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Association of Serum Calcium Concentration with Blood PH, Blood Minerals, Age and Parity in Cows after Calving

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分娩牛における血清カルシウム濃度の血液 pH，血液ミネラル，年齢，産次との関連

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要　　旨

分娩牛における血清カルシウム濃度，血液 pH，血液ミネラル濃度，年齢および産次との関連を調査した。北海道 3 農家の分娩牛 151 頭から頸静脈血を採材したところ，151 頭中 101 頭に低カルシウム血症がみられ，23 頭が重度，78 頭が軽度であった。血液アシドーシスの発生率は低カルシウム血症の軽度および重度それぞれで 53.8%および 82.6%であった。また，血清カルシウム濃度は血清リン濃度と血液 pH と有意に正の相関を，また年齢，産次および血清マグネシウム濃度と有意に負の相関をみとめられた。

キーワード：アシドーシス，牛，低カルシウム血症

Abstract

We investigated the association between the serum calcium concentration (Ca), blood pH, blood minerals, age and parity in cows after calving. For this, 151 cows were bled from the jugular vein within three days after calving in three dairy farms in Hokkaido. Of these, 101 developed hypocalcemia defined as serum Ca concentration<8.0 mg/dl, and mild and severe hypocalcemia was detected in 78 and 23 cows, respectively. The incidence rates of blood acidosis in mild and severe hypocalcemia was 53.8% and 82.6%, respectively. Serum Ca showed a significant positive correlation ($p<0.05$) with serum phosphate concentration and blood pH, and a significant negative correlation ($p<0.05$) with age, parity, and serum magnesium concentration.

Key Words: acidosis, cattle, hypocalcemia

Dairy cows are vulnerable to metabolic disorders, including calcium deficiency, which may contribute to the incidence of various diseases [1, 5]. Hypocalcemia is a biochemical abnormality caused by metabolic alkalosis relative to the ingestion of a cationic diet [3, 4, 13, 16]. Hypocalcemia may be subclinical or exhibit clinical signs. Numerous scientists have defined the clinical case as being less than 5.5 mg /dl of serum calcium concentration (Ca), and subclinical case as being between 5.5 and 8 mg/dl of serum Ca [3, 8]. Hypocalcemia decreases by replacing cationic with anionic diets to induce metabolic acidosis [2, 12, 19]. Metabolic acidosis results in the activation of calcium homeostasis by increasing the sensitivity of target tissues, such as the kidney and bone, to parathyroid hormone [6]. However, hypocalcemia in cows occurs every year and it is necessary to study the etiological factors of hypocalcemia in a dairy field. This investigation was conducted to determine the association of serum Ca with blood pH, animal's age, parity and other blood minerals, namely serum sodium concentration (Na), serum potassium concentration (K), serum phosphate concentration (P), and serum magnesium concentration (Mg).

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Table 1. The incidence rates of hypocalcemia and blood acidosis in the investigated cows.

Investigated cows	Hypocalcemia		
		Mild	Severe
n	Ca [a] <8mg/dl	5.5 ≦ Ca [a] <8mg/dl	Ca [a] <5.5mg/dl
151	66.9% (101/151)	51.7% (78/151)	15.2% (23/151)
Acidosis [b]			
49.0% (74/151) [c]	54.5 % (55/101) [d]	46.2% (36/78) [d]	82.6% (19/23) [d]

a) serum calcium concentration
b) blood pH less than 7.40
c) incidence rate of blood acidosis in investigation cows
d) incidence rate of blood acidosis to cows of each upper hypocalcemia

Within three days after calving on three farms in Hokkaido, 151 blood samples were collected from the jugular vein of 151 Holstein cows ranging in age from 1.8 to 9.7 years, with the parity ranging from 1 to 7. Serum Ca, P, Mg, Na, and K were analyzed using blood biochemistry analyzer /Beckman CX 5/, and blood pH was measured in whole blood supplied with heparin lithium using blood gas analyzer / Chiron 386/. Serum Ca was used to identify hypocalcemia with less than 8.0 mg/dl, and hypocalcemia was further classified into mild (serum Ca: 5.5～<8.0 mg/dl) and severe (serum Ca:<5.5 mg/dl). Blood acidosis and blood alkalosis were defined as less than 7.40 of blood pH and more 7.41 of blood pH, respectively.

Data were input in the software "excel" of Co. Microsoft. Pearson correlation coefficient and statistical p-value were calculated among serum calcium concentration, blood pH, other blood minerals, animal's age and parity. Statistical significance was set at $p<0.05$.

The incidence rates of hypocalcemia and blood acidosis in cows are summarized in Table 1. The incidence rate of hypocalcemia in this study was 66.9% (101/151). The incidence rate of mild and severe hypocalcemia was 51.7% (78/151) and 15.2% (23/151), respectively. Previous reports have indicated that the high incidence of hypocalcemia could be linked to the onset of lactation [14, 17]. This result also showed a high proportion of hypocalcemia in cows within three days after calving which was due to the start of lactation.

An incidence rate of blood acidosis was observed in 54.5% (55/101) of cows with hypocalcemia, as shown in Table 1. Moreover, the incidence rate of blood acidosis and blood alkalosis in mild hypocalcemia was 46.2% (36/78) and 53.8% (42/78), respectively. Conversely, the incidence rate of blood acidosis and blood alkalosis in severe hypocalcemia was 82.6% (19/23) and 17.4% (4/23), respectively. It seemed that blood acidosis might be associated with the aggravation of the hypocalcemia.

Pearson correlation analysis was used to quantify correlations among blood minerals, blood pH, age and parity. These results are shown in Table 2. Serum Ca exhibited a significant positive correlation ($p<0.05$) with P ($r=0.670$), pH ($r=0.317$), and a significant negative correlation ($p<0.05$) with parity ($r=-0.563$), age ($r=-0.534$), Mg ($r=-0.327$), and Na ($r=-0.162$). However, no correlation was detected between serum Ca and serum K. Associations between serum Ca and age or parity were consistent with previous studies [7, 15, 18], which have reported that hypocalcemia frequently occurred in multiparous old cows than in primiparous young cows. Clinical hypocalcemia (milk fever) have been reported to be characterized by moderate or conspicuous hypocalcemia accompanied by hypophosphatemia [9, 10, 11].

This result can be summarized as follows: As the 0.317 of correlation coefficient between serum Ca and blood pH was low, serum Ca was shown to have a weak positive correlation with blood pH in this study. To date, this is the first study to evaluate the positive association between serum Ca and blood pH. A additionally, the incidence rate of acidosis in severe hypocalcemia was higher than that of mild hypocalcemia. Blood acidosis in cows after calving might be linked to aggravation of hypocalcemia. These results are different from previous reports, which have shown that blood acidosis leads to increases in serum Ca and then prevents hypocalcemia [2, 6, 12, 19].

Table 2. Pearson correlation coefficient and statistical p value among variables (n=151).

Variable	pH	Mg	P	Na	K	Age	Parity	Ca
Mg	−0.013	1						
	0.876							
P	0.318	−0.425	1					
	<.05	<0.05						
Na	−0.380	−0.141	−0.019	1				
	<.05	0.084	0.818					
K	−0.207	−0.198	−0.07	0.324	1			
	<.05	<.05	0.408	P <.05				
Age	−0.211	−0.022	−0.418	0.156	0.278	1		
	<.05	0.792	<.05	0.056	<.05			
Parity	−0.248	0.009	−0.450	0.173	0.283	0.971	1	
	<.05	0.913	<.05	<.05	<.05	<.05		
Ca	0.317	−0.327	0.670	−0.162	0.116	−0.534	−0.563	1
	<.05	<.05	<.05	<.05	0.156	<.05	<.05	

Note: Correlation coefficient is shown as the above value in each variable line.
The p-value is shown as the below value in each variable line, and $p<0.05$ is significant.

The phenomenon that hypocalcemia might be aggravated by blood acidosis could not be explained within the limits of this investigation. Data collection is necessary on the developmental mechanism of hypocalcemia, especially an association between serum calcium concentration and blood pH in cows after calving.

In conclusion, this study noted that the serum Ca concentration in cows after calving has a positive correlation with serum P concentration and blood pH, and has a negative correlation with serum Na concentration, serum Mg concentration, animal age, and parity. Additionally, the incidence rate of acidosis in severe hypocalcemia was higher than that in mild hypocalcemia, and most severe hypocalcemia cows had blood acidosis.

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