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OVERVIEW

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Diagnostic imaging in Crohn's disease: comparison of magnetic resonance imaging and conventional imaging methods

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Abstract Conventional enteroclysis remains the method of choice in the diagnosis of inflammatory small bowel disease. The reported sensitivity rates, however, for the diagnosis of extraintestinal processes, such as fistulae and abscesses, are moderate. Computed tomography (CT) is the method of choice for the diagnosis of extraintestinal complications. The anatomical designation of the affected bowel segment may, however, prove difficult due to axial slices, and the applied radiation dose is high. The use of magnetic resonance imaging (MRI) in the diagnosis of inflammatory small bowel disease is a relatively new indication for the method; prerequisites were the development of breathhold sequences and phased array coils. Optimized magnetic resonance tomographic imaging requires a combined method of enteroclysis and MRI, which guarantees an optimal filling and distension of the small bowel. The high filling volume leads to a secondary paralysis of the small bowel and avoids motion artifacts. In a trial of 84 patients with histological and endoscopic correlation the sensitivity in diagnosing inflammatory bowel disease was 85.4% for enteroclysis and 95.2% for MRI, and the specificity was 76.9% for enteroclysis and 92.6% for MRI. As none of the abscesses was diagnosed with enteroclysis, the sensitivity was 0% for enteroclysis, but 77.8% for MRI. The sensitivity in diagnosing fistulae was 17.7% for enteroclysis and 70.6% for MRI. In summary, MRI can detect the most relevant findings in patients with inflammatory small bowel disease with an accuracy superior to that of enteroclysis.

Keywords MRI · Abdomen · Crohn's disease · Inflammatory small bowel disease

Introduction

Magnetic resonance imaging (MRI) has found increasing application in cases of inflammatory bowel disease since the middle of the 1990s [1]. Although establishing itself as the imaging method of choice in the diagnosis of complex perianal fistula systems, its role in the work-up of inflammatory diseases of the small bowel is practically nonexistent [2, 3]. Not until recently have procedural refinements made the potential application of the method in the routine clinical work-up of Crohn's disease a matter for serious discussion.

Fundamental principles of MRI diagnostics

As with computed tomography (CT), MRI is a cross-sectional imaging technique. However, MRI exhibits certain advantages over CT, such as superior tissue contrast, the absence of radiation exposure, and the ability to selecting various cross-sectional planes (transverse, coronal, sagittal). The major drawback in comparison with CT is the significantly poorer resolution of MRI. Hence the basic prerequisite for the useful application of MRI in the work-up of small-bowel disease entities was the development of improved sequences and dedicated ab-

dominal coils. The currently available sequences permit examination in breath-hold technique or with respiratory triggering. The construction of better body surface coils has resulted in improved detail resolution of even minor morphological changes.

As is the case with ultrasound and CT-based diagnostic procedures, detection of inflammatory bowel disease using MRI depends on the visualization of circumscribed areas of thickening of the intestinal wall. This visualized thickening of the bowel wall is correlated with changes in the small bowel identified in pathological and histological examination [1]. Recent studies have shown that procedural refinements have increased the ability of MRI to provide data which supplement clinical and endoscopic findings [4, 5, 6, 7, 8, 9, 10]. This is true particularly when MRI is combined with conventional Sellink enteroclysis [5, 9, 10]. This is the basis of the so-called "magnetic resonance Sellink," a term which is becoming routine in clinical jargon. This method, which is described in the present report, provides the optimum prerequisites for MRI examination and, by permitting comparison of MRI and conventional imaging findings, allows confirmation of the method.

Technique

The first step is conventional enteroclysis. Following transnasal intubation the tip of the duodenal catheter is advanced to the vicinity of the ligament of Treitz. Once the catheter is placed, monocontrast is achieved by administering 800 ml barium sulfate solution. Double contrast is then achieved by the administration of 1200 ml methyl cellulose solution mixed with a positive or negative MRI contrast medium at a proportion of 1:10. Negative MRI contrast media results in the lumen of the small bowel appearing "black" or lacking all signal intensity in MRI, while positive contrast media produce increased signal intensity, with a "white" appearance of the small bowel lumen. Following completion of conventional enteroclysis and documentation of findings, patients receive 20 mg *N*-butyl scopolamine bromide intravenously (Buscopan, Boehringer, Ingelheim, Germany) to reduce bowel peristalsis. Thereafter patients undergo MRI.

Axial and coronal sections are acquired in MRI. The axial images resemble those of CT while the coronal images correspond to findings of enteroclysis. First, T1-weighted sequences are obtained in breath-hold technique. It is in these that the thickening of the intestinal wall is best identified. Next, T2-weighted sequences, also in breath-hold sequence, are acquired; these are particularly well suited for detecting abscesses, whose central, fluid-containing region displays high signal intensity, appearing bright white. Thus the method's sensitivity in detecting abscesses is particularly high in T2-weighted images. Thereafter coronal and axial T1-weighted sequences are again acquired following intravenous administration of gadolinium DTPA. Because inflamed small bowel segments display significant contrast medium uptake, such images provide useful data regarding local sites of inflammation.

The combination of conventional enteroclysis and MRI provides for optimum distention of the intestinal lumen and homogeneous distribution of contrast medium, leading to adequate visualization of the region of interest. This creates the optimum conditions for detecting both intra and extraluminal changes (Fig. 1) [5].

Findings in the literature

Shoenut et al. [1, 6] published the first report on the role of MRI in diagnosing Crohn's disease. These researchers showed not only that MRI is highly sensitive in the primary work-up of suspected cases of Crohn's disease, but also that the degree of contrast medium uptake is correlated significantly with the histological extent of the inflammation [6]. In the latter point, MRI was superior even to endoscopy [6].

Since the middle of the 1990s there have been increasing efforts to establish a role for MRI in the diagnosis of Crohn's disease. At first, MRI proved inferior to enteroclysis, showing a sensitivity of only 70% in detecting inflammatory small bowel changes in a study by Rollandi et al. [7]. This was due, among other factors, to insufficient contrast of the bowel, particularly the terminal ileum. The introduction of oral MRI contrast media significantly improved the results of abdominal MRI examinations. According to Kaminski et al. [8], 62% of pathological abdominal lesions were more clearly demarcated following oral bowel contrasting than in native sequences. To further improve the contrast of the intestine, it was then attempted to combine MRI with conventional enteroclysis, with the difference that methylcellulose, which forms an obligatory element of enteroclysis, is mixed with an oral MRI contrast medium [9, 10]. In addition to comparable results for enteroclysis and MRI in the primary diagnosis of Crohn's disease (sensitivity 95.8–100% for MRI), studies have demonstrated the superiority of MRI in diagnosing extraintestinal complications specific to Crohn's disease [9, 10]. In a study by Holzknecht et al. [10] MRI yielded additional findings in 33% of cases which escaped even retrospective detection by enteroclysis.

Particularly desirable would be the exclusive use of MRI, avoiding enteroclysis. Of interest in this regard is the experience of Schunk et al. [11]. The so-called "hydro-MRI," which uses no oral MRI contrast medium but only dilute methylcellulose solution, has the disadvantage that intraluminal liquid and the contents of abscesses show the same signal intensities in both T1- and T2-

Fig. 1a,b A 47-year-old woman with Crohn's disease. **a** Evidence of severe stenosis of the terminal ileum at enteroclysis. **b** Coronal, T1-weighted MRI. In addition to the stenosis, MRI shows evidence of multiple small fistulae into mesenteric adipose tissue

weighted sequences, with potential negative effects on the sensitivity of the method in the diagnosis of abscesses.

Our findings

MRI has become widely accepted at the University Hospital of Ulm. Nearly 200 patients with suspected or confirmed Crohn's disease have been examined. Technique and study designs have been described in prior reports [5, 9, 12] (D. Wruk, unpublished data). The study designs were approved by the institutional ethics committee, and informed consent was obtained from all patients who participated. We present a short summary of these reports [5, 9, 12] (D. Wruk, unpublished data). Clinical findings are compared with those obtained at conventional enteroclysis and, if available, surgical findings.

Crohn's disease was present in 117 of 194 patients. MRI identified a thickening of the intestinal wall of 5–10 mm (mean 7.7) in all patients with concomitantly increased contrast medium uptake following intravenous contrast medium administration. In 26 patients MRI identified segmental involvement of the small bowel, which in 19 cases escaped detection by enteroclysis. The length of stenosis ranged from 2.5 to 15 cm (mean 9.4) and corresponded to the findings in conventional enteroclysis. In 35 patients with severe stenoses there was significant prestenotic dilatation.

MRI was also significantly superior to conventional imaging techniques in the diagnosis of fistulae and abscesses (Fig. 2). For example, MRI identified fistulae in 33 patients and abscesses in 12 which had escaped detection by enteroclysis. In a subgroup of 84 patients whose findings were confirmed either histologically or as a result of surgery, MRI detected chronic inflammatory changes in the small bowel with a sensitivity of 95.2%, compared with 85.4% for enteroclysis. The corresponding specificities were 76.9% for enteroclysis and 92.6% for MRI. In no case did enteroclysis detect abscesses; hence its sensitivity stood at 0%, compared to 77.8% for MRI (correct positive results in seven of nine patients). For fistulae, sensitivities were 17.7% for enteroclysis and 70.6% for MRI (correct positive results in 12 of 17 patients; see Table 1). There were therefore some fistulae and abscesses which were not visualized even by MRI. Responsible in most cases for false negative findings were conglomerate tumors in which the presence of inflammatory small bowel adhesions impeded the diagnosis of enteroenteral fistulae and abscesses (D. Wruk, unpublished data).

Table 1 Comparison of enteroclysis and MRI (*n*=85, histological and endoscopic correlation)

	Sensitivity (%)		Specificity (%)	
	Enteroclysis	MRI	Enteroclysis	MRI
Inflammatory bowel disease	85.4	95.2	76.9	92.6
Fistulae	17.7	70.6	–	–
Abscesses	0	77.8	–	–

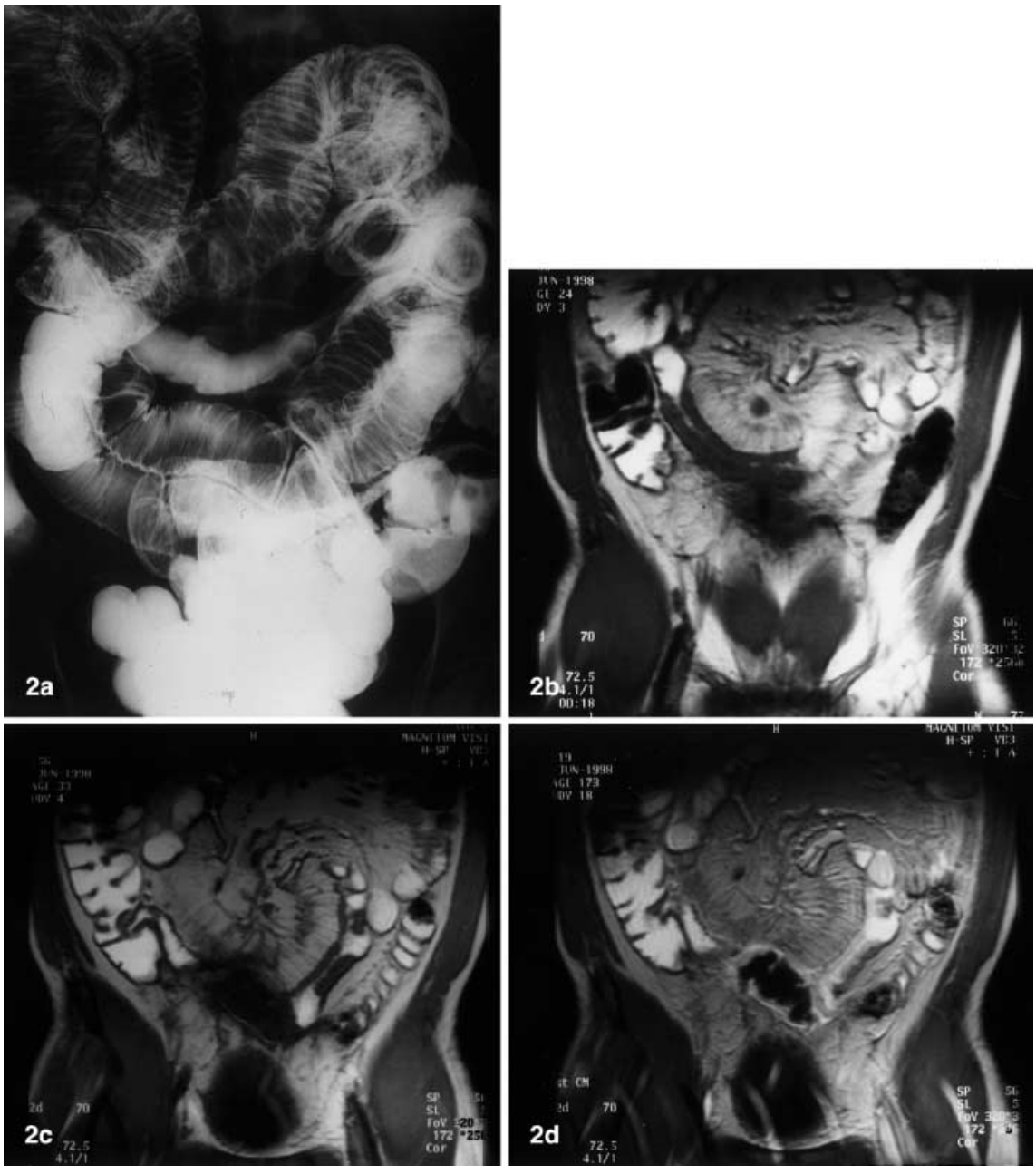

Fig. 2a–d A 38-year-old man with Crohn's disease. **a** Involvement of a long segment of an ileal loop in the mid-abdomen at enteroclysis. **b** Coronal, T1-weighted; significant thickening of the bowel wall in the inflamed small bowel loop. **c** Coronal, T1-weighted MRI 5 mm further ventrally; evidence of a low signal intensity lesion in the mid-abdomen and an additional bowel segment in the left mid-abdomen with thickening of the intestinal wall. This segmental involvement was not detected, even retrospectively, in the findings from enteroclysis. **d** MRI following intravenous administration of gadolinium DTPA. The pattern of contrast medium uptake clearly indicates the presence of an abscess

Comparison with conventional techniques

Enteroclysis

Enteroclysis using double-contrast remains the gold standard in the work-up of both inflammatory and malignant diseases of the small bowel since its entire length is not accessible to endoscopic examination [13, 14]. Disadvantages of the method include the radiation exposure (reported in the literature as averaging 6000 cGy/cm^2) and the fact that trans- or extramural changes may escape detection altogether [13, 14, 15]. Despite these lim-

itations, findings published in the literature suggest a sensitivity of up to 100%, with a specificity as high as 98.3% and a diagnostic accuracy reaching 99.3%; these publications, however, show some problems with the verification of the findings [16, 17]. On the other hand, practically no reliable data are available regarding the sensitivity of enteroclysis in the diagnosis of fistulae and abscesses. Whether the reported sensitivity and specificity of enteroclysis must be corrected on the basis of competing data from MRI, as is implied by the findings of the present study, remains to be determined in future investigations.

Ultrasound

Inflammatory disease in small bowel segments is associated with thickening of the intestinal wall; this is reliably visualized by diagnostic ultrasound, particularly in the terminal ileum. The sensitivity of ultrasound in diagnosing Crohn's disease is reported to be between 67% and 96% (average around 80%) [18, 19, 20]. Problems with ultrasound include questions regarding its objectivity, the difficulty in quantifying sonographic findings, particularly the length of affected bowel segments, visualization of segmental involvement, and the detection of extraintestinal complications of the disease [18, 19, 21, 22]. In a study published by Maconi et al. [18] the diagnosis of abscesses which had not spread retroperitoneally was possible in five of six cases using ultrasound (sensitivity: 83.3%) while enteroenteral fistulae were detected with a sensitivity of 50%. To date no study has directly compared the results of ultrasound with those of MRI.

Computed tomography

As with ultrasound, the diagnosis of Crohn's disease using CT depends on the detection of thickening of the intestinal wall, which is present in 100% of patients in acute phases of the disease [23, 24, 25]. Although CT provides reliable data regarding the presence of Crohn's disease and, because of its ability to evaluate the entire abdomen, is highly sensitive in detecting extraintestinal complications, CT remains an adjuvant, not alternative, technique to enteroclysis in cases in which extraluminal complications of the disease, such as an abscess, are suspected (Fig. 3) [24]. This is because, in addition to the unavoidable radiation exposure to the patient, the anatomical correlation of the acquired images is often difficult, since they are acquired only in an axial plane.

Kolkman et al. [26] compared CT with granulocyte scintigraphy in 32 patients and found that the sensitivity and specificity of the former were 71% and 98%, respectively. CT diagnosed abscess with 100% sensitivity and fistulas with 80% sensitivity (specificity: 100%). A prerequisite for correct CT diagnosis is ensuring contrast of the small bowel, which requires the intake of at least 1000 ml oral contrast medium. In addition, patients should receive ca. 100 ml iodine-containing contrast medium intravenously to improve tissue contrast. Intestinal contrasting can be optimized further by administering the contrast medium through a duodenal catheter [25]. In this case the barium solution must be greatly diluted to avoid artifacts. Because of the significant number of barium artifacts encountered at the high concentrations necessary for conventional enteroclysis, a combination of CT and enteroclysis, analogous to the method described above, is impossible [5].

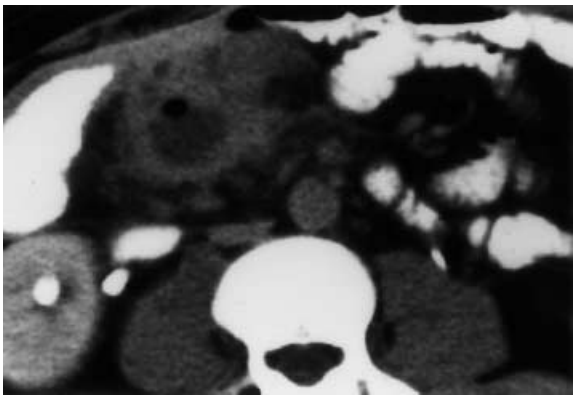

Fig. 3 CT in a 42-year-old man with Crohn's disease and a loop abscess

Future prospects

Data published to date suggest that MRI has the potential to assume an important role in the routine diagnosis of Crohn's disease, since clinically relevant findings have higher sensitivity and specificity when this method is used. One requirement would be that MRI be able to completely replace enteroclysis without the requirement for combined use of the two methods [11]. This possibility is currently being investigated in running clinical studies. At present MRI of the abdomen is of proven efficacy in the follow-up of confirmed Crohn's disease [5, 10, 11, 27].

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