MR Enterography in Pediatric Inflammatory Bowel Disease- Where do we Stand?

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INTRODUCTION

Nearly, 10–25% of inflammatory bowel disease(IBD) is diagnosed in children. There is a surge in the pediatric inflammatory bowel disease (PIBD) cases diagnosed in the last decade.[1] Srivastava et al. in a multicentric study from India have shown Crohns disease(CD) as the most common type, occurring in two thirds of the overall PIBD patients. It is well known that adolescents form a large proportion of the PIBD, with >50% of the cases occurring in the 10–18years age group[2] Imaging of the bowel is required as a part of small bowel evaluation at diagnosis in all IBD patients except typical ulcerative colitis(UC). Similarly during the management course, imaging is commonly required to diagnose complications and assist therapeutic decisions. Various imaging modalities have been traditionally used like gastro-intestinal contrast series (eg: barium meal follow through, barium enema) and later CT enterography(CTE). MR enterography(MRE) has taken tremendous strides in the last decade and is currently the recommended imaging in children with IBD.[3] There is a sense of under utilization of pediatric MR enterography with most centers preferring CT, which may not be the right choice always.We discuss the role of MR enterography in PIBD, highlighting its diagnostic performance and comparison with CT enterography.

MR Enterography

MR enterography allows for evaluation of the bowel lumen and wall, adjacent mesentery and soft tissues, as well as a variety of extraintestinal abdominopelvic IBD manifestations while sparing the patient any risks associated with ionizing radiation. MR enterography can be used to initially support the diagnosis of IBD, particularly small bowel Crohns disease, while also proving useful in identifying a variety of disease-related complications, including strictures, fistulae, and abscesses. The procedure may be performed in an awake state as in a cooperative older child or using general anesthesia(GA) in younger children. Mollard et al. showed that in children less than 10 years of age, >90% of MR enterographic examinations were performed under GA.[4] However, this constituted only 20% of the total pediatric MR enterographic examinations performed in their high volume center.[5] Limiting the motion artifacts and breath holding is required to allow certain sequences which are necessary for interpreting the study. Biphasic oral contrast like polyethylene glycol, lactulose, barium etc. are commonly used for bowel distension. Small volume lactulose protocol using only 150ml of total fluid (50ml of lactulose in 100ml of water) 1hour prior to the scheduled scan (followed by advice to drink water freely before imaging) has shown to be useful with good compliance.[6] Gadolinium based intravenous contrast is used in those not contraindicated. Intravenous glucagon is used as a spasmolytic agent for improved visualization of the small and large bowel. Commonly used pulse sequences include T2-Weighted single-shot fast spin echo (FSE)/ single-shot turbo spin echo, FIESTA(Fast imaging employing steady-state acquisition), balanced steady state free precession(SSFP),diffusion-weighted imaging(DWI), and precontrast and postcontrast T1-weighted fat saturated(most often two-dimensional or 3D GRE).Unlike CT enterography,MR enterography also allows for cine imaging and for imaging that highlights multiple determinants of image contrast (eg: T1 and T2 relaxivity, diffusion-weighted imaging [DWI], pre-and postcontrast imaging etc.). MR enterography gives excellent details of the lumen, bowel wall and perienteric abnormalties.[7] Imaging findings commonly found include those of active inflammation like bowel wall thickening with hyperenhancement, edema, restricted diffusion in DWI, mesenteric hypervascularity(comb's sign), fat stranding, fibrofatty proliferation or complications like stricture, fistula, abscesses, perianal disease(Figures 1a,1b,2a,2b). Imaging findings associated with active inflammation, stricturing and penetrating crohns disease are presented in table 1.

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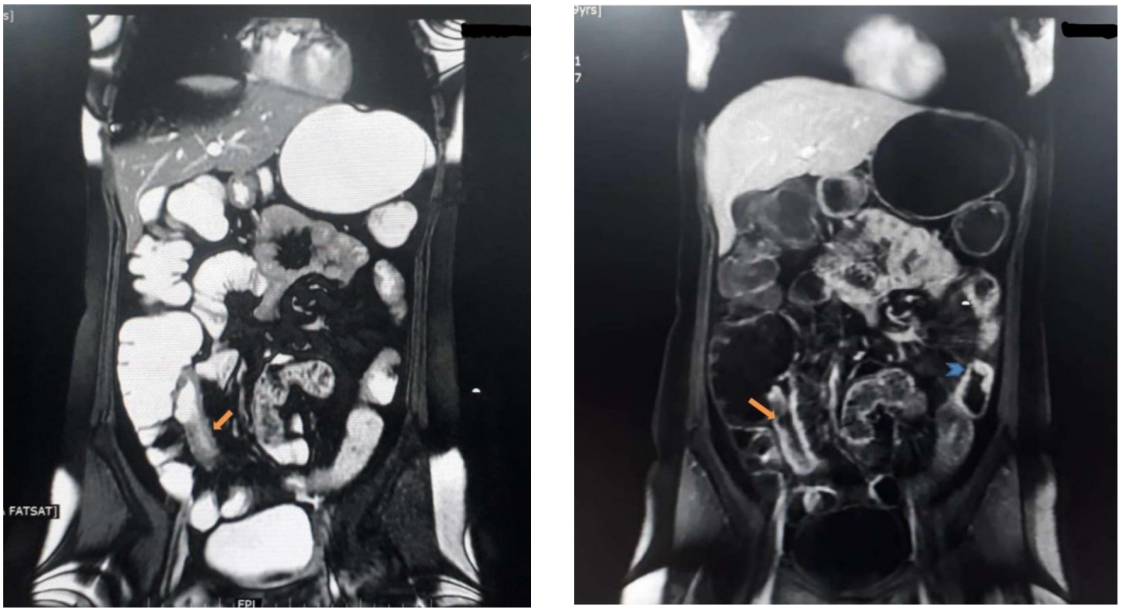

Figure 1:

1) Images in an 18 year old boy with active CD. (a) Coronal FIESTA Fat saturated sequence showing irregular concentric short segment distal ileal wall thickening (arrow). (b)Post contrast T1 weighted 3D GRE sequence showing irregular bowel wall thickening with hyperenhancement involving the distal ileum(arrow) and descending colon (arrowhead).

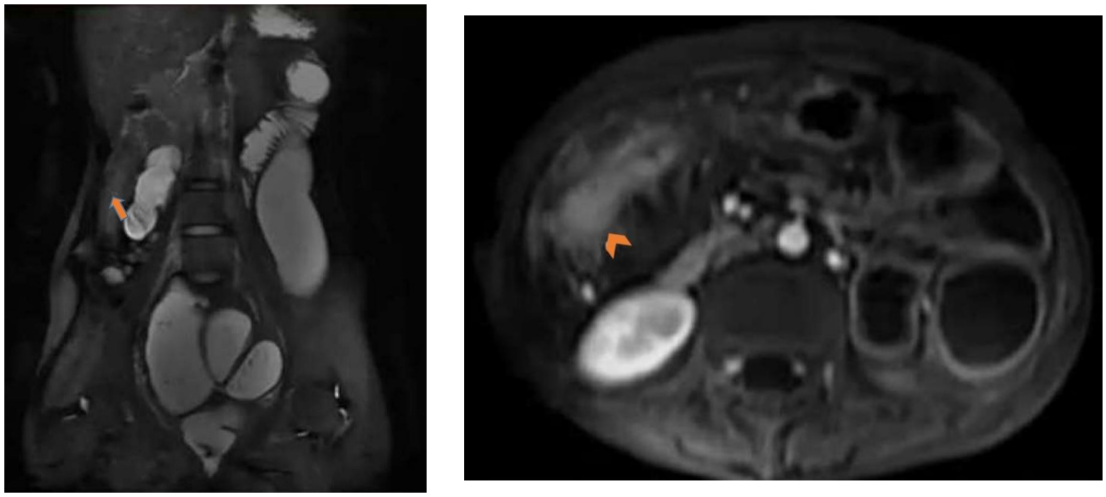

Figure 2:

2) Images in a 17year old girl with refractory CD (a)Coronal T2 SSFSE showing hyperintense(edema) smooth circumferential wall thickening of ascending (arrow),transverse colon and terminal ileum.(b) On post contrast axial T1 sequence there is hyperenhancement with luminal narrowing of the ascending(arrowhead), transverse colon and terminal ileal bowel wall suggestive of long segment inflammatory stricture.

Table 1: Imaging findings associated with crohns disease	
1) Active inflammation: **Bowel wall features** - Mural hyperenhancement - Wall thickening with mural hyperenhancement - Intramual edema - Restricted diffusion - Featureless ahaustral (lead pipe) appearance of colon (more common with UC) **Mesentery** - Perienteric edema - Engorged vasa recta(comb sign) - Fibrofatty proliferation	**2) Stricturing disease** - Stricture with signs of active inflammation - Stricture without signs of active inflammation - Stricture with upstream bowel dilatation(upstream bowel segment dilatation >3cm) - Stricture with no upstream bowel dilatation **3) Penetrating disease** - Sinus tract - Fistula(simple or complex) - Abscess - Inflammatory mass - Free perforation

Role in PIBD

1. Determination of the disease extent, particularly involvement of small bowel in a child with suspected or newly diagnosed PIBD (other than typical UC) at presentation. In our country, a common differential diagnosis for crohns disease is intestinal tuberculosis, where CT is preferred for simultaneous evaluation of necrotic lymph nodes, ascites, peritoneal involvement and possibly combining it with a HRCT of chest in the same session. For afore mentioned reasons and familiarity of the procedure, in countries with high prevalence of tuberculosis, CT is usually preferred for this indication. However, head to head studies comparing CTE and MRE in differentiating microbiologically confirmed abdominal tuberculosis in children are lacking.
2. Evaluation of worsening clinical status or suspected disease-related complications (both CD and UC). In children with intestinal obstruction due to stricturing disease, MR enterography is indicated for assessing the presence of fibrosis, active inflammation or both. This has considerable bearing on whether the child would benefit from medical management or requires surgery. Although comparable in detecting active inflammation, Quencer et al. showed MR enterography to be significantly superior to CT in detecting mural fibrosis using histology as the reference standard.[8] Ream et al. showed increasing bowel wall restricted diffusion as lower apparent diffusion coefficient (ADC) values is associated with multiple MRI findings that are commonly seen with active inflammation in pediatric small bowel Crohns disease.[9] Serial ADC values may help in assessing the severity of inflammation in respective segments of the bowel wall over time. Radhakrishnan et al. showed strong positive correlation between MRE scores and PCDAI, predicting disease activity non invasively akin to fecal calprotectin.[10]
3. Evaluation of response to medical treatment.
4. Differentiation of CD from UC in the setting of indeterminate colitis
5. Evaluation of J-pouch complications following proctocolectomy
6. Evaluation of the extent and severity of perianal disease. By defining the exact course of the fistula tract(combining with fistulography) and establishing whether it involves the ischioanal or ischiorectal fossae or extends through the pelvicfloor musculature, MR imaging can guide surgical management and provide prognostic information.
7. Evaluation of extraintestinal IBD manifestations like sclerosing cholangitis (combining with high resolution T2 MR cholangiopancreatography sequences) and sacroiliitis.
8. Cine imaging provides functional information about bowel motility and can be used to evaluate strictures, adhesions. However, pediatric experience for this is limited.

Diagnostic performance and comparison with CT enterography

In a systematic review by Yoon et al. pediatric MR enterography demonstrated a high diagnostic performance(sensitivity and specificity of 86% and 91% respectively) in the detection of active inflammation in children with known or suspected inflammatory bowel disease.[11]

Although statistically not significant, Quencer et al. showed diagnostic accuracy of 83.6% for MRE against 81.9% for CTE in detecting active disease compared to the histologic gold standard.[8] Contrastingly, Gale et al. in their comparative study between CT and MR enterographyshowed mural features (wall thickening>3 mm, mural hyperenhancement) were diagnosed with similar accuracy, but perienteric features(mesenteric hypervascularity, edema, fibrofatty proliferation and lymphadenopathy) were picked up better on CT enterography[12] For detection of mural fibrosis, MR was significantly better than CTenterography.[8] Comparison of important merits and demerits of both the imaging procedures is shown in the table 2.

MR enterography severity scores

Severity of disease in MRE was evaluated using different validated scores like MR enterography global score(MEGS) and CD MRI index. Clinical disease activity in pediatric crohns disease is assessed by the pediatric crohns disease activity index(PCDAI). Radhakrishnan et al. showed MEGS had a strong positive correlation with PCDAI compared to CD MRI index score.[10] MEGS may provide an alternative to endoscopy in disease monitoring, showing

Table 2: Comparing merits and demerits of CT and MR enterography

Clinical utility	MR enterography	CT enterography
Advantages	• Safe (no use of ionizing radiation) • Best to differentiate mural inflammation from fibrosis • Can guide management (especially surgical) in perianal disease and its complications • Potential role in the monitoring of active inflammation (using serial ADC values) • For extra-intestinal IBD manifestations like sclerosing cholangitis, sacroiliitis	• Easier to perform, less costly • Emergency situations (eg: suspected intestinal perforation)
Limitations	• May require general anesthesia • Long examination time • Lack of appropriate state of the art imaging protocol • Lack of experience reviewing and interpreting in children • Contraindicated in presence of certain implantable devices	• Ionizing radiation (Effective radiation dose for a single standard CT enterography=12–20mSv; equivalent to 4 to 7 years of cumulative natural radiation exposure)

good positive correlation with fecal calprotectin.[13] Components of MEGS are shown in table 3. For the purpose of calculating the MEGS score the bowel is divided into eight anatomical segments: jejunum; ileum; terminal ileum; ascending, transverse, descending, and sigmoid colon; and rectum. The total length of disease (irrespective of mural scores) within each segment is measured to provide a multiplication factor (ranging from 1 to 2) for each segmental score. Individual segmental scores are summed and then 5 points added if lymph nodes ≥1 cm (short axis diameter), comb sign, fistulae (entero-enteric, entero-cutaneous or entero-vesical) or abscesses are present. The final summed score constitutes MEGS.[14]

Radiology report impression statements

Checklist of the radiology report impression statements in children with a suspected or diagnosed crohns disease is given in table 4.[15]

Table 3: MEGS scoring: Scoring method for Small Bowel and Colonic Segments and Extra-Mural Features. Score Per Segment: Jejunum, Ileum, Terminal Ileum, Caecum, Ascending, Transverse, Descending, Sigmoid colon and Rectum (Jejunal Score×Factor for Jejunum Involved Length)+(Proximal Ileum Score×Factor for Proximal Ileum Length)+ (Terminal Ileum Score×Factor for Terminal Ileum Length)+(Caecum Score×Factor For Caecum Length)+(Ascending Score×Factor for Ascending Length)+(Transverse Score×Factor for Transverse Length)+(Descending Score×Factor for Descending Length)+(Sigmoid Score×Factor for Sigmoid Length)+(Rectum Score×Factor for Rectum Length)+Score for Abscess+Score for Fistula+Score for Adenopathy+Score for Comb Sign= MRI Score (Total Possible Score 296)

Score	0	1	2	3
Mural Thickness* Small bowel	<3mm	3–5mm	6–7mm	>7mm
Mural T2 signal**	Equivalent to normal bowel wall	Minor increase in signal: bowel wall appears dark grey on fat-saturated images	Moderate increase in signal: bowel wall appears light grey on fat-saturated images	Marked increase in signal: bowel wall contains areas of white high signal approaching that of luminal content
Peri-mural T2 signal (mesenteric edema)	Equivalent to normal mesentery	Increase in mesenteric signal but no fluid	Small fluid rim (≤ 2mm)	Large fluid rim (≥ 2mm)
T1 Enhance-ment***	Equivalent to normal bowel wall	Minor enhancement: bowel wall signal greater than normal small bowel but significantly less than nearby vascular structures	Moderate enhancement: bowel wall signal increased but somewhat less than nearby vascular structures	Marked enhancement:bowel wall signal approaches that of nearby vascular structures
Mural enhancement pattern	N/A or homogenous	Mucosal	Layered	
Haustral loss (colon only)	None	<1/3 segment	1/3 to 2/3 segment	>2/3 segment

*Measured using electronic callipers; **compared with normal small bowel; ***compared with nearest vessel

Additional score for extramural features		
Score	0	5
Lymph nodes (≥1cm measured in shortest diameter)	Absent	Present
Comb sign	Absent	Present
Abscess	Absent	Present
Fistulae	Absent	Present

Table 4: Radiology report impression statements for suspected or diagnosed crohns disease at MR enterography

Inflammation impression statements
- No imaging signs of active inflammation
- Nonspecific signs of bowel inflammation*
- Active inflammatory small bowel crohns disease without luminal narrowing
- Active inflammatory small bowel crohns disease with luminal narrowing
- Crohns disease with no imaging signs of active inflammation

Stricture impression statements
- Stricture with imaging findings of active inflammation
- Stricture without imaging findings of active inflammation

Penetrating disease impression statements
- Sinus tract
- Fistula
- Abscess
- Inflammatory mass
- Free perforation

Perianal disease impression statements
- Fistula
- Abscess

Other complications impression statements
Femoral head avascular necrosis, sacroiliitis, primary sclerosing cholangitis, mesenteric venous thrombosis or chronic mesenteric venous occlusion, pancreatitis, neoplasm,cholelithiasis, or nephrolithiasis

*describes bowel loops that have segmental symmetric mural hyperenhancement and/or enhancing wall thickening in a patient without a proven crohns disease diagnosis

CONCLUSION

MR enterography has its own advantages over CT and has been recommended as the imaging of choice, however it is often under-utilised owing to the costs, requirement of general anesthesia and inability to perform breath holding sequences. Although CTE will continue to have its own place as in emergency situations or where MR is contraindicated, otherwise for most situations MRE should be the preferred modality. Increasing use of MRE will help in reducing the burden of ionizing radiation especially knowing repeated imaging procedures are often necessary in these children. MR enterography severity scores like MEGS may reduce the need for repeated endoscopies and supplement fecal calprotectin in disease monitoring. We believe that each center should have a state of the art MR enterography protocol with regular inter-disciplinary consultations between the pediatric gastroenterologist and the radiologist to enhance its utility where clinically indicated.

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