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Original Article

Role of Magnetic Resonance Enteroclysis in the Assessment of Pathologies of Small Bowel

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Abstract

background: Examination of the gastrointestinal (GI) tract for both anatomy and pathology is essential in diagnosing GI diseases. Traditional radiology has historically played a pivotal role, alongside endoscopy which remains primary despite limitations. However, non-invasive cross-sectional imaging modalities such as ultrasound (US), computed tomography (CT), positron-emission tomography (PET), and magnetic resonance imaging (MRI) have revolutionized GI tract assessment. These modalities offer enhanced resolution, 3D imaging, and contrast enhancement, with multimodal approaches such as PET-CT and PET-MRI improving sensitivity and specificity in tissue pathology studies. US, due to its affordability, non-invasiveness, and high diagnostic accuracy, has gained prominence in GI disease diagnosis, particularly with Doppler and contrast-enhanced US providing critical blood flow data. Magnetic resonance enteroclysis (MRE) has emerged as a standard imaging test for evaluating small-bowel (SB) pathologies, necessitating standardized practices in indications, interpretation, and methodology. MRE accurately assesses intraluminal, parietal, and extraluminal aspects of the SB, distinguishing between neoplastic and non-neoplastic diseases. This study aims to present the MRE technique, interpret imaging findings, and compare them with final diagnoses, emphasizing its role and advantages in diagnosing SB pathologies through rigorous methodological steps.

Objective: This study evaluates the role of MRE in diagnosing SB pathologies, including inflammatory bowel diseases (IBD) and their extraluminal complications and extraintestinal manifestations. It focuses on assessing disease activity, treatment response, and distinguishing inflammatory from fibrotic strictures in conditions such as Crohn's disease (CD) and ulcerative colitis (UC).

Materials and Methods: A retrospective and prospective study conducted over 5 years starting from May 2019 to July 2024 (5 years) at the Department of Radiology, Sri Ramachandra Institute of Higher Education and Research, involved 34 patients with various SB pathologies undergoing MRE. Clinical and histopathological evaluations were compared with MRE findings. Statistical analysis determined the sensitivity and specificity of MRE as a diagnostic tool.

Results: The study showed a slight male predominance among patients, with ages ranging from 1 to 80 years, most commonly affected between 21 and 40 years. Common symptoms included abdominal pain, vomiting, weight loss, and diarrhea. MRE identified bowel wall thickening, strictures, fat stranding, fistulas, lymph node enlargement, and ascites, with CD being the most prevalent diagnosis. Histopathological examination confirmed IBD in the majority as well as other pathologies such as tuberculosis and validating MRE diagnoses.

Conclusion: MRE proves effective in diagnosing a wide range of GI pathologies, particularly inflammatory small-bowel disorders such as CD and UC. Its comprehensive imaging capabilities provide crucial insights for precise diagnosis and treatment planning, making it a preferred first-line imaging technique due to its non-invasiveness and absence of radiation exposure.

Key words: Acute myeloid leukaemia, Chloromas, Extramedullary ovarian granulocytic sarcoma/chloroma, Granulocytic sarcomas, Hematopoietic and lymphoid tissues, Leukemia; Myelogenous; Chronic; BCR-ABL Positive, Leukemia; Myeloid; Acute, Leukemia; Promyelocytic; Acute, Myelodysplastic Syndromes, Myeloid precursor cells, Myeloid sarcoma (granulocytic sarcoma or chloroma), Ovarian granulocytic sarcoma, Primary ovarian granulocytic sarcoma, Sarcoma; Myeloid

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INTRODUCTION

The small intestine constitutes the longest section of the digestive tract, comprising 90% of the gastrointestinal (GI) absorptive area and spanning about 75% of its total length (approximately 6 m, 4 times longer than the large intestine).[1] Due to its extensive length and complex,

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varied looping structure, small-bowel (SB) diseases present significant challenges for endoscopic evaluation. Up to 5% of patients with recurrent GI bleeding are not diagnosed through standard procedures such as gastroscopy and colonoscopy, often implicating the small intestine as the source.[2]

Small-bowel diseases have a low prevalence, and their clinical diagnosis is complicated by non-specific symptoms and a low index of suspicion, leading to diagnostic delays and subsequent treatment challenges. Therefore, accurate radiologic examinations play a crucial role not only in identifying small-bowel diseases but also in documenting normal morphology reliably. Conventional enteroclysis has been effective in excluding SB diseases and in evaluating patients suspected of intestinal diseases.[3]

Magnetic resonance imaging (MRI) of the bowel primarily employs three sequences: The single-shot fast spin echo T2 sequence with half-Fourier reconstruction, such as half-Fourier acquisition single-shot turbo spin echo (HASTE) or SSFSE, is commonly used in medical imaging. For T2-weighted images free from motion artifacts, balanced steady-state free precession (e.g., True fast imaging with steady-state precession [FISP], FIESTA) sensitive to mesenteric changes, and dynamic fast 3D spoiled gradient echo T1 fat-suppressed post-contrast sequence (e.g., VIBE, LAVA) to assess bowel enhancement patterns. Technological advancements, including higher magnetic field strengths (e.g., 1.5 T and 3 T), multichannel phased array coils, and parallel image processing, have significantly enhanced MR bowel imaging, facilitating the development and clinical application of MRI protocols for SB (Magnetic resonance enteroclysis [MRE]) and colon (MR colonography) evaluations.[4]

Traditional methods such as small-bowel follow-through examination or barium enteroclysis are being replaced by cross-sectional imaging techniques, which allow simultaneous assessment of luminal integrity, mural deformities, and extraluminal disease extension. Endoscopic methods (ileocolonoscopy, capsule endoscopy, and double-balloon enteroscopy) offer advantages in assessing mucosal abnormalities and obtaining histologic biopsies. However, they are invasive and may have limitations due to bowel structures.

Methods such as double-balloon enteroscopy and wireless capsule endoscopy (WCE) necessitate specialized equipment and expertise, usually found exclusively at large tertiary-care centers.[5]

Cross-sectional imaging modalities such as computed tomography (CT) and MRE are used for SB evaluation, providing adequate luminal filling, distension, and detailed visualization of the intestinal wall. However, the cumulative ionizing radiation dose, particularly in younger patients undergoing conventional enteroclysis or CT enteroclysis (CTE) as follow-up examinations, can be substantial.[5]

MRE, a combined functional and morphological imaging method recently introduced into clinical practice, offers high image quality without ionizing radiation exposure. It provides exceptional soft-tissue contrast resolution, generates images in multiple planes, and allows repeated data acquisitions to evaluate SB mobility over time, aiding in diagnosing low-grade stenosis and identifying obstruction levels.[6,7]

MRE is an advanced method for imaging the SB that combines the advantages of conventional enteroclysis with those of cross-sectional imaging. Its primary benefit lies in comprehensive visualization, encompassing luminal, mural, and extramural abnormalities simultaneously. Thus, this study aims to evaluate the efficacy of MRE in diagnosing SB disorders.

Role of magnetic resonance enteroclysis in the assessment of pathologies of small bowel.

Aim

The aim of the study was to assess the usefulness of MR ENTEROCLYSIS in the diagnosis of various SB pathologies.

Objectives

The objectives of the study are as follows:

- To analyze the MR features in SB pathologies.
- To correlate the MR imaging features with scopy findings wherever feasible.
- To correlate the MR findings with histopathology/clinical follow-up/follow-up studies.

Review of Literature

Anatomical aspects of the digestive system

The digestive system is a tubular structure that extends from the upper part of the esophagus to the anal canal. Along most of its length, it maintains a consistent structural pattern, although there are exceptions such as the upper esophagus and the anal sphincter, which consist of striated muscle rather than smooth muscle (Rutishauser, 1994). In addition, the stomach has an oblique layer of muscle. The principal components of the digestive system include:

- The mouth
- The esophagus
- The stomach
- The duodenum
- The liver and pancreas

- The jejunum
- The ileum
- The colon
- The rectum
- The anus[9]

Anatomy of the SB [Figure 2]

The small intestine is crucial in the digestive system, responsible for breaking down and absorbing essential nutrients necessary for optimal bodily function. It accomplishes this through a complex interplay of blood vessels, nerves, and muscles working harmoniously to fulfill its functions.

The small intestine averages between 3 and 5 m in length and is composed of three segments: The duodenum, jejunum, and ileum, collectively orchestrating digestion and absorption processes.[10-12]

- Duodenum: The shortest segment, measuring 20–25 cm in length, connects the stomach's antrum through the pylorus and transitions into the jejunum. Shaped like a "C," it surrounds the pancreas and receives chyme, pancreatic enzymes, and bile, uniquely containing Brunner's glands histologically.[13]
- Jejunum: Spanning approximately 2.5 m, the jejunum features plicae circulares (circular folds) and villi that enhance the absorption of digested products.
- Ileum: Extending about 3 m, the ileum ends at the cecum and primarily absorbs remaining nutrients, including Vitamin B12 and bile acids.[13]

Cellular layers

The small intestine consists of four layers:

- Mucosa: The innermost layer composed of simple columnar epithelium housing absorptive cells (enterocytes), goblet cells, and enteroendocrine cells. Enterocytes are adorned with microvilli, significantly increasing surface area for absorption. Plicae circulares, villi, and crypts within this layer further augment surface area and serve as sites for stem cell activity.[13,14]
- Submucosa: A layer of connective tissue containing blood vessels, nerves, and lymphatics, notable for Brunner's glands in the duodenum responsible for mucous secretion.[15]
- Muscularis propria: It consists of two layers of smooth muscle – outer longitudinal and inner circular – that facilitate intestinal movement. The myenteric (Auerbach's) plexus embedded within regulates these contractions.[16]
- Serosa: The outermost layer comprising epithelium and mesothelium, covering the jejunum, ileum, and anterior duodenum, except for the posterior duodenum which lacks this covering due to its retroperitoneal position.[16]

The small intestine plays a critical role in digestion through nutrient absorption and food propulsion in the GI tract [Figure 3]. The following details the specific functions of each segment:

Duodenum

Chemical Digestion: The duodenum forms the connection between the stomach's pylorus to the initial part of the small intestine. Food passes from the stomach to the duodenum through the pylorus. Structurally, it spans about 10 inches in a curved "C" shape around the pancreas. The duodenum acts as a receiving site for digestive enzymes supplied by the liver, pancreas, and gallbladder through ducts connecting these organs to the duodenum. Hormone-producing glands within its lining play a crucial role in coordinating the release of these enzymes in response to food presence. The duodenum receives innervation from the celiac plexus, primarily through sympathetic input from the greater and lesser splanchnic nerves, and parasympathetic input from the vagus nerve. It begins at the duodenal bulb and extends to the ligament of Treitz (duodenojejunal flexure). Functionally, the duodenum is very important for iron absorption, with some absorption of folate also occurring here.

Jejunum

The jejunum is the second segment of the small intestine, primarily located in the left upper quadrant of the abdomen. It serves as the primary site for absorbing folate (B9). Its deep red appearance during endoscopic examination is due to extensive vascularization. Functionally, the myenteric plexus within the jejunum stimulates intestinal contractions that aid in mixing food with digestive enzymes. Peristalsis, the process that moves food through the digestive tract, is a critical function of the jejunum. Both the duodenum and jejunum feature mucosal linings with numerous folds and projections that significantly increase the surface area for nutrient absorption. Approximately 95% of carbohydrates and proteins, along with 90% of water, are absorbed in these segments, with the remaining absorption occurring in the large intestine.

Ileum

The ileum is the final segment of the small intestine, predominantly located in the right lower quadrant of the abdomen. It is the longest portion of the small intestine, characterized by thinner walls and reduced vascularization. The ileum primarily facilitates the slower movement of food through peristalsis. Separating the ileum from the large intestine (colon) is the ileocecal valve, which is regulated by hormonal and nervous signals to control food passage and prevent bacterial migration. Paneth cells are secretory cells located in the crypts of Lieberkühn in the ileum, where they provide protection against bacteria. The ileum is crucial for absorbing Vitamin B12 and bile salts. Innervation of both the jejunum and ileum is managed by the superior mesenteric plexus extending from the lower part of the

celiac plexus. Sympathetic innervation predominantly comes from the greater and lesser splanchnic nerves, while parasympathetic innervation is mediated by the vagus nerve.

In summary, the small intestine plays a pivotal role in digestion, nutrient absorption, and food propulsion within the GI system. Each segment – duodenum, jejunum, and ileum – contributes uniquely to these essential functions, ensuring efficient nutrient uptake and waste elimination [Figure 1].

Pathophysiology

The small intestine, the longest segment of the GI tract, plays a crucial role in digestion and nutrient absorption. Dysfunction within this vital organ can lead to various conditions, including congenital deformities, growths, obstructions, chronic diseases, and infections.

Below is a non-exhaustive list detailing several significant pathologies of the SB:

SB obstruction (SBO)

- The primary cause of mechanical SBO is most commonly post-surgical adhesions.
- Other causes include strangulated hernia, malignancies, inflammatory bowel disease (IBD), foreign bodies, volvulus, and stool impaction.[21]

Enteritis

- Inflammation of the small intestine often arises from factors such as radiation exposure or infections caused by viral (e.g., Norovirus) or bacterial (e.g., Clostridium difficile and escherichia coli) pathogens.

Peptic ulcer disease (PUD)

- Increased gastric acid secretion leads to erosion of the GI tract's inner lining.
- PUD primarily affects the stomach and proximal duodenum but can extend to the esophagus, distal duodenum, or jejunum.[22]

Irritable bowel syndrome (IBS)

- IBS is characterized by visceral hypersensitivity and motility disturbances.
- Symptoms include abdominal pain, bloating, diarrhea, and constipation.[23]

Celiac disease

- An autoimmune disorder affecting the small intestine triggered by gluten consumption.
- Immune response to gluten leads to inflammation and damage in the small intestine.[25]

Crohn's disease (CD)

- An autoimmune condition causing full-thickness inflammation of the GI tract.
- SB involvement occurs in about one-third of patients, commonly affecting the terminal ileum.[26]

Small intestinal bacterial overgrowth (SIBO)

- SIBO is characterized by an overabundance of bacteria in the small intestine, often occurring post-surgery due to altered GI transit.

Intussusception

- It occurs when one part of the small intestine slides into another, causing obstruction and potentially bowel ischemia.[5]

Carcinoma of the small intestine

- It represents less than 5% of all GI malignancies and includes various types such as adenocarcinoma, neuroendocrine tumors, lymphoma, GI stromal tumors (GISTs), leiomyosarcoma, and metastatic disease.

These pathologies underscore the critical functions of the small intestine and highlight the diverse range of conditions that can impact its structure and function, necessitating timely diagnosis and appropriate management strategies.

Radiological Review

In a study by Rieber *et al.* (2000), 50 patients with SB disease underwent SB enteroclysis followed by MRI incorporating T1-weighted and T2-weighted sequences. Patients were administered either positive or negative oral MR contrast media. MRI successfully identified abscesses and fistulae in 20 patients, demonstrating 100% sensitivity for abscess detection and 83.3% sensitivity for diagnosing fistulas. Positive oral contrast facilitated the detection of bowel wall thickening, whereas negative contrast provided superior identification of post-contrast changes. However, negative contrast could potentially obscure loop abscesses on T1-weighted imaging alone. Based on their findings, the authors recommended MRI as a preferred imaging modality for patients suspected of having extraintestinal complications, citing its dependable diagnostic capabilities.[48]

Akman *et al.* (2005) conducted a prospective study to evaluate conventional enteroclysis (CE) findings in conjunction with MRE for assessing SB disease. The study included 32 patients with established or suspected SB abnormalities who underwent both procedures. MRE complemented CE by providing additional details on mucosal, mural, and extramural changes such as wall thickness, enhancement patterns, and perienteric

findings. Although MRE did not identify short structures, it significantly contributed to characterizing obstruction levels and disease extent, especially among patients with a history of abdominal malignancies. The combined approach of CE and MRE demonstrated particular utility in managing advanced IBD or neoplasms.

Frøkjær *et al.* (2005) conducted a study comparing MRI with conventional enteroclysis (CE) in 36 patients suspected of CD. They optimized the MRI protocol by administering plum juice and fiber laxatives orally and acquiring T2-weighted and gadolinium-enhanced T1-weighted images. Virtual endoscopy was performed alongside MRI, while CE involved barium and air administration through duodenal intubation. MRI detected small-bowel changes in 12 patients, identifying pathology missed by CE in three cases. Moreover, MRI revealed abdominal changes in significantly more patients than CE (a 70% increase, $p<0.001$), showing a strong correlation with endoscopic findings. High interobserver agreement was noted for MRI pathological changes ($P < 0.001$), and patients reported less discomfort during MRI compared to CE ($P < 0.001$). Due to its effectiveness in demonstrating small-bowel pathology without radiation exposure, MRI with this technique was preferred over conventional enteroclysis.

Herman *et al.* (2005) aimed to enhance the visualization of small- and large-bowel anatomy and pathology, particularly in cases involving post-operative or complex multisegmental inflammatory changes, using a dual-contrast technique (DCT) for MRE with luminal contrast media of opposing signal characteristics. Sixty patients underwent radiological procedures in the form of MRE with the ferrous oxide-based negative contrast agent in the SB, and about 30 of these patients also received rectal instillation of water for positive contrast (DCT). About two observers evaluated the degree of distention and ease of identifying bowel anatomy and pathologies using a 4-point scale. The study showed that DCT significantly improved distention and identification of the large bowel and terminal ileum ($P \leq 0.0001$; $P = 0.034$). The interobserver consensus for most of the pathologies was enhanced with DCT, except for "pre-stenotic dilatation." Overall, thorough MR imaging of the small and large bowel with DCT helps us in the recognition of altered anatomy and most of the pathologies in inflammatory and post-surgical bowel conditions.

Albert *et al.* (2005) investigated the diagnostic efficacy of capsule endoscopy (CE) compared to MRI in SB CD. They conducted a prospective evaluation of CE, MRI, and double-contrast fluoroscopy in 52 patients suspected of having the disease, with 41 ultimately diagnosed with SB CD. CE could not be performed in 14 patients due to strictures. Among the remaining 27 patients, SB CD was identified in 25 cases by MRI, 21 cases by CE, and seven cases by fluoroscopy. CE alone provided diagnosis in four patients. While CE showed slightly higher sensitivity than MRI, MRI detected inflammatory conglomerates and enteric fistulae in some instances. The study concluded that CE and MRI complement each other in diagnosing SB CD, with CE effective in detecting mucosal lesions and MRI beneficial for identifying transmural disease and extraluminal lesions.

Golder *et al.* (2006) emphasized the significance of SB MRE and WCE as innovative diagnostic methods for evaluating SB conditions. Their study compared WCE and MRE in detecting SB pathologies among 36 patients with indications such as CD, obscure GI bleeding, and tumor surveillance. WCE demonstrated superior performance over MRE, detecting more inflammatory lesions in CD patients and identifying angiodysplasia as a source of bleeding in cases of GI bleeding. In contrast, MRE revealed extraintestinal pathologies in some patients. Overall, WCE proved more effective in diagnosing inflammatory lesions and obscure GI bleeding compared to MRE.

Tillak *et al.* (2008) conducted a comparison between MRE and wireless video capsule endoscopy (VCE) in detecting and classifying SB CD proximal to the terminal ileum. Nineteen patients diagnosed with CD were included in the study. MRE and CE demonstrated agreement in 85% of evaluated segments regarding the presence or absence of pathology. Regarding lesion severity assessment, MRE and CE concurred in 56% of segments. MRE underestimated pathology in 14% and revealed more severe pathology in 12% of segments compared to CE. CE identified subtle or severe mucosal pathology that was missed by MRE. However, CE overlooked severe inflammatory changes detected by MRE in 2% of segments. MRE is less effective in detecting superficial mucosal disease but reliably identifies severe inflammatory changes within the bowel wall. Both imaging modalities are complementary, with MRE recommended for severe CD cases and situations where involvement beyond the mucosa is suspected.

Lawrence *et al.* (2009) conducted a study to evaluate the necessity of a nasojejunal tube (NJT) during enteroclysis and the feasibility of performing examinations exclusively in the supine position. They gathered data from 108 patients undergoing SB MRI over a span of 32 months. The findings indicated similar distal SB distension and artifact effects between magnetic resonance follow-through (MRFT) and MRE. However, proximal SB distension was frequently inadequate in MRFT, particularly among patients aged over 50 years. In conclusion, MRE was favored as the optimal method for SB MRI examinations due to its superior ability to distend the proximal SB.

Gabriele *et al.* (2009) conducted a prospective study to evaluate the effectiveness of MRE in detecting small-bowel neoplasms among symptomatic patients. They employed conventional endoscopy, tissue specimen analysis, capsule endoscopy, conventional enteroclysis, and follow-up observations as comparative standards.

A total of 150 patients (83 males, 67 females; mean age: 42.6 years; age range: 17–84 years), suspected clinically of small-bowel neoplasms with normal upper and lower GI endoscopy findings, underwent MRE. The study evaluated MRE results for focal irregular bowel wall thickening, small-bowel solid masses, and stenosis. The positive MRE diagnostic findings were compared with histopathologic results from surgical (n = 19) or endoscopic (n = 2) procedures. The negative radiological MRE final results were compared with enteroscopy (n = 5), capsule endoscopy (n = 53), or conventional enteroclysis (CE), followed by clinical follow-up and observation (n = 71). The radiological diagnostic efficacy was assessed on a per-patient basis.

The study successfully performed MRE in all 150 patients, identifying 19 small-bowel neoplasms on histopathologic examination, including carcinoid neoplasms, adenocarcinomas, stromal tumors, lymphomas, angiomatous masses, small-bowel metastases, leiomyoma, adenoma, and lipoma. The sensitivity, specificity, and accuracy in detecting various small-bowel lesions were 86% (19 out of 22), 98% (126 out of 128), and 97% (145 out of 150), respectively. Two MRE examinations resulted in false-positive findings, and three yielded false-negative results. In conclusion, MRE is a dependable method for detecting small-bowel neoplasms in symptomatic patients.

Fork *et al.* (2012) investigated the clinical utility of MRE and CTE in patients who experienced delayed or missed delivery of a test capsule for video capsule enteroscopy (VCE). They identified 75 patients with this issue, of whom 70 agreed to participate. MRE was performed in 44 patients and CTE in 26. Lesions consistent with Crohn's disease were identified in five patients by MRE, 1 by CTE, and 4 by VCE (with one patient having lesions detected by both MRE and VCE). Among patients without alarm symptoms, no significant lesions were found on imaging. VCE was performed in 20 patients, predominantly under 50 years of age, where MRE or CTE did not detect any stenotic lesions. The remaining 50 patients did not undergo further endoscopic procedures, indicating satisfaction with the diagnostic information provided by MRE or CTE.

Wiarda *et al.* (2012) conducted a study to compare the diagnostic effectiveness of MRE and capsule endoscopy (CE) against balloon-assisted enteroscopy (BAE) in patients suspected or diagnosed with Crohn's disease (CD) of the SB. Patients underwent MRE, followed by CE and BAE, with those exhibiting high-grade stenosis on MRE skipping CE. The study included 38 patients, predominantly females (71%), with an average age of 36 years. Among them, 16 were diagnosed with active CD, while 13 had suspected very high-grade stenosis on MRE and, therefore, did not undergo CE. The various statistical analytic parameters such as sensitivity, positive predictive value (PPV), specificity, and negative predictive value (NPV) of MRE and CE for SB CD activity were assessed. MRE showed superior sensitivity and PPV in comparison to CE, which was limited by the occurrence of stenotic lesions that led to capsule retention in one patient.

Faggian *et al.* (2016) investigated small-bowel neoplasms, which account for 3%–6% of all GI tract tumors. These lesions often face delayed diagnosis due to their rarity, low clinical suspicion, and limitations of conventional radiologic examinations. While conventional enteroclysis and capsule endoscopy are commonly utilized, their ability to assess mural and extramural extents of small-bowel tumors is limited. Multidetector computed tomographic enteroclysis and MRE offer comprehensive imaging of intraluminal, mural, and extraintestinal abnormalities. The study included examinations of 67 patients clinically suspected of intestinal neoplasia, with 23 receiving a confirmed diagnosis. Malignant neoplasms were identified in 17 cases, while six instances involved benign neoplasms. The sensitivity of MRE for detecting small-bowel neoplasms was 87.5% and 91.6%, respectively. MRE provides detailed anatomical and functional information with superior soft-tissue contrast and multiplanar imaging, all without ionizing radiation. Differentiating small-bowel neoplasms from non-neoplastic conditions relies on MR findings, lesion appearances, contrast enhancement patterns, and stenosis characteristics.[15]

MATERIALS AND METHODS

Study Design

This was a retrospective and prospective observational study.

Study Setting

Department of Radiology and Imaging Sciences, SRIHER.

Study Period

The study period was May 2019–July 2024 (5 years).

Criteria for Inclusion and Exclusion

Inclusion criteria

Patients presenting clinical features suggestive of SB pathology were included in the study.

Exclusion criteria

The following criteria were excluded from the study:

- Patients lost to follow-up.
- Patients unable to undergo MRI (e.g., due to pacemakers, claustrophobia).

Sequential history taking, imaging, and data collection were done as in the pro forma enclosed.

Machines Used

- 3 T (GE Signa Architect 128 Channel MRI) using phased array abdomen coil in the supine position.
- GE signa HD× 1.5T MR magnet,
- Siemens magneto avanto 1.5 T.

Equipment

An 15 F (120 cm) or 12 F (120 cm) or 15 F (150 cm) nasojejunal catheter used, topical anesthetic to ease passage of the enteric tube.

General technique

The patient does not eat after midnight.

Complying with institute protocols, all patients provided written consent before the procedure.

An enteric tube (e.g., a naso-jejunal tube) was advanced beyond the pylorus under fluoroscopy. The tip was positioned in the proximal jejunum.

Patients were positioned inside the magnet. To distend the SB, methylcellulose-water solution (total 1500–2000 mL), was infused at a rate of 120–150 mL/min. The MR protocol involved employing RARE (T2-weighted half-Fourier rapid acquisition with relaxation enhancement) single-shot sequences and repeated during normal breathing until the methylcellulose water solution reached the ascending colon, ensuring adequate distension of the entire SB. If required 20 mg of hyoscine butyl bromide (Buscopan) was intravenously administered to reduce small-bowel peristalsis and prolong small-bowel distention.

The following sequences were obtained-

- SSFSE
- True FISP with and without fat saturation
- Flash 2D with fat saturation
- Axial DWI
- Axial lava gradient DIXON

The MR examination included cross-sectional imaging with axial, sagittal, and coronal single-shot HASTE sequences, as well as True FISP sequences with and without fat suppression (repetition time msec/echo time msec 3.6–3.8/1.5–1.7; matrix 192 × 340; section thickness/gap mm 5/0), to better examine the SB morphologically. MRI scans utilized a phased-array coil on a 3 T (GE SIGNA ARCHITECT 128 CHANNEL MRI).

Following this, VIBE T1 Flash 3D FAT-SAT sequences (repetition time msec/echo time msec, 3.24/1.24; field of view, 400 mm, adjusted according to patient size; matrix, 288 × 512; flip angle, 10°; single signal acquisition; and section thickness, 2.50 mm) were obtained in multiple breath-hold series. Intravenous contrast was administered as needed. These sequences were repeated at least 7 times consecutively during expiratory apnea at intervals of 0°, 30', 60', 90', and 120' after contrast injection (0.1 mmol/kg gadolinium at 2 mL/s).

Diffusion-weighted MRI (DW-MRI) was conducted in the true axial plane using a single-shot spin-echo echo-planar imaging (SE-EPI) sequence with b-values of 0 and 800 s/mm² (repetition time msec/echo time msec, 5600/80; field of view, 500 mm, adjusted based on patient size; matrix, 288 × 512; section thickness, 6 mm). This sequence was obtained during multiple breath-hold sessions.[19]

We aim to evaluate the role of MRE in diagnosing SB pathologies and correlate these findings with colonoscopic, surgical, or histopathological results or clinical follow-up.

Statistical analysis was performed on pathological findings in the SB to detect any significant differences, using a significance level of $P < 0.05$.

Significance of the project/trial: The study will assess the role and effectiveness of MRE as a diagnostic tool for evaluating SB pathologies.

RESULTS

The data collected were inputted into Microsoft Excel and analyzed using IBM SPSS Statistics for Windows, Version 29.0 (Armonk, NY: IBM Corp).[20] Descriptive statistics, frequency analysis, and percentage analysis were applied to categorical variables, while mean and standard deviation were used for continuous variables. Receiver Operating Characteristic curve analysis included sensitivity, specificity, PPV, NPV, and accuracy to assess the effectiveness of MR diagnosis in predicting the final diagnosis. A significance level of $P < 0.05$ was utilized for all statistical analyses.

Analysis of the data from MRE revealed a notable trend:

In the majority of patients, the radiological findings revealed bowel wall thickening, fat stranding, and lymph node enlargement.

Parameter	Haste with fat saturation	True FISP with and without fat saturation	Haste With fat saturation	Flash 2D with fat saturation	DWI	Lava gradient Dixon
Plane	Coronal	Coronal and Axial	Coronal and Axial	Coronal and Axial	Axial	Coronal and Axial
Breath hold	No	Yes	Yes	Yes	Yes Multiple breath hold series	Yes
Slice thickness (mm)	50	5	5	5	6 mm	5 mm
Slice distance		0	0	0	5	0
Field of view (mm^2)	250×250	Coronal: 400×400	Coronal: 400×400	Coronal: 400×350	400 mm	512
	Axial: 350×240	**Axial: 350×350**	**Axial: 350×350**	**Axial: 350×262**	**Axial: 256×256**	**Axial: 512x 512**
MATRIX	218×256	151×256	205×256	157×256	288×512	268×206
TR (ms)	849	5.04	849	212	1.5	5
TE (ms)	58	2.52	58	308	75	0
Flip angle (º)	150	80	150	70	90	15
Imaging time per volume (S)	0.8	26	23	23(x2)		

FISP=Fast imaging with steady-state precession; Flash=Fast low angle shot

Table 1: Distribution of gender: Men exhibited a higher prevalence of pathologies compared to females

Gender distribution	Frequency	Percent
Female	14	41.2
Male	20	58.8
Total	34	100.0

In this study, the majority of patients were found to have IBD in the form of Crohn's disease and ulcerative colitis (UC). In ten patients, MR imaging was found to be negative.

In this study, the clinical diagnosis in the majority of patients was Crohn's disease and tuberculosis.

In this study, the histopathological report revealed that the majority of patients had IBD in the form of Crohn's disease and UC.

In this study, MR diagnosis in the majority of the patients revealed Chron's disease.

In this study, the final diagnosis for the majority of patients was Crohn's disease.

Other associated findings found in some patients included.

- Pancreatitis[17]
- Gastritis
- Hemorrhoids
- Diverticulosis
- Hematoma

ROC Curve

Lower values of the test result variable(s) indicate stronger evidence supporting a positive actual state, with the positive actual state defined as 1.0.[18]

DISCUSSION

Several reports have investigated the potential of MRI examination of the SB. The primary advantages of MRI can be outlined as follows: no radiation exposure, exceptional soft-tissue contrast-enhancing tissue characterization, the ability to provide projectional, and cross-sectional imaging in all three dimensions, which is valuable for mapping small intestinal pathology, and the availability of multiple contrast sources, facilitating comprehensive morphological and functional evaluation of the small intestine.

Critical factors for a successful MRI examination of the small intestine encompass hardware and software considerations, the selection of intraluminal contrast agent, and the method of contrast administration. Regarding the latter, two primary approaches have been recommended: Oral administration and infusion through a nasojejunal catheter. Various intraluminal contrast agents are utilized with oral administration. Oral administration of intraluminal contrast agents is generally preferred by patients compared to the infusion technique through duodenal intubation. However, it may significantly prolong the examination time, up to 2 hours. Furthermore, consistent luminal distention cannot always be ensured, which may compromise the accuracy of diagnoses. In addition, the reliability of wall-thickness measurements is questionable when optimal luminal distention is not achieved.

MRE, a recently introduced method in clinical practice, integrates functional and morphological imaging, offering both high-quality images and the advantages of volume challenge. Recent findings indicate that the functional insights provided by MRE are comparable to those of conventional enteroclysis. Moreover, this technique offers inherent benefits such as a detailed assessment of bowel wall morphology and mesenteries.

Table 2: Age distribution: Individuals aged between 21 and 40 years exhibited a higher incidence of pathologies

0–10 years	11–20 years	21–30 years	31–40 years	40–50 years	50–60 years	60–70 years	70–80 years
1	3	11	7	2	2	5	3

Descriptive statistics

	N	Minimum	Maximum	Mean	SD
Age years	34	13.0	79.0	38.6	19.0

Table 3: Complaints: Common complaints reported by patients included abdominal pain, vomiting, and weight loss. These symptoms serve as crucial clinical indicators, often associated with underlying GI pathologies.

Complaints	Frequency	Percent
Abdominal pain	28	28.0
Bloody stools	3	3.0
Loose stools	3	3.0
Weight loss	5	5.0
Vomiting	7	7.0
Anemia	1	1.0
Constipation	1	1.0
Diarrhea	1	1.0
Frequent motion	1	1.0
HIV	1	1.0

Table 4: Bowel involvement/site: In this study, it was observed that the large bowel, as well as the combined small and large bowel, were predominantly involved in the majority of cases.

Small bowel	Large Bowel	Both-small bowel and large bowel
4	13	7

Site	Frequency
Small bowel	4.0
Large bowel	13.0
Both	7.0
Total	24.0

Table 5: Radiological features

Radiological features	Frequency
Bowel wall thickening	15
Stricture	8
Fat stranding	11
Lymph node enlargement	13
Fistula	10
Perianal abscess	0
Ascites	3

Table 6: Number of bowel pathologies detected

Total number of bowel pathologies detected	24

Number of bowel pathologies detected	Frequency
Chron's disease	10
Henoch-Schonlein purpura	2
Infective	4
Ulcerative colitis	5
Tuberculosis	3
Total	24

Table 7: Clinical diagnosis

Clinical diagnosis	Frequency	Percent
Chronic gastritis	1	2.9
Crohn's disease	8	23.5
Crohn's disease/TB	3	8.8
Enteritis	1	2.9
Gastritis	3	8.8
Henoch-Schonlein purpura	2	5.9
Ileitis	1	2.9
Ileocecal Tb	1	2.9
Ileocecal adhesions	1	2.9
Infectious	1	2.9
Inflammatory/malignancy	1	2.9
Pancreatitis	1	2.9
Phlegmatous mass	1	2.9
Small-bowel strictures	1	2.9
Total	34	100.0

Table 8: SCOPY and HPE diagnosis

SCOPY and HPE diagnosis	Frequency
Chron's disease	10
Henoch-Schonlein purpura	2
Infective	4
Ulcerative colitis	5
Tuberculosis	3
Normal	4
Not done	6
Total	34

In this study, we have quantitatively and qualitatively evaluated the role of MRE in the diagnosis of SB pathologies. About 34 patients with clinical features that may indicate SB pathology who underwent MRE from May 2019 to July 2024 (5 years) were included in this study. Sequential history taking, imaging, and data collection were done.

Complying with institute protocols, all patients provided written consent before the procedure. An enteric tube (e.g., a nasojejunal tube) was advanced beyond the pylorus under

Table 9: MR diagnosis

MR diagnosis	Frequency
Normal	11
Chron's disease	10
Henoch-Schonlein purpura	2
Ulcerative colitis	5
Left paraduodenal hernia	1
Tuberculosis	3
Infective	2
Total	34

Table 10: Final diagnosis

Final Diagnosis	Frequency
Chron's disease	10
Henoch-Schonlein purpura	1
Infective	4
Ulcerative colitis	5
Tuberculosis	3
Normal	10
Total	34

Table 11 : Mr diagnosis versus final diagnosis

Pathology/Disease	MRD	FD
CD	10	10
Ulcerative colitis	5	5
Infective etiology	2	4
Henoch-Schonlein purpura	2	2
Tuberculosis	3	3
Left paraduodenal hernia	1	0
Total	23	24

MRD: M.R diagnosis, FD: Final diagnosis, CD: Chron's disease

	MRD		FD	
	Frequency	Percent	Frequency	Percent
Abnormal	23	67.6	24	70.6
Normal	11	32.4	10	29.4
Total	34	100.0	34	100.0

	MRD	FD
Abnormal	67.6	70.6
Normal	32.4	29.4

MRD * FD cross-tabulation

Count	FD		Total
	Abnormal	Normal	
MRD			
Abnormal	23	0	23
Normal	1	10	11
Total	24	10	34

MR diagnosis versus final diagnosis	
The number of radiological diagnosis that tally with the final diagnosis	33
No significant abnormality detected	10

MR with final diagnosis					
	FD		Total	Sensitivity	95.8
	Abnormal	Normal		Specificity	100.0
MRD					
Abnormal	23	0	23	PPV	100.0
Normal	1	10	11	NPV	90.9
Total	24	10	34	Accuracy	97.1

Table 12: Area under the curve

Test result variable (s)				
Area	SD[a]	*P*	95% CI	
			LB	UB
0.979	0.025	0.0005[b]	0.931	1.000

[a]Under the non-parametric assumption, [b]Null hypothesis: True area=0.5. The test result variable (s): MRD has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased. CI: Confidence interval, SD: Standard deviation, MRD: M.R diagnosis

Area under the curve			
Area	p-value	95% CI	
		LB	UB
0.979	0.0005 **	0.931	1.000

**Highly significant at *P*<0.01 level

Table 13: Case processing summary

FD	Valid N (listwise)
Positive[a]	24
Negative	10

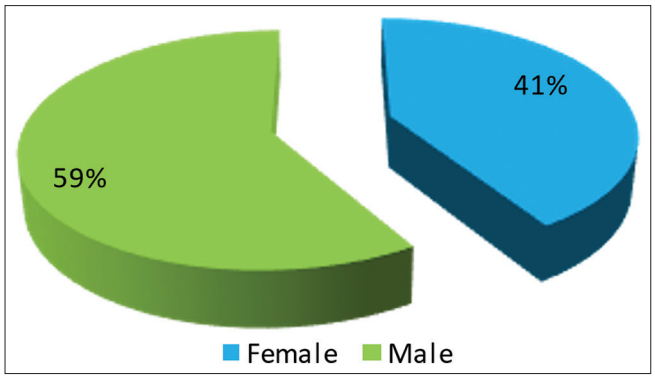
FD: Final diagnosis. Significance value 'a': 0.01

Table 14: Sensitivity and specificity

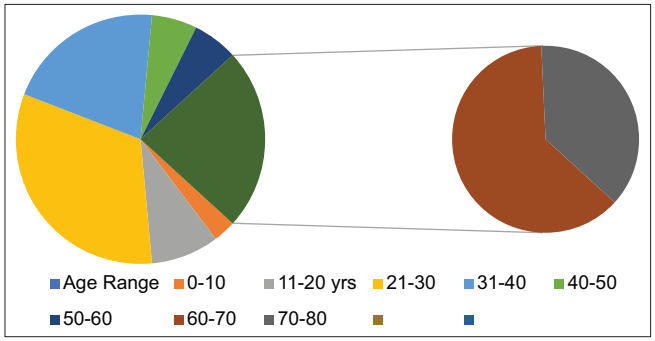
Statistical Parameters	Percentage
Sensitivity	95.8
Specificity	100.0
PPV	100.0
NPV	90.9
Accuracy	97.1

PPV: Positive predictive value, NPV: Negative predictive value

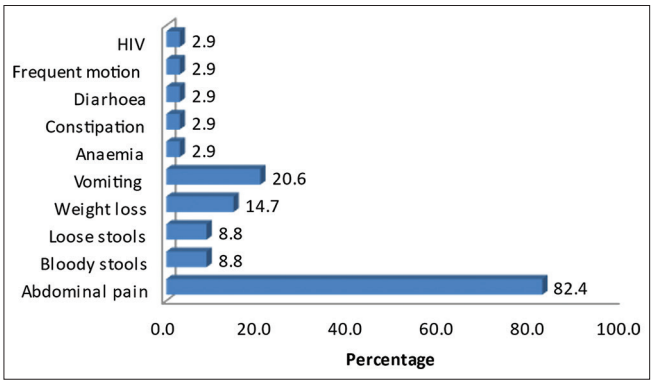
the guidance of fluoroscopy. The tip was positioned in the proximal jejunum. Patients were positioned inside the magnet. To distend the SB, methylcellulose water solution (total 1500–2000 mL) was infused at a rate of 120–150 mL/min. The MR protocol involved employing RARE (T2-weighted half-Fourier rapid acquisition with relaxation enhancement) single-shot sequences and repeated during normal breathing until the methylcellulose water solution



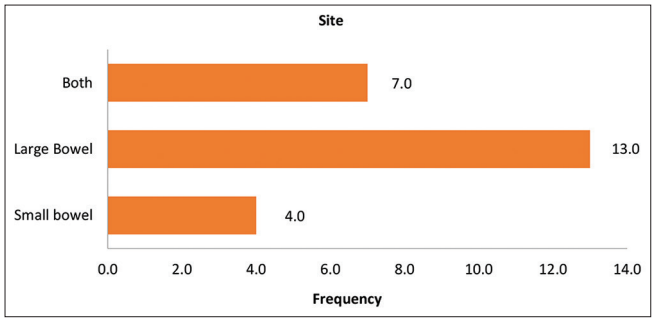
Graph 1: Distribution of gender of study subjects



Graph 2: Distribution of age (years) of study subjects

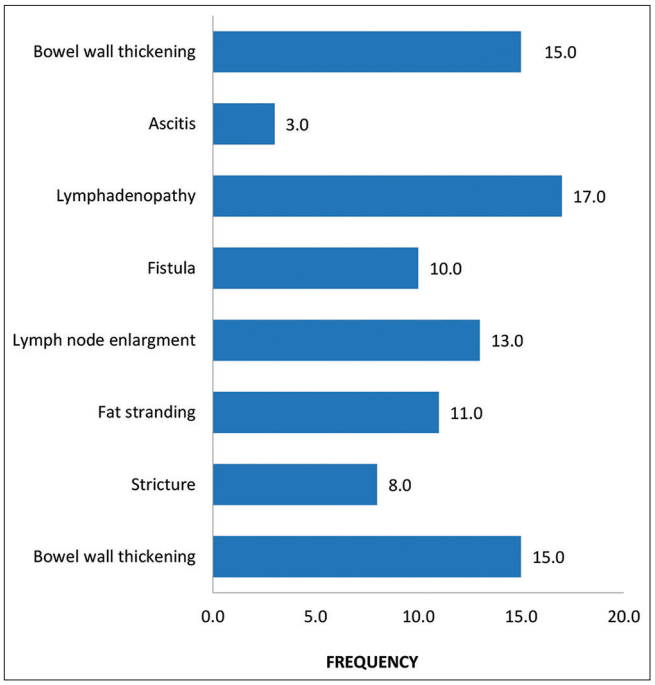


Graph 3: Distribution of symptoms/complaints

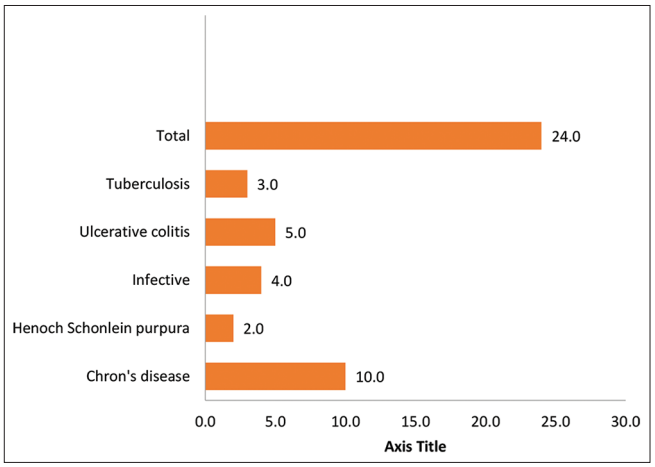


Graph 4: Distribution of bowel involvement

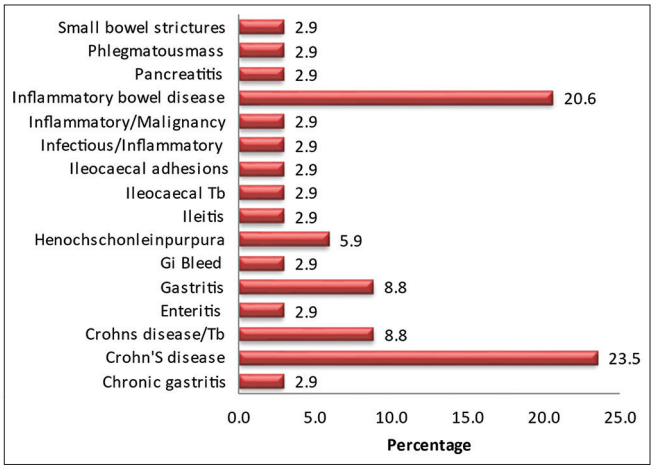
reached the ascending colon, ensuring adequate distension of the entire SB.



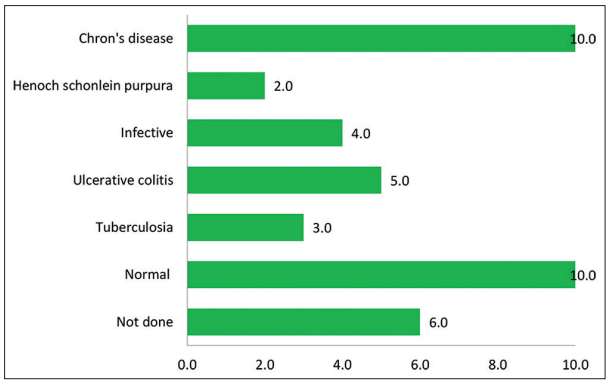
Graph 5: Distribution of radiological features



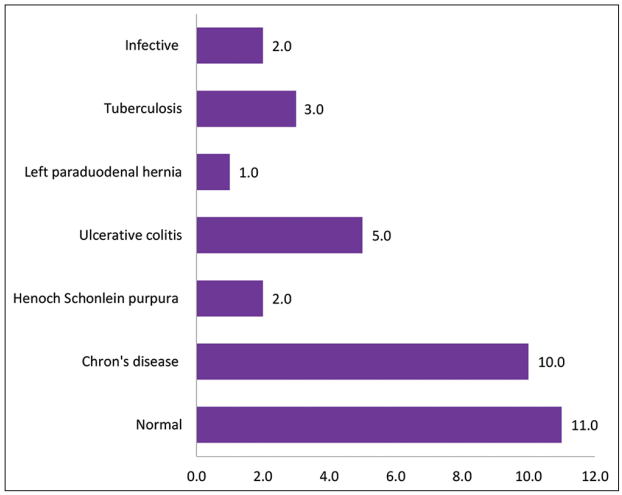
Graph 6: Number of bowel pathologies detected



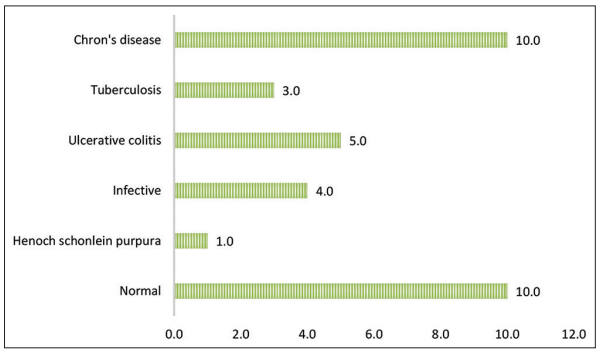
Graph 7: Frequency and percentage of clinical diagnosis



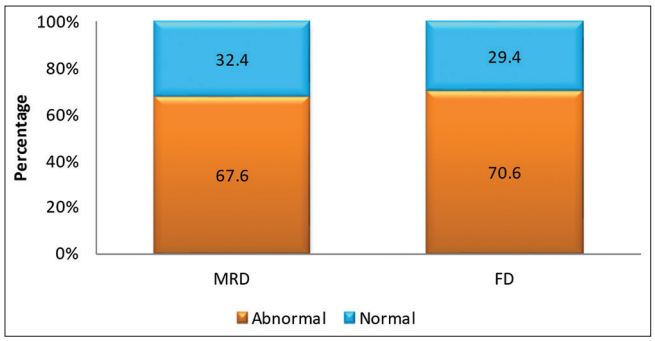
Graph 8: SCOPY and HPE diagnosis



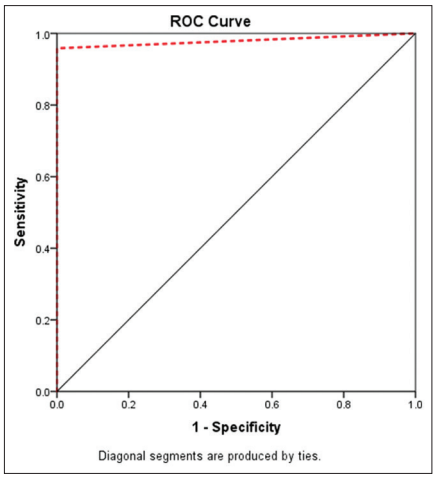
Graph 9: MR diagnosis



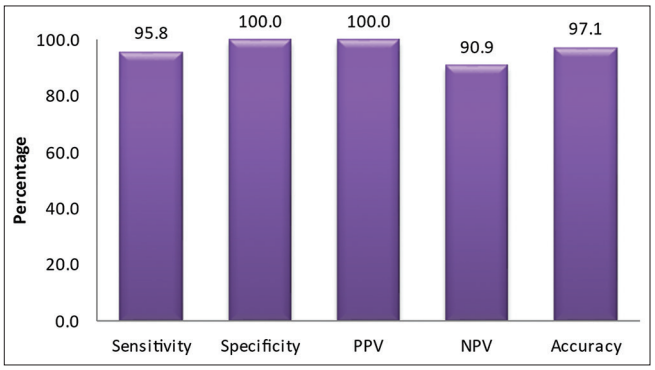
Graph 10: Final diagnosis



Graph 11: MR diagnosis versus final diagnosis



Graph 12: ROC curve



Graph 13: Efficacy of MR with final diagnosis

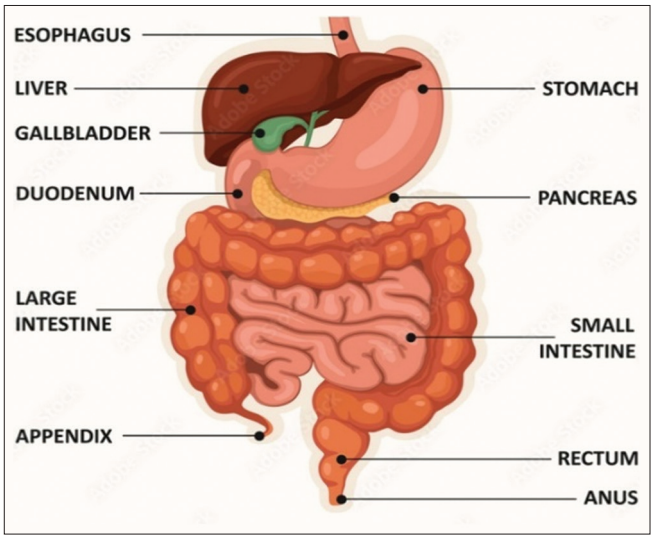


Figure 1: Digestive system

data for the patients and corroborated them with MR enteroclysis findings.

Statistical analysis was performed to compare MR diagnosis results with final diagnosis results. To describe about the data descriptive statistics frequency analysis,

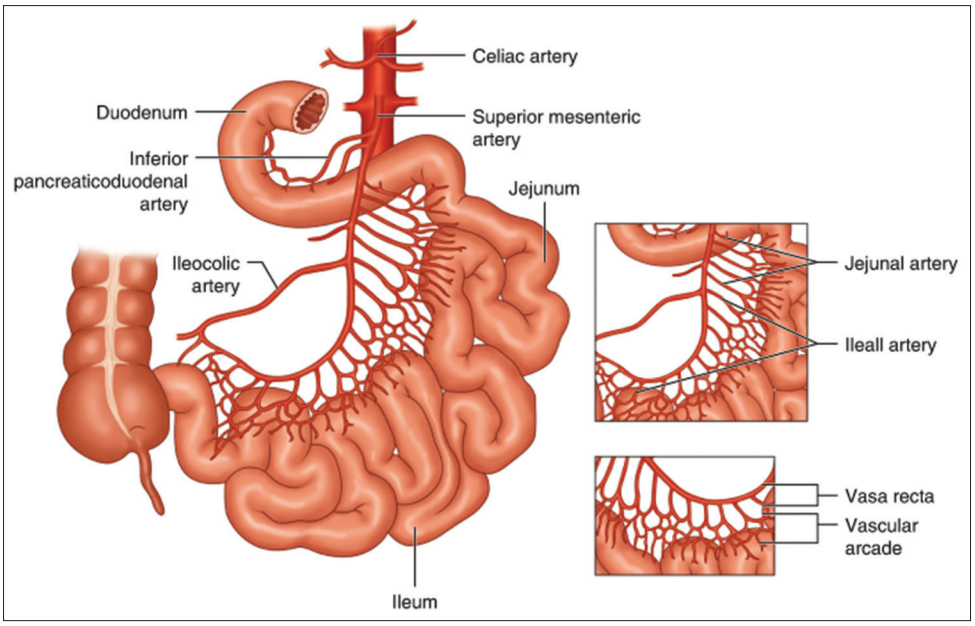


Figure 2: Anatomy of small intestine

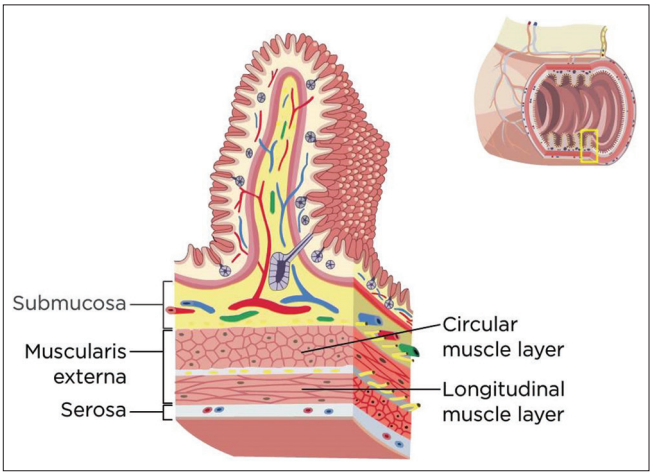


Figure 3: Layers of small intestine

percentage analysis was used for categorical variables and the mean and SD were used for continuous variables. To find the efficacy of the MR diagnosis to predict, the final diagnosis the received operating curve with sensitivity, specificity, PPV, NPV, and accuracy was used. In the above statistical tools, probability values $P < 0.05$ were considered as significant.

The following findings were observed:

Age and Gender

In this study, it was found that men exhibited a higher prevalence of pathologies compared to females [Graph 1 and 2]. The study had a slight male preponderance with 20 (58.8%) males and 14 (41.2%) females [Table 1]. The age ranges between 1 and 80 years, with the majority of patients between 21 and 30 years. In this study, it was found that individuals aged between 21 and 40 years exhibited a higher incidence of pathologies [Table 2].

Complaints

Common complaints reported by patients included abdominal pain, vomiting, weight loss, diarrhea, and loose tools with the most common complaint being abdominal pain (28 %) and vomiting (7%) [Table 3, Graph 3].

Bowel Involvement

In this study, it was observed that the large bowel was predominantly involved in the majority of cases [Graph 4].[13] The number of patients in whom only the SB was involved was 4. The number of patients in whom both the SB and large bowel were involved was 7 [Table 4].

Radiological Features

In this study, MRE revealed bowel wall thickening,[15] strictures,[8] fat stranding,[11] fistulas,[10] lymph node enlargement,[13] and ascites [Graph 5].[3] In the majority of patients, the radiological findings revealed bowel strictures, fat stranding, and lymph node enlargement [Table 5].

Number of Bowel Pathologies Detected

In this study, the total number of bowel pathologies detected was 24 [Graph 6]. The frequency of various bowel wall pathologies detected included-Chron's disease,[10] Henoch-Schonlein purpura,[2] infective,[4] UC,[5] and tuberculosis.[3] [Table 6].

In this study, MRE revealed bowel wall thickening, strictures, fat stranding, fistulas, lymph node enlargement,

and peri-anal abscess [Table 5]. In the majority of patients, the radiological findings revealed bowel strictures, fat stranding, and lymph node enlargement.

A similar study conducted by Akman *et al*., titled "A Combination of SB Imaging Methods Evaluating the Usefulness and Role of MRE," demonstrated that MRE provided significant supplemental information concerning both mural and extramural aspects. This included the evaluation of pathological wall-thickness, enhancement patterns associated with disease activity, perivisceral collections, abscess formations, mesenteric fibrofatty proliferation, lymphadenopathy, and increased perienteric vascularity. MRE did not reveal short strictures; however, for patients with a history of abdominal malignancy, MRE facilitated the characterization of obstruction levels and disease extent.

In a study conducted by Herfarth titled "Frequency and Nature of Incidental Extra-Enteric Lesions Found on MRE in Patients with IBD," a retrospective analysis was carried out on 1154 MR-E scans performed in 1006 patients. A total of 1113 extra-enteric findings were identified in 600 out of 1006 patients (59.6%). Among these findings, 180 (16.2%) were deemed to have high significance, 212 (19.0%) moderate significance, and 721 (64.8%) low significance. When analyzed by patient group, 12.0% of the findings in IBD patients were clinically significant, compared to 13.7% in patients with suspected bowel diseases (SBD) and 33.3% in those with suspected bowel malignancy (SBM). The most frequent major findings were abscesses (69.9%) in the IBD group and extraintestinal tumors, metastases, or masses in the SBD (41.9%) and SBM groups (74.2%), respectively.

CONCLUSION

The study demonstrates that MRE detects a considerable number of extra-enteric findings, underscoring its role as a valuable cross-sectional imaging modality for SB evaluation.

In a similar study conducted by A.J. Aschoff, the effectiveness of MRI in assessing intra- and extramural changes in the small intestine was evaluated. Forty patients with known or suspected SB disease underwent MR imaging immediately after conventional enteroclysis using barium and a mixture of methyl cellulose and gadolinium-DTPA.

Among 24 patients with no pathological findings on conventional enteroclysis, MRI detected intra-abdominal abnormalities such as intestinal wall thickening and abscess formation in six cases. For the remaining patients, MRI showed consistent findings compared to conventional data and provided additional valuable information about extraluminal involvement, including mesenteric lymph node enlargement, fistulas, and abscesses.

MRI, conducted using this technique, provided valuable additional information regarding intra and extraluminal changes with high image quality.

A study led by Rieber *et al*., titled "MRI in the diagnosis of SB disease: Use of positive and negative oral contrast media in combination with enteroclysis," aimed to evaluate additional MRI findings following SB enteroclysis and compare the effectiveness of positive and negative intraluminal contrast agents. The research involved 27 patients diagnosed with Crohn's disease and two patients with surgically confirmed SB tumors. In 21 patients where neither conventional enteroclysis nor MRI detected pathology, clinical follow-up (average 8.4 months, range 6–12 months) indicated spontaneous resolution of symptoms within days to weeks of presentation.

Among patients with Crohn's disease, MRI revealed mucosal changes indicating intestinal wall thickening (mean 0.8 cm, range 0.5–1.1 cm) observed during enteroclysis. All patients exhibited abnormal contrast medium uptake following intravenous Gd-DTPA administration, with segmental involvement of two (in four patients) or three (in one patient) intestinal segments. Intestinal wall thickening seen on MRI corresponded to moderate stenosis (mean 10 cm, range 2–40 cm) in all cases, often accompanied by pre-stenotic dilatation. Additional MRI findings included identification of enteroenteric or enterocutaneous fistulae in 19 patients and loop abscesses in five patients, confirmed surgically.

Comparing MRI with enteroclysis, MRI demonstrated higher sensitivity (83.3% vs. 16.7%) and diagnostic accuracy (93.3% vs. 52.6%) in detecting fistulae, with comparable specificity (100% for both). MRI also detected fat-tissue hyperplasia ("creeping fat") in 11 patients, consistent with observations during conventional enteroclysis. Minor artifacts from air bubbles were noted in 11 MRI scans, but neither positive nor negative oral contrast media-induced intraluminal artifacts.

The study concluded that MRI, particularly when utilizing T1-weighted sequences with post-contrast enhancement and fat suppression, effectively detected fistulae and abscesses. Positive oral contrast media improved the identification of abscesses between intestinal loops on T1-weighted post-contrast sequences, whereas T2-weighted sequences were necessary with negative oral contrast media due to similar signal intensities. Intestinal wall thickening was best visualized by the contrast between positive intraluminal contrast medium and inflamed intestinal wall, though this contrast was diminished by Gd-DTPA enhancement.

Overall, MRI using specific sequences and contrast agents proved superior to enteroclysis for detecting and characterizing SB diseases such as Crohn's disease, offering enhanced diagnostic capabilities for complex pathologies such as fistulae and abscesses.

Clinical Diagnosis

The majority of the patients were clinically diagnosed to have Chron's disease [Table 7].[8]

Scopy and HPE Diagnosis

In this study, the histopathological report revealed that out of 34 the majority of patients had IBD in the form of Crohn's disease[10] and UC [Graph 7].[6] The other bowel pathologies detected through HPE included infective[4] and tuberculosis.[3] The HPE report was found to be normal in about four of them [Graph 8]. The histopathological examination was not done in six of them [Table 8].

MR Diagnosis

In this study, MR diagnosis in the majority of the patients revealed Chron's disease[10] and UC.[5] The other bowel pathologies detected through MR diagnosis included infective enteritis, tuberculosis, Henoch-Schonlein's purpura, and paraduodenal hernia [Table 9 and Graph 9].

Final Diagnosis

In this study, the final diagnosis for the majority of patients was Crohn's disease[10] and UC [Tables 10-14].[5]

The study found that 33 MR diagnoses matched the final diagnosis accurately, encompassing all cases of IBD, including Crohn's disease (CD) and UC [Table 10 and Graph 10].

IBD, comprising Crohn's disease and UC, presents with characteristic symptoms such as diarrhea, abdominal pain, tenesmus, and fecal urgency for UC, while CD symptoms vary based on the site and extent of GI inflammation [Graph 11 and 12]. SB involvement in CD may lead to less typical symptoms such as fever, fatigue, and weight loss. Symptoms often fluctuate between active phases and periods of remission. Extraintestinal manifestations, such as arthritis, skin and ocular conditions, and hepatobiliary issues like primary sclerosing cholangitis, occur in a significant number of IBD patients. Children with CD may experience growth delay, underscoring the need for the early diagnosis and monitoring to mitigate potential growth impairment. Malnutrition due to malabsorption of nutrients can exacerbate symptoms in IBD.

Diagnosing IBD typically involves clinical evaluation, endoscopic findings, and histopathology. Laboratory tests such as anemia, hypoalbuminemia, and elevated inflammatory markers support diagnosis but may be normal in some patients. Imaging techniques such as upper GI series with SB follow-through, CT, magnetic resonance enterography, MRE, and capsule endoscopy are crucial for assessing disease activity and distinguishing between CD and UC.

MR imaging is particularly advantageous for evaluating the small intestine due to its lack of ionizing radiation, ability to combine morphological and functional data, excellent soft-tissue contrast, and safe contrast agent profile. MRE, specifically, enables detailed assessment of bowel wall thickness and surrounding structures, aiding in both diagnosis and staging of diseases like IBD.

Our study confirms the efficacy of MRE in detecting and ruling out SB pathologies, particularly IBD such as Crohn's disease and UC. Despite challenges with patient acceptance and longer examination times, nasojejunal administration ensures consistent and controlled bowel distension, improving examination quality compared to oral contrast methods. Coronal single-shot spin-echo sequences are valuable for assessing narrowed segments and differentiating contractions from strictures, while DW MRI provides insights into lesion characterization through apparent diffusion coefficient measurement. High interobserver agreement underscores the reproducibility of MRE for evaluating SB abnormalities.[21]

In a study conducted by Silit *et al.*, abnormalities were detected by MRE in 11 out of 19 patients (57.9%). Eight of the 19 patients (42.1%) had normal findings on MRE.

In a similar study conducted by Prassoulos *et al.*, titled "MR enteroclysis imaging of Crohn disease," 1.5–2 L of an isosmotic water solution was administered through a nasojejunal catheter to achieve bowel distension, aiding in the identification of wall abnormalities. The study employed various imaging sequences such as true FISP, HASTE, and post-gadolinium T1-weighted three-dimensional fast low-angle shot sequences in an integrated MRE examination protocol to address specific limitations of each sequence [Graph 13]. While conventional enteroclysis may better delineate superficial abnormalities, MRE accurately depicts characteristic transmural abnormalities of Crohn's disease such as bowel wall thickening, linear ulcers, and cobblestoning, particularly with the true FISP sequence. MRE is comparable to conventional enteroclysis in detecting the number and extent of involved SB segments and revealing luminal narrowing or pre-stenotic intestinal dilatation. The clinical usefulness of MRE in Crohn's disease is yet to be fully determined. At present, it may be utilized for follow-up studies of known disease, assessing disease activity, and determining the extramucosal extent and spread of the disease process.

In a study conducted by Koh *et al.* titled "MRI Evaluation of the Activity of Crohn's Disease," 23 patients were identified with active disease and seven with inactive disease. A total of 124 out of 168 bowel segments underwent assessment using both MRI and either endoscopy or surgery. On a per-patient basis, MR imaging demonstrated an overall sensitivity of 91% and specificity of 71% in detecting active disease. In comparison, the Crohn's disease activity index showed a sensitivity of 92% and specificity of 28%. On a per-segment basis, MRI achieved sensitivity and specificity rates of 59% and 93%, respectively. Criteria such as bowel wall thickening exceeding 4 mm, bowel wall enhancement (abnormal to normal bowel signal intensity ratio > 1.3:1), and increased mesenteric vascularity proved effective in identifying active disease. A layered enhancement pattern observed post-gadolinium IV administration was notably specific for active inflammation.

MRI is valuable for evaluating Crohn's disease activity and can provide assistance when clinical scoring results are inconclusive.

Kilcoyne *et al.* published a paper in 2016 titled " IBD imaging: Current practice and future directions" to evaluate the role of imaging in IBD, encompassing the detection of extraluminal complications and extraintestinal manifestations of IBD, evaluation of disease activity and treatment response, and differentiation of inflammatory from fibrotic strictures. IBD, a chronic idiopathic GI disorder, includes CD and UC as distinct yet related intestinal conditions. The paper discusses the advantages and disadvantages of various IBD imaging modalities to optimize both imaging and clinical assessment of IBD patients. Conventionally, assessing bowel involvement in IBD relied on imaging methods to examine parts of the SB inaccessible to optical endoscopy, often using barium fluoroscopic techniques. However, there has been an increasing adoption of cross-sectional imaging techniques such as CT and MRI due to their ability to assess both mural and extramural manifestations of IBD simultaneously. The article also highlights recent advancements in imaging technology that improve the ability to non-invasively monitor disease activity and treatment response. This review provides an overview of the current imaging approach in IBD and discusses the evolving role of emerging imaging modalities.

MRE serves as a minimally invasive diagnostic technique in IBD, offering multiplanar diagnostic insights into both intra- and extramural involvement of the SB. Due to concerns regarding cumulative ionizing radiation from imaging studies and the need for frequent disease activity reassessment in IBD patients, MRE is increasingly favored over CT enterography (CTE), particularly in pediatric and young adult populations. MRE involves the use of large-volume oral contrast for bowel distention along with various pulse sequences such as T2-weighted, balanced steady-state free precession, and multiphase T1-weighted fat-suppressed contrast-enhanced sequences to improve detection of bowel wall abnormalities. Biphasic MR contrast agents, which appear hypointense on T1-weighted images and hyperintense on T2-weighted images, are commonly employed, enabling assessment of bowel wall folds on T2-weighted images while preserving mucosal enhancement data on T1-weighted images. Enteric contrast agents are administered orally to ensure consistent contrast opacification of the SB throughout the examination. Unlike CT, MRE's spatial resolution poses challenges in assessing collapsed bowel loops, necessitating adequate enteric contrast for optimal distension. The total volume of enteric contrast typically ranges from 1 to 2 L over 45–60 min in adults, with adjustments based on weight for pediatric patients. Some institutions administer anti-peristaltic agents to reduce bowel motion artifact, though this approach may cause nausea in certain patients. Patient positioning during MRE varies across institutions, with supine positioning preferred for patient comfort in some settings and prone positioning favored in others to compress the bowel and shorten scan times.

MRE, akin to CTE, involves placing a nasojejunal catheter and directing the infusion of enteric contrast for uniform bowel distension. However, dynamic thick slab MRI techniques now allow contrast infusion under real-time MR guidance until adequate SB distension is achieved. Studies comparing MRE versus enteroclysis in detecting Crohn's disease have found MRE to be superior, particularly in identifying milder superficial pathology and jejunal disease.

Key disease features consistently associated with disease activity in IBD include wall thickness, mural T2 signal intensity, and post-contrast enhancement. Unlike CTE, MRE offers multiphase post-contrast T1-weighted fat-suppressed imaging, enabling the detection of mucosal hyperenhancement on enteric phase images indicative of active inflammation. Other signs of active inflammation on MRE include bowel wall thickening, ulceration, prominent vasa recta (comb sign), and mesenteric fat stranding. Cinematic steady-state free precession images are useful for distinguishing diseased bowel from normal underdistended bowel based on peristalsis. The availability of T2-weighted and multiphase T1-weighted post-contrast images in MRE facilitates distinguishing inflammatory from fibrotic strictures. Prospective studies have shown MRE to be superior to CTE in detecting fibrotic bowel strictures in Crohn's disease (CD).

This retrospective and prospective study aimed to evaluate the role of MRE in diagnosing SB pathologies. The key and main/relevant findings from this study are summarized below:

- The study showed a slight male preponderance with 20 (58.8%) males and 14 (41.2%) females.
- Patients ranged in age from 1 to 80 years, with the majority falling between 21 and 30 years.
- Individuals aged 21–40 years exhibited a higher incidence of pathologies.
- Common patient complaints included abdominal pain (28%), vomiting (7%), weight loss, diarrhea, and loose stools.
- The large bowel was predominantly involved in 13 cases, while the SB was solely involved in four cases and both the small and large bowel were involved in seven cases.
- MR enteroclysis revealed various radiological findings including bowel wall thickening (15), strictures (8), fat stranding (11), fistulas (10), lymph node enlargement (13), and ascites (3), with strictures, fat stranding, and lymph node enlargement being most common.
- A total of 24 bowel pathologies were detected, including CD (10), Henoch-Schonlein purpura (2), infective enteritis (4), UC (5), and tuberculosis (3).
- Histopathological examination revealed Crohn's disease (10), UC (6), infective (4), tuberculosis (3), normal findings in four cases, and no HPE examination done in six cases.
- MR diagnosis predominantly identified CD (10) and UC (5), along with other pathologies such as infective enteritis, tuberculosis, Henoch-Schonlein's purpura, and paraduodenal hernia.
- The final diagnosis for most patients was Crohn's disease (10) and UC (5).
- MR diagnosis matched the final diagnosis in 33 cases, yielding a sensitivity of 95.8% and specificity of 100%.

Limitations

- Low sample size

In conclusion, this study underscores MRE as an effective diagnostic tool for identifying a wide range of GI pathologies. The high prevalence of observed pathologies and the strong diagnostic accuracy of MRE highlight its clinical significance. The comprehensive imaging capability of MRE, covering both small and large-bowel segments, provides clinicians with crucial insights into pathology extent and distribution, aiding precise diagnoses and treatment planning without radiation exposure.

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