



Assessment of Small Bowel Motility Using Cine-magnetic Resonance Imaging in Patients Suspected With Chronic Intestinal Pseudo-obstruction

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Background/Aims

Chronic intestinal pseudo-obstruction (CIPO), characterized by dilated small or large intestine on CT, has a high postoperative recurrence rate. In contrast, focal hypoganglionosis with adult-onset megacolon (FHAM) generally shows a good postoperative prognosis. This study aims to evaluate the utility of cine-MRI in differentiating between these 2 diseases by assessing small bowel (SB) motility and its correlation with clinical outcomes.

Methods

The clinical features and outcomes of 41 prospectively enrolled patients suspected of having CIPO who underwent cine-MRI were reviewed. Multi-slice cine-MRI was conducted.

Results

Of 41 patients suspected of having CIPO, 17 showed SB dilatation on CT, while 24 did not. According to cine-MRI, 3 exhibited decreased SB motility, while 38 showed no motility reduction. Among the 17 patients with dilated SB on CT, only 3 demonstrated decreased SB motility on cine-MRI. By contrast, all patients with nondilated SB on CT exhibited normal SB motility on cine-MRI. Patients with decreased SB motility showed a higher rate of postoperative disease recurrence ($P = 0.011$) and continuation of medication after surgery ($P = 0.020$) than in those with normal SB motility.

Conclusions

Cine-MRI is useful in assessing SB motility that cannot be detected on CT. Its usefulness extends to aiding surgical decision-making, particularly in differentiating between FHAM and CIPO.

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Key Words

Dilatation; Intestinal obstruction; Intestine, small; Magnetic resonance imaging; Megacolon

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Introduction

Chronic intestinal pseudo-obstruction (CIPO) is a rare condition characterized by recurrent symptoms of intestinal obstruction with radiological features of dilated small bowel (SB) or colon in the absence of any mechanical occlusive lesions.^{1,2} Previous studies in Korea have described a small number of patients with segmental colon dilatation associated with short stenotic regions of the colon but without mechanical obstruction.³⁻⁷ Postoperative pathological findings revealed hypoganglionosis localized to this focal stenosis.^{6,7} Yoon et al,⁷ have reported on this specific group as focal hypoganglionosis with adult-onset megacolon (FHAM), and focal stenosis has been termed focal functional narrowing (FFN). For FHAM, surgery is a viable treatment option, especially considering its localized nature within a specific colon region.^{7,8} Unlike FHAM, CIPO involves the entire gastrointestinal (GI) tract, predominantly affecting the SB, and has a poor postoperative prognosis.⁹⁻¹¹ Thus, accurate differentiation between CIPO and FHAM is crucial, and the assessment of SB motility can be helpful in differential diagnosis between the 2 conditions.

Various methods are used to assess SB motility, each with its advantages and limitations. Although SB manometry is known to be useful in evaluating SB motility, it is invasive and has limitations in evaluating distal SB.^{12,13} Meanwhile, a computed tomography (CT) scan is less invasive and available in most institutions, although it is limited in assessing motility with static images. Occasionally, a dilated colon and SB on the static image of a CT scan in patients with FHAM can mimic the radiological findings of CIPO with a distended SB. Recently, cine-magnetic resonance imaging (MRI), which is a type of MRI sequence used to capture motion, has emerged as a promising technique for evaluating SB motility.¹⁴ Therefore, cine-MRI has an important role in the accurate assessment of SB dysmotility compared with CT scan with static images. Moreover, a recently published review paper has also emphasized

the use of cine-MRI for diagnosing CIPO.¹¹ However, no study has yet compared the clinical efficacy of cine-MRI in distinguishing between CIPO and FHAM.

Therefore, we investigated the utility of cine-MRI in evaluating SB motility among patients suspected of having CIPO. In addition, we compared the CT and cine-MRI findings and the clinical outcomes of patients according to SB motility.

Materials and Methods

Patients and Study Design

This study was performed in a tertiary referral center in Seoul, South Korea. Altogether, 84 adult patients were prospectively recruited with a suspicion of CIPO between January 2017 and March 2023. The inclusion criteria were as follows^{4,7}: (1) chronic refractory constipation, recurrent abdominal pain, and abdominal distension suggestive of subocclusive episodes; (2) presence of bowel dilatation and/or intestinal air–fluid levels on CT scan; and (3) no evidence of structural disease causing obstruction on colonoscopy and CT scan. Six patients were excluded because they did not meet the inclusion criteria. Among the remaining 78 patients, 37 did not undergo cine-MRI. Cine-MRI could not be performed in patients with severe bowel distension due to the risks associated with bowel preparation, and those who could not afford the examination or could not cooperate. Finally, 41 patients who fulfilled the inclusion criteria and underwent cine-MRI were enrolled in this study (Fig. 1). The Institutional Review Board of Asan Medical Center approved the study protocol (No. 2016-1145), and written informed consent was obtained from all participants before enrollment.

Magnetic Resonance Imaging Protocol

Cine-MRI was performed using a 3-Tesla system (Ingenia; Philips Healthcare, Best, The Netherlands) and a balanced steady-

state free precession (2-dimensional balanced turbo-field echo sequence) to obtain a dataset that encompassed a diverse range of bowel motility. The temporal resolution was 0.5 seconds per image. Since February 22, 2022, our institution has transitioned from using free-breathing technique to breath-hold image acquisition. Cine-MRI was performed after the patient underwent fasting for 6 hours. Patients were required to ingest 1.2 L of oral polyethylene glycol within 30 minutes prior to the examination to fill the SB loops. The time a patient spends in the scanner is about 30 minutes. Further technical details of the cine-MRI protocol are provided in Table 1. Abdominal radiologist (D.W.K.) with 5 years of experience in bowel cine-MRI qualitatively assessed SB motility. The degree of SB motility was determined as follows¹⁵: grade 1, adynamic (non-peristaltic) wave; grade 2, decreased but preserved motility; and grade 3, normal motility.

Definition

FFN was defined as an abrupt decrease (focal stenosis) in the colonic diameter within the limits of the junctional area between the dilated and nondilated colon,⁷ and this was confirmed by CT scan. A minimum colonic diameter of > 5.0 cm suggested colonic dilata-

tion.^{3,5,6} SB dilatation was defined as a minimum diameter of > 2.5 cm.^{16,17} Several GI functional tests, including the high-resolution anorectal manometry (HRAM), colon transit test, high-resolution esophageal manometry, and gastric emptying scan, were performed to exclude pan-GI dysmotility. These tests were performed based on a previously published protocol.^{18,19}

Data Collection

We collected baseline data on patient demographics, including sex, date of birth, symptom onset, diagnosis, body mass index, past medical and surgical history, symptoms, and use of medications. Results of radiological studies (CT scan and cine-MRI), colonoscopy, and functional tests as well as laboratory findings were collected by reviewing the medical records.

The clinical outcomes included disease-related hospitalization and surgery during follow-up period, and improvement of symptoms and/or maintenance of medication at the last follow-up visit. In patients who received surgical treatment, postoperative outcomes including disease recurrence, which was defined as rehospitalization and/or reoperation for treating symptoms and complications of disease were also investigated.

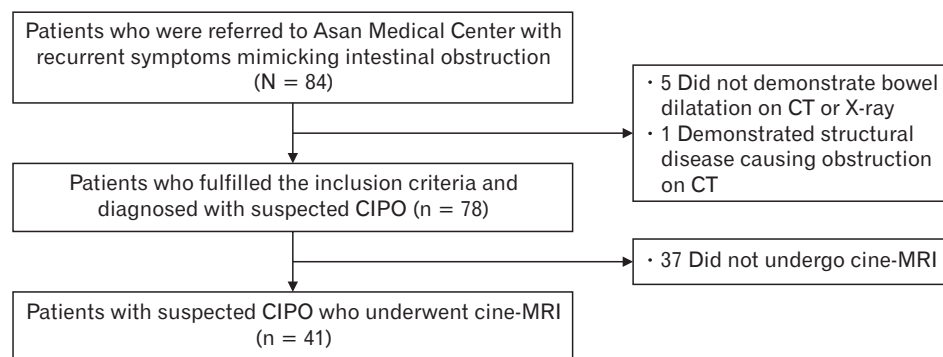


Figure 1. Study flowchart. CIPO, chronic intestinal pseudo-obstruction.

Table 1. Cine-magnetic Resonance Imaging Protocol

Category	Description
Device	Philips Ingenia (3T)
Preparation	Fasted for 6 hr Oral administration of 1.2 L polyethylene glycol (for 30-40 min; 150 mL every 5 min)
Image acquisition	2D coronal
Field of view	Cover whole bowel (10-20 slices) (from the anterior abdominal wall to the rectum)
Spatial resolution	0.9 mm × 0.9 mm
Slice thickness	8 mm
Interslice gap	10 mm
Temporal resolution	0.5 sec/frame
Acquisition time	22 sec (45 frames/slice)

Statistical Methods

Descriptive statistics were used to analyze the demographic, disease, and treatment characteristics. Categorical variables are described as frequencies (%), and continuous variables are presented as means and standard deviations or medians and interquartile ranges (IQRs). Differences in disease characteristics between cohorts were compared using a Student *t* test or Mann–Whitney *U* test for continuous variables and Fisher’s exact test or the chi-squared test for categorical variables where appropriate. A two-sided *P*-value < 0.05 was considered significant. All analyses were performed using IBM SPSS statistics 21.0 for Windows (IBM Corp., Armonk, NY, USA).

Table 2. Clinical and Demographic Characteristics of Included Patients

Characteristics	Patients suspected with CIPO (n = 41)
Sex (female)	29 (70.7)
BMI at diagnosis (kg/m ²)	20.2 (18.9–21.8)
Age at symptom onset (yr)	49.1 (37.1–57.6)
Age at diagnosis (yr)	50.3 (37.5–61.1)
Duration from onset to diagnosis (mo)	10.0 (3.9–61.5)
Main presenting symptoms at diagnosis	
Constipation	32 (78.0)
Abdominal pain	29 (70.7)
Abdominal bloating	19 (46.3)
Nausea/vomiting	6 (14.6)
History of disease-related medication	37 (90.2)
Number of regular medicines at diagnosis	3.0 (2.0–4.0)
History of disease-related hospitalization	33 (80.5)
Number of hospitalizations before diagnosis	1.0 (1.0–2.5)
History of abdominal surgery ^a	10 (24.4)
Underlying disease	
Endocrine diseases	12 (29.3)
Cardiovascular diseases	1 (2.4)
Connective tissue diseases	1 (2.4)
Neuromuscular diseases	0 (0.0)
Cancers	1 (2.4)
Psychiatric diseases	1 (2.4)

^aAbdominal surgeries included uterine myomectomy, hysterectomy, pyloric stenosis myotomy, and low anterior resection.

CIPO, chronic intestinal pseudo-obstruction; BMI, body mass index. Values are expressed as n (%) or medians (interquartile ranges).

Results

Baseline Characteristics of the Patients

Table 2 summarizes the baseline clinical characteristics of the patients. The median age of symptom onset of the patients was 49.1 years (IQR, 37.1–57.6 years), and the median time from symptom onset to diagnosis was 10.0 months (IQR, 3.9–61.5 months). The most common symptom was constipation (78.0%), followed by abdominal pain (70.7%), abdominal bloating (46.3%), and nausea/vomiting (14.6%). In total, 37 patients (90.2%) had a history of

Table 3. Computed Tomography Imaging, Functional Test, and Laboratory Test Findings

Characteristics	Patients suspected with CIPO (n = 41)
CT imaging	
Dilatation of small bowel	17 (41.5)
FFN on CT	36 (87.8)
Location of FFN	
Splenic flexure	13 (36.1)
Descending colon	11 (30.6)
Sigmoid colon	7 (19.4)
Transverse colon	5 (13.9)
Maximal diameter of colon (mm)	87.0 (67.5–112.5)
Maximal diameter of small bowel (mm)	38.0 (34.0–48.0)
Colonoscopy, performed ^a	35 (85.4)
Laboratory test	
CRP (mg/dL)	0.1 (0.1–0.2)
Albumin (g/dL)	3.9 (3.4–4.1)
Hemoglobin (g/dL)	12.2 (11.3–13.7)
Paraneoplastic antibody, abnormal ^b	4/32 (12.5)
Functional test	
CTTS (hr)	67.2 (60.0–72.0)
Anorectal physiology ^c	
HRAM, abnormal	32/37 (86.5)
Esophageal manometry, abnormal	7/10 (70.0)
Gastric emptying scan, delayed	2/10 (20.0)

^aNo lesions causing mechanical obstruction were identified in all patients who underwent colonoscopy.

^bAll patients with abnormal findings in the paraneoplastic antibody demonstrated non-specific findings in additional tests and were negative in the follow-up antibody test.

^cRectoanal inhibitory reflex was present in all patients.

CIPO, chronic intestinal pseudo-obstruction; CT, computed tomography; FFN, focal functional narrowing; CRP, C-reactive protein; CTTS, colon transit time study; HRAM, high-resolution anorectal manometry. Values are expressed as n (%) or medians (interquartile ranges). If the test was performed on some patients, it was expressed as n/N (%).

using medications for symptom relief and 33 patients (80.5%) had history of hospitalizations due to severe GI symptoms. Ten patients (24.4%) had received previous abdominal surgeries, including uterine myomectomy, hysterectomy, pyloric stenosis myotomy, and low anterior resection due to colon cancer. Among 41 patients, 12 (29.3%) had endocrine diseases (including 9 patients with diabetes mellitus and 1 patient with thyroid disease).

Diagnostic Findings and Functional Tests Results

Table 3 summarizes the diagnostic findings and functional test results of patients. In the CT scan, SB dilatation was demonstrated in 17 patients (41.5%), with a median maximal diameter of the SB measuring 38.0 mm (IQR, 34.0-48.0 mm). All patients exhibited colon dilatation, with a median maximal diameter of the colon measuring 87.0 mm (IQR, 67.5-112.5 mm). FFN of the colon was noted in 36 patients (87.8%). Colonoscopy was performed in 35 patients (85.4%), and no lesions causing mechanical obstruction were identified in any of those who were examined.

Functional tests were conducted in some of the total patients, resulting in the following outcomes (Table 3). The rectoanal inhibitory response was intact in all patients who were examined. HRAM revealed an abnormal pattern in 32 out of 37 patients. The colon transit test was performed on 34 of the patients, with a median re-

sult of 67.2 hours (IQR, 60.0-72.0 hours). As a result, 32 patients were categorized as having delayed colonic transit based on published control values.^{19,20} Esophageal manometry was performed on 10 patients; 3 exhibited normal motility, 7 demonstrated ineffective esophageal motility, and none had classic achalasia. A gastric emptying scan was performed in 10 patients, of whom 8 had normal liquid and solid gastric emptying times.

Comparison of Cine-magnetic Resonance Imaging Results and Computed Tomography Findings

Of 41 patients, 38 patients (92.7%) demonstrated normal SB motility (grade 3) on cine-MRI, whereas 3 patients (7.3%) had decreased but preserved SB motility (grade 2), and none demonstrated adynamic waves (grade 1). Figure 2 and Supplementary Video demonstrates that patients with grade 3 exhibited active movement in the SB, whereas those with grade 2 displayed reduced motility.

We then compared the findings from CT and cine-MRI. The median time interval between the dates of CT and cine-MRI was 1.1 months (IQR, 0.3-2.9 months). All 24 patients who demonstrated nondilated SB on CT also exhibited normal SB motility on cine-MRI. However, among the 17 patients who exhibited SB dilatation on CT, 3 had decreased SB motility, whereas 14 had normal SB motility on cine-MRI (Fig. 3). Consequently, among

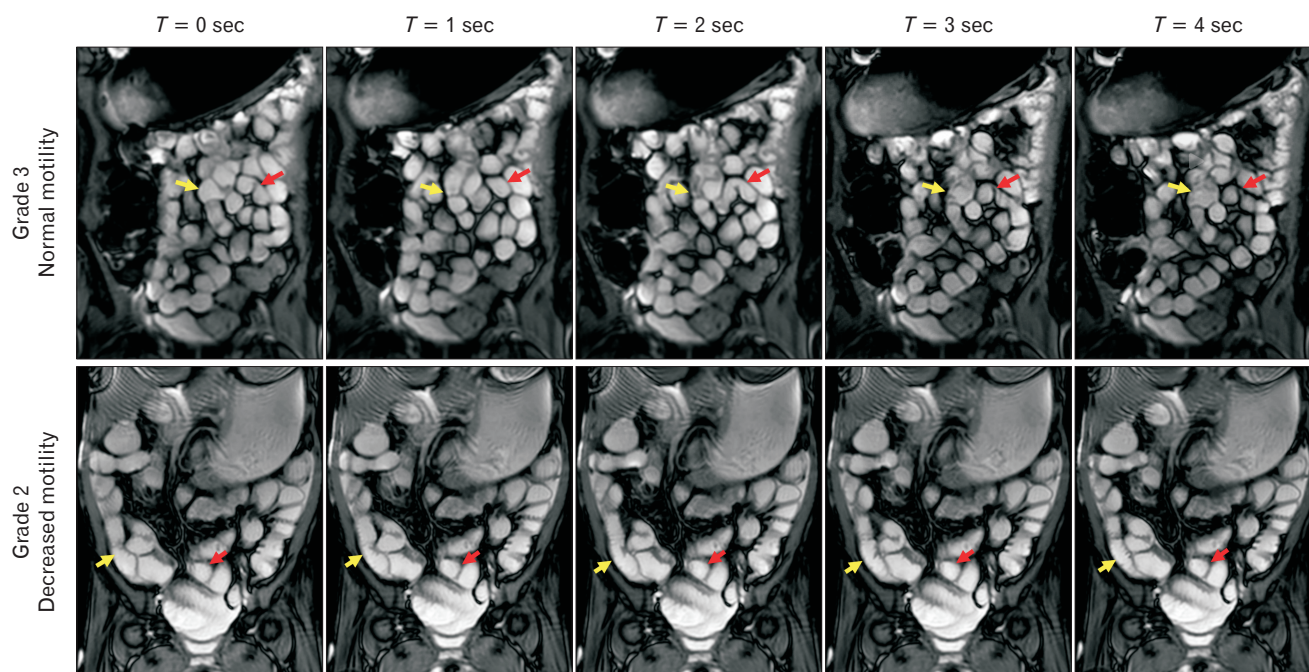


Figure 2. Cine-MRI in patients with normal small bowel (SB) motility (grade 3) and decreased SB motility (grade 2). Coronal images visualize the gastrointestinal tract at 5 moments in time (0, 1, 2, 3, 4, and 5 seconds) of a cine-MRI. Red and yellow arrows indicate 2 specific points on the small bowel whose movement is tracked over time, demonstrating contractility of several loops of the small bowel.

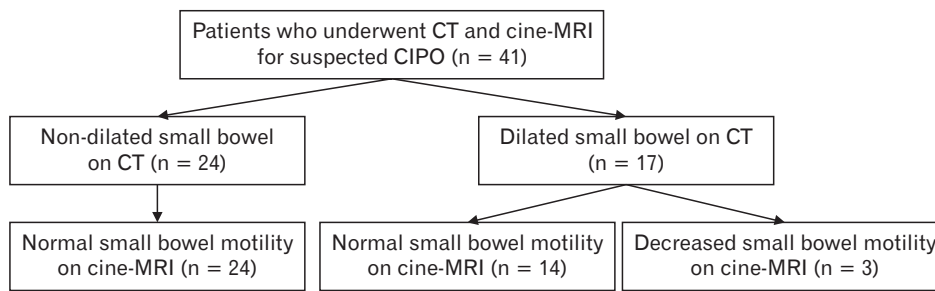


Figure 3. Comparison of small bowel-related findings on CT and cine-MRI. CIPO, chronic intestinal pseudo-obstruction.

Table 4. Clinical Outcomes of Patients With Normal and Decreased Small Bowel Motility

Clinical outcomes	Normal small bowel motility ^a	Decreased small bowel motility ^a	P-value
All patients (n)	38	3	
Duration of follow-up period (mo)	13.6 (4.0-19.8)	12.3 (1.6-29.4)	0.981
Disease-related hospitalization	21 (55.3)	3 (100.0)	0.254
Number of hospitalizations during follow-up	1.0 (0.0-1.0)	2.0 (1.0-3.0)	0.033
Disease-related surgery	20 (52.6)	3 (100.0)	0.243
Improvement of symptoms at the last follow-up	32 (84.2)	0 (0.0)	0.008
Maintenance of medication at the last follow-up	19 (50.0)	3 (100.0)	0.235

^aSmall bowel motility was evaluated using cine-magnetic resonance imaging. Values are expressed as medians (interquartile ranges) or n (%).

Table 5. Postoperative Outcomes of Patients With Normal and Decreased Small Bowel Motility

Postoperative outcomes	Normal small bowel motility ^a	Decreased small bowel motility ^a	P-value
Patients who received surgical treatment (n)	20	3	
Duration from diagnosis to surgery (mo)	3.4 (1.4-9.6)	7.4 (0.2-30.8)	0.966
Duration of postsurgical follow-up (mo)	9.1 (3.7-15.3)	5.7 (0.7-6.0)	0.355
Post-surgical outcomes			
With disease recurrence	3 (15.0)	3 (100.0)	0.011
With rehospitalization	2 (10.0)	3 (100.0)	0.006
With reoperation	1 (5.0)	0 (0.0)	1.000
Discontinuation of medications	16 (80.0)	0 (0.0)	0.020
Death	0 (0.0)	1 (33.3)	0.130

^aSmall bowel motility was evaluated using cine magnetic resonance imaging. Values are expressed as medians (interquartile ranges) or n (%).

patients with SB dilatation, requiring further differentiation from CIPO, 82.4% (14 of 17 patients) were identified as more eligible for FHAM after confirming normal SB motility via cine-MRI.

Clinical Outcomes and Postoperative Outcomes

The median number of disease-related hospitalizations during the follow-up period was higher in patients with decreased SB motility than in patients with normal motility (2.0 [1.0-3.0] vs 1.0 [0.0-1.0], $P = 0.033$). Among those with normal SB motility, 21 (55.3%) experienced disease-related hospitalizations, and 20

(52.6%) received disease-related surgeries during a median follow-up period of 13.6 months. All 3 patients with decreased SB motility had disease-related hospitalizations and surgeries during a median follow-up period of 12.3 months. The rate of symptom improvement at the last follow-up visit was significantly higher in patients with normal SB motility than in those with decreased motility (84.2% vs 0.0%, $P = 0.008$) (Table 4).

Table 5 summarizes the postoperative outcomes of each patient who received disease-related surgery. Rehospitalization due to disease recurrence was significantly lower (10.0% vs 100.0%, $P =$

0.006), and discontinuation of medications was more achievable in patients with normal SB motility than in those with decreased motility (80.0% vs 0.0%, $P = 0.020$). Among the patients with normal SB motility, all 20 patients who underwent colon resection were pathologically confirmed to have hypoganglionosis in the FFN. Over a median postoperative follow-up period of 9.1 months, 1 patient (5.0%) required reoperation (total colectomy) owing to disease recurrence 2 years after the first subtotal colectomy.

All 3 patients with decreased SB motility underwent surgery. One patient underwent an ileocecectomy because of recurrent abdominal pain and distension and was diagnosed with idiopathic CIPO. Another patient was suspected of having CIPO secondary to multiple myeloma and underwent a loop ileostomy owing to refractory symptoms.²¹ The third patient underwent a laparotomy for suspected perforation due to severe bowel dilatation. The patient required total parenteral nutrition despite surgery because of distended small and large intestines. During a median postoperative follow-up period of 5.7 months, all 3 patients required rehospitalization and maintenance of medications. The patients with multiple myeloma expired owing to the progression of the underlying multiple myeloma.

Discussion

This study evaluated the utility of cine-MRI to assess SB motility in patients with suspected CIPO. Among the 41 patients, 17 (41.5%) exhibited SB dilatation on CT, a finding more compatible with CIPO. However, within this group, 82.4% (14 of 17) were identified as eligible for FHAM upon confirmation of normal SB motility through cine-MRI. We could confirm better postoperative prognosis in patients with normal SB motility in terms of disease recurrence and discontinuation of medications. Thus, assessing SB motility by cine-MRI could be helpful in surgical decision-making in patients with suspected CIPO.

Previous studies have reported on a specific group of patients characterized by a segmental megacolon with a focally narrowed colonic segment connecting the proximally dilated and distally nondilated segments.^{3-6,22} Histopathological findings after bowel resection revealed hypoganglionosis localized to this focally narrowed colonic segment.^{6,22} Yoon et al,⁷ have reported on this specific group as “focal hypoganglionosis with adult-onset megacolon (FHAM).” Several previous studies have reported a favorable prognosis after segmental resection of the colon when pseudo-obstruction is caused by a localized lesion, such as FHAM.^{8,22} In particular, Yoon et al,⁷ have reported significant improvements in the Global Bowel Satisfac-

tion scale score and bowel frequency among patients with FHAM postoperatively. By contrast, CIPO, a disabling and potentially life-threatening condition characterized by episodic obstruction-mimicking symptoms, has something in common with FHAM in that no anatomical lesions cause mechanical obstruction.^{1,2} FHAM involves only a portion of the colon, whereas CIPO can involve the entire GI tract, predominantly affecting the SB.²³ Unlike FHAM, CIPO requires chronic conservative treatment because of its high postoperative recurrence rate.^{9,24} Thus, differentiating between these 2 diseases is crucial, and assessing SB motility function may be helpful in differential diagnosis.

The cornerstone for the diagnosis of FHAM and CIPO rests upon the demonstration of distended bowel loops with air–fluid levels on plain radiography or CT scan.^{1,7} These methods are non-invasive and can be performed in any institution. However, these tests provide only static images; therefore, a dilated bowel does not indicate that the bowel has motor dysfunction. In this study, of 17 patients who exhibited a dilated SB on CT, only 3 had decreased SB motility on cine-MRI. The remaining 14 patients demonstrated normal SB motility on cine-MRI despite exhibiting a dilated SB on CT. Based on the literature, SB manometry has been used to diagnose and characterize patients with CIPO.²⁴⁻²⁶ However, it is invasive, and measurement of motility is limited to the proximal SB.²⁶ Further, this technique is not widely available, and among the 41 patients included in this study, none underwent SB manometry. Moreover, a recently published review study regarding CIPO has also emphasized the clinical usefulness of cine-MRI in the diagnosis of CIPO.¹¹

In this context, cine-MRI can be used as a noninvasive and radiation-free method for assessing GI motility function, as it allows for the dynamic evaluation of organ function.^{14,27-29} Menys et al,³⁰ have reported a prospective study using cine-MRI to compare SB motility between CIPO and healthy controls using automated software quantification. In the study, patients with CIPO exhibited significantly lower resting SB motility compared to the control group. They suggested this method as a potential diagnostic tool for assessing SB motility function in CIPO. Meanwhile, Ohkubo et al,³¹ evaluated SB motility in patients with CIPO using diameter measurements of selected loops in cine-MRI. Similarly, this study also demonstrated significantly higher luminal diameter and lower contraction ratio in patients with CIPO compared to healthy volunteers and patients with irritable bowel syndrome. Several studies have investigated the usefulness of evaluating GI motility function through cine-MRI in CIPO.³⁰⁻³³

To the best of our knowledge, this is the first study to evaluate

the usefulness of cine-MRI in differentiating FHAM and CIPO. One case report documented successful surgical treatment in a patient with chronic idiopathic colonic pseudo-obstruction after careful preoperative imaging including cine-MRI.³⁴ However, in this case, cine-MRI was used as a tool to assess colon motility, while enteroclysis was used to confirm the intactness of SB motility. In the current study, 82.4% of patients who demonstrated SB dilatation on CT actually had normal SB motility on cine-MRI, a finding more consistent with FHAM than CIPO. We used a qualitative analysis method based on visual assessment to evaluate SB motility using cine-MRI. Although many quantitative methods are being proposed, there is still no clear standard, and the technology is not yet in a fully developed stage.^{15,35,36} Therefore, our study involved qualitative analysis by one experienced reader. The qualitative assessment has the limitation of being less sensitive and possible variability between readers. However, it has the advantage of faster reading time and is more suitable for daily clinical practices.¹⁵ Further research is needed regarding standard analysis methods and interpretation of cine-MRI.

In this study, 92.7% of patients had normal SB motility, and 7.3% had decreased SB motility on cine-MRI. Based on SB motility function, patients with normal motility could be diagnosed as suspected FHAM, and patients with decreased motility could be diagnosed as suspected CIPO. In a previous study, the diagnostic criteria for FHAM were defined as chronic and refractory symptoms along with colon dilatation of > 5 cm and FFN without an evident structural cause on CT and/or colonoscopy.⁷ According to these diagnostic criteria, of 38 patients exhibiting normal SB motility, 36 met the criteria for a diagnosis of FHAM, excluding 2 individuals who had no prominent FFN on CT. These 2 patients underwent CT scans at local hospitals with different protocols before being referred to our center. These 2 patients did not undergo colon resection; therefore, the exact presence of FFN could not be confirmed. Among the 20 patients who underwent colon resection, all exhibited focal hypoganglionosis limited to FFN, which is a reasonable finding for FHAM. For functional test results, some patients exhibited abnormal findings in anorectal manometry and colon transit time. However, as observed in a previous study, these abnormal findings could potentially be secondary change to chronic refractory constipation.⁷ Moreover, the rectoanal inhibitory response was intact in all patients without evidence of adult-onset Hirschsprung's disease.^{37,38} Meanwhile, all 3 patients with decreased SB motility exhibited delayed gastric emptying time and dysfunction of esophageal motility, which were suitable results to panenteric nature of CIPO.¹¹ According to a recent review article,

cine-MRI is emphasized in the diagnosis of CIPO, whereas the roles of esophageal manometry and gastric emptying scan are relatively less emphasized.¹¹

Regarding postoperative outcomes, patients with normal SB motility has significantly better outcomes in postoperative recurrence and discontinuation of drug use, which are consistent with the results of a previous study.^{6-8,22} Among patients with normal SB motility, 1 reoperation and 2 rehospitalizations occurred because of disease recurrence. One patient who underwent subtotal colectomy required subsequent total colectomy. Pathology review revealed hypoganglionosis at the distal margin of the initial resected specimen, suggesting inadequate resection. After experiencing recurrent symptoms for 2 years post-initial surgery, the patient underwent total colectomy and has remained symptom-free until now. Among the patients requiring rehospitalization, 1 had decreased ganglion cells confirmed at the distal resection margin after subtotal colectomy, suggesting a potential recurrence. Additional reoperation was considered, although the patient refused and is currently maintaining medical therapy. Although the remaining patient, who had a loop colostomy, considered total colectomy because of recurrent symptoms, the patient was lost to follow-up. In patients with FHAM, adequate resection margins including FFN seem necessary, and further study is needed to determine the appropriate surgical approach for each patient. Among patients with decreased SB motility, all 3 patients who received surgery required repeated hospitalization and maintenance of medication, which are findings consistent with the disease progress of CIPO.^{23,24}

Our study has several limitations. First, cine-MRI is not yet widely available, and there are currently no established standards for interpreting its results. In the era of artificial intelligence in radiology and quantitative imaging, various quantitative analysis methods for interpreting cine-MRI are being developed; however, a standard method is yet to be established. Despite its limited use, cine-MRI has shown potential as a valuable imaging modality, and our study utilized qualitative methods based on criteria from previous studies.³⁵ Further accumulation of cine-MRI data and establishment of a gold standard for cine-MRI analysis are necessary to enhance its utility and reliability in clinical practice. Second, the extreme rarity of FHAM and CIPO make it difficult to reduce the bias and generalize our conclusions. We could not accumulate a sufficient number of patients to determine an appropriate sample size based on statistical analysis. Prospective evaluations are required to establish the usefulness of cine-MRI in patients suspected with CIPO. Third, patients with severe bowel distension were excluded due to the inability to undergo cine-MRI, potentially introducing

selection bias. This limitation arises from the inherent constraints of the examination, which necessitates bowel preparation and patient cooperation. The low incidence of decreased or adynamic motility observed in the cine-MRI results of this study could be attributed to this bias. Finally, cine-MRI was not directly compared with other modalities used to diagnose GI motility disorders such as SB manometry. Nevertheless, our study has the strength of being the first study to evaluate the usefulness of cine-MRI in differentiating CIPO and FHAM.

To summarize, FHAM is a new subtype of megacolon demonstrating dilatation of bowel proximal to FFN that has normal SB motility. Of the 17 patients who exhibited both SB and colon dilatation, 14 (82.4%) had normal SB motility, which could have been missed by CT alone but was confirmed through cine-MRI. Regarding postoperative outcomes, patients with normal SB motility demonstrated better outcomes than those with decreased motility in terms of postoperative disease recurrence and discontinuation of drug use.

In conclusion, cine-MRI was valuable for assessing SB motility that could not be detected on CT. It can also be helpful in making surgical decisions by differentiating between FHAM and CIPO.

Supplementary Material

Note: To access the supplementary video mentioned in this article, visit the online version of *Journal of Neurogastroenterology and Motility* at <http://www.jnmjournal.org/>, and at <https://doi.org/10.5056/jnm24130>.

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Sik Byeon, Suk-Kyun Yang, Seong Ho Park, Chang Sik Yu, and Seung-Jae Myung participated as a supporting role in the conceptualization and supervision; and Seung-Jae Myung acquired funds and supervised this study. All authors critically revised the manuscript and approved its final version.

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