TECHNICAL NOTES

Concentration of Calcium, Phosphorus, and 1,25-Dihydroxyvitamin D in Plasma of Dairy Cows During the Lactation Cycle[1]

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ABSTRACT

Concentrations of calcium, phosphorus, and 1,25-dihydroxyvitamin D in plasma of four young, four nonparetic aged, and four paretic aged cows were measured during the lactation cycle. Concentration of 1,25-dihydroxyvitamin D in plasma was elevated significantly in paretic aged cows as compared to nonparetic aged and young cows from the day of calving to 3 days postcalving. In paretic aged cows, severe hypocalcemia and hypophosphatemia developed on the day of calving, whereas hypocalcemia and hypophosphatemia were only transient in nonparetic aged and young cows at this time. Changes were only minor in concentration of 1,25-dihydroxyvitamin D in plasma from 7 days postcalving to 7 days precalving in all cows.

INTRODUCTION

Calcium concentration in plasma is maintained within a narrow range (9 to 11 mg/100 ml) in dairy cattle, except near parturition (5, 6, 7). Once the concentration of calcium falls below or rises above this range, the homeostatic mechanism for calcium is triggered. This mechanism may involve parathyroid hormone, thyrocalcitonin, and the vitamin D endocrine system (2). Vitamin D must be activated metabolically to 1,25-dihydroxyvitamin D [1,25-$(OH)_2$D] before it can elicit target tissue (intestine, bone, kidney) response (2). Metabolic activation of vitamin D to yield 1,25-$(OH)_2$D is controlled indirectly by the concentration of calcium (through parathyroid hormone) and directly by the concentration of phosphorus in plasma (2).

Parturient paresis is a metabolic disorder that occurs in aged dairy cows near parturition (6). Although the exact cause of parturient paresis is not known, clinical signs are from the failure of the homeostatic mechanism to maintain the concentration of calcium in plasma in the face of the sudden drain of calcium with initiation of lactation. A hypocalcemic tetany results, and if not treated, 60 to 70% of afflicted cows will die (10).

Horst et al. (5) reported changes in concentration of calcium, phosphorus, and 1,25-$(OH)_2$D in plasma during the period immediately around parturition. The purpose of our investigation was to measure concentrations of calcium, phosphorus, and 1,25-$(OH)_2$D in plasma during the lactation cycle in young ($\leq$ second parity), aged ($\geq$ third parity) nonparetic, and aged paretic dairy cows.

EXPERIMENTAL PROCEDURE

Three groups of four Holstein cows each were used: young ($\leq$ 2nd parity), aged ($\geq$ 3rd parity) nonparetic, and aged paretic. Cows were handled under usual herd management. Ration consisted of various portions of a grain mixture, corn silage, alfalfa silage, and alfalfa-bromegrass hay.

Blood samples were taken on these days: precalving 28, 14, 7, 5, 3, 1; day of calving; and days postcalving 1, 3, 5, 7, 14, 28, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330, and 360. The sample on day of calving was taken as close as possible to calving. The 360-day sampling depended upon the calving interval. Body weight and feed intake were taken on 3 consecutive days with day of blood sampling as the center date. Daily milk weights were recorded.

Heparinzed plasma was obtained from jugular blood samples and immediately stored at -20°C until analysis.

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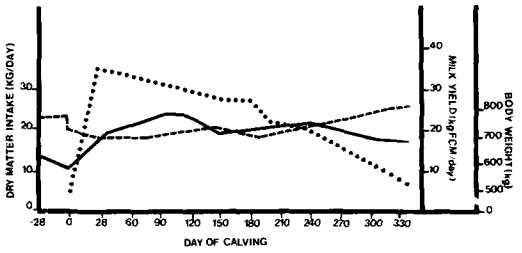

Figure 1. Dry matter intake (————), milk yield (.....), and body weight (— — — —) of aged dairy cows during the lactation cycle.

Calcium in plasma was measured by atomic absorption spectrophotometry with a Perkin Elmer Model 403 instrument (8). Phosphorus concentrations were determined colorimetrically by method of Chen et al. (1). Plasma 1,25–$(OH)_2D$ was measured by a competitive protein binding assay as described by Eisman et al. (3). Statistics were according to the procedure of Duncan as described by Steel and Torrie (9).

RESULTS

Milk production (4% fat-corrected milk), body weight, and dry matter intake curves for the aged (nonparetic and paretic) and young cows appear in Figures 1 and 2, respectively. Milk production peaked at 4 wk postcalving. The young cows were predominantly second lactation animals, and they had a higher expected 305-day lactation record at the start of the experiment than did the aged cows. Dry matter intake peaked at 13 to 14 wk postcalving for both young and aged cows. Body weight returned to wk 1 (postcalving) 20 to 24 wk postcalving. Changes of milk production, daily dry matter intake, and body weight were similar to those reported by others (4) and suggest that these cows were managed under "normal" conditions so that no undue stress should have occurred. Therefore, changes in concentration of calcium, phosphorus, and 1,25–$(OH)_2D$ in plasma during the lactation cycle should reflect "normal" changes.

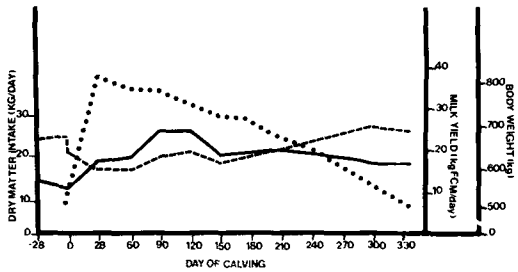

Figure 2. Dry matter intake (————), milk yield (.....) and body weight (— — — —) of young dairy cows during the lactation cycle.

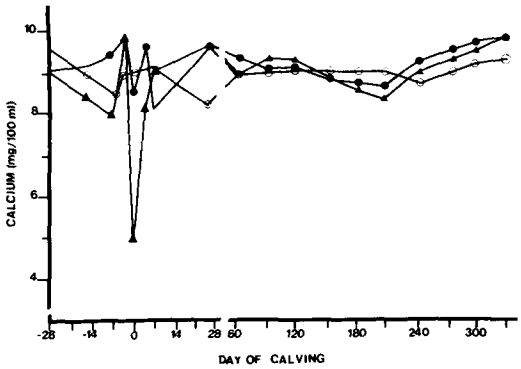

Figure 3. Concentration of calcium (mg/100 ml) in plasma of aged paretic (▲————▲), aged nonparetic (●————●), and young (○————○) cows during the lactation cycle. Zero represents parturition, negative values to the left of zero represent the days precalving, and positive values to the right of zero represent the days postcalving. Values for each point represent the mean of four cows.

The period of greatest calcium and 1,25–$(OH)_2D$ (Figures 3, 5, and 6) fluctuation

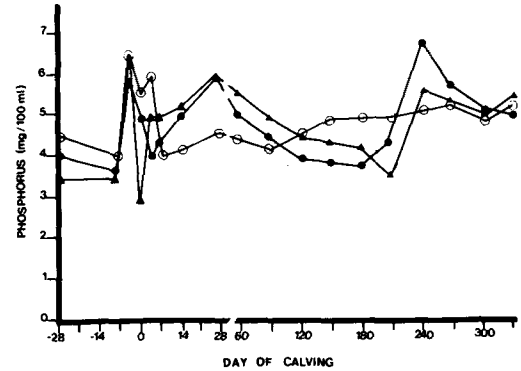

Figure 4. Concentration of phosphorus (mg/100 ml) in plasma of aged paretic (▲————▲), aged nonparetic (●————●), and young (○————○) dairy cows during the lactation cycle. For details, see Figure 3.

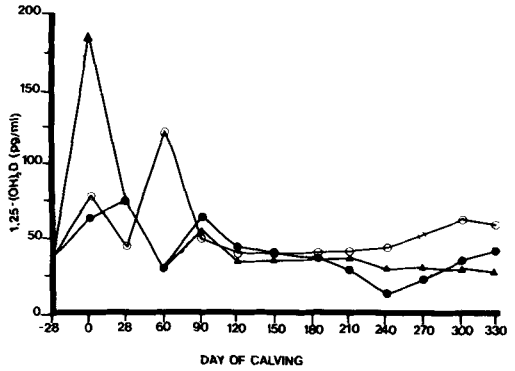

Figure 5. Concentration of $1,25-(OH)_2D$ (pg/ml) in plasma of aged paretic (▲———▲), aged nonparetic (●———●), and young (○———○) dairy cows from 28 days postcalving. For details, see Figure 3.

was from 7 days precalving to 7 days postcalving in aged paretic cows. The closer the cow was to parturition and initiation of lactation, the greater the challenge to calcium homeostasis (6). This was reflected by a decreased concentration of calcium and an increased concentration of $1,25-(OH)_2D$ in plasma of aged paretic cows. Cows able to cope with this challenge had only a transient hypocalcemia (Figure 3) and hypophosphatemia (Figure 4) during parturition; however, aged paretic cows that could not adjust to the challenge had a greater ($P<.05$) hypocalcemia (Figure 3) and hypophosphatemia (Figure 4) and elevated plasma $1,25-(OH)_2D$ ($P<.05$) (Figures 5 and 6) at calving.

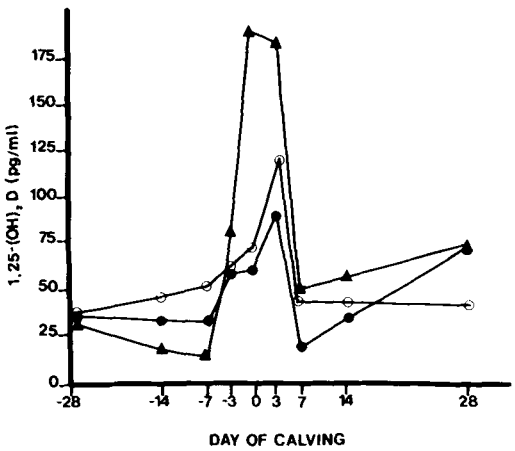

Figure 6. Concentration of $1,25-(OH)_2D$ (pg/ml) in plasma of aged paretic (▲———▲), aged nonparetic (●———●), and young (○———○) dairy cows during the lactation cycle. For details, see Figure 3.

Subsequent to day 7 postcalving, only minor changes occurred in the concentration of calcium in the plasma of all cows (Figure 3). Phosphorus concentration in plasma, which is not regulated as tightly as calcium concentration, showed greater fluctuation during this same time (Figure 4). The concentration of $1,25-(OH)_2D$ in plasma (Figure 5) changed little after peak lactation (Figure 1) in the aged cow groups. At this point cows are usually in positive calcium balance (6). The young cows had a spike in $1,25-(OH)_2D$ concentration at 60 days postcalving. The reason for this significant ($P<.05$) increase in plasma $1,25-(OH)_2D$ is unknown. The cows' homeostatic mechanisms were able to maintain calcium and phosphorus concentrations in plasma within a narrow range once adjustment to parturition and peak milk production had occurred.

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