原　著

Short Communication

Relationship between Fluid Volume and Expanding Plasma Volume in Mature Cows with Naturally Occurred Dehydration

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ABSTRUCT

The objectives of this study were to determine the correlation between intravenous fluid volume of hypotonic fluid and relative plasma volume (rPV) in 61 dehydrated lactating Holstein cows weighing 590.9±60.4 kg. There were significant and good positive correlations between the infused volume of hypotonic fluid and rPV at 24 hrs after fluid administration by polynomial regression analysis ($p<0.001$). The calculated infusion volumes of hypotonic fluid were 11.8 and 26.4 mL/kg. The infusion volume of 11.8 mL/kg is enough to remaining to pre value. And the infusion volume of 26.4 mL/kg is plasma volume up to 10% higher than the pre value in dehydrated cows at 24 hrs after fluid administration based on results of polynomial regression analyses.

[Key Words] cow, expanding plasma volume, fluid volume

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Fluid and electrolyte replacement therapy in cow is an essential therapeutic tool that should be used by every bovine practitioner [4]. Though oral or intraruminal administration is inexpensive and very effective, many mature cows with an obstructive gastrointestinal disease and those with severe dehydration are rehydrated by intravenous administration [8]. However, several factors such as restriction for long-term intravenous administration limit the frequency and effectiveness of fluid therapy in mature cows. The cost of commercial fluids for intravenous rehydration therapy for mature cow is also often too great to be economically feasible in bovine practice[1].

Nearly all of the review articles on the subject of fluid therapy contain a table for estimating dehydration status based on clinical signs, which are based largely on a theory and experience. The theory implies the assumption that by replacing the amount of lost water with appropriate solutions one can return the animal to its original body weight and normal hydration status [8]. No all tables can accurately predict the amount of body water an animal has lost or the amount required for returning to normal hydration. In the example, mature cow suffering from carbohydrate engorgement or vagal indigestion may actually gain significant body weight and yet become

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clinically dehydrated because the rumen fills with fluids [8]. Those conditions can lead to the use of inadequate volumes, especially with mature cow.

Lactated Ringer's solution, such as Hartmann's solution, is by far the most versatile of the fluids generally used in small animal practice [1-3]. Person et al. [7] suggested that hypotonic saline solution with 2.5% dextrose appeared to be the most appropriate solution when moderate dehydration of children had to be corrected in a short time. Another studies showed that hypotonic Ringer's solution with 2.5% dextrose did not change the plasma osmotic pressure or serum electrolyte balances in cow and induced a proper reabsorption rate of glucose in the renal system [9-11]. Those results suggest that hypotonic solution is a better choice for rehydration therapy for mildly dehydrated cow [5,10].

The objectives of this study were to determine the correlation between intravenous fluid volume of hypotonic fluid and changes in plasma volume and to determine the smallest volume of intravenously administration that was necessary for improvement is extracellular volume in mature cow with naturally occurring dehydration.

All procedures were in accordance with the National Research Council Guidelines for the Care and Use of Laboratory Animals (National Academy Press, 1996). Experiments were performed on 61 dehydrated lactating Holstein cows weighing 590.9±60.4 kg. In those cows, dehydration accompanied with puerperal fever (17), intestinal emphysema (10), ruminal impaction (9), ketosis (6), mastitis (4), pneumonia (4) or other diseases (11) was detected on the basis of physical examination. Veterinary practitioners determined the fluid volume and infusion rate by examining the dehydration status of the cows. Approximately 15 min before fluid infusion, a 14-gauge catheter (IV catheter for animals; Nippon Zenyaku Kogyo Co., Ltd., Fukushima) was inserted percutaneously into the right jugular vein for infusion of fluids. The commercial fluids used in this study were as follows; 1/2 lactated Ringer's+2.2% glucose (Toucho-haruzen V injection, Nippon Zenyaku Kogyo) and 1/2 Ringer's + 2.5% glucose (Toucho-Ringer's, Nippon Zenyaku Kogyo).

Venous blood samples were anaerobically collected in a heparinized 1-ml syringe from the left jugular vein immediately before (pre), immediately after (post), and at 24 hrs after the intravenously fluid infusion. The blood samples were analyzed for pH, hematocrit value (Ht), concentrations of hemoglobin (Hb) and ionized calcium (iCa) by an automatic analyzer (i-STAT 200A, i-STAT Co., East Windsor, NJ, USA). Some venous samples were centrifuged, and plasma was collected and stored at -20° C until assay. The concentrations of ionized sodium (Na^+), potassium (K^+) and chloride (Cl^-) in plasma were measured by the electrode methods, with an automatic analyzer (model 644; Bayer Medical, Tokyo). The plasma osmotic pressure was determined by the freezing point depression method using an osmometer (One-Ten Osmometer; Fiske Associates, Massachusetts, USA). Immediately before blood sampling, the heart rate, respiratory rate and rectal temperature of each animal were recorded.

Relative changes in plasma volume (rPV) were calculated from Hb and Ht, using the following accepted formula [5,9-11].

$$rPV=\frac{Hb_{pre}}{Hb_{samp}}\times\frac{(100-Ht_{samp})}{(100-Ht_{pre})}\times100$$

Where Hb_{pre} and Ht_{pre} were Hb and Ht at pre and, Hb_{samp} and Ht_{samp} were Hb and Ht, respectively, at each sampling point.

Data are shown as the mean ± standard deviation. The mean values for each sampling point were compared with the mean value at pre, using the Bonferroni test as post-hoc test after analysis of variance by one-way ANOVA. The variables at post or 24 hrs after fluid infusions and infused volume of fluid

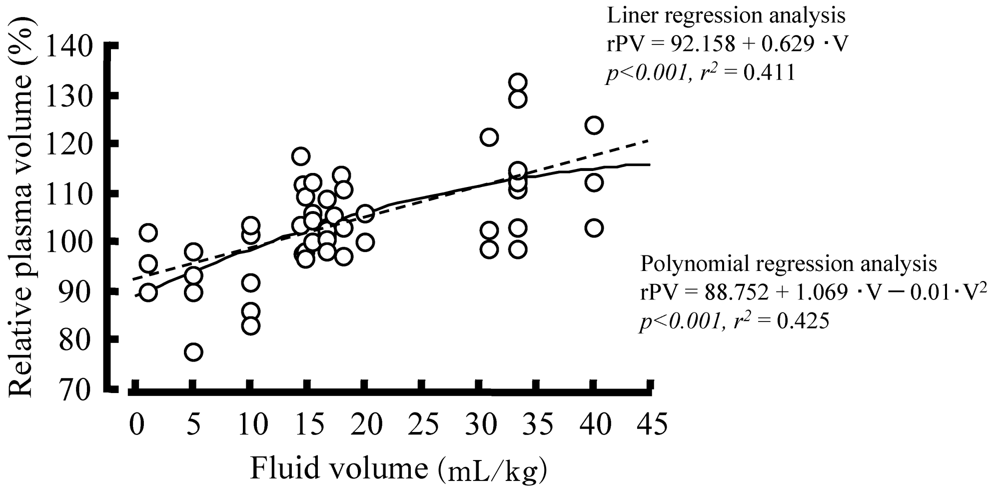

Fig. 1 Relationship between infused volume (V) of hypotonic fluid and relative changes in plasma volume (rPV) at 24 hrs after the fluid administration in dehydrated cows.
Dotted and solid lines represent the liner and polynomial regression lines, respectively. There were significant positive correlations between V and rPV by liner ($p<0.001$, $r^2=0.411$) and polynomial regression analysis ($p<0.001$, $r^2=0.425$).

were evaluated by liner and polynomial regression analyses. Those statistically analyses were performed using a software package (stat View Japanese Edition, Ver. 5, Hulinks Japan, Tokyo, Japan). The significance level was $p<0.05$.

The average fluid volume in this study was 19.6 ± 10.8 mL/kg. It ranged from 1 to 40 mL/kg. In 68.9% (42/61) of cows, the improvement in dehydration was considered to be successful as estimated by veterinary practitioner. In 19 cows, whose hydration status was not improved at 24 hrs after fluid infusion, a lower dose of fluid (≤ 10 mL/kg) was given to 11 of them (57.8%). This value was 78.6% (11/14) for the cows received a lower doses of fluid (≤ 10 mL/kg). In the 8 remaining cows, diagnostic categories by veterinary practitioner were as follows: intestinal emphysema (3), mastitis (2), puerperal fever (1), pneumonia (1) and Caesarean section (1). We have observed no relationship between improvement of hydration status and diagnostic categories.

Telltale signs including the development of moist rale on auscultation and the presence of a moist cough or a serious nasal discharge indicated that the infusion rate or volume given was excessive [6]. Venous congestion, especially of the jugular vein, and a sustained rise in central venous pressure to 4.4 mmHg should also be taken as signs that the infusion rate or the volume given was excessive [2,6]. In this study, no clinical signs, such as moist rale on auscultation, moist cough, jugular vein congestion, ophthalmoptosis, salivation or arrhythmia, were observed throughout fluid infusion. The IV infusion of approximately 40 mL/kg of hypotonic fluid, such as maximum infused volume in this study, did not induce any abnormal clinical signs caused by plasma expansion in the dehydrated cows.

There were no significant differences in the heart rate, respiratory rate, rectal temperature, concentrations of Na, K, iCa, and osmolarity, and pH among each sampling period (Table 1). Despite significantly positive correlations between the infused volume of hypotonic fluid and rPV at immediately after fluid infusion, estimated by liner ($y=0.344V + 108.175$, $p<0.01$, $r^2=0.120$) and polynomial regression analyses ($y=0.004V^2 + 0.173V + 109.487$, $p<0.05$, $r^2=0.122$), were detected, it is inappropriate to discuss the correlations in this article because multiple correlation coefficients were small. Figure 1 shows the rela-

Table 1 Relative plasma volume and plasma electrolyte variables before and after the fluid therapy in the cows (mean ± standard deviation)

Parameters		pre	post	24 hrs
rPV	%	100	116.3±14.7	105.1±17.9
pH		7.407±0.041	7.394±0.041	7.406±0.037
Na^+	mM	140.8±3.4	139.0±3.9	140.8±2.9
K^+	mM	3.77±0.41	3.55±0.6	3.83±0.40
Ca^{++}	mM	1.245±0.137	1.259±0.223	1.259±0.085
Cl^-	mM	101.7±4.6	100.4±4.5	103.3±4.3
Osmolarity	mOsmol/L	287.1±9.4	286.5±11.0	286.7±7.3

tionship between the infused volume of hypotonic fluid (mL/kg) and rPV (%) at 24 hrs after fluid infusion in dehydrated cows. There were significant and good positive correlations between the infused volume of hypotonic fluid and rPV at 24 hrs after fluid administration by liner ($y = 0.629V + 92.158$, $p<0.001$, $r^2 = 0.411$) and polynomial regression analyses ($y = -0.010V^2 + 1.069V + 88.752$, $p<0.001$, $r^2 = 0.425$), respectively. The calculated infusion volumes of hypotonic fluid were 11.8 and 26.4 mL/kg. The infusion volume of 11.8 mL/kg is enough to remaining to pre value. And the infusion volume of 26.4 mL/kg is plasma volume up to 10% higher than the pre value in dehydrated cows at 24 hrs after fluid administration based on results of polynomial regression analyses.

When clinical application of fluid therapy to rehydrate cows with naturally occurring dehydration was carried out based on previous studies [5,10], improvements were observed in 68.9% of cows. Our results suggest that hypotonic fluids are choice for rehydration therapy for dehydrated cows without any adverse reaction, and it might be administrated at a volume of up to 11.8 mL/kg BW.

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原　著

脱水成牛における低張性輸液剤投与量と循環血漿量との関係

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要　約

61頭のホルスタイン種乳牛を用いて低張電解質輸液剤の投与量と相対循環血漿量との関係を多項回帰分析により評価した。その結果、輸液剤投与開始後24時間目の相対循環血漿量は、低張電解質輸液剤の投与量に対して有意に正の相関性を示した（*p*<*0.001*）。この回帰式より、輸液療法翌日において、輸液前の循環血液量を維持または10%増加させるためには、それぞれ11.8 および26.4 mL/kg以上の低張電解質輸液剤を少なくとも輸液するべきである。