

Serum Parathyroid Hormone Levels and Mineral Profiles in High Producing Dairy Cattle Around Calving Period

¹S.M. Abd-Allah and ²H.A. Bakr

¹Department of Theriogenology,

²Department of Animal Medicine, Faculty of Veterinary Medicine, Beni-Suef University, Egypt

Abstract: The aim of this study was to attempt at providing a complete picture of dynamics of selected biochemical blood parameters (parathyroid hormone, Calcium, Phosphorus, Sodium, Potassium, Chlorine and ionized calcium) around calving period in high producing dairy cattle (Holstein breed), giving new and useful information about the guidelines for the management strategies during different physiological phases. Seven pregnant Holstein cows were blocked by parity and fellow during the peri-parturient, calving and post-parturient period. Jugular blood samples were taken 8-15 days prior to expected calving, at calving and in day seven post-calving to estimate serum concentrations of Parathyroid Hormone (PTH), Calcium (Ca), Sodium (Na), Potassium (K), Chlorine (Cl) and ionized Calcium (i Ca). Results indicated that the level of PTH at calving time and in seven days post calving was significantly higher ($p < 0.05$) than those in pre-partum and this is vice versa for blood calcium and ionized calcium. However, the levels of Na and Cl in pre-partum were significantly higher ($p < 0.05$) than those at calving and post-partum. Other mineral levels were not significantly change over time of study. The present study indicates that serum PTH and some electrolytes could be severely altered in dairy around the time of calving.

Keywords: Dairy cow, minerals, parathyroid hormone, periparturient period

INTRODUCTION

The most critical time in the life of a dairy cow is the days around parturition. The cow's metabolism is under severe stress as she transitions to lactation to meet requirements for milk production, so her body has a high nutrient demand.

Parathyroid hormone is a single-chain polypeptide made up of 84 amino acids secreted by the chief cells in parathyroid gland. It augments the absorption of calcium from the intestines and simultaneously conditions its re-absorption from the skeleton (Horst *et al.*, 1994, 1997).

PTH is the principal hormone involved in the fine regulation of Ca homeostasis. The hypercalcemic biological action of PTH is by direct influence on target cells in bones (osteoclasts and osteocytes) and kidney (proximal and distal tubules) and by indirect action on the duodenum.

In bones, PTH causes bone resorption by mobilizing Ca from the center to surface of bones and helps solubilize the mineral from the bone by producing an acid environment in the adjacent extracellular fluid.

PTH directly and rapidly affect the tubular cells, preventing resorption of phosphate by the proximal tubules which lowering resorption of Ca in distal tubules. It also enhances the renal conversion of 25-

hydroxyvitamin D3 into 1, 25-dihydroxy D3. By this additional 1, 25-dihydrovitamin D3, PTH indirectly increases the absorption of Ca ions in the duodenum and of phosphate ions in the jejunum (Goff, 2000).

Calcium (Ca) is a mineral that plays a central role in maintaining the homeostasis of animals including muscle contraction, blood coagulation, enzyme activity, neural excitability, hormone secretion and cell adhesion, in addition to being an essential structural component of the skeleton (Capen and Rosol, 1993).

Aside from this process, it is also a factor in controlling phosphorus metabolism through its resorption in the skeletal system as well as in stimulating the emission of phosphates through the kidneys during the status of inorganic phosphorus excess in the body fluids (Jorgensen, 1974).

Horst *et al.* (1994) reported that cows affected by parturient paresis as a rule have a higher level of PTH in their blood.

In pregnant cows, the maintenance of Ca homeostasis varies with Ca composition of the prepartal diet. In cows fed high Ca prepartal diets, Calcitonin hormone (CT) becomes the major hormone near parturition and during the early postpartum period. The hypocalcemic effect of CT predominates and causes the blood Ca level to fall to less than 50% of the normal concentration (parturient paresis, or hypocalcaemia

associated with parturition) in spite of an increase in the release of PTH and the PTH response to hypocalcaemia is an unsuccessful increase of intestinal absorption rather than the corrective measure of bone resorption.

An increased secretion of CT prepartum, when the cows are fed the high Ca diet, may be a factor contributing to the postpartum failure of increased PTH to rise the blood CA level.

Ca is involved in the pathogenesis of metabolic diseases that disrupt the normal regulation of Ca balance and may result in hypocalcemia and hypercalcemia (Chew *et al.*, 1992). The precise control of Ca ion in extracellular fluids is vital, therefore, to the health of man and animal.

To maintain a constant concentration of Ca, despite variations in intakes and excretion, endocrine control mechanisms have evolved that primarily include parathyroid hormone which played the major role in the control of blood Ca.

Sodium is a major extracellular cation and plays an active part in regulating the neutrality of blood serum. The chlorides of blood, consisting mainly of sodium chloride, make up more than half of the acid ions; consequently the chlorides have a principal effect on the acid-base relatively.

Potassium is the third most abundant element in the animal body as well as the potassium is a major intracellular cation and is involved in the osmotic regulation of tissue fluids and acid-base balance.

An ionic balance exists among K, Na, Ca and Mg (Radostits *et al.*, 2010).

Milk secretion markedly increased electrolytes output, which was compensated for only partially by increased intake. This was associated with marked reduction of electrolytes losses in excreta, partially that of Na, K and Cl (Shalit *et al.*, 1991; Silanikove *et al.*, 1997). During lactation, electrolytes (Na, K and Cl) are lost in milk, at initiation of lactation, urea was the main component contributing to urine osmolarity whereas the contributions of Na, Cl and K were very low, after peak lactation, urea concentration in urine was reduced and electrolytes concentrations were slightly increased.

The low electrolytes concentration particularly Cl and Na in the very early phase of lactation (between parturition and peak of lactation may reflect either electrolytes deficiency.

Our goal was to evaluate changes in serum parathyroid hormone and some electrolytes (Na, Ka, Ca, P, Cl and ionized Ca) pre-calving (8-15 days before day of calving), calving time and seven days after calving in high producing dairy cows.

MATERIALS AND METHODS

Seven pregnant Holstein cows of 3rd parity were blocked by calving date and follow one week after parturition.

The cows were belonging to a private dairy farm and were fed total mixed ration that were formulated to meet nutrient requirements at this period (NRC, 2001).

The selected animals were proven to be apparently healthy and free from internal and external parasites and kept in a hygienic barn and also the cows subjected daily for general clinical examination throughout the time of experiment to detect any abnormalities in health status.

Jugular blood samples were collected from each cow in 8-15 days before calving, at calving and on the day seven post-calving. Clear sera were obtained immediately and kept frozen at about -20c for biochemical analysis.

Parathyroid hormone was quantified by standard homologous double antibody radioimmunoassay (Berson and Yallow, 1963).

Serum total calcium level was estimate photometrically according to method described by Gitelman (1967) by using a test kit supplied by Human Gesellschaft Fur Biochemic and und Diagnostica mbH. Max-Planck-Ring 21-65205 Wiesbaden-Germany.

Serum phosphorous level was determined photometrically UV according method described by Daly and Ertingshausen (1972) and Gamst and Try (1980) by using test kit.

Serum Na, K, ionized Ca and Chlorine were estimated by ST-200 Plus electrolytes analyzer, SENSE Core Medical instrumentation. Pvt. Ltd., India.

Data were analyzed using analysis of variance using SPSS, Version 16. All the results were expressed as mean values and Standard Deviation (S.D.).

RESULTS

The concentration of serum parathormone hormone (pg/mL), Ca, iCa, P₀₄, Na, Ka, Cl levels were presented in Table 1.

The level of the serum PTH at calving time and on day seven post-calving was significantly higher ($p < 0.05$) than those in pre-partum. In contrast with the level of PTH, the serum calcium and ionized calcium levels on the day of calving and on day seven post-calving were significantly lower ($p < 0.05$) than those in pre-partum period.

Table 1: Mean values (\pm S.D.) of PTH, Ca, i Ca, P, Na, K and Cl serum contents in seven holstein cows, over periparturient period

Parameters	Prepartal period	At calving	Postpartum period
PTH (pg/mL)	29.58 \pm 11.24 ^a	53.73 \pm 16.92 ^b	40.70 \pm 11.98 ^b
Ca (mg/dL)	8.60 \pm 0.49 ^a	7.22 \pm 0.76 ^b	6.79 \pm 0.73 ^b
i-Ca (mmol/L)	0.452 \pm 0.007 ^a	0.366 \pm 0.100	0.325 \pm 0.009 ^b
P ₀₄ (mg/dl)	5.73 \pm 1.14	5.30 \pm 1.35	5.25 \pm 0.93
Na (mmol/L)	138.49 \pm 2.94 ^a	133.68 \pm 1.64 ^b	134.64 \pm 1.02 ^b
K (mmol/L)	4.83 \pm 0.51	4.84 \pm 0.34	4.95 \pm 0.24
Cl (mmol/L)	110.71 \pm 2.99 ^a	105.52 \pm 0.66 ^b	106.70 \pm 1.62 ^b

Values having the different letters are significantly different at $p < 0.05$

The levels of Na and Cl in pre-partum were significantly higher ($p < 0.05$) than those at calving and post-partum.

The serum inorganic phosphate and potassium levels were not significantly change over the time of the study.

DISCUSSION

The obtained results reflect a situation in which the animals can deal with critical situations because of the proper functioning of the parathyroid and the appropriate ability of the body to utilize the available Ca reserves and can maintain Ca, at such level clinical signs of hypocalcemia can be prevented.

The high level of PTH at calving time and in day seven post-calving as well as the low levels of calcium and ionized calcium at same time. The obtained results confirm the opinion of Mayer *et al.* (1969) and Goff (2000) who observed that a decrease in serum calcium concentration in all examined cows occurs during the calving period which is closely related to the rise in PTH level and simultaneously delayed return of the calcium value to normal levels paralleled to the drop in the concentration of this hormone. Typically, serum PTH increases near calving, activating bone resorption and renal tubular re-absorption to increase blood Ca (Goff, 2000). Although, the serum calcium levels were subnormal during calving day and in day seven post-calving, no clinical signs of hypocalcemia were observed in the present study as there is a sufficient level of PTH during concurrent with hypocalcemia to mobilize the calcium from the skeletal reserve and from the digestive system (Boda and Cole, 1954). As blood Ca concentration decreases, PTH concentration increases. High concentrations of PTH promote the production of 1- α -hydroxylase in the Kidney, the enzyme that converts 25-OH to 1, 25-dihydroxyvitamin D3. When blood Ca is within the normal range, PTH secretion decreases and 1, 25-dihydroxyvitamin D3 is catabolized through a negative feedback mechanism and 25-OH is diverted to inactive compounds (Horst *et al.*, 1994, 1997).

The serum Ca and ionized Ca levels at calving and in the day seven post-calving were significantly lower ($p < 0.05$) than that recorded during pre-partum, that can be attributed to the loss of Ca in milk synthesis (Benjamin, 1984). The decline in blood calcium may be rapid in certain high producing dairy cows near parturition and the imitation of lactation. Because bone resorption during the prepartal period often is relatively low owing to a substantial intake of dietary calcium, there is a relatively small pool of active bone resorbing cells capable of responding rapidly to PTH. Therefore, when PTH secretion increases because of the rapidly developing hypocalcaemia, the increase in activity of the few active osteoclasts present on bone surfaces in

insufficient to reduce the plasma calcium concentration to normal. The activation and subsequent conversion of preosteoclasts to osteoclasts under increased PTH with expansion of the pool of active bone resorbing cells requires time and an adequate concentration of Ca in extracellular fluids and if the extracellular Ca falls below a critical level, the increased circulating concentration of PTH may be ineffective in causing an elevation of cytosol calcium in target cells to activate new bone resorbing cells (Thomas and Charles, 1997).

Another explanation, which is recorded by Yves *et al.* (1991), in pregnant cows, the maintenance of Ca homeostasis varies with Ca composition of the prepartal diet. In cows fed high Ca prepartal diets, Calcitonin hormone becomes the major hormone (CT) near parturition and during the early postpartum period. The hypocalcaemic effect of CT predominates and causes the blood Ca level to fall to less than 50% of the normal concentration (parturient paresis, or hypocalcaemia associated with parturition) in spite of an increase in the release of PTH and the PTH response to hypocalcaemia is an unsuccessful increase of intestinal absorption rather than the corrective measure of bone resorption. An increased secretion of CT pre-partum, when the cows are fed the high Ca diet, may be a factor contributing to the postpartum failure of increased PTH to raise the blood Ca level.

The levels of Na and Cl in pre-partum were significantly higher ($p < 0.05$) than those at calving and post-partum due to their secretion in milk (Shalit *et al.*, 1991; Silanikove *et al.*, 1997).

Concerning the serum Po_4 concentrations were insignificantly altered over time of study as milk phosphorus output is directly related to milk yield, as milk phosphorus concentration is constant (Valk *et al.*, 2002) as increasing the milk production, more phosphorus from the ingested amount is transferred to milk and less is excreted with feces (Valk *et al.*, 2002).

CONCLUSION

Our data confirm that the peri-parturient period is the more sensible, by a metabolic point of view for the high production dairy cow, so the information provided in this study, can be a useful tool in managing and preventing the deficiencies typical of high production cows. This information may help refine dietary mineral recommendations for lactating dairy cows. Moreover, determining its usefulness for routine diagnosis in the case of disturbances in the calcium, phosphorus and PTH levels in dairy cattle, when the necessity of prognosis as to the use of therapeutic measures arises.

REFERENCES

- Benjamin, M.M., 1984. Outline of Veterinary Clinical Pathology. Iowa State University Press, Ames, Iowa, 50010, USA.

- Berson, S.A. and R.S. Yallow, 1963. Immunoassay of bovine and human parathyroid hormone. *P. Natl. Acad. Sci. USA*, 49: 613-617.
- Boda, J.M. and H.H. Cole, 1954. The influence of dietary calcium and phosphorus on the incidence of milk fever in dairy cattle. *J. Dairy Sci.*, 37: 360-372.
- Capen, C.C. and T.J. Rosol, 1993. Hormonal Control of Mineral Metabolism. In: Borjrab, M.J. (Ed.), *Disease Mechanisms in Small Animal Surgery*. Lea & Febiger, Philadelphia, Pennsylvania, pp: 841-857.
- Chew, D.J., L.A. Nagode and M. Carothers, 1992. Disorders of Calcium: Hypercalcemia and Hypocalcemia. In: Dibartola, S.P. (Ed.), *Fluid Therapy in Small Animal Practice*. Saunders, Philadelphia, Pennsylvania, pp: 116-176.
- Daly, J.A. and G. Entringshausen, 1972. Direct method for determining inorganic phosphate in serum with the "CentrifChem". *Clin. Chem.*, 18(3): 263-265.
- Gamst, O. and K. Try, 1980. Determination of serum-phosphate without deproteinization by ultraviolet spectrophotometry of the phosphomolybdic acid complex. *Scand. J. Clin. Lab. Inv.*, 40: 483-486.
- Gitelman, H., 1967. Clinical chemistry-calcium-o-cresolphthalein complexone method. *Anal. Biochem.*, 20: 521.
- Goff, J.P., 2000. Pathophysiology of calcium and phosphorus disorders: Metabolic disorders of ruminants. *Vet. Clin. N. Am-Food A.*, 16: 319-337.
- Horst, R.L., J.P. Goff and T.A. Reinhardt, 1994. Calcium and vitamin D metabolism in the dairy cow. *J. Dairy Sci.*, 77: 1936-1951.
- Horst, R.L., J.P. Goff, T.A. Reinhardt and D.R. Buxton, 1997. Strategies for preventing milk fever in dairy cattle. *J Dairy Sci.*, 80: 1269-1280.
- Jorgensen, N.A., 1974. Combating milk fever. *J. Dairy Sci.*, 57: 933-944.
- Mayer, G.P., C.F. Ramberg, D.S. Kronfeld, R.M. Buckle, L.M. Sherwood, D. Aurach and J.T. Potas, 1969. Plasma parathyroid hormone concentration in hypocalcemic parturient cows. *Am. J. Vet. Res.*, 30: 1587-1597.
- NRC, 2001. *Nutrient Requirements of Dairy Cattle*. 7th rev. Edn., National Academies Press, Washington, DC.
- Radostits, O.M., C.C. Gay, D.C. Blood and K.W. Hincheliff, 2010. *Veterinary Medicine*. 10th Edn., Harcourt Publishers Ltd., Harcourt place, 32 Jamestown Road, London NW1 7BX. UK.
- Shalit, U., E. Maltz, N. Silanikove and A. Berman, 1991. Water, Sodium, Potassium and Choline metabolism of dairy cows at the onset of lactation in hot weather. *J. Dairy Sci.*, 74: 1874-1883.
- Silanikove, N., E. Maltz, A. Halevi and D. Shinder, 1997. Water, Na, K and Cl metabolism in high yielding dairy cows at the onset of lactation. *J. Dairy Sci.*, 80: 949-956.
- Thomas, J.R. and C.C. Charles, 1997. Calcium Regulating Hormones and Diseases of Abnormal Mineral Metabolism. In: Kaneko, J.J., J.W. Harvey and M.L. Bruss (Eds.), 5th Edn., *Clinical Biochemistry of Domestic Animals*. Academic Press, London, pp. 619-702.
- Valk, H., L.B.J. Sebek and A.C. Beynen, 2002. Influence of Phosphorus intake on excretion and blood plasma and saliva concentrations of phosphorus in dairy cows. *J. Dairy Sci.*, 85: 2642-2649.
- Yves, P., P. Lowis-Philippe and D. Robert, 1991. Physiology of Small and Large Animals. In: *Endocrine and Reproductive Functions*. B.C. Dekor Inc., Philadelphia, Hamilton, pp: 521-526.