PARATHYROID HORMONE LEVEL IN BLOOD OF COWS WITH DIFFERENT FORMS OF CLINICAL HYPOCALCAEMIA

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Abstract

The research was intended to determine the parathyroid hormone (PTH) level in various forms of clinical hypocalcaemia in dairy cows with the use of the immunochemiluminometric assay (ICMA), routinely applied in humans for the measure of the hormone. The study was conducted on 59 cows of the lowland black-and-white and HF breeds, as well as crossbreds. Symptoms of clinical hypocalcaemia were confirmed in 47 animals. The symptoms occurred in the animals during the post-calving period, i.e. from several hours to about a week after calving. In the cows with clinical symptoms of hypocalcaemia the PTH level demonstrated a negative correlation with the low values of total calcium in the serum with the exception of the group of downer cows. The lowest PTH levels were confirmed in the downer cows, in which no beneficial effects of medical treatment were noted. The ICMA with human antibodies proved to be also valid for measuring the level of PTH in cows. It is relatively inexpensive and fairly quick method.

Key words: dairy cows, hypocalcaemia, parathyroid hormone, calcium.

In ruminants, the metabolism of calcium, phosphorus, and to a lesser extent of magnesium, undergoes hormonal regulation. According to the commonly held opinion, for the proper absorption of these elements from the digestive system, accumulation or removal from the skeleton or amount of their excretion through urination, the following factors are responsible: parathyroid hormone (PTH), calcitonin (CT), derived from vitamin D and its active metabolite 1,25-(OH)2 cholecalciferol, and to a minimal degree gonadal hormones, as well as selected glucocorticoids (1, 4, 5, 7, 12-14, 21). PTH plays a primary role in all conditions relevant to lowering the calcium level in extra-cellular fluids below the accepted norms (hypocalcaemia) (15, 20). As a result of its increase in the blood, aside from directly influencing particular body systems in ruminants, PTH stimulates the metabolism of vitamin D and consequently creates the active metabolite 1,25-(OH)2D through the kidney cells. This means that one of the primary factors that can influence the occurrence of a state of hypocalcaemia, and indirectly the development of clinical forms of hypocalcaemia, is an unsatisfactory level of PTH (8, 16, 19).

Parathyroid hormone is a single-chain polypeptide made up of 84 amino acids. Secreted by the parathyroid gland, it augments the absorption of calcium from the intestines and simultaneously conditions its re-absorption from the skeleton (9). Aside from this process, it is also a factor in controlling phosphorus metabolism through its re-absorption 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 (11). The decrease in calcium concentration in the plasma, especially of its ionized form, causes the increased secretion of PTH by the parathyroid, with the consequential rapid rise in the removal of calcium from the bones and the sudden increase in the re-absorption of calcium by the kidneys (10). On account of this, according to Horst et al. (9) cows affected by parturient paresis as a rule have a higher level of PTH in their blood. The above seems worth noting to help diagnosing different status of clinical hypocalcaemia. This is also the reason for finding fast and simple methods for measuring parathyroid hormone in many types of animals. On account of the technique of its application and the time required for results, up to now the radioimmunometric assay (IRMA) for measuring PTH in cats, dogs, cows and horses has not met with routine usage (6, 16), especially in dairy cattle. When it comes to the application of the immunochemiluminometric assay (ICMA) in animals, preliminary results seem to be promising. This has been particularly confirmed in measuring PTH in horses. Taking into account the speed with which results are obtained as well as the detection of lower levels of PTH in the serum, this method seems to be more sensitive and dependable. This fact has inclined us to adapt the method for routine diagnosis in the case of clinical disturbances in the calcium-phosphorus and magnesium metabolism in dairy cattle. At present, the ICMA is utilized more frequently in people rather than IRMA.
The assumption of the research was to measure PTH levels in various forms of clinical hypocalcaemia in dairy cows using the ICMA based on human antibodies. Moreover, determining its usefulness for routine diagnosis in the case of disturbances in the calcium-phosphorus and magnesium metabolism in dairy cattle, when the necessity of prognosis as to the use of therapeutic measures arises.

Material and Methods

The research was conducted on 59 cows of the lowland black-and-white and HF breeds, as well as crossbreds, aged from 2.5 to 15 years. Symptoms of clinical hypocalcaemia were confirmed in 47 animals, while 12 did not show any clinical signs (control group). The cows were fed pellet concentrates or full-portioned feeds (with grain addition), hay and corn or sugar beet leaf silage. The investigations were performed from 1999 to 2002. The sick cows showed clinical signs from the digestive, nervous, and motor systems, typical for clinical hypocalcaemia. The research concerned clinical cases that occurred in the post-calving period, i.e. from several hours to approximately a week after parturition. The animals with confirmed clinical signs originated from farms with herds of several or a few dozen dairy cows, with average or good feeding and good or very good milk yield. Cows that were ill were kept in the same place as the healthy cows.

On the basis of the speed with which the symptoms of the illness occurred as well as the results of clinical and biochemical examinations, 3 groups of animals were distinguished, which were characterized by different pictures of clinical symptoms.

The first group was made up of 12 cows in which clinical tests confirmed nervous disturbances such as excitability and increased sensitivity, with occasional ticks and spasms of single parts of skeletal muscles. Clinical examinations showed reduced appetite or its total loss or loss of thirst as well as a decrease in milk yield of varying degrees, which the owners of the cows reported in interviews. The animals of this group were found to be standing or lying down, however, while the medical treatments were administered they took on an uncoordinated standing position.

The second group was made up of 18 cows in which a drastic development of nervous symptoms, ranging from lowered consciousness to comas, was observed. These symptoms were always preceded by a lack of appetite or thirst as well as a total drop in milk yield. The animals were always in a lying position during medical treatment. In most of these cows the described symptoms occurred in a period of several days after calving.

Seventeen cows from the third group were in the lying position at the moment of collecting material for testing. Although they did not demonstrate any disturbed consciousness, the primary symptom was their difficulty in standing up. From the onset of the disease until the investigations were conducted, the animals did not demonstrate any essential symptoms of a limited appetite or thirst or even a decrease in milk yield. On the basis of the results of medical treatment this group was divided into two subgroups. The first subgroup (IIa) was made up of 9 cows that after the treatment were able to stand up and later did not demonstrate any disturbances in their motor system. The second subgroup (IIb), in which there were 8 cows, consisted of animals that were unable to stand up after the treatment and because of their worsening health status were directed to the emergency slaughter.

The fourth group of 12 clinically healthy cows was the control. They came from farms where clinical cases had been noted. The cows were from a similar period after calving, they were of a similar age and production capacity as the diseased cows.

Clinical examinations and the collection of blood samples were carried out at the same time when medical treatment was initiated. The research material was always collected directly after the initial diagnosis and before administration of the medication. At the moment of each sample collection, the following features were thoroughly analysed: the clinical state of the examined animal, feeding management, feed quality, milk production and conditions in which the animal was kept, as well as its treatment, with particular attention paid to the changes in the position of the animal. Blood from all the cows was collected from the external jugular vein. The PTH level in blood serum was measured immunometrically by the use of the Intact PTH Test Units and IMMULITE Analyzer. Total Ca content was determined by the spectrophotometric atomic absorption method utilizing the PERKIN ELMER – 4100 apparatus.

The results of the biochemical examinations were submitted to a statistical analysis. The analysis was carried out using the t-Student test on the Statistica 5.0 program. The calculation was done at $P \leq 0.05$ and $P \leq 0.01$.

Results

At the moment of collecting the samples for biochemical examination, the lowest values of PTH were found in subgroup IIb as well as group II and were 6.84 and 13.35 pg/ml, respectively (Table 1). The PTH level in subgroup IIb differed in a statistically significant way from the values of group I (19.61 pg/ml), subgroup IIIa (25.09 pg/ml), and group IV (19.84 pg/ml).

The total Ca level in the serum of the investigated cows of groups I and II (Table 1) was considerably lower than the accepted norm and was 1.20 and 1.21 mmol/l, respectively, and did not differ statistically in a significant way between both mentioned groups of the animals. In subgroups IIIa and IIIb the total Ca level was 1.89 and 1.78 mmol/l, respectively, and was statistically significantly higher in relation to groups I and II. In the control group of cows in which clinical symptoms were not observed (IV), the average total Ca level was 2.00 mmol/l and was significantly higher than the levels observed in all the remaining groups, and simultaneously lower than the generally accepted norms.
Table 1
Total plasma calcium (mmol/l) and PTH (pg/ml) levels in sick and control cows

<table>
<thead>
<tr>
<th>Group and number of animals</th>
<th>Parameters</th>
<th>X</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (12)</td>
<td>Ca</td>
<td>1.20&lt;sup&gt;Ab&lt;/sup&gt;</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>PTH</td>
<td>19.61&lt;sup&gt;AlBalc&lt;/sup&gt;</td>
<td>13.58</td>
</tr>
<tr>
<td>II (18)</td>
<td>Ca</td>
<td>1.21&lt;sup&gt;Ab&lt;/sup&gt;</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>PTH</td>
<td>13.35&lt;sup&gt;AlBad&lt;/sup&gt;</td>
<td>12.56</td>
</tr>
<tr>
<td>IIIa (9)</td>
<td>Ca</td>
<td>1.89&lt;sup&gt;BCa&lt;/sup&gt;</td>
<td>0.61</td>
</tr>
<tr>
<td></td>
<td>PTH</td>
<td>25.09&lt;sup&gt;Aece&lt;/sup&gt;</td>
<td>17.46</td>
</tr>
<tr>
<td>IIIb (8)</td>
<td>Ca</td>
<td>1.78&lt;sup&gt;ACa&lt;/sup&gt;</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>PTH</td>
<td>6.84&lt;sup&gt;Bad&lt;/sup&gt;</td>
<td>6.28</td>
</tr>
<tr>
<td>IV (12)</td>
<td>Ca l</td>
<td>2.00&lt;sup&gt;BCa&lt;/sup&gt;</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>PTH</td>
<td>19.84&lt;sup&gt;Aae&lt;/sup&gt;</td>
<td>14.90</td>
</tr>
</tbody>
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a, b, c; A, B, C – relevant differences between particular groups (P ≤ 0.05); (P ≤ 0.01)

**Discussion**

Evaluating the hormonal regulation in cows afflicted with clinical hypocalcaemia on the basis of the PTH level it can be observed that the lowest level of this hormone was confirmed in subgroup IIIb and group II. It should be noted that the cows from these groups in the first case were unsuccessfully treated and sent to the emergency slaughter, while those in the second case were afflicted with the heaviest and most severe clinical form of hypocalcaemia with symptoms of a seriously lowered level of consciousness (a coma). The results obtained in the control group (i.e. the group of clinically healthy cows showing an insignificant biochemical values typical for hypocalcaemia) 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 utilise the available Ca reserves. What is more, they can maintain Ca at such a level at which clinical signs can be prevented. The obtained results confirm the opinion of Body and Cole (3) who claimed that hypocalcaemia may not occur if there is a sufficient level of parathyroid hormone to mobilise the calcium from the skeletal reserve and from the digestive system. Likewise in the course of their research Mayer et al. (17) observed that a decrease in calcium concentration in serum 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 norms parallel to the drop in the concentration of this hormone.

The low levels of PTH measured in some cows could have been caused by a number of factors. The most common one mentioned in such cases is improper feeding by the owners of the animals, especially if too high portions of calcium are given. This stimulates the release of calcitonin, a hormone that is to an extent in opposition to PTH and limits the ability of the body to react quickly in time of crisis, consequently influencing the development of hypocalcaemia after calving (2, 19). The low levels of PTH might also result from the initial disturbances in the body in the form of weaker secretions of this hormone, but research on this hypothesis conducted by Reinhardt et al. (19) did not unequivocally confirm this assumption. However, most often lowered production and release of PTH result from the administration of too large medical calcium doses, which act in a way similar to feeding errors. Our own observations and exact analyses of the amount of administered calcium medications have confirmed this in many of the consulted cases. The consequences of such actions, as Mayer et al. (17) claim, support presented by Ramberg et al. (18) suggestion, that the parathyroid is suppressed, leading to partial or total irreversible structural changes in the cells of this organ. Thus it seems that on the basis of our own research results and those of earlier investigations of other authors the measurement of parathyroid hormone levels can have a major diagnostic significance in hypocalcaemia cases that are difficult to treat and relapses of severe hypocalcaemia in the form of post-calving paralysis occurs.
Applying the ICMA for measuring of the PTH level through the utilization of human antibodies enables the rapid and inexpensive, diagnostics of disturbances in hormonal calcium metabolism in dairy cows. This creates the opportunity of testing individual samples at every stage of the disease, which is particularly important for individual treatment of the cows. The superiority of this method over the still utilized radiological method was reported by Toribio et al. (22) in their detailed research on PTH in horses. On the basis of the listed advantages it can be concluded that the method may be routinely utilized in diagnostic testing. This concerns individual cases as well as entire herds of dairy cattle in which diseases based on deficiencies occur. However, it seems necessary to conduct further investigations in order to establish the range of appropriate PTH levels in relation to various physiological periods and disease status in dairy cows.

References