NOTE *Internal Medicine*

Relationship between Depression Score and Acid-Base Status in Japanese Black Calves with Diarrhea

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ABSTRACT. We evaluated the relationship between depression score and acid-base status in 84 purebred and crossbred Japanese Black calves. The bicarbonate ($p<0.001$) and base excess concentrations ($p<0.001$) were significantly and negatively correlated with the depression scores of the calves. The proposed diagnostic cutoff point for a depression score that indicates severe metabolic acidosis (BE < –10 mM) is 6.5 based on analysis of the ROC curve. The sensitivity and specificity were 88.4% and 81.2%, respectively. The depression scoring system is a useful tool for evaluation of the acid-base status of purebred and crossbred Japanese Black calves. In addition, a depression score of 6.5 suggests severe metabolic acidosis and that intravenous infusion of sodium bicarbonate solution is necessary.

KEY WORDS: calf, depression score, Japanese Black calf.

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Calves are more sensitive to fluid loss than adult cattle because they have a higher total body water content and extracellular fluid volume than adults. Fecal fluid loss in profuse watery diarrhea can reach 13 to 18% of body weight per day [1]. Regardless of the causes of diarrhea in calves, a predictable set of physiological and metabolic events develops, including dehydration, hypovolemic shock, azotemia, and loss of bicarbonate and electrolytes from extracellular fluids [10]. When calves severely affected by diarrhea become dehydrated and develop metabolic acidosis, one objective of treatment is to correct these problems [13, 14, 17]. Oral rehydration fluids are administered on a daily basis to dehydrated calves in veterinary practice. If treatment with oral fluids is unsuccessful, intravenous restoration for the acid-base disorder is performed [6–8]. Although lactated Ringer's solution is used to replace the volume of total body water and to correct to electrolyte status in small animals and horses, it dose not usually correct the metabolic acidosis in calves with severe diarrhea [6, 11, 12, 15, 16]. Sodium bicarbonate is specifically effective for acute and severe metabolic acidosis because it has rapid effect when given intravenously [7, 9, 15, 16]. Nevertheless, rapid administration or an overdose of sodium bicarbonate solution has been associated with paradoxical cerebrospinal fulid acidosis, leftward shift of the oxyhemoglobin dissociation curve leading to decreased downloading of oxygen, intracellular shift of potassium in exchange for hydrogen ions causing hypokalemia, tetany due to decreased ionized calcium, and overshot alkalosis [2, 5]. Therefore, the acid-base equilibrium should be evaluated before administering sodium bicarbonate solution.

An automated blood gas analyzer is the preferred tool for determining the acid-base status of calves because pH, partial pressures of carbon dioxide (pCO_2), and the bicarbonate (HCO_3^-) concentration can be obtained with great precision and with a quantity of whole blood as small as 100 *µl* [10]. When blood gases cannot be determined, the total carbon dioxide (TCO_2) concentration, which is provided as part of a serum biochemistry profile, can be used as a substitute for the HCO_3^- concentration as an indicator of the presence of metabolic acidosis [10].

Subjective methods of quantifying the magnitude of acidosis in calves with diarrhea would appear to be clinically important from the standpoint that such a system would obviate the necessity of determining blood gases under field conditions. Kasari and Naylor [10, 11] and Garcia [4] have established subjective methods of estimating bicarbonate replacement requirements in calves using clinical scoring systems. However, it is not clear whether these scoring systems are suitable for Japanese black calves. Therefore, the primary purpose of this study was to evaluate the relationship between acid-base status and the depression score established by Kasari [8–12] in Japanese black calves. An additional objective was to confirm the depression score at which sodium bicarbonate administration is necessary for calves with severe metabolic acidosis.

All procedures were in accordance with the Guide for the Care and Use of Laboratory Animals of National Research Council (National Academy Press, 1996). A total of 84 calves with a mean age of 20.4 ± 8.0 days (from 8 to 30 days old) were used in the experiments; 42 of the calves were Japanese Black and 42 of the calves were the first filial generation of a Japanese Black male and Holstein female (F1). Fifty-six of the calves suffered from diarrhea and the other 28 were healthy.

Venous blood samples were collected anaerobically in 1 *µl*-heparinized syringe, and the tip of the syringe was capped immediately after blood sampling. Immediately

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after collection, the blood samples were analyzed for pH and pCO_2 using an automatic analyzer (i-STAT 200A or 300F, i-STAT Co., East Windsor, NJ, U.S.A.) at 37°C. The values of pH and pCO_2 were automatically corrected to correspond to the calf's rectal temperature. The TCO_2, HCO_3^-, and base excess (BE) were calculated from the values obtained by the automatic analyzer using accepted formulas [3].

A depression score based on dehydration (enophthalmos), neurologic (suckle reflex, ability to stand, menace reflex, tactile responses), and cardiovascular (warmth of extremities and oral cavity) signs was recorded according to Kasari's guidelines immediately before blood sampling [8–12]. Table 1 shows Kasari's numerical scoring system, which was used in this study to quantify the clinical signs of calves with metabolic acidosis [8–12]. The variable scores were summed to yield a minimum depression score of zero in healthy calves and a maximum possible depression score of 15 in severely affected calves [8–12].

Data are expressed as means ± standard deviation. The relationships of the depression scores with each biochemical parameter were evaluated by Spearman's rank test using a software package (StatView Japanese Edition, Ver. 5, Hulinks Japan, Tokyo, Japan). Receiver operating characteristic (ROC) analysis was used to characterize the sensitivity and specificity of the depression scores to BE concentration using a software package (Prism 4 for Macintosh, Ver. 4, GraphPad Software, Inc., San Diego, CA, U.S.A.). The significance level was $p<0.05$.

Figure 1 shows the relationships of the depression scores with pH, TCO_2, HCO_3^-, and the BE concentrations of the calves. The pH values of calves with severe metabolic acidosis were significantly and negatively correlated with their depression scores ($p<0.001$, $r^2=0.536$). The TCO_2 ($p<0.001$, $r^2=0.406$), HCO_3^- ($p<0.001$, $r^2=0.444$), and BE concentrations ($p<0.001$, $r^2=0.484$) of the calves were also significantly and negatively correlated with the depression scores in calves with metabolic acidosis.

In bovine practice, calves that have the ability to stand, a slightly cold mouth, and weak suckle reflex are considered to have a BE = –10 mM and severe acidosis [4]. In general, sodium bicarbonate should be used for treatment of severe acidemia (BE < –10 mM), and acetated or lactated Ringer's solution should be used to correct less severe metabolic acidosis [1]. The area under the ROC curve for a depression score identifying severe metabolic acidosis (BE < –10 mM) was 0.921 ($p<0.001$, Fig. 2). Taking the treadoff between sensitivity and specificity into consideration, we chose the cutoff for the depression score at 80% sensitivity in order to increase accuracy while maintaining specificity in the range of 80%. The proposed diagnostic cutoff point for a depression score that indicates severe metabolic acidosis (BE < –10 mM) was set to 6.5 based on analysis of the ROC curves (likelihood ratio: 4.86). The sensitivity and specificity of the proposed diagnostic cutoff for the depression score were 88.4% and 81.2%, respectively.

Subjective methods of quantifying the magnitude of acidosis in calves would appear to be clinically important from the standpoint that such a system would obviate the necessity of determining blood gases under conditions. Kasari and Naylor demonstrated a significant correlation between depression score and base deficit (negative BE) in twelve Charolais and Simmental calves [11, 12]. The results of this study in purebred and crossbred Japanese Black calves support the results of Kasari and Naylor [11, 12]. Therefore,

Table 1. Numerical scoring system to quantify clinical signs in calves with metabolic acidosis

Variable	Score	Interpretation
Enophthalmos	1	Slight separation of nictitating membrane from eyelids
	2	Marked separation of nictitating membrane from eyelids
Suckle reflex	0	Strong organized suckle
	1	Weak coordinated suckle
	2	Disorganized chewing
	3	Absent
Menace reflex	0	Strong instantaneous reflex
	1	Slow delayed reflex
	2	Absent
Tactile response	0	Skin twitch with head movement toward flank
	1	Skin twitch with no head movement toward flank
	2	No skin twitch and no head movement toward flank
Ability to stand	0	Ability to stand unassisted
	2	Inability to stand unassited
Warmth of oral cavity	0	Normal mucosa warmth
	1	Cool mucosa
	2	Cold mucosa
Warmth of extremities	0	Normal skin warmth
	1	Cool skin
	2	Cold skin

The variable scores are summed to yield a minimum score of 0 for healthy calves and a maximum possible score of 15 for severely affected calves. This scoring system was established by Kasari and is detailed elsewhere [10–12].

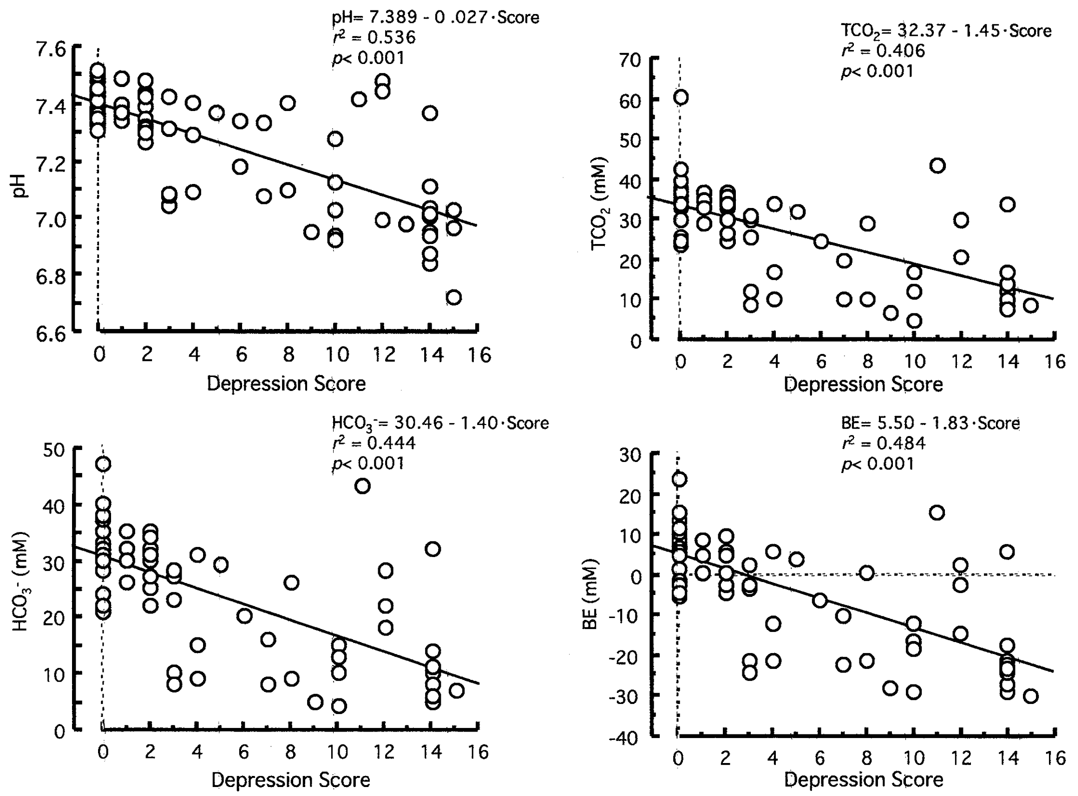

Fig. 1. Graphs depicting the relationships of depression score with venous pH, total carbon dioxide (TCO_2), bicarbonate (HCO_3^-), and base excess (BE) concentrations in 84 Japanese Black and crossbred calves with or without metabolic acidosis. The minimum and maximum depression scores were 0 and 15, respectively. Solid lines represent linear regression lines.

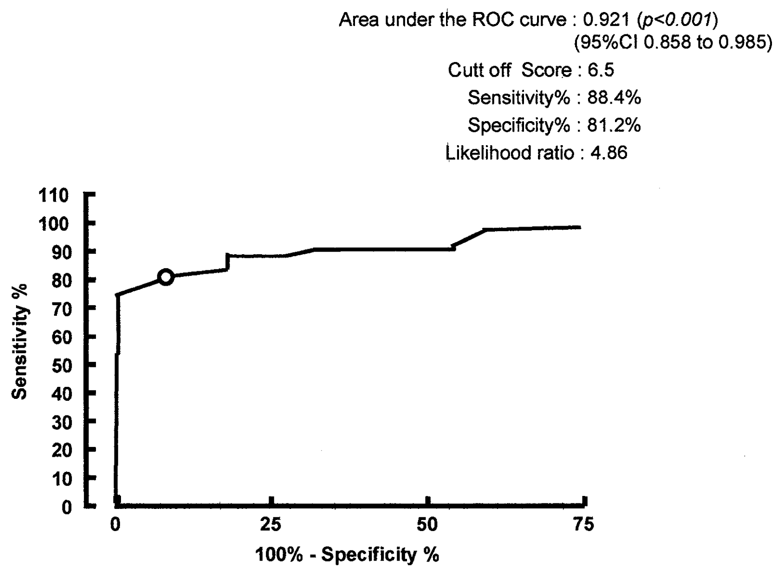

Fig. 2. Receiver operating characteristic (ROC) curves for depression scores in detecting severe metabolic acidosis (BE < –10 mM) in 84 Japanese Black and crossbred calves. The mean area under the ROC curve (AUC) is shown for each ROC curve. The open circle represents the cutoff point. True-positive fraction = sensitivity (%); false-positive fraction = 100 - specificity (%).

this study demonstrates that the depression scoring system is suitable for evaluating the acid-base status of purebred and crossbred Japanese Black calves.

In conclusion, the depression scoring system established by Kasari is a useful tool for evaluation of the acid-base status of not only Charolais and Simmental calves but also purebred and crossbred Japanese Black calves. In addition, a depression score of more than 6.5 suggests severe metabolic acidosis (BE < –10 mM) and that intravenous infusion with sodium bicarbonate solution is necessary.

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