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Research article

Backwash ileitis in ulcerative colitis: Are there MR enterographic features that distinguish it from Crohn disease?

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ABSTRACT

Objective: To reveal the MR enterography (MRE) findings that distinguish backwash ileitis (BWI) from terminal ileitis due to Crohn's disease (CD) and to determine the usability of barium studies manifestations (ileocecal valve (ICV) gaping, terminal ileum dilatation) in MRE for the diagnosis of BWI in ulcerative colitis (UC) patients by pointing at the diagnostic performance of these imaging findings.

Subjects-methods: The study population consisted of patients who were diagnosed as ulcerative colitis (UC), and underwent 1.5 T MRI between August 2011 and November 2017 to rule out small bowel involvement. The matched controls were comprised of Crohn's patients examined at the same period. Ileocolonoscopic/ histopathologic findings were accepted as reference standard. Mural/extramural changes in bowel segments, ileocecal valve (ICV) gaping, terminal ileum dilatation, restricted diffusion and anatomical extent of involvement were evaluated. In UC patients, the association between ICV gaping and terminal ileum dilatation and BWI was assessed by $\chi 2$ test. The diagnostic accuracy of these two findings in BWI was determined.

Results: Sixty patients were included in the study (30 UC; 30 CD; mean age, 43 years in both groups). Ileocecal valve gaping and terminal ileum dilatation were significantly more frequent among BWI patients ($p < 0.001$) in UC. Patients with BWI showed a higher rate of pancolitis (88.9%). Median terminal ileum wall thickness was found to be significantly greater in patients with CD ($p < 0.001$).

Conclusion: In patients with definite diagnosis of UC, ileocecal valve gaping and terminal ileum dilatation suggest the development of BWI. However, these findings cannot be use to differentiate cause of terminal ileitis in patients with unconfirmed diagnosis and do not give reliable information about the causative factor of ileitis.

1. Introduction

The term inflammatory bowel disease (IBD) denotes a genetically, immunologically and histopathologically heterogeneous group of disorders with various systemic and extraintestinal manifestations [1]. Two major phenotypes of IBD are ulcerative colitis (UC) and Crohn's disease (CD) that are clinically and prognostically distinct from each other. Imaging findings, endoscopic studies, and histological data, together with clinical assessment, can be used to help distinguish these two forms, determine prognosis, assess disease activity, and to inform treatment decision-making [2].

Intubation and biopsy of the terminal ileum during colonoscopy has become a standard procedure in the evaluation and management of patients suspected or known to have IBD [3,4]. In about 25% of patients with UC, the distal few centimeters of terminal ileum is found to be inflamed [5,6]. An abnormal appearance of the terminal ileum observed radiologically or endoscopically in patients with UC [6] is originally named as backwash ileitis [BWI). The pathogenesis of this disorder is uncertain but may relate to reflux of colonic contents into the terminal ileum, hence the term "BWI". Classically, this ileitis is considered to occur only in the presence of extensive/pancolitis [7–9] but there are evidences that the ileitis in UC may also represent primary ileal mucosal inflammation [10]. Although very rare, it is also shown that few UC patients with BWI may have "only left-sided colonic disease" [11].

Backwash ileitis, once, has been an identifiable disorder at barium

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studies (both in double contrast colon enema and small bowel follow through). It may be manifested by a widely patent ileocecal valve (ICV) with persistent dilatation of terminal ileum. The mucosa may have granular appearance. Ulcerations are not common. Stenosis of the ileocecal valve is not seen and the cecum is a normal caliber. Cobblestoning and strictures do not occur [5,6].

In UC patients suspected of having BWI, MRE may be an alternative diagnostic option for the evaluation of terminal ileum. Limited coverage of conventional endoscopic techniques in the small bowel and the possibility of overlook of ileal lesions in both ileocolonoscopy and histopathology [3,10] may be the other reasons for performing MRE in UC. While the incidence of IBD has increased over years and MRE has become indispensable method in assessing patients with IBD, BWI seems to remain underdiagnosed with this technique. MRE appears to have the potential for identifying ileal changes in UC with BWI [12], however, there is limited literature on this subject. Therefore, the purpose of this study is to determine whether the major findings of BWI at conventional barium studies (i.e. ICV gaping and terminal ileum dilatation) can be adapted for MRE method, and to assess the usefulness of these findings for diagnose BWI in UC.

2. Materials and methods

2.1. Ethical considerations

This retrospective study was approved by the institutional review board with waivers of the informed consent.

2.2. Study population

From the RIS/PACS (Radiology Information System/Picture Archiving and Communication System; Centricity 5.0 RIS-i, GE Healthcare) of our institution, the patients in whom MRE was performed between December 2011 and September 2017 and whose MR reports were diagnosed as UC were initially identified by one of the authors (A.E.). Clinical reports, laboratory data, endoscopy and histopathology results of these patients were obtained from the hospital information system. Their demographic and clinical characteristics were documented and their definite diagnosis were determined. Patients older than 18 years of age and patients in whom ileocolonoscopy / histopathology results were available were included in the study. Patients with indeterminate colitis and patients whose MRE examinations were recorded as suboptimal (due to conditions such as motion and metal artifacts and insufficient bowel distention) in MR reports were excluded from the study. The study group consisted of 30 patients diagnosed as UC. Again, the patients in whom CD was suspected at MRE during the same interval, were identified from the PACS. Out of these cases, the patients with definite diagnosis of CD was determined from the medical records. The CD patients with upper abdominal penetrating complications (internal fistulization, mesenteric sinus), abscess formation, and stricturing disease with varying degrees of intestinal obstruction were excluded from the study. Thirty Crohn's patients, manually matched to UC patients by age and gender, constituted the control group. During matching for age, the age difference was accepted as maximum ± 3 years.

2.3. MR Enterography technique

Patients fasted for at least 6 h prior to imaging. An enteric contrast agent which was composed of at least 1500 ml drinking water and 125–130 mL of lactulose solution (Osmolak 667 mg 250 ml or Duphalac 670 mg/ml) was administered orally to maintain small bowel distention. Patients were instructed to drink this solution over a period of 45 to 60 min before undergoing MRE. To ensure the consistent bowel distention, the patients consumed approximately 550 ml aliquots of the solution at every 20 min (a total of 3 doses) before the scanning. Just before entering the scanner, the patients were asked to drink an additional 500 ml of water for distention of the duodenum and proximal jejunum. At the beginning of the examination, immediately after cine imaging, patients were given intravenous (IV) 0.5 mg of glucagon to reduce motion artifacts arising from bowel peristalsis. Towards the end of the examination, a second 0.5 mg IV dose of glucagon was administrated prior to 3D fat-suppressed contrast – enhanced GE T1- weighted sequence which is most likely to be affected by the intestinal peristaltism artifacts.

MR enterography was performed at a 1.5 T scanner (Optima 450 w, GE Healthcare). The patients were scanned in the prone position using a dedicated phased array torso coil. The following protocol was utilized for the assessment of the small bowel: cine imaging with 2D balanced steady state free precision [SSFP; FIESTA] sequence; TR/TE, 3,9/1,6 ms; flip angle, 60°; matrix size, 224 × 320; slice thickness, 6.0 mm; gap, 0.5 mm); sagittal single-shot fast spin-echo (SSFSE) (TR/TE, 1200/85 ms; matrix size, 320 × 192; slice thickness, 5.0 mm; gap, 0.0 mm)), coronal SSFSE (TR/TE, 1200/85 ms; matrix size, 320 × 192; slice thickness, 3.5 mm; gap, 0.0 mm), axial SSFSE (TR/TE, 1,200/85 ms; matrix size, 320 × 192; slice thickness, 5.0 mm; gap, 1.0 mm), axial fat-suppressed FSE (TR/TE, minimum/100 ms; matrix size, 320 × 224; slice thickness, 5.0 mm; gap, 1.0 mm), coronal heavily T2-weighted thick slab (SSFSE) (TR/TE, minimum/minimum; matrix size, 480 × 256; slice thickness, 40 mm; gap, 0.5 mm), and coronal heavily T2-weighted thin slices (SSFSE) (TR/TE, minimum/100 ms; matrix size, 320 × 256; slice thickness, 3.5 mm; gap, 0.0 mm). After the IV administration of 0.2 ml/kg of gadolinium chelate at an injection rate of 2–3 ml/s, dynamic images including precontrast, arterial, enteric (45–50 seconds after initiating injection of contrast agent) and equilibrium phases were acquired in coronal plane with 3D fat-suppressed GE T1- weighted (LAVA-flex) sequence. (TR/TE, 2.1 ms/not open; flip angle, 12°; matrix, 440 × 396; slice thickness, 3.2 mm; gap, 0.0 mm). Parallel imaging with a reduction factor 2 was used for cine FIESTA and all contrast-enhanced sequences. The table time for MR enterography was approximately 40 min.

2.4. Endoscopy

All patients underwent ileocolonoscopy under sedation or anaesthesia. One day prior to the procedure, bowel preparation was achieved. For each patient, an independent gastroenterologist (blind to the MRE findings) performed the endoscopy using the standard technique. Terminal ileum was intubated and mucosal biopsy samples were obtained in patients who are technically suitable for the procedure. Ileocolonoscopy and MR enterography examinations were performed within 2–6 weeks of each other.

2.5. MRI data analysis

After determination of the eligible patients for the study, the names and protocol numbers of 30 UC and 30 CD patients were written on separate papers by a person who is not an author of this study and names were selected by drawing lots by two other authors (D.K.Ö and A.G.Ç). The MRE images of the randomly selected patients were retrospectively evaluated at the PACS monitor in a blinded manner without knowledge of whether they were from a patient with CD or a patient with UC.

All MR enterography findings were analyzed with consensus by two observers. The following imaging findings were evaluated for this current study: intestinal wall thickness (≥ 3 mm was considered abnormal), mural edema, mural hyperenhancement (assessed in images acquired at enteric phase), mural fat deposition, pseudopolyp formation, comb sign, ICV gaping, terminal ileum dilatation, restricted diffusion in intestinal wall and anatomical extent of involvement. ICV gaping was defined as constantly wide-open appearance of the ICV orifice which has normally slit-like morphology. Although there is no

consensus for a maximum diameter of terminal ileum under normal conditions, it was considered dilated when it measures ≥ 19 mm [13].

Even though the examinations were not intended for colonic evaluation, detectable colonic features of UC and CD were identified and analyzed. The length and location of involved colonic segments were recorded. The morphologic features used to establish a MRE diagnosis of UC [14,15] included colonic wall thickening, uniform and continuous involvement of the colon without gross skip areas, mural enhancement of colonic wall after contrast medium injection, mural "stratification", loss of haustration, development of inflammatory pseudopolyps, colonic submucosal fat deposition, rectal or left- sided involvement, widening of the presacral space (extramural fat proliferation in perirectal space), and absence of sinus or fistul tracts. UC is divided by disease extent into proctosigmoiditis, left-sided colitis, extensive colitis and pancolitis. The type of UC was accepted as proctosigmoiditis when the inflammation was confined to the rectum and rectosigmoid colon [16]. Left-sided colitis was defined as inflammation extending from the rectum proximally to the splenic flexure [17]. Colitis was accepted as an extensive type when inflammation was present proximal to the splenic flexure [18]. The pancolitis was diagnosed when UC spreaded throughout the large intestine from cecum to rectum [19]. The patients were considered to have BWI when endoscopic and/ or histological inflammation that extends from the cecum continuously into the terminal ileum in a UC patient with extensive colitis or pancolitis [8,9].

MRE diagnosis of CD was made based on a combination of the following features [14,15]: typical segmental nature of bowel involvement with skip areas, mural thickening (in both small bowel and/or colon), heterogeneous enhancement of the bowel wall resulting in a "target" appearance, ulcerations (irregularity and deep depressions at mucosal surface), "cobblestone" appearance in intestinal mucosal surface (depressions separated by islands of mucosal projections), mural edema, luminal spasm associated with bowel wall thickening, inflammatory pseudopolyps in chronic cases, fibrostenotic lesion, luminal retraction, and formation of pseudodiverticula and sacculations of the bowel wall. Mesenteric findings associated with CD including fibrofatty proliferation, perienteric inflammatory stranding, perienteric free fluid, "the comb sign"(enlarged mesenteric vascular branches traversing the mesenteric fat to penetrate the muscularis propria of the diseased bowel),and significant mesenteric lymph node enlargement were also used to making the MRE diagnosis of CD, but only the findings indicated in second paragraph of this section were statistically analyzed as study parameters. Presence of any situation associated with IBD (primary sclerosing cholangitis, perianal fistula) were noted. As mentioned above, the patients with abdominal complications (sinus tracts, internal/ enterocutaneous fistulas, abscesses and fibrotic strictures associated with varying degrees of obstruction) were not included in the study.

2.6. Statistical analysis

The analysis was performed using IBM SPSS for Windows version 11.5 (SPSS, Chicago, IL, USA). Descriptive statistics summarize all study variables of interest. Normally distributed continuous variables were expressed as mean ± standard deviation while the continuous variables that do not have normal distribution were expressed as median (minimum-maximum). Also categorical variables were summarized as counts (percentages).

Agreement between MR enterographic and histopathologic diagnosis was calculated using kappa statistics. Agreement was interpreted as follows: 0–0.2 = poor agreement; 0.30.4 =fair agreement; 0.5–0.6 = moderate agreement; 0.7–0.8 =strong agreement; and > 0.8 =almost perfect agreement.

Comparisons of non-normally distributed continuous variables between UC and CD groups were performed using 'Mann Whitney-U test'. In UC patients, the association between major findings of BWI defined for conventional barium studies (ICV gaping and terminal ileum dilatation) and BWI was assessed by chi-square test. The diagnostic accuracy of these two findings in BWI was also determined. The significance level was set at a p value of less than 0.05.

Table 1
Comparison of colonic findings detected at MRE in the ulcerative colitis and Crohn's disease patients.

Findings	Ulcerative colitis		Crohn's disease		p value
	Frequency	(%)	Frequency	(%)	
Wall thickening					
Rectum	21	70	5	16.7	< 0.001*
Sigmoid colon	21	75	7	25	< 0.001*
Descending colon	16	53.3	6	20	0.007*
Transverse colon	15	50	7	23.3	0.032*
Ascending colon	11	36.7	8	26.7	0.405
ICV	6	21.4	21	70	0.001*
Mural edema					
Rectum	19	63.3	2	16.7	< 0.001*
Sigmoid colon	20	66.7	4	13.3	< 0.001*
Descending colon	13	43.3	6	20	0.052**
Transverse colon	10	33.3	5	16.7	0.136
Ascending colon	11	36.7	5	16.7	0.080
ICV	3	10	18	60	< 0.001*
Mural Hyperenhancement* **					
Rectum	18	62.1	5	17.2	< 0.001*
Sigmoid colon	20	69	7	25	0.001*
Descending colon	14	48.3	5	17.2	0.012*
Transverse colon	12	41.4	5	17.2	0.043**
Ascending colon	9	31	6	20.7	0.368
ICV	4	13.8	19	65.5	< 0.001*
Mural fat deposition					
Rectum	7	23.5	0	0	0.011*
Sigmoid colon	7	23.3	0	0	0.011*
Descending colon	5	16.7	2	6.7	0.466
Transverse colon	4	13.3	0	0	0.112
ICV	2	6.7	7	23.3	0.145
Diffusion restriction					
Rectum	9	42.9	2	13.3	0.077
Sigmoid colon	11	52.4	3	20	0.049**
Descending colon	8	36.4	3	20	0.442
Transverse colon	5	22.7	2	13.3	0.677
Ascending colon	7	31.8	2	13.3	0.262
ICV	3	13.6	8	53.3	0.025*
Comb sign					
Sigmoid colon	15	50	4	13.3	0.002*
Descending colon	14	46.7	5	16.7	0.012*
Transverse colon	11	36.7	4	13.3	0.037*
Ascending colon	6	20	5	16.7	0.739
Loss of haustration					
Sigmoid colon	22	73.3	4	13.3	< 0.001*
Descending colon	22	73.3	4	13.3	< 0.001*
Transverse colon	19	63.3	3	10	< 0.001*
Ascending colon	8	26.7	3	10	0.095
Pseudopolyps					
Sigmoid colon	8	26.7	0	0	0.005*
Descending colon	9	30	1	3.3	0.006*
Transverse colon	5	16.7	0	0	0.052**
Ascending colon	3	10	0	25	0.237
ICV gaping	6	20	3	10	0.472

Note._*Statistically significant results, ** At the limit of statistical significance
ICV = ileocecal valve.
***Enhancement in enteric phase.

3. Results

The study included 30 UC patients (mean age, 43.7 ± 13.3 years, range 18–70 years). Eighteen of the patients were male (60%) and twelve were female (40%). The control group consisted of 30 Crohn's

Table 2
Comparison of MRE findings in terminal ileum between ulcerative colitis and Crohn's disease patients.

Findings	Ulcerative colitis		Crohn's disease		p value
	Frequency	(%)	Frequency	(%)	
Wall thickening	2	6.9	24	80	< 0.001*
Mural edema	1	3.3	22	75.9	< 0.001*
Mural hyperenhancement**	0	0	22	75.9	< 0.001*
Diffusion restriction	0	0	11	73.3	< 0.001*
Comb sign	0	0	18	60	< 0.001*
Terminal ileum dilatation	6	20	0	0	0.024*

Note._*Statistically significant results.
**Enhancement in enteric phase.

Table 3
Ileocecal valve and terminal ileum findings in BWI patients.

Case	Age	Gender	Terminal ileum	ICV
1	28	M	Dilated (26 mm)	Closed
2	39	F	Dilated 30 mm)	Wide open (11 mm)
3	43	F	Dilated (26 mm)	Wide open 12 mm)
4	43	F	Dilated (30 mm)	Wide open (13 mm)
5	45	F	Dilated (27 mm)	Wide open (8.8 mm)
6	50	M	Normal	Wide open (6 mm)
7	62	F	Normal	Wide open (12 mm)
8	67	M	Normal	Closed
9	70	M	Dilated (35 mm)	Closed

Note._ ICV = ileocecal valve.

patients (mean age, 43.9 ± 13.5 years, range 20–73 years) with same genders as in the study group.

The kappa agreement coefficient between MRE and histopathology in diagnosing UC and CD was almost perfect (Kappa = 0.867) and statistically significant ($p < 0.001$). 93.3% of patients with histopathological diagnosis of UC were also diagnosed with MRE as UC. 93.3% of patiens with histopathologic diagnosis of CD were also diagnosed with MRE as CD. In this current study, out of 60 patients, 4 patients had discordant results with pathology. One patient with continuous involvement of left hemicolon and rectum with loss of haustra and minimal wall thickening, and another patient with pancolitis and gaping of ICV were thought to be UC according to MRE findings. However, those patients have been diagnosed with CD, based on histopathologic examination. Additionally, two patients with proctosigmoiditis and having perianal fistulas at the same time were thought to have CD whereas the final diagnosis was UC at histopathology.

The frequency of MRE findings detected in colon and ICV in the CD and UC patients and the statistical differences between the groups are shown in Table 1. Loss of haustration in UC was significantly more common in the transverse colon, descending colon, and sigmoid colon than that in patients with CD ($p < 0.001$) (Table 1). There was no significant difference between UC and CD patients in terms of ICV gaping ($p = 0.472$). At the colonic level, wall thickening, mural edema, mural hyperenhancement, mural fat deposition and pseudopolyp formation were more frequent in UC with left sided involvement (Table 1).

A statistically significant difference ($p = 0.024$) between UC and CD patients was found in terms of terminal ileum dilatation. Terminal ileum dilatation was seen in none of the Crohn's patients in our study. With regard to the mural changes in the terminal ileum, wall thickening, mural edema, mural hyperenhancement and diffusion restriction were statistically more frequent ($p < 0.001$) in Crohn's patients than that in UC patients (Table 2). In terminal ileum involvement, the frequency of "comb sign" was significantly higher in patients with CD ($p < 0.001$). "Comb sign" at the level of terminal ileum was not detected in any UC patient with BWI.

Terminal ileum wall thickening was present in 24 Crohn's patients and in 2 UC patients (Table 2). Median terminal ileum wall thickness

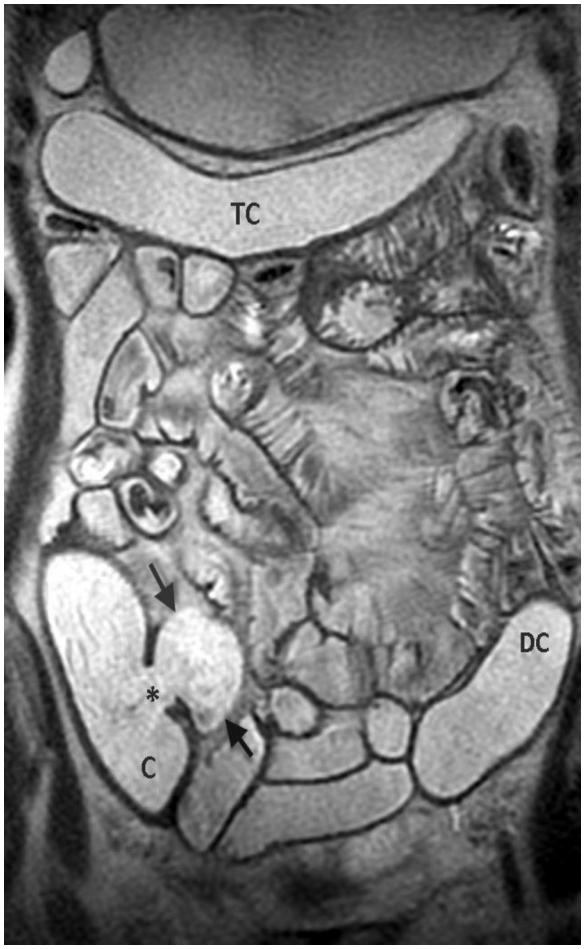

Fig. 1. A 44-year-old woman with BWI. Coronal T2 - weighted SSFSE MR image shows widely patent ICV orifice (*) due to inflammation-induced malfunction and dilated terminal ileum (arrows). Note loss of colonic haustrations and absence of wall thickening in terminal ileum.
C: Cecum, TC: Transverse colon; DC: Descending colon.

was found to be greater in patients with CD (6.5 mm, minimum-maximum, 3.0–14 mm) than that in UC patients (3.1 mm, minimum-maximum, 3.0–3.2 mm), and there was statistically significant difference between them (< 0.001). The length of the "terminal" ileum segment with thickened wall was found to be greater in patients with CD, but this difference was not statistically significant ($p = 0.098$). The median (minimum-maximum) length of involved terminal ileum was 9 cm (3.5–40) in CD and 4 cm (3.5–4.5) in UC.

Out of 30 UC patients, 9 of them (30%) had BWI with ileocolonoscopic and/or histopathologic diagnosis. UC patients with BWI showed a higher rate of pancolitis (88.9%). Pancolitis were present in 33.3% of

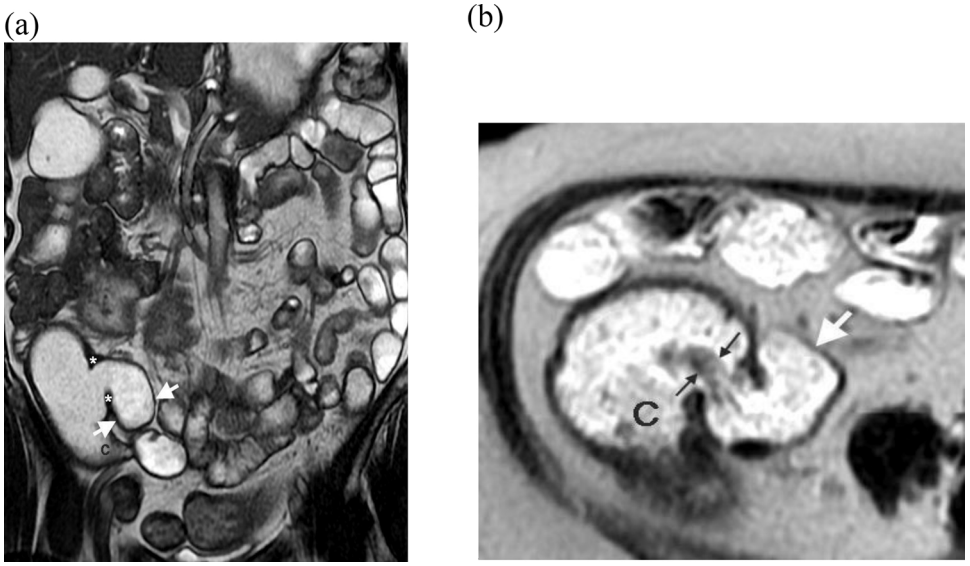

Fig. 2. A 62-year-old woman with BWI. **A,** Coronal SSFP and B, Axial T2 - weighted SSFSE MR image show widely patent ICV orifice and dilated terminal ileum (arrows). Asterisks on **A,** indicate atrophic ICV lips allowing free reflux of colonic contents into the ileum. Note absence of wall thickening in terminal ileum. Regurgitant flow (black arrows on **B**) originated from cecum (C) and directed toward terminal ileum lumen through ICV orifice can be seen.

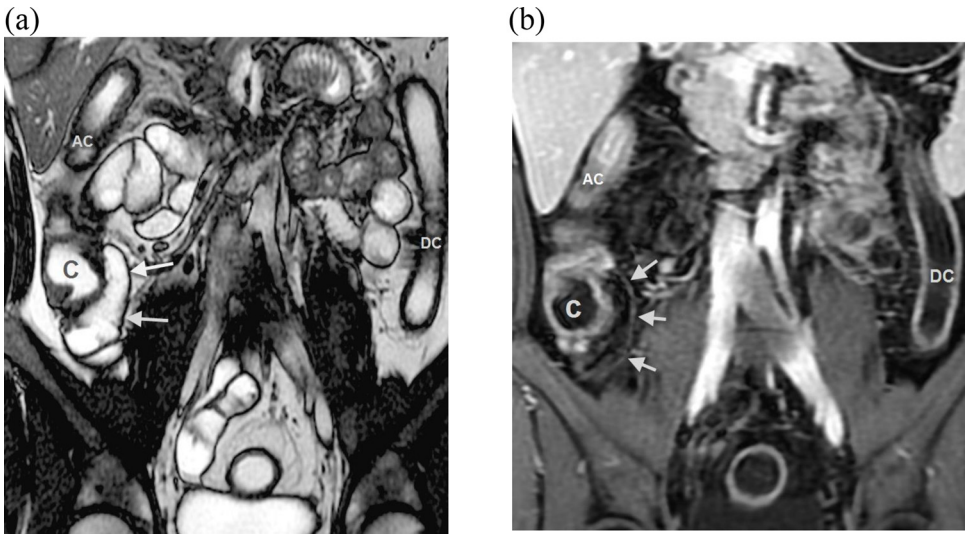

Fig. 3. A 28-year-old man with BWI who treated with total colectomy and ileo-anal anastomosis. At pathologic examination of surgical specimen, involvement of both terminal ileum and ICV, compatible with BWI and diffuse active colitis characterized by ulceration and pseudopolyp formation were detected. **A,** Coronal SSFP MR image reveals normal ICV and dilated terminal ileum (arrows) measuring 26 mm in diameter. **B,** Coronal contrast-enhanced fat-suppressed T1- weighted 3D gradient –echo image of the same patient shows no mural thickening and no hyperenhancement at inflamed terminal ileum. Note loss of colonic haustrations.
C: Cecum, AC: Ascending colon; DC: Descending colon.

UC patients without BWI. However, the difference was slightly statistically significant ($p = 0.051$).

Ileocecal valve gaping and terminal ileum dilatation were statistically significantly more frequent among BWI patients ($p < 0.001$ and $p < 0.001$, respectively). Six of the 9 BWI patients had a widely patent ICV, and/or dilatated terminal ileum (Table 3). Both ICV gaping and terminal ileum dilatation were present in 4 of 9 BWI patients (Figs. 1 and 2). Only ICV gaping (n = 2) or terminal ileum dilatation (n = 2) were detected in 4 patients (Fig. 3). In a patient with BWI, neither of these findings were present but he had only mild terminal ileal wall thickening (Fig. 4). The sensitivities and specificities of ICV gaping and terminal ileum dilatation in the diagnosis of BWI in patients with UC were 67% (95% CI, 0.35–0.88), 100% (95% CI, 0.85–1), and 67% (95% CI, 0.35–0.88), 100% (95% CI, 0.85–1), respectively. The accuracy rate was 90%(95% CI, 0.79–1) in both conditions (Table 4).

Nine of the patients (15%) had extraintestinal manifestations associated with IBD. Primary sclerosing cholangitis was present in two patients with UC. Perianal disease was present in 7 patients (5 with CD and 2 with UC).

4. Discussion

In our study, 30% (9/30) of UC patients had BWI. The prevalance of BWI is reported as 17–22% in adults with UC undergoing colonic resection [10,11]. In contemporary initial endoscopic terminal ileum biopsy specimens, Goldstein and Dulai found it to occur in 6% of patients with UC, and these patients all have moderately to markedly active cecal chronic UC [7]. Same authors also analyzed terminal ileum sections, from 250 UC total colectomy specimens resected during 3 periods between 1960–2004, and found that 32.8% of UC specimens had mildly to markedly active BWI. The incidence of BWI reported by the authors has decreased over time. The decreasing prevalence of BWI is most likely related to advances in diagnostic and therapeutic methods in UC [7].

In this study, we found the orifice of the ICV was widely patent in 20% of UC patients at MRE. The ICV, a circular muscle sphincter, marks the junction between the ileum and the cecum and appears as a slit-like opening in normal subjects. The ileum partly invaginates into the cecum, forming lips superior and inferior to the ileocecal orifice. These lips, together with a connected frenulum which is a small fold covered with colonic mucosa, form the ICV. Inner surface of the lips of the ICV is covered with ileal mucosa. Because the circular muscle layer is poorly developed in the lips, the ICV has very little sphincteric action and is not competent in every subject. This leads retrograde flow of colonic content into the terminal ileum and can be seen as an opacification of the terminal ileum which is a common normal finding during a barium

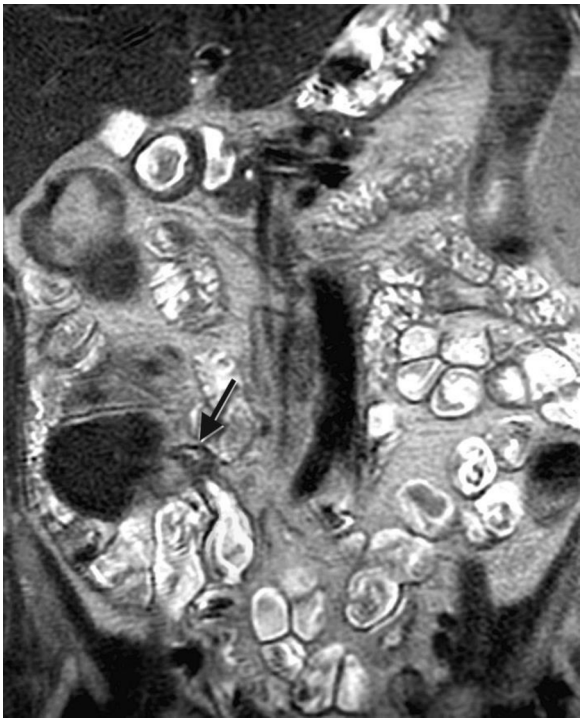

Fig. 4. A 67-year-old man with BWI. Coronal T2 - weighted SSFSE image reveals mild wall thickening and luminal spasm in terminal ileum (arrow). The contraction in terminal ileum segment was persistent and did not open in cine imaging or in other sequences (not shown). Consequently, the luminal contraction was not secondary to peristalsis. At endoscopy, hyperemic, eroded areas in terminal ileum which show marked mucosal fragility were reported suggesting luminal spasm induced by active inflammation. No ICV gaping or terminal ileum dilatation are seen in this patient with pancolitis and BWI.

enema examination [20]. In our study, the persistent gaping of the ICV is found to be very specific (100%) finding in UC and wide orifice of ICV in UC patients may be a good distinctive sign in detecting BWI. Characteristic of UC is bowel involvement essentially confined to the superficial layers of the colon. The inflammation is limited to the mucosa, with occasional extension into the superficial submucosa and progresses in a confluent manner. The terminal ileum is involved over a small length in continuity with the cecal inflammation, particularly when the UC has been total and chronic [7,21]. The mucosal inflammation of the frenulum and lips of ICV may reduce the valve function and causes the valve (which is already weak in closure function) to remain constantly open. In our study, this finding was rare (10%) in CD than that in UC. However, no significant difference was found between the groups in terms of ICV gaping. This indicates that the presence of ICV gaping cannot be used to differentiate terminal ileitis due to CD from BWI due to UC.

On barium examinations, the lumen of the terminal ileum is usually normal or dilated in BWI cases [5]. In our study, dilatation was detected in terminal ileum in 66.7% of UC patients with BWI. The stasis that occurs from inflammation-induced colonic hypomotility [4] may be responsible for the dilatation of the ileal lumen. A statistically significant difference between UC and CD patients was found in terms of terminal ileum dilatation. This finding was seen only in UC patients in our study., Exclusion of stricturing/obstructing CD cases, while selecting study population, may play role in this context.

The ileal inflammation seems to be not severe in UC patients with terminal ileum involvement [11]. It is associated with neutrofilic infiltration in the lamina propria, focal cryptitis and abscesses. However, in Crohn's ileitis more intense inflammatory process which is transmural in nature is observed [4]. In line with this observation, in this current study, increased wall thickness in terminal ileum was detected in 6.9% (n = 2) of the UC patients whereas it was detected in 80% (n = 24) of CD patients. Median terminal ileum wall thickness associated in UC was 3.1 mm while it was 6.5 mm in Crohn's ileitis. This difference was probably due to mild and superficial inflammatory changes within the ileum in UC. Other features in terminal ileum like mural edema, mural hyperenhancement, restricted diffusion in the bowel wall and "comb sign" were significantly more common in CD while they were not remarkable findings associated with UC.

Haskell et al. reported that, 94% of UC patients who had inflammatory changes in the ileum had pancolitis, which was significantly higher than the rate of pancolitis (39%) in patients without ileal disease. These authors suggested that, ileal erosions, although rare, can occur in patients without cecal involvement, which may indicate pathogenetic mechanisms other than reflux should be considered in the etiology of ileitis in UC patients [11]. This view has been supported by earlier study conducted by Geboes et al. It has been demonstrated in that study that, nearly half of the UC patients with ileal involvement had only left sided UC [22]. On the other hand, Goldstein et al. [7]. have recommended to restrict the use of term "BWI" only to active enteritis involving ileum contiguously from cecum. In another two studies, Abdelrazeq et al. [10] and Sahn et al. [23] found no case of BWI without concomitant pancolitis. Yamamoto et al. also accepted ileitis cases with normal cecum as non-backwash ileitis. In their study, the incidence of BWI in patients with pancolitis was 33%. They observed dilated patulous ICV with endoscopy in all BWI patients with pancolitis. Pancolitis was detected 11% of patients without ileal inflammation [21]. In our study, pancolitis was present in 88.9% of BWI patients whereas panulcerative colitis rate in patients without ileal involvement was 33.3%.

Although UC is primarily treated medically, surgery may be required in patients who become refractory to medical management or develop serious complications. The most common surgical procedure

Table 4
Association of ICV gaping and terminal ileum dilatation in ulcerative colitis patients with BWI and diagnostic efficacy of these two findings in BWI.

		BWI		p	Sensitivity (95% CI)	Specificity (95% CI)	Accuracy (95% CI)
		Present n (%)	Absent n (%)				
Widely patent ICV	Present	6 (66.7)	0	< 0.001*	67% (0.35-0.88)	100% (0.85-1.00)	90% (0.79-1.00)
	Absent	3 (33.3)	21 (100.0)				
Terminal ileum dilatation	Present	6 (66.7)	0	< 0.001*	67% (0.35-0.88)	100% (0.85-1.00)	90% (0.79-1.00)
	Absent	3 (33.3)	21 (100.0)				

Note._*Statistically significant results.
ICV = ileocecal valve; CI: confidence interval.

for UC is total proctocolectomy and ileal-anal pouch. Because the proctocolectomy specimens, as well as the endoscopic and histopathologic observations in UC, comprise limited terminal ileal portion, it is not possible to estimate the exact extent of ileal involvement in BWI. Although, it is commonly defined as an inflammation in the distal few centimeters of terminal ileum, BWI may progress up to 15 cm along with the terminal ileum [21]. In earlier autopsy series of UC cases, the extent of ileal inflammation has been reported to vary from 3 to 45 cm [24,25]. In our study, the length of the terminal ileum segment with thickened wall was found to be greater in patients with CD, but this difference was not statistically significant ($p = 0.098$). This insignificant difference may be due to the limited number of patients that enrolled the study.

Definitive diagnostic criteria for BWI have not been determined yet. Several investigators attempted to update and revise definition of BWI in the context of distinguishing BWI and CD in endoscopic and histopathologic basis [6,7,10,11]. Observations regarding the MR enterographic distinction of BWI are not well documented in the literature as well. In a study performed in pediatric age group using MRI, no significant increase in ileal wall thickness was found in any UC patient but mild mural contrast enhancement in 3 of 7 UC patients with BWI was detected. This suggested that UC does not deeply involve the ileal wall as occurs in CD ileitis [12].

Our study has several limitations including its retrospective nature and its small sample size. Another limitation may be that, the gaping of ICV is not specific for the UC. Widely patent ICV can be seen in colonic tuberculosis, cathartic colon, Behçet's disease, amebiasis, carcinoma, and in CD (according to our study, 10% in CD). Among these diseases, tuberculosis is the most well-known factor. However, in intestinal tuberculosis, gaping ICV is commonly associated with narrowing of the terminal ileum (Fleischner sign) [26]. A similar wide-open appearance of the ICV can be seen in patients with prolonged cathartic abuse [26]. Combination of histologic features coupled with clinical and endoscopic data allows for accurate differentiation in the majority of the above-mentioned disorders.

In conclusion, prominent wall thickening, mural edema, mural hyperenhancement, mural restricted diffusion and "comb sign" at the level of terminal ileum were significantly more common in Crohn's ileocolitis and can be accepted as suggestive findings of terminal ileitis in CD. On the other hand, the features that favor a diagnosis of BWI in UC patients were widely patent ICV orifice and dilated terminal ileum. In patients with final diagnosis of UC, presence of these findings suggest the development of BWI. However, based on only these two findings, it is not possible to get reliable information about the causative factor of terminal ileitis. Further studies in large cohort of patients are warranted to determine the feasibility of MRE technique in detection of BWI and also to assess validity and reproducibility of our study findings.

Conflict of interest

The authors or authors' institutions have no conflicts of interest. The authors of this manuscript declare no relationships with any companies, whose products or services may be related to the subject matter of the article.

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