Subclinical Hypocalcemia, or Milk Fever, in Dairy Cows – Why All the Fuss?

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With the initiation of lactation and continued milk production, tremendous adaptations occur in the dairy cow because of the increased need for nutrients to support milk synthesis. Besides the increased need for energy and amino acids for colostrum and afterward for milk synthesis, the requirement for calcium increases two- to three-fold over that required by the dairy cow before calving. Shortly before calving, a dairy cow deposits 8 to 10 g/d of calcium into her fetus, but when she calves, 20 to 30 g/d are secreted into colostrum and milk. Thus, metabolic adaptations must take place to support the increased need for calcium. If they do not take place soon enough or of sufficient magnitude, the concentration of calcium in the blood drops below a critical threshold and clinical and subclinical hypocalcemia, or milk fever, can result.

Role of Calcium

Calcium is vital for skeleton tissue and smooth muscle and nerve function including gastrointestinal motility and skeletal muscle strength. The lowest concentration of blood calcium usually occurs within 12 to 24 hours of calving and generally returns to normal in healthy cows within 2 to 3 days post-calving. Clinical hypocalcemia is the most recognized disease in dairy cattle by dairy farmers, with an incidence rate around 5%. Jersey and Guernsey cattle are more susceptible to the disorder. One reason for this is that Jersey cattle have fewer vitamin D receptors than Holstein cattle. Incidence increases with higher milk production and successive lactation. First-calf heifers rarely develop clinical hypocalcemia because they produce less colostrum and milk and can more rapidly mobilize calcium from bone in their growing skeleton. Reinhardt and co-workers at the National Animal Disease Center in Ames, Iowa, found the prevalence of clinical hypocalcemia was 1% for first-lactation, 4% for second-lactation, 7% for third-lactation, and 10% for fourth-lactation Holstein cows in a study where 1,462 cows were sampled.

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The concentration of calcium in blood is tightly regulated through control of absorption of dietary calcium and release or uptake of calcium from bone. Two hormones, parathyroid hormone (known as PTH) and 1,25-dihydroxy vitamin D_3, control these processes. As the concentration of calcium decreases in the blood, PTH is secreted and acts at the kidney to decrease the excretion of calcium in the urine. This change allows for only small adjustments in the concentration of blood calcium. If greater amounts of calcium are needed, as with the initiation and maintenance of lactation, PTH acts on bone, and calcium is reabsorbed and released into the blood. In addition, PTH acts on the kidney and results in the conversion of a vitamin D metabolite into 1,25-dihydroxy vitamin D_3. Then 1,25-dihydroxy vitamin D_3 can regulate the absorption of calcium from the small intestine through active transport. In order for PTH to be secreted and effectively bind to its receptor, adequate magnesium and a slightly less alkaline blood pH (known as metabolic acidosis) are needed, thus illustrating the need to provide adequate amounts of magnesium in pre-fresh diets and balance these diets to provide a negative cation-to-anion difference (DCAD) in order to prevent hypocalcemia.

Subclinical Hypocalcemia

Dairy cows with subclinical hypocalcemia do not show clinical symptoms but have a low blood concentration of calcium usually within 24 hours after calving. Thus, the only way to know whether dairy cows are experiencing subclinical hypocalcemia is to analyze blood for the concentration of calcium within the first 1 to 2 days after calving. Early clinical symptoms (stage 1: the cow is still able to stand) can include excitability, nervousness, shifting of weight, and shuffling of hind feet. These are not noted with subclinical hypocalcemia.

Dairy cows with blood calcium concentrations at or below 8.0 mg/dl (2.0 mmol/l) but not showing clinical signs are considered subclinically hypocalcemic. At this cut-off point, Reinhardt and co- workers in a study with 1,462 dairy cows determined that 50% of mature dairy cows and 25% of first-calf heifers experienced subclinical hypocalcemia. Oetzel at the University of Wisconsin has estimated that the economic cost of subclinical hypocalcemia in a dairy herd is four times the cost of clinical cases, resulting in a substantial impact on profitability of dairy operations. This increased economic cost is attributed to the greater number of cows with subclinical versus clinical hypocalcemia even though a subclinical case costs 40% of a clinical case.

Recently, Martinez and co-workers at the University of Florida suggested that this cut-off should be raised to 8.5 mg/dl (2.1 mmol/l) because cows below this concentration were more likely to develop metritis or metabolic disorders. Using this higher criterion, Reinhardt and co-workers' data indicate that over 65% of mature cows and 51% of first-calf heifers were below this threshold. These data and those from other researchers indicate (1) subclinical hypocalcemia does occur in a large number of dairy

cows, but (2) not all fresh cows experience a drop in blood calcium concentration just after calving. Research suggests that subclinical hypocalcemia may be directly associated with other metabolic disorders and may be the primary or secondary cause of decreased performance.

Implications of Hypocalcemia on Performance

Hypocalcemia impacts fresh cow health, future milk production, and reproductive performance. Studies also have shown that immune function is compromised in dairy cows with low blood calcium concentrations. Cows with lower blood calcium concentrations within the first day after calving are more likely to have a displaced abomasum, ketosis (and fatty liver), retained placenta and resulting metritis, and mastitis. Some studies have shown a decrease in feed intake and rumination and corresponding higher non-esterified fatty acid (NEFA) concentrations after calving. Cows with high body condition at calving also are more likely to have hypocalcemia. Other studies have failed to show a negative response on feed intake and milk production. Jawor and co-workers at the University of British Columbia showed that cows with subclinical hypocalcemia stood 2.6 hours longer in the 24-hour period before calving and produced 12 pounds more milk during weeks 2, 3, and 4 of lactation. In this study, all third- or greater lactation cows received a preventative calcium therapy after calving regardless of their blood calcium concentration.

Prevention of Hypocalcemia

Prevention of hypocalcemia generally occurs through modifications to the pre-fresh or close-up diet. These changes allow for the physiological system which mobilizes calcium to be primed and ready for the increased demand for calcium associated with the synthesis of colostrum and milk.

1. **Low calcium diets pre-fresh:** Although this practice does reduce the incidence of hypocalcemia, it is difficult to implement on the farm. To be effective, diets must provide less than 20 g of available calcium. These diets often contain very low quality forages that may limit intake, yet low intake pre-fresh is not desired. In some grazing situations (e.g., depending on forage species and pasture fertility), low calcium diets may be possible.
2. **Low potassium forages/diets pre-fresh:** Incorporating low potassium forages (e.g., corn silage) into diets for pre-fresh dairy cows may decrease the likelihood of clinical hypocalcemia but not the incidence of subclinical hypocalcemia. Changes in the dietary cation-anion difference (DCAD) may not be large enough to cause metabolic acidosis and prevent a subclinical drop in blood calcium concentration when low potassium forages are fed without additional dietary modifications of chlorine and sulfur. The DCAD influences the pH of the blood and the

responsiveness of tissues to PTH and the cow's ability to reabsorb calcium from bone and absorb dietary calcium from the small intestine.

3. **Feeding anionic salts for 21 days pre-fresh:** Feeding a negative DCAD diet 21 days pre-fresh has been shown to prevent clinical (a five-fold reduction) and subclinical hypocalcemia. Diets should be formulated to result in a dietary DCAD of -10 to -15 mEq/100g dietary dry matter using the most palatable of anionic mineral supplements.

   Many commercially available anionic mineral or protein-based supplements are available for use in formulating these diets. Before formulating diets, the amount of potassium and sodium provided through forages and other feedstuffs should be kept as low as possible. Close-up diets should be formulated with about 1.0% calcium and 0.35% magnesium to prevent hypocalcemia. Phosphorus concentration of close-up diets should be 0.25% to 0.3% because excess phosphorus (0.4% total diet) increases the risk for hypocalcemia.

   Urine pH should be used as an indicator of whether DCAD management is effective. However, urine pH does not indicate a reduction in the risk of hypocalcemia. Urine should be collected midstream after cows are fed the anionic salt diet for at least 48 hours. Urine should be free of fecal material. For Holstein cows, urine pH should be between 6.2 and 6.8 (at least less than 7.0) and for Jersey cows between 5.8 and 6.3. If the average urine pH is between 5.0 and 5.5, excessive anions are being fed (coming from both feed and water sources), and the diet needs to be reformulated to prevent a drop in dry matter intake.

   The verdict is still out on whether it is detrimental, neutral, or perhaps beneficial to provide anionic salts to virgin heifers. Early studies showed a decrease in dry matter intake in heifers fed anionic salts, but other more recent studies have not shown this decrease. Feeding anionic salts to virgin heifers increases feed costs especially with unclear benefits or detriments when supplemented.

   Anionic salts are usually fed for 21 days prior to calving and are not recommended to be fed for the entire dry period. In herds managed for short dry periods (40 to 45 days dry), feeding and managing dry cows in two separate groups may not be feasible, and feeding anionic salts the entire dry period may be needed to accommodate available facilities and labor. In a recent study by Weich and co-workers at the University of Minnesota, anionic salts were fed 0 (control was no anionic salts pre-fresh), 21, or 42 days before calving. No differences in dry matter intake before or after calving or milk production were seen when anionic salts were supplemented for 21 or 42 days before expected calving date. More studies are needed before extending or reducing the number of days pre-fresh anionic salts are fed in the field.

Bottom Line

Prevention of hypocalcemia (low concentration of blood calcium) around calving is an important component when designing transition cow programs for optimum post-calving health, reproduction efficiency, and milk production. Adequate calcium is important for colostrum and milk synthesis, muscle and nerve function, and immunity. Clinical cases of hypocalcemia are easy to diagnose and for dairy managers to understand that feeding and management changes are needed to prevent future cases. On the other hand, subclinical hypocalcemia is not easy to diagnose and may be a contributing factor in herds with a high incidence rate of metabolic disorders. Subclinical hypocalcemia potentially occurs in over 50% of dairy cows, does not present with recognizable symptoms, and can only be diagnosed when blood samples are collected within the first 1 to 2 days post-calving and blood calcium concentration is determined to be below 8.5 md/dl. As with all metabolic disorders, prevention is the key, and the use of anionic salts and other management strategies may help prevent this metabolic disorder.