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INDICATORS OF MINERAL AND ENERGY METABOLISM IN THE THREE DAYS FOLLOWING MILK FEVER SYMPTOMS IN DAIRY COWS

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Abstract

A total of 60 dairy cows met the requirements of the study (50 disease cases and 10 as the control group), located on 10 farms in the central Lublin region. The cows were aged 3 to 8 years, with good or very good milk production and about a week after parturition. They were first divided into two groups based on their clinical symptoms of milk fever. During the experiment, two subgroups were distinguished from the groups, based on the condition of the animals during the observation period. At 24, 48 and 72 hour,s blood was taken from the animals after no clinical symptoms were detected and at least 36 hours after the last administration of medicines. In the first days of the analysis, low levels of minerals (calcium – Ca and inorganic phosphorus – Pi) and low concentrations of glucose and cholesterol with simultaneously higher amounts of free fatty acids (FFA) were observed in the serum. On the second day of the analysis, these levels had dropped and on the third day some of the cows were observed to have small problems with appetite or difficulty getting up; therefore, after taking material for evaluation and analysis, treatment was begun or prophylaxis increased. Based on the results, the authors can conclude that the major health threat to cows recovering from milk fever appears 2 to 3 day after the subsidence of any signs of acute hypocalcaemia, and 3 days after the last application of medicines. Cows which had been clinically healthy in this period showed significant differences in biochemistry results versus the control groups and needed to receive prophylactic preparations to resolve the mineral and energy insufficiencies. Our observations suggest the necessity for check-up blood tests in cows for 3 days after an episode of milk fever, as well as mineral and energy prophylactic supplementation during that time.

Keywords: milk fever, dairy cows health, hypocalcaemia, phosphorus, glucose.

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WSKAŹNIKI PRZEMIANY MINERALNEJ I ENERGETYCZNEJ W PIERWSZYCH TRZECH DOBACH PO USTĄPIENIU OBJAWÓW PORAŻENIA POPORODOWEGO U KRÓW MLECZNYCH

Abstrakt

Do badań zakwalifikowano 60 krów mlecznych (50 szt. przypadki chorobowe i 10 szt. grupa kontrolna) pochodzących z 10 gospodarstw centralnej Lubelszczyzny. Zwierzęta miały od 3 do 8 lat, cechowały się dobrą lub bardzo dobrą produkcją mleczną i znajdowały w okresie ok. tygodnia po porodzie. Początkowo podzielono je na dwie grupy na podstawie przebiegu objawów klinicznych porażenia poporodowego. W trakcie badań wydzielono z poszczególnych grup po dwie podgrupy, ze względu na stan zwierząt podczas okresu obserwacji. Od zwierząt pobierano krew po 24, 48 i 72 godzinach od ustąpienia wszystkich objawów klinicznych i jednocześnie przynajmniej 36 godzin po ostatniej podaży leków. W pierwszym dniu analiz stwierdzono niski poziom wskaźników mineralnych (Ca i Pn) oraz glukozy i cholesterolu, ale jednocześnie wyższą wartość wolnych kwasów tłuszczowych (WKT) w surowicy krów. Natomiast w drugim dniu analiz poziomy te obniżyły się, a trzeciego dnia u części krów wystąpiły nieznaczne problemy z apetytem lub problemy ze wstawaniem, dlatego po pobraniu materiału do badań i wykonaniu analiz u tych krów ponownie rozpoczęto terapię lub wzmożono profilaktykę. Stwierdzono, że największe zagrożenie dla zdrowia krów w okresie rekonwalescencji po porażeniu poporodowym występuje po 2 – 3 dniach od ustąpienia objawów ostrej hipokalcemii i po 3 dniach od ostatniej podaży leków. Krowy, które w tym okresie były klinicznie zdrowe, w badaniach biochemicznych wykazywały duże różnice w porównaniu z grupą kontrolną i powinny otrzymywać preparaty zapobiegające niedoborom mineralnym i energetycznym. Z obserwacji własnych wynika, że istnieje konieczność wykonywania kontrolnych badań krwi u krów w okresie 3 dni po przebytym porażeniu poporodowym i profilaktycznego suplementowania preparatami mineralno-energetycznymi.

Słowa kluczowe: porażenie poporodowe, zdrowotność krów mlecznych, hipokalcemia, fosfor, glukoza.

INTRODUCTION

During the postpartum period, different metabolic disorders of varying intensity can be observed including hypocalcemia, which is the consequence of hormonal, production and feeding changes. In this period the organism has to deal with an increased use of its own reserves and nutrients absorbed from the digestive tract (GOFF, HORST 1997, KONDRACKI, BEDNAREK 1997, STEC et al. 2000). Appropriate calcium-phosphorus metabolism is maintained mainly by hormonal regulation, based mostly on parathormone (PTH), calcitonin (Calc) and vitamin D metabolite activity as well as some glucocorticoid and sex hormone activity (THIEDE 1994, GOFF, HORST 1997, KUREK, STEC 2005). Modern prophylaxis of hypocalcaemia is based on this regulation, decreasing the calcium content in the diet before parturition to cause increased concentration of parathormone in the blood and simultaneously better usage of calcium from the feed and reserves mobilization from the bone system (GOFF 2008).

In the postpartum period, animals need more energy, which coinciding with a higher risk of hypocalcaemia, makes milk fever more likely to occur (GOFF, HORST 1997, VERNON 2002, SOBIECH et al. 2010). Acute clinical hypocalcaemia of the peripartum period, known as milk fever, is a condition described as resulting from a low calcium concentration in the extracellular space in cows. However, the phosphorus and magnesium concentration, and the dynamics of energy conversions in the organism, affect the clinical symptoms and total calcium concentration in cows (SANSOM et al. 1983, FENWICK 1988, PEHRSON et al. 1998, LARSEN et al. 2001). In dairy herds, the comatose form of milk fever is most often diagnosed, characterized by progressing neural signs (consciousness disorders) from drowsiness to coma and characteristic lateral recumbence with the cow's head on the back. Other developments are the loss of milk yield, appetite and thirst. Another frequent form is a milk fever syndrome characterized by psychomotor excitation in the standing position.

According to our own experiment, these two forms of milk fever differ in their magnesium levels with very low concentrations of calcium (Ca) and inorganic phosphorus (Pi). The concentration of magnesium (Mg) is much lower (although not below physiological values) in hyper excitability and high in the comatose form (KUREK, STEC 2004*a*, 2005). While describing the clinical forms of hypocalcaemia, SANSOM et al. (1983) and FENWICK (1988) observed changes in magnesium levels, some researchers recorded only hypermagnesemia (BJÖRKMAN et al. 1994), while others did not notice any changes in Mg concentration (PEHRSON et al. 1998). Acute hypocalcaemia affects mostly cows after 3 lactations (≥ 5 years), but may be observed in young animals as well. It is mostly observed within 72 hours of parturition. Based on our own observations, the incidence clinical cases in different dairy cow herds, despite the constant improvement in housing and nutrition, is about 2-8 % of livestock, which is confirmed in other publications (ESSLEMONT, KOSSAIBATI 1996, HOUE et al. 2001, HORST et al. 2003). The course of milk fever and the condition of cows which recover from it cause large economic losses and often lead to the culling of many animals. The most frequent complications responsible for losses in dairy herds are: metritis, fetal membranes retention, abomasal displacement or ulceration, limb and muscle injuries, or udder injuries or inflammations (HORST et al. 1997, HOUE et al. 2001, DEGARIS, LEAN 2009). The current understanding of milk fever and losses caused in dairy herds by its consequences is unsatisfactory. In particular, there are very few publications concerning systemic changes and decreased farming efficiency in the days following the treatment and the subsidence of the clinical symptoms, which is especially important for herd management. Such data are available only regarding animals with complications during the illness or immediately afterwards. For this reason, a decision was made to examine animals which were considered healthy by framers after acute hypocalcaemia, and to analyze their basic biochemistry profile during the recovery. The aim was to determine if, and to what extent, high-yielding cows after an incident of milk fever require some prophylactic or medical treatment once the clinical symptoms are subsiding in order to normalize the mineral and energy metabolism.

MATERIAL AND METHODS

In 2005-2011, a study was conducted on a group of 60 HF cows aged between 4 and 9 years. 50 cows were diseased animals and 10 healthy individuals were the control group. The animals came from 10 farms housing between 30 to 300 dairy cows, located in the central Lublin region. The farms had similar housing conditions and a feeding system based on the TMR technology. The feeds were corn silage, haylage, silage from grass or beet tops, beet pulp, hay, straw, concentrates with the addition of cereals, as well protein and mineral supplements. The feed ration was based on the production level, physiological period and the animals' age. Feeding animals on the farms was based on the fodders/24-hours/animal: corn silage (15-18 kg), hay silage (16-17 kg), hay (1-2 kg), wheat or barley straw (1-2 kg), grass silage, beet tops or beet pulp (4-5 kg), home-made concentrate from cereal grains – triticale, wheat, oats (4-5 kg) as well as supplements in doses dependent on the productivity and the commercial preparation (approximately 0.05-0.2 kg), all-mash feed with the protein content of 18-36% depending on milk yield (2-5 kg), mineral and vitamin supplements in doses dependent on the productivity and applied supplement (approximately 0.1-0.3 kg). The experiment encompassed cows with milk fever during the period from a few hours to 3 days after delivery. Sick cows presented clinical signs from the gastrointestinal tract, nervous and musculoskeletal system, typical for hypocalcaemia. Animals with clinical changes had medium or good body condition, and good or very good milk yield (35-50 l daily at peak lactation before sickness). Based on the rapidity and character of the clinical symptoms, as well biochemistry results confirming different kinds of hypocalcaemia, two groups of animals with different clinical image of the disease were distinguished. Group I included 20 cows with excitation and hypersensitivity, occasional tremors and contractions of single muscle groups; cold peripheral body parts, lack of appetite or thirst, difficulty in defecating, and different milk yield loss. Besides, the cows were able to stand up, although the standing position seemed hesitant or animals would lie down and then attempted to stand up again during the treatment. The remission of clinical symptoms was observed 24-48 hours from the start of treatment. The moment the cows fell ill, they showed a significantly decreased Ca concentration (average 1.58 mmol l^{-1}) in the serum, quite a large decrease of Pi (1.01 mmol l^{-1}) and a low concentration of Mg (0.7 mmol l^{-1}). Glucose and cholesterol in the serum were within the lower physiological norm limits. Group II included 30 cows which had milk fever with rapid consciousness disorders, from drowsiness to coma. During the course of the disease, these animals showed no appetite or thirst, ceased milk production, had a characteristic downer cow's syndrome with lateral recumbence, holding the head on the back, kept the limbs spread forward, unable stand up, their peripheral body parts were cold, urination or defecation stopped and some cows suffered from tympanites. At the onset of the condition, the Ca concentration was very low (average 1.4 mmol l^{-1}), Pi was 0.29 mmol^{-} l^{-1} and Mg concentration was 1.4 mmol l^{-1}. Glucose and cholesterol were on the lower level of the physiological norm (WINNICKA 2011). In both groups during milk fever there were no significant changes in potassium (K) levels in the serum and free fatty acids (FFA) in the plasma. During the study, group II was additionally divided into two subgroups according to the animals' health status. Group IIa (25 animals) included cows with higher milk yield after the illness and in which the farmers saw no health changes. Group IIb (5 animals) included cows which, 3-4 days after milk fever had subsided, preferred the lying position and had difficulty standing up. Group III, the control, included healthy animals (10 cows), which were in the same physiological condition and came from the same farms as the cows with clinical hypocalcaemia.

Clinical examination and blood sampling were done in both groups 24, 48 and 72 hours after all clinical symptoms had subsided and at least 24 hours from the last administration of medications. In the control group, blood was taken 96, 120 and 144 hours after delivery, therefore material collection from clinically healthy cows was optimized to 24 hours after possible hypocalcaemia. Blood was drawn from the jugular vein into heparinized tubes. After centrifugation, total calcium (Ca), total magnesium (Mg), inorganic phosphorus (Pi), glucose and cholesterol in the serum were determined by colormetry with commercial tests on a BS-130 MINDRAY. The potassium level was assayed by the ion selective electrode method on an AVL 9180. The concentration of free fatty acids (FFA) was assessed by the titrimetric method.

All results were statistically analyzed using Statistica 5.0 PL software. Significance of differences between averaged values was estimated by the *t*-Student test, at significance levels of $p \leq 0.05$ and $p \leq 0.01$.

RESULTS

Animals which had milk fever with excitatory symptoms (group I) at the beginning of the experiment did not show any clinical signs and yielded approximately 30 liters of milk per day. By the third day, 3 cows (15 %) had worse appetite and lower milk production, although the test results were close to other cows in the same group (therefore they did not form another subgroup). The results from the third blood sample justified a decision to start mineral, vitamin and energy supplementation for the whole group. In group II cows, which had the comatose form of milk fever two cows could not stand up between the second and third day of the study. During the next few hours, 4 other cows were observed to have similar symptoms. The animals were reluctant to remain standing or chose to lie down. The laboratory tests results led to an immediate decision to commence treatment and to isolate this group from other animals. Based on the farmers' experience, such cases had happened before in cows which had recovered from milk fever and clinically did not need prophylactic treatment with vitamin and mineral supplements.

The lowest calcium levels (but not statistically significant) in the first blood sample were observed in animals which had previously exhibited the excitatory symptoms. The lowest Pi levels were observed in those groups which had previously had comatose milk fever (Table 1), although the results for group I were much lower than the concentrations observed in the con-

Table 1

The mean concentration of ions in the groups

Groups	Sampling hours	Analyzed parameters (mmol l^{-1})			
		Ca	Mg	Pi	K
I	24	2.01±0.17^{Aa}	0.93±0.2	1.23±0.19	4.6±0.7
	48	1.87±0.19^{ABb*}	0.91±0.2*	1.25±0.14	4.5±0.8
	72	1.74±0.17^{Bc**}	0.82±0.2*	1.36±0.18	4.3±0.5
II a	24	2.09±0.34	1.14±0.2	1.20±0.34*	4.5±0.5
	48	1.99±0.13	1.12±0.1	1.24±0.22*	4.4±0.3
	72	1.98±0.17*	1.14±0.2	1.17±0.27**	4.6±0.6
II b	24	2.08±0.22	1.12±0.1	1.12±0.21*	4.2±0.4
	48	2.01±0.11	1.15±0.1	1.03±0.28**	4.1±0.6
	72	1.99±0.19*	1.13±0.1	1.01±0.32**	4.3±0.2
III	96	2.11±0.31	1.01±0.3	1.64±0.33	4.7±0.3
	120	2.13±0.35	1.10±0.2	1.67±0.24	4.6±0.5
	144	2.14±0.41	1.09±0.2	1.82±0.22	4.7±0.4

a, *b*, *c* – statistically significant difference between the means at $p \leq 0,05$
A, *B*, *C* – statistically significant difference between the means at $p \leq 0,01$
* – statistically significance of differences between control and experimental group at the same sampling time at $p \leq 0,05$
** – statistically significance of differences between control and experimental group at the same sampling time at $p \leq 0,01$

trol group. The concentrations of Mg and K were within physiological norm (WINNICKA 2011). Group IIb featured the highest values of FFA with a low glucose level (Table 2). On the second day, group I showed a decrease of the Ca level relative to the first blood sample, with values statistically significantly lower than in the control group. This group had the lowest Mg concentration albeit within normal limit. The lowest average Pi values were observed in group IIb, statistically lower than the results in group III. The largest FFA concentration and the lowest glucose concentration were observed in group IIb, although these values were not statistically significant in comparison to the other groups and previous samples. At 72 hours after the subsidence of milk fever clinical symptoms group I cows, very low concentrations of Ca (statistically significantly lower than in the control group) and low (but within normal limit) Mg concentrations were found (statistically lower than samples from other groups). On the same sampling time, low levels of calcium and very low levels of phosphorus were found in group II, markedly low in group IIb, where the average inorganic phosphorus level was statistically significantly lower than in the analogous samples in the control group. This group had the highest levels of FFA, exceeding the physiological norm and significantly higher than values from other animals, and the lowest glucose and cholesterol levels (Table 2). All the groups showed

Table 2

The mean content of FFA, glucose and cholesterol in serum

Groups	Sampling hours	Analyzed parameters (mmol l^{-1})		
		glucose	cholesterol	FFA
I	24	3.3±0.6	3.4±0.8	608.4±123.1^{a}
	48	3.0±0.5	3.3±0.5	624.4±78.4^{ab}
	72	2.6±0.9	2.7±0.6	688.3±108.3^{b}
II a	24	3.1±0.3	2.9±0.3	668.4±182.2
	48	2.9±0.4	2.9±0.2	602.3±192.3
	72	2.9±0.3	3.1±0.5	617.9±104.3
II b	24	2.7±0.2	2.2±0.2*	723.4±133.2
	48	2.7±0.2	2.0±0.1*	766.4±100.2*
	72	2.6±0.1	2.0±0.2*	728.5±83.4*
III	96	3.5±0.3	3.9±0.7	618.8±125.4
	120	3.6±0.4	4.2±0.6	612.3±143.3
	144	3.6±0.3	4.3±0.7	588.5±173.3

a, *b* – statistically significant difference between the means at $p \leq 0,05$
A, *B* – statistically significant difference between the means at $p \leq 0,01$
* – statistically significance of differences between control and experimental group at the same sampling time at $p \leq 0,05$
** – statistically significance of differences between control and experimental group at the same sampling time at $p \leq 0,01$

decreasing average Ca levels during the whole study, contrary to the control group. The average potassium value also fluctuated, and was lower in the experimental groups than in the control groups, although the difference during recovery were not significant.

DISCUSSION

Postpartum paresis causes the largest economic losses in dairy herds, due to complications either during the course of the illness or later because of the postpartum immunosuppression (Kimura et al. 2006). In cows with hypocalcaemia, the percentage of cases with fetal membranes retention and uterine disorders is several-fold more significant (ERB et al. 1985, CORREA et al. 1993, HOUE et al. 2001). In cows with hypocalcaemia, the incidence of uterine inflammation increases (WHITEFORD, SHELDON 2005, KIMURA et al. 2006), the process of uterus involution slows down and reproduction failures occur (BORSBERRY, DOBSON 1989, KAMGARPOUR et al. 1999, WHITEFORD, SHELDON 2005). There are reports on increased cases of ketosis and abomasum dysfunction (HOUE et al. 2001, GOFF 2003). Additionally, during hypophosfatemia there may be complications involving lameness and different peripartum recumbence (KUREK et al. 2010). However, most of these complications are not combined directly with the downer syndrome but with subclinical hypocalcaemia during the postpartum period (HOUE et al. 2001, GOFF 2003, KIMURA et al. 2006). These facts justify the assumption that the subclinical disorders observed during our study between the first and third day after the clinical symptoms had subsided can be as threatening and dangerous as milk fever itself. For herd management, it is necessary to prevent such a development. In some animals, this condition can lead to clinical disorders like the postpartum downer syndrome, worse appetite and lower milk yield, as was observed during this study.

Apparently healthy cows without any clinical symptoms showed significantly different laboratory test results than other cows from the same farms not suffering from milk fever. These animals were poor in mineral deficiency and feed conversion rate. Nevertheless, a large percentage of cows not suffering from milk fever often had different levels of subclinical hypocalcaemia and subclinical phosphorus deficiency, as observed during studies concerning high-yield dairy herds (ESSLEMONT, KOSSAIBATI 1996, GOFF, HORST 1997, HORST et al. 2003, GOFF 2008, HOUE et al. 2006). The biochemistry tests show the necessity for increased mineral supplementation (Ca and Pi) in all cows after milk fever, and simultaneous Mg supplementation in animals which had excitatory parturient paresis. Our results confirm the need for milk fever prevention and simultaneous prevention of subclinical hypocalcaemia, not only before delivery but also during the whole early postpartum period, which can be more significant (GOFF, HORST 1997, KONDRACKI, BEDNAREK 1997, PEHRSON et al. 1998, BEDNAREK, KONDRACKI 2000, STEC et al. 2000, HORST et al. 2003, GOFF 2008). Following the comatose form of milk fever, cows show significantly lower phosphorus concentrations than in the excitatory form, which poses a risk for postpartum downer cow syndrome with typical symptoms (KUREK, STEC 2004*a*,*b*, KUREK et al. 2010). Ca, Mg and Pi concentrations during the study show that correct parenteral treatment of milk fever maintains the stability of mineral metabolism for as long as 48 hours after mineral preparation administration. Afterwards, apart from slightly increased milk production and adequate nutrition of cows after an episode of the disease, the significantly lower concentrations of these minerals justify further supplementation. In our study, the cows which had had the comatose form of milk fever revealed energy balance disturbances with a significant

FFA increase and glucose decrease, especially in group IIb (free fatty acids > 700 μmol^{-1}/l). Some animals in this group could be considered as having subclinical ketosis. The results prove that it is necessary to develop a more precise energy balance management plan for cows which had the comatose form of postpartum paresis, both during the illness and afterwards, as also shown in other studies (Stec et al. 2000, Kurek, Stec 2004*a*,*b*, Vernon 2002). Many farmers use energy-rich substances added directly to water just after delivery. The study shows that this practice is advisable not only after delivery but also in cows which have previously been afflicted by milk fever.

CONCLUSIONS

Most studies on milk fever focus on the course of the illness, and observations concerning animal health afterwards are scanty (Sansom et al. 1983, Fenwick 1988, Björkman et al. 1994, Larsen et al. 2001, Kurek, Stec 2004*a*,*b*, 2005, Sobiech et al. 2010). Also, supplementation is aimed at preventing the disease only during the first 3 days after delivery (Horst et al. 1997, Bednarek et al. 2000, Stec et al. 2000, Goff 2008). Our study shows the necessity for longer monitoring periods of the animal's condition following delivery (with or without milk fever signs). For several days postpartum cows should receive higher doses of calcium and phosphorus preparations as well as energy supplements, due to significantly low calcium levels found in the third blood samples. Considering the low calcium levels in the control group during the whole study, full mineral prophylactics in high yielding cows should be an ordinary practice, and for a week after delivery doses of minerals cannot be adjusted to milk yields alone. The check-up of animals' condition cannot be based solely on clinical examination, as all the animals in group IIb showed no changes until the third to fourth day after the treatment of the comatose form of milk fever. Some animals with subclinical changes will not show significant symptoms (group IIb), but can produce significantly less milk than animals with an adquate level of macronutrients. Subclinical signs may be overlooked, and this can to large economic losses.

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