Magnetic Resonance Enterography

Goals & Objectives

- Imaging modalities in IBD
- Role and timing of MRE
- MRE technique
- MRE findings

Role of Imaging in IBD

- Screening
  - confirm suspected IBD
  - exclude other pathology
- Diagnosis
  - complications → medical versus surgical Rx
- Monitoring
  - treatment response
  - flare-ups
- Surgical planning

Bowel Investigations

**IMAGING**

- AXR erect/supine +/- CXR
- Small bowel follow-through (SBFT)/enteroclysis
- Abdominal Ultrasound
- CT enterography (CTE)/enteroclysis
- MR enterography (MRE)/enteroclysis/Pelvic MRI/ MR colonography (MRC)
- WBC-labeled or PET scan
- Angiography (DSA)

**NON-IMAGING**

- Capsule endoscopy (CE)
- Device assisted enteroscopy (DAE) - single (SBE)/double balloon (DBE)/spiral, "gold standard"
- Upper endoscopy - to 3rd part duodenum
- Ileocolonoscopy - to distal 5 to 50cm of ileum

Plain abdominal radiography:

- establish if colitis is present +/- extent
- if bowel obstruction or perforation suspected
- exclude toxic megacolon

MAGNETIC RESONANCE ENTEROGRAPHY

Ultrasound

- Determining disease extent and severity
- Assess perforating complications of CD
- Ultrasound and MRI preferred, as patients often young and likely to require repeat imaging over time


CT Enterography

- Indications: CTE = MRE sensitivity
  - intestinal and extra-intestinal disease and Cx response to therapy
- Benefits of CTE vs MRE:
  - better spatial resolution, faster, cheaper, more accessible
- Benefits of MRE vs CTE:
  - better contrast resolution, no radiation
Role of CTE? IF MRI CONTRAINDICATED

SBFT: 1.8 - 2.2 mSv
CTE: 3.5 mSv 10 yo

MAGNETIC RESONANCE ENTEROGRAPHY

MR Enterography

• Assess disease extent:
  - intestinal and extra-intestinal disease
• Assess disease activity:
  - inflammation
  - damage e.g. fibrostenotic disease, fistulae & abscesses
• Advantages:
  - better contrast resolution
  - no ionizing radiation (unless MR enteroclysis)
  - minimally invasive (unless MR enteroclysis)
• Disadvantages:
  - MR enteroclysis better for superficial ulcers*
  - drinks not always well tolerated/vomiting/diarrhoea
  - occasional side effects from antispasmodics
  - time, cost and access


MODALITY SENSITIVITY
SPECIFICITY

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<th>MODALITY</th>
<th>SENSITIVITY (%)</th>
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<tr>
<td>US</td>
<td>89.7</td>
<td>95.6</td>
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<tr>
<td>MR</td>
<td>(23)</td>
<td>(62.8)</td>
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<td>87.8</td>
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<td>CT</td>
<td>84.3</td>
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Comparison of MR enterography and histopathology in the evaluation of pediatric Crohn disease

32 patients MRE positive reports and histology within 2/12 retrospective review
Mean age 13.2 years, range 6-17
Overall sensitivity (149 segments) = 94%
Terminal ileitis sensitivity = 93%
Segmental disease sensitivity = 65%
(specificity 90%, PPV 85%, NPV 76.5%)


Pelvic MRI

• Define perianal disease
  - fistula/abscess extent
  - anatomic location: inter/trans/extra-sphincteric
  - guide therapy
• Dedicated technique – plus or minus MRE:
  - Coronal STIR
  - Sagittal and axial T2 TSE FS
  - Coronal and axial T1 TSE
  - Post GBCA 3 plane T1 TSE FS


MR Colonography

• Limited application in children due colonic IBD pattern and extent
• Outcomes: variable*
  - Ajaj - IBD: 87%, specificity 100%
  - Schrey - CD sens. 32%, UC sens. 59%
• Technique:
  - colonic preparation
  - Buscopan
  - bright (GBCA) or dark lumen (water)
  - up to 2.5 liters
• Imaging findings:
  - bowel wall thickening
  - bowel wall enhancement
  - perifocal lymph nodes
  - loss of haustral folds


PET study using [18F]FDG to measure glucose metabolism in bowel of 13 yo girl with known Crohn disease who presented with acute flare-up of symptoms

(Mernagh J and Somers S. CMAJ 1999 Nov; 161(9) 1139)

Sensitivity 98%
Specificity 83%*
PPV 93%
NPV 95%
Dose ~ 4mSv

PET study using [18F]FDG to measure glucose metabolism in bowel of 13 yo girl with known Crohn disease who presented with acute flare-up of symptoms

(Mernagh J and Somers S. CMAJ 1999 Nov; 161(9) 1139)
1. Inflammatory bowel disease – confirmed or suspected Crohn disease, ulcerative colitis, indeterminate colitis
2. Infiltrative small bowel disease / polyps
3. Abdominal pain +/- weight loss for Ix (if normal abdominal ultrasound)
1. Vascular malformation / occult GI bleeding (i.e. adults 21% sensitivity cf DBE)
1. Transplanted bowel

**MAGNETIC RESONANCE ENTEROGRAPHY**

**MRE Indications**

**MRE Evidence Based Comparison**

**Timing**

**Technique**

1. Oral Contrast
2. Antispasmodics
3. IV Gadolinium
4. MRE Protocol
5. Future Directions
**MAGNETIC RESONANCE ENTEROGRAPHY**

**Oral Contrast Characteristics**

- ACCEPTABLE
- DISTENSIBLE
- BIPHASIC
- AVAILABLE

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*e.g.* Sorbitol, metamucil,

* Dark on T1 for mucosa post GBCA
* Bright lumen on T2 to define wall

Aim:

**Biphasic:**

*e.g.* pineapple juice (PJ)

- T1 low
- T1 high/T2 low signal

Volumen (DB), PEG.

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**MAGNETIC RESONANCE ENTEROGRAPHY**

**Available Biphasic Oral Contrast**

**Distensible**

**Acceptable – Drinking Trial**

Grade of distension: 5 = very good distension; 1= collapsed bowel

(Kuehle C et al. AJR 2006 Oct;187(W375-85))

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**MAGNETIC RESONANCE ENTEROGRAPHY**

**Oral Contrast Distension**

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**MAGNETIC RESONANCE ENTEROGRAPHY**

**Biphasic Oral Contrast**

Biphasic:

- T1 high/T2 low signal (T2 negative)
e.g. pineapple juice (PJ)

- T1 low/T2 high signal (T2 positive)
e.g. Sorbitol, metamucil,

Volumen (DB), PEG.

Aim:

* Bright lumen on T2 to define wall
* Dark on T1 for mucosa post GBCA

(Riordan RD et al. BJR 77 (2004), 991-999)
MAGNETIC RESONANCE ENTEROGRAPHY

Oral Contrast Availability

- Volumen (low density barium sulfate) required special consent from Health Canada
- 3% Sorbitol prepared by pharmacy with one week shelf-life

...a heavy New Wave band from Missoula, Montana.

MAGNETIC RESONANCE ENTEROGRAPHY

Patient Instructions

- No special diet required
- 6 hour fast
- Arrive 90 minutes pre scan for IV
- Oral contrast as per weight based protocol

MAGNETIC RESONANCE ENTEROGRAPHY

Standing Orders – Oral Contrast

<50 kg child
1 hour prior to scan give _______ mL p.o (10mL/kg)
30 minutes prior to scan give _______ mL p.o (5mL/kg)
Immediately prior to scan give _______ mL p.o (5mL/kg)
After 1st sequence give additional _______ mL p.o (5 mL/kg) prn as per Radiologist if contrast is inadequate i.e. not reached cecum.

≥ 50 kg child
1 hour prior to scan give 450 mL p.o
30 minutes prior to scan give 450 mL p.o
Immediately prior to scan give 450 mL p.o
After 1st sequence give 250 mL p.o prn as per Radiologist if contrast is inadequate i.e. not reached cecum.
Ask the patient to go to the washroom to void before going onto the MRI table.

MAGNETIC RESONANCE ENTEROGRAPHY

Acceptability

THE START:

Tip #1
- Add flavoring - give patients a choice!
- Keep it cold
- Lots of encouragement CRITICAL!!!
- Nasogastric tube rarely needed

Tip #2
- if late starting drinks e.g. arrive late, delay MRI
- if MRI is running behind, delay start of drinking
MAGNETIC RESONANCE ENTEROGRAPHY

Technique

1. Oral Contrast
2. Antispasmodics
3. IV Gadolinium
4. MRE Protocol
5. Future Directions

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Standing Orders – Buscopan

<50 kg child

1st Dose: Give hyoscine butylbromide (Buscopan) _____ mg IV over 2 minutes (0.3 mg/kg to a maximum dose of 20 mg) when prep in cecum, as confirmed by Radiologist.

2nd Dose: Give hyoscine butylbromide (Buscopan) _____ mg IV over 2 minutes (0.3 mg/kg to a maximum dose of 20 mg) immediately prior to administration of IV contrast.

≥ 50 kg child

1st Dose: Give hyoscine butylbromide (Buscopan) 20 mg IV over 2 minutes when prep in cecum, as confirmed by Radiologist.

2nd Dose: Give hyoscine butylbromide (Buscopan) 20 mg IV over 2 minutes immediately prior to administration of IV contrast.

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Standing Orders – Glucagon

<20 kg child

1st Dose: Give glucagon 0.25 mg IV over 45 seconds when prep in cecum, as confirmed by Radiologist.

2nd Dose: Give glucagon 0.25 mg IV over 45 seconds immediately prior to administration of IV contrast.

≥ 20 kg child

1st Dose: Give 0.5 mg IV over 45 seconds when prep in cecum, as confirmed by Radiologist.

2nd Dose: Give 0.5 mg IV over 45 seconds just prior to IV contrast

If using Glucagon – give apple juice prior to patient leaving MRI department.

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Drug information – Buscopan

- Onset GI tract effect: < 1 minute
- Duration GI effects: ~23 minutes

- Availability: USA vs. Europe, Canada & Australia
- Cost: Buscopan (20mg/ml US$6.70) vs. Glucagon (1mg/ml US$129.88)
- Patient tolerance: Buscopan >> Glucagon
- Dose frequency: none, one or two

Inject slowly!
Buscopan over 2 minutes or Glucagon over 45 seconds

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Cine trueFISP
pre Glucagon

Post Glucagon
**Drug Information** - Glucagon

- **IV Gadolinium**
  - 0.1 mmol/kg, e.g., gadopentetate dimeglumine (Magnevist) @ 0.2 ml/kg or gadobutrol (Gadovist) @ 0.1 ml/kg
  - Via power injector @ 2-3 ml/sec preferred
  - Following hand injection of 2nd dose Buscopan/Glucagon
  - Consistent timing e.g., @ 45 sec

- **IV GBCA timing** - multiphasic?
  - Immediate dynamic phase
  - 40-45 sec enteric phase
  - 70 sec portal venous phase
  - Delayed 5-8 minutes

**Sick Kids Protocol - Sequences**

<table>
<thead>
<tr>
<th>EVALUATION SCANS → ASSESS ILEOCAL FILLING</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
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<tbody>
<tr>
<td>CORONAL HALF FOURIER SINGLE-SHOT TURBO SPIN ECHO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Oral contrast NOT at terminal ileum/cecum yet?

- If stomach full:
  - wait 5 min. and repeat scout
  - off table and walk around
  - go to washroom again
- Extra 5 ml/kg (≥ 50 kg 250 ml)
- Lie down on right side
- Water chaser?

**Tip #4**

**MAGNETIC RESONANCE ENTEROGRAPHY**

**Image Optimization**

**CINE STEADY STATE FREE PRECESSION (SSFP) IMAGING**

Assess motility and strictures

**AXIAL HALF FOURIER SINGLE-SHOT TURBO SPIN ECHO**

Bowel wall thickening and edema
Mesenteric inflammation

- T2 HASTE FS SIEMENS 1.5 T
- SSH T2 SPAIR PHILIPS 3T

**CORONAL HALF FOURIER SINGLE-SHOT TURBO SPIN ECHO**

Lymphadenopathy
Vessels and vascular thickening
("Comb" sign)

- T2 HASTE FS SIEMENS 1.5 T
- SSH T2 SPAIR PHILIPS 3T
- T2 SS FSE FS GE 1.5T

**AXIAL SSFP IMAGING**

- T2 TRUEFISP FS SIEMENS 1.5 T
- BTFE FS PHILIPS 3T

**CORONAL SSFP IMAGING**

- T2 TRUEFISP SIEMENS 1.5 T
- BTFE FS PHILIPS 3T
- FIESTA FS GE 1.5T
CORONAL DWI & ADC MAPS
Restricted enhancement of inflamed bowel, lymph nodes and abscesses

CORONAL & AXIAL ULTRA FAST 3D GRADIENT ECHO
Mural and peri-intestinal enhancement
Fistulae
Lymph node enhancement
MSK enhancement

CORONAL PRE & POST CONTRAST ULTRA FAST 3D GRADIENT ECHO
Magnetic Resonance Enterography
Image Optimization

Tip #5
- Patient to washroom pre-scan to empty bladder +/- bowels
- Same patient pre and post void

Magnetic Resonance Enterography
Image Optimization

Tip #6
- Coronal - large rectangular FOV liver to rectum in single region
- Axial - single FOV liver to rectum OR two stacks
  however
  - Cecal pole/terminal ileum/ileocecal valve MUST 1 region

Magnetic Resonance Enterography
Image Optimization

Tip #7
- Cine true FISP/balanced TFE (SSFP)
  - 5-7 slices coronally pre 1st dose Buscopan
  - 40 slices at each table position over 12 sec
  - Centre mid slice on ileocecal junction

- Supine versus prone positioning?
  - Shorter coronal scan time reduces motion artifact in prone
  - Compliance in children better supine
MAGNETIC RESONANCE ENTEROGRAPHY

**Technique**

1. Oral Contrast
2. Antispasmodics
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5. Future Directions

**Future Directions**

- Diffusion weighted imaging (DWI)
  - to detect inflammation
  - B = 50/400/800 mm$^2$/sec (Philips & GE 100/600)
  - lower pole kidneys to pelvis
- Near Future
  - qualitative +/- quantitative assessment?
  - extend coverage to include proximal jejunum?
  - axial acquisitions now, potential for coronal?
  - perfusion versus diffusion/restriction?

**MRI Features of IBD**

- **Mural**
  - Bowel wall thickening
  - Mucosal enhancement/oedema
  - Strictures +/- presstenotic dilatation
  - Ulcers/fissures/fistulae
- **Extra-mural GIT**
  - Abscesses
  - Fibrofatty proliferation
  - Mesenteric lymphadenopathy
  - "Comb" sign
  - Thrombosed
- **Extra-intestinal**
  - Biliary - gall stones, cholecystitis, sclerosing cholangitis
  - Renal - pelvic/ganmatric
  - MSK - vertebral, SIJ inflammation, entheseopathy

**Findings**

- Acute inflammation = medical
- Fibrostenotic = surgical
- Penetrating = medical/surgical

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Pathology</th>
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<tbody>
<tr>
<td>T2 Haste</td>
<td>Bowel wall thickening and oedema, Mesenteric inflammation</td>
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<tr>
<td>Cine</td>
<td>Assess motility and strictures</td>
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<tr>
<td>True FISP</td>
<td>Lymphadenopathy, vessels and vascular thickening (&quot;Comb&quot; sign)</td>
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<tr>
<td>T1 FS</td>
<td>Mural and peri-intestinal enhancement</td>
</tr>
<tr>
<td>VIBE</td>
<td>Fistulae</td>
</tr>
<tr>
<td>VIBE</td>
<td>Lymph node enhancement</td>
</tr>
<tr>
<td>VIBE</td>
<td>MSK enhancement</td>
</tr>
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</table>
Bowel wall thickening and enhancement

Jejunal bowel wall thickening

Mesenteric lymphadenopathy

"Comb" sign

Duodenal bowel wall thickening and enhancement

T2 SH FS

T1 THRIVE FS

T1 FS POST 6D

BTFE
Fibrofatty proliferation & "Comb" sign

1.5 T trueFISP T1 FS post gd

Fibrofatty proliferation, bowel wall thickening and enhancement with ileal stricture

T2 haste

Post Gd T1 FS VIBE

Deep ileal ulcers and arthropathy ?

Post 6d T1 FS VIBE

Fistulae arising terminal ileum

T2SSh SPAIR

B1FE F5

Anterior abdominal wall collections and fistulae

Fistula

Perianal fistula
Striated bowel wall with oedema
Loss of haustra transverse colon
Striated enhancement and left common iliac vein thrombus
Arthropathy
Bilateral sacroiliitis
Inflamed appendix and terminal ileum with sinuses
Acute on chronic bowel changes
? Gall stone
Mesenteric inflammation?
MAGNETIC RESONANCE ENTEROGRAPHY

Thank you

Questions?

Thanks to the team involved who helped establishing the MRE service at Sick Kids:
- Paul Babyn MD
- Albert Aziza MRI manager
- Andrei Vladimirov MRT Tech
- Sumeet Gupta MRI tech
- Sandra Burton MRI Nurse

- and not least our "patient" patients and their families!