

Characteristics of Fluid Composition of Left Displaced Abomasum in Beef Cattle Fed High-Starch Diets

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ABSTRACT. To clarify the pathophysiology of left displaced abomasum (LDA), beef cattle fed high-starch diets were examined. The abomasal pH in beef cattle with LDA was lower than that in non-LDA reference animals (data from beef cattle at an abattoir, suggesting that it facilitated acidity. Bacteriological examinations of the abomasal fluid in cattle with LDA revealed the presence of *Pseudomonas* spp., *Clostridium* spp. and *Candida* spp., presumably reflecting the accelerated influx of ruminal fluid into the abomasum. Biochemical analyses of serum revealed that LDA cattle had higher lactic acid and lower vitamin A and E levels than non-LDA reference animals. These results indicate that beef cattle with LDA may suffer from vitamin A and E deficiencies due to maldigestion of starch and the high acidity of abomasal fluid.

KEY WORDS: abomasal fluid, beef cattle, left displaced abomasum, starch diets, vitamin A

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Left displaced abomasum (LDA) in dairy cattle has been associated with the influx of volatile fatty acids (VFAs) into the abomasum, caused by overfeeding of concentrates, decreased mobility of the abomasum and/or accumulation of gas in the abomasum [15]. Although there have been many reports dealing with LDA in dairy cattle [1, 3, 10, 11], to date, few are available regarding beef cattle, probably due to the continuous, largely unaltered feeding throughout the periparturient period in beef cattle [14]. In fact, the incidence of LDA has been confirmed to be lower in beef cattle than in dairy cattle.

Previously, we reported changes in blood chemistry in beef cattle with LDA in comparison with non-LDA animals, indicating the involvement of high-starch diets [5]. In the present study, we confirmed beef cattle with LDA and examined the abomasal fluid compositions to clarify the pathophysiology. To evaluate abomasal fluid and blood chemistry levels of beef cattle with LDA, those data from non-LDA beef cattle at an abattoir were used as reference. Beef cattle with right displaced abomasum were excluded from this investigation, because of their extremely low incidence.

Crosses (F1, beef cattle) of Japanese Black and Holstein dairy cows raised on the same farm (Miyagi, Japan) as in previous investigations [5, 6] were used. Approximately 3,000 animals were given diets consisting of rice straw (20–25%) and concentrates (75–80%), including starch (40–45%), from 13 months after birth for finishing (estimated

vitamin A levels: 420 IU/kg). To prevent muscular interstitial edema, additional vitamin A was added into the diets (up to 600 IU/kg) during the finishing phase (approximately 2 months to complete). The incidence of LDA on this farm was 2.09–4.05% between 2002 and 2007, similar to the average incidence for dairy cows in Japan [Japanese Ministry of Agriculture, Forestry and Fisheries of Japan. 2005. www.maff.go.jp/j/tokei/kouhyou/katiku_kyosai/]. The relatively high incidence of LDA on this farm may be due to the addition of the high-starch diet to encourage growth.

Beef cattle with LDA appeared at 19 months old, on average, and were diagnosed by clinical symptoms, such as loss of appetite and a pinging sound in the left ventral abdomen. They were then subjected to surgery. Beef cattle without LDA were declared healthy, following clinical observations and hematological, blood chemistry and necropsy findings.

Body weight and age ranges of beef cattle with LDA (16 steers and 4 heifers) were 388–672 kg and 13–27 months old, and non-LDA reference animals (14 steers and 5 heifers) were 595–780 kg and 27–33 months old, respectively (Table 1). No difference in the incidence of LDA between steers and heifers was noted.

The abomasal fluid was collected aseptically during

Table 1. Summarized profile of beef cattle used in the present study

Groups	n			Body weight ^{a)} (kg)	Age (Month)
	Heifer	Steer	Total		
LDA	4	16	20	388–672	13–27
Non-LDA (Reference control)	5	14	19	595–780	27–33

a) Body weight in cattle with LDA was measured immediately before surgery, and that in cattle with non-LDA was determined at an abattoir. LDA: Left-displaced abomasum.

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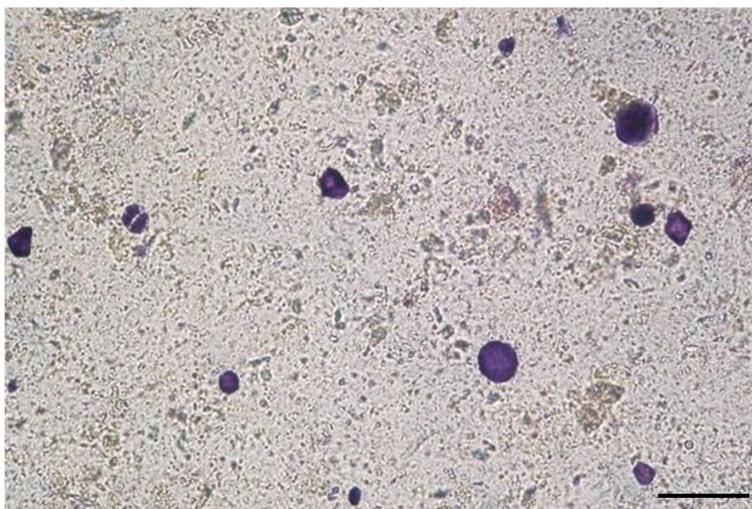


Fig. 1. Presence of undigested particles in the abomasal fluid of beef cattle with LDA. The particles were confirmed to be starch (purple) using the iodo-starch reaction. Bar=200 μm .

surgery in beef cattle with LDA and at the abattoir in beef cattle without LDA. Starch in the abomasal fluid was confirmed with the iodo-starch reaction [9]. The abomasal pH was measured using a pH meter (Horiba D-52 pH meter, Kyoto, Japan). For *Bacillus* spp. testing, the abomasal fluid was streaked on HI agar plates with sheep blood (Becton Dickinson, Tokyo, Japan) and incubated at 37°C for 48 hr. Colonies were examined by microscopy after Gram staining and were confirmed using an API50CH identification kit (Sysmex bioMerieux, Marcy l'Etoile, France). To isolate *Pseudomonas* spp., fluid was streaked on DHL agar plates (Nissui Pharmaceutical, Tokyo, Japan) and incubating at 37°C for 18 hr. Colonies on the plate were further incubated on HI agar plates with sheep blood to obtain pure cultures. They were examined by microscopy after Gram staining and identified using an API20E identification kit (Sysmex bioMerieux). For the isolation of *Clostridium* spp., fluid was streaked on CW agar plates (Nissui Pharmaceutical) containing kanamycin, and the plates were incubated anaerobically inside a Gas Pack (Mitsubishi Gas Chemical, Tokyo, Japan) at 37°C for 24 hr. Colonies that developed were examined by microscopy after Gram staining and were identified using the API20E kit. For the isolation of *Candida* spp., fluid was streaked on a selection agar plate and identified using the API identification kit (Sysmex bioMerieux) for yeast-like fungi. The assays were performed by an independent testing service (Kyoto Animal Diagnostic Laboratory, Kyoto, Japan).

Blood was collected from the jugular vein using an evacuated collection tube at the operation or at the abattoir. Using serum, lactic acid, glucose, free fatty acid, total cholesterol, uric acid nitrogen, total protein, albumin, calcium, inorganic phosphorus, asparagine aminotransferase, γ -glutamyl transpeptidase, sodium, potassium and chloride were analyzed with an automated analyzer (Dimension RxL, Dade Beh-

ring, Tokyo, Japan), and vitamins A (VA) and E (VE) were measured using high-performance liquid chromatography (Shimadzu LC-10A, Kyoto, Japan).

Quantitative data are expressed as means \pm standard deviations (SDs). For reference, differences between beef cattle with LDA and the non-LDA group were examined using Student's *t*-test.

Undigested particles in the abomasal fluid were observed by microscopy only in beef cattle with LDA. Because these particles became purple with the iodo-starch reaction, they were identified as starch (Fig. 1).

Serum vitamin A (49 ± 34 IU/dl) and vitamin E (219 ± 82 $\mu\text{g}/\text{dl}$) values in beef cattle with LDA were significantly lower than those in non-LDA reference animals (114 ± 66 IU/dl and 449 ± 66 $\mu\text{g}/\text{dl}$, respectively). During the fattening process in beef cattle, restricted vitamin A feeding is commonly used to enhance fat marbling in the sirloin portions [12]. However, severe vitamin A deficiency in beef cattle given restricted vitamin A feeding has been recognized from 18–22 months old [7, 16] consistent with LDA events. Lower vitamin A level of beef cattle with LDA in the present study seems to relate to the onset of LDA which occurred prior to start of vitamin A additive diet.

According to our previous work, serum vitamin A in beef cattle with LDA was significantly lower than in the non-LDA healthy animals and resulted in a reduced appetite [5]. A decreased serum vitamin E is then considered to result from the reduced appetite due to the vitamin A-deficient diet [5]. Reduced appetite has been reported to be an initial event for the onset of LDA [5]. Thus, vitamin A deficiency may even be a prerequisite for the onset of LDA.

The serum lactic acid value (11.4 ± 6.7 mg/dl) in beef cattle with LDA was significantly higher than in non-LDA reference animals (4.4 ± 2.2 mg/dl), suggesting that rumen acidosis was induced by the high-starch diet, consistent with

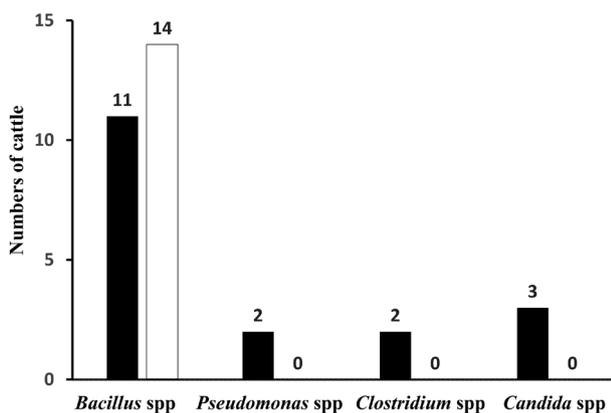


Fig. 2. Bacteria confirmed in the abomasal fluid of beef cattle with LDA (closed columns, $n=20$) or non-LDA (open columns, $n=19$). The figures above the respective columns indicate the numbers of beef cattle with *Bacillus* spp., *Pseudomonas* spp., *Clostridium* spp. and *Candida* spp.

a previous report [13]. The abomasal pH (1.73 ± 0.71) in beef cattle with LDA was significantly lower than that (3.78 ± 0.87) in non-LDA reference animals. Dairy cattle fed high-concentrate diets, including starch, were reported to suffer from rumen acidosis, leading subsequently to a high incidence of LDA [11]. Because beef cattle fed high-starch diets exhibited a low abomasal pH with undigested starch, the facilitated acidity in the abomasal fluid may be a trigger for the onset of LDA. That is, high abomasal acidity may be related to decreased mobility of abomasal smooth muscle, although the causal relationship between abomasal acidity and LDA remained unexplored.

Microbiological examinations revealed the presence of *Pseudomonas* spp., *Clostridium* spp. and *Candida* spp. only in the abomasal fluid of beef cattle with LDA (Fig. 2). However, no difference in *Bacillus* spp. between beef cattle with and without LDA was noticed. These findings indicate that the presence of the bacteria in the abomasum of dairy cattle with LDA may be due to the same mechanism as the accelerated influx of VFA and gas in the abomasum [8, 15]. Thus, the addition of a probiotic agent, including lactic acid-producing bacteria, to diets may be useful for prevention or treatment of LDA in beef cattle, by improving ruminal pH and VFA [2, 4]. Regarding *Bacillus* spp., however, any role remains unclear. The differences in the incidence of LDA between Holstein dairy and beef cattle in Japan are considered to be due to differences in feeding programs.

In conclusion, our results demonstrate that beef cattle with LDA may suffer from vitamin A deficiency, due to maldigestion of starch and high acidity in the abomasal fluid.

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