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Concentrations of GH, IGF-I, Insulin, and Glucose in Postnatal Beef Calves

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Story in Brief

Seventeen Hereford and Hereford x Angus cows were utilized to determine plasma concentrations of growth hormone (GH), insulin-like growth factor I (IGF-I), insulin, and glucose in calves after birth. Body condition (BCS; 1=emaciated, 9=obese) of cows was determined 30 d before calving as an indicator of prenatal nutrition of calves. Cows were defined to be in moderate (BCS=5; n=6) or good (BCS³ 5.5; n=11) condition. Cows were observed for calving three times daily. Jugular blood samples were collected from calves on d 1 (within 24 h after birth), 2, 3, 4, 6, 8, and 14 after birth. On d 2 after calving, blood samples were collected from cows. Growth hormone, IGF-I, insulin, glucose, non-esterified fatty acids (NEFA), and total plasma proteins were quantified in each blood sample. Hematocrits were evaluated on d 1, 2, and 14 for calves and d 2 for cows. Bulls weighed more at birth than heifers. Hematocrits for calves were similar on d 1 and 14, but hematocrits of calves on d 2 were greater than for cows. Concentrations of IGF-I, insulin, and plasma proteins were similar for calves and cows on d 2 after birth. Calves had greater concentrations of GH and glucose in plasma on d 2 compared with cows. Cows had greater NEFA concentrations than calves on d 2. Concentrations of NEFA in calves decreased while concentrations of glucose and plasma proteins increased from d 1 to d 2. Concentrations of GH in calves decreased from d 2 through d 14, but IGF-I increased. Plasma concentrations of GH, IGF-I, NEFA, glucose, and protein in calves change rapidly after birth. Consumption of milk soon after birth increases glucose and protein in blood plasma and may enhance survival.

(Key Words: GH, IGF-I, Insulin, Glucose, Neonate Calves.)

Introduction

Calves experience dynamic changes after birth. Growth hormone concentrations in the plasma of Holstein fetuses were 10 times greater than in their dams (Oxender et al., 1972a; 1972b), and GH concentrations of Holstein bull calves were greatest at birth and decreased by 1 mo of age (Purchas et al., 1970). Plasma IGF-I increased with age in beef calves (Kerr et al., 1991), and concentrations of glucose and insulin in plasma were increased within 60 min after birth (Garry et al., 1996). Relationships between hormones controlling growth and energy utilization with plasma glucose and NEFA during the first 2 wk of life in beef calves have not been characterized. The objectives of this experiment were to determine plasma concentrations of GH, IGF-I, insulin, and glucose in beef calves after birth, and to compare plasma hormones in calves with cows on d 2 following birth. The effects of prenatal nutrition on endocrine function of beef calves were evaluated.

Materials and Methods

Spring calving Hereford and Hereford x Angus cows (n = 17) were utilized to determine endocrine function and energy metabolites in calves following birth. Before calving, cows grazed native range at the Range Cow Research Center. During the winter, cows were managed in two groups to develop differing body condition scores (BCS; 1 = emaciated, 9 = obese; Wagner et al., 1988) at calving. One group was fed .7 kg/d/cow of a 38% crude protein supplement, and a second group was supplemented with 1.4 kg/d/cow. As an indicator of prenatal nutrition of calves, BCS of cows was determined 4 wk prior to calving and cows were defined to be in moderate (BCS = 5; n = 6) or good (BCS ³ 5.5; n = 11) condition. Cows were observed for parturition three times daily.

Jugular blood samples were collected from calves within 0 to 24 h on the day of birth (d 1), and on 2, 3, 4, 6, 8, and 14 d of age. At the first blood sampling, calves were classified into three groups: 1) calves that had not nursed, 2) calves that had possibly nursed, and 3) calves that had

definitely nursed. On d 2 after calving, a blood sample was also collected from cows. Blood samples were collected in tubes containing EDTA, cooled to 4° C. Plasma was obtained by centrifugation and stored at –20° C until analyzed for concentrations of red blood cells, total plasma protein, GH, IGF-I, insulin, glucose, and NEFA.

Hematocrits were determined for calves on d 1, 2, and 14, and for cows on d 2 after calving by centrifugation in microhematocrit tubes. Total plasma protein was evaluated with a refractometer. Plasma concentrations of GH, IGF-I, and insulin were determined by radioimmunoassay. Glucose and NEFA were quantified by a colorimetric procedure.

Blood constituents of calves and cows were compared using students t-test. The relationship of birth weight and blood constituents in calves on all sampling days were determined with partial correlations adjusted for age. Split-plot analysis of variance was used to determine the influence of precalving BCS on plasma constituents of calves. Precalving BCS was the main plot, and day of sample was the subplot. Means were compared by protected least significant differences.

Results and Discussion

Bull calves were heavier at birth than heifers (40 ± 1 vs 37 ± 1 kg; $P<.05$), which is consistent with previously published data (Neville, 1962, Cundiff et al., 1966).

Prenatal nutrition of calves as indicated by precalving BCS of cows did not alter plasma concentrations of GH, IGF-I, or NEFA in calves, however plasma concentrations of proteins, insulin, and glucose were altered. Calves with dams in moderate condition had greater total plasma protein (7.4 vs 6.7 g%, respectively; $P<.05$) and glucose (106 vs 95 mg%, respectively; $P<.08$) concentrations than calves with dams in good condition. There was an interaction between precalving BCS of cows and plasma insulin concentrations of calves ($P<.05$). Calves with moderate condition dams had greater insulin from 2 to 8 d of age compared with calves with dams in good condition. Rasby et al. (1990) found that the placenta of thin cows weighed more than the placenta from moderate cows, possibly allowing more nutrients to pass to the offspring. Also, body condition of cows at calving can influence the birth weight of calves (Spitzer et al., 1995). In this experiment, calves from moderate condition cows may be predisposed to greater concentrations of plasma constituents due to a prenatal compensatory mechanism such as placental size.

Consumption of colostrum before the first sample of blood was collected influenced plasma concentrations of protein, NEFA, insulin, glucose, and IGF-I in calves (Table 1). Calves that had not nursed before the first sample had less ($P<.05$) plasma protein compared with calves that had nursed, however NEFA concentrations were greater ($P<.05$) for calves that had not nursed. Calves that had nursed had greater concentrations of insulin ($P<.05$) and glucose ($P<.08$) compared with calves that had not nursed. Calves that had not nursed had greater ($P<.05$) concentrations of IGF-I compared with calves that had nursed, however GH was not influenced by consumption of milk. These results demonstrate the influence the first milk intake has on the endocrine function of calves, and illustrate the importance of providing milk to calves as soon as possible after birth.

Hematocrits of calves were similar on d 1 and d 14. Calves had greater ($P<.01$) hematocrits than cows on d 2, but concentrations of plasma proteins were similar (Table 2). Hematocrits are elevated after acute periods of water deprivation in weaned beef calves (Lents et al., 1996) and mature beef cows (Wettemann et al., 1995) due to reduced plasma volume. These data indicate calves may have produced more red blood cells or may have been partially dehydrated. Plasma proteins of calves increased ($P<.01$) from 1 to 2 d of age (5.8 vs 7.2 g% for d 1 and 2, respectively; Table 3) and then were constant through 14 d of age. This increase in plasma proteins of calves is associated with the first nursing. Plasma proteins increase after ingestion of colostrum (Wilson et al., 1994).

Cows had greater NEFA concentrations than calves ($P<.01$; Table 2). Increased NEFA concentrations occur during periods of nutritional restriction, and indicate mobilization of body fat reserves for energy (Lents et al., 1996). After calving, cows must begin to produce milk. Energy demands of lactation may exceed energy supplied by supplementation and dormant native range in February. Cows mobilize energy reserves in the form of NEFA during this time of inadequate nutrient availability (Wettemann et al., 1995). Age of calf also influenced NEFA

(P< .01). Concentrations of NEFA of calves were greatest on d 1 but decreased by 2 d of age (850 vs 283 meq/L for d 1 and 2, respectively; Table 3) and remained unchanged through 14 d of age. This decrease in NEFA concentrations from 1 to 2 d of age corresponds to the first nursing. Calves had greater initial NEFA concentrations because they were mobilizing fat reserves for energy demands. However, after calves began receiving nutrients in the form of milk, NEFA concentrations decreased.

Calves had greater (P<.01) plasma glucose concentrations than cows, but plasma insulin concentrations were not different (Table 2). Calves do not have a functional rumen at this time, and glucose concentrations in calves are similar to those in monogastrics. Age of calf altered (P<.01) glucose but not insulin concentrations. Glucose concentrations increased from 1 to 2 d of age (77 vs 108 mg% for d 1 and 2, respectively; Table 3) but did not differ from 2 to 14 d of age. This increase in plasma glucose concentrations between 1 and 2 d of age corresponds to the first nursing of the calf, and indicates that calves were gaining energy from milk.

Concentrations of GH were greater (P<.01) for calves than cows, however IGF-I concentrations were similar (Table 2). Concentrations of GH in Holstein fetuses are 10 times greater than the GH concentrations of their dams (Oxender et al., 1972a; 1972b). There was an interaction (P<.07) between birth weight and age of calf on GH concentrations of calves (Figure 1). Calves that were heavier at birth had greater GH on d 3 and 8 compared with calves that weighed less. However, birth weight is confounded with sex of calf. Growth hormone is secreted in pulses from the pituitary (Hayden et al., 1992; Enright et al., 1994). In this experiment, blood samples were collected once a day. It is possible that a few calves were bled at the peak of a GH pulse and this would increase average concentrations. Concentration of GH in both heavy and light calves changed similarly during the first 14 d after birth. Growth hormone was initially elevated on d 1, increased from 1 to 2 d of age, and slowly decreased from 2 to 14 d of age. Concentrations of GH in Holstein bull calves were greatest after birth, but then decreased (Purchas et al., 1970). Concentrations of IGF-I increased linearly from 1 to 14 d of age (P<.001; Table 3). Other investigators have also found that IGF-I increased with age in calves (Kerr et al., 1991). These results indicate that the liver is becoming responsive to GH and secreting greater amounts of IGF-I.

Birth weight of calves was not significantly correlated with GH, IGF-I, plasma protein, or NEFA, however there was a negative correlation between birth weight of calves and plasma concentrations of insulin (r = -.26; P<.05) and glucose (r = -.20; P<.1). These were not strong relationships, however calves with greater weights at birth had less insulin and glucose concentrations in plasma.

In conclusion, calves experience dynamic changes during the early postnatal period. This is demonstrated by rapid alterations in plasma concentrations of GH, IGF-I, NEFA, glucose, and protein. In addition, concentrations of glucose and GH are greater in the calf than the dam on d 2. Consumption of milk soon after birth rapidly increases energy and protein in blood plasma and may enhance survival.

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Table 1. Effect of first suckling on concentrations of plasma constituents on d 1 in calves.

	Calf Status[1]			
Constituent	Not Nursed	Possibly Nursed[2]	Had Nursed[3]	SE
Calves, No.	5	7	5	--
GH, ng/mL	69	47	56	16
IGF-I, ng/mL	46[a]	22[b]	19[b]	4
Plasma protein, g%	4.8[a]	5.8[b]	6.9[c]	.3
NEFA, meq/L	968[a]	1068[a]	425[b]	355
Insulin, ng/mL	.33[a]	1.8[b]	2.6[c]	.4
Glucose, mg%	53[x]	77[y]	102[z]	10

[1]Indicates if calves had or had not nursed before the first sample.
[2]Calves were £ 2 h of age.
[3]Calves were > 2 h of age.
[a,b,c]Means with different superscript letters differ (P<.05).
[x,y,z]Means with different superscript letters differ (P<.08).

Table 2. Constituents in plasma of calves and cows on d 2 after calving.

Constituent	Calves	Cows	SE
Hematocrits, %	38[a]	35[b]	.7
Plasma protein, g%	7.4	7.2	.2
NEFA, meq/L	283[a]	1020[b]	52
Glucose, mg%	108[a]	71[b]	4
Insulin, ng/mL	2.8[a]	2.1	.6
GH, ng/mL	96[a]	35[b]	7
IGF-I, ng/mL	21	24	3

[a,b]Means with different superscript letters differ (P<.01).

Table 3. Effect of calf age on concentrations of plasma constituents.

	Calf age (d)							
Constituent	1	2	3	4	6	8	14	SE
Plasma protein, g%	5.8[a]	7.2[b]	7.3[b]	7.2[b]	7.1[b]	7.1[b]	6.8[b]	.2

NEFA, meq/L	850^{a}	283^{b}	--	257^{b}	262^{b}	--	--	49
Glucose, mg%	77^{a}	108^{b}	106^{b}	104^{b}	--	--	--	5
IGF-I, ng/mL	28^{ab}	21^{a}	21^{a}	23^{a}	30^{b}	33^{bc}	38^{c}	3
^{a,b,c}Means with different superscript letters differ (P<.05).								

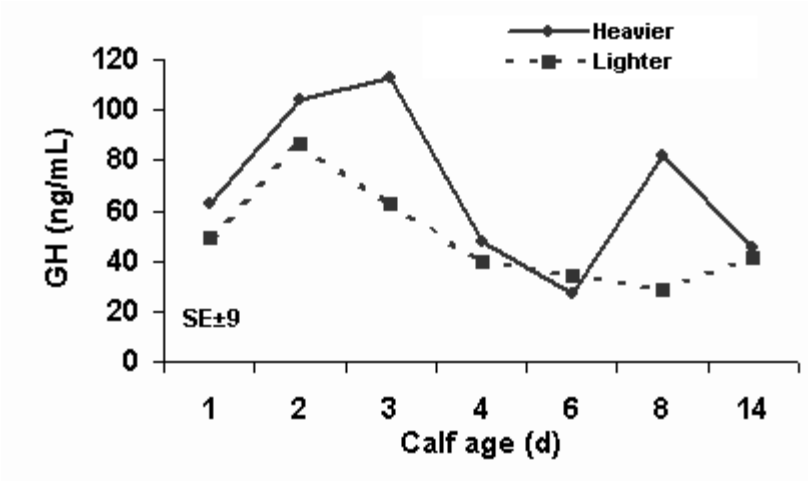

Figure 1. Effect of age on growth hormone in plasma of calves (birth weight x day; P<.07).

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