Severe Hypoplasia of the Omasal Laminae in a Japanese Black Steer with Chronic Bloat—A Case Report

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Uro-paper to monitor the pH and presence of urobilinogen, blood, bilirubin, ketone bodies, glucose, and protein in urine. The hematological and serum biochemical analyses results are summarized in Table 1. All hematological analysis results were within the normal ranges. Serum biochemical analysis indicates slightly higher levels of serum hepatic enzymes, which might be due to transportation to the hospital. Serum electrolyte analysis revealed normal sodium, potassium and chloride levels. The urine analysis results were also within the normal ranges. Two days after hospitalization, intensive treatment for chronic bloat was initiated and included removing the gases with a stomach tube; oral administration of vegetable oil, anti-foaming agent, ruminators, and probiotic agents; rumen transfaunation with freshly strained rumen juice; and administration of metoclopramide or neostigmin. During the approximately 2 weeks treatment period, the clinical conditions of bloat were observed, and the maximal abdominal distension was assessed each day. During hospitalization period, the steer showed good appetite and normal regurgitation (chewing), and the amount and consistency of feces were normal. The maximal abdominal distension (186 cm at circumference) tended to decrease (170 cm) during metoclopramide or neostigmine administration. Thereafter, since no further improvement in clinical conditions was observed (Fig. 1), all medications were discontinued after 2 weeks, and the steer was fed for 6 months without any medications to monitor the bloat and body weight change. Feces was examined during the later observation period and found to contain large hay particles (>2 cm) (Fig. 2-a) in comparison with feces from healthy Japanese Black heifers (17-months age; Fig. 2-b) as control that was fed the same diet. At age 16-months, since the steer weighed approximately 240 kg (normal steer at the same age weighs > 350 kg) and showed growth retardation, it was euthanized and necropsied to confirm the primary etiology of bloat. A blood sample was collected before euthanasia, and hematological and serum biochemical analyses were conducted as mentioned earlier. As shown in Table 1, the results of both analyses were within the normal ranges, except for slightly higher levels of WBC and GGT, and slightly lower level of AST, due to unknown reasons.

Macroscopic observation during necropsy revealed adhe-

Table 1. Hematological analysis results of the steer with bloat after hospitalization

<table>
<thead>
<tr>
<th></th>
<th>Day 1</th>
<th>Day 157</th>
<th>Reference values $^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBC ($\times 10^{12}/\mu l$)</td>
<td>707</td>
<td>936</td>
<td>500–1000</td>
</tr>
<tr>
<td>WBC ($\times 10^{3}/\mu l$)</td>
<td>105</td>
<td>134*</td>
<td>40–120</td>
</tr>
<tr>
<td>PCV (%)</td>
<td>26</td>
<td>30</td>
<td>24–46</td>
</tr>
<tr>
<td>TP (g/dl)</td>
<td>5.9</td>
<td>6.4</td>
<td>5.7–8.1</td>
</tr>
<tr>
<td>Hemoglobin (g/dl)</td>
<td>8.7</td>
<td>13.7</td>
<td>8–15</td>
</tr>
<tr>
<td>AST (U/l)</td>
<td>103</td>
<td>69*</td>
<td>73–132</td>
</tr>
<tr>
<td>GGT (U/l)</td>
<td>25*</td>
<td>28*</td>
<td>6–17</td>
</tr>
<tr>
<td>T-Bil (mg/dl)</td>
<td>0.2</td>
<td>0.1</td>
<td>0.01–0.5</td>
</tr>
<tr>
<td>BUN (mg/dl)</td>
<td>9.6</td>
<td>15.3</td>
<td>6–27</td>
</tr>
<tr>
<td>Creatinine (mg/dl)</td>
<td>1.3</td>
<td>1.2</td>
<td>1–2</td>
</tr>
<tr>
<td>T-Chol (mg/dl)</td>
<td>96</td>
<td>108</td>
<td>65–220</td>
</tr>
<tr>
<td>Glucose (mg/dl)</td>
<td>93*</td>
<td>70</td>
<td>45–75</td>
</tr>
<tr>
<td>Sodium (mEq/l)</td>
<td>141</td>
<td>–</td>
<td>132–152</td>
</tr>
<tr>
<td>Potassium (mEq/l)</td>
<td>4.3</td>
<td>–</td>
<td>3.9–5.8</td>
</tr>
<tr>
<td>Chloride (mEq/l)</td>
<td>107</td>
<td>–</td>
<td>95–110</td>
</tr>
</tbody>
</table>

*: Without normal reference values.
$^a$: Veterinary Medicine, A Textbook of the Diseases of Cattle, Sheep, Pigs, Goats and Horses 9th Ed.
HYPOPLASIA OF OMASAL LAMINAE IN CATTLE

Fig. 3. Postmortem examination of the omasum revealed hypoplasia of the omeral laminae (large arrows) and undigested large straw (small arrow).

Histologically, although severe hypoplasia of the omeral laminae was observed macroscopically, pathological abnormalities of tissue structures of the stratified squamous epithelium and omeral papillae were not confirmed via microscopic observations (Fig. 5).

The steer showed first bloat symptom at approximately 2-months age, which might be strongly related to the change of main feeds (from milk to forage) at weaning and development of the forestomach functions of the steer. Based on the clinical history of the present steer, we can exclude dietary effect as a possible cause of bloat because other cattle, including a calf, who were fed under the same conditions did not exhibit any bloating symptoms during the critical period. Chronic recurrent ruminal tympany usually occurs in calves of three to nine months. The etiology of recurrent tympany in calves may be inadequate fiber intake and poor rumen development. Occasionally, the thoracic esophagus and/or cardia is obstructed by external pressure due to mediastinal lymphadenopathy, which may lead to chronic pneumatic lesions. Rumination of the affected calves is usually normal, and many of them eventually recover spontaneously [17]. After the first rumenotomy at age 2 months in the present steer, which temporally confirmed no abnormalities in the rumen and reticulum, the steer showed recurrent ruminal tympany, and the clinical symptoms of bloat appeared to be shifted to those of chronic ruminal bloat without mortality. The following possible causes of chronic ruminal bloat in adult cattle are reported: adhesion formation with signs reflecting poor ruminal contractility subsequent to vagal nerve injury, tetanus, mediastinal lymph node enlargement, thymic lymphosarcoma, omasal transport failure, etc. [15, 17]. The eructation capacity of a healthy ruminant exceeds the maximal rate of gas production, even at the highest rate of microbial fermentation. Therefore, bloat does not occur due to excessive gas production but due to eructation failure [7]. The present steer did not exhibit previously mentioned typical symptoms of bloat, such chronic loss of appetite and decreased feces output, during the observation period [5]. In contrast, it showed normal rumination, appetite, and ruminal movement, while the amount and consistency of feces were appropriate. The reticulo-rumen motility is required for rumination progression, while extra reticular contraction is unessential for regurgitation since fixation or removal of the reticulum does not prevent rumination [2]. Therefore, based on clinical and hematological analyses results, the steer was diagnosed to have dysfunction of the distal part of the forestomach or abomasum, and we decided to observe the clinical conditions of bloat for prolonged duration.

The single most important laboratory test of vagal indigestion is serum or plasma chloride determination [19]. Cattle with a distended rumen and normal plasma chloride level show abomasal reflex loss, which indicates that the lesion is in the omasal canal or reticulum [19]. The hematological and serum biochemical analysis results of the present steer at the early observation stage were within the normal ranges; this may exclude the above-mentioned abnormalities. The size of digested plant fragments in ruminant feces is also suggested to provide an indirect measure of forestomach function since solid matter normally remain in the rumen until its particle size becomes sufficiently small to pass through the reticulo-omasal orifice [2]. The reticulo-rumen motility stratifies the ruminal contents, with dense fibrous material floating on top of a more fluid layer. A similar phenomenon is reported in cattle [11]. Excessively large fibers (>5 mm) or fine plant particles in the feces indicate a rapid or prolonged rumen turnover time, respectively. The nature of feces can also provide information on diet, i.e., numerous corn kernels may indicate excessive grain consumption [2]. The nature and characteristics of feces typify vagal indigestion: scant volume and pasty consistency feces that often contain 2- to 4-cm- long hay pieces suggest poor digestion. The reticulo-omasal orifice and/or the omasum determine the hay particle size transported to
the abomasum, and if the either of them is impaired, longer hay particles are transported into the lower tract [19]. Welch [18] studied the fecal particle size distribution in long hay-fed steers, and reported that 59.6% fecal samples passed through a 300-µm sieve, while only 2.1% were retained on a 2.4-mm sieve. Feces examination of the present steer at the later observation period revealed larger hay particles (>2 cm) than those in control heifers’ feces. The omasum is situated centrally in the anterior abdomen; this prevents examination via abdominal palpation and percussion [2]. Therefore, based on the fecal examination of the present steer conducted before euthanasia, we reconfirmed that the

Fig. 4. Macro-morphological observations of the ruminal papillae, reticulum cellulae and omasal laminae from the present steer (a, c, and e, respectively) and 20-months age of healthy Japanese Black cow as control (b, d, and f, respectively). Note the hypoplasia of the omasal laminae of the present steer (circle).
possible cause of bloat might be a functional disease of the distal part of the forestomach. These results strongly suggest that fecal examination together with pathological analysis is an important clinical examination to diagnose omasum functions.

The forestomach of cattle is a specialized fermentation vat consisting of 2 primary structures- the reticulorumen and omasum- functionally separated by the reticulo-omasal orifice- a sphincter-like structure. The omasum is a compact spherical organ comprising the omasal canal and omasal body. Motility of the omasal canal is coordinated with that of the reticulorumen, while omasal body contractions occur independently and slower than reticulorumenal contractions [2]. The muscularis mucosae and intermediate muscle sheet in the omasal laminae may contribute to its independent movement from the external wall [1, 4]. The function of the omasum is not completely understood. However, it plays an important role in: (1) transportation of appropriately sized feed particles from the reticulorumen to the abomasums; (2) reticular groove closure; (3) ingesta fermentation; and (4) absorption of water, volatile fatty acids (VFA), and minerals [21]. Therefore, based on clinical, hematological, and pathological analysis results, we speculated that although the steer had abnormal omasal laminae morphology and normal omasum function regarding absorption of water, VFA, and minerals, the omasum function for fermentation and digestion of food was abnormal.

The number of omasal laminae in cattle ranges from 122 to 169 [8]. The omasal laminae are muscular sheets comprising 2 lateral layers and an intermediate smooth muscle layer, covered with non-glandular stratified squamous epithelium [4, 20]. Forestomach movements are essential for fermentation and are effective through the following steps: (1) mechanical maceration of the ingesta and its inoculation with rumen micro-organisms, (2) mixing saliva with the rumen contents to buffer VFAs, (3) prevention of local accumulation of VFAs, (4) assisting VFA removal by the rumen wall, and (5) elimination of fermentation gases [6]. The sensory innervation of the reticulo-omasal orifice is assumed to participate in regulating the ruminant stomach motility and the passage of ingesta [16]. Additionally, the omasal laminae motility is reported to be independent of the omasal wall and reticulo-omasal orifice. The omasal laminae contracts in an aboral direction from the free border toward the base [1]. Kitamura et al. [3] studied the distribution of nerves showing immunoreactivity to some polypeptides in the margin of the reticulo-omasal orifice and omasum in cattle and reported that substance P-immunoreactive nerves were abundant at the periphery of the omasal laminae musculature; they suggested that these nerves might play important role in regulating the omasal laminae motility and omasal canal activity. In contrast, vasoactive intestinal polypeptide-immunoreactive nerves were abundant in the omasal wall, suggesting their substantial involvement in regulating omasal wall motility. It was proposed that the impairment of normal eructation may constitute: (1) esophageal obstruction, (2) esophageal occlusion, (3) spasm of the esophageal musculature, or (4) frothing of the forestomach contents that prevents the opening of the cardia for eructation [7]. Therefore, the cause of bloat in the present steer is probably malfunction of the region from the cardia to the reticulo-omasal orifice extending to the omaso-abomasal orifice due to hypoplasia of the reticular groove and omasal laminae. This region may play a key role in the pathophysiology of bovine bloat.

In conclusion, based on clinical and pathological analyses, the present steer was diagnosed to have congenital hypoplasia of reticular groove and omasal laminae. To our knowledge, this is the first report of hypoplasia of reticular groove and omasal laminae. To our knowledge, this is the first report of hypoplasia of reticular groove and omasal laminae. To our knowledge, this is the first report of hypoplasia of reticular groove and omasal laminae. To our knowledge, this is the first report of hypoplasia of reticular groove and omasal laminae.

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