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Original Research Article

Imaging Classification of Constipation

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Abstract

Objectives: The diagnosis of patients with chronic constipation is very complicated. This study aimed to develop a simple imaging classification for the diagnosis of chronic constipation by abdominal computed tomography (CT).

Methods: Sixty-two patients who underwent abdominal CT in our hospital between January and June 2022 were enrolled. The CT values of the stool in the rectum and cecum were measured in patients with chronic constipation (C group) and in those without (non-C group).

Results: A strong correlation was observed between the Bristol Stool Form Scale (BSFS) and the CT value of rectal stool. Furthermore, the rectal stool CT value was significantly higher in patients with chronic constipation than in those without. The CT value of cecal stool did not differ between the two groups. The cecal stool CT value was significantly higher in patients with severe constipation (BSFS 1) than in those with BSFS 2-6. A cutoff CT value of 100 was selected as the optimal value for indicating chronic constipation.

Conclusions: Abdominal CT was useful in the diagnosis of chronic constipation. If the patient had constipation, the optimal cutoff CT value was 100.

Keywords

constipation, abdominal CT, imaging classification

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Introduction

Chronic constipation is a common gastrointestinal disorder, with a global prevalence of 12.0%-17.0%[1]. This disorder has been reported to worsen survival by more than 20% at 15 years[2]. Chronic constipation has also been reported to be a risk factor for not only cardiovascular events[3] but also venous thrombosis and developing chronic kidney disease[4,5]. Furthermore, chronic constipation has been reported to be involved in a vicious cycle of reduced daily activity and labor productivity and frailty in elderly persons[6,7]. Because chronic constipation is associated with many other health-related issues, it is a very important condition to diagnose and treat in clinical practice. Currently, the diagnosis is made using the Rome Criteria lV classification (Table 1)[8,9], but it is very difficult for nonspecialists to use this method for diagnosis.

In the present study, computed tomography (CT) scans of

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Table 1. Rome IV Diagnostic Criteria for Functional Constipation.

1	Must include two or more of the following.
2	Straining during more than 1/4 (25%) of defecations
3	Lumpy or hard stool (Bristol Stool Form Scale 1–2) more than 1/4 (25%) of defecations
4	Sensation of incomplete evacuation more than 1/4 (25%) of defecations
5	Sensation of anorectal obstruction/blockage more than 1/4 (25%) of defecations
6	Manual maneuvers to facilitate more than 1/4 (25%) of defecations (e.g., digital evacuation and support of the pelvic floor)
7	Fewer than three SBM per week
8	Loose stools are rarely present without the use of laxatives
9	Insufficient criteria for irritable bowel syndrome

※Criteria fulfilled for the last 3 months with symptom onset at least 6 months prior to diagnosis

patients with chronic constipation were retrospectively reviewed, and an imaging classification, which is important for the diagnosis and treatment of chronic constipation, is proposed.

Methods

Study design

This was a retrospective study of a prospectively recorded database of 62 cases that underwent abdominal CT at Ehime University Hospital in Japan between January and June 2022. This study protocol was approved by the Medical Ethics Committee of Ehime University. The requirement for written informed consent was waived for this study because of its retrospective design.

Patients

We enrolled patients in this study who underwent abdominal CT for postoperative follow-up or for abdominal screening as author's outpatient. Patients were included and divided into two groups for analysis: patients with chronic constipation (C group) and those without (non-C group). The Rome Criteria IV were used to determine if the patients were constipated.

Measurement method

CT examinations were performed using a 320-row multidetector CT scanner (Aquilion ONE; Canon Medical Systems Corporation, Tochigi, Japan). In patients who underwent abdominal CT, stool CT values were measured at the sites of fecal impaction in the rectum and cecum. The maximum CT value among three regions of interest at each site was used as the measurement value. The SYNAPSE software program, version 5.5 (Fujifilm Medical, Tokyo, Japan) was used for measurement of the CT value.

Statistical analysis

The SPSS software program, version 28.0 (IBM, Tokyo, Japan) was used for statistical analysis. All data are expressed as medians with interquartile range (IQR). Differences in patients' clinical data were assessed with the χ^2 test and the unpaired Student's *t*-test, as appropriate. The relationship between the Bristol Stool Form Scale (BSFS) and the CT value was assessed by Spearman's correlation coefficient. Receiver operating characteristic (ROC) curves were constructed to determine the ability of the CT value to predict the development of constipation. The cutoff CT value for constipation screening was also determined by ROC analysis using the Youden index. A *p*-value less than 0.05 was considered to indicate statistical significance.

Results

Patients' characteristics

Data were collected for 62 patients who underwent abdominal CT during the study period. Sixty-two (29 male, 33 female) patients with a median age of 72.5 (IQR: 61-79) years and a median body mass index (BMI) of 23.0 (IQR: 20.1-25.7) kg/m^2 were enrolled. They were divided into the C group (n = 25; 40.3%) and the non-C group (n = 37; 59.7%). The Rome Criteria IV was used to determine if the patients were constipated. The patients' characteristics are shown in Table 2. BMI was significantly higher in the C group than in the non-C group. Other factors (e.g., age, sex, smoking, alcohol, comorbidities, and laxatives) did not differ significantly.

CT value of stool by BSFS

The CT value of stool was assessed by BSFS (Table 3). A strong correlation was observed between the BSFS and the CT value of rectal stool (Spearman's correlation coefficient: r = −0.707, $p < 0.01$) (Figure 1). Patients with BSFS 1 had significantly higher CT values of stool in the cecum than patients with BSFS 2-6 (Table 4).

CT values of stool in the C and non-C groups

Table 5 shows the CT values of rectal and cecal stool. Patients in the C group had a significantly higher CT value of

Table 2. Patient Characteristics in the Constipation and No Constipation Groups.

Variables	Total (n = 62)	C group (n = 25)	Non-C group (n = 37)	*p*-Value
Age, years	72.5 (61–79)	74 (63–78)	72 (61–79)	0.46
Sex (male/female), n (%)	29 (46.8):33 (53.2)	12 (48):13 (52)	17 (45.9):20 (54.1)	0.92
BMI, kg/m^2	23.0 (20.1–25.7)	24.8 (21.1–26.3)	22.2 (19.5–24.8)	0.03
Smoking (yes:no) (%)	3 (4.8):59 (94.2)	0 (0):37 (100)	3 (12):22 (88)	0.27
Alcohol (yes:no) (%)	21 (33.9):41 (66.1)	9 (24.3):16 (75.7)	12 (48):25 (52)	0.98
Comorbidities, n (%)				
Diabetes	11 (17.7)	6 (16.2)	5 (20)	0.47
Hypertension	26 (41.9)	8 (21.6)	18 (72)	0.89
Heart diseases	4 (6.5)	3 (12)	1 (2.7)	0.40
Neurological disorder	4 (6.5)	3 (12)	1 (2.7)	0.40
Abd operation (yes:no), n (%)	50 (80.6):12 (19.4)	20 (80):5 (20)	30 (81.1):7 (18.9)	0.82
Polysurgery (yes:no), n (%)	19 (30.6):43 (69.4)	6 (24):19 (76)	13 (35.1):24 (65.9)	0.51
Use of laxatives (yes:no), n (%)	22 (35.5):40 (64.5)	10 (40):15 (60)	12 (32.4):25 (67.6)	0.53
Magnesium oxide		8	8	0.36
Elobixibat hydrate		1	2	0.80
Kampo		2	2	0.68
Other		0	3	0.14
BSFS 1/2/3/4/5/6/7	8/13/12/21/5/3/0	8/12/5/0/0/0/0	0/1/7/21/5/3/0	

Table 3. CT Values of Stool in the Cecum and Rectum.

BSFS	n = 62	CT value (HU)	
		Cecum	Rectum
1	8	73.3 ± 10.3	132.6 ± 27.0
2	13	54.7 ± 13.2	122.0 ± 23.2
3	12	60.8 ± 12.4	102.5 ± 27.3
4	21	56.6 ± 13.9	75.1 ± 19.3
5	5	57.8 ± 15.8	67.2 ± 26.9
6	3	54.7 ± 10.7	57.7 ± 9.3

rectal stool than patients in the non-C group ($p < 0.01$). There were no differences in the CT values of cecal stool between the groups.

ROC analysis for diagnosis of chronic constipation

To determine the diagnosis of constipation, ROC analysis of the CT value of stool in the rectum was performed (Figure 2). As presented in Table 6, the CT value demonstrated acceptable accuracy (AUC: 0.954, sensitivity: 1, specificity: 0.838). The Youden index was 91.

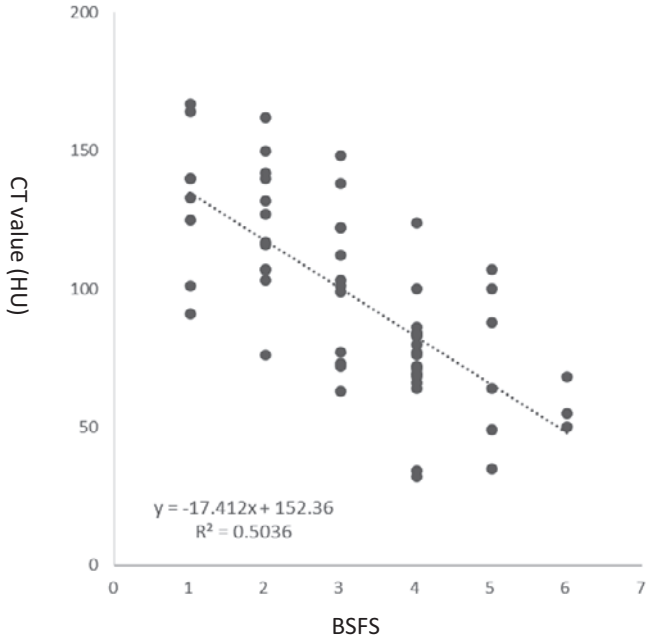

Figure 1. Relationship between BSFS and the CT value of rectal stool (r = 0.71, $p < 0.01$).
BSFS: Bristol Stool Form Scale, CT: computed tomography

Discussion

To the best of our knowledge, this is the first report of the CT values of stool in patients with chronic constipation. When stool is observed on CT, it is considered to be hard. However, there have been no reports of either the actual measurement of CT values or the clinical application of the CT values of stool.

The CT value is defined as follows[10]. The value of air is minus 1000, and that of water is 0. Based on this, other CT values are determined. Generally, adipose tissue has a negative value, whereas other tissues have positive values. For example, the CT value of the liver is approximately 50-80, and that of the bone is 200-500. In the present study, the CT value of stool in the colon ranged from approximately

30 to 150. The CT values ranged from 30 to 80 in the cecum and from 80 to 150 in the rectum. CT values increase as stool progresses through the large intestine because of the absorption of water from the stool. Approximately 9 l of water enters the intestinal tract, with 7.5 l absorbed in the small intestine and 1.5 l in the large intestine per day. Of that amount, only approximately 100 ml is excreted, and most of that is also absorbed in the large intestine[11]. The CT value is low in the cecum because the stool in this part normally contains a lot of water. When the stool reaches the rectum, most of the water has been absorbed, so the CT value is high.

Constipation can be quantified and defined by the CT value. CT values of stool in the rectum were significantly higher in the C group than in the non-C group. This is attributed to the low water content of stool in patients with constipation. Conversely, the CT values in the cecum showed no difference between the C and non-C groups. This is attributed to the decrease in water content of stool during passage through the colon. The water content determines whether the patient becomes constipated. In the present study, the cutoff CT value of rectal stool in the C group was evaluated, and the Youden index was 91, as shown in Table 4. From the perspective of accuracy and specificity, a CT value of 100 was selected as the cutoff value.

In cases of severe constipation, high CT values are observed even in the cecum. Though CT values of intracecal stool showed no statistical significance between the C group and the non-C group, a subanalysis comparing patients with BSFS 1 with those with BSFS 2-6 showed that the CT values were significantly higher in patients with BSFS 1. These results suggest that patients with very hard stool may already be absorbing water at the cecal stage, at the end of small intestinal transit.

Treatment for constipation will be simpler with proper measurement of the CT values of stool. Since many patients with chronic constipation are thought to have water absorption in the large intestine, the choice of a drug such as elobixibat hydrate, which replenishes water in the large intestine, is considered more physiologically relevant[12]. Conversely, patients with extremely hard stool are thought to have already absorbed water in the cecum and therefore, may need a drug that results in secretion of water in the small intestine, such as lubiprostone or linaclotide[13,14]. In addition, patients who complain of constipation even though their CT values are not high may require drugs that promote

Table 4. CT Value of Stools by BSFS.

n = 62		CT value (HU) Cecum	
BSFS 1	n = 8	73.3 ± 10.3	*
BSFS 2–6	n = 54	56.6 ± 13.3	

*$p < 0.01$ significant difference

Table 5. CT Values of Stool in the C and Non-C Groups.

n = 62		CT value (HU)		
		Cecum	Rectum	
Non-C group	n = 37	56.3 ± 13.3	75.4 ± 21.4	*
C group	n = 25	62.3 ± 14.5	127.0 ± 22.1	

*$p < 0.01$

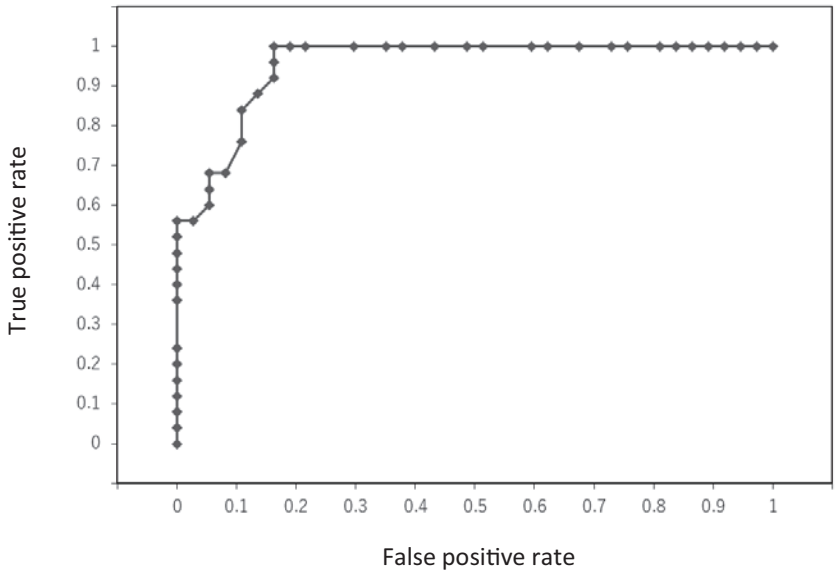

Figure 2. ROC analysis for diagnosis of chronic constipation.
ROC: receiver operating characteristic

Table 6. Cutoff Value, Sensitivity, and Specificity of CT Value.

	Cutoff value	Sensitivity (%)	Specificity (%)	AUC	Standard error	*p*-Value	95% CI	
							Lower limit	Upper limit
CT value (HU)	91	1	0.838	0.954	0.023	0.000	0.909	0.999

intestinal peristalsis. Therefore, the imaging classification developed in the present study is useful for not only diagnosis but also patient management. Though not described in this report, we have experienced a case in which the CT number was reduced to less than 100 and symptoms improved after drug treatment. Consequently, we believe that the CT values of stool can be used to determine the effectiveness of treatment.

The maximum CT value of stool was the focus in the present study; however, the minimum and average CT numbers are also of interest. Though not shown in the present study, they have not been found to be as useful as the maximum value so far.

The present study has some limitations that must be considered when interpreting the results. The sample size was small, and only data from a single center were analyzed. Moreover, defecation timing and psychological stress were not taken into account, but the bowel appearance on CT is affected by the timing of defecation, and psychological stress has been found to enhance colonic motor activity. In the future, large-scale studies will be needed to confirm the utility of the proposed imaging classification of constipation.

Conclusion

Abdominal CT is a useful modality for diagnostic classification of constipation. A CT value of 100 may be the optimal reference value for the diagnosis of constipation. Therefore, imaging classification may be useful in clinical practice for the diagnosis of constipation.

Conflicts of Interest

There are no conflicts of interest.

Author Contributions

Kei Ishimaru, Hiroshi Kakuto, Shungo Yukumi, Satoshi Akita, Yusuke Ogi, Satoshi Kikuchi, Motohira Yoshida, and Shigejiro Koga wrote the main text. Kei Ishimaru, Hiroshi Kakuto, and Shungo Yukumi prepared Tables 1-5. All authors checked and approved the final manuscript for submission.

Approval by Institutional Review Board (IRB)

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