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## Utility of CT Enteroclysis for Small Intestinal Hemorrhage

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**Abstract Purpose:** To examine the utility and limitations of computed tomography enteroclysis (CTE) in examining clinically suspected small intestinal hemorrhage. **Subjects and Methods:** Subjects comprised 41 patients (16 men, 25 women) with suspected gastrointestinal bleeding based on fecal occult blood or tarry stool between April 2008 and August 2010. CTE was performed after the cause of bleeding could not be clearly identified on upper or lower gastrointestinal endoscopy. Capsule endoscopy was also performed in 25 patients and double balloon endoscopy in 13 patients. **Results:** CTE findings were obtained for 17 of 41 patients (41%), suggesting vascular malformation in 9 patients (22%), inflammatory bowel disease in 7 (17%), and small intestinal tumor in 1 (2%). Capsule endoscopy or double balloon endoscopy confirmed these suspicions in all except 1 patient with angiodysplasia confirmed angiographically and 1 patient with a false-positive finding of tumor. In 20 of the 24 patients showing no abnormalities on CTE, no obvious source of bleeding was found with capsule endoscopy or double balloon endoscopy. **Conclusion:** CTE can successfully detect a wide variety of lesions, including not only Crohn's disease and vascular malformations, but also drug-induced small intestinal injury, small intestinal tuberculosis, and nontuberculous mycobacteriosis.

*Key words:* CT enteroclysis, double balloon endoscopy, capsule endoscopy, obscure gastrointestinal bleeding

### Introduction

Computed tomography enteroclysis (CTE) is a technique in which water or other negative contrast media is infused into the small intestine, expanding the lumen and thus enabling evaluation of lesions in the small intestine that are difficult to see with conventional CT. In recent years, the diagnostic performance of CTE has been reported to be good for Crohn's disease and vascular malformations in particular.<sup>1,2</sup> At the same time, endoscopic observation of the small intestine

has increased with the appearance of capsule endoscopy and double balloon endoscopy, which have been shown to be effective in detecting small intestine lesions, particularly in the diagnosis of obscure gastrointestinal bleeding.<sup>3</sup> In addition, low-dose-aspirin and nonsteroidal anti-inflammatory drugs (NSAIDs) have been widely recognized in recent years to cause damage not only to the upper gastrointestinal tract, but also to the small intestinal mucosa.<sup>4,5</sup> This study compared CTE to capsule endoscopy and double balloon endoscopy in 41 patients in whom

small intestinal hemorrhage was suspected clinically, and investigated its utility and limits.

### Subjects and Methods

Subjects comprised 41 patients (16 men, 25 women) in whom gastrointestinal bleeding was suspected clinically from positive results for fecal occult blood or tarry stool between April 2008 and August 2010. In these 41 subjects, CTE was performed because the cause of bleeding could not be clearly identified on upper or lower gastrointestinal endoscopy. Mean age was 67.3 years. Capsule endoscopy was also performed in 25 patients and double balloon endoscopy in 13 patients. Informed consent was obtained from all the patients prior to the examinations, which were performed in accordance with our hospital's institutional review board. CTE and Capsule endoscopy or double balloon endoscopy were performed within 7 days.

### CT enteroclysis

Enteral contrast medium: An enteral contrast medium was infused into the small intestine via a duodenal tube, and dynamic CT of the abdominopelvic region was performed. First, an endoscope was inserted through the nose to the third portion of the duodenum, and the guide wire was advanced to the jejunal side through the forceps channel. Carbon dioxide was used in the air supply so that air would not remain in the small intestine as much as possible. Next, a duodenal tube (16-Fr gastroenterography balloon catheter) was inserted into the duodenojejunal flexure via the guide wire. After expanding and fixing the end balloon of the duodenal tube, about 1,500–2,000 ml of intestinal lavage agent (isoosmotic polyethylene glycol (PEG)) warmed to about 37 °C was infused into the small intestine at a rate of about 150 ml/min using a power injector.

CT imaging: Immediately after infusion of the intestinal lavage agent was completed,

Table 1 Diagnostic yields of CTE and further examinations

CTE diagnosis	No.	Final diagnosis	No.	Further examinations	No.
Positive findings	17				
Vascular malformation	9	Angiodysplasia	8	CE	4
				DBE	2
				Lower endoscopy	1
				CE and Angiography	1
		AVM	1	CE and Angiography	
Inflammatory bowel disease	7	Drug-induced injury	4	CE and DBE	2
				CE	2
		Tuberculosis	1	CE	
		NTM	1	CE	
		Crohn's disease	1	DBE	
Small bowel tumor	1	No positive findings	1	DBE	
No positive findings	24				
		No positive findings	20	CE or DBE	
		Drug-induced injury	2	CE	
		NTM	1	DBE	
		Angiodysplasia	1	DBE	

CE: capsule endoscopy, DBE: double balloon endoscopy

AVM: arteriovenous malformation, NTM: nontuberculous mycobacteriosis

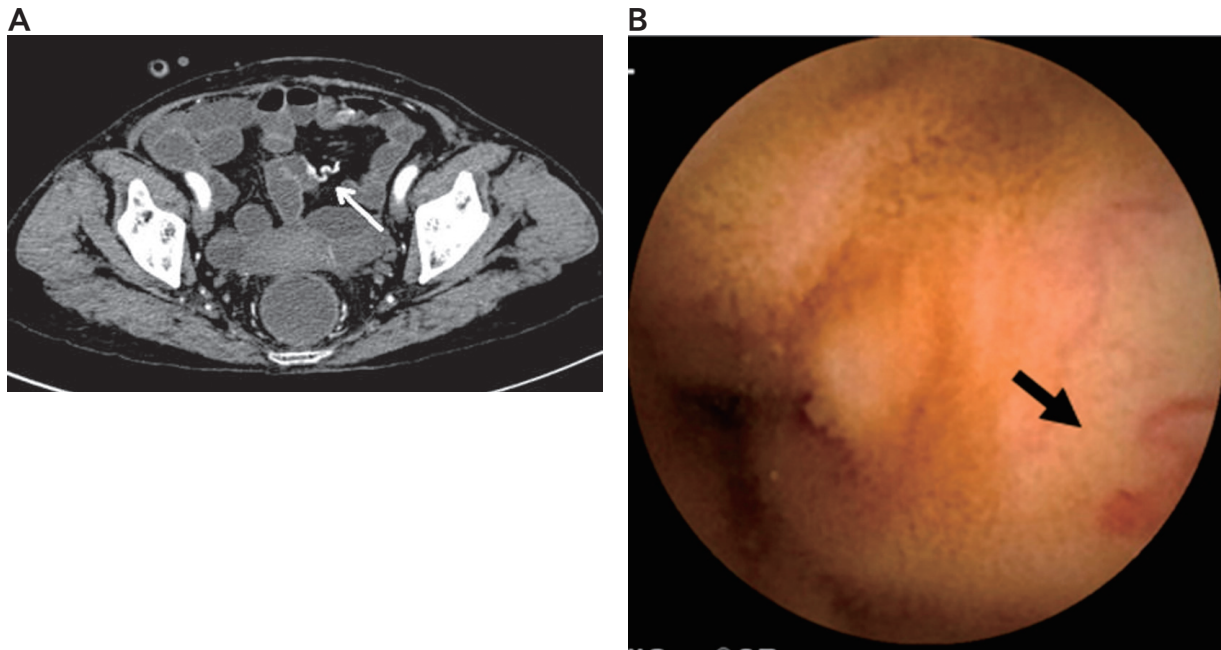


Fig. 1 A 65-year-old woman with small intestinal AVM.

A: In CTE, a nodular hypervascularity was seen in the small intestine, and together with an image of nearby dilated blood vessels (white arrow), AVM was suggested.

B: A submucosal tumor-like shadow and dilated blood vessels (black arrow) were seen in capsule endoscopy, and AVM was diagnosed.

patients were moved into the CT room and dynamic CT of the abdominopelvic region was performed. First, a plain CT was taken, and if the lavage agent had not filled the small intestine sufficiently, a further 200-500 ml of lavage agent was added. For the contrast study, 100 ml of nonionic contrast medium was rapidly infused at 3 ml/s, and imaging was performed from the level of the diaphragm to the pubic symphysis in the early and late arterial phases after 25 and 40 s, in the portal vein phase after 70 s, and in the late phase after 150 s, during one breathhold at each point.

**Image analysis:** The early arterial phase after 25 s was used in CT angiography, and the late arterial phase was used mainly in evaluating lesions of the small intestine. The portal vein phase was used in evaluation of abdominal organs, and the late phase was used in evaluation of pelvic organs. Imaging conditions for the CT system (Somatom Definition Dual-Source CT; Siemens, (Germany)) were collimation of 1 mm and table speed of 8 mm. Reconstituted axial and coronal im-

ages were made with slice thickness of 2 mm and slice interval of 2 mm.

## Results

CTE findings were obtained in 17 of the 41 patients (41%). Vascular malformation was suspected in 9 patients (22%), and inflammatory bowel disease was suspected in 7 (17%). In the remaining patient (2%), tumor of the small intestine was suspected. The diagnostic yields of CTE and further examinations are given in Table 1.

Of the 9 patients with suspected vascular malformation, angiodysplasia was diagnosed with capsule endoscopy in 4 and with double balloon endoscopy or lower gastrointestinal endoscopy in 3. In 1 patient, only blood was visualized with capsule endoscopy, and angiodysplasia was diagnosed on angiography. In the remaining patient, arteriovenous malformation (AVM) was diagnosed on angiography (Fig. 1).

Of the 7 patients with suspected inflammatory bowel disease, capsule endoscopy was

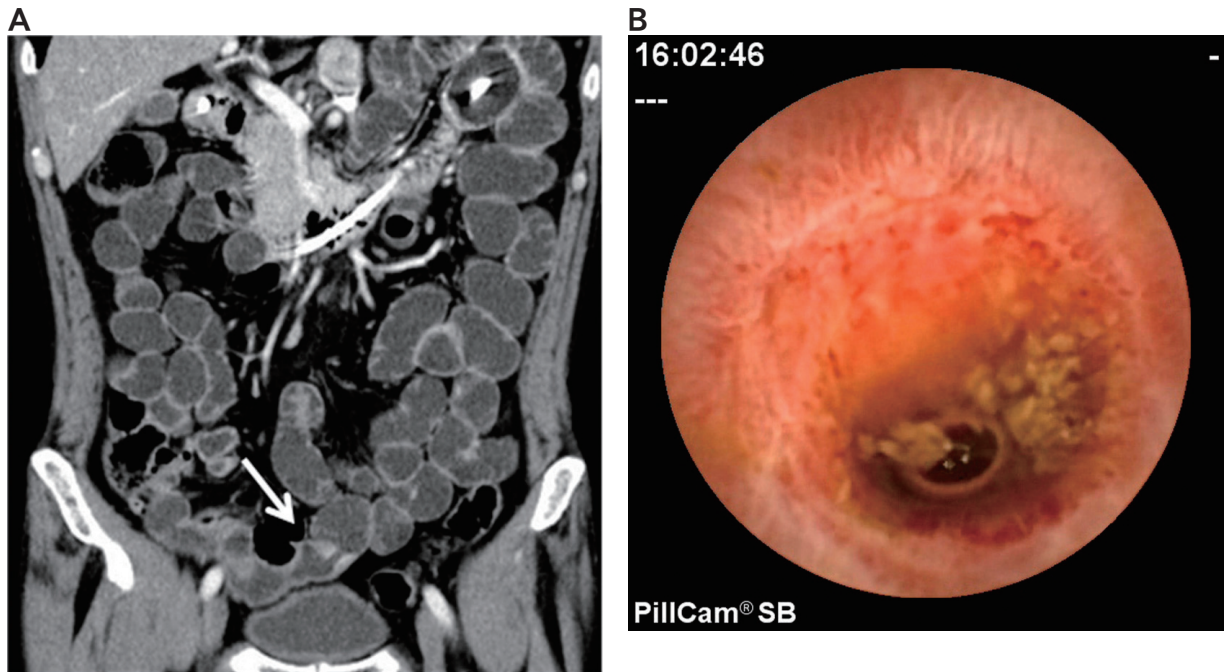


Fig. 2 A 63-year-old man with NSAID-induced small intestinal injury.  
 A: Wall thickening (white arrow) was seen in the ileum with CTE. On a coronal image, stenosis in the same location was suspected.  
 B: Circular ulcers in the ileum were seen with capsule endoscopy. Based on the history of the patient, NSAID-induced ulcers were diagnosed. The capsule endoscope was temporarily blocked at the site by suspected stenosis on CTE.

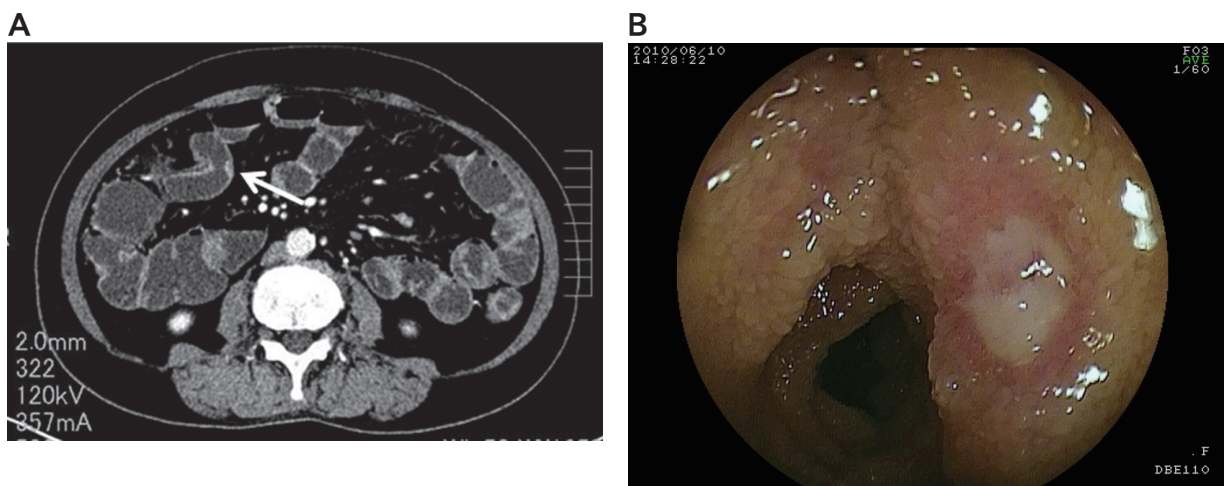


Fig. 3 A 64-year-old woman with nontuberculous mycobacteriosis of the small intestine.  
 A: Enhancement (white arrow) of the mucosal surface in the ileum was seen on axial imaging.  
 B: Small intestinal ulcer was seen with double balloon endoscopy, *Mycobacterium gordonae* was detected in culture, and nontuberculous mycobacteriosis of the small intestine was diagnosed.

performed in 5 and double balloon endoscopy in 2. Based on endoscopic and clinical findings, 4 patients were diagnosed with drug-

induced enteritis from NSAIDs and aspirin, 2 patients were diagnosed with small intestinal tuberculosis and nontuberculous mycobac-

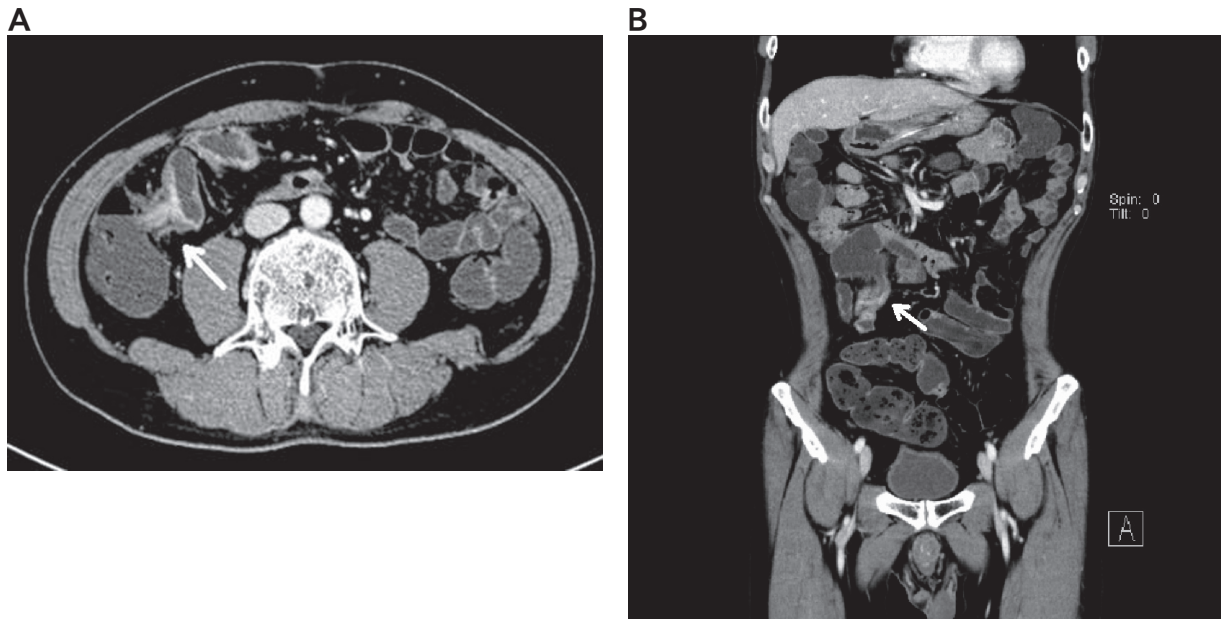


Fig. 4 A 56-year-old woman with Crohn's disease.

A: A stenotic lesion in the terminal ileum was seen on CTE axial images, with an accompanying contrast effect in the mucosa (arrow).

B: On coronal images, a stenotic lesion thought to be a skip lesion was seen in another site (arrow), suggesting Crohn's disease. Double balloon endoscopy was subsequently performed and Crohn's disease was diagnosed.

teriosis, and 1 patient was diagnosed with Crohn's disease. Of the 4 patients with drug-induced enteritis, thickening of the wall with mural stratification and double-halo appearance, and lumen stricture were seen (Fig. 2). In the remaining 2 patients, significant enhancement of bowel wall with no or mild mural thickening and creeping fat along the wall were seen. Local edematous thickening of the wall accompanied by marked enhancement of the mucosa was seen in small intestinal tuberculosis, and mural thickening and contrast enhancement of the terminal ileum was seen in nontuberculous mycobacteriosis (Fig. 3). In the patient with Crohn's disease, mural thickening with strong enhancement and luminal narrowing was discontinuously seen in the distal and terminal ileum (Fig. 4).

In the 1 patient (3%) with suspected tumor of the small intestine, no obvious abnormalities were seen in double balloon endoscopy and this was considered a false-positive case.

In 20 of the 24 patients in whom no abnormalities were seen on CTE, no obvious source of bleeding was found with capsule endoscopy or double balloon endoscopy. Of the

4 cases thought to be false-negatives, mild non-specific inflammation signs such as erosions or redness were seen in 2 patients, and from the clinical course these patients were diagnosed with drug-induced enteritis caused by aspirin. In one of the remaining patients, scattered small ulcers were seen in the lumen with double balloon endoscopy, and nontuberculous mycobacteriosis was diagnosed. In the other remaining patient, angioectasia was seen in the terminal ileum, and improvement in melena was seen with ablation by endoscope.

## Discussion

Bleeding in the small intestine was particularly difficult to diagnose among these cases of gastrointestinal hemorrhage. Small intestinal hemorrhage includes obscure gastrointestinal bleeding (OGIB), and traditionally tests with push-type small bowel endoscopy or intraoperative endoscopy have been undertaken. However, capsule endoscopy, a low-invasive method of observing the small intestine, has appeared in recent years and is

gaining popularity. In particular, the diagnostic performance of this method for small intestinal hemorrhage is thought to be good. Ell et al.<sup>6</sup> compared capsule endoscopy and push-type small bowel endoscopy in patients with suspected small intestinal hemorrhage or OGIB, and reported that the diagnostic rate was better with capsule endoscopy. Together with double balloon endoscopy, capsule endoscopy is currently thought to be the best test in searching for the cause of small intestinal hemorrhage. However, problems have also been pointed out in these modalities. For example, the capsule can become stuck in patients with marked stenosis or the range of observation can be decreased in the distal ileum due to increased residue.<sup>7,8</sup>

Meanwhile, low invasive test methods to evaluate small intestinal lesions with CTE have also been reported.<sup>1,2</sup> In a physiological state, the small intestine is collapsed and varying amounts of gas and feces are seen in the lumen, making information on the mucosal surface rather difficult to obtain. In CTE, the lumen of the small intestine is distended appropriately with the infusion of PEG as a negative contrast medium, and gas and feces are removed. Although a sense of abdominal fullness occurs because the intestinal canal is filled with a large volume of contrast medium, no marked complications were seen in this study and acceptability was thought to be high. In addition, PEG is an isotonic fluid, and almost no absorption in the intestinal tract is seen. This method can therefore be used in patients with drinking restrictions, such as those with heart failure, and is very versatile. Compared with endoscopy, image quality in CTE depends less on operator skill, and together with information on the intestinal tract wall, parenteral information such as abscesses, fistulas, and inflammatory influences on the surroundings can also be obtained. Deep areas beyond stenotic regions, which are difficult to reach with an endoscope, can likewise be evaluated. CTE also has disadvantages, in that the method cannot be applied in patients with renal dysfunction or iodine allergy, since an intravenous nonionic contrast medium must be used with this test.

In this investigation, CTE was performed

in 41 patients with OGIB, and findings were seen in 17 patients. One case was found to be a false-positive, with the collapsed intestinal tract mistaken for a tumor. Among the remaining 16 patients, vascular malformation was seen in the largest number of patients (9 patients). Mylonaki et al.<sup>9</sup> detected small intestinal hemorrhage in 34 patients with capsule endoscopy, the cause of which was angiodysplasia in the largest number (16 patients). Diagnosis of OGIB is important in diagnosing vascular malformation. Only one false-positive case was identified from CTE together with findings from capsule endoscopy or double balloon endoscopy, and the ability of CTE to detect vascular malformation is considered high.

Much attention has also been directed in recent years to drug-induced small intestinal injury as a cause of small intestinal hemorrhage.<sup>10,11</sup> Reflecting the aging of society in recent years, occasions for the administration of NSAIDs are increasing in the field of orthopedics, and low-dose aspirin administered for thrombus prevention is spreading rapidly in cardiovascular and cerebrovascular medicine. Measures to counter the damage to gastrointestinal mucosa from these drugs are urgently needed. Circular ulcers or multiple ulcers are often presented in endoscopic findings of NSAID-induced small intestinal injury, and lesions with accompanying longitudinal or diagonal ulcers or stenosis have also been reported.<sup>12</sup> Around 1990, there was a clinical focus on NSAID-induced small intestine mucosal damage, and cases of membranous stenosis related to characteristic X-ray findings have been occasionally reported since that time,<sup>13-16</sup> but small lesions are not visualized well with X-rays. The advent of capsule endoscopy and double balloon endoscopy in recent years has enabled the detection of small lesions, and the number of reports on X-ray findings is decreasing. Since only minute changes related to small lesions are often seen on CT, similar to X-ray findings, there have been no comprehensive reported cases related to small intestinal damage induced by NSAIDs or other drugs with CTE. In this study, lesions were indicated with CTE in 4 of the 6 patients who were thought to have drug-induced small intestinal injury.

In all 4 positive patients, a fairly high level of inflammatory change together with ulcers was seen with capsule endoscopy and double balloon endoscopy. CTE findings were homogeneously hyperenhancement of the wall and creeping fat adjacent mesentery in 2 patients, and luminal stenosis with mural stratification and double-halo appearance in 2 patients. In all cases, lesions were mostly localized in a small range, and in cases of suspected drug-induced small intestinal injury, close observation with a focus on hyperenhancement and thickness of the wall was thought to be needed. The 2 false-negative cases presented only mild inflammation findings, such as erosion or redness, in endoscopy, and identification with CTE was considered difficult.

There is concern that small intestinal tuberculosis and nontuberculous mycobacteriosis will also increase with the increase in immunocompromised patients from the use of immunosuppressants in many fields as society ages. Diagnostic imaging of enteric tuberculosis is achieved mainly with radiographic contrast studies<sup>17</sup> or endoscopy.<sup>18</sup> Few reports have investigated CTE. In cases of tuberculosis of the small intestine and nontuberculous mycobacteriosis in our study, enhancement of the intestinal tract wall was seen in 1 patient and non-specific inflammatory findings, such as mild wall thickening with enhancement of the mucosal layer, were seen in the other patient. Since the number of patients was small, accumulation of more cases will be necessary in the future. However, in cases when localized inflammatory findings of the intestinal tract wall are encountered, differentiation of small intestinal tuberculosis together with drug-induced small intestine damage may be necessary. In the case of nontuberculous mycobacteriosis that was thought to be a false-negative, diffuse small aphtha was occasionally seen in the jejunum, but were difficult to see on CTE.

The diagnostic performance of CTE for Crohn's disease is considered to be high. Sailer et al.<sup>19</sup> compared conventional small intestinal contrast using barium and CTE in 50 patients with Crohn's disease, and reported that CTE was superior in detecting intramural and extramural lesions related to Crohn's disease. Liu et al.<sup>2</sup> performed CTE in the

small intestine of Crohn's disease patients, and reported its utility in not only detecting lesions and searching for complications, but also in evaluating lesion activity. Figure 4 shows CTE findings for a patient with suspected Crohn's disease. Findings consistent with active Crohn's disease included wall thickening of the ileum with accompanying enhancing effect of the mucosal surface, strong stenosis, enlargement of surrounding mesenteric lymph nodes, and skip lesions. Since strong stenosis was seen, the scheduled capsule endoscopy was cancelled and Crohn's disease was diagnosed from double balloon endoscopy. With CTE, the presence or absence of stenosis, its location, its length, and other information can be obtained. This method is also useful in the subsequent test strategy, such as avoiding blockage of the capsule endoscope.

## Conclusion

CTE was performed in 41 OGIB patients. A wide variety of lesions could be detected with CTE, including not only Crohn's disease and vascular malformations such as AVM, but also drug-induced small intestinal injury, small intestinal tuberculosis, and nontuberculous mycobacteriosis, which are expected to increase in the future. Patients with stenosis are not unusual among cases showing OGIB, and CTE may be considered effective in the initial approach for close investigation of OGIB, including avoidance of obstruction of capsule endoscopy.

## Conflict of Interest

The authors state no conflict of interest.

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