



Comparative Evaluation of CT Enterography and MR Enterography in Evaluation of Small Bowel Pathologies

Authors

Dr Vanaja¹, Dr Hanumath Prasad², Dr Shanthi Sree.V³, Dr Veena⁴,
Dr Anil Kumar⁵, Dr Shivani Gogi⁶

¹PG Student, ^{2,3}Associate Professor, ^{4,5,6}Assistant Professor

Dept of Radio-Diagnosis, Gandhi Medical College, Secunderabad, Telangana State

Corresponding Author

Dr Shanthi Sree.V

Email: drshanthisree@yahoo.com

Abstract

Aims and objectives: 1) To study the role of CT Enterography and MR Enterography in diagnosing various small bowel diseases. 2) To compare the diagnostic significance of CT Enterography with MR Enterography 3) To evaluate the clinical significance of various imaging findings as detected on CT and MR enterography.

Summary: A prospective observational study done in 50 patients with clinical symptoms of small bowel diseases who underwent ileocolonoscopy were included in the study. CT and MR enterography was performed in all the patients and findings analyzed. Further they were followed up with HPE/Surgical findings. The sensitivity and specificity of CTE for diagnosing small bowel diseases was found to be 89.6% and 66.6% respectively. The sensitivity and specificity of MRE for diagnosing small bowel diseases was 88.8% and 78.2% respectively. The sensitivity and specificity of CTE for diagnosing Crohn's disease was 77.7% and 95.1% respectively. The sensitivity and specificity of MRE for diagnosing Crohn's disease was 77.7% and 97.5% respectively.

Keywords: Small bowel imaging, CT enterography, MR enterography.

Introduction

The small bowel imaging is difficult and challenging because of its positioning, length, and motility. For many years, the most common radiologic modality for evaluating small bowel diseases are conventional small bowel follow through and endoscopy however these studies did not provide extramural involvement of the disease and were time consuming, involves radiation, and become tedious in performing the study in every patient with clinical suspicion of small bowel disease. With the development of multislice CT,

imaging larger volume at faster speed and multiplanar reconstruction after the procedure makes CT a more convenient procedure for examining small bowel diseases. But the main disadvantage of CT is that it is based on ionizing radiation. As a result MR imaging methods developed for imaging small bowel diseases with advent of fast sequences like HASTE, Tru FISP. These sequences can be performed without artifact from peristalsis and allows the imaging of both intra- and extra luminal disease. This has to be considered as patients with Crohn's disease

already have an increased risk for developing gastrointestinal cancer. Even subtle disease manifestations may be detected when distension of the small bowel is achieved. There are two techniques MR enteroclysis and MR enterography. Enteroclysis requires the placement of nasojejunal tube under fluoroscopic guidance and large volume of oral contrast is administered through the tube. Enterography refers to the use of oral contrast agents designed to distend the lumen of the small bowel, without being reabsorbed.

CT Enterography was first introduced by Raptopoulos et al in 1997. CTE is a new non-invasive imaging technique that offers superior small bowel visualization as compared to abdominopelvic CT. As the bowel loops are usually collapsed differentiating bowel wall thickening from collapsed segments is difficult with CT without enteric contrast and intravenous contrast¹. Neutral or low density oral contrast mixture is used and CT examination is done during the enteric phase following I.V. contrast administration. This maximizes contrast between lumen and enhancing small bowel wall. Positive oral contrast agents (containing iodine or barium) are not routinely used because they obscure mucosal enhancement, intraluminal hemorrhage and assessment of subtle mural disease.

Advantages of CTE- Better spatial resolution, Fewer motion artifacts, Increased availability of CT scanners, Lower cost & Shorter examination time.

Disadvantage:- Ionizing radiation

MR Enterography

MRI is an imaging modality with high contrast resolution of soft tissue without using ionizing radiation and also having multiplanar imaging. Due to the development of shorter scanning techniques, e.g. single shot techniques, the entire small bowel can be visualized without artifacts caused by small bowel peristalsis and respiration movements². MRI can evaluate features like bowel wall thickness, wall enhancement, bowel wall edema, ulceration, perimural infiltration, and

lymph node evaluation, contrast enhancement, adhesions, strictures, fistula, perianal fistulas, abscess, bowel obstruction, all of which are important features to be observed in small bowel disease and MRI is a single stop to visualize all these findings^{3,4}.

Advantages of MR Enterography:- Better contrast resolution, Better distinction between acute and chronic disease with techniques such as DWI, Evaluation of bowel peristalsis by dynamic imaging, Superior evaluation of perianal disease, MRI does not use ionizing radiation, Tissue contrast is superior in MRI than that of CT, Intravenous contrast material for MR imaging has a good safety profile and MR enterography with contrast can be used in patients in whom CT with I.V contrast cannot be taken like patients with allergic reactions to CT iv contrast and patients with elevated serum creatinine. great benefit to pregnant patients, patients with renal failure and low GFR and patients with possibility of risk of developing nephrogenic systemic fibrosis.

Limitations of MR Imaging

Cost of the study, Claustrophobia, Spatial and temporal resolution is comparatively lower in MRI than CT., Some patients may have difficulty in breath holding.

Materials and Methods

A prospective observational study done in 50 patients during January 2014 to October 2015. The included patients admitted with clinical diagnosis of small bowel disease and who underwent prior ileocolonoscopy. The study was done in Department of Radio diagnosis, Gandhi medical college. CT Enterography was performed on 16 slice CT scanner (EMOTION) of Siemens Ltd. MR Enterography was performed on 1.5 tesla MRI scanner (AVANTO) of Siemens Ltd.

Inclusion criteria:

- 1) All patients in the department of gastroenterology and general surgery with clinical diagnosis of small bowel

disease and underwent prior ileocolonoscopy

- 2) Age group 20-60 years with normal serum creatinine.

Exclusion criteria:

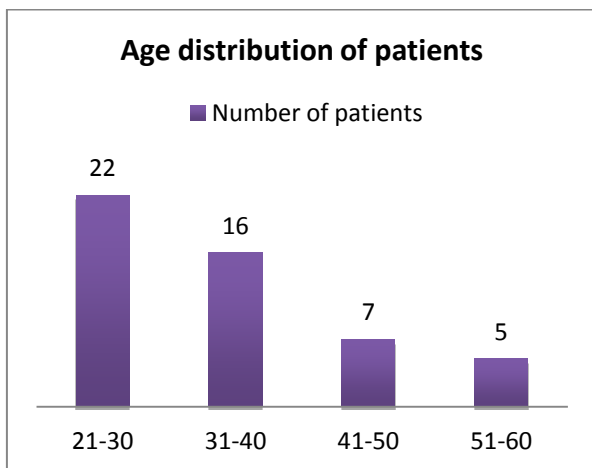
- 1) Patients with previous history bowel surgeries with diagnosis of malignancy, Hirschsprung’s disease, history of post operative adhesions, traumatic bowel injuries, enteric perforations.
- 2) Patients below 20 and above 60 years age group.

Discussion & Observations

A prospective observational study done in 50 patients during January 2014 to October 2015 in patients admitted with clinical diagnosis of small bowel disease and who underwent prior ileocolonoscopy. Among the 50 patients with clinical diagnosis of small bowel disease, abnormal findings on imaging were noted in 27 patients (54%) and rest of the 23 cases were normal (46 %).

Age distribution

The distribution of age in our study was as follows



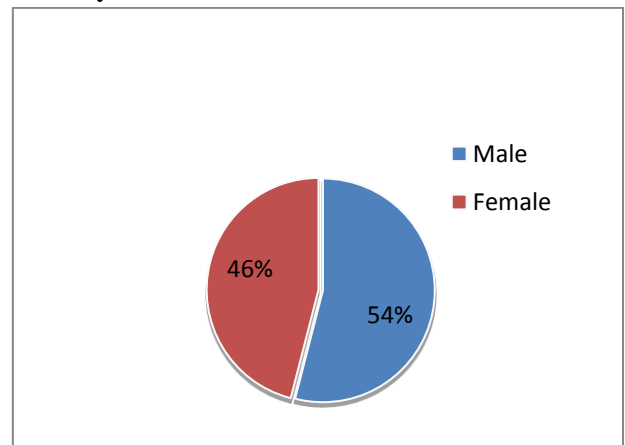
Pic 1: The predominant age group involved in this study was 21-30 yrs constituting 44% (n=22), followed by 31-40 yrs (n=16), 41-50 yrs (n=7), and 51-60 yrs (n=5).

The mean age was 29 years in a study done by Seung Soo Lee et al in 2008 ⁽¹⁾ Crohn’s disease is a chronic inflammatory bowel condition with

onset usually in young adulthood. Twenty to thirty percent of patients are younger than 20 years old. According to Shauna Duigenon⁽⁵⁾, Crohn’s disease has a bimodal peak-first peak in the second or third decade of life and a smaller peak in the sixth or seventh decade. There is equal evidence, however, of a unimodal peak in the second or third decade that explains the high incidence in the adolescent population. Michael Dam Jensen et al, 2011 ⁽⁶⁾ studied 45 patients and found that the median age was 39 years in the study.

Gender distribution

The distribution of cases according to gender in our study was as follows



Pic 2 : The most common gender involved in this study was males, constituting 27 out of 50 patients (54%), followed by females constituting 23 (46%).

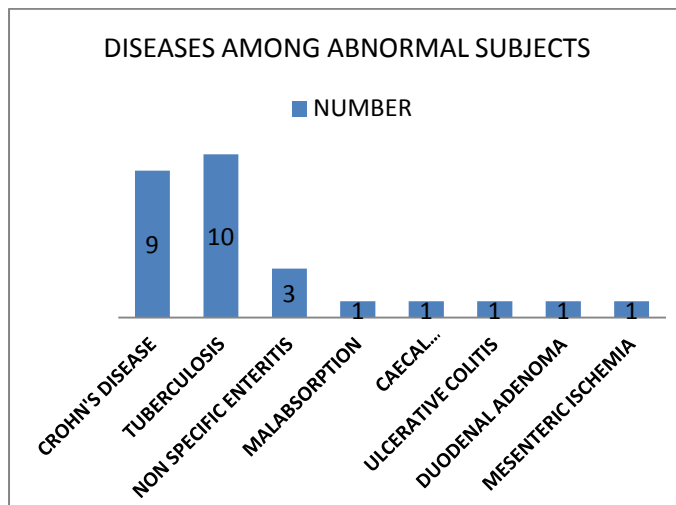
Hassan A. Siddiki et al, 2009⁽⁷⁾ found in their study of 33 patients with small bowel Crohn’s disease that 55% were men and 45% were women. In a study by Seung Soo Lee et al, 2009 ⁽¹⁾ they found that 17 out of 31 patients with small bowel disease were males and 14 were females.

Symptoms at Presentation

The Most common symptom with which the patients presented was pain abdomen constituting 22 patients (44.4%), followed by diarrhea constituting 16 patients (32%), loss of weight in 9 patients (18%), abdominal distension and vomitings both noted in 7 patients (14%), fever in 4 patients (8%) and loss of appetite in 3 patients (6%).

Case distribution

The distribution of pathologies in our study group were as follows



Pic 3: Among the 27 cases with abnormal findings on imaging, majority⁽¹⁰⁾ were tuberculosis (37 %), 9 were Crohn's disease (33 %), 3 were non specific enteritis (11.1 %) and one case each of malabsorption (2%), caecal adenocarcinoma (2 %), ulcerative colitis(2%), duodenal adenoma (2 %)and mesenteric ischemia (2 %).

Among 35 patients included in a study by Luciana Costa-Silva et al, 2010⁽⁸⁾, 14 patients were Crohn's disease, where signs of disease activity were observed in 8 patients with identification of mural thickening and hyper enhancement in 100% of the cases. In the other 6 cases, signs compatible with the presence of Crohn's disease were observed, although without suggesting the presence of inflammatory activity. Among the 9 cases of crohn's disease, the most common segment of small bowel involved was terminal ileum, found in 7 patients (77.7%), ileocaecal junction in 4 patients (44.4%) and jejunum in 2 patients (22.2%).

In a study done by Michael Dam Jensen et al, 2011 (6), in 35 patients who had active small bowel crohn's disease, the most common segment of bowel involved was terminal ileum followed by jejunum.

Interpretation of CT and MR Enterography

Diagnostic Quality of Bowel Distension: Rakesh Sinha et al 2013⁽⁹⁾ done a study on the impact of divided oral contrast ingestion on bowel distension and quality of images in MR enterography 64. As adequate distension is imminent for the successful study patient compliance, timing of imaging, amount of contrast ingested is important.

Three Grades in MR Enterography:* Grade 3: All the bowel loops are well distended. - confident diagnostic study.* Grade 2: Few bowel loops are less distended and remaining are well distended and opacified – diagnostic study.* Grade 1: Most of the bowel loops are unopacified hence non diagnostic study.

For grading measurement should be done at axial TRUFISP images with fat suppression. Fat suppression is needed to eliminate black boundary artifact. Measurements should be taken at normal bowel segments as there may be alterations due to bowel mural wall thickness in diseased portions. Three measurements are taken at ileum, jejunum and caecum and average of three values should be taken.

Results of this study are:

- 1) Bowel diameter more than 1.95 cm are in the grade 3 quality and best for diagnostic interpretation.
- 2) Most of the patients have grade 3 distension with divided dose preparation.
- 3) Suboptimal distension with poorer image quality in standard dose preparation.
- 4) Increasing bowel diameter and diagnostic image quality has strong positive correlation.

Another study done by Jensen et al⁽⁶⁾ compared image quality and also disease evaluation in CT and MR Enterography stated that CT has a better image quality because of little motion artifact due to fast acquisition. Inter observer agreement for disease evaluation, was high for CT and moderate for MR enterography. In this study it was also

found that disease evaluation of small bowel is both observer and modality dependent, Both techniques had comparable diagnostic yields inspite of the difference & concluded that MR enterography is an acceptable alternative to CT enterography

Characterisation of Small Bowel Pathology

Damian Tolan et al ⁽¹⁰⁾ described several criteria to help to characterize abnormal small bowel segments, including pattern of contrast enhancement, length of involvement, degree and symmetry of wall thickening, location in proximal/distal jejunum/ileum, location of pathology within the small bowel wall (mucosal /

submucosal / serosal) and associated abnormality in the adjacent mesentery or vessels.

Key Tips in Image Analysis

- 1) Improve bowel distension by active supervision and encouragement of oral contrast intake.
- 2) The lumen should be carefully navigated.
- 3) Multiplanar views should be used.
- 4) Differential contrast enhancement of the bowel is a cardinal sign.
- 5) Jejunum enhances more than the ileum.
- 6) Collapsed bowel loops and focal small bowel spasm can mimic pathology, associated changes should be looked for.

Table – 1 :Characterisation of mural thickening

Mild (3–4 mm)	Moderate (5–9 mm)	Severe (>10 mm)
Hypoalbuminaemia, infectious enteritis and occasionally ischaemia or mild Crohn's disease	Crohn's disease, intestinal ischaemia, intramural haemorrhage, angio-oedema, vasculitis, early adenocarcinoma and lymphoma	Neoplasm including lymphoma, vasculitis, Crohn's disease, intramural haemorrhage and, rarely, in infectious colitis; most cases of thickening >20 mm are due to neoplasms or intramural haemorrhage

Table – 2: Small bowel wall thickening

Symmetrical	Asymmetrical
Benign conditions and some cases of lymphoma	Crohn's disease, tuberculosis, adenocarcinomas and gastrointestinal stromal tumours

Table – 3 : Site of abnormality in the small bowel

Proximal	Distal
Adenocarcinoma and coeliac disease	Lymphoma and carcinoid tumours, Crohn's disease (most commonly affects the terminal ileum with skip lesions elsewhere)

Table –4 : Site of involvement of bowel wall layer

Mucosa	Submucosa	Serosa
Crohn's disease, tuberculosis and neoplasms (i.e.adenocarcinoma, infectious conditions and vasculitides)	Intramural haemorrhage, vasculitis, ischaemia, hypoalbuminaemia and angio-oedema	Metastases, endometriosis, carcinoid and other inflammatory conditions in the peritoneum

CASE 1 30 year old male presented with pain abdomen

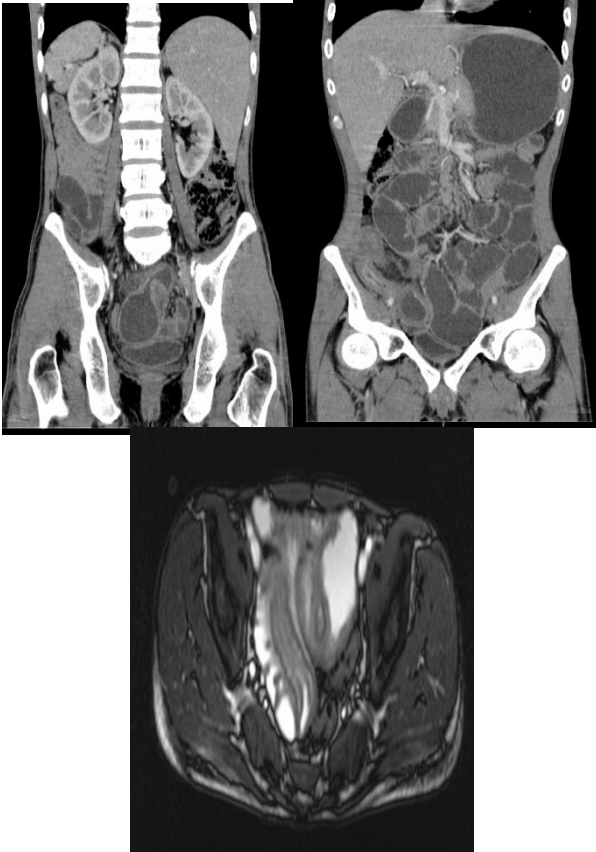


Figure 3-Coronal CT enterography, Axial TruFISP MR enterography images showing mucosal hyperenhancement wall thickening with luminal narrowing in terminal ileum S/O CROHN'S DISEASE confirmed on Ileocolonoscopy & HPE.

CASE 2 A 22 year old male presented with pain abdomen and bile stained vomitings. Colour Doppler s/o thrombosis of intra and extrahepatic portal veins, SMV and collaterals at splenic hilum



Figure 4 -BMFT showing long segment (11cm) incomplete stricture in distal jejunum

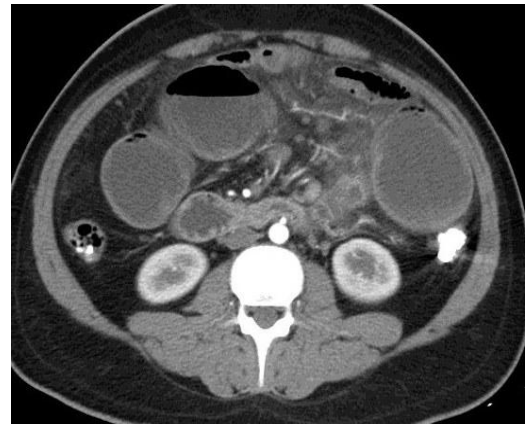


Figure 5-Axial CT enterography image showing incomplete stricture of distal jejunum with adjacent mesenteric inflammation with dilatation of proximal jejunum

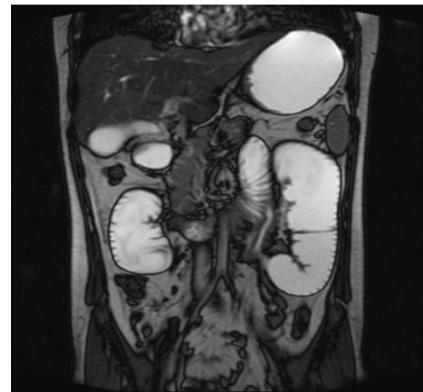


Figure 6-Coronal tru FISP MR enterography showing long segment T2 hypointense stricture in distal jejunum with proximal dilatation. S/O MESENTERIC ISCHEMIA DUE TO SMV THROMBOSIS.

CASE 3 A 22yr old male presented with fever, pain abdomen, loss of weight

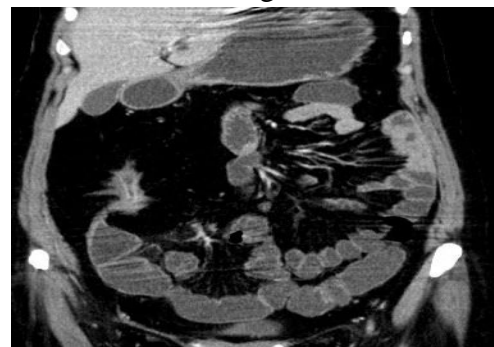


Figure 7-Coronal CT enterography image showing irregular wall thickening with hyperenhancing mucosa, adjacent mesenteric fat stranding in ascending colon S/O KOCH'S-ETIOLOGY

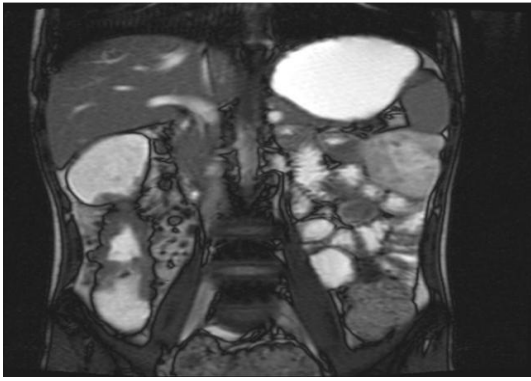


Figure 8-Coronal TruFISP MR Enterography image showing irregular wall thickening of ascending colon with luminal narrowing S/O KOCH'S confirmed on ileo colonoscopy and HPE

CASE 4 A 42 yr old female presented with pain abdomen and loss of weight



Figure 9 -Axial and coronal CT enterography images showing long segment luminal narrowing with enhancing wall thickening in terminal ileum S/O ILEOCAECAL TUBERCULOSIS.

Case 5 A 28 year male presented with pain abdomen, loss of weight loss of appetite.



Figure 10-Coronal CT enterography image showing stratified enhancement of the distal ileum with luminal narrowing and engaged vasa recta (comb's sign) s/o crohn's disease.



Figure 11-Coronal TruFISP MR enterography image showing symmetrical circumferential wall thickening in distal ileum with engorged vasa recta S/O CROHN'S DISEASE IN DISTAL ILEUM.

CASE 6 A 30 year old female presented with loose stools and loss of weight



Figure 12-Coronal TruFISP MR enterography image showing thickened mucosal folds in ileal loops (jejunalization of ileal loops) S/O MALABSORPTION, confirmed on HPE as caeliac disease

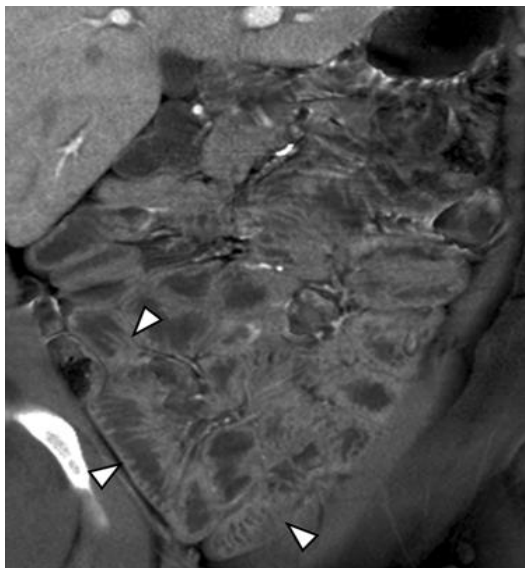


Figure 13-Coronal CT enterography image showing jejunalization of ileal loops noted in right lower quadrant S/O MALABSORPTION.

In 9 patients out of 50 in the present study, Crohn's disease was detected on CTE, out of which 7 patients correlated with HPE (true positive) and HPE was negative in 2 patients. Among rest of 41 patients in whom CTE was negative for crohn's disease, HPE detected

crohn's in 2 patients and HPE was negative in 39 patients (true negative). Hence the specificity and sensitivity of CTE for crohn's disease are 77.7% and 95.1% respectively.

In the present study of 50 patients, in 8 patients crohn's disease was found on MRE, out of which 7 correlated with HPE (true positives), and HPE was found negative in 1 patient. Among rest of 42 patients, in whom MRE was negative for crohn's, 2 were detected positive on HPE and 40 were negative (true negative). Hence the sensitivity and specificity of MRE for crohn's disease are 77.7% and 97.5% respectively. In most of the studies in literature sensitivity and specificity of MRE is equal to or higher than that of CTE. According to Lee et al 2009 (1) the sensitivity and specificity of CTE for diagnosing active CD was 89% and 80% respectively and these for MRE were 83% and 100% respectively. The sensitivity of detecting extra enteric complications was 100% for both CTE and MRE. Schreyer A. G et al(11), 2009 found that for small bowel and colon assessment, there was no significant difference for image quality between CTE and MRE. Inflammation diagnosis was not significantly different between CT (69.4%) and MRE (71.4%). Colonic inflammation was diagnosed in 30.2% based on CT and 14.3% based on MRE. The sensitivity and specificity of MRE for detection of small bowel CD was 74% and 80% as compared to 83% and 70% with CTE ($p>0.5$) according to Michael Dom Jensen et al(6). In the present study, both CTE and MRE showed similar capability of detecting active small bowel inflammation, as well as extra enteric complications. But MRE was found to have significantly more motion artifacts than CTE. Although MRE is costlier than CTE, it can be repeated without subjecting the patient to ionizing radiation. MRE and CTE detected small bowel stenosis with 55% and 70% sensitivities respectively and 92% specificity according to Hassan A Siddiki et al(7), 2009. The sensitivities of MRE and CTE for detecting active small bowel crohn's disease were similar (90.5% and 95.2% respectively).

In the present study, both CTE and MRE showed similar capability of detecting active small bowel inflammation, as well as extra enteric complications. But MRE was found to have significantly more motion artifacts than CTE.

Although MRE is costlier than CTE, it can be repeated without subjecting the patient to ionizing radiation.

Limitations: The main limitations of this study are that it did not include pediatric population as there was risk of exposure to ionizing radiation. The study included a smaller sample of patients as most of them with small bowel disease were not able to take the neutral enteric contrast for bowel distension as they already had pain abdomen or vomiting as their complaint. CTE and MRE could not be performed on the same day as both studies included administration of intravenous contrast agents.

Summary: A prospective observational study done in 50 patients with clinical symptoms of small bowel diseases who underwent ileocolonoscopy were included in the study. CT and MR enterography was performed in all the patients and findings analyzed. Further they were followed up with HPE/Surgical findings. Predominant age group involved in this study was 21-30 yrs constituting 44%(n=22), followed by 31-40 yrs (n=7), and 51-60 yrs (n=5). Males were more in number constituting 27 out of 50 patients (54%), followed by females constituting 23 (46%).

Among the 50 patients with clinical diagnosis of small bowel disease, abnormal findings on imaging were noted in 27 patients (54%) and rest of the 23 patients were normal. Adequacy of bowel distention was relatively better with CTE, constituting 29 out of 50 cases showing grade 3 distention, 18 cases showing grade 2 distention and 3 patients showing grade 1 distention. Among the 9 cases of crohn's disease, the most common segment of small bowel involved was terminal ileum, found in 7 patients (77%), ileocaecal junction in 4 patients (44.4%) and jejunum in 2 patients (22.2%). The sensitivity and specificity of CTE for diagnosing small bowel diseases was

found to be 89.6% and 66.6% respectively. The sensitivity and specificity of MRE for diagnosing small bowel diseases was 88.8% and 78.2% respectively. The sensitivity and specificity of CTE for diagnosing crohn's disease was 77.7% and 95.1% respectively. The sensitivity and specificity of MRE for diagnosing Crohn's disease was 77.7% and 97.5% respectively.

References

1. SeungSoo Lee, MD, Tack Sun Oh, MD, Hye Jin Kim, MD, Jun-Won Chung, MD, Seong Ho Park, MD, Ah Young Kim, MD, and Hyun Kwon Ha, MD. *Obscure Gastrointestinal Bleeding: Diagnostic Performance of Multidetector CT Enterography.* Radiology 2008;247:64-79
2. Fidler JI. MR imaging of the small bowel. *Radiol Clin North Am.* 2007 Mar;45(2): 317-31.
3. Gölder SK1, Schreyer AG, Endlicher E, Feuerbach S, Schölmerich J, Kullmann F, Seitz J, Rogler G, Herfarth H. Comparison of capsule endoscopy and magnetic resonance (MR) enteroclysis in suspected small bowel disease. *Int J Colorectal Dis.* 2006 Mar;21(2):97-104. Epub 2005 Apr 22.
4. Tolan DJ1, Greenhalgh R, Zealley IA, Halligan S, Taylor SA. MR enterographic manifestations of small bowel Crohn disease. *Radiographics.* 2010 Mar;30(2): 367-84. doi: 10.1148/rg.302095028.
5. Shauna Duigenan and Michael S. Gee – Imaging of pediatric patients with inflammatory bowel disease – *AJR* Oct 2012, Volume 199, Number 4.
6. Michael Dam Jensen, Jens Kjeldsen, Soren Rafael Raelson & Torben Nathan – Diagnostic accuracies of MR enterography and CT Enterography in symptomatic Crohn's Disease *Scandinavian Journal of gastroenterology.* Vol 46, 2011- Issue 16
7. Siddiki HA1, Fidler JL, Fletcher JG, Burton SS, Huprich JE, Hough DM, Johnson CD, Bruining DH, Loftus EV Jr,

- Sandborn WJ, Pardi DS, Mandrekar JN. Prospective comparison of state-of-the-art MR enterography and CT enterography in small-bowel Crohn's disease. *AJR Am J Roentgenol.* 2009 Jul;193(1):113-121.
8. Luciana Costa-Silva; Tatiana Martins; Maria do Carmo Friche Passo CT enterography: a preliminary experience in the evaluation of small bowel diseases *Radiol Bras vol.43 no.5 São Paulo Sept./ Oct. 2010*
9. Rakesh Sinha and Sudarshan Rawat MRI enterography with divided dose oral preparation: Effect on bowel distension and diagnostic quality *Indian J Radiol Imaging.* 2013 Jan-Mar; 23(1): 86–91.
10. Tolan DJ1, Greenhalgh R, Zealley IA, Halligan S, Taylor SA. MR enterographic manifestations of small bowel Crohn disease. *Radiographics.* 2010 Mar;30(2): 367-84. doi: 10.1148/rg.302095028.
11. Schreyer AG1, Geissler A, Albrich H, Schölmerich J, Feuerbach S, Rogler G, Völk M, Herfarth H. Abdominal MRI after enteroclysis or with oral contrast in patients with suspected or proven Crohn's disease. *Clin Gastroenterol Hepatol.* 2004 Jun;2(6):491-7.