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A Case of Enterolithiasis in a Grant's Zebra (*Equus burchelli boehmi*) and Analysis of the Enterolith

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Abstract : We describe a case of enterolithiasis in an eight-year-old male Grant's zebra (*Equus burchelli boehmi*) that died after a 10-day history of depression, anorexia, dehydration and colic. On necropsy, an enterolith was discovered at the conjunction of the descending colon and the rectum. The spherical enterolith weighed 1,660 g and was 13.5 cm × 8 cm in size. According to scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS), the nidus consisted primarily of SiO_2 with outer layers of magnesium and phosphate. The formation of enteroliths is closely related to diet. We suggest that this captive zebra's diet, which consisted primarily of alfalfa hay with mineral supplements, was the cause of enterolithiasis in this case. This is the first report of enterolithiasis in a captive equid in Korea. Our findings provide information valuable for the development of dietary guidelines to prevent enterolithiasis in captive wild equids.

Key words **:** enterolithiasis, Grant's zebra(*Equus burchelli boehmi*), alfalfa hay, SEM.

Introduction

Equine enterolithiasis is a disease characterized by pathologic mineral concretions in the gastrointestinal tract that are typically composed of struvite (magnesium ammonium phosphate). Obstruction of the colon and death may result from the aboral movements of enteroliths that form in the right dorsal colon and migrate to the narrow transverse or small colon (4,7,8,9). Clinical signs of enterolithiasis include colic, anorexia, depression, and absence of defecation due to partial or complete obstruction of the lumen. A number of factors are associated with enterolith formation, including the presence of nidi, diet, intestinal luminal pH, soil type, age, and breed (4,7,9).

Definitive diagnoses of enterolithiasis are made via abdominal radiography, exploratory celiotomy, necropsy or rectal palpation (1,4,7,9). The use of abdominal radiography is is limited by the size of the patient and the capacity of the radiographic equipment (7). On rare occasions, one may palpate an enterolith per rectum, particularly if it is present in the distal small colon (8). There are no reliable diagnostic predictors of enterolithiasis (5,7). Surgery is the only option for removal of an impacted enterolith in the large colon, with prognosis determined at the time of surgery. If surgery is performed during the early stages of disease, the prognosis is typically excellent. However, if colon rupture has already occurred, gross peritoneal contamination will occur and in these instances, euthanasia is recommended (9).

Although equine enterolithiasis has been reported in domestic horses since the 1800s, it has only recently been reported in zebras, including Hartmann's mountain zebra (*Equus zebra hartmannae*) (3) and Grant's zebra (*Equus burchelli boehmi*) (6). We describe a case of enterolithiasis in a male Grant's zebra that was raised in a zoo, including clinical signs, pathologic findings and the results of analysis of the enterolith.

Case

An eight-year old intact Grant's zebra stallion (*E. burchelli boehmi*) presented with watery diarrhea, depression, anorexia, dysstasia, and muscle tremors. The zebra was born and raised in captivity, on soil footing outdoors and concrete footing indoors. At presentation, the zebra's body weight was 200 kg. The zebra was maintained on 7 kg of alfalfa hay per day with tap water provided for drinking water.

Tentatively, the zebra was diagnosed with colic and was treated with flunixin (Fluximine®, 1.1 mg/kg, Bomac Laboratories, New Zealand) by dart. The zebra initially ate a small amount of its regular diet and appeared to be recovering, but then began to bloat again and exhibit symptoms of extreme pain including that stamping and bared teeth. To relieve the pain, the zebra was again treated with flunixin by dart and exhibited a temporary recovery, but clinical signs including bloating, anorexia, unwillingness to move and biting his cage bars soon returned. We diagnosed a partial obstruction of the intestinal tract and ileus. The zebra was treated with metoclo-

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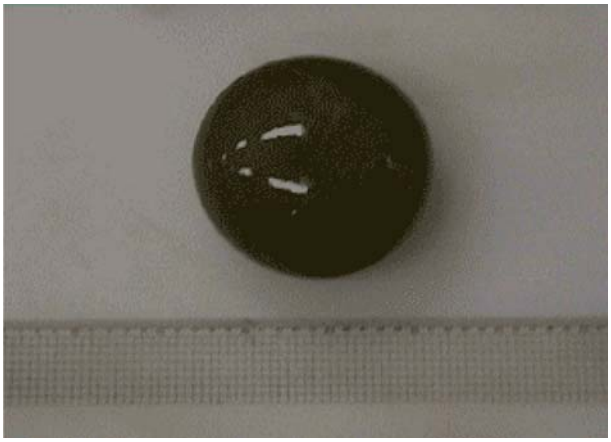

Fig 1. A smooth-surfaced enterolith found in the colon of an eight-year-old Grant's zebra stallion (width 13.5 cm, length 8 cm, weight 1.66 kg).

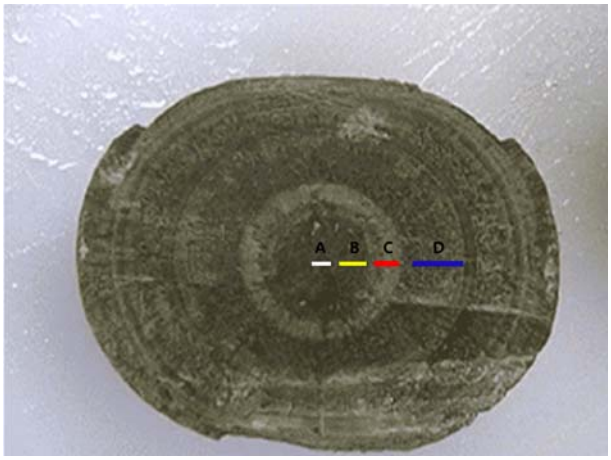

Fig 2. The cut surface of the enterolith reveals concentric rings (A, white line, nidus of enterolith; B, yellow line, second layer; C, red line, third layer; D, blue line, fourth layer).

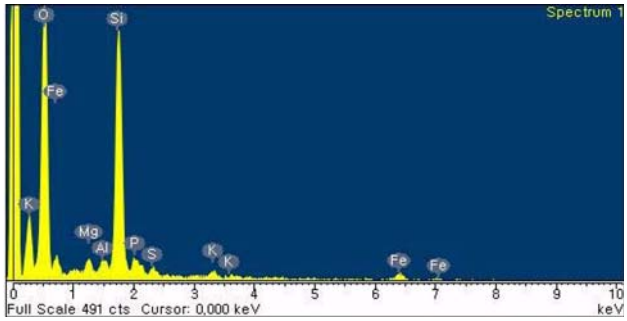

Fig 3. Quantitative analysis of the nidus (layer A) by SEM and EDS, the Si and O peaks are predominant.

promide (Macperan®, 0.1 mg/kg, Dong-Hwa Pharm., Korea), enrofloxacin (Baytril®-50, 2.5 mg/kg, Bayer Healthcare Korea, Korea), and flunixin by dart without success. The zebra's symptoms continued to worsen, with dehydration, ptyalism, and dystasia, and the zebra died despite the administration of fluid therapy.

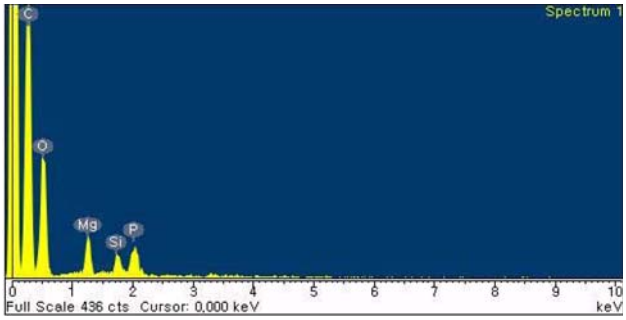

Fig 4. Quantitative analysis of layer B by SEM and EDS, with MG and P peaks predominant.

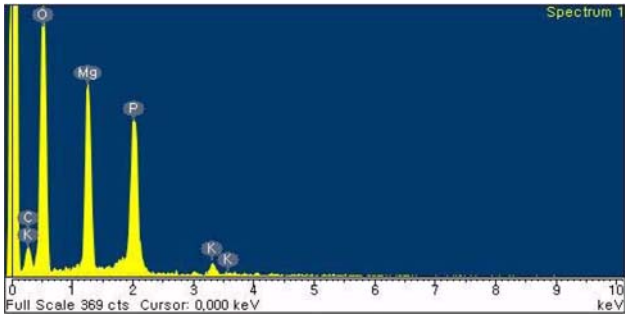

Fig 5. Quantitative analysis of layer C by SEM and EDS, with MG and P peaks predominant.

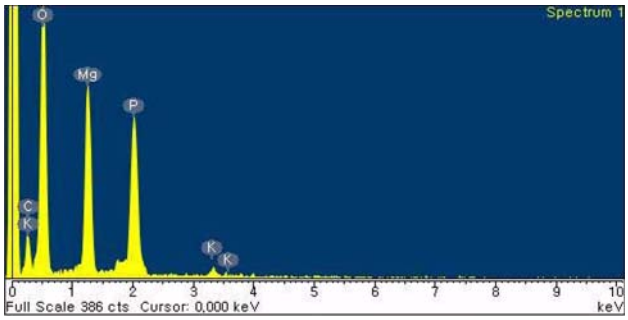

Fig 6. Quantitative analysis of layer D by SEM and EDS, with MG and P peaks predominant.

Postmortem examination revealed a great deal of ascites in the abdominal cavity as well as a spherical enterolith (weight 1.66 kg, size 13.5 cm × 8 cm) with a smooth greenish surface at the junction of the descending colon and rectum (Fig 1). We observed a hemorrhagic necrotic region 10 cm in diameter where the colon had been occluded by the enterolith. We cut and divided the enterolith into four sections (A,B,C,D) by layer for quantitative analysis by scanning electron microscope (SEM; JSM-6700F, Jeol, Japan) and energy dispersive X-ray spectrometer (EDS; INCA, Oxford, England) (Fig 2). Layer A consisted primarily of silicon and oxygen (SiO_2) (Fig 3), while the other layers (B, C, and D) were made up of magnesium (Mg) and phosphorus (P) (Fig 4,5, and 6).

Discussion

Equine enterolithiasis is characterized by the formation of pathologic mineral concretions in the gastrointestinal tract that are typically composed of struvite (magnesium ammonium phosphate). The disease has been associated with a number of factors, such as the presence of nidi, diet, intestinal luminal pH, and type of drinking water provided (4,7).

NidI are found in almost all enteroliths, and therefore it has been suggested that a foreign body must be present to act as a core for deposition of minerals. Silicon dioxide appears to be the most common nidus material and because it is a constituent of normal field stones may be easily ingested (7). Ingested nails, rope, and hair might also act as a nidus material (8). Enterolith shape varies depending on number present in the gastrointestinal tract. Single enteroliths are usually spherical, whereas multiple enteroliths may be polyhedral as a result of contact abrasion (7,9). Enteroliths are usually found in the right dorsal colon or transverse colon (7,8,9), and the incidence of equine enterolithiasis is highest in horses between five and 10 years of age. There are reports of fast-growing enteroliths that attain sizes large enough to obstruct the intestinal tract within two years (5).

In the present case, we discovered a single enterolith located at the conjunction of the descending colon and rectum that was spherical in form. According to SEM and EDS analysis of the enterolith, the nidus consisted primarily of SiO_2 (Fig 3). The outer layers consisted primarily of Mg and P (Fig 4, 5, and 6). Therefore, we concluded that the enterolith was made up of struvite, like those described in previous reports of equine enterolithiasis (4,7,10). The age of the zebra in this case is also consistent with the ages of greatest incidence in previous reports.

Long-term ingestion of alkalinizing feed rich in protein, phosphorus, and magnesium, such as alfalfa hay or pellets, is an important contributing factor to enterolith formation. Alfalfa contains the components of struvite, which is the most common enterolith compound. Furthermore, the elevated luminal pH in the large colon produced by alfalfa consumption favors the precipitation of struvite (9). Enterolithiasis is associated with feeding alfalfa hay over a wide geographic range, with horses in California having the highest incidence because the Mg content of hay grown in certain areas of California has been shown to be higher than average for the United States (5). Drinking water with high Mg ion content may also be a contributing factor to the formation of enteroliths, but a recent study reported that although the Mg levels in well water in some parts of California were much higher than the national average, the magnesium content of water was minimal when compared with that of alfalfa. In the present case, the zebra was fed 7 kg of alfalfa hay every day and provided with tap water *ad libitum*. The alfalfa hay was imported from California, and we conclude that diet was the cause of enterolith formation in this case.

In enterolithiasis, the prognosis is excellent if surgery is performed early (7,8,9). We observed clinical signs including apparent colic and a small amount of evacuation in the present case, and therefore enterolithiasis was suspected, but definitive diagnosis was complicated by the fact that the zebra was not tame, and the enterolith was detected only upon necropsy.

As the intestinal lumen could be obstructed rapidly after beginning of enterolith movement, prevention is as important as treatment. We recommend against the provision of alfalfa hay as the major source of roughage for captive equids, and believe that at least 50% should be provided as grass or grass hay. If this is not possible, twice-daily administration of an acidifier, such as 1 cup of apple cider vinegar added to grain, is recommended to counteract the alkalinizing properties of alfalfa (9). Dietary prevention of enterolithiasis is especially critical for untamed captive animals, as differential diagnosis, surgical treatment, and postoperative care are very difficult to provide to such animals, especially in zoo settings.

Conclusion

This report describes a case of enterolithiasis in a captive, zoo-born eight-year old Grant's zebra stallion. The zebra exhibited clinical signs including anorexia, bloating, absence of defecation, and colic before death. At necropsy, an enterolith was found at the junction of the descending colon and rectum, with luminal necrosis at the site of occlusion.

Diagnosis and treatment of enterolithiasis in wild equids is difficult, and death may occur due to obstruction shortly after the first clinical signs. Therefore, it is just as important to prevent the disease as it is to treat it. This is the first report of enterolithiasis in Korea. Our findings may aid in the prevention and diagnosis of enterolithiasis in captive wild equids in the future.

Acknowledgements

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그랜트얼룩말에서 발생한 장결석증과 결석의 분석

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요 약 : 동물원에서 사육중이던 8년령의 수컷 그랜트얼룩말이 10일간 침울, 식욕부진, 탈수, 산통의 임상증상을 보이다 폐사하였다. 부검시 하행결장과 직장의 연접부에 무게 1,660 g의 장결석(가로 13.5 cm × 세로 8 cm)이 발견되었다. 발견된 결석을 주사전자현미경과 에너지 분산형 X선 분광기로 분석한 결과 결석의 중심부는 SiO_2가 가장 많이 검출되었고, 그 외층은 마그네슘과 인이 가장 많이 검출되었다. 장결석의 생성은 미네랄 성분이 다량 함유된 알팔파 건초의 급여와 깊은 연관이 있는데, 본 예의 장결석증 또한 알팔파 건초의 급여에 기인한 것으로 판단되었다.

주요어 : 장결석증, 그랜트얼룩말, 알팔파 건초, 주사전자현미경.