Serous Fat Atrophy of a Reticulated Giraffe (*Giraffa camelopardalis*)

Hwanyul Yong*

Seoul Zoo, Gwacheon 427-080, Korea

ABSTRACT

A female reticulated giraffe (*Giraffa camelopardalis*), 20-month-old, 342 kg, died at Seoul Zoo on January 2, 2009 after a stressful episode of chronic diarrhea. Given the appearances postmortem, it was strongly suspected that the giraffe suffered from malnutrition for a long time. Typical appearances of serous fat atrophy were shown on most fat tissues of body organs such as heart, bone, liver, mesentery and kidney. In this study, the sudden death that had been known as "peracute mortality syndrome" was clearly identified to have resulted from a lack of understanding the Browser's diet and general failure in giraffe husbandry. Individualized care and high quality hay must be provided to compensate higher consumption of metabolic energy and to prevent animal loss in winter season.

(Key words : giraffe, serous, fat, atrophy, nutrition)

INTRODUCTION

Giraffe (*Giraffa camelopardalis*) is a picky browser in the wild. When reared at zoos, browsing ruminants, especially captive giraffes, must be fed partly with their original fodder because the physical structure of commercial grass or alfalfa hay is harsh for them to digest (Hatt *et al.*, 2005; Hummel *et al.*, 2008; Jurado *et al.*, 2008).

If special care is not provided, zoo giraffes could anytime encounter digestive problems like serous fat atrophy, phytobezoars, rumen acidosis, and partial loss of the dorsal rumen papillation (Herter, 1898; Gradwell, 1976; Spalinger *et al.*, 1993; Potter and Clauss, 2005; Hummel *et al.*, 2008). Serous fat atrophy is a pathologically degenerative change with complete absence and serous atrophy of body fat stores that is absorbed and taken by a serous fluid. Due to the low quality of hay, the giraffes could ingest these hay in comparatively lesser amounts than grazing ruminants naturally would.

The term, "peracute mortality syndrome" was introduced more than 30 years ago simply because no reasons for death were identified then. However, the reason had become obvious since fundamental causes were proved to result from reciprocal effects between teeth abrasion and attrition due to low quality hay and decreased intake of hay by worn-out teeth. Surprisingly, in this report in which a juvenile female giraffe was proved to have died of serious starvation, we showed how inappropriate husbandry led a juvenile giraffe to exorbitant death which occurred in winter temperature-ranged on average from 0.2℃ to 8.0℃.

CASE REPORT

A 20-month-old female giraffe, captive born and weighed 342 kg, had suffered loss of weight, weakness, significant loss of appetite along with chronic diarrhea for several months. Furthermore, right before death, physical injury occurred due to repeated collapses after treatments of fluid therapy. In the middle of night, she directly died of aspiration of rumen contents (Fig. 4).

On postmortem, serous atrophy of fat tissues was particularly prevalent all over the internal organs with no dental problem (Fig. 2). The typical appearance of serous fat atrophy was shown in the heart (Fig. 1). Serious or mild pathological

Fig. 1. Serous fat atrophy of a giraffe's heart. (A) Typical type of serous fat atrophy was observed on the upper surface of pericardium. (B) Serous transformation of fat tissues was shown attached to the inner walls of atrium and ventricle.

* Correspondence : E-mail : getzoopregnant@seoul.go.kr

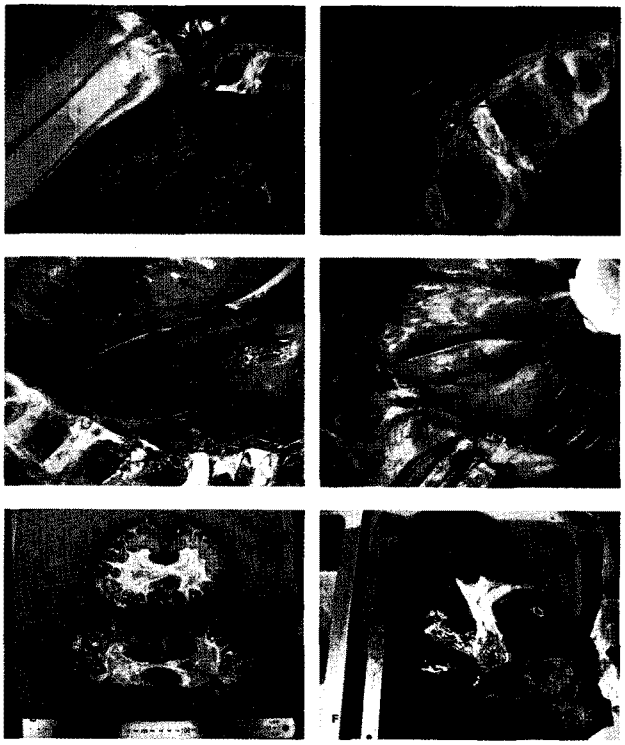

Fig. 2. Systemic diffusion of serous fat atrophy. (A) Serous fat atrophies (arrows) were found in thoracic cavity, (B) sternal bone, (C) mesentery, (D) abdominal cavity, (E) renal calyx and (F) right lobe of liver.

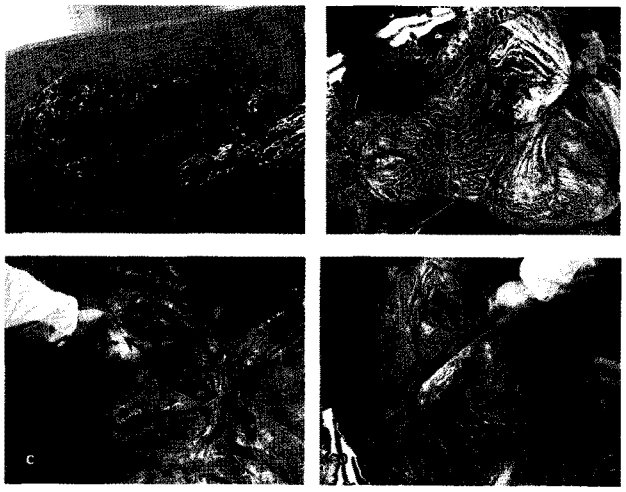

Fig. 3. Abnormal changes of small intestines, abomasum and rumen. (A) Serious congestion and thin layer were observed in the membrane of small intestines, and (B) Abomasum also showed congestion and partial ulcerations. The four arrows indicate the boundary of abomasum. (C) A phytobezoar was palpated between abomasum and duodenum. (D) Light coloration and thin layer of rumen papilli were seen near a ruminal groove.

Fig. 4. Rumen contents obstruct the tracheal tube. Tracheal blockade was the direct cause of death. Ruminal contents spread into trachea, main bronchus and bronchi.

appearances were shown in the thoracic cavity (Fig. 2A), skeletal muscles of sternum (Fig. 2B), mesentery (Fig. 2C), abdominal cavity (Fig. 2D), kidney (Fig. 2E) and liver (Fig. 2F). Unlike the other organs, the fat of the liver was not materially reduced by fat starvation (Herter, 1898). The phytobezoar, located between abomasum and duodenum, would be a direct cause for chronic diarrhea (Fig. 3C). The abomasum and small intestines showed congestion and ulceration (Fig. 3A and 3B). Given the shortage, partially thin layer and light coloration of rumen papilli, it was easy to conclude that the giraffe had been improperly fed for a real long time (Fig. 3D).

DISCUSSSION

Mostly serous atrophy of fat tissues would happen in cachexia (Cho *et al.*, 2006). When suffering from malnutrition, depot fat and lipid vacuoles are progressively mobilized and reduced in size and replaced by proteinaceous fluid which transforms the fat depots to gelatinous masses of serous atrophy (Steinberg *et al.*, 1987). The juvenile female giraffe in this study showed a serious lack of adipose tissues in abdominal and thoracic cavities that is observed in aged and young animals (Clauss *et al.*, 2003). Taking all findings into consideration, the poor nutritional environment that the juvenile female giraffe had been exposed to for a long time caused digestive abnormality physically and microbiologically with obstruction of abomasum, chronic diarrhea, continuous indigestion, lethargy and ataxia that ended in death in the inclement weather of winter season.

Here at Seoul Zoo, giraffes have been fed daily 7 kg of alfalfa hay, 2 kg of grass hay, 4.4 kg of concentrates and 6.2 kg of sweet potato, carrot, cabbage, lettuce, onion, apple and mineral

rock. The giraffe is enthusiastic about eating leafy branches, but it is very hard to afford giraffes to all leaves. According to all the postmortem appearances showing serous fat atrophy of all internal organs, a staple of medium-priced alfalfa hay seemed not enough to support giraffes' nutritional demand (Fig. 1 and 2). The quality of the alfalfa hay is a critical factor that determines the amount of energy derived from the roughage source (Potter and Clauss, 2005). Only high-quality alfalfa hay should be fed to giraffes (Ullrey *et al.*, 1997). Giraffes cannot thrive solely on grass or alfalfa hay diets, unlike many browsing or grazing ruminants can do (Spalinger *et al.*, 1993; Clauss *et al.*, 2003). Feeding them on browse in a part of diets should be considered even though there is a seasonal limitation of supplying it (Hatt *et al.*, 2005; Hummel *et al.*, 2008).

The word "peracute" in the term "peracute mortality syndrome" is not a proper description as pathological appearances and sudden death result from long-term nutritional problems and the term was reflected by human perception (Potter and Clauss, 2005).

At Seoul Zoo, the giraffes are sometimes observed to eat foreign bodies such as grass roots and dead tree's bark. The ball-shaped conglomerate shown in Fig. 3 is commonly called phytobezoar, composed of plant material that form in the abomasum and duodenum (Fig. 3C and 3D) and can irritate mucosal membrane and block the passage of ingesta (Fig. 3A). The blockage of digestive track by phytobezoars has been reported repeatedly in giraffe and mule deer (*Odocoileus hemionus*) (Gradwell, 1976; Steinberg *et al.*, 1987), while there were no reports in captive grazing ruminants. The location of phytobezoars is known to be mainly in the abomasum (Fig. 3B~3D), and its formation is often related to a physical structure of fiber or grass intake (Gradwell, 1976). In ruminants, the bigger the particle size of forage that was fed, the more potential digestive problems like "rumen blockage" and bezoar formation could happen (Gradwell, 1976; Hatt *et al.*, 2005). Mean fecal particle size is so different between free-ranging and captive giraffes that the physical suitability and digestibility of zoo diets must be seriously reconsidered (Hummel *et al.*, 2008).

The female giraffe died of environmental and nutritional intolerances in her second winter after passing safely through the first winter. The giraffe in her first months would depend more on the milk of the mother giraffe rather than on concentrates or hay, and the nutritional demand of the young giraffe may be satisfied mostly with the milk of mother giraffe.

The relationship between oral stereotypy and nutritional stress is considered to be very close (Langman *et al.*, 1978; Fernandez *et al.*, 2008; Jurado *et al.*, 2008). Making giraffes busy can partially change the oral stereotypy, for example, by increasing the time used to obtain food (Fernandez *et al.*, 2008). High levels of concentrated feeds cause rumen acidosis (Mason and Latham, 2004) and have been related to oral stereotypy in other ungulates (Redbo *et al.*, 1998; Waters *et al.*, 2002). Licking nonfood object increase saliva production and therefore buffers gut acidity (Mason and Latham, 2004). In captive giraffe, increasing a roughage proportion will be prophylactic against the development of rumen acidosis (Hatt *et al.*, 2005).

A young male giraffe that was born at Seoul Zoo on May 26, 2008 does not lick any nonfood objects because the young giraffe does not depend on hay-derived nutrition as much as adult giraffes do.

Giraffes are passive obligatory heterothermic (Langman and Maloiy, 1989) which means that body temperatures could drop close to 36℃ at an ambient temperature of 16℃ (Langman *et al.*, 1982). On the basis of the data from the Korea Meteorological Administration, ambient temperature range was from 0.2℃ to 8.0℃ during the period of serial deaths. In the winter season, exhibiting giraffes in the outer enclosure for a long time would be detrimental as the animals need more energy to maintain the normal body temperature of 37.5~38.8℃ (Bush *et al.*, 1980). Without additional supplement of zoo diet, they don't have a choice but constantly use body fat tissues until death.

The giraffes at Seoul Zoo are raised with grazer animals like waterbuck and springbuck that graze on the grass on the ground, but the giraffes also are sometimes observed to graze on the grass. Malnutrition in the form of energy deficiency is a major problem in captive giraffes (Potter and Clauss, 2005). However, starvation-induced severe serous atrophy is reversible with nutritional intervention (Steinberg, 1987).

This report showed that more delicate and cautious care in nutritional and environmental conditions must be provided to prevent animal loss in the winter season.

REFERENCES

Bush M, Custer RS and Whitla JC. 1980. Hematology and serum chemistry profiles for giraffes: Variations with sex, age and constraint. J. Zoo. Anim. Med. 11:122-129.

Cho HS, Shin SS and Park NY. 2006. Balantidiasis in the gastric lymph nodes of Barbary sheep (*Ammotragus lervia*): An incidental finding. J. Vet. Sci. 7:207-209.

Clauss M, Kienzle E and Hatt JM. 2003. Feeding practice in captive wild ruminants: peculiarities in the nutrition of browsers/concentrate selectors and intermediate feeders. A review. Zoo Animal Nutrition vol. II. Fürth, 27-52.

Clauss M, Lechner-Doll M, Flach EJ, Tach C and Hatt JM. 2001. Comparative use of four different marker systems for the estimation of digestibility and low food intake in a group of captive giraffe. Zoo. Biol. 20:315-329.

Fernandez LT, Bashaw MJ, Sartor RL, Bouwens NR and Maki TS. 2008. Tongue twisters: Feeding enrichment to reduce oral stereotypy in giraffe. Zoo. Biol. 27:200-212.

Gradwell DV. 1976. A case of abomasal impaction in a captive giraffe. Koedoe. 19:179-180.

Hatt JM, Schaub D, Wanner M, Wettstein HR, Flach EJ, Tack C, Hässig M, Ortmann S, Hummel J and Clauss M. 2005. Energy and fibre intake in a group of captive giraffe (*Giraffa camelopardalis*) offered increasing amounts of browse. J. Vet. Med. A. Physiol. Pathol. Clin. Med. 52:485-490.

Herter CA. 1898. An experimental study of fat starvation with especial reference to the production of serous atrophy of fat. J. Exp. Med. 3:293-314.

Hummel J, Fritz J, Kienzle E, Medici EP, Lang S, Zimmermann W, Streigh WJ and Clauss M. 2008. Differences in fecal particle size between free-ranging and captive individuals of two browser species. Zoo. Biol. 27:70-77.

Jurado OM, Clauss M, Streich WJ and Hatt JM. 2008. Irregular tooth wear and longevity in captive wild ruminants: a pilot survey of necropsy reports. J. Zoo. Wildl. Med. 39:69-75.

Langman VA and Maloiy GM. 1989. Passive obligatory heterothermy of the giraffe. J. Physiol. 415:89.

Langman VA, Bamford OS and Maloiy GM. 1982. Respiration and metabolism in the giraffe. Resp. Physiol. 50:141-152.

Langman VA. 1978. Giraffe pica behavior and pathology as indicators of nutritional stress. J. Wildl. Manage. 42:141-147.

Mason GJ and Latham NR. 2004. Can't stop, won't stop: is stereotypy a reliable animal welfare indicator? Anim. Welf. 13:557-569.

Potter JS and Clauss M. 2005. Mortality of captive giraffe (*Giraffa camelopardalis*) associated with serous fat atrophy: A review of five cases at Auckland Zoo. J. Zoo. Wildl. Med. 36:301-307.

Redbo I, Redbo-Tortensson P, Odberg FO, Hedendahll A and Holm J. 1998. Factors affecting behavioural disturbances in race-horses. Anim. Sci. 66:475-481.

Spalinger DE, Robbins CT and Hanley TA. 1993. Adaptive rumen function in elk and mule deer. Can. J. Zool. 71:601-610.

Steinberg SE, Nasraway S and Peterson L. 1987. Reversal of severe serous atrophy of the bone marrow in anorexia nervosa. J. Parenter. Enteral. Nutr. 11:422-423.

Ullrey DE, Crissey SD, Edwards MS and Tesar MB. 1997. Hay quality evaluation. NAG Handbook Fact Sheet 001. Nutrition Advisory Group, American Zoo and Aquarium Assoc., Silver Spring, MD, USA.

Waters AJ, Nicol CJ and French NP. 2002. The development of stereotypic and redirected behaviors in young horses: The findings of a four-year prospective epidermiological study. Eq. Vet. J. 34:572-579.

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