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Introduction to Periparturient Diseases of Cattle

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1.1 Introduction

The term "periparturient" arises from the word "parturition" and the prefix "peri," which literally but vaguely means "around." The periparturient period in cattle refers to the 2 to 3 weeks pre- and postpartum and is a transitional period characterized by changes in endocrine status of the animal for lactogenesis and parturition. It is also characterized by changes in tissue metabolism, nutrient utilization, and disruptions in immune system functions (Kimura et al. 2006; Borsberry and Dobson, 1989).

The periparturient or transition period starts 4 weeks before and ends 4 weeks after calving and is marked by a significantly increased risk of disease. This duration primarily involves a series of adjustments to meet the demands of lactation, a process referred to as "homeorhetic". Homeorhetic processes entail long-term physiological adaptations to changing states, such as transitioning from a nonlactating to a lactating state or from a nonruminant to a ruminant state. These processes encompass a combined series of metabolic changes that enable animals to adapt to the challenges of their altered state.

Disruptions in homeorhetic changes often result in homeostasis disorders, which leads to conditions like hypocalcemia, downer-cow syndrome, hypomagnesemia, ketosis, udder edema, abomasal displacement, metritis, and poor fertility, all of which are interconnected. The shifts in endocrine function and metabolism that accompany calving as well as the onset of lactation make the transition period inherently challenging for vets.

Despite these complexities, the potential to enhance subsequent production, health, and reproduction has spurred research into the nutritional management of periparturient cows. In broad terms, the goal for the transition cow is to minimize the risk of metabolic disorders related to macro-mineral metabolism, such as calcium (Ca), magnesium (Mg), or phosphorus (P) deficiencies, and to avoid imbalances of sodium (Na) and potassium (K). The aim is also to prevent lipid metabolism issues that stem from insufficient energy intake during the dry period and early lactation as well as to maintain proper rumen function amid dietary changes and support an effective immune response (Akers et al. 1979).

Many cows affected by these periparturient diseases are over conditioned, which increases their vulnerability to conditions like milk fever, ketosis, digestive disorders, retained fetal membranes, metritis, mastitis, and foot problems. The morbidity (50–90%) and mortality (60%) rates can be high in affected herds (Grunes 1973).

Periparturient, production, and metabolic diseases are most important in dairy cows and pregnant ewes, compared to other domestic farm animals for whom a sporadic incidence is noticed. The higher susceptibility to disease during the periparturient period is attributed to the extremely high turnover of fluids, salts, and soluble organic materials during the early part of lactation. Because of this rapid rate of exchange in water, sodium, calcium, magnesium, chlorides, and phosphates, a sudden change in their excretion or secretion (in milk or by other routes) or a sudden variation in their intake because of changes in ingestion, digestion, or absorption, may cause abrupt, damaging changes in the internal environment of the animal. It is the volume of change in intake and secretion as well as the rapidity with which they can occur that affects the

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metabolic stability of the cow. In addition, if the continued nutritional demands of pregnancy are exacerbated by an inadequate diet in the dry period, the incidence of metabolic disease will increase.

One of the major challenges faced by dairy farmers and veterinarians is the maintenance of a cow's health during the periparturient period. The incidence of these diseases is an important source of economic loss to the dairy industry. Studies have verified that the incidence of metabolic and production-related diseases including milk fever, mastitis, fatty liver disease, ketosis, metritis, hypomagnesemia, and abomasal displacements is highest during the periparturient period, and complications from dystocia and retained placentas commonly occur (Markusfeld 1987).

The initiating factor occurs before parturition, mainly during the dry period for most of these diseases. This is because pregnant heifers and cows in dry period are the most neglected animals on a farm due to poor housing and feeding conditions. This often results in decreased milk yield, poor reproductive efficiency, and increased periparturient disorders. Cows with high production are always at risk of problems in the early lactation period or periparturient period. As lactation is an extremely intensive metabolic process, high yielding cows may face severe metabolic disturbances around the period of parturition and lactation. The etiological factors can be hormone, metabolite, or nutrition based, which may lead to a metabolic imbalance in the animal. These imbalances, if prolonged, may result in extreme periparturient disorders that are detrimental to animal production and health.

Nutritional management in the early dry period is important for maintaining the health and productivity of cows in the transition period (Dann et al. 2006) as dry matter intake tends to decrease by more than 30% in the last 3 weeks of gestation (Hayirli et al. 2002). The incidence of metabolic diseases can be reduced by increasing dry matter intake and minimizing the period of a negative energy balance after calving (Roche et al. 2000).

Nutritional and sanitation requirements of the periparturient cow are understood better. Unfortunately, management and environmental conditions change constantly, and new problems develop as rapidly as old problems are solved. There is difficulty determining what a "normal" cow might be in a "normal" environment (Mather and Melancon 1981). Seasonal calving is often used in grazing dairy farms to maximize pasture nutrient utilization and avoid temporary environmental constraints, such as heat stress, during early lactation and the breeding period. In this type of dairy production system, reproductive efficiency is essential to obtain a concentrated calving season on a yearly basis. Cows must become pregnant in a short and preestablished period of time that in many cases uses a calendar day to begin and end it for all cows.

When concerned with breed susceptibility to periparturient diseases, between species and individuals, susceptibility varies according to the internal metabolism and quantity of milk production. Likewise, variation in the susceptibility between groups is due to variations in genetic (or) management factors. However, among all the breeds of dairy cattle, Jersey cows are high milk yielders and are found to be at high risk of developing periparturient diseases. Similarly, Guernsey's breed is reported to be more susceptible to ketosis (Radostits et al. 2006).

Several conditions such as milk fever, ketosis, injuries to the birth canal, nerve paralysis, mastitis, and metritis occur at a higher frequency during the periparturient period in cattle (Goff and Horst 1997). These conditions account for up to 8% of all diseases in dairy cattle (Markusfeld 1987) and cause substantial losses to the dairy industry in terms of increased generation interval, loss of genetic pool, increased deaths, reduced productivity of the animals, and the cost of treatment (Erb et al. 1985). To be successful and remain competitive, milk producers must minimize losses from infertility. Factors that affect fertility include both herd-level management and individual cow factors. In this case, clinical reproductive diseases cause short-term problems and milk yield losses as well as have long-term, harmful effects on fertility (Roche et al. 2000). Moreover, cows that present with periparturient diseases are more susceptible to developing other diseases (Williams et al. 2007); thus, a healthy passage through the transition period is essential for proper reproductive efficiency in dairy cows. Assessing the impact of gynecological diseases on the overall level of reproductive processes has been well documented in European dairy cattle in temperate climates (Gilbert 2011). A great number of these studies were carried out in herds with two milkings per day, without the use of recombinant bovine somatotropin (rBST), throughout lactation and at latitudes where the heat load is not a serious hurdle for dairy operations. The dramatic increase in nutritional demands at the onset of lactation, coupled with the concurrent appetite suppression near calving, leads to extreme metabolic stress. Excessive mobilization of adipose tissue occurs to meet the nutritional demands of lactation and results in elevated concentrations of non-esterified fatty acids (NEFA) and ketones, such as β-hydroxybutyric acid (BHBA), in the circulation. Extensive evidence has shown that elevated NEFA and BHBA can alter immune functions, which contributes to immune suppression (Ingvartsen and Moyes 2015). During the periparturient period, cattle suffer from oxidative stress, which refers to the accumulation of reactive oxygen species (ROS) when their production exceeds the neutralizing capacity of antioxidant mechanisms, and it has been identified as a significant underlying factor of periparturient immunosuppression.

Metabolic diseases are associated with significant economic losses due to a significant decrease in milk yield and impaired reproductive performance in animals (Wang et al. 2021). Attention to detail and an understanding of reproduction, metabolism, digestive functions, milk secretion, and all aspects of husbandry are essential. To be successful, producers must minimize reproductive failure because reproductive performance affects the quantity of milk produced per cow per day of herd life, the number of potential replacements needed to maintain a constant herd size, and the longevity of the cow in the herd. In practice, this translates into well-designed programs for herd health, milking, feeding, and reproductive management that minimize involuntary culling problems in cows by maintaining healthy, profitable cows.

The periparturient period is associated with multiple changes including hormonal changes, moving from a nonlactating to lactating state, and a major drop in feed intake. For these reasons, the serum levels of major macro minerals and glucose frequently change during this period (DeGaris and Lean 2008). Metabolic diseases are associated with low concentrations of these components in the blood. Moreover, subclinical forms of mineral deficiencies have been incriminated in decreasing production levels and decreased feed efficiency, which can cause huge losses to dairy farmers (Bacic et al. 2007). In this regard, metabolic profiling, which refers to the analysis of blood biochemical constituents, and monitoring parameters like milk production, urinalysis, and rectal temperature, are important tools for detecting metabolic disorders in dairy cattle before any clinical manifestations appear.

During the periparturient period, cattle are prone to disorders or diseases like milk fever, ketosis, post-parturient hypomagnesemia, post-parturient hypophosphatemia, ruminal acidosis, laminitis, fatty liver, fatty cow syndrome, hypokalemia, abomasal displacement (left side, right, or anterior), abomasal torsion, udder edema, mastitis, metritis, retention of the placenta, and pyometra.

Milk fever, or hypocalcemia, is the major periparturient disease in adult, lactating, dairy cattle during the third parity and older. It commonly occurs during the first 48 hours after parturition and less frequently, just before and even several weeks before parturition. It develops due to a decrease in the ionized calcium concentration in the body fluids and is characterized by generalized muscular weakness that results in sternal recumbency with a lateral deviation of the head and neck (Figure 1.1), anorexia, ruminal atony, scanty feces, and if not treated, it can lead to circulatory collapse and death (Radostits et al. 2006).

Ketosis in ruminants, particularly in cattle, is unique as it is as a primary metabolic disorder or syndrome distinct from any other recognized disease; it is characterized by abnormally high levels of acetone bodies in the blood and urine of cows displaying ketosis symptoms (Sjollema and Van Der Zande). Ketosis is commonly reported in fat, high producing cows 7–10 days after calving and is characterized by rapid weight loss, loss of appetite, dry feces, decreased milk production, and in many cases, nervous disturbances. Ketosis most commonly affects cows after their third to sixth calving, particularly when they are stabled. Repeated attacks could occur following subsequent calvings (Hutyra and Marek).

Post-parturient hemoglobinuria (PPH) is a common issue in lactating dairy cattle that primarily affects highly productive animals, it is characterized by intravascular hemolysis, anemia, and hemoglobinuria. This condition is most commonly observed in cattle during their third to sixth lactation periods, and the highest risk periods are during late pregnancy through early lactation and from calving up to 1 month post parturition, most cases occur 2 to 4 weeks postpartum. Hemoglobinuria is more frequent in buffaloes compared to crossbred cows in their third lactation, with the highest incidence occurring during the winter season. While the exact cause of PPH remains unknown, it has been linked to potential factors such as phosphorus depletion or hypophosphatemia, copper deficiency, and certain hemolyzing substances found in specific feeds. The disease carries economic losses including treatment costs, decreased milk production, and high mortality rates.

Figure 1.1 Milk fever in cattle.

Post-parturient hypomagnesemia, or low blood magnesium levels, is a condition more common in cattle with a clinical presentation that ranges from acute with sudden death to subacute and chronic with varying symptoms.

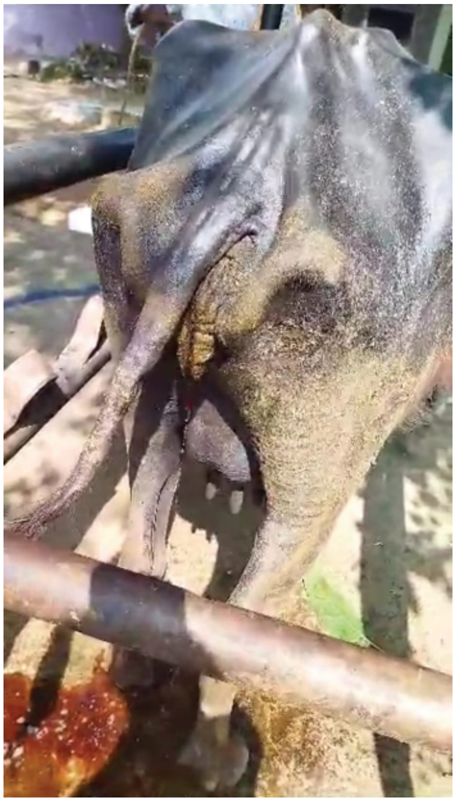

Figure 1.2 Post-parturient hypophosphatemia in cattle.

Occurrence is influenced by several factors including nutrition, lactation, and environmental conditions. The disease is characterized by hyperexcitability, incoordination, nervousness, seizures, and death. Prophylactic measures are important for prevention and involve soil and forage assessment as well as dietary supplementation with magnesium sources. Treatment options include intravenous, subcutaneous, or oral administration of magnesium-containing solutions (Figure 1.2).

Another condition is "downer cow complex," which encompasses various peripartum diseases in dairy cows that are often interconnected. Its incidence has risen due to drastic changes in management practices, in particular, the shift from individual cow care to group-focused approaches. The group feeding of dry and lactating cows has led to the overfeeding of dry cows, which makes them more susceptible to metabolic and infectious diseases, calving issues, and reduced fertility. These conditions are referred to by several names, including "downers," "alert downers," "atypical milk fever," "creeper cows," and "fat cow syndrome" (FCS). Complications that result from parturient hypocalcemia (milk fever) often involve muscle, tendon, or nerve injuries.

Over conditioned, dry cows may experience the entire FCS, which includes foot abscesses, parturient hypocalcemia, retained placentas, metritis, ketosis, abomasal displacement, diarrhea, and mastitis. Such cases have a poor prognosis, even with extensive treatment. The prevention of FCS in a herd can be challenging and requires months of proper management to improve the physical condition of over conditioned cows. Factors like low milk production, extended calving intervals, feeding excessive concentrates after peak lactation or during the dry period, and free-choice access to corn silage or high quality hay contribute to the development of FCS. Protein underfeeding or an early reduction in milk production combined with corn silage can also lead to energy over consumption and over conditioning in cows.

Hypokalemia in periparturient cattle is a commonly noticed disorder often associated with conditions such as left-displaced abomasa (LDA), right-displaced abomasa (RDA), abomasal volvulus (AV), abomasal impaction, clinical mastitis, retained placentas, and hepatic lipidosis. Severe hypokalemia in cows leads to decreased smooth muscle tone in the gastrointestinal tract, signs of depression, and profound skeletal muscle weakness that sometimes results in recumbency. The rise in severe hypokalemia cases may be attributed to factors like increased milk yield and the administration of multiple isoflupredone acetate doses to treat ketosis. The incidence of hypokalemia is common in lactating cows compared to beef cattle and is likely due to the higher incidence of LDA, RDA, and AV in dairy cows, conditions that cause alkalemia by sequestering chloride in the gastrointestinal tract, which decreases dietary chloride intake and causes potassium loss in the milk of lactating dairy cows. Hypokalemia can also occur in cattle with metabolic alkalosis or hyperglycemia due to a shift of potassium from extracellular to intracellular spaces. To develop effective treatment protocols for hypokalemic lactating dairy cows, a thorough understanding of the mechanisms that lead to hypokalemia is necessary.

Dairy cows experience moderate to severe fatty liver upon calving, which is associated with health issues that include mastitis, displaced abomasa, retained placentas, metritis, poor reproductive performance, immune suppression, ketosis, and production losses. Fatty liver occurs when the liver synthesizes triglycerides faster than they are removed through hydrolysis or secretion via very low-density lipoproteins (VLDLs). Ruminants have an unusually slow rate of hepatic VLDL secretion, possibly due to limited essential nutrients for lipoprotein assembly. Attempts to supplement these nutrients have not been successful. Microsomal triglyceride transfer protein (MTP) is essential for VLDL assembly. It consists of a larger and a smaller subunit. Hepatic MTP may be a key factor in determining the rate of VLDL secretion and the severity of fatty liver in dairy cows. Nutritional manipulation, such as increasing energy consumption at calving, adjusting dietary carbohydrate content, or supplementing with propylene glycol, can reduce fat mobilization from adipose tissue and hepatic triglyceride concentration. In vitro studies have shown that increasing fatty acid concentrations in media or the presence of insulin and glucagon can impact bovine hepatocyte metabolism.

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