Evaluation of Blood Acid-Base Balance after Experimental Administration of Endotoxin in Adult Cow

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ABSTRACT. Escherichia coli endotoxin was administered intravenously to 7 Holstein adult cows, to evaluate the effect of endotoxin on acid-base balance. Endotoxin shock was observed immediately after the administration of endotoxin. A loss of appetite and depression of digestive tract motility continued for about 120 hr after the challenge. Metabolic alkalosis following hypochloremia and hypokalemia were particularly pronounced at 12 to 72 hr after the administration of endotoxin. — KEY WORDS: bovine (adult), endotoxin, metabolic alkalosis.

Experimental and clinical studies have shown that endotoxin plays a pivotal role in triggering the development of the clinical and laboratory manifestations of gram negative septicaemia. The clinical symptoms of septicaemia usually include depression, fever, congestion of mucosa, tachycardia and diarrhea [10, 15]. A disorder of acid-base balance has been shown to be one of the responses to endotoxin challenge [8, 12]. However, the precise mechanism of endotoxin in mediating certain pathophysiological events associated with adult Holstein cows remains unclear. This study was designed to clarify the relationships between the clinical symptoms and the disturbances of blood gas and electrolyte values following intravenous administration of endotoxin.

Ten Holstein-Friesian cows were used in the experiments. Seven cows were given endotoxin and three cows were injected with saline as the control group. All the cows had different body condition scores, and their body weights varied between 550 to 800 kg. The cows were given hay and water freely during the experimental period, and they were all treated according to the Laboratory Animal Control Guidelines of Rakuno Gakuen University. These guidelines are basically in conformity with the American Association of Laboratory Animal Control Guidelines established by the National Institutes of Health.

Endotoxin extracted from Escherichia coli (lipopolysaccharide O26:B6 Difco, Detroit, MI, U.S.A.) was intravenously injected rapidly at a dose of 0.025 mg/kg in a saline solution. Blood samples were collected immediately before administration of the endotoxin and at 0.5, 1, 2, 4, 6, 12, 24, 36, 48, 72, 96, 120, and 240 hr after the administration of endotoxin. Serum sodium, potassium and chloride concentrations were measured by ion specific electrolyte. Hematocrit values were determined by a microhematocrit method, and total serum proteins by using a refractometer. In order to measure the blood gas, arterial and venous blood was taken from the caudal artery and jugular vein. Blood pO2, pH, base-excess (BE), and bicarbonate level were measured in a 178 pH/Blood Gas Analyzer (CORNING) within 30 min after blood collection.

Student’s t test was used to compare responses between groups of each time interval, and values of p<0.05 were regarded as significant.

Following the administration of endotoxin, a significant increase in the respiratory rate occurred within 1 hr after the endotoxin administration. In injected cows, there were no significant changes in rectal temperature (data not shown). The cows showed a complete loss of appetite immediately after the administration of endotoxin, but started to eat a little hay after 10 to 24 hr. Compared with the cows administered only saline, the cows which were administered endotoxin all showed a loss of appetite and anorexia during 24 to 120 hr. Clinical signs of depression of rumen sound, and tarry or watery diarrhea were confirmed in six of the seven endotoxin-administered cows during 2 to 10 hr. However, these findings were not seen at 12 hr in any of the cows. Depression of digestive movement and a decrease of feces excretion were seen during 24 to 120 hr. The most severely affected cow was not able to stand immediately after the administration of endotoxin, and excreted black tarry feces at 120 hr after the endotoxin challenge. In addition, polyuria was observed in all cows from 6 to 12 hr after the administration of endotoxin. Dehydration characterized by decreasing skin turgor and development of enophthalmos occurred progressively in all the cows from 24 to 120 hr after the endotoxin challenge.

A significant increase in arterial pH was detected during 24 to 48 hr after the administration of endotoxin. The bicarbonate levels rose significantly from 12 to 48 hr after the administration of endotoxin. The levels of BE increased significantly from 12 to 48 hr after administration (Fig. 1). A significant decrease of arterial pO2 was observed at 0.5 hr, and returned to the base line at 6 hr. A significant second decrease in arterial pO2 was detected during 12 to 48 hr after the endotoxin administration (Fig. 2). Serum chloride concentrations decreased significantly at 36 to 48 hr after the endotoxin administration. The level of chloride recovered to the normal range at 120 hr. The concentration of serum potassium significantly decreased at 36 to 96 hr after endotoxin challenge. Serum sodium concentration...
increased significantly at 12 to 24 hr and peaked at 12 hr after injection of endotoxin, and returned to the base line by 48 hr (Fig. 3). The value of hematocrit increased significantly at 36 hr after the challenge. Total protein levels peaked at 36 hr after injection (data not shown). All parameters recovered to the base line by 240 hr in all cows.

All cows injected with endotoxin developed metabolic alkalosis with pronounced hypochloremia and hypokalemia. An intravenous endotoxin challenge induces metabolic acidosis in many animals, such as horses, dogs or calves [6, 8, 10, 12]. In our results, a decrease in the arterial pO2 values was similar to that in calves administered endotoxin [10, 11], and is possibly due to a sympathomimetic effect, since similar effects were observed after the administration of a minute amount of endotoxin [6]. In the present study, however, metabolic alkalosis was detected following hypernatremia, hypokalemia and hypochloremia.

Acid-base disorders similar to those described in this study have been reported in upper internal disturbances in adult cows, such as displacement, torsion or atony of abomasum [1, 4, 5, 11, 14]. This is because the process of acid secretion involves the removal of a chloride ion from the circulation in exchange for a bicarbonate ion, and chloride accumulation within the abomasum leads to
hypochloremia and metabolic alkalosis [11, 14]. These changes have also been seen in ruminants with experimental occlusion of the duodenum, and the degree of hypochloremia progressed in direct relation to the duration of occlusion [5, 13]. Metabolic alkalosis following an injection of endotoxin may be related to the abomasal hypomotility, the same mechanism as that previously reported for abomasal disorders in ruminants [5, 13]. Moreover, black tarry feces were excreted from the most severely affected cow at 120 hr after endotoxin challenge. This clinical finding was probably due to a disorder of the abomasal function, as black feces in cows have been regarded as a characteristic clinical sign of abomasal disease, such as bleeding ulcers and a right displacement of the abomasum [2, 9]. Cattle with abomasal complications showed the accumulation of hydrochloric acid-rich abomasal secretion [13].

Dehydration may have also affected the acid-base balance of the adult cows in this study. It is known that endotoxin induces hypernatremia or necrosis in the mucosa of the digestive tract, and hemorrhagic, secretomotory diarrhea in animals [6, 7]. In a previous study of dogs, moreover, endotoxin challenge induced polyuria and increased renal blood flow [3]. These indirect effects of endotoxin suggested that the systematic loss of fluid and electrolytes might have been occurring in the treated cows.

In conclusion, the present data demonstrate that endotoxin can induce metabolic alkalosis, while it induces metabolic acidosis in cows [12]. Further studies are needed to clarify the association between changes in the acid-base balance and effects of endotoxin in adult cows.

REFERENCES