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【 CASE REPORT 】

Bowel Obstruction due to Shiitake Mushrooms: Diagnostic Features on Computed Tomography

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Abstract:
Shiitake mushrooms are edible mushrooms popular in East Asian cuisine. We herein report a 69-year-old man with abdominal distension and vomiting after ingesting several pieces of sautéed Shiitake mushrooms. Abdominal computed tomography (CT) revealed ring-shaped and crescent-shaped low-density objects (-100 to -300 Hounsfield units) in the ileum. Based on the specific shapes and CT numbers of the foreign bodies, he was diagnosed with small bowel obstruction due to Shiitake mushrooms. After conservative treatment, he passed four pieces of Shiitake mushrooms. Despite the rarity, the condition can be diagnosed before exploratory surgery by careful and detailed interpretation of CT findings.

Key words: bowel obstruction, food-induced small bowel obstruction, computed tomography, Shiitake mushrooms

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Introduction

Large and undigested foods can cause blockage of the intestine and induce small bowel obstruction. In Japan, this condition is categorized as food-induced small bowel obstruction (FIBO), and the causative foods include *konnyaku* (*Amorphophallus konjac*), seaweed, Shiitake mushrooms (Fig. 1) and rice cakes (*mochi*). Since FIBO is a rare etiology of small bowel obstruction, its diagnosis before surgery is usually challenging.

We herein report a rare case of bowel obstruction due to Shiitake mushrooms and discuss the characteristic features of this condition on computed tomography (CT). In addition, we compared the CT findings of Shiitake mushrooms according to several cooking methods and pinpoint the diagnostic features.

Case Report

A 69-year-old man was admitted to our hospital due to abdominal distention and intermittent vomiting. Three days prior, he had sautéed and swallowed whole several Shiitake mushrooms without dentures. He had a medical history of pneumothorax, but he denied any history of surgery, radiotherapy, or psychiatric disorders. He was afebrile and hemodynamically stable (blood pressure: 150/96 mmHg; pulse rate: 99 beats/min).

A physical examination revealed a distended abdomen, hyperactive bowel sounds, and diffuse mild abdominal tenderness. Initial laboratory investigation demonstrated only mild inflammation. The white blood cell count was 14,900/mm^3, and C-reactive protein was 2.4 mg/dL. In addition, liver and renal function tests were unremarkable.

Abdominal X-ray showed small bowel distention with air-fluid levels (Fig. 2). CT of the abdomen revealed a dilated small bowel with the transition point at the distal ileum and

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Figure 1. **Shiitake mushrooms (Source: Wikipedia, frankenstoen, Portland, Oregon).**

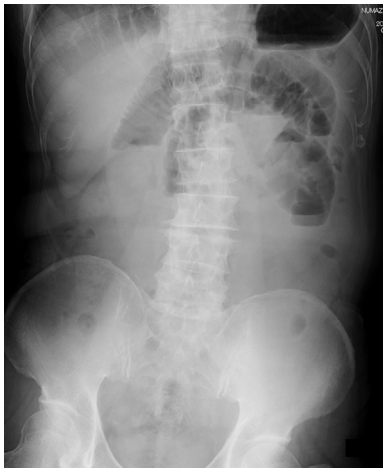


Figure 2. **Abdominal X-ray showing small bowel distension with air-fluid levels.**

a 32-mm ring-shaped low attenuating foreign body at the proximal side (Fig. 3A, arrow). Although it resembled intestinal gas on the abdominal window setting (window level: 49, window width: 354) (Fig. 3A), the lung window setting (window level: -500, window width: 1,500) revealed the foreign body as a low-attenuation mass that was completely different from air (Fig. 3B). The CT number of the mass ranged from -100 to -300 Hounsfield units (HU). In addition, three similar-looking foreign bodies with ring-like or crescent-like shapes were also visualized in the ileum (Fig. 3C, D, arrowheads). Based on his dietary history and CT findings, he was diagnosed with bowel obstruction due to Shiitake mushrooms.

He was treated with fasting and parenteral nutrition. On the third day of hospitalization, a bowel movement was noted, and he passed four pieces of Shiitake mushrooms, subsequently improving his symptoms. On the tenth hospital day, CT of the abdomen showed neither bowel dilatation nor a foreign body in his intestinal tract, and he was discharged the next day.

Discussion

Food impaction in the gastrointestinal tract, which is a rare cause of bowel obstruction, accounts for 1.9% of all cases of small bowel obstruction (1). In Japan, the condition is called FIBO, but it is sometimes described as phytobezoars in reports outside Japan. The concept of FIBO partially overlaps with that of phytobezoars. FIBO usually occurs due to food impaction a few days after food intake, whereas bezoar-induced intestinal obstruction occurs when bezoars that form in the stomach travel into the small intestine. Impacted foods are usually fresh and completely different from bezoars, such as diospyrobezoars and trichobezoars, which are formed in the stomach.

As ingredients and cooking methods vary among food cultures, there are also various causes of FIBO. Causative entities of FIBO in previous reports have included oranges, grapefruit, mangoes, bananas, persimmons, dried fruits, and carrots (2-6). In Japan, the primary causative foods for bowel obstruction are *konnyaku* (*A. konjac*), seaweed, Shiitake mushrooms, and rice cakes (*mochi*) (1, 7-11).

Shiitake mushrooms (*Lentinula edodes*, xiang-gu in Chinese) are an edible mushroom native to East Asia and a popular ingredient in various East Asian cuisines (12, 13). During spring, it sprouts in mountainous areas, where it grows to over 5 cm in size, and Japanese people sauté and eat it whole as a seasonal tradition. However, because Shiitake mushrooms are mostly composed of insoluble fiber, their size and shape remain roughly the same size in the intestinal tract if not chewed, hence causing bowel obstruction.

Our search of the literature on bowel obstruction due to Shiitake mushrooms using PubMed and Ichushi, a Japanese medical literature search engine, from 1980 to 2021 identified 23 reports of 26 cases (1, 8-10, 12-31). There were only six reports in English, and all others were written in Japanese. The details of those reported cases are summarized in Table. The median patient age was 62 years old, and the man-to-woman ratio was 9:17.

Shiitake mushrooms range in size from 5.0 to 7.5 cm and are typically not cut into smaller pieces and incompletely chewed (23, 30). Due to its small diameter and relatively weak peristaltic activity, impaction of Shiitake mushrooms usually occurs in the terminal ileum. Our review of the literature showed that 21 cases (80.8%) had obstruction in the ileum, and the median size of the Shiitake mushrooms was 6 cm (Table). Most of the patients had problems concerning mastication, such as an edentulous status or ill-fitting dentures, and had a habit of swallowing without properly chewing. It is postulated that swallowing Shiitake mushrooms whole or in large pieces with a background of dental disorders is the most common cause for Shiitake mushroom-induced intestinal obstruction.

Generally, it is challenging to diagnose FIBO before sur-

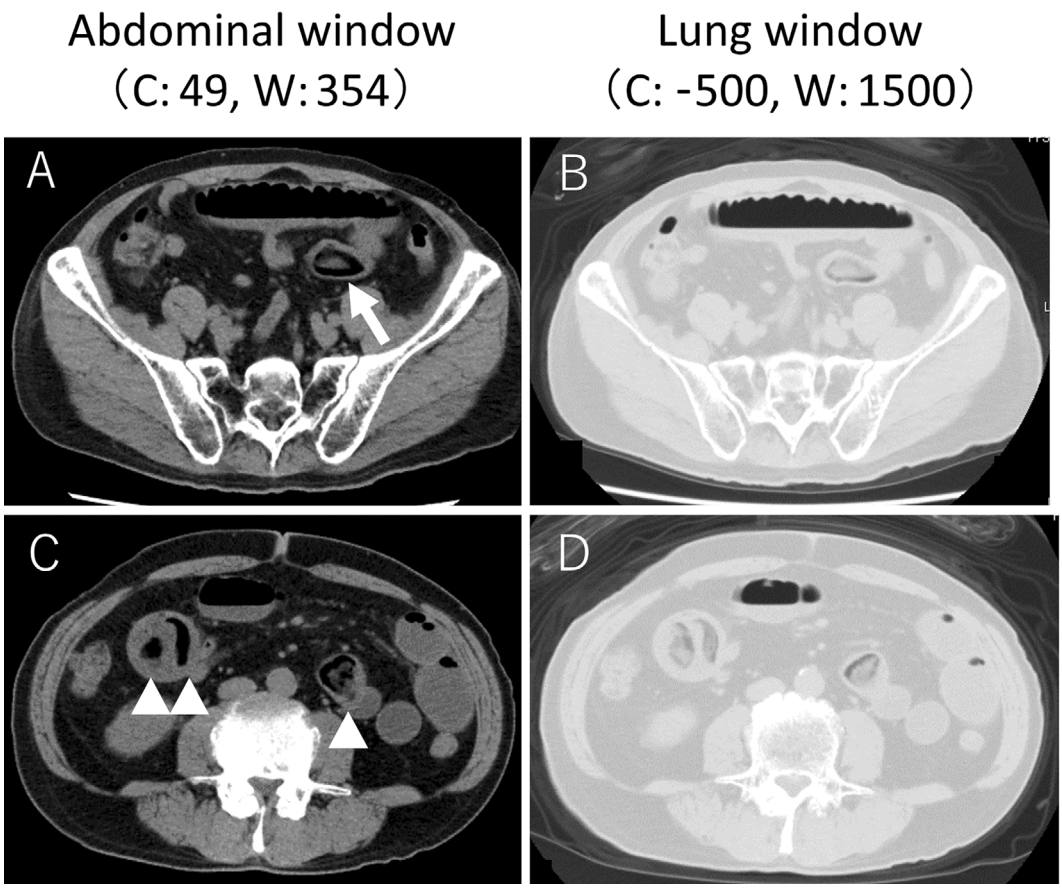


Figure 3. **Computed tomography findings of the abdomen. (A) A ring-shaped foreign body is identified at the proximal area of the transition point in the ileum (arrow). (B) The foreign body is easily distinguishable from bowel gas on the lung window setting. (C) Three other ring-shaped or crescent-shaped objects are found in the proximal ileum (arrowheads). (D) These objects have the same features as the foreign body in (B) on the lung window setting.**

gical treatment, as it is a rare causes of bowel obstruction and is often indistinguishable from obstruction due to other factors. Although the most useful modality to determine the location and etiology of intestinal obstruction is contrast-enhanced CT, food impaction can often be overlooked if physicians do not keep this uncommon etiology in mind. In Japan, only 13% of cases of FIBO were correctly diagnosed before surgery (1). Needless to say, it is essential to carefully evaluate the CT images at the area of the transition point in order to identify the cause of FIBO. Previous studies have reported that air bubbles in the dilated proximal segments of the transition point usually mean mechanical obstruction of the intestine, which was described as having a mottled appearance, soft-tissue attenuation, and a mosaic low-attenuation region, the most famous of which is the "small bowel feces sign" (32, 33). Kawano et al. highlighted the impacted air-containing mass in patients with FIBO and reported it as a "bubbly mass and impaction" (10). Chen et al. measured the food debris length and mean attenuation in patients with small bowel obstruction and concluded that pieces of food debris in patients with phytobezoars were shorter and had lower attenuation than those with adhesive intestinal obstruction (34). One of the CT findings of FIBO may be a compact air-containing mass that is impacted at the transition point of the intestine. In addition to these findings, several distinct CT findings of FIBO have been previously reported. For example, on CT, rice cakes are visualized in the gastrointestinal tract as high-density objects of 120-260 HU (7, 11), and a stone from a Japanese apricot (*ume*) is visualized as a ring-shaped high-density object (35).

Some CT findings of bowel obstruction due to Shiitake mushrooms have been reported. Shozushima et al. described the impacted Shiitake mushroom as a low-density mass that looked like a Shiitake mushroom (22). Kusumoto et al. reported a fusiform region of low attenuation (-162 HU) at the proximal area of an obstruction (23). Moriwaki et al. described the foreign body as an irregular mosaic low-attenuation region, similar to that of the whole mushroom (30).

Shiitake mushrooms have a specific shape that resembles an umbrella (Fig. 1). It has a round-shaped cap and a club-shaped stem, and the stem is often cut before being sautéed or boiled. When the mushroom causes intestinal obstruction, it is usually swallowed whole, and its shape in the gastrointestinal tract is preserved. Impacted Shiitake mushrooms

Table. Characteristics of Cases of Bowel Obstruction Due to Shiitake Mushrooms.

Number of cases	26	
Age (years) [median, (range)]	62 [50-89]	
Gender (male:female)	9:17	
Days after ingestion to onset (days) [median, (range)]	3 [1-21]	
Obstruction site	Ileum	21 (80.8%)
	Jejunum	2 (7.7%)
	Duodenum	2 (7.7%)
	Colon	1 (3.8%)
Size of Shiitake mushroom (cm) [median, (range)]	6 [2-9]	
Risk factors	Dental disorder	12 (46.2%)
	Psychiatric disease	6 (23.1%)
	Swallowing habit	5 (19.2%)
Treatment	Surgery	21 (80.8%)
	Conservative	3 (11.5%)
	Endoscopy	2 (7.7%)
Diagnosis before surgery	Bowel obstruction	15 (71.4%)
	FIBO	3 (14.3%)
	Shiitake mushroom	1 (4.8%)
	Others	2 (9.5%)

FIBO: food-induced bowel obstruction, Shiitake mushroom: bowel obstruction due to Shiitake mushrooms

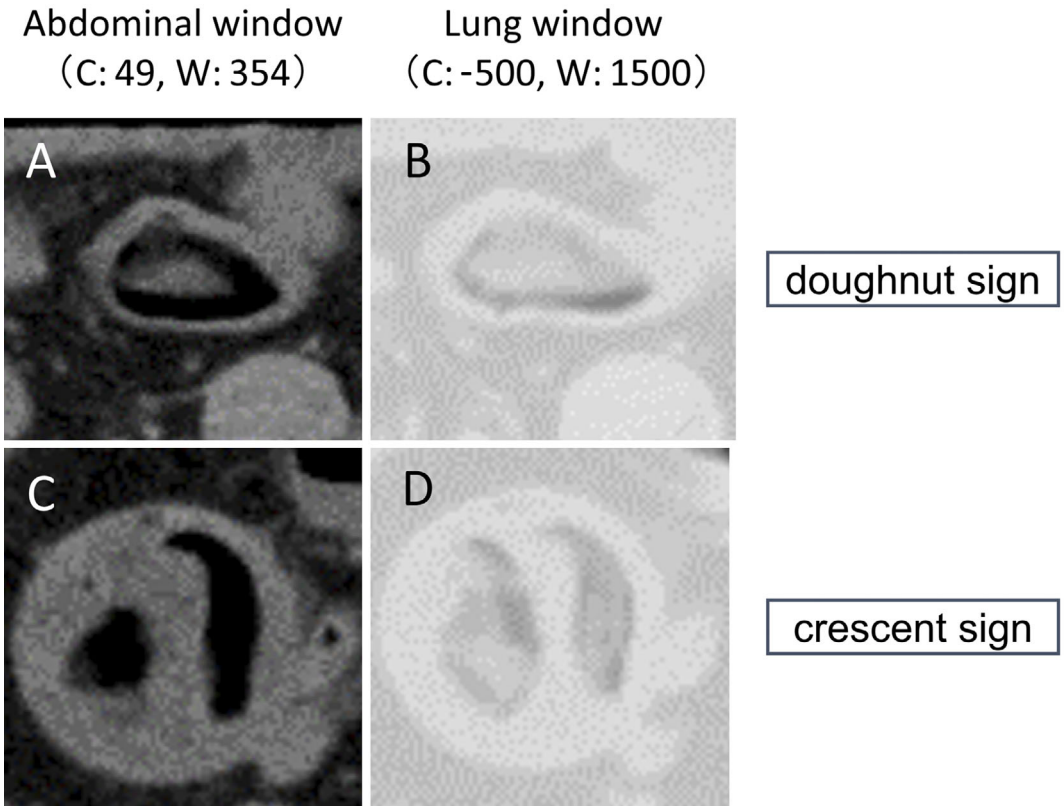
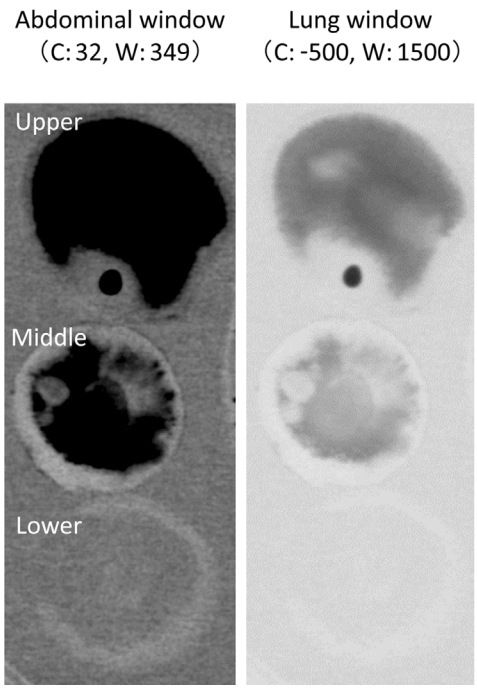


Figure 4. "Doughnut sign" (A, B) and "crescent sign" (C, D) on computed tomography. Each sign is depicted on both the abdominal window setting (A, C) and lung window setting (B, D).

therefore generally show the same form on CT. As Shiitake mushrooms look round or ring-shaped when viewed from the top, we called this CT finding the "doughnut sign." In addition, from the side, it looks like a crescent moon, hence the term "crescent sign." In our case, four Shiitake mushrooms were identified in the ileum on CT. Some of them



	CT number [HU]
Raw Shiitake	-500
Sautéed Shiitake	-200～ -350
Boiled Shiitake	30～60

Figure 5. **Raw (upper), sautéed (middle), and boiled (lower) Shiitake mushrooms were scanned by computed tomography and shown here both on the abdominal and lung window settings. The computed tomography values of raw, sautéed, and boiled Shiitake mushrooms were -500 HU, -200 to -350 HU, and 30 to 60 HU, respectively.**

featured the "doughnut sign" (Fig. 4A, B), while others showed the "crescent sign" (Fig. 4C, D). Although the authors of previous reports have not described the shape of these mushrooms on CT in detail, some of the images in their reports presented with the "crescent sign" (22, 23).

In addition, we examined the CT values of Shiitake mushrooms cooked by different methods: sautéed (roasted in a frying pan on medium heat for 5 minutes) and boiled (boiled in a pot on medium heat for 10 minutes). Raw, sautéed, and boiled Shiitake mushrooms were embedded in gelatin and scanned using CT. Raw Shiitake had very low attenuation with abundant air (Fig. 5, upper), boiled Shiitake appeared as an isodense mass, similar to water (Fig. 5, lower), and sautéed Shiitake showed intermediate attenuation (Fig. 5, middle). The CT numbers of the raw, sautéed, and boiled Shiitake were -500 HU, -200 to -350 HU, and 30 to 60 HU, respectively (Fig. 5). In our case, the CT number of the foreign body in the intestine ranged from -100 to -300 HU, consistent with sautéed Shiitake mushrooms. Since mushrooms are formed by aggregated fungal filaments, they contain a large amount of air, which reduces the CT number with partial volume effects. However, while they may mimic air-like masses on the abdominal window setting on CT, Shiitake mushrooms become distinguishable from air on the lung window setting, as shown in our case report. Since sautéed Shiitake mushrooms have specific shapes and densities on CT, a detailed interpretation of CT images makes it possible to suspect this mushroom as the cause of bowel obstruction.

Our review of the literature revealed that 21 cases (80.8%) were treated with surgery, and only 1 of them was diagnosed as Shiitake mushroom-induced bowel obstruction before surgery (26) (Table). Fifteen patients (71.4%) underwent surgery under a provisional diagnosis of bowel obstruction. However, among the three cases diagnosed with Shiitake mushroom-induced bowel obstruction before surgery based on the patient's history and CT findings, two were treated using endoscopy (21, 22), and one improved conservatively (28). We speculate that many cases treated with conservative management, as seen in our case, have not been reported. Although the preoperative diagnosis of bowel obstruction due to Shiitake mushrooms is challenging, an accurate and prompt diagnosis may help avoid invasive surgeries for patients with this condition.

In conclusion, bowel obstruction due to Shiitake mushrooms is a rare etiology of intestinal obstruction, but it can be diagnosed before exploratory surgery if a clinician carefully evaluates CT images, since impacted Shiitake mushrooms have specific forms and densities. As the globalization of food culture is expanding, physicians not only in East Asia but also worldwide should be aware of the clinical features and pathognomonic findings on CT of bowel obstruction due to Shiitake mushrooms.

The authors state that they have no Conflict of Interest (COI).

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