

Effect of Intravenous Infusion of Isotonic Sodium Bicarbonate Solution on Acidemic Calves with Diarrhea

Kazuyuki SUZUKI¹, Toshihide KATO², Gensei TSUNODA³, Shigehiro IWABUCHI⁴, Kimi ASANO¹ and Ryuji ASANO¹

¹Department of Veterinary Medicine, College of Bioresource Sciences, Nihon University, 1866 Kameino, Fujisawa, Kanagawa 252-8510, ²Yamagata Prefectural Federation of Agricultural Mutual Aid Associations, 286-1 Aza Kitakawahara, Sichiura, Yamagata, Yamagata 990-2171, ³Fukushima Prefectural Federation of Agricultural Mutual Aid Associations, 2-15-7 Kuwano, Koriyama, Fukushima 963-8025 and ⁴Central Research Laboratories, Nippon Zenyaku Kogyo Co., Ltd, 1-1 Aza Tairanoue, Sasagawa, Koriyama, Fukushima 963-0196, Japan

(Received 2 April 2002/Accepted 13 September 2002)

ABSTRACT. The effect of 1.35% isotonic sodium bicarbonate solution (ISB) administered intravenously on acid-base equilibrium was examined in 18 acidemic Japanese black beef calves with spontaneous diarrhea. The infusion volumes of ISB were decided based on the first half volumes of base needed. In 72.2% (13/18) of calves, improvement of acidemia was detected. There was good correlation ($r=0.693$, $p<0.01$) between infused volume of ISB and changes in base excess ($y=1.097x + 4.762$). Infusion volumes of ISB were 7.5, 10.2, 12.9 and 15.7 ml/kg, respectively, enough to correcting the first half of 5, 10, 15 and 20 mEq/l of base deficit in acidemic calves. Our finding suggested that ISB could be used to correct metabolic acidosis without altering electrolyte concentrations in calves.

KEY WORDS: acid-base equilibrium, calf, sodium bicarbonate.

J. Vet. Med. Sci. 64(12): 1173-1175, 2002

In calves, metabolic acidosis occurs in diarrhea according to its severity and duration [10, 17]. The acidosis is partially related to gastrointestinal loss of bicarbonate and also to decreased renal excretion of hydrogen ion [17]. Sodium bicarbonate is specifically effective in cases of acute and severe metabolic acidosis, and it has a rapid effect when given intravenously (IV) [4-8, 11]. Sodium bicarbonate solution, the alkalinizing agent of choice, is most often used as a 7.0% hypertonic solution that is commercially available in Japan. The positive inotropic effect is rapid, usually within 2 to 5 min of infusion of a hypertonic solution, such as 7.2% hypertonic saline and 7.0% hypertonic sodium bicarbonate solutions [2, 15]. These responses are produced by increased osmolarity of 30 to 150 mOsmol/l [14]. However, an abrupt change in osmolarity can lead to cerebral hemorrhage due to alterations in electrolytes, water and acid-base status [4].

A previous study [16] indicated that isotonic sodium bicarbonate solution (ISB, 1.35% NaHCO₃) could restore the acid-base equilibrium without altering plasma osmolarity, hemodynamic status and respiratory function in normal Holstein calves. Therefore, ISB in this study we used to restore spontaneous metabolic acidosis in calves, in order to confirm its safety and alkalinizing effects. In addition, we also evaluated the relationship between correcting base deficit and apparent volume of ISB in acidemic calves with spontaneous diarrhea.

Experiments were performed on 18 diarrheic 16.8 ± 12.1-day-old Japanese Black beef calves weighing 32.8 ± 4.3 kg. In these calves, metabolic acidosis accompanied with diarrhea was detected on the basis of physical examination and blood gas analysis by using an automatic analyzer (i-STAT 200, i-STAT Co., East Windsor, NJ, U.S.A.). Approxi-

mately 15 min before ISB infusion, a 16-gauge catheter (Sefelet Catheter NSL-16WOT, Nipro, Osaka, Japan) was implanted percutaneously into the right jugular vein for infusion of ISB. The administration volumes of ISB were decided based on the first half volumes of base needed that were calculated based on formulae for extracellular base excess (BE) from blood gas analysis. The amounts required were calculated according to the following formula [5, 7, 9, 10, 12, 16]:

Base needed (mEq) = Body weight (kg) × Base deficit (mEq/l) × Coefficient of distribution (l/kg)

The coefficient of distribution represents the volume of bicarbonate in extracellular space. However, clinicians in veterinary practice use various coefficients of bicarbonate distribution when calculating bicarbonate requirements (for example, 0.3 [12], 1/3 [9], 0.5 [1, 8], or 0.6 [5, 18]). A previous study [16] indicated that the apparent coefficient of distribution of bicarbonate was 0.401 in normal Holstein calves. In this study, therefore, 0.4 was used as the coefficient of distribution. The administration volumes of ISB were decided based on the first half volumes of base needed, over a period of about 30 min [4].

Venous blood samples were anaerobically collected in a heparinized 1-ml syringe from the left jugular vein immediately before, after, and at 24 hr after the ISB infusion. The blood samples were analyzed for pH, blood gases, hematocrit value, and concentrations of BE, hemoglobin and electrolytes by an automatic analyzer (i-STAT 200A) at 37°C, within 5 min of collection. The measured values of pH and blood gases were automatically corrected to correspond to each calf's rectal temperature. Changes in relative plasma volume (rPV) were calculated from hemoglobin concentration and hematocrit value, using accepted formulas [3, 13].

Relative changes in base excess (Δ BE) were derived from the following equation:

Δ BE = BE_{after} - BE_{before}, where BE_{before} and BE_{after} are the BE concentrations immediately before and after administration, respectively [16].

Calves were assessed by the supervising veterinarian at 24 hr after the ISB infusion. Clinical signs were rated as follows: worsened, unchanged, slightly improved, moderate improvement or largely improved/disappeared, as compared to the assessment before the ISB infusion.

Data are shown as means \pm SD. Data were analyzed, using repeated-measures analysis of variances (ANOVA). The variables included in the model were time, ISB infusion, and interaction of time and fluid infusion. The BE at the end of the ISB infusions and infused volume of sodium bicarbonate were evaluated by linear regression analysis. The significance level was $p < 0.05$.

Telltale signs of excessive rate and volume of fluid infusion, such as moist rales on auscultation, moist cough, jugular vein congestion, ophthalmoptosis and salivation [9], were not observed throughout the ISB infusion. The presenting clinical sign was largely improved in 6 calves, 6 demonstrated slight to moderate improvement and the clinical sign was unchanged in 6 calves. Changes of rPV followed a pattern similar to that of a previous study [16]. The before infusion values of sodium and potassium concentration were 133.5 ± 6.4 and 4.73 ± 0.84 mEq/l, respectively. These electrolyte concentrations did not change during the ISB infusion and were unchanged at 24 hr after the ISB infusion. The infusion of ISB significantly increased the pH level from 7.265 ± 0.063 pre-infusion to 7.333 ± 0.038 after the ISB infusion ($p < 0.01$). The pre-injection values of BE concentrations were -7.7 ± 5.2 mEq/l. The infusion of ISB significantly increased the BE concentration, which reached -2.3 ± 4.1 mEq/l after the ISB infusion ($p < 0.01$). In 72.2% (13/18) of calves, improvement of acidemia was considered to be successful as determined by the correction of the first half of the base deficit. The rPV increased markedly after ISB infusion, reaching $117.8 \pm 11.7\%$. The rPV in calves with improvement of metabolic acidosis ($n=13$) increased markedly after the ISB infusion, reaching $121.8 \pm 12.0\%$, and then remained up to 10% higher than the pre-infusion levels for 24 hr after the ISB infusion. In contrast, the rPV in calves without improvement of acidosis was significantly decreased at 24 hr after the ISB infusion, reaching $89.5 \pm 8.4\%$ (Fig. 1). There was a good correlation between the infused volume of bicarbonate and Δ BE ($y=0.367x - 0.255$), with a correlation coefficient of 0.693 ($p < 0.01$). The coefficient of distribution for the base was 0.367. Figure 2 shows the relationship between the infused volume of ISB (m/kg) and Δ BE (mEq/l) in acidemic calves with naturally occurring diarrhea. There was a good correlation between infused volumes of ISB and Δ BE ($y=1.097x + 4.762$), with correlation coefficient of 0.693 ($p < 0.01$). In treating metabolic acidosis, the veterinarian must determine the dose and rate of administration of sodium bicarbonate. It is recommended that the first half of the base needed should be corrected in

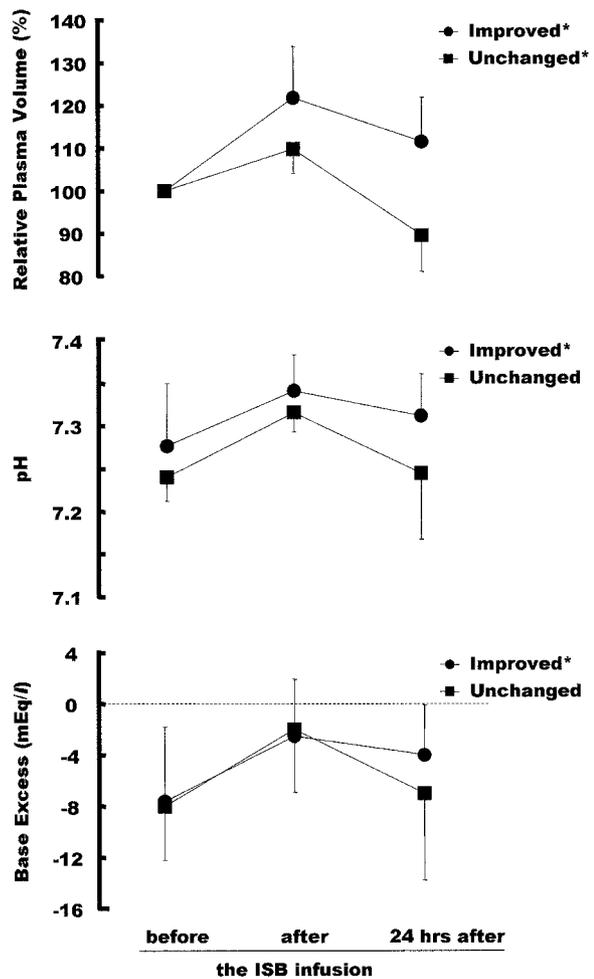


Fig. 1. Graphs depicting the relative plasma volume (rPV), pH and base excess (BE) in spontaneous acidemic calves administered 1.35% NaHCO₃ (ISB). Asterisks indicate $p < 0.05$ by ANOVA.

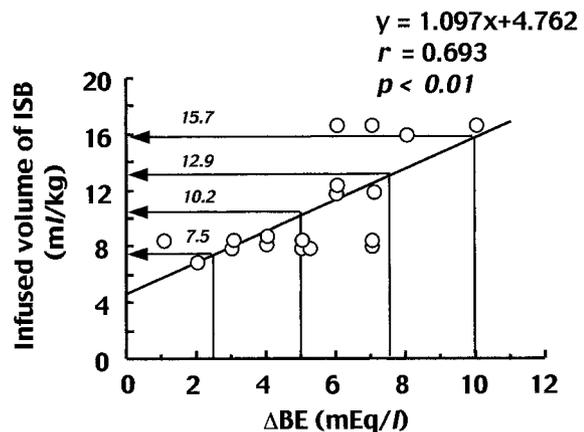


Fig. 2. Relationship between infused volume of 1.35% NaHCO₃ (ISB) and relative changes of base excess (Δ BE) in 18 acidemic calves. Solid line represents the linear regression line ($r=0.693$, $p < 0.01$).

30 min [4].

When clinical application of ISB was carried out based on previous study [16], improvements of spontaneous metabolic acidosis were observed in 72.2% of calves. Infusion volumes of ISB were 7.5, 10.2, 12.9 and 15.7 ml/kg, enough to respectively correct the first half of 5, 10, 15 and 20 mEq/l of base deficit in acidemic calves. It is demonstrated that ISB could be used to correct metabolic acidosis without altering the electrolyte concentrations in calves. Therefore, IV infusion of ISB should be used as a treatment for spontaneous metabolic acidosis associated with diarrhea in calves.

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