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UPDATE

Detection of inflammatory bowel disease: diagnostic performance of cross-sectional imaging modalities

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Abstract

Different cross-sectional imaging techniques can be used as a diagnostic tool for the evaluation of inflammatory bowel disease (IBD). In this report the diagnostic performances of ultrasonography, magnetic resonance imaging and computed tomography in the detection of IBD and the evaluation of known IBD are described, together with a short update on patient preparation and imaging technique of the respective modalities discussed.

Key words: Inflammatory bowel disease—Ultrasonography—Magnetic Resonance Imaging—Computed Tomography—Diagnostic performance

Introduction

Chronic inflammatory bowel disease (IBD) consists of two main subtypes, i.e., Crohn's disease (CD) and ulcerative colitis (UC). During the last decades, the incidence of CD has continued to increase worldwide, reaching incidence rates ranging from 3.1 to 14.6/100,000 in North America and from 0.7 to 9.8/100,000 in Europe [1]. Incidence rates of UC differ greatly between studies and regions, varying from 1.5 to 24.5 per 100,000 person-years [1, 2].

Crohn's disease can be localized in any part of the gastrointestinal tract, although the location of predilection is the terminal ileum, involvement of the terminal ileum is observed in 90% of the patients with small-intestinal CD, who in turn constitute 30–40% of all CD patients. In 40–55% of the patients both ileum and colon are affected, while in a minority (15–25%) only a colonic localization is observed.

The earliest change caused by CD occurs in the mucosa and submucosa and consists of hyperemia and edema. Tiny aphthoid or superficial ulcerations can be seen when disease progresses. In more severe disease, the disease extends transmurally with sometimes serosal involvement. In this stage, mucosal ulcerations merge to form deep longitudinal and transverse ulcerations while bowel wall thickening and narrowing of the bowel lumen can be observed due to significant mucosal edema and associated bowel spasms. In long-standing disease, chronic obstruction can develop due to scarring, luminal narrowing, and stricture formation. Extramural manifestations of CD are fistulas, abscesses, adhesions, creeping fat, and enlargement of lymph nodes.

Ulcerative colitis exclusively affects the colon with a predictable way of spreading from distal to proximal in a continuous manner; the rectum is often involved, but rectal sparing can be observed. In previous cases, small superficial erosions can be seen, whereas in more severe disease these ulcerations can be quite large. However, only in very severe disease they penetrate the muscularis layer. The mucosa is thickened because of round-cell infiltration in the lamina propria. In chronic UC, a marked hypertrophy of muscularis mucosae can be seen, causing contraction, shortening, and narrowing of the involved colon. The submucosa becomes thickened because of the deposition of fat or, in acute or subacute cases, edema [3, 4].

Diagnostic modalities

The gold standard examination for the small bowel traditionally has been small bowel barium examination

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Fig. 1. VCE image of a 14-year-old male patient with known CD. VCE was performed as small-bowel disease was suspected. Image shows severe inflammation of the small bowel with a stenosis.

(SBE), either by using an enteroclysis technique or by using small-bowel follow-through [5, 6]. SBE is invasive and burdensome, and requires an extensive bowel preparation (dietary restrictions, use of laxatives). Moreover, in the young population of CD patients, the ionizing radiation required for SBE limits the use of this technique for follow-up of disease.

The advent of video capsule endoscopy (VCE) and double-balloon endoscopy (DBE) has increased the diagnostic possibilities. For VCE a capsule is swallowed after a fasting period of up to 12 h and is propelled through the bowel by peristalsis. Thus, the mucosal surface of the small bowel can be depicted in detail (Fig. 1). However, with VCE there is no facility to increase visibility by insufflation of air or by tissue rinsing. Moreover, tissue sampling and therapeutic interventions are not possible. The use of VCE is contraindicated in patients with (suspicion of) obstruction due to the risk of capsule retention.

For DBE, a high-resolution video-endoscope with a flexible overtube is used. By alternately inflating and deflating two balloons attached to the overtube and endoscope the small bowel is threaded on the overtube. Both an oral and an anal approach are possible; for the oral approach no specific preparation is required, although patients are asked to fast for at least 6 h before the procedure. If the anal approach is used, bowel cleansing such as is employed for traditional colonoscopy is used. By using both the anal and oral approach, DBE allows visualization of the entire small bowel, with the possibility of obtaining tissue for analysis and the added advantage of the possibility of endoscopic therapy (e.g. dilatation of a stricture, cauterization of a bleeding site). For DBE conscious sedation is a necessity.

Traditionally, ileocolonoscopy (CS) with tissue sampling is considered to be the most valuable tool for diagnosis and follow-up of disease in the colon and terminal ileum [5, 7]. As UC solely affects the mucosa of the colon, CS would suffice for diagnosis of disease and evaluation of disease activity and extent. However, when strictures are present as a complication of disease, these might hamper execution of a complete examination, while in severe attacks of UC CS is relatively contra-indicated due to the increased risk of bleeding or perforation. For ileocolonic localizations of CD CS would suffice as well, although inspection of the terminal ileum is reported to fail in up to 27.8% of examinations [8, 9].

Cross-sectional imaging modalities

The trans- and extramural extent of IBD cannot be visualized with any of the abovementioned techniques. Much research has been directed toward the potential of cross-sectional imaging modalities for the diagnosis and evaluation of IBD as with these techniques the bowel lumen, the bowel wall and the extra-intestinal abdomen including the visceral fat, the lymph nodes and the vascular structures feeding and draining the bowel can be visualized. An added advantage of these techniques is the fact that they are limitedly to non-invasive.

Ultrasonography (US), computed tomography (CT) and magnetic resonance imaging (MRI) are often used for the evaluation of the abdomen. While in the USA the technique of choice is CT, in Europe the focus is more on MRI and US. This inclination is reflected by the majority of CT studies on IBD patients originating from the USA, while the majority of published studies on MRI and US has been conducted in Europe.

Ultrasonography

Patient preparation and US technique. Patients are usually asked to fast for several hours before the scan to diminish peristaltic movements and the amount of intraluminal air; in the available literature the minimum fasting time described is 4 h, whereas overnight fasting is also sometimes employed. Usually, no additional dietary or cleansing measures are taken. Due to the limited patient preparation necessary and the non-invasive nature of this examination, US can be considered to be a relatively patient-friendly and straightforward examination.

Ultrasonography is mostly performed without the use of enteral contrast medium. In two recent studies, the effect of enteral contrast medium for diagnosis of IBD of the small bowel was investigated; higher sensitivity values were obtained when enteral contrast medium had been administered [10, 11]. In both studies the additional value of enteral contrast medium permitted detection of jejunal lesions that had escaped detection with

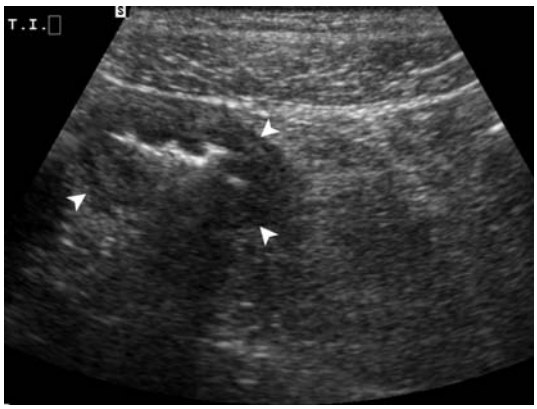

Fig. 2. A 14-year female patient with known CD and intermittent abdominal pain. US image shows the thickened wall of the terminal ileum (*arrowheads*) with some infiltration of the perivisceral fat.

conventional US. For colonic IBD, use of enteral contrast medium also increased accuracy [12, 13].

High-frequency transducers are preferred, such as 7.5 MHz [13–16].

The use of Doppler-US might provide helpful additional information on IBD, particularly on the degree of disease activity. Using Doppler-US the vascularity of the bowel wall can be assessed according to the intensity of color signals and/or by the analysis of Doppler curves (measurement of resistive index) obtained from vessels detected within the bowel wall. Measurement of flow parameters of the superior and inferior mesenteric arteries can also be performed.

Imaging criteria. The criterion that is most extensively used for the diagnosis of CD is bowel wall thickening. In most studies, the bowel wall is considered to be thickened when thickness exceeds 3 mm (Fig. 2). In a meta-analysis conducted by Fraquelli et al. [17] concerning US in CD the respective diagnostic accuracies of different cut-off values were compared; sensitivity for diagnosis of CD decreased using a cut-off value of 4 mm instead of 3 mm (from 88% to 75%), but specificity increased slightly (from 93% to 97%). Other features that are considered characteristic of CD on US are the presence of a stiff bowel wall, modification or disappearance of bowel wall stratification, presence of deep ulcers (seen as interruption of the submucosal hyperechoic rim by a hypoechoic tract), a reduction of peristalsis and loss of haustration in the colon. Extramural findings are fibrofatty proliferation, enlarged lymph nodes, and/or the presence of an abscess or fistula.

Bowel wall thickening is considered to be a characteristic feature of UC as well. Mural stratification is preserved in most UC patients due to the superficial pattern of inflammation. This feature can be used to differentiate between CD and UC, although this was not regarded sufficient for differentiation in all studies on this topic [12, 13]. In long-standing UC a tubular appearance of the colon and loss of haustration can be seen.

Diagnostic accuracy of US. Most studies regarding diagnostic accuracy of US for diagnosis and follow-up of IBD have been conducted in the last decade. Although reported sensitivity and specificity values are high, with the state-of-the-art equipment diagnostic accuracy could possibly be higher than that previously reported.

In the hands of an experienced radiologist, US can be very accurate for the detection of IBD. Reported sensitivity values of US for the detection of IBD in patients with suspected disease vary from 76% to 92% [15, 18, 19]; specificity values are also high. In patients with proven IBD, reported sensitivity values for US are higher, probably reflecting a higher index of suspicion [10, 20]. Reported segmental sensitivity values are lower; these are below 78%, even if gray-scale US is combined with power Doppler [21, 22]. Regarding the detection of extramural complications, fistulas and abscesses can be identified accurately on US [23, 24] (Fig. 3).

Although many US studies have been carried out, most concerned either CD patients or both CD and UC patients, and reported accuracy values are usually applicable for both subgroups of disease. Although in the study by Limberg and Osswald [13] separate accuracy values are provided for US and CD, it is not clear from these data if accuracy values were obtained from post hoc separation of data. To our knowledge, as of yet no prospective study has been performed with predetermined imaging parameters to differentiate between CD and UC.

Although US can be used for the assessment of both small bowel and colon, disease localized in the duodenum and jejunum is often missed [18, 19, 25]. Moreover, the rectum and distal sigmoid cannot be visualized accurately due to their pelvic location. This makes US less suitable for the assessment of UC.

Doppler US has been proved useful in assessing whether IBD is in an active phase or in remission; significant correlations were found between Doppler parameters and disease activity, both in UC [26] and in CD [27]. However, the only distinction made was between active and inactive disease, meaning no conclusions can be drawn about the severity of active disease from these data. As of yet, there is no standardized scale to determine the degree of disease activity on US, neither for CD nor for UC.

The spatial resolution of US is not high enough to permit the detection of superficial pathology, making this modality less suitable for the diagnosis of early diseases when compared with SBE. Although SBE can reportedly be highly accurate when performed by skilled radiologists [28, 29], compared with VCE or DBE its sensitivity

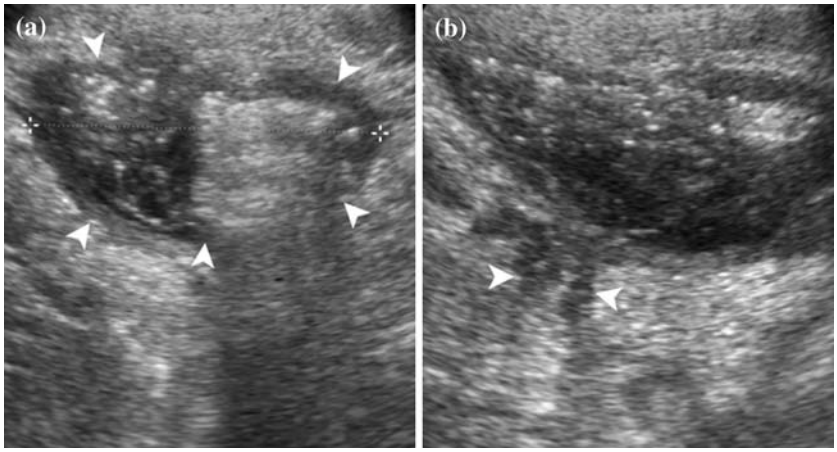

Fig. 3. A 25-year-old female patient with known CD of the terminal ileum. **A** US image shows a large abscess (*arrowheads*) that was located ventrally and cranially of the bladder. **B** US image shows a fistula (*arrowheads*) that originated from the abscess.

is low [30]. In this regard, comparison between US and VCE and/or DBE might be very interesting in order to determine the accuracy of US for small lesions and accuracy for bowel segments that are difficult to access. To our knowledge, no comparative studies have been performed as of yet.

Computed tomography

Patient preparation. Patients are usually asked to fast for several hours before the scan to diminish peristaltic movements [31–33]. In addition, in some institutions a bowel-cleansing regimen is applied, as a rule consisting of mild laxatives. Dietary restrictions are also often applicable. Although with this bowel preparation residual feces are usually present to some degree, the mural presentation of disease enables the identification of disease even if the bowel wall is partly obscured.

There is consensus as to the indispensability of enteral contrast medium for an abdominal CT examination for IBD. The contrast medium of choice should be neutral (meaning an attenuation value comparable with water), as a neutral contrast medium allows optimal distinction between bowel wall and lumen. While in some institutions enteral contrast medium is administered orally (CT enterography), in other institutions controlled distention is achieved by inflow of contrast medium through a nasojejunal catheter (CT-enteroclysis). Although by some authors CT-enteroclysis is propagated as the controlled infusion provides a more consistent distention of the small bowel than CT-enterography, especially of the jejunum [34], others report that with the right choice of contrast medium and correct timing of intake excellent distention of all small bowel loops can be obtained after the oral administration of contrast medium [31, 33]. In only one small study, CT enteroclysis and CT enterography were compared, but both the degree of luminal distention and the diagnostic accuracy did not show significant differences [35].

Imaging technique. Technical developments have allowed the widespread use of multi-slice scanners. With these scanners volumes can be scanned in a very short breath hold, allowing the acquisition of isotropic voxels for multiplanar reformatting. Thin slices should be used to permit the detection of subtle pathology.

Before CT enterography sometimes metoclopramide is given to increase gastric emptying and peristaltic movements of the small bowel [31]. The use of antiperistaltic drugs is not standard. In a recently published update on CT enteroclysis, Rajesh and Maglinte [32] report that in their institution all patients undergoing CT enteroclysis receive conscious sedation. Although this most probably decreases patient discomfort to a large degree, this can considerably increase the in-hospital time for patients as they will have to stay in a recovery unit after the procedure until the anesthetic effects have worn off.

Intravenous contrast medium should be administered for a comprehensive CT examination of the bowel. In a recent study, the optimal timing of scanning after the administration of intravenous contrast medium was determined; Schindera et al. [36] found that peak mural enhancement of normal small-bowel wall occurs on average about 50 s after contrast administration or 14 s after peak aortic enhancement.

Imaging criteria. The main feature considered indicative of both CD and UC is bowel wall thickening. Whereas in earlier studies cut-off values for pathological bowel wall thickening have varied between 2.5 mm and 10 mm, in recent publications of experts in the field bowel wall thickness exceeding 3 mm is described as pathological [31, 33] (Fig. 4). Mural thickening is not seen in early superficial disease, precluding CT from being a first-line examination for (suspicion of) superficial disease.

Increased bowel wall enhancement after the administration of intravenous contrast medium is also considered as an indicative of active disease [37–39]. Whereas in

Fig. 4. A 60-year old female patient who underwent CT enterography for suspected bowel obstruction. Just 1 month earlier at ileocolonoscopy CD of the terminal ileum was discovered; the terminal ileum was not intubated because of the stenosis. Axial image shows the severely thickened bowel wall of the ileum (*arrowheads*) with only a pinpoint bowel lumen remaining.

earlier studies the only distinction regarding enhancement was between pathological enhancement (i.e., hyperenhancement) and normally enhancing bowel walls, in a recent publication the degree of mural enhancement was found to correlate with disease activity [38].

Bowel wall enhancement can be transmural, but also layered. This layered enhancement pattern, which is represented by a thickened intestinal wall with a middle layer of low attenuation surrounded on each side by layers of higher attenuation, has been termed the target sign; this is due to the presence of edema or the deposition of fat in the submucosa.

Diagnostic accuracy of CT. The accuracy of CT has mainly been investigated for small-bowel disease. In suspected CD sensitivity was 83% when compared with SBE [40]. When compared with ileoscopy sensitivity values vary from 80% to 88% [34, 35, 41]. Segmental sensitivity of CT was somewhat lower (71.8%) in a study by Molnar et al. [42], comparing CT with SBE and CS.

Superficial lesions (such as aphthoid lesions) are not accurately visualized on CT, making CT less suitable as a first-line examination for the suspicion of mild disease. This was already evident from studies comparing CT with CS and/or SBE, but in a recent meta-analysis comparing CT with VCE was shown that the yield of CT compared with the yield of CE was 30% vs. 69% [43]. No comparative studies have been published regarding CT vs. DBE.

Extramural complications are well shown on CT, although the lower contrast resolution of CT makes this modality less suitable for the detection of fistulas and abscesses than MRI in patients with CD [44] (Fig. 5). In a recent study, the relationship between increased attenuation of perivisceral fat and disease activity was determined; one of the most specific markers of active disease was increased attenuation in the perivisceral fat [37].

Hardly any studies have focused on the accuracy of CT colonography for the detection of ileocolonic IBD. This is possibly partly due to the fact that for the rectal administration of contrast medium the rectum is obscured by the rectal catheter, precluding diagnosis of rectal IBD, specifically UC. It does seem clear that CTC is unable to detect ulcerative lesions; even diffuse inflammation with large ulcerations can be missed. CTC might however be useful in patients with colonic stenosis or narrowing [45, 46].

Magnetic resonance imaging

Patient preparation. While in some studies on MRI a period of several hours of fasting was deemed sufficient, in others full bowel cleansing was performed, as the reference standard, (i.e., CS) was performed on the same day. There is no consensus yet as to what constitutes the optimal bowel preparation for MRI. However, as a limited bowel preparation does not seem to negatively affect accuracy, it might be sufficient to limit the bowel preparation to a fasting period taking into account the patient-friendliness of the respective preparations.

Luminal distention by means of use of enteral contrast medium is indispensable for an adequate evaluation of the bowel as collapsed bowel can hide or mimic disease. As was the case with CT, for MRI of the small bowel contrast medium is either administrated by mouth or by enteroclysis. An advantage of MR enteroclysis over MR enterography is the fact that it allows fluoroscopic monitoring of the inflow of contrast medium and thereby provides functional information on bowel distensibility. An advantage of MR enterography is the fact that it can be considered more patient-friendly and also that no ionizing radiation is necessary. To our knowledge, only one study has been carried out in which both methods of contrast medium administration were compared. In this study by Schreyer et al. [47] all patients (n = 21) underwent both MRI enterography and MRI enteroclysis; no difference in accuracy compared with SBE was noted by the investigators (Fig. 6).

Whereas for MR enteroclysis mostly a methylcellulose suspension is used, for MR enterography many different contrast media have been tested. The main subdivision is between positive, negative, and biphasic contrast media. A biphasic contrast medium performs best for the identification of pathology on both T2-and T1-weighted sequences as adequate delineation between hypointense bowel wall and hyperintense lumen is seen on T2-weighted sequences while on T1-weighted images the enhancing bowel wall can be easily discriminated from the hypointense lumen. An artificial sugar-solution

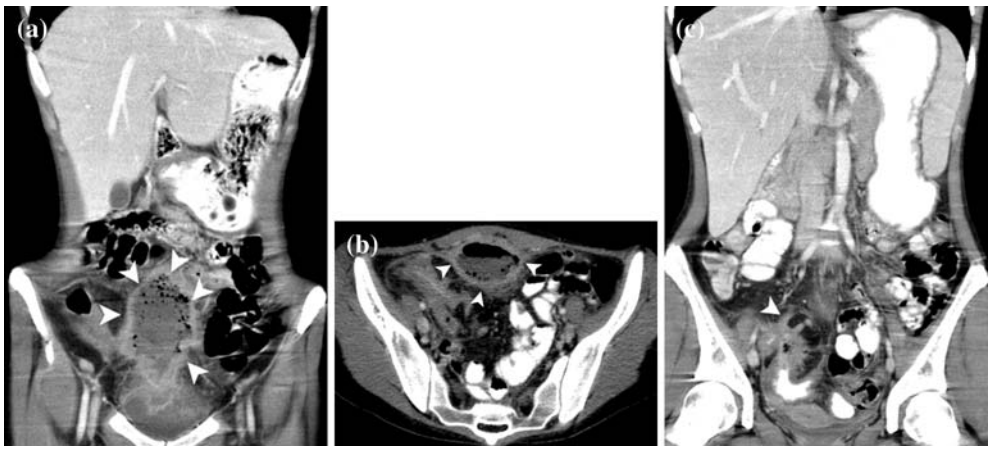

Fig. 5. A 25-year-old female patient with known CD of the terminal ileum (same patient as pictured in Fig. 3). A CT-scan was performed to determine involvement of the small bowel. **A** Coronal image shows the abscess (*arrowheads*). **B** Axial image again shows the abscess again (*arrowheads*). **C** Coronal image shows the fistula (*arrowhead*).

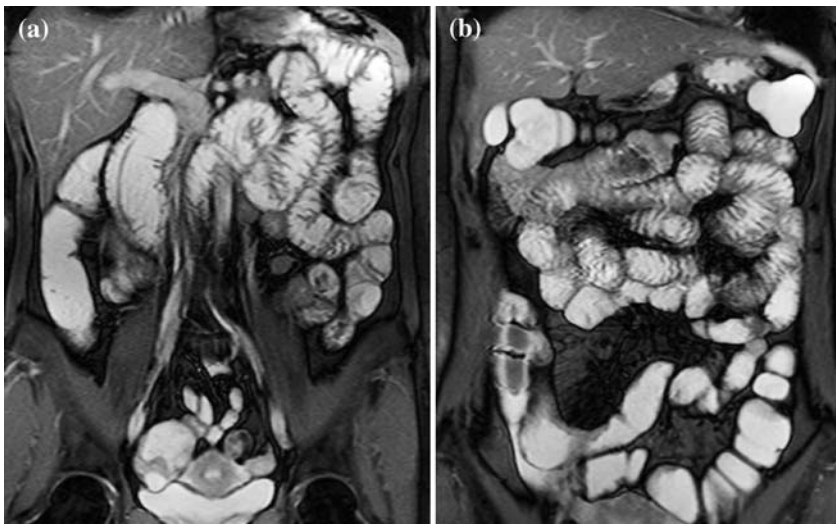

Fig. 6. **A** A 38-year-old female with complaints of vomiting and an iron-deficiency anemia who was suspected of CD and underwent MRI-enteroclysis to evaluate the small bowel. Coronal TrueFISP image shows good distention of jejunal bowel loops after controlled infusion of contrast medium. **B** A 12-year-old male patient with known CD who underwent MR enterography for the evaluation of the small bowel. Coronal TrueFISP image shows good distention of jejunal bowel loops after oral administration of contrast medium.

(mannitol or sorbitol) has been shown to cause good distention of small bowel loops with negligible side effects [48, 49].

Imaging technique. Mostly, both T2-weighted and T1-weighted sequences are used for the MRI evaluation of the bowel. On T2-weighted images the bowel wall can be appreciated and bowel wall stratification—if present—can be well apprehended. As feces can show bright signal intensity on T1-weighted sequences, it is important to perform a pre-contrast T1-weighted sequence in order to be able to determine whether high signal intensity was already present before intravenous contrast administration, indicating the presence of stool.

Another sequence that is propagated by many authors is the TrueFISp sequence, a sequence that is insensitive to motion and breathing artifacts. This sequence, that makes use of a T2/T1 ratio, adequately delineates the bowel wall and the mesentery, allowing adequate assessment of disease (Fig. 7). When combining a T2-weighted sequence or TrueFISP sequence and a T1-weighted sequence, a comprehensive MRI examination can be carried out in less than 30 min.

Imaging criteria. A bowel wall thickness exceeding 3 mm should be considered as an indicative of disease. Besides bowel wall thickening the most important criterion indicative of active IBD is pathological bowel wall enhancement after the administration of intravenous gadolinium. Bowel wall enhancement can always be seen as the bowel is a highly vascularized structure. However, in active IBD increased enhancement can be observed, due to the increased vascularization and the increased capillary leakage of the affected tissue (Fig. 8). In CD it has been hypothesized that the degree of enhancement correlates with the degree of disease severity, but this statement has not been extensively corroborated [50–53].

Bowel wall stratification can be observed on T2-weighted images as a bright line within the two dark stripes of the mucosal and muscularis propria layers, likely related to the presence of fat or edema in the submucosal layer. On fat-suppressed T2-weighted images

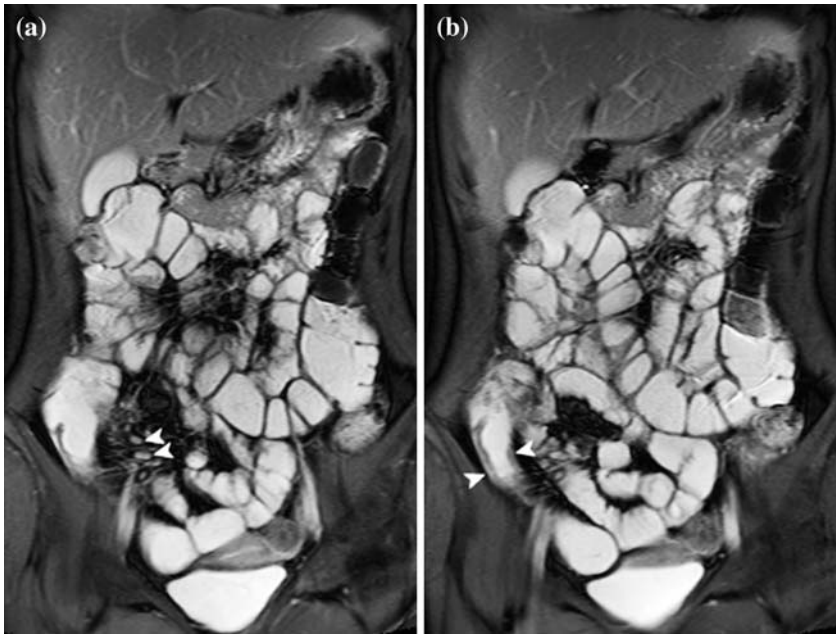

Fig. 7. A 18-year-old female patient with known CD. MRI-enterography was performed for suspicion of active CD of the neoterminal ileum. **A** Coronal TrueFISp image shows enlarged mesenteric lymph nodes (*arrowheads*). **B** Coronal TrueFISP image shows thickened bowel wall of the neoterminal ileum (*arrowheads*).

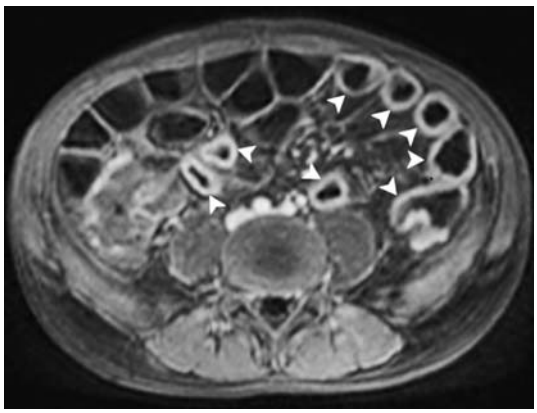

Fig. 8. A 12-year-old male patient with known CD who underwent MR-enterography for the evaluation of the small bowel (same patient depicted in Fig. 6b). Axial T1-weighted image shows pathological enhancement of thickened small-bowel loops after administration of intravenous contrast medium (*arrowheads*). Approximately, 1 m of small bowel (terminal jejunum, proximal ileum) was shown to be affected.

it is possible to determine the nature of the bright signal as a persistent bright signal suggests the presence of edema, whereas complete suppression of the submucosal signal suggests fat infiltration and quiescent disease [54].

Extramural manifestations of disease that can be identified on MRI are fistulas, abscesses, fibrofatty proliferation, and enlarged lymph nodes.

Diagnostic accuracy. The accuracy of MRI of the small bowel has been extensively investigated. In many European institutions, conventional enteroclysis is increasingly being replaced by MRI enteroclysis or MRI enterography as MRI has proved to be highly accurate in both the detection of disease in patients with known IBD as in patients in whom IBD of the small bowel was suspected [52, 55, 56]. However, the studies that have been performed were mostly small and concerned selected populations with either a high suspicion of disease or known CD of the small bowel. Larger studies including the full spectrum of disease activity should be conducted.

As was the case with CT and US, MRI is not suitable for the detection of superficial disease due to the limited spatial resolution. This finding is corroborated by a study comparing MRI and VCE in patients with CD [57]. Significantly more inflammatory lesions were detected with VCE in the jejunum and partly in the ileum of patients with CD. However, these findings had no effect on the therapeutic approach of the individual patients. The accuracy of MRI has not been compared with DBE as of yet.

As mentioned before, MRI can be used for the evaluation of extramural disease. Due to the high contrast resolution abscesses are very conspicuous on T1-weighed fat suppressed images after the administration of intravenous Gadolinium. MRI is also very sensitive for the detection of fistulas [47, 52, 58] (Fig. 9).

In recent years, the accuracy of MRI for the detection of ileocolonic IBD has been investigated by means of MRI colonography. After administration of rectal contrast medium the colon (and sometimes the terminal ileum) was assessed for disease. Conflicting results were reported: while in one study high accuracy values were reported [59], in others segmental sensitivity values were around 32% [60, 61].

Regarding the accuracy of MRI in differentiation between CD and UC conflicting results have been re-

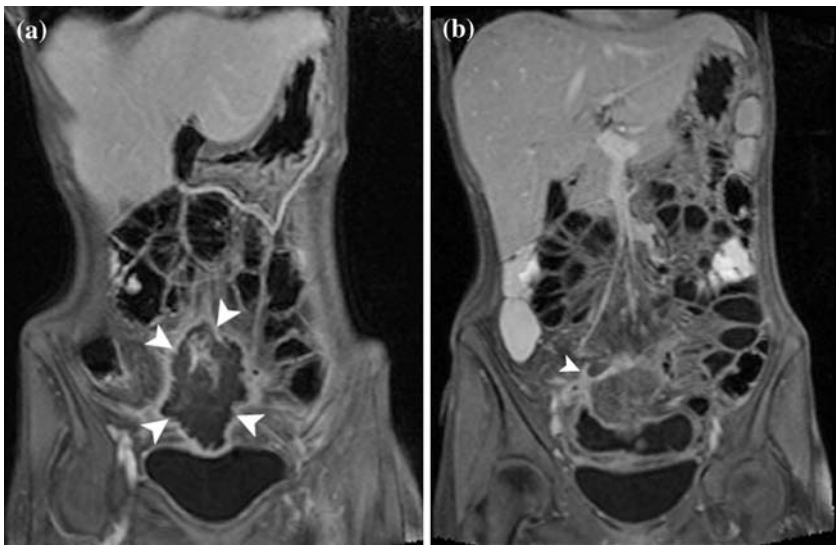

Fig. 9. A 25-year-old female patient with known CD of the terminal ileum (same patient as pictured in Figs. 3 and 5). **A** Coronal T1-weighted image clearly shows the abscess (*arrowheads*) that was also depicted on US and CT. **B** Coronal T1-weighted image showing a fistula

ported; while some authors report that based on the location of inflammatory changes, the degree of involvement, the continuity or discontinuity of disease, and the presence of complications it was possible to differentiate between CD and UC [51, 62], others report a limited value in differentiation of disease [63].

Theoretically, a whole-bowel examination would be possible with MRI, by the administration of contrast medium orally and rectally. This has been attempted [64, 65] and was deemed feasible. More research is needed to establish the diagnostic value of this combined approach. At the moment, MRI colonography does not seem to be able to replace CS.

Discussion

Compared with conventional imaging methods, CT, US, and MRI are accurate methods for the detection of IBD of the small bowel, both in patients suspected of disease as in patients with known IBD. Although subtle lesions cannot be depicted with any of these modalities, clinically more relevant findings can be accurately depicted. Therefore, cross-sectional imaging should be incorporated in a comprehensive clinical evaluation of suspected IBD and for follow-up of CD. The exact role cross-sectional imaging techniques can play for follow-up in UC should be more extensively studied.

As US is easily accessible, widely available, and inexpensive, it is recommended to use abdominal US as first-line modality in patients with suspected IBD of the small bowel. MR enterography would be a good alternative, especially as the assessment of the degree of disease activity can be better performed on MRI than on US. Although CT enterography is a very accurate technique and is used in many institutions, its role in IBD is limited by the ionizing radiation needed, especially due to the repetitive use for follow-up in often young individuals. If possible, it might be advisable to reserve this technique for patients in whom imaging is needed at very short notice as CT enterography can be performed very fast and is readily available.

Although VCE has shown to be more accurate in depicting subtle lesions in the small bowel than MRI or CT, its role should be limited as of yet as the true benefit of VCE is not clear yet. As there are presently no standardized criteria for the diagnosis of CD with VCE, definitions with regard to what constitutes a positive finding might differ between studies. Moreover, the clinical significance of finding a single mucosal break or a few superficial aphthous lesions is not clear yet. Also, specificity and positive predictive values for VCE have not been established. At this time, it might be good to reserve VCE as a second-line modality if cross-sectional imaging has not shown abnormalities but the suspicion of disease remains standing despite these negative findings.

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