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Effects of subcutaneous calcium administration at calving on mineral status, health, and production of Holstein cows

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ABSTRACT

The objective of this study was to determine effects of subcutaneous (s.c.) infusions of Ca at calving day on serum concentrations of Ca, P, Mg, β-hydroxybutyrate (BHB), glucose, body condition score (BCS), milk yield, and health in fresh cows receiving a dietary cation-anion difference diet during the dry period. Three hundred seventy-five fresh Holstein cows were blocked based on parity (143 cows in first parity, 108 cows in second parity, and 124 cows in third or greater parity) and randomly assigned to 1 of 4 experimental treatments immediately after calving. Treatments were control group without infusion (control; n = 190); 1 s.c. infusion of 250 mL of 40% Ca borogluconate ($1SC_{250}$; n = 72) at calving; 1 s.c. infusion of 500 mL of 40% Ca borogluconate ($1SC_{500;}$ n = 63) at calving; 2 s.c. infusions of 250 mL of 40% Ca borogluconate, one immediately after calving and the second 12 to 18 h after first infusion ($2SC_{250;}$ n = 50). Blood samples were collected immediately after parturition and at 1, 2, 4, and 7 d in milk (DIM) for Ca, P, and Mg determination. Milk production, milk composition, and somatic cell count were recorded monthly up to 90 DIM. The evaluation of BCS was performed at calving and at 38 DIM. A subset of 9 cows per treatment group was randomly chosen to measure serum concentration of glucose and BHB at 2, 4, and 7 DIM. Total serum Ca in $1SC_{250}$ (8.95 mg/dL), $1SC_{500}$ (9.27 mg/dL), and $2SC_{250}$ (9.07 mg/dL) was greater during the first week postpartum compared with control (8.45 mg/dL). Serum concentrations of P, Mg, BHB, glucose, and milk yield were not affected by treatments. The dry matter intake during the first 24 h after calving was higher for treatments $1SC_{250}$ (13.5 kg), $1SC_{500}$ (15.0 kg), and $2SC_{250}$ (15.6 kg) relative to control (12.5 kg). Milk somatic cell counts were lower for $1SC_{500}$ (90.5 cells/mL) and $2SC_{250}$ (82.2 cells/mL) than control (132.8 cells/mL). Risk ratio was >1 for development of metritis, and clinical and subclinical endometritis in control cows relative to $2SC_{250}$ cows, which indicates a higher risk of developing disease for control cows (2.03, 1.7, and 1.8 times, respectively). These results suggest that prophylactic s.c. infusions of Ca at calving can improve postpartum Ca status in Holstein cows and intake at 1 DIM. Given the reduction of metritis, clinical and subclinical endometritis, and subclinical hypocalcemia with treatment, the effect of s.c. Ca supplementation on immune status warrants further investigation.

Key words: calcium status, subcutaneous infusion, uterine disease, fresh cow

INTRODUCTION

Hypocalcemia is a peripartum metabolic disorder observed when cows are unable to maintain normal blood Ca concentrations at the time of calving (Goff and Horst, 1997). The prevalence of clinical hypocalcemia has been reported to be 5% (McLaren et al., 2006), whereas in multiparous cows subclinical hypocalcemia (**SCH**) can be as high as 54% (Reinhardt et al., 2011). Calcium not only plays an essential role on skeletal and smooth muscle contractions but also in immune function of dairy cows (Kimura et al., 2006). Several studies found clinical hypocalcemia associated with multiple postpartum disorders such as dystocia, uterine prolapse, retained fetal membranes (**RFM**), endometritis, poor fertility, mastitis, and reduced rumen and abomasum motility (Curtis et al., 1983; Borsberry and Dobson, 1989; Goff, 2004). Although clinical hypocalcemia is clearly a critical disorder for fresh cows, SCH has been shown to have an important detrimental effect on postpartum health. Cows with SCH are at greater risk for metritis and displaced abomasum culling and show an impaired hepatic lipid metabolism (Chapinal et al., 2011; Martínez et al., 2012; Roberts et al., 2012; Chamberlin et al., 2013).

Unfortunately no cow-side tests are available for immediate diagnosis of hypocalcemia on farm. Thus, to prevent SCH some herds could benefit from implementing prophylactic strategies such as anionic salt programs. Although this strategy has decreased the

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incidence of SCH in some studies (Oetzel et al., 1988; Moore et al., 2000), it was unsuccessful in Ramos-Nieves et al. (2009). Alternative prophylactic approaches are Ca supplementation following calving by the oral, intravenous (**i.v.**), or subcutaneous (**s.c.**) route (Melendez et al., 2002; Sampson et al., 2009; Oetzel and Miller, 2012; Mohebbi-Fani and Azadnia, 2012; Blanc et al., 2014). When cows on an anionic program were supplemented with oral or i.v. Ca, no effects were found with regard to plasma concentration of macrominerals (Ca, P, Mg) or metabolites (NEFA, BHB, and glucose) at 2, 3, 6, 9, and 12 DIM (Melendez et al., 2002). However, Oetzel and Miller (2012) reported that lame cows and high-producing multiparous cows responded positively to oral Ca supplementation. Based on a recent kinetic study (Blanc et al., 2014), the prophylactic treatment of hypocalcemia with i.v. Ca resulted in an initial hypercalcemia, peaking 1 h after treatment initiation, followed by hypocalcemic levels that reached nadir 24 h after treatment (Blanc et al., 2014). Thus, i.v. Ca administration may not be the best route for administration.

In cases of clinical hypocalcemia, s.c. Ca is being used after i.v. Ca treatment to prolong Ca absorption (Oetzel, 1988; Goff, 1999; Brozos et al., 2011), but its application as a prophylactic strategy has received minimal attention. Literature on s.c. Ca infusion for cows as a prophylactic strategy to prevent SCH is scarce (Mohebbi-Fani and Azadnia, 2012; Miltenburg et al., 2016). We hypothesize that s.c. Ca could be used as a prophylactic strategy to reduce hypocalcemia on dairies. Our objective was to study various s.c. Ca supplementation regimens at calving to evaluate implications on macromineral status and blood metabolites, as well as production and animal health of Holstein cows receiving a DCAD dietary cation-anion difference diet during the dry period.

MATERIALS AND METHODS

Cow and Herd Management

The study was conducted on an Iranian commercial dairy farm housing 3,000 Holstein dairy cows, with an average daily milk production of 34 kg/d. A total of 375 Holstein cows in their first (n = 143), second (n = 108), and third or greater (n = 124) lactation were enrolled in the study. The experiment was conducted from April 2013 to August 2013. During the close-up period, 18 ± 3 d before expected calving date, cows were housed in a dry-lot facility and fed once a day a prepartum diet formulated to have a negative calculated DCAD (−130 mEq/kg; Table 1) through limiting the supply of Na and K and increasing the amount of supplemental Cl.

After showing primary signs of calving, farm personnel moved cows to individual calving pens where they stayed up to 24 h after calving for DMI measurements. Farm personnel were present at the maternity pen 24 h/d in 8 h shifts. Once cows calved, they were offered 31 kg of feed on as-fed basis. Feed was pushed every 8 h at the beginning of each maternity personnel shift. Refusals were weighed back 24 h after feeding. Twenty-four hours after calving, cows were moved to a free-stall barn and fed a TMR diet ad libitum 3 times a

Table 1. Ingredient and nutrient profile of close-up and fresh cow diets (DM basis)

Item	Diet	
	Close-up	Fresh
Ingredient (% of DMI)		
Legume hay, mature	16.96	24.13
Corn silage, normal	36.93	18.41
Wheat straw	—	1.54
Barley grain, ground, dry	18.44	4.89
Corn grain, ground, dry	8.48	18.92
Cottonseed, whole seed with lint	4.11	7.47
Canola meal	2.74	2.45
Soybean meal, solvent, 44% CP	4.07	10.51
Meat meal	—	2.03
Soybean seeds, whole heated	0.90	4.83
Calcium soap of fatty acids	0.48	0.90
Wheat, bran	1.62	—
Salt	—	0.17
Sodium bicarbonate	—	0.89
Mg oxide	—	0.22
Calcium carbonate	1.53	0.72
Calcium phosphate (Di-)	—	0.17
Vitamin premix	2.03[1]	1.0[2]
Bentonite	—	0.10
Toxin binder	—	0.10
Ammonium chloride	0.85	—
Mg sulfate	0.85	—
Chemical composition		
NE_L[3] (Mcal/kg)	1.6	1.72
CP (%)	13.3	18.7
RDP (%)	10.0	13.1
RUP (%)	3.30	5.6
NDF (%)	34.2	31.7
Forage NDF (%)	25.3	21.1
ADF (%)	21.7	21.8
NFC (%)	42.2	38.7
Ether extract (%)	3.9	5.7
Ca (%)	1.27	1.10
P (%)	0.35	0.50
Mg (%)	0.20	0.35
Na (%)	0.02	0.34
K (%)	1.20	1.40
Cl (%)	0.81	0.33
S (%)	0.35	0.22
DCAD[4] (mEq/kg)	−130	276

[1]8,000 IU of vitamin A/kg, 2,500 IU of vitamin D_3/kg, and 100 IU of vitamin E.

[2]1,800,000 IU of vitamin A/kg, 400,000 IU of vitamin D_3/kg, 8,000 IU of vitamin E, and 3,000 mg of antioxidant.

[3]Estimated from NRC (2001).

[4]DCAD calculations were performed according to the following equation (NRC, 2001): DCAD (mEq/kg) = (Na + K) − (Cl + S).