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Crohn's disease Imaging and Possible Role of Magnetic Resonance Imaging: Review article

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ABSTRACT

Background: While the terminal ileum is most commonly affected, Crohn's disease (CD) is characterized by transmural inflammation involving skip lesions that ranges from the mouth to the anus. Extraenteric symptoms of CD include painful ulceration and, in the long run, the formation of sinus tracts; these tracts can be linked to abscesses and fistulae. For both the initial diagnosis and subsequent follow-up, magnetic resonance imaging (MRI) is essential as traditional methods fail to accurately evaluate many small bowel and extraenteric diseases.

Objective: We aimed in this review article to assess Possible Role of MRI in detection of CD.

Methods: In our search for information on CD and the role of MRI, we used Google Scholar, Science Direct, PubMed, and other internet databases. Additionally, the writers combed through relevant literature for references; however, they only included research that were either very recent or thorough, covering the years from 2010 to 2023. Due of lack of translation-related sources, documents in languages other than English were excluded. Excluded from consideration were works in progress, unpublished publications, abstracts from conferences, and dissertations that did not form part of broader scientific investigations.

Conclusion: In comparison with CT enterography (CTE) as well as more conventional barium-based fluoroscopic exams (such as small bowel series as well as enteroclysis), MRI offers a number of important benefits. Irritable bowel disease (IBD) patients, who often have symptoms early in life and may need numerous imaging exams to track therapy progress, benefit greatly from MRI because it does not involve ionizing radiation.

Keywords: Crohn's disease, MRI**.**

INTRODUCTION

Transmural inflammation and skip lesions are hallmarks of CD, which can affect any part of the body (that could occur starting from the mouth to the anus) but mostly the terminal ileum. Extraenteric symptoms of CD include painful ulceration and, in the long run, the formation of sinus tracts. These tracts can be linked to abscesses and fistulae. MRI is vital for both the initial diagnosis and subsequent follow-up evaluations of small bowel and extraenteric diseases since these areas cannot be thoroughly evaluated using traditional methods **(1).**

The emergence of Crohn's disease in developing nations is closely tied to the expansion of modern lifestyles and westernization **(2)**.

Twenty-five percent of all instances of Crohn's disease manifest during childhood or adolescence, and the disease's peak occurrence occurs in the decades following puberty **(3).**

Tissue inflammation, brought on by an uncontrolled immune response to luminal bacterial antigens, is the foundation of Crohn's disease pathogenesis. In a CD patient, this process begins when immune cells invade the intestines. Natural killer cells, CD14 monocytes, B-cells, CD4 T-cells, and CD8 T-cells are all part of this category of cells. The release of mucus in the intestines is one of the immune-mediated pathways that makes people more susceptible to CD. Evidence from a mouse model suggests that CD is associated with mucus-reducing Muc2 gene variations. In addition, the condition has been linked to chemicals that mediate bacterial adhesion. A good example of this is the fucosyltransferase gene (FUT2), which produces soluble ABO antigens by secretion. Variants in FUT2 reduce antigen release, modify bacterial interaction, and increase the risk of CD in certain people **(4).**

Crohn Disease Imaging

1. Radiography:

There isn't much use for standard radiographs with barium studies when it comes to Crohn's disease. Since endoscopy may identify inflammatory changes earlier than barium enema, it has mostly supplanted it as the primary diagnostic tool. According to the appropriateness criteria set out by the ACR, it is typically not a good choice for making a first diagnosis of Crohn's disease. When making an initial diagnosis of CD, radiographs of the abdomen have their limitations **(5).**

The diagnosis of CD is made indirectly due to the restricted ability to directly observe intestinal abnormalities. In critically sick patients, radiographs can help evaluate CD consequences, such as signs of blockage or free air in a bowel rupture **(6).**

A. Aphthoid ulcers: Barium scans reveal aphthoid ulcers (seen in the image below) in 25-50% of CD patients. In cases of CD, they are seen in up to 75% of surgical specimens. When comparing endoscopy and barium examinations, the latter is somewhat better for revealing localized or few aphthoid ulcers **(7).**

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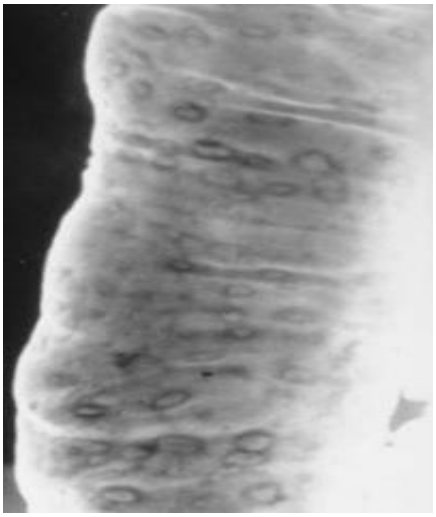

Figure (1): Aphthous sores. In Crohn's disease, a double-contrast barium enema shows many aphthous ulcers [8].

B. Cobblestoning: The creation of fissures or fistulas and deep knife-like linear clefts is the foundation of "cobblestoning" when inflammation spreads through the layers of submucosa and muscularis. They encircle radiolucent islands of mucosa that are either circular or oval in shape, and they look like a reticular network of grooves filled with barium. Reduced lumen diameter and restricted distensibility are long-term effects of transmural inflammation. The end consequence is a radiographic string sign that shows extensive inflammation and fibrosis around the perimeter, which causes the luminal constriction to extend in lengthy segments [9].

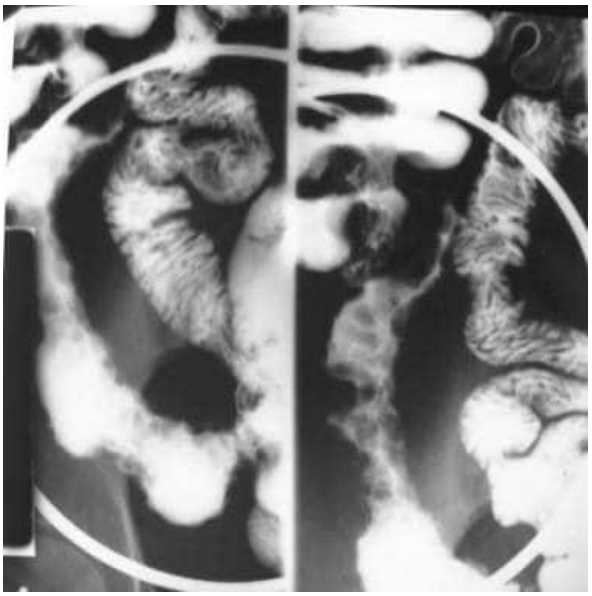

Figure (2): Crohn disease cobblestoning. A small-bowel follow-through study's spot image of the terminal ileum shows cobblestone-like linear longitudinal and transverse ulcerations.

It is worth mentioning that the terminal ileum is more affected by inflammation and fibrofatty growth on the mesenteric side, and that the implicated loop has shifted away from the typical small bowel [10].

2. Ultrasound (SBUS):

This method offers a thorough assessment of the abdominal viscera and bowel without the use of radiation and is safe and easy to tolerate. This method has been favored for younger patients who are not overweight, since being overweight makes a complete physical examination difficult. Although it requires specialized training and skill to utilize. It is still regarded as being on par with endoscopy and MRI [11].

3. Endoscopic imaging:

The most reliable method for diagnosing CD and collecting tissue samples for histological assessment is ileocolonoscopy. A diagnosis of CD can be made through endoscopic examinations that reveal skip lesions and a patchy distribution of inflammation. When looking at CD macroscopically, you may notice aphthous erosions (ulcers with a diameter less than 5 mm) or longitudinal ulcers (ulcers with a diameter bigger than 5 mm) that look like cobblestones. One indicator of disease severity is whether an ulcer is superficial or deep, defined as per the extent to which it erodes the muscularis propria. In contrast to UC, CD is associated with a lower incidence of rectal involvement and chronic inflammation over the body [12].

Although ileocolonoscopy and radiological results that were negative in the past, current guidelines suggest saving small-bowel capsule endoscopy (SBCE) for patients with a high suspicion of CD [13]. SBCE is a patient-wearable data recorder that uses a disposable capsule-shaped instrument that the patient swallows to detect mucosal abnormalities, such as small intestinal ulcers or aphthous erosions [12].

In patients with known CD (13% risk) or probable CD (1.6% risk), obstructive symptoms or stenosis increases the likelihood of capsule retention. For these cases, the gold standard for evaluation is specialized small-bowel cross-sectional imaging [13].

The invasive and time-consuming procedure known as device-assisted enteroscopy is reserved for a small subset of patients who require a histological diagnosis or who may benefit from endoscopic therapy. For small-bowel CD diagnosis, device-assisted enteroscopy is not a first-line method due to its complexity and high cost [14].

CT enterography

Despite CT's long history of use in assessing extra-enteric CD problems such bowel blockages and distensions, abscesses, and fistulas, two tweaks to the conventional abdominal CT methods have shown remarkable promise in imaging the small intestine. These methods deviate from conventional abdominal CT in a number of ways: They employ multi-detector computed tomography (MDCT) with thin slices and

short reconstruction intervals, they inject the contrast material intravenously and scan delays are utilized to optimize the gut wall development [15].

To obtain sufficient luminal distension, large amounts of enteric contrast medium are needed. Both nasojejunal tube injection and oral administration of this contrast medium are used in CT enterography (CTE) and CT enteroclysis respectively [16].

Contrast transection endoscopy (CTE) is quickly replacing other methods of diagnosing small bowel diseases because patients tolerate peroral contrast medium administration better and it produces tolerable levels of luminal distension. Extensive research has been conducted on CTE since its introduction by Raptopoulos *et al.* in 1997 to evaluate CD severity. This new imaging modality is highly effective at showing small bowel abnormalities, whether they are intraluminal, intramural, or extra-enteric and thus, it performs well as a diagnostic tool [17].

CT enterography techniques:

In contrast-enhanced tomography (CTE) procedures to detect small-bowel distention, a CT scan of the abdomen is performed during the intestinal phase following the intravenous administration of contrast agents and a mix of oral contrast agents with low-density or neutral-density [18].

1) Small bowel distension:

Before, during, and after the procedure, the patient is to drink 1.5-2 liters of oral contrast medium. The success of CTE depends on patient compliance, hence it is highly suggested that patients be encouraged and supervised during the oral phase. Some examples of neutral oral contrast agents with water-like CT attenuation properties are polyethylene glycol, 3% sorbitol, milk, and a low-density (0.1%) barium solution. Due to its rapid reabsorption, water alone usually does not give enough distension, despite the fact that it is suggested by certain researchers [16].

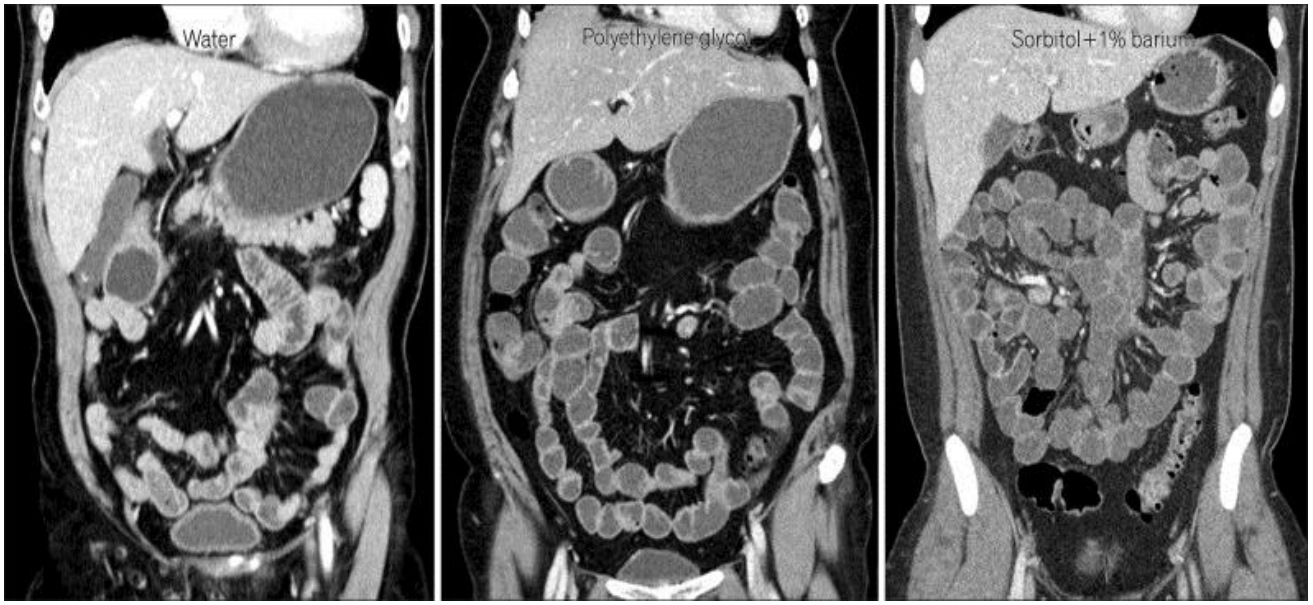

Figure (3): Many neutral enteric contrast agents were utilized. CT enterography using polyethylene glycol (in the middle image) as well as sorbitol (in the right image) that extends through small bowel, while at the CT enterography utilizing the water (in the left image) that extends through the small-bowel loop suboptimally [15].

2) Intravenous contrast agent administration: CTE exams typically involve the intravenous administration of low-osmolality iodinated contrast material through a power injector and a peripheral catheter that is 18-gauge or bigger. The standard CTE procedures performed at Seoul National University Hospital in Korea involved injecting a patient with a 555 mgI/kg iodinated contrast agent or 1.5-1.6 mL/kg contrast medium containing 350-370 mgI/mL contrast agent over a 30-second period [16].

3) CT Image acquisition: It is common practice to use sub-millimeter collimation to gather CTE pictures from the diaphragm level all the way to the perianal area. This produces an isotropic volumetric data set, which can then be used to create 3D reconstructions and 2D multiplanar reformatted (MPR) images. Using the thin section data, the primary review can also utilize thicker reconstructed 2.5-5 mm axial views, which are commonly overlaid with a 1.25-2.5 mm slice. You can produce further reformation or reconstruction images, or utilize them for problem-solving, using the sub-millimeter axial source images if necessary [16].

Though, the majority of CTE images are captured during the enteric phase (approximately 40 seconds after the injection of contrast medium begins) and the portal venous phase (approximately 70-80 seconds later), there are authors who contend that single-phase enteric- or portal venous phase CTE yields sufficient results in both adults and children while minimizing radiation exposure [(19)].

MRI

Bowel distention: Acquiring small bowel distention can be done in two ways. Both MR enterography and MR enteroclysis include the use of a nasojejunal tube to provide contrast to the digestive tract [(20)].

Oral contrast: There are a number of choices when it comes to oral contrast. The 2% Mannitol in water solution is utilized, which is well-received by patients and produces high contrast between the lumen and intestinal wall on both the T1 and T2 sequences. A word of caution: The methane gas produced by the breakdown of Mannitol should not be administered during or immediately following an MRI if the colonoscopy will involve electrocoagulation [(21-24)].

Indications: When diagnosing gastrointestinal disorders, MRI is a popular imaging method due to its long history of use. While MRI can be helpful in evaluating many gastrointestinal issues, the main reason it is used is to diagnose, track, and identify complications related to inflammatory bowel disease (IBD) [(24)].

There are a lot of advantages of MRI over computed tomography (CTE) and older, more traditional barium-based fluoroscopic tests. For patients with IBD, which often manifests at an earlier age and may have repeated imaging exams to track treatment progress, the fact that MRI does not employ ionizing radiation is a major benefit [(25)].

Compared to CTE, MRI offers better contrast resolution and multiphasic post-contrast sequences, making it more sensitive to the identification of fibrosis and hyperemia in the bowel walls, as well as providing better insights into the degree of inflammation in the small intestine [(1)].

In addition, unlike CTE, MRI may assess the motility of the small intestine using "cine" sequences, which can reveal masses, adhesions, strictures, inflammation, and other abnormalities. Last but not least, perianal fistulas, found in as many as 25% of CD patients, and any associated abscesses can be better evaluated with MRI than with CTE due to its superior soft tissue contrast resolution [(1)].

Technique:

Quick imaging methods, luminal distension, and a 6-hour fast are necessary for magnetic resonance enterography (MR enterography). For this reason, proper colonic distention is essential for post-contrastographic image detection of wall thickening and parietal enhancement. Different oral contrast agents have different effects on T1 and T2-weighted imaging, which determine how they are categorized for obtaining a well-distended lumen. Use positive contrast agents such as diluted gadolinium, certain fruit juices, or milk to achieve a high intraluminal signal. On the other hand, these chemicals can shorten T1, which means it can be more difficult to detect mucosal enhancement in T1-weighted sequences following gadolinium injection [(26)].

Negative contrast agents, like superparamagnetic iron oxide, on the other hand, establish a low intraluminal signal (low T2 and T1), allowing for a more accurate assessment of the intestinal walls [(27)].

Nevertheless, biphasic contrast agents (methylcellulose, mannitol & polyethylene glycol) are the most widely used because of their hyperosmolar action, which causes luminal distention. Also, the favorable effect of their high signal intensity on T2-weighted sequences allows for the evaluation of wall thickening. In these images, the lumen is hyperintense and the bowel walls seem hypointense. This biphasic contrast agent uses low intraluminal signal to improve the depiction of wall enhancement on T1-weighted images acquired following gadolinium injection (negative impact) [(28)].

As previously stated, MR enterography in CD is most commonly performed using biphasic contrast agents. Patients are advised to consume 1.5-2 liters of a biphasic contrast agent water solution 45 minutes before the procedure [(18)].

Reducing peristalsis and acquired abdominal volume in MR sequences, improving the separation of bowel loops, and ultimately decreasing blurring and bowel motility anomalies can be achieved by putting the patient in prone decubitus. The supine position is required for patients with abdominal stomas or entero-cutaneous fistulas, as well as those who are uncooperative. Before T2-weighted sequences and contrast media administration, it is advised to administer 20 mg of hyoscine butylbromide intravenously to further reduce intestinal peristalsis [(29)].

Phased-array coils are used in magnetic resonance enterography to enhance spatial resolution and signal-to-noise ratio while concurrently decreasing acquisition time through parallel imaging and faster sequences [(30)].

Assessment of disease activity:

Evidence from clinical, endoscopic, and histological studies has supported the use of certain MRI imaging features as biomarkers for active Crohn's disease. Consistent with previous research, thickening of the gut walls in either the small or large intestines indicates ongoing inflammation. When the intestinal wall thickness is more than 3 mm, it is often thought by many writers to be abnormal, and the severity of the disease is inversely proportional to the

wall thickness. Another marker of active inflammation is bowel wall edema, which is shown by a mural hyperintense signal compared to skeletal muscle on T2-weighted sequences [(29)].

On fat-saturation sequences, the mural T2 hyperintense signal is typically most noticeable. There is a correlation between the severity and pattern of intestinal wall augmentation and disease activity. It is possible to see normal underdistended bowel loops with diffusely elevated mural enhancement relative to normal gut, which is a sign of ongoing inflammation; however, this imaging feature is less specific than others. Research has demonstrated that early mucosal hyperenhancement during the intestinal phase is associated with mucosal neutrophilic infiltration and is a more specific indicator of active inflammation. The serosa and mucosa/submucosa complex are hyperenhanced, with an intervening hypoenhancing muscularis propria, in a layered enhancement pattern that is linked with intestinal fibrosis and active inflammation [(25)].

Standard clinical practice does not use quantitative studies of increased kinetics, despite their usefulness in predicting active inflammation. Mucosal ulceration, an unusual feature in MRI that indicates active disease in CD, can only be reliably detected with a certain amount of small bowel distention. Oussalah *et al.* found a sensitivity of 37.5%, specificity of 88.79%, and an area under the curve (AUC) of 0.631 (p = 0.0001) when they compared endoscopic signs of inflammation with mucosal ulcers seen at MRI. Mucosal ulcers on MRI are usually the outcome of more severe inflammation. This is likely due to the fact that ulcers in actively inflamed bowel loops are typically not highly visible since they are not extremely distensible [(27)].

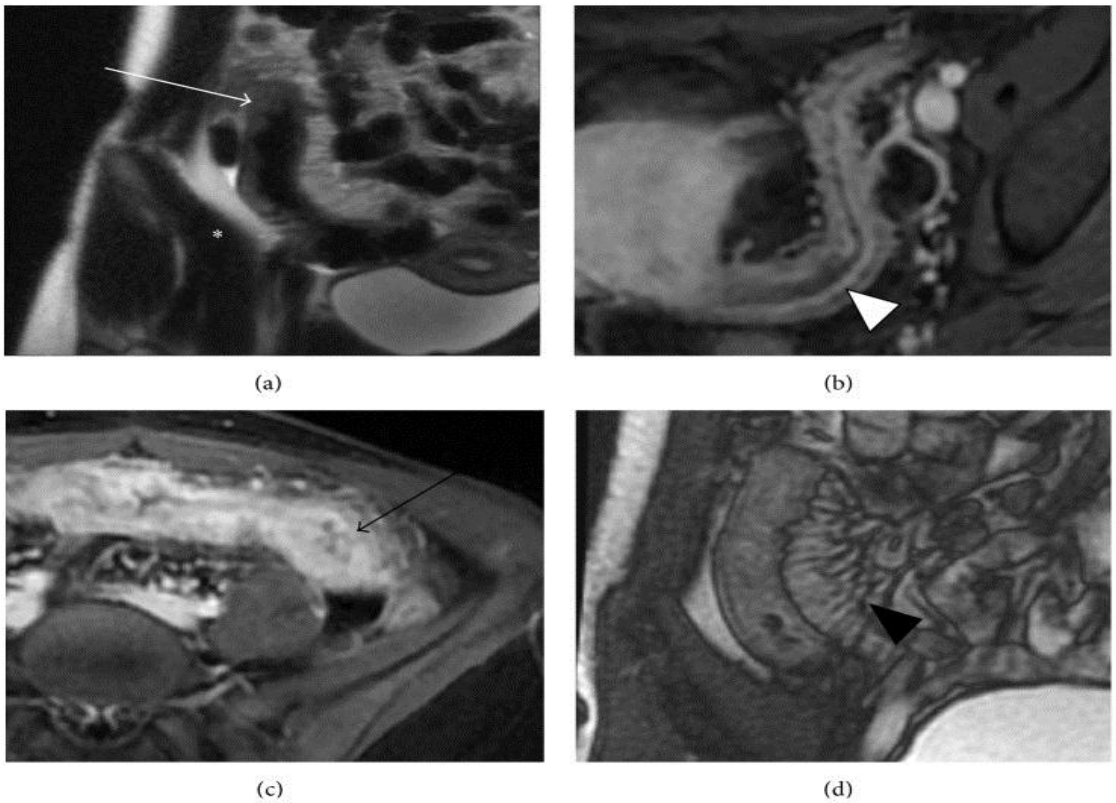

Figure (4): Signs of active CD as revealed by MR enterography. [(a) Coronal T2-weighted image showing thickening of wall (arrow), axial T1-weighted fat-suppressed postcontrast images that were collected in enteric (b) and delayed (c) phases showing early mucosal (b), arrowhead) with progressive transmural ((c), arrow) enhancement; coronal balanced steady-state free precession image (d) showing mesenteric hypervascularity (arrowhead) [(20)].

Advantages and disadvantages of MRI

When it comes to pelvic CD localization, MRI is the gold standard because it is radiation-free and another option for diagnostics. It plays a significant role in surgical planning due to its high diagnostic accuracy, capacity to examine the whole digestive system, multiplanar reconstructions, excellent imaging of soft tissues, and easy detection of problems (strictures, abscesses, and fistulas) [(16)].

Patients for whom US is inadequate (such as those who are overweight) can nevertheless benefit from the excellent visualization it provides by virtue of the panoramic image it affords the entire abdominal region, mesenteric tissue, and retroperitoneum area. Because it is time-consuming, requires specialized radiological competencies, and is costly, MRI is regrettably underutilized in clinical practice. Metal objects, claustrophobia, and MR contrast agent sensitivities are among other potential restrictions [(16)].

The use of CTE and MRI allows for the efficient and accurate evaluation of CD within the small intestine. Compared to traditional barium examinations, these imaging modalities are more accurate at detecting CD problems and, in certain cases, even better at detecting small bowel involvement. A neutral oral contrast agent must be consumed continuously by the patient for 45-60 minutes before the examination begins to guarantee adequate distention of the small intestine. Because of their equal performance in CD diagnosis and disease activity evaluation, there is continuous discussion regarding the relative benefits of CTE and MRI. However, the best imaging modality for CD patients is ultimately determined by the clinical environment **(16)**.

Due to its higher spatial resolution and capacity to define regions of bowel involvement, CTE is the preferred modality for the initial diagnosis of CD. Additionally, when patients with a history of CD present with new acute symptoms such as fever, leukocytosis, or peritoneal indications, contrast-enhanced CT is the imaging modality preferred. The CT's better capacity to identify intraperitoneal free air and its quick acquisition time led to this suggestion. Technological advancements in MRI, such as faster gradients and stronger receiver coils, will increase the robustness of radiation-free MRI, which will see more use in younger patients and those having serial and repeated imaging examinations for known CD and symptomatic recurrences. Due to the chronic and remitting nature of their condition, many young CD patients commonly have recurrent CT scans. Therefore, it is vital to reduce radiation exposure during CTE. Consequently, it is important for radiologists to be knowledgeable with methods that decrease radiation exposure. These methods include reducing the number of CT phases, appropriately shielding uninvolved organ parts, employing automated dose modulation, and utilizing iterative reconstructions to achieve low-dose CT **(16)**.

CONCLUSION

In comparison with CT enterography (CTE) as well as more conventional barium-based fluoroscopic exams (such as small bowel series as well as enteroclysis), MRI offers a number of important benefits. IBD patients, who often have symptoms early in life and may need numerous imaging exams to track therapy progress, benefit greatly from MRI because it does not involve ionizing radiation.

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