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SHORT COMMUNICATION

Changes in the blood electrolyte, BUN and glucose values in diarrheic Hanwoo neonatal calves

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Calf diarrhea is a major health concern in the livestock industry that requires accurate analysis for appropriate treatment. Dehydration and electrolyte imbalance are the most significant consequences of diarrhea in calves. Until now, the reference values of blood analysis of Hanwoo neonatal calves have not been well known. Recently, portable blood analyzers have made it possible to immediately analyze blood in the farm and provide suitable treatment for the patients. We analyzed electrolytes, blood urea nitrogen (BUN) and glucose in the blood of 179 Hanwoo neonatal calves, including 79 with diarrhea. These 179 calves were divided into 3 groups based on their age. Values of sodium (Na^+) and glucose were significantly lower in diarrheic calves (1～30 days), while potassium (K^+) and chloride (Cl^-) values were higher in diarrheic calves (1～30 days). BUN values, which are closely related to dehydration due to diarrhea, increased in diarrheic calves of all ages. Therefore, these data can be used as reference values for blood analysis and treatment of healthy or diarrheic Hanwoo neonatal calves within 30 days of age.

Key Words: Blood chemistry, Hanwoo calf, Diarrhea

INTRODUCTION

Diarrhea can create serious economic losses for livestock farms (Done et al, 1980; Kwon et al, 2000). Diarrhea causes the loss of water and electrolytes in the body and can be fatal, especially in newborn calves (Hartmann et al, 1984; Hartmann and Reder, 1995; Lorenz, 2004). In addition, diarrhea caused by infection with viruses, bacteria, parasites, etc, can lead to secretory or exudative stool. Therefore, analysis of the pathogens in calf diarrhea is necessary for appropriate treatment (Acres et al, 1977; Done et al, 1980; Tzipori et al, 1980; Lofstedt et al, 1999; Kwon et al, 2000; Kang et al, 2004; Muktar et al, 2015).

Recently, with the advent of portable blood analyzers, it has become possible to immediately analyze the patient's condition and its severity in the field and calculate the appropriate dosage to support fluid treatment. This advance has made it possible to treat patients faster than ever before.

However, bovine serum biochemistry analyses have been mainly conducted with adult cattle, and we lack analyses considering neonatal calves of varying age brackets (Grove-White and White, 1993; Hartmann and Reder, 1995; Constable, 2004). For this reason, serum biochemical reference values from adult cattle often have to be used to determine the health of neonatal calves (Smith, 2015).

Therefore, in this study, we analyzed the electrolytes (sodium, potassium, chloride), blood urea nitrogen (BUN) and glucose values of healthy and diarrheic Hanwoo neonatal calves in different age brackets. Reference values for biometric data, such as electrolyte, BUN and glucose levels, of healthy Hanwoo calves of different growth stages are presented.

MATERIALS AND METHODS

Animals and sample collection

A total of 179 Hanwoo neonatal calves that were within 30 days of birth and raised at 35 farms, in Gimje city, Jeonbuk, Republic of Korea were sampled from 2019 to 2020. These neonatal calves were divided into one of three groups according to their age: 1 to 10 days (n=51), 11 to 20 days (n=57), and 21 to 30 days (n=71) (Table 1).

Stool obtained by rectal stimulation was immediately collected and transferred to the laboratory in a refrigerated state for further fecal examination. After blood was collected through the jugular vein, the blood was inserted into a lithium heparin vacutainer tube.

Fecal examination

Feces were subdivided into solid, semi-solid, loose, and watery stools. Solid and semi-solid stools were classified as normal while loose and watery stools were classified as diarrhea. Major pathogens known to cause calf diarrhea include *Cryptosporidium parvum* (*C. parvum*), rotavirus, bovine coronavirus, *Escherichia coli* (*E. coli*), *Giardia duodenalis* (*G. duodenalis*), bovine viral diarrhea virus (BVDV), *Salmonella* spp., and *Eimeria* spp. (Mahlum et al, 2002; Cho et al, 2010; Kim et al, 2018).

To identify the pathogens present in stool samples, feces of 79 diarrheic calves were initially screened using an antigen diagnosis kit (Rapid BoviD-5 Ag, Bionote, Korea) (*Cryptosporidium*, rotavirus, Bovine Coronavirus, *E. coli* (K99, F17), *Giardia*). These 79 fecal samples were also examined by reverse transcriptase-polymerase chain reaction (RT-PCR) targeting BVDV and *Salmonella* spp., as well as the other five pathogens noted above. The negative feces were selected as a control group for RT-PCR.

To detect the presence of *Eimeria* spp., the 79 fecal samples were suspended in a solution of 2.5% potassium dichromate and then transported to the laboratory. In the laboratory, fecal samples were analyzed to detect oocysts using floatation methods with Sheather's solution (saturated sugar solution; specific gravity 1.28) and examined microscopically (×400 magnification) based on the morphological features of *Eimeria* spp. oocysts.

Table 1. Classification of 179 Hanwoo neonatal calves according to diarrhea and age

	1～10 days	11～20 days	21～30 days	Total
Healthy	18	36	46	100
Diarrheic	33	21	25	79
Total	51	57	71	179

Analysis of electrolytes (sodium, potassium, chloride), BUN and glucose

Blood collected from the jugular vein was immediately measured in the field using the EC8+ cartridge of i-STAT (Abbott, Priceton, NJ, USA).

Statistical analysis

All statistical analyses were performed using the SPSS 24.0 software package (SPSS, Chicago, IL, USA). The results are expressed as mean±standard error of the mean (SEM). Age-related changes in blood test results were compared using two-tailed independent t-tests depending on the results of normality tests (Shapiro-Wilk test). All graphical evaluations were performed using GraphPad Prism 6 for Windows (GraphPad Software Inc., San Diego, CA, USA). Differences with *P* values of less than 0.05, 0.01 and 0.001 were considered statistically significant.

RESULTS

Analysis of electrolytes, BUN and glucose

The mean values for electrolytes, BUN and glucose in each group are listed in Table 2. In diarrhea-negative calves, the mean values of sodium (Na^+) were constant

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regardless of age. However, the mean value of Na^+ was significantly lower in all diarrhea-positive age groups except the 11∼20 days age group (139±5.6 mEq/L). The mean value of potassium (K^+) was low only in the diarrhea-positive, 11∼20 days age group (4.61±0.9 mEq/L), and significantly higher at other ages. The mean value of chloride (Cl^-) was lower only in the diarrhea-positive group of 21∼30 days age group (96.6±13.0 mEq/L). The mean value of electrolytes in calves of all ages with diarrhea varied (Table 2 and Fig. 1).

Table 2. The mean values of electrolytes, blood urea nitrogen (BUN) and glucose in 179 Hanwoo neonatal calves according to diarrhea and age

Item	Diarrhea	1∼10 days	11∼20 days	21∼30 days	1∼30 days
Na^+ (mEq/L)	Negative	142±3.7	138±3.1	139±1.5	139±3.0
	Positive	137±7.1†	139±5.6	129±11.2‡	135±9.3‡
K^+ (mEq/L)	Negative	5.81±0.5	5.23±0.7	4.97±0.5	5.22±0.7
	Positive	6.15±1.6†	4.61±0.9	5.32±1.8*	5.47±1.6
Cl^- (mEq/L)	Negative	99.4±2.3	98.2±2.2	98.8±2.3	98.6±2.2
	Positive	105±9.3†	107±8.8‡	96.6±13.0	103±11.3‡
BUN (mg/dL)	Negative	9.77±4.9	9.05±3.2	8.13±2.8	8.79±3.5
	Positive	46.9±30.7‡	41.6±32.4‡	54.9±34.6‡	48.0±32.4‡
Glucose (mg/dL)	Negative	104±19.2	110±17.1	109±20.1	108±18.9
	Positive	83.7±46.1	90.2±40.1†	115±67.2	95.5±53.6*

Na^+, sodium; K^+, potassium; Cl^-, Chloride.
Data are presented as mean±standard error of the mean (SEM).
P values were obtained using two-tailed independent t-tests (*$P<0.05$, †$P<0.01$, ‡$P<0.001$).

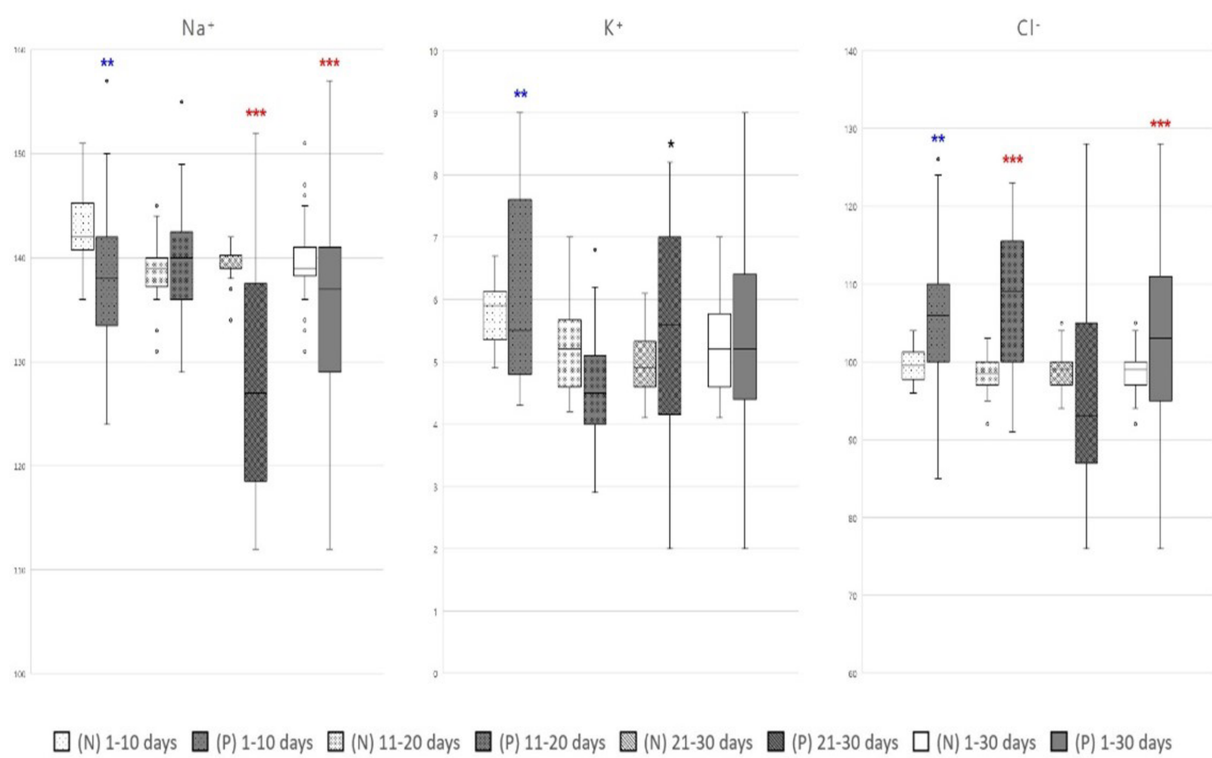

Fig. 1. Comparison in electrolytes values in 179 Hanwoo neonatal calves according to diarrhea and age. Na^+, sodium; K^+, potassium; Cl^-, Chloride; (N), without diarrhea; (P), with diarrhea. *P* values were obtained using two-tailed independent t-tests (*$P<0.05$; **$P<0.01$; ***$P<0.001$).

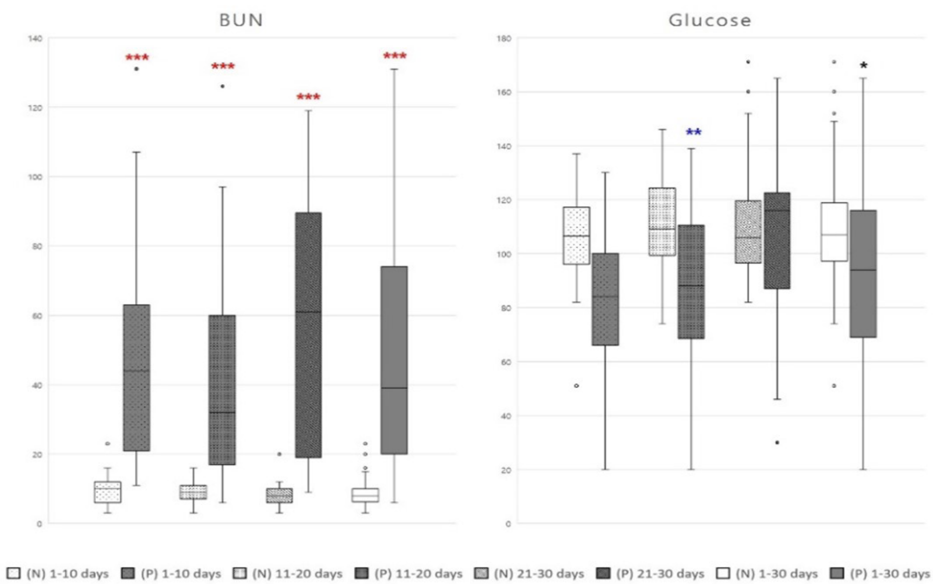

Fig. 2. Comparison in blood urea nitrogen (BUN) and glucose values in Hanwoo neonatal calves according to diarrhea and age. (N), without diarrhea; (P), with diarrhea. *P* values were obtained using two-tailed independent t-tests (**P*<0.05; ***P*<0.01; ****P*< 0.0011).

The mean values of BUN were highly elevated regardless of age in diarrhea- positive calves, and these values significantly differed between normal and diarrheic calves regardless of age (P<0.001). Mean values of glucose were constant regardless of age in diarrhea-negative calves, but this was not true of diarrhea-positive calves. There was a significant difference between normal and diarrhea calves within the 11~20 days age group (P<0.01) (Table 2 and Fig. 2).

Detection of pathogens from diarrheic calves

Of the 179 Hanwoo neonatal calves enrolled in this study, 79 diarrheic calves were identified. Calves from 1~10 days age group had the highest number of diarrheic individuals (33/51), followed by the 21~30 and 11~20 days age groups with 25/71 and 21/57 diarrheic individuals, respectively. Samples were collected from these 79 diarrheic calves and were tested for pathogens; in this analysis, 36 calves (45.6%) showed the presence of rotavirus, while 13 (16.5%) were positive for BVDV, 13 (16.5%) were positive for *E. coli*, 10 (12.7%) were positive for *Eimeria* spp., 4 (5.1%) were positive for *C. parvum*, and 3 (3.8%) were positive for coronavirus. However, no calves were found to be positive for *G. duodenalis* or *Salmonella* spp.

DISCUSSION

A total of 179 Hanwoo neonatal calves within 30 days of age were sampled to investigate how electrolyte, BUN and glucose levels differed between normal and diarrheic animals. Of the 179 calves enrolled in this research, 79 calves were identified as having diarrhea at the time of the experiment, and the pathogens causing diarrhea were identified in their feces. As a result, electrolyte, BUN and glucose were found to be significantly different between normal and diarrheic calves.

Until now, blood analysis equipment has not been widely used in the field due to its weight and size. However, recently, by using a portable hematology analyzer such as i-STAT, rapid treatment has possible through immediate blood analysis of sick calves. This technology is expected to be useful in realistic clinical applications, like this study (Lee et al, 2015).

Hyponatremia in diarrheic calves depends on the initial cause and severity of disease (Constable et al, 2017). In this study, the mean values of Na^+ in diarrheic calves were generally lower (Table 2 and Fig. 1) As is true of other studies, it is believed that Na^+ loss was due to diarrhea (Ewaschuk et al, 2003; Lee et al, 2020).

In contrast, the mean values of K^+ in this study were generally higher in diarrheic calves (Table 2 and Fig. 1).

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Calves with diarrhea may be hyperkalemic, normokalemic, or hypokalemic despite systemic potassium depletion due to increased fecal loss (Constable et al, 2017; Lee et al, 2020). In addition, the mean value of Cl^- was generally higher in diarrheic calves in this study (Table 2 and Fig. 1). On the other hand, hypochloremia has been observed in diarrheic calves in other studies (Sayers et al, 2016; Constable et al, 2017). Elevated values of K^+ and Cl^- in diarrheic calves may be a temporary compensatory effect of Na^+ loss, but a larger population must be studied to compare these results with those of other studies.

In calves with diarrhea, BUN values were significantly higher at all ages ($P<0.001$) (Table 2 and Fig. 2). Many studies have also reported abnormally high values of BUN in diarrheic calves (Fayet and Overwater, 1978; Constable et al, 2017; Lee et al, 2020). In the case of diarrhea-induced dehydration, the amount of body fluid and blood decreases. When blood volume decreases, the amount of blood entering the kidneys and the amount of urea filtered by the kidneys decreases. Eventually, nitrogen accumulates in the body and BUN rises. The reference deviation of BUN is also very large. When the BUN value exceeds 80, the prognosis is often poor and intensive treatment is required. However, more research on prognosis is needed (Naylor, 1989; Groutides and Michell, 1990).

The mean values of glucose were constant at all ages in normal calves, but glucose levels in diarrheic calves were low at 1~20 days of age and became higher than those of the healthy calves at 21~30 days of age (Table 2 and Fig. 2). In the case of diarrheic calves, the reference deviation is very high depending on the calves' condition. Diarrheic calves have very low glucose levels due to a lack of energy and poor milk consumption. To obtain significant results related to glucose levels, studies considering more Hanwoo neonatal calves with diarrhea are needed.

In this study, reference values of biometric data such as electrolyte, BUN, and glucose levels of healthy and diarrheic Hanwoo neonatal calves were presented by age. The results of this study can be used to help identify, treat, and manage the condition of Hanwoo neonatal calves within 30 days of age.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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