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ORIGINAL ARTICLE

Clinical and CT findings of small bowel obstruction caused by rice cakes in comparison with bezoars

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Abstract

Purpose Rice cakes have not been recognized as a cause of small bowel obstruction (SBO) worldwide. We compared clinical and CT findings of rice cake SBO versus SBO due to bezoars, the most common cause of food-induced SBO.

Methods Twenty-four patients with rice cake SBO ($n=17$) or bezoar SBO ($n=7$) were retrospectively evaluated for clinical findings and the following multi-detector CT (MDCT) features: identification of the transition zone, presence of intraluminal lesions, degree of obstruction, and length and attenuation of obstructing materials. Categorical variables were compared by Fisher's exact test, and continuous variables by independent *t* test.

Results None of the rice cake SBO patients required surgery, whereas 4/7 (57%) bezoar SBO patients underwent surgery. On MDCT, rice cake residues were recognized as well-defined intraluminal lesions of shorter length (29.8 ± 4.6 mm vs. 47.7 ± 10.8 mm for bezoars; $p<0.0001$) and higher attenuation (106 ± 27.8 HU vs. -62.8 ± 14.7 HU for bezoars; $p<0.0001$).

Conclusions Rice cake SBO patients did not require surgery. On MDCT, rice cake residues were significantly shorter and higher in attenuation than bezoars. These findings facilitate diagnosis and support the conservative management of rice cake SBO.

Keywords Rice cake · Bezoar · Small bowel obstruction · Food-induced small bowel obstruction · Multi-detector CT

Introduction

Food-induced small bowel obstruction (SBO) is a rare condition caused by routinely eaten food and accounts for 0.3–4% of all causes of SBO [1, 2]. A variety of food can cause SBO, and Japanese rice cake is one of them. Called *mochi* in Japan, rice cakes are a much loved traditional dish which is popularly eaten particularly during the first week of the New Year and celebratory occasions. In Japan, several cases of airway or bowel obstruction associated with the ingestion of sticky *mochi* are reported every year. Given the rising popularity of Japanese food culture in Western countries, understanding clinical and imaging features of rice cake SBO is of great significance to the medical communities worldwide.

Determining the cause of food-induced SBO is critical when deciding treatment options. Computed tomography (CT) is an indispensable tool for establishing the diagnosis of SBO, localizing the site of obstruction, and determining the cause [3]. While much is reported on CT findings of SBO caused by bezoars migrating into the small intestine [4–11], little is known about other rare types of food-induced SBO, and available studies are limited to case reports [12, 13]. English medical literature on rice cake SBO is even rarer [14–16], and its imaging features and differences from other food-induced SBO have not been studied systematically. In this study, we retrospectively evaluated clinical and multi-detector CT (MDCT) findings of rice cake SBO in comparison with bezoars, one of the most well-studied and common causes of food-induced SBO.

Materials and methods

Subjects

The study was conducted at our hospital and three affiliated institutions and was approved by the institutional review board of each institution. Formal consent is not required

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due to the retrospective nature of the study. Patient anonymity was maintained.

Subjects were identified by searching electronic medical records created between October 2007 and September 2017 at each institution. Inclusion criteria were record of a detailed medical interview regarding the history of food and snack intakes, CT findings that were consistent with the food consumption history, and sufficient record to rule out other causes or surgically confirmed presence of undigested food at the site of SBO. The search identified a total of 24 cases of SBO caused by either rice cake or bezoar. Rice cake SBO ($n = 17$; male:female = 9:8) was confirmed by the record of detailed history taking including the consumption of several rice cakes within a week before the symptom onset and the presence of undigested food at the site of SBO on MDCT images. Diagnosis of bezoar SBO ($n = 7$; male:female = 5:2) was based on the regular consumption of persimmons, a common cause of bezoars, combined with characteristic CT findings (two cases), detection of tannin from the surgically retrieved bezoar (four cases), or colonoscopically confirmed presence of a bezoar with characteristic shape and color in the colon (one case). The characteristic CT findings of a small bowel bezoar demonstrated a well-defined, oval, nonhomogeneous mass consisting of gas and soft tissue previously reported [4–9, 11].

Clinical data collection and analysis

One board-certified radiologist with more than 8 years of experience, otherwise independent of the present study, retrospectively reviewed the clinical data from the medical records of the 24 patients with SBO. Data included were age, gender, complaints (e.g., abdominal pain and vomiting), factors predisposing to SBO (eating habits such as eating too quickly or gulping, tooth loss and denture wearing that may cause mastication difficulty, diabetes, dementia, mental illness and other preexisting conditions, and history of abdominal surgery), laboratory variables [white blood cell (WBC) count and C-reactive protein (CRP)] on the day of first consultation (or admission), treatment modality, and outcome. The monthly incidence was also compared between rice cake SBO and bezoar SBO.

MDCT data collection and analysis

MDCT examinations

All 24 patients had undergone 16- or 64-row MDCT examinations on the first consultation (or admission) day. Unenhanced CT was performed in all patients, and both unenhanced and contrast-enhanced CT were performed in one patient. Contrast-enhanced CT was taken in a single phase at 90 s after intravenous administration of 80 mL of iodinated contrast material at a rate of 3 mL/s. No oral contrast media was used. In all 24 patients, CT was performed from the upper margin of the diaphragm to the pubic symphysis in the axial plane with a section thickness of 5 mm without intersection gap. Coronal reformatted images of 2–5 mm slice thickness were obtained in 12 patients. Sagittal reformatted images of 1.5 mm thickness were also obtained in one of those 12 patients. Reformatted images were all non-enhanced.

Qualitative MDCT image analysis

All MDCT images were evaluated and reviewed independently by two board-certified radiologists with more than 8 years and 24 years of experience in gastrointestinal radiology. They knew the research purpose but were blinded to the clinical data and diagnostic results. The following was evaluated visually: (1) identification of a transition point between the dilated proximal and the decompressed distal small bowel loops; (2) presence of intraluminal lesion that suggests the cause of SBO; (3) degree of obstruction ("low-grade" if a moderate amount of gas and liquid stool was observed in the ascending colon, "high-grade" if only minimal gas or liquid stool was seen in the ascending colon, and "complete" if the ascending colon was totally collapsed without gas or fluid in its lumen [17]); (4) presence of mesenteric fat stranding adjacent to the site of the obstruction; (5) presence of intraperitoneal fluid; and (6) presence of intra-abdominal abnormal air (abdominal free air, pneumatosis intestinalis and portal venous gas). After completing the review, a final consensus meeting was held to resolve any discrepancies in MDCT interpretation that occurred between the two readers. Inter-reader variability was assessed with the kappa (κ) statistic.

Quantitative MDCT analysis

In addition to the visual assessment, the following parameters were determined by the same two radiologists: (1) maximal length of the obstructing structure identified at the site of SBO through to the dilated bowel and (2) CT attenuation of the identified structure in the dilated bowel [as Hounsfield units (HU) within the circular 1-cm^2 ROI]. To ensure reliability and reproducibility, the two readers separately performed all quantitative measurements on a PACS workstation. The quantitative parameters were then averaged as the final measurement results and further used to assess the interobserver variability using the κ statistic.

Statistical analysis

All statistical analyses were performed with GraphPad Prism version 7.02 (GraphPad Software, San Diego, CA)

and JMP® 13 (SAS Institute, Cary, NC). Categorical variables were compared using Fisher's exact test, whereas continuous variables were compared using independent *t* test. Further, the κ coefficient was used to assess the interobserver agreement for qualitative and quantitative MDCT data, and the differences of the two observers' measurements for each continuous variable (difference of obstructive structure length, > 34 mm or ≤34 mm (the value was the average of obstructive structure lengths for all 24 patients); difference of CT attenuation, > 0 HU or ≤ 0 HU) were then defined. The 95% CI was computed for each κ estimate. For each variable, interobserver agreement coefficients were interpreted as described by Landis and Koch [18]: $\kappa = 0.21$–0.40, fair agreement; $\kappa = 0.41$–0.60, moderate agreement; $\kappa = 0.61$–0.80, substantial agreement; and $\kappa = 0.81$–1.00, almost perfect. The receiver operating characteristic (ROC) curve was used to determine the optimum cut-off values for the quantitative MDCT parameter (the length of obstructing materials) to differentiate the two groups. The area under the ROC curve (AUC) was calculated for the predictive accuracy of the parameter. The Youden index (sensitivity + specificity − 1) was used to select the optimal cut-off points of the ROC curves. Differences were considered statistically significant when $p < 0.05$.

Results

Clinical findings

Patient characteristics and results of statistical comparison between rice cake SBO and bezoar SBO are summarized in Table 1. The mean age at the onset was marginally significantly ($p < 0.1$) lower for rice cake SBO than for bezoar SBO. Abdominal pain was the most common clinical sign of both types of SBO but relatively more common in rice cake SBO. Diabetes was a significantly more frequent comorbidity in bezoar SBO patients. CRP was significantly higher in

Table 1 Comparison of clinical and laboratory parameters between rice cake SBO and bezoar SBO

Clinical and laboratory parameters	Rice cake SBO ($N=17$)	Bezoar SBO ($N=7$)	*p* value
Mean age, years (range)	66.4 (44–80)	74.9 (63–86)	0.0889
Sex			0.6529
Male	9 (53.0)	5 (71.4)	
Female	8 (47.0)	2 (28.6)	
Chief complaints			
Abdominal pain	17 (100)	5 (71.4)	0.0761
Nausea/vomiting	7 (41.2)	4 (57.1)	0.6591
Gulping habit	2 (11.7)	0 (0)	> 0.9999
Dentition			
Toothless	1 (5.8)	1 (14.2)	0.5072
Medical history			
Diabetes mellitus	2 (11.7)	4 (57.1)	0.0196*
Psychiatric disorder	2 (11.7)	1 (14.2)	> 0.9999
Previous surgery	7 (41.1)	2 (28.6)	0.6687
Gastrectomy	0 (0)	1 (14.3)	
Appendicectomy	3 (17.6)	0 (0)	
Hysterectomy	4 (23.5)	0 (0)	
Others	0 (0)	1 (14.3)	
Laboratory findings			
White blood cell count ($\times 10^3/\mu L$)	11.2 ± 2.2	8.9 ± 3.1	0.0635
C-reactive protein (mg/dL)	0.4 ± 0.7	8.1 ± 9.1	0.0031*
Treatment			< 0.0001*
Conservative	15 (88.2)	0 (0)	
Treatment	2 (11.8)	7 (100)	
Stomach tube	0 (0)	1 (14.3)	
Ileus tube	2 (11.8)	2 (28.6)	
Surgery	0 (0)	4 (57.1)	

Categorical data are expressed as number of patients (percentage), and continuous data are expressed as mean ± standard deviation

*A *p* value of <0.05 indicates a significant difference

bezoar SBO patients than in rice cake SBO patients. While 15/17 of patients with rice cake SBO improved by conservative treatment consisting of fasting and intravenous fluid, none of the bezoar SBO patients improved by conservative treatment. The remaining two patients with rice cake SBO required ileus tube insertion. For bezoar SBO, 3/7 patients received gastric or ileus tube decompression, and surgery was required in 4 patients. No significant difference was observed in gender, complaints of nausea/vomiting, predisposing factors other than diabetes, and WBC count between the two groups.

The monthly incidence of SBO was observed in January (12/24; 50%), and 11 of them were rice cake SBO. The incidence of rice cake SBO in January (11/17; 64.7%) was more than triple of that observed in the other months.

MDCT imaging findings

The qualitative and quantitative MDCT features of rice cake SBO and bezoar SBO are summarized in Table 2. There was no significant difference in the number of patients with an identified transition point, the presence of intraluminal lesions, mesenteric fat stranding, and/or intraperitoneal fluid, or by the bowel obstruction grade. Intra-abdominal abnormal air (abdominal free air, pneumatosis intestinalis or portal venous gas) was not observed in any of the patients. Agreement was moderate for the visual assessment of degree of obstruction ($\kappa = 0.70$, 95% CI from 0.438 to 0.962), mesenteric fat stranding ($\kappa = 0.69$, 95% CI from 0.377 to 1.000) and intraperitoneal fluid ($\kappa = 0.66$, 95%CI from 0.360 to 0.959). All the agreements of remaining visual assessments were perfect ($\kappa = 1.00$, 95% CI from 1.000 to 1.000).

Rice cake SBO patients had a significantly shorter maximal length ($p < 0.0001$) and higher attenuation of food residues than in bezoar SBO patients ($p < 0.0001$). All of the CT attenuation values of rice cake residues were positive (75.3–181.0 HU), and all of the CT attenuation values of bezoars were within the fat level (− 93.8 to − 47.3 HU).

Representative images of rice cake SBO and bezoar SBO were selected based on the MDCT findings and are shown in Fig. 1 and Fig. 2, respectively. A simple decision rule for distinguishing between rice cake SBO and bezoar SBO is to establish a cut-off point for the length of obstructing materials. The ROC curve showed that a cut-off value of <38.7 mm (AUC 0.962; sensitivity 85.7%) was predictive of rice cake SBO. The CT values of intraluminal lesion between rice cake group and bezoar group were significantly different ($p < 0.0001$). All CT values in the rice cake group were positive, while all CT values in the bezoar group were negative. Interobserver agreement was substantial for the measurement of the length of obstructing structure ($\kappa = 0.82$, 95% CI from 0.587 to 1.000) and perfect for CT attenuation ($\kappa = 1.00$, 95% CI from 1.000 to 1.000).

Discussion

The present study included the largest number of patients with rice cake or *mochi* SBO to date. We found that rice cake SBO likely develops at a slightly younger age without particular predisposing factors, causes abdominal pain, has lower CRP, and improves by conservative treatment compared to bezoar SBO. More than half of the rice cake SBO occurred in January (11/17; 65%). On MDCT, differentiation of rice cake SBO from bezoar SBO was possible only by

Table 2 Comparison of MDCT features between rice cake SBO and bezoar SBO

MDCT features	Rice cake SBO ($n = 17$)	Bezoar SBO ($n = 7$)	p value
Identification of transition point	17 (100)	7 (100)	
Presence of intraluminal lesion	17 (100)	7 (100)	
Degree of obstruction			0.2053
Low grade	13 (76.5)	3 (42.8)	
High grade	2 (11.7)	3 (42.8)	
Complete	2 (11.7)	1 (14.3)	
Mesenteric fat stranding	3 (17.6)	2 (28.6)	0.1948
Intraperitoneal fluid	8 (47.1)	4 (57.1)	0.6534
Abdominal free air	0 (0)	0 (0)	
Pneumatosis intestinalis	0 (0)	0 (0)	
Portal venous gas	0 (0)	0 (0)	
Maximal obstructing material length (mm)	29.8 ± 4.6	47.7 ± 10.8	<0.0001*
Mean attenuation (HU)	106.5 ± 27.8	−62.8 ± 14.7	<0.0001*

Categorical data are expressed as the number of patients (percentage), and continuous data are expressed as mean ± standard deviation

*A p value of <0.05 indicates a significant difference

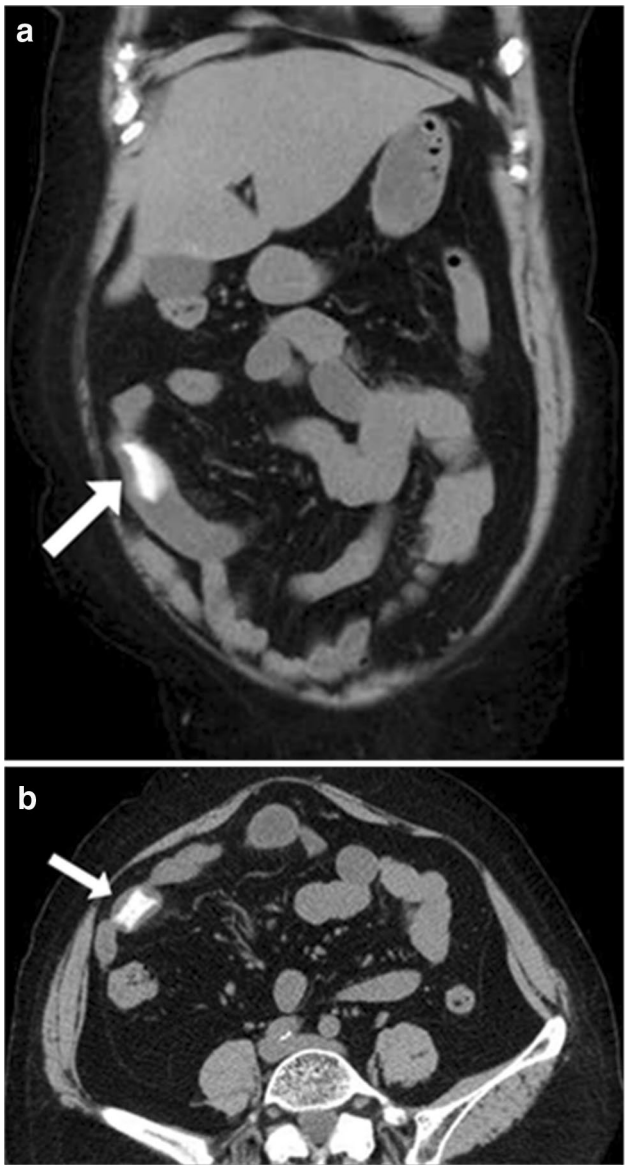

Fig. 1 A typical MDCT appearance of rice cake SBO in a 72-year-old man. Coronal (**a**) and axial (**b**) unenhanced MDCT images demonstrate a well-defined intraluminal high-attenuation mass (arrow) at the transition point proximal to the collapsed small bowel. The length of the intraluminal mass was about 28.3 mm and the mean attenuation was about 158 HU

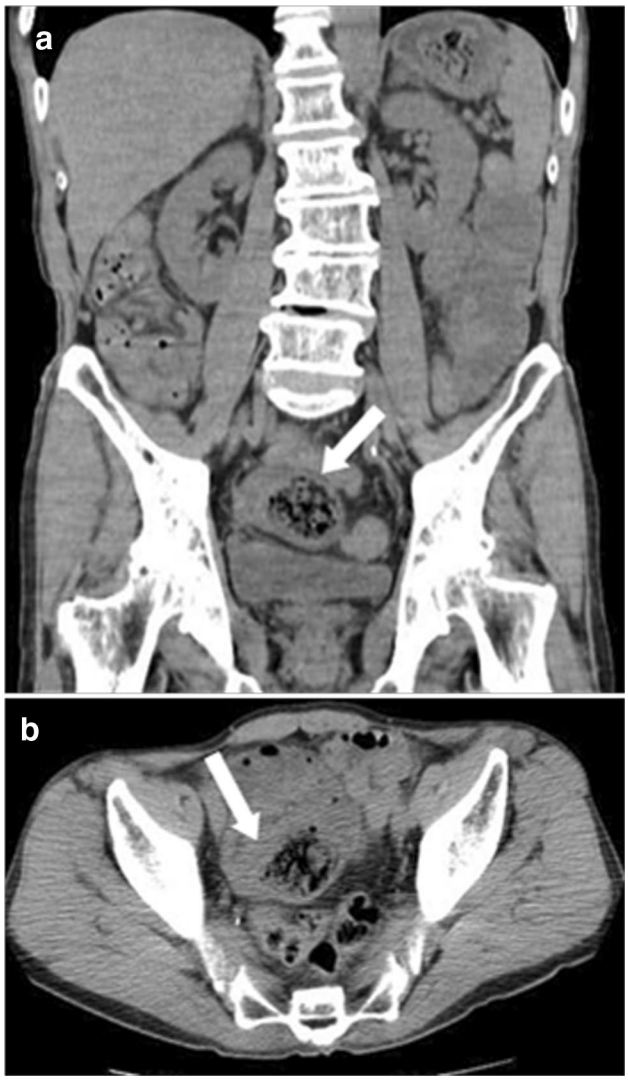

Fig. 2 A typical MDCT appearance of bezoar SBO in an 84-year-old man. Coronal (**a**) and axial (**b**) unenhanced MDCT images demonstrate a well-defined intraluminal mass containing soft tissue attenuation with air bubbles (arrow) at the transition point proximal to the collapsed small bowel. The length of the intraluminal mass was about 45.1 mm and the mean attenuation was about − 94 HU

quantitative analysis; rice cake residues were significantly shorter in length and higher in attenuation than bezoars.

In the previous case reports of SBO caused by rice cake [14–16], rice cake residues were observed as homogenous high-density structures in the transition zone on CT. Although our findings were consistent with these reports, this description alone is rather subjective. To further improve the diagnostic accuracy, we evaluated other image features both qualitatively and quantitatively. We selected bezoar SBO as a control, because its CT findings and mechanisms are well documented [4–9, 11]. Since a bezoar consists of ingested food materials mixed with air bubbles in the body, bezoar SBO is often identified as a characteristic "bubbly and mass impaction" on CT. This seemed easily distinguishable from rice cake SBO. Our results showed that the rice cake residue had a mean attenuation value of 106.5 ± 27.8 HU indicating a highly radiodense structure compared to bezoars that had a mean attenuation value of -62.8 ± 14.7 HU. Apart from the rice cake, kelp, one of traditional Japanese foods, can also be a cause of SBO. Though kelp contains iodine, high-density structures causing SBO in the transition zone have not been described but "bubbly mass and impaction" like bezoar SBO in the previous reports of

SBO caused by kelp [19, 20]. In these reports, obstructing contents were found to be non-digested and swollen kelp, so it was suggested that intestinal fluid makes kelp-containing iodine less dense. We think that the effect of swelling by intestinal fluid seems less occurred in rice cake. Additionally, an obstructing material shorter than 38.7 mm is likely indicative of rice cake SBO rather than bezoar SBO. We also found that rice cake SBO was more likely of a lower grade obstruction and tended to have less mesenteric fat stranding and intraperitoneal fluid (Table 2).

The age of onset was higher for bezoar SBO than for rice cake SBO. This is probably because bezoar formation takes time and involves reduced intestinal motility, while rice cakes are popular across all ages in Japan. Diabetes is one of the factors that affect intestinal motility [21] and was found at a significantly higher rate in bezoar SBO patients in the present study (4/7; 57.1%). Abdominal complaints are almost always present in SBO, but these are neither specific nor diagnostic. In fact, these complaints were similar between rice cake SBO and bezoar SBO in our study. Patient's factors predisposing to food-induced SBO are diverse including age-related reduction in bite force [22]. In our study, elderly patients aged over 65 years accounted for 75% of all subjects, and predisposing eating habits or tooth loss were found in 16.7%. Three patients (12.5%) had dementia or mental illness, and nine (37.5%) had a history of abdominal surgery. Except for age and diabetes, the frequencies of these factors were similar between rice cake SBO and bezoar SBO.

SBO is commonly treated conservatively if there is no clinical or radiographic sign of bowel ischemia. Surgery is required if the condition does not improve. The majority of the previously reported rice cake SBO patients recovered without an aggressive approach [16], whereas most of the bezoar SBO patients required surgical intervention [8, 23]. Our findings were consistent with these previous reports. Therefore, CT diagnosis of rice cake SBO plays a key role in avoiding unnecessary invasive interventions. Significantly lower, almost normal CRP values in rice cake SBO (mean 0.4 ± 0.7 mg/dL) at the onset of symptoms may also suggest that conservative treatment is possible, although the reason for lower CRP values is not understood.

In Japan, *mochi* is frequently eaten for New Year's celebrations and other festive occasions. Not surprisingly, the incidence of rice cake SBO was the highest in January in the present study (11/17; 65%). Miura et al. also reported that 57.1% (8/14) of hospital admissions due to rice cake bowel obstruction occurred in January and 14.3% (2/14) in November and December [15]. In addition, Oka et al. showed similar results with more cases of rice cake bowel obstruction, 59.4% (47/79) in January, 7.6% (6/79) in November and 13.9% (11/79) in December [16]. This seasonal trend, however, may be unique to the Japanese population, and rice cake obstruction may occur any time during the year in other countries, because rice cakes are sold throughout the year.

There are several limitations in the present study. First, cases were retrieved from multiple centers and may have inherent variability. This was unavoidable because of the rarity of food-induced SBO. Second, the study was conducted in a retrospective design. It is ideal to conduct a prospective study. Third, in cases for which surgical removal or endoscopy was not performed, causes were determined solely based on the patient interview and/or the clinical course. It is often difficult to identify the cause of SBO only with CT findings. The most important information in the diagnosis of patients with SBO is confirmation of the meal contents, which the patients had eaten. Because many of the food-induced SBO cases are responsive to conservative therapy, it would be unethical or unrealistic to confirm all the causes by an invasive method.

This study included the largest number of patients with rice cake SBO to date. The clinical and MDCT imaging characteristics of rice cake SBO can be summarized as follows in comparison with bezoar SBO: (1) more frequent complaints of abdominal pain, (2) lower CRP value, (3) better response to conservative therapy, (4) identified as higher density materials at the transition point, and (5) smaller obstruction material length. On MDCT, rice cake SBO was significantly different from bezoar SBO only when its length and attenuation were quantitatively measured. Rice cake SBO was most frequently observed in January (65%). As with other geographically or culturally unique diseases, rice cake SBO has the potential to become a worldwide problem in this age of globalization of culture and trade. Therefore, it is important to raise awareness of this type of SBO along with appropriate diagnostic and management considerations.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical statement Informed consent was waived because of the retrospective nature of our study with pre-existing data. This study was approved by our institutional research board. We declare that all human studies have been performed in accordance with the ethical standards laid down in the 1964 Helsinki declaration and its later amendments.

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