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Displacement of the large colon in a horse with enterolithiasis due to changed positions observed by computed tomography

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Computed tomography (CT) was performed for an 18-year-old female pony with enterolithiasis in the prone and supine positions. CT images from the prone position revealed displacement of the large dorsal colon, which contained an enterolith to the ventral side of the abdomen, and those from the supine position revealed displacement to the dorsal side. A high-density material suggestive of a metallic foreign body was also observed in the enterolith core. An enterolith (422 g, 104 mm) was surgically removed from the large dorsal colon. This caused no complications after surgery and increased the horse's weight. Changing positions during CT helps identify the exact location of enterolith and intestinal displacement due to enterolith weight, as well as size and number.

Key words: *computed tomography (CT), displacement, enterolithiasis, position*

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In horse, enterolithiasis is a cause of partial or complete intraluminal obstruction due to enteroliths, which mostly contain magnesium ammonium phosphate and are commonly identified in the right dorsal, transverse, and small colons [10]. Certain breeds, such as the Arabians, Quarter Horses, Ponies, Thoroughbreds, Morgans, and American Miniatures over 3 years of age exhibit a high prevalence of enterolithiasis [6, 10]. Feeding increased amounts of alfalfa, reducing daily access to pasture grass, and a lack of exercise are risk factors for enterolithiasis [3]. A high prevalence of enterolithiasis is observed in California horses because their diets contain high amounts of components of enteroliths, the ingestion of which causes alkalization of the intestinal environment and increases the magnesium concentrations, thereby resulting in enterolithiasis [4]. Clinical symptoms include intermittent colic, anorexia, and depression [5]. Abdominal radiography is used for diagnosis and has positive and negative predictive values of 96.4% and 67.5%, respectively [8]. However, high-energy X-ray units are required for abdominal radiography, which are not always readily available. Abdominal ultrasound is often limited except to rule out other disorders. Therefore, enterolithiasis often goes undiagnosed until enteroliths cause heavy obstruction. The radical treatment is surgical removal of the enteroliths. Many horses satisfactorily convalesces after surgery with good prognosis [6].

Computed tomography (CT) was first introduced in horse clinics in 1989 [2]. In previous studies, only the head, cervical spine, and limbs were subjected to CT because the gantry size was limited [7–9]. Here the authors report whole-body imaging of a horse with enterolithiasis using a large gantry CT unit. To identify the exact location of the enterolith and displacement of the digestive tract, both the prone and supine positions were examined.

An 18-year-old female pony (body weight, 158 kg; height, 115 cm) with long-term anorexia and poor condition (body condition score, 2) was admitted to Azabu University Veterinary Medical Teaching Hospital. Complete blood cell count and biochemical analysis was shown in Table 1. Packed cell volume and hemoglobin showed slight anemia, and alkaline phosphatase was increased; these were considered to be due to aging. Abdominal radiography was performed using a radiographic instrument (MRAD-A80S RADREX, Toshiba, Tokyo, Japan) at 150 kV and 10 mAs, and images were obtained from the standing horse. A high-density oval object was detected at the bottom of the abdomen, which was diagnosed as an enterolith (Fig. 1). CT was performed to observe the exact location, size, and

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Table 1. Complete blood cell count and biochemical analysis of the case

WBC	$(\times 10^2/\mu l)$	75.5	TP	(g/d*l*)	6.8	Na	(mmol/*l*)	141.2
Neu	$(\times 10^2/\mu l)$	43.7	Alb	(g/d*l*)	3.1	K	(mmol/*l*)	4.13
Band	$(\times 10^2/\mu l)$	-	ALT	(IU/*l*)	7	Cl	(mmol/*l*)	104.6
Seg	$(\times 10^2/\mu l)$	-	ALP	(IU/*l*)	498			
Lym	$(\times 10^2/\mu l)$	26.9	GGT	(IU/*l*)	18			
Mono	$(\times 10^2/\mu l)$	2.4	Tchol	(mg/d*l*)	116			
Eos	$(\times 10^2/\mu l)$	2.2	TG	(mg/d*l*)	17			
Baso	$(\times 10^2/\mu l)$	0.3	Tbil	(mg/d*l*)	0.64			
RBC	$(\times 10^4/\mu l)$	637	Cre	(mg/d*l*)	1.3			
PCV	(%)	26.6	BUN	(mg/d*l*)	30.6			
Hgb	(g/d*l*)	9.5	Ca	(mg/d*l*)	12.1			
MCV	(fl)	41.8	IP	(mg/d*l*)	2.6			
MCH	(pg)	14.9	Glu	(mg/d*l*)	97			
MCHC	(g/d*l*)	35.7	LDH	(IU/*l*)	210			
PLT	$(\times 10^4/\mu l)$	25.3	CK	(IU/*l*)	176			

number of enteroliths. Premedication with medetomidine [5 μg/kg, intravenous (i.v.)] and rapidly infusing with guaifenesin (50 mg/kg, i.v.) until the case became ataxic. Anesthesia was then induced using thiamylal sodium (4 mg/kg, i.v.) and diazepam (30 μg/kg, i.v.) and maintained through inhalation of isoflurane. CT images were obtained using a 16-row multidetector CT scanner (Aquilion Large Bore, Toshiba, Tokyo, Japan) at Obihiro University of Agriculture and Veterinary Medicine, with 135 kV, 250 mA, and a slice thickness of 2.0 mm. Once anesthesia was induced, the case was placed in a prone position on the CT patient table (Fig. 2, left), and a further scan was performed after changing the position to supine (Fig. 2, right). Sagittal and three-dimensional (3D) images were obtained using image-processing software from the Digital Imaging and Communications in Medicine files. CT images showed an enterolith, approximately 100 mm, in the large dorsal colon; the colon was displaced to the ventral side of the abdomen in the prone position (Fig. 3, left) and to the dorsal side in the supine position (Fig. 3, right). The enterolith was located at the bottom of the abdomen in the radiograph, but the dorsal colon was displaced to the bottom of the abdomen because of the enterolith's weight. Furthermore, CT images revealed a high-density material in the enterolith core, suggesting the presence of a metallic foreign body (Fig. 4). Following CT examination, the case was moved to an operating room while maintaining general anesthesia for celiotomy. After the mid-line incision of the ventral body, the large dorsal colon was pulled out from the incision. The surgeon tried to move the enterolith to the pelvic flexure; however, it could not be moved because of its size. Therefore, the portion of the large dorsal colon immediately above the enterolith was incised, and the enterolith was removed. The enterolith (422 g, 104 mm) and a large amount of hard feces were removed from the diaphragmatic flexure at the large dorsal colon (Fig. 5, left); mineral analysis revealed that it comprised 50% magnesium ammonium phosphate and 50% calcium phosphate. After an enterolith, which had been identified by CT, was removed, the incision was closed. The removed enterolith was scanned, and an object similar in shape to a staple was observed in the enterolith core in the 3D CT images (Fig. 5, right). The CT images of the removed enterolith also showed a metallic material in the enterolith core surrounded by a concentric pattern and small caverns in patches (Fig. 6). The authors did not have any information concerning whether or not this case had been exposed to any risk factors such as high amounts of alfalfa or reduced access to pasture grass. While previous studies have reported that the common material in enterolith cores was a small stone, we hypothesized that staples could be the cause of enteroliths following accidental ingestion [4].

Fig. 1. Lateral radiograph of the horse. A high-density oval object was revealed at the bottom of the abdomen.

Fig. 2. The horse in the prone (left) and supine (right) positions on the CT table.

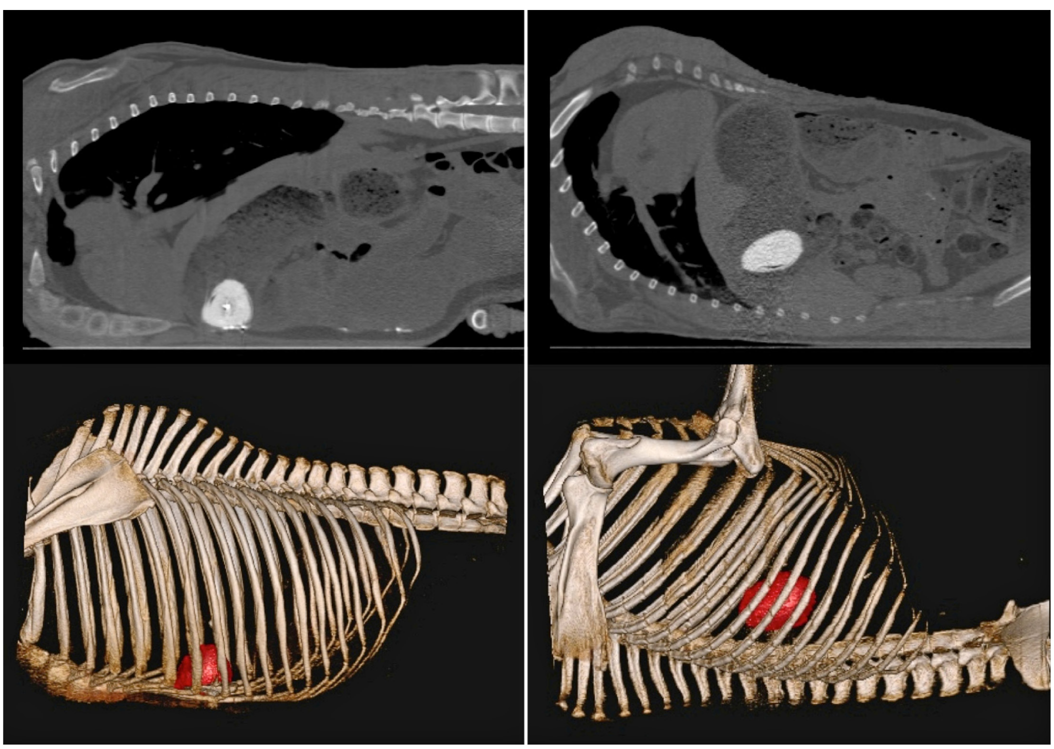

Fig. 3. Sagittal and 3D CT images taken in the prone (left) and supine (right) positions. The colon was displaced to the ventral side of the abdomen in the prone position (left) and to the dorsal side in the supine position (right).

Therefore, caution should be taken to prevent the accidental ingestion of staples, which are often present in cardboard or baggage. In dairy cows, metallic foreign bodies cause traumatic pericarditis, whereas in horses, these could cause enterolithiasis. Therefore, feed control is important in minimizing the risk of enterolithiasis. However, although the most common complications among horses were reported to be postoperative diarrhea and peritonitis [1], the present case presented no complications after surgery and regained her appetite, resulting in a weight gain from 158 to 205 kg in 6 months.

In this study, CT examination was performed using both

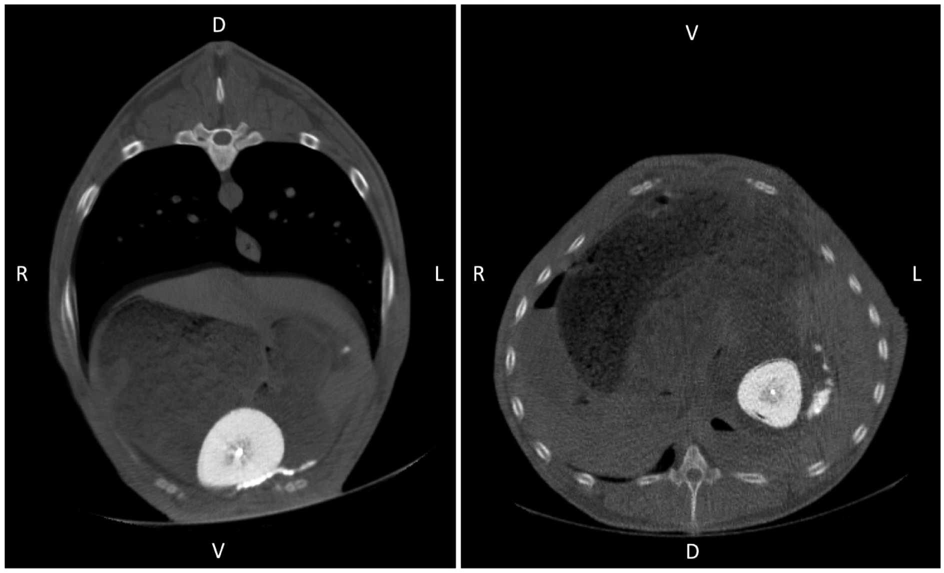

Fig. 4. Transverse CT images in the prone (left) and supine (right) positions. CT images revealed a high-density material in the enterolith core, suggesting the presence of a metallic foreign body.

Fig. 5. A enterolith following removal from the large dorsal colon (left), and a 3D CT image of the enterolith (right). The enterolith was 422 g and 104 mm long. The 3D CT image revealed an object similar in shape to a staple in the enterolith core.

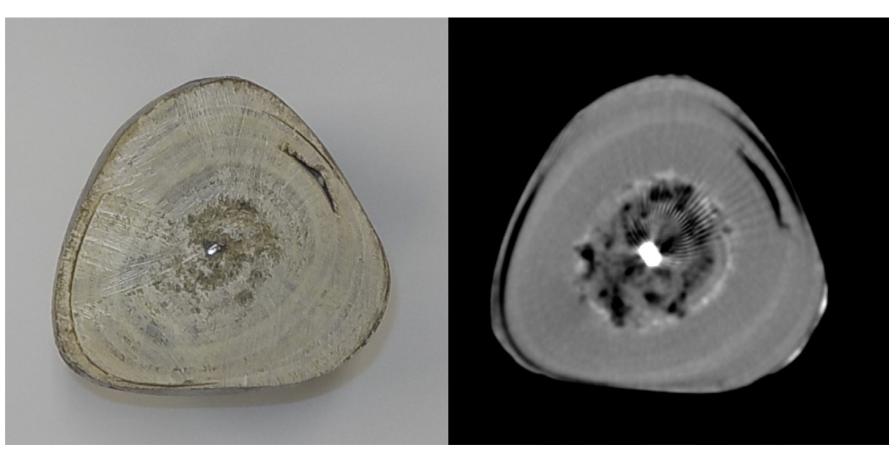

Fig. 6. A section of the removed enterolith (left) and the CT image of the enterolith (right). A metallic material was identified in the enterolith core surrounded by a concentric pattern and small caverns in patches.

prone and supine positions, which made it possible to identify intestinal displacements including gravity effects due to changed positions. Because the surgeon could identify before surgery that the dorsal colon was moved to the far dorsal side in the abdominal cavity, the exploration time was shortened. In the case CT examination before surgery, CT should be perform in the same position as surgery. This enables surgeons to know the actual location of the organs and digestive tract.

CT also supplies the information of the size of enterolith. Detected enteroliths can be magnified in radiographs, but CT can be used to determine the accurate size of each enterolith, which helps surgeons to particularly recognize enteroliths during surgery. Approximately 40% of cases with enterolithiasis have multiple enteroliths [10]. CT provides information regarding enterolith number. Enteroliths can be detected in radiograph, but the observation area of radiograph is much smaller than the body of horses. Therefore, the possibility of failure to detect all enteroliths cannot be denied. In surgery, it is necessary to search the entire gastrointestinal tract to ensure that there are no enteroliths remaining in it. In the present case, the size and number of enteroliths to be removed had already been identified before the surgery; therefore, further exploration was not required, and this might have contributed to shortened surgery time. In addition, this might have reduced the possibility of the risk of complications due to manual operation while exploring the gastrointestinal tract.

Based on our clinical experience, intestinal gas associated with colic disappears when patients undergo surgery in the supine position. And rolling treatment is applied for displaced abomasum in cows. In addition, the reticulum metallic foreign body in cows is sometimes not found in the recumbent position in surgery or necropsy. The above suggest that intestinal displacement can occur by changing the position of the patient.

Changing positions during CT helps identify the exact location of enterolith and the intestinal displacement due to enterolith weight, as well as size and number. To our knowledge, this is the first study reporting a whole-body CT on a living horse.

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