotics, anti-TNF (infliximab)
- 2/3 to 3/4 of CD patients require surgery at some point
- Ultimate goal of medical therapy in CD:
  - Achieve clinical response and sustained remission
  - Prevent strictures and penetrating complications that lead to surgery
Advantages of MRI over CT

• Radiation free
• Higher tissue contrast
• Comprehensive examination: Bowel and perianal fistulas
• Functional assessment:
  ✓ Peristalsis
  ✓ Diffusion
  ✓ Enhancement/perfusion
CT related radiation

<table>
<thead>
<tr>
<th>Diagnostic Procedure</th>
<th>Effective Dose (mSv)</th>
<th>Time Period for Equivalent Effective Dose from Natural Background Radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest x ray (PA)</td>
<td>0.02</td>
<td>2.4 days</td>
</tr>
<tr>
<td>CT abdomen</td>
<td>8 (3.5-25)</td>
<td>2.7 years</td>
</tr>
<tr>
<td>CT pelvis</td>
<td>8 (3.3-10)</td>
<td>2.7 years</td>
</tr>
</tbody>
</table>

Note: yearly limit for radiation workers in the US 50 mSv
http://www.fda.gov/Radiation-EmittingProducts/
27 year old female with Crohn colitis

Effective CT dose = 11.4 mSv
Roles of MRI

• Diagnose CD
• Assess extent of lesions
• Assess for complications (abscess/phlegmons, fistulas, obstruction, stenotic lesions)
• Assess response to treatment
• Marker of severity (MaRIA and Clermont scores)
  – MaRIA = 1.5 × wall thickening (T1, mm) + 0.02 × RCE + 5 × edema + 10 × ulceration
  – Clermont = 1.646 × wall thickening + 1.321 × ADC + 5.613 × edema + 8.306 × ulceration + 5.039

Limitations of MRI

- Longer exam
- Not as sensitive to air
- Limited availability
- Quality can be suboptimal (poor breath-holding, limited bowel distention)
Patient preparation

- 6 hours of fasting
- Check contra-indications to MRI
- Glucagon (1 mg IM)
MR Enterography protocol (≤ 45 min)

• 1.5T or 3T multichannel systems
• Axial and coronal single shot T2 HASTE
• Axial T1 in- and out-of-phase
• DWI (detection of abscesses, fistulas, inflammation)
• Axial and coronal dynamic 3D GRE T1 pre- and post-contrast: 25, 60, 180 sec

Optional:
   Peristalsis (Tfisp/Fiesta)
Oral contrast agents

- Need neutral biphasic non-absorbable agents with minimal water absorption by the bowel
- VoLumen (Bracco Diagnostics): berry flavored low concentrated barium sulfate suspension (0.1% weight/volume) contains sorbitol and a gum
- Breeza (Beekley medical): lemon and lime flavored contains sorbitol, mannitol, and xantham gum without barium sulfate
- Performs similarly to VoLumen, with better taste, and greater willingness for repeat drinking (Kolbe. AJR 2016; Dillman, Radiology 2018)
- Mannitol, PEG, sorbitol and lactulose, methylcellulose, metamucil
- Ingestion of up to 1000 ml 45-60 min prior to scanning
## Imaging findings associated with SB CD inflammation

<table>
<thead>
<tr>
<th>Segmental mural hyperenhancement</th>
<th>Intramural edema</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Asymmetric</td>
<td>Stricture</td>
</tr>
<tr>
<td>• Stratified (bi-or tri-laminar)</td>
<td>• Possible stricture without upstream dilation (&lt; 3 cm)</td>
</tr>
<tr>
<td>• Homogeneous, symmetric</td>
<td>• Stricture with mild upstream dilation (3 - 4 cm)</td>
</tr>
<tr>
<td>Wall thickening</td>
<td>• Stricture with moderate/severe upstream dilation (&gt;4 cm)</td>
</tr>
<tr>
<td>• Normal</td>
<td>Ulcerations</td>
</tr>
<tr>
<td>• Mild (3-5 mm)</td>
<td>Sacculations</td>
</tr>
<tr>
<td>• Moderate (&gt;5 - 9 mm)</td>
<td>Restricted Diffusion</td>
</tr>
<tr>
<td>• Severe (≥10 mm)</td>
<td>Diminished Motility</td>
</tr>
<tr>
<td>Imaging Findings of Penetrating CD</td>
<td>CD changes in the mesentery</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td><strong>Fistulas</strong></td>
<td>Perienteric edema/inflammation</td>
</tr>
<tr>
<td>• Sinus tract</td>
<td>Engorged vasa recta</td>
</tr>
<tr>
<td>• Simple fistula</td>
<td>Fibrofatty proliferation</td>
</tr>
<tr>
<td>• Complex fistulas</td>
<td>Mesenteric venous thrombus/occlusion</td>
</tr>
<tr>
<td>• Inflammatory mass</td>
<td>Adenopathy</td>
</tr>
<tr>
<td>• Abscess</td>
<td></td>
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</tbody>
</table>
Active CD

Enhancing TI

Comb sign

Nodes
Active CD in TI and perianal fistula
CD with complex internal fistulas
CD, TI Involvement and small abscess
Abscesses in CD
CD-Enterocutaneous fistula
CD-Fistula between sigmoid colon and bladder
14 year old female with CD and large complex abscess
CD-Stenotic lesion
CD-Stenotic lesion
CD with complex internal fistulas
Complex entero-enteric fistulas in CD
New directions
## Diagnostic performance of MRE for prediction of mucosal healing (n=24)

<table>
<thead>
<tr>
<th></th>
<th>AUC</th>
<th>p</th>
<th>Threshold</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clermont pre- treatment</strong></td>
<td>0.835</td>
<td>0.016</td>
<td>24</td>
<td>100</td>
<td>69</td>
</tr>
<tr>
<td>Clermont post- treatment</td>
<td>0.912</td>
<td>0.003</td>
<td>9</td>
<td>71</td>
<td>100</td>
</tr>
<tr>
<td>Wall thickness post-treatment</td>
<td>0.938</td>
<td>0.001</td>
<td>6</td>
<td>67</td>
<td>100</td>
</tr>
<tr>
<td>MaRIA post-treatment</td>
<td>0.901</td>
<td>0.004</td>
<td>18</td>
<td>100</td>
<td>77</td>
</tr>
<tr>
<td>( \Delta )MaRIA</td>
<td>0.813</td>
<td>0.024</td>
<td>-25</td>
<td>71</td>
<td>77</td>
</tr>
</tbody>
</table>
20-yo man with ileal CD with mucosal healing post treatment

ΔMaRIA -86.8%
ΔClermont -75.8%
21-yo woman with ileal CD with lack of mucosal healing post treatment

ΔMaRIA 0.1%
ΔClermont -2.8%
DWI in CD

- DWI may have a role as a quantitative measure of inflammation and fibrosis in CD
- Inflamed bowel segments show restricted diffusion compared with normal bowel (Oto. Academic Radiology 2009, Oto. JMRI 2011)
- Significant negative association between ADC in bowel wall and MRI markers of disease activity (Ream. Pediatric radiology 2013)
- ADC lower in areas of transmural fibrosis compared to inflamed nonstenotic segments and normal bowel (Kovanlikaya. Abdominal imaging 2014)
Prediction of tissue composition of stenotic lesions in CD

- 35 CD patients with SB resection and MRI assessed
- Layered pattern at early post-contrast phase more frequent with marked inflammation
- ADC significantly lower and MaRIA score significantly higher in inflammation grade 2-3 vs. grade 1
- Significant correlations between inflammation grade and ADC/MaRIA score ($r = -0.396/0.376$, $P<0.02$)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Inflammation</th>
<th>Prominent muscle hypertrophy vs. prominent fibrosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AUC</td>
<td>p</td>
</tr>
<tr>
<td>Length of involved bowel</td>
<td>0.7</td>
<td>0.036</td>
</tr>
<tr>
<td>Wall thickness on T2WI</td>
<td>0.64</td>
<td>0.142</td>
</tr>
<tr>
<td>Wall thickness on T1WI</td>
<td>0.725</td>
<td>0.018</td>
</tr>
<tr>
<td>ADC</td>
<td>0.728</td>
<td>0.029</td>
</tr>
<tr>
<td>MaRIA score</td>
<td>0.736</td>
<td>0.013</td>
</tr>
<tr>
<td>Clermont score</td>
<td>0.667</td>
<td>0.11</td>
</tr>
</tbody>
</table>
Summary

• MRI is an excellent modality for SB imaging in IBD
• MR enterography should be used in young patients, preferably to CT
• MRI: best imaging modality for perianal fistulas
• Role of functional imaging (DWI, peristalsis) remains to be determined
Progression of digestive disease damage (Lémann score) and inflammatory activity

CDAI: Crohn's Disease Activity Index; CDEIS: Crohn’s Disease Endoscopic Index of Severity; CRP: C-Reactive Protein

Pariente B et al. Inflamm Bowel Dis 2011;17(6):1415-22
MRI report

• SB: inflammation, extent of lesions, stenosis, fistulas, SBO
• Colon: inflammation, distention
• Rectum-anus: proctitis, perianal fistulae
• Fluid collections, abscesses
• Nodes
• Upper abdomen: biliary system (PSC)
UC findings

- Diffuse colon wall thickening, wall edema
- Ahaustral colon
- No fistula or stenotic lesions
- No skip lesions, no abscess
- Superficial inflammation
- Patients may be imaged after total proctocolectomy (J pouch)
- Risk of CRC
UC

T2 fat sat | HASTE | DWI | Post-contrast T1
Quantitative imaging techniques

- DWI
- DCE-MRI
- Magnetization transfer ratio (potential marker of fibrosis)
- Quantification of bowel peristalsis
- FDG PET-MRI
Fibrostenotic vs. inflammatory lesions

- Direct relationship: Mural enhancement and response to medical therapy (Zappa, 2011)
- Fibrostenotic Subtype: fixed narrowing, wall thickening, surgical therapy
  - Prestenotic dilation (+/-, less likely to respond to medical therapy)
  - Reduced enhancement
  - Decreased T2 signal
  - Decreased FDG Avidity
- Inflammatory Subtype: Stricture responds to medical therapy
  - TTP – Enhancement
  - Increased T2 SI – stratified
  - Increased FDG Avidity (Catalano. Radiology 2016)
  - ? Low ADC