Prenatal Nutrition and Postnatal Growth and Metabolism of Calves

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Story In Brief

Increased nutrient intake of cows during mid-gestation did not influence growth rate of calves or concentrations of glucose, insulin, or IGF-1 in plasma after weaning. Differential counts of white blood cell, after treatment of calves with glucocorticoids, were not influenced by prenatal nutrition. A greater availability of nutrients prenatally did not alter endocrine function of calves at 8 mo of age.

Keywords: Calves, Growth, IGF, Insulin, Prenatal Nutrition

Introduction

Inadequate nutrition during late gestation in the bovine affects fetal and placental functions and may influence postnatal functions of the calf. Decreased nutrient intake of cows and a subsequent reduction in body condition score during late gestation increased chorioallantoic and cotyledonary weights and reduced concentrations of fructose in amnionic fluid (Rasby et al. 1990). A decrease in nutrient intake of cows resulted in decreased fetal weight which was associated with decreased cotyledonary weight at 125 d of gestation (Ford et al. 2005). After nutritional realimentation, fetal weight of nutrient restriction cows returned to that of control calves on d 250 of gestation and was related to increased growth and vascularity of the caruncular tissues. Nutrient restriction during early gestation significantly reduced the number of myofibers in each muscle bundle of the bovine fetus (Du et al., 2005). This reduction was not recovered by nutritional realimentation during the late stage of gestation, and resulted in fetal muscles with a reduced number of myofibers of larger diameter. Calves exposed to high prenatal nutrient intake during mid gestation had greater concentrations of glucose in plasma after weaning and decreased ability to clear glucose from plasma (Kastner et al., 2004). Undernutrition (50% of recommended nutrition) during late gestation (d 110 to term) of ewes resulted in lambs that had decreased ability to clear glucose from plasma which was associated with reduced GLUT 4 glucose transporter in adipose tissue and increased adipose tissue mass at 1 yr of age (Gardner et al., 2005).

Administration of dexamethasone increased concentrations of plasma glucose and insulin and decreased plasma concentrations of IGF –I and II in lactating dairy cows (Maciel et al., 2001). Treatment of animals with dexamethasone may be a technique to evaluate energy availability and a method to evaluate the response to stress.

Materials and Methods

At 69 ± 7 days of gestation, 21 Hereford x Angus multiparous cows were stratified by BW and body condition score (BCS) and randomly assigned to two groups. High nutrition cows (n =10) grazed dormant native grass pasture with a 50% concentrate 50% roughage supplement at libitum for 103 d and calves were weaned (120 d of age). Low nutrition cows (n =10) grazed dormant native grass pasture without supplement and calves were weaned at 205 d. After 103 d

on treatment, Low and High cows were maintained in the same pasture and fed 1.4 kg/d/head of a 40% CP supplement until parturition. After calving, all cows received 1.8 kg/d/head of supplement and hay ad libitum until spring pastures contained adequate protein. Calves were born on February 15 ± 7 d. Calves (Low; five steers and five heifers; High; six steers and four heifers) were weaned at 231 ± 7 d of age and maintained as a group.

Forty-one days after weaning, calves were transported (15 km) and confined in pens (2.3 x 4.8 m). Calves were blocked by prenatal nutritional treatment and sex, assigned to one of six pens, and fed 4.2 kg of a 16% CP, 60% TDN diet at 0800 h. Two 10-mL blood samples were obtained via jugular puncture into tubes containing EDTA or Heparin between 1330 and 1430 on d –1, 0, 1, 2, 3, 5, and 7. On d 0, animals were treated with dexamethasone (40 μg/kg of BW) after blood sampling. Samples were maintained at 4°C, centrifuged within 2 h (2600 x g for 15 min), and plasma was stored at –20°C. A 5 μL drop of blood was smeared on a slide, then fixed using fast green and stained using xanthane and thiazine. Differential white blood cells counts were determined by two technicians. Concentrations of glucose in plasma were analyzed by a colorimetric procedure (Infininity glucose reagent, Thermo Electron Corporation). Plasma insulin (Bossis et al., 1999), IGF-I (Echternkamp et al., 1990) and cortisol (Coat-A-Count cortisol kit, Diagnostic Products Corp.) were analyzed by radioimmunoassay. The plasma samples collected with Heparin were used for cortisol analysis. The sensitivity of the cortisol assay was 0.1 ng/mL, and addition of 0.1, 0.5, and 1 ng to 1 mL of plasma resulted in recovery of 104, 91 and 90 %, respectively. When 0.1, 0.2, 0.25 and 0.3 mL of plasma were assayed, concentrations of cortisol were parallel to the standard curve.

Calves were weighed at birth and at 181 ± 7, 231 ± 7, 272 ± 7, 307 ± 7, and 415 ± 7 d of age. Cow weights were obtained at 162 ± 7d of gestation and at 181 ± 7 and 231 ± 7 d post partum. Body condition scores (BCS: 1 = emaciated; 9 = obese; Wagner et al., 1988)) were obtained on 162 ± 7 d of gestation and 231 ± 7 d post partum. Calf weights were analyzed using the GLM procedure of SAS with treatment and sex in the model, along with the interaction. Weights and BCS of cows were analyzed using the GLM procedure of SAS with treatment in the model. Concentrations of glucose, insulin, IGF-1, and cortisol in plasma were analyzed using the Proc Mixed procedure of SAS as a repeated measure with treatment, sex, laboratory assay block, date, and the interactions in the model. Differential white blood cell counts were analyzed by each cell type as repeated measures using the Proc Mixed procedure of SAS. The model contained treatment, sex, date, technician and all interactions with $P>0.10$.

Results and Discussion

Weight of cows at 162 ± 7 d of gestation was greater ($P<0.001$) for High (733 ± 59 kg) than for Low (478 ± 30 kg) cows. At 181 ± 7 d postpartum, High cows (664 ± 44 kg) were heavier ($P<0.001$) than low cows (587 ± 34 kg). At 231 ± 7 d postpartum, High cows (631 ± 42 kg) were heavier ($P<0.01$) than the Low cows (561 ± 34 kg). BCS of high cows was greater ($P<0.0001$) than low cows (7.1 ± 0.4; 4.3 ± 0.2 respectively) at 162 ± 7 d of gestation. At weaning (231 ± 7 d postpartum), BCS was greater ($P <0.01$) in High cows (5.4 ± 0.4) then in Lows cows (4.8 ± 0.3).

Birth weight of calves was not influenced by prenatal treatment or sex ($P>0.10$; Table 1). Body weights from birth to weaning were similar ($P>0.20$) for calves from High and Low cows regardless of sex. Steers were heavier than heifers at 415 ± 7 d of age ($P<0.05$).

Plasma concentrations of glucose, insulin, and IGF-I in calves at 272 ± 7 d of age were not influenced (P>0.10) by prenatal nutrition. Plasma concentrations of glucose (figure 1) increased (P<0.001) from d 0 to d 1 (84 ± 3 mg/dl to 143 ± 3 respectively) after dexamethasone treatment. Plasma glucose concentrations were similar to pretreatment levels by d 3 after administration of dexamethasone. Insulin (figure 2) increased (P<0.001) from 1.7 ± 0.3 ng/mL, on d 0 to 5.7 ± 0.3 ng/mL on d 2 after treatment with dexamethasone. Insulin concentrations were similar to pretreatment concentrations on d 7. Concentrations of IGF-I in High and Low calves were 62 ± 5 and 66 ± 5 respectively. Administration of dexamethasone did not influence concentrations of IGF-I. Concentrations of cortisol (d 0 = 16.1 ± 2 ng/mL) decreased (P<0.01) during d 2 to 6 after dexamethasone treatment (cortisol < 0.1 ng/mL) and were not influenced by prenatal nutrition. Concentrations of cortisol were less than pretreatment concentrations on d 7 (1.8 ± 1.9 ng/mL).

There was a sex x date effect (P<0.05) on the percentage neutrophils in blood after treatment of calves with dexamethasone (figure 3). This effect was associated with a greater percentage of neutrophils in heifers than steers before treatment and at 2 d after treatment with dexamethasone. The percentage lymphocytes (figure 4) had a sex x date effect (P<0.01), that was associated with a greater percentage lymphocytes in steers than heifers on d -1 and 0. There was a treatment x date (P<0.001) interaction for percentage monocytes. High and Low calves averaging 2.06 ± .15 and 1.52 ± 0.15 respectively, and High calves had greater numbers of monocytes during d -1 through d 2 of sampling then Low calves. Dexamethasone treatment decreased the percentage monocytes in the blood.

Table 1. Least square means and standard errors of calf weights in Kg by day of age

Day of age	Low Steer	Low heifer	High Steer	High heifer
Birth weight	35.1 ± 5.3	34.2 ± 1.8	39.1 ± 3.6	35.1 ± 2.42
181 ± 7	230.0 ± 21.3	228.9 ± 14.0	250.2 ± 25.2	233.1 ± 22.2
213 ± 7	263.9 ± 22.9	262.3 ± 19.4	281.3 ± 28.2	263.7 ± 22.1
272 ± 7	279.5 ± 21.0	282.8 ± 25.4	302.2 ± 21.7	280.3 ± 17.5
307 ± 7	283.4 ± 19.4	285.2 ± 18.0	304.3 ± 19.1	283.8 ± 26.8
417 ± 7	473.5 ± 53.3[a]	437.9 ± 11.4[b]	490.2 ± 35.3[a]	446.8 ± 33.4[b]

[a, b] sex effect P=0.02

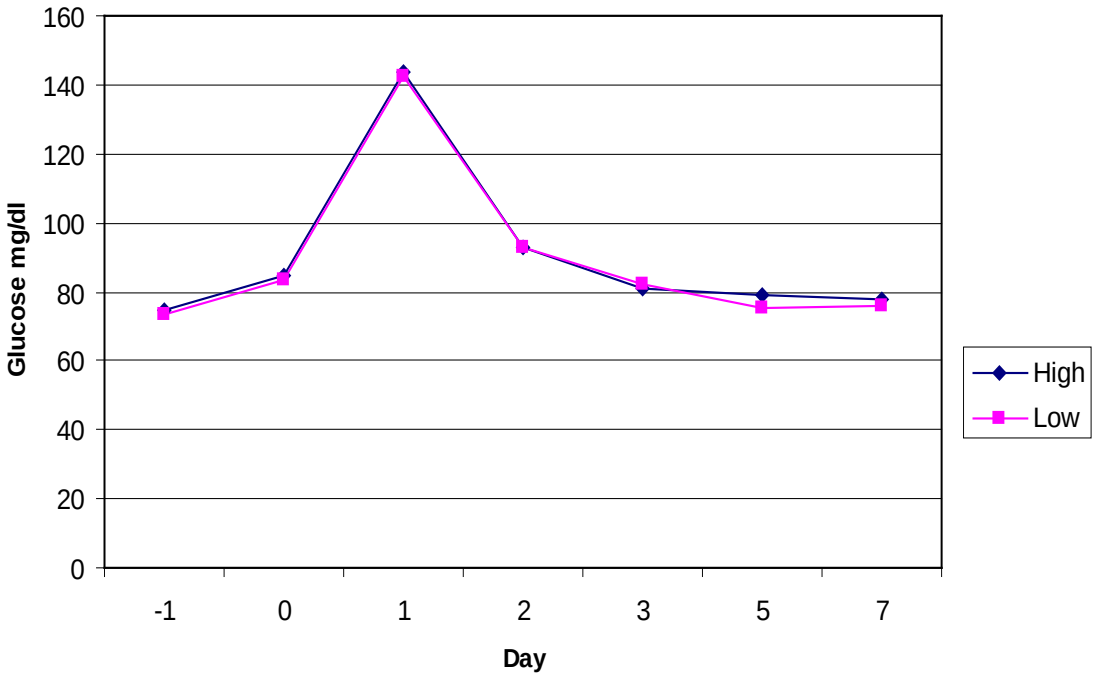

Figure 1. Influence of prenatal nutrition on concentrations of glucose in plasma of calves treated with dexamethasone after weaning (MSE= 132.5).

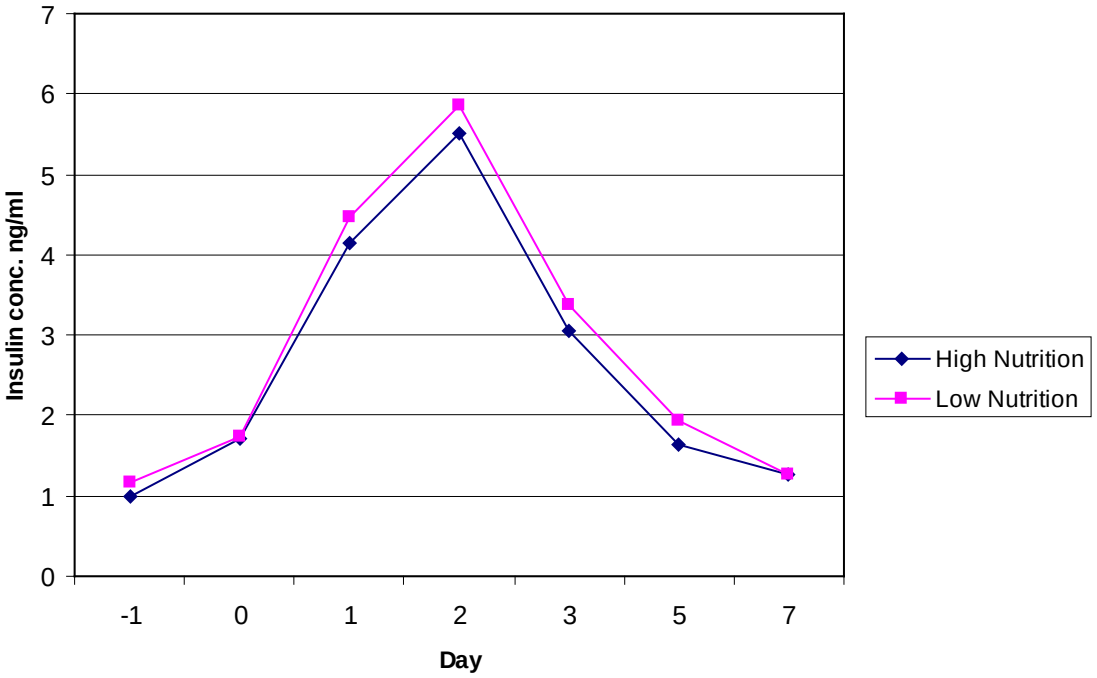

Figure 2. Influence of prenatal nutrition on concentrations of insulin in plasma of calves treated with dexamethasone after weaning (MSE= 1.7).

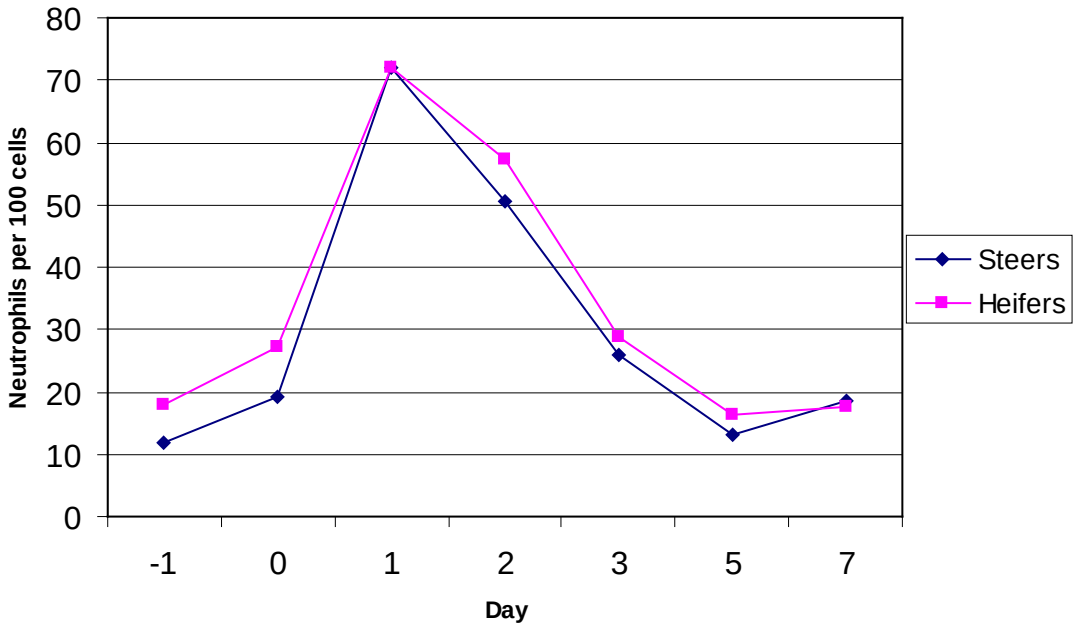

Figure 3. Neutrophil numbers in blood after treatmentof calves with dexamethasone after weaning (MSE = 67.57; sex x day, P= 0.03).

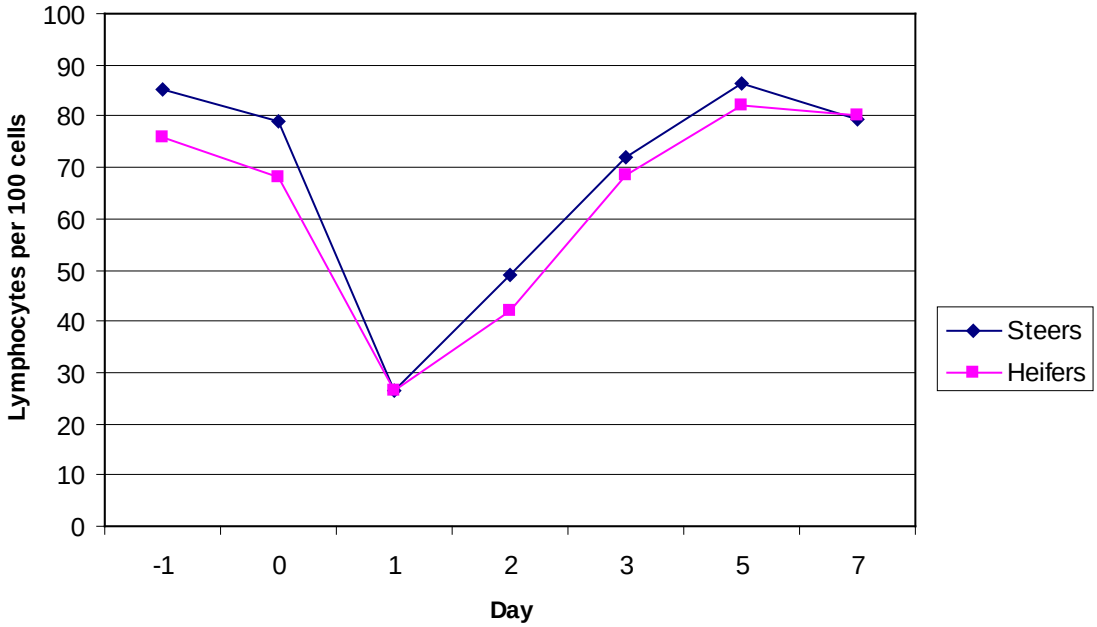

Figure 4. Lymphocyte numbers in blood after treatmentof calves with dexamethasone after weaning (MSE= 72.64; sex x day , P= 0.006)

Implications

Calves exposed to low or high prenatal nutrition respond similarly to treatment with dexamethasone after weaning. Low or High prenatal nutrition did not affect the glucose or insulin after weaning or the response to treatment with dexamethasone. There was no difference in the white blood cell response to treatment with dexamethasone.

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