Physiological changes in hematological parameters of black-and-white cows at the beginning of lactation

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Abstract. The onset of lactation can affect the condition of cows, affecting the metabolic processes throughout the body and hematological parameters. The blood parameters of high-milk cows after the first and after the second calving were evaluated in the work. 47 fully healthy pregnant cows were selected 3 weeks before the expected calving. These included first-heifers and re-calving purebred cows of a black-and-white breed. The animals were divided into two groups according to the number of pregnancies available in their lives: the group of first-born heifers consisted of 22 heads, the group of re-calves included 25 heads. The examination was performed 3 weeks before calving and 3 weeks after calving with taking blood samples. The first heifers after calving showed a decrease in the concentration of glucose, total protein and albumin with a significant increase in the concentrations of malondialdehyde, non-esterified fatty acids and globulin compared with the first study. Re-calved cows showed a significant decrease in the amount of glucose, total protein and albumin in the blood, combined with a significant increase in cholesterol and malondialdehyde levels compared to their pre-calving values. In re-calving cows, a significant decrease in non-esterified fatty acids was noted in comparison with calved first-calf cows. During the transition phase, control of the main hematological parameters is necessary for the timely prevention of pathology in first-heifers and re-lost cows.

1 Introduction

A very important period in cattle is the time interval between 3 weeks before calving and 3 weeks after it [1]. Cows at this stage of ontogenesis experience a number of physiological and biochemical changes that can contribute to increasing the vulnerability of their body to the existing conditions of their maintenance [2]. This period is physiologically significant due to the fact that the volume of feed consumed decreases on its attraction, which forms a negative energy balance and increases the body's absorption of fat from its depot primarily in the form of non-esterified fatty acids [3].

The assessment of the parameters of the blood of the body is very important for assessing the state of their health in any conditions [4]. It is influenced by a lot of factors,

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including growth processes, pregnancy, calving, the number of past lactation, the nature of
current lactation [5]. It is known that cows have an adaptive reaction after calving,
manifested by a change in metabolism and an increase in the formation of reactive oxygen
species in the blood [6]. Despite the fact that reactive oxygen species are standard products
of all metabolic processes, in case of their excess, the development of oxidative damage,
various cellular structures throughout the body is possible [7,8]. This occurs in the case of
weakening of the physiological antioxidant mechanisms of the body that restrain
oxygenation [9]. In these conditions, the evaluation of blood parameters is of great
diagnostic importance. According to their level, it is possible to judge the state of the
animal's body and make a reliable forecast about its dynamics [10]. In addition, calved
cows have a negative energy balance, which is accompanied by fluctuations in the
concentrations of different metabolites in the blood. This is especially evident at the initial

The purpose of the study: to evaluate the features of the physiological response of the
leading hematological indicators of black-and-white cows to the completion of pregnancy,
calving and the beginning of lactation in first-heifers and in cows calving repeatedly.

2 Materials and methods

The implementation of the entire study described in this article was approved by the local
Ethical Committee for Animal Research, established at the Russian Biotechnological
University of Moscow, Russia (minutes of meeting No. 2 of 09.02.2021). The research was
conducted in the laboratory of the Department of Veterinary Medicine of the Russian
Biotechnological University, Moscow, Russia.

47 pregnant cows of black-and-white breed (body weight 460-650 kg aged 2 to 5 years
4 weeks before the expected calving) were taken into the study. In repeat-breeding cows,
the volume of milk yield for the previous lactation was at least 6000 liters. The cows were
divided into two groups according to the number of pregnancies they had: for a group of
first heifers, which included 22 heads, and for a group of re-calving cows, consisting of 25
animals. After a week of observation, blood samples were taken from the animals for
analysis. Repeated blood collection from all cows was performed three weeks after calving.

The criteria for including cows in the study were the absence of health problems in the
past, a sufficient degree of fatness, the course of calving without peculiarities, for re-
calving cows, the duration of previous lactation should have been over 200 days with an
average daily intake of at least 30 liters per day.

Blood was taken from each animal from the tail vein into a plastic tube. Before taking
blood, an anticoagulant solution was placed in a test tube to obtain serum after coagulation
of the blood placed in it. The serum levels of glucose, total protein, albumin, cholesterol,
triglycerides, non-esterified fatty acids, malon dialgid and total antioxidant protection were
determined using special test kits (BioDiagnostic, USA). The level of haptoglobin was
determined using the immunoturbidimetric method [12]. The Student's t-criterion was
calculated.

3 Results and discussion

Three weeks before calving, the main number of indicators taken into account in the study
differed between the groups of observed animals (Table 1).

According to the level of total protein, the first heifers were initially inferior to the re-
calving cows by 16.4%. The amount of albumin showed a tendency to a lower level in first-
time calving cows (4.6%). Re-calving cows before calving had a higher level of globulins
in the blood (by 34.8%). The level of haptoglobin in their blood before calving was also 78.3% higher than in the blood of the first heifers during this follow-up period. Before calving, no significant differences were found between groups of cows in terms of glucose levels. The content of non-esterified fatty acids in the blood was higher in the first heifers by 50.0%. At the same time, the levels of cholesterol and triglycerides in their blood were inferior to those of repeat calves by 18.9% and 38.1%, respectively. The value of their total antioxidant protection in the re-calves was 56.1% higher, and the content of malondialdehyde in their blood was 74.3% lower than in the first heifers.

Table 1. Blood counts in cows taken in the study

<table>
<thead>
<tr>
<th>Parameters evaluated in animals</th>
<th>First-calf cows</th>
<th>Re-calving cows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 weeks before calving, n=22</td>
<td>3 weeks after calving, n=22</td>
</tr>
<tr>
<td>Total protein, g/l</td>
<td>68.1±0.92</td>
<td>58.6±3.23*</td>
</tr>
<tr>
<td>Albumin, g/l</td>
<td>34.5±0.53</td>
<td>11.7±0.31**</td>
</tr>
<tr>
<td>Globulin, g/l</td>
<td>32.2±0.44</td>
<td>42.5±1.77**</td>
</tr>
<tr>
<td>Haptoglobin, mmol/l</td>
<td>2.3±0.22</td>
<td>3.4±0.23**</td>
</tr>
<tr>
<td>Glucose, mmol/l</td>
<td>2.86±0.15</td>
<td>2.13±0.21**</td>
</tr>
<tr>
<td>Non-esterified fatty acids, mmol/l</td>
<td>0.39±0.06</td>
<td>0.96±0.16**</td>
</tr>
<tr>
<td>Cholesterol, mmol/l</td>
<td>2.59±0.33</td>
<td>2.79±0.32</td>
</tr>
<tr>
<td>Triglyceride, mmol/l</td>
<td>0.42±0.09</td>
<td>0.43±0.06</td>
</tr>
<tr>
<td>Total antioxidant capacity, mmol/l</td>
<td>0.66±0.11</td>
<td>1.10±0.16**</td>
</tr>
<tr>
<td>Malondialdehyde, mmol/ml</td>
<td>2.58±0.14</td>
<td>1.58±0.41**</td>
</tr>
</tbody>
</table>

Note: the reliability of the differences between the indicators p<0.05 (one icon) and p<0.01 (two icons). * – between the initial and final levels of indicators in both groups of cows; + – between the initial levels of indicators in the compared groups of cows; – between the final levels of indicators in the compared groups of cows.

In first-calf cows, the recorded indicators experienced dynamics between three weeks before calving and three weeks after calving (Table 1). The amount of total protein in first-calf cows decreased by 16.2% between both observations. The amount of albumin in their blood decreased 2.9 times compared to the baseline level. For the first time, calving cows showed an increase in the level of globulins in the blood by 31.9%. The level of haptoglobin in their blood before calving was 47.8% lower than after it. Before calving, the glucose level in the blood of the first heifers was 34.3% higher than in the repeated study. The content of non-esterified fatty acids in their blood was initially low, and after 3 weeks after calving it increased by 2.5 times. The content of cholesterol and triglycerides in their blood had no significant differences between the two studies conducted. The level of total antioxidant protection of the body in the first heifers increased by 66.7% between observations, and the content of malondialdehyde in their blood decreased by 63.2%.

In re-calving cows, the recorded indicators also experienced dynamics during the observation between three weeks before calving and three weeks after it (Table 1).
The concentration of total protein in re-calving cows decreased by 20.5% between both observations. The level of albumin in their blood decreased by 3.2 times compared to the baseline level. Re-calving cows showed an increase in the level of globulins in the blood by 14.0%. The content of haptoglobin in their blood before calving was 36.7% higher than after it. Before calving, the glucose level in the blood of these cows was 51.9% higher than three weeks after it. The content of non-esterified fatty acids in their blood was initially low, and 3 weeks after calving it was 42.3% higher than the outcome. The cholesterol level in their blood during the period under consideration increased by 17.2%, and the amount of triglycerides decreased by 38.1% between the two studies conducted. The total antioxidant protection of the body in cows calving repeatedly increased by 27.2% between the observations performed.

Three weeks after calving, the main number of indicators taken into account in the study differed between the groups of cows observed (Table 1).

According to the level of total protein, the first heifers at the end of the observation were inferior to the re-calving cows by 12.3%. At this stage, the amount of albumin in the blood of cows of both groups was comparable. Re-calving cows after calving had a higher level of globulins in the blood (by 16.5%). The level of haptoglobin in their blood after calving was 13.3% lower than in the blood of the first heifers. Three weeks after calving, the glucose content in the blood of the re-calves was 18.9% lower. The amount of non-esterified fatty acids in the blood at the end of the observation was 2.6 times higher in the first heifers. At the same time, the cholesterol level in their blood at the end of the follow-up was 29.4% lower than that of repeat calves with comparable triglyceride levels. The level of total antioxidant protection three weeks after calving in the re-calves was 19.1% higher, and the content of malondialdehyde in their blood was 26.4% lower than in the first heifers.

4 Discussion

The conducted observation helped to identify changes in the hematological, and, consequently, in the metabolic profile of black-and-white cows before and after calving in first-borns and in repeat-borns. The work carried out made it possible to evaluate the features of changes in hematological parameters and biomarkers of oxidant processes during the transition of their body from pregnancy to lactation. Monitoring of these changes is of great importance for determining the health status of cows and can help predict the dynamics of the metabolic status of animals during this period [13]. Taking into account the results of the study, it can be assumed that in the postpartum period, the negative energy balance of the first heifers is more pronounced. At the same time, the development of a certain imbalance of pro-oxidants /antioxidants was noted in the postpartum period in primiparous cows, being present in repeat-giving cows only before calving.

The state of metabolism in an animal is of great importance for the formation of its morphofunctional status [14]. During the assessment of the metabolic state of cows, the nature of the previous ontogenesis is of serious importance [15]. At the same time, it is clear that lactation strongly affects all the reserves available in the cow's body [16].

In the course of the study, the first heifers after calving revealed a significant decrease in the amount of glucose, total protein and albumin in the blood, with an increase in the content of malonic dialdehyde, non-esterified fatty acids and globulin in comparison with their levels before calving. Earlier observations showed a higher level of non-esterified fatty acid in the first heifers between 2 and 8 weeks in the postpartum period [17]. At the same time, in another study, the authors found that the level of non-esterified fatty acids increases from 1 week before calving, which is then replaced by a gradual decrease after calving. These circumstances suggest that the increase in the level of non-esterified fatty
acids of first-calf cows may be caused by the high energy needs of these animals for their growth, the needs for the implementation of the first lactation and stress caused by the first calving [18]. There is also an opinion that the first heifers may be more susceptible to the development of a deficiency in nutrients and energy during and after calving. A significant decrease in the level of total protein at this time develops, apparently, due to the fact that the body of cattle uses amino acids obtained during protein degradation as a biologically significant source of energy in the synthesis of ATP [19].

In our study, some hypoglycemia was noted in the first heifers after calving, which is consistent with earlier research results [17]. A very high need for glucose is associated with the development of their body's stress on the formation of milk, leading to some hypoglycemia. There is an opinion of some researchers that glucose is an insensitive marker of energy processes in cattle due to their perfect homeostatic regulation of its level [20]. At the same time, there is an opinion that the amount of glucose in the blood in the blood in combination with the level of non-esterified fatty acids in it is very significant for assessing the energy potential of an animal [21].

The registration of hematological parameters in re-calving cows allowed us to establish a significant decrease in their glucose, total protein and albumin, combined with an increase in the amounts of cholesterol and malondialdehyde compared with the end of pregnancy. An increase in glucose demand during the onset of lactation, primarily in highly productive cows, can lead to the development of episodes of hypoglycemic state [22]. A negative energy balance during the beginning of lactation, especially in highly productive dairy cows, stimulates the use of protein and fat reserves in the animal's body in order to compensate for the condition, which is manifested by a decrease in protein levels in their blood after calving [23].

A significant increase in the cholesterol content in the blood after calving was found in re-calving cows. This observation is consistent with the previously obtained results of other research authors, who noted that the level of cholesterol in the blood is slightly higher in re-calving cows at the beginning of lactation. This circumstance contributes to the mobilization of fat, which is realized at this time. The concentration of cholesterol at the very end of pregnancy and during calving turns out to be slightly lower than during the second week of lactation, due to the high needs of the fetus during its intrauterine development, and as a result of the high activity of the ovaries implementing intensive synthesis of steroid hormones. A more significant increase in cholesterol concentration in re-calving cows is probably caused by greater mobilization of it from different tissues, high consumption and assimilation of feed, and very active synthesis of steroid hormones and molecules of different lipoproteins after calving [24].

In earlier studies, when comparing the condition of first-calf cows and re-calves, minor differences were shown in a number of biochemical parameters, including levels of glucose, albumin, total protein, triglycerides and cholesterol [25], which is consistent with the results of our work.

Comparing the condition of cows after calving of first heifers and calves, a significant decrease in the indicators of non-esterified fatty acids was found. In the course of previous observations, contradictory results were obtained, for example, some researchers wrote that the dynamics of non-esterified fatty acids is more significant in cows that have already gone through several calving in their lifetime [26]. In other studies, it was not possible to find significant differences in the level of non-esterified fatty acids between re-calved and cow heifers. Another study showed that non-esterified fatty acids strongly correlate with the duration of the lactation process than with the duration of pregnancy. Previous observations have shown that first-calf cows have a clear negative energy balance, which is associated with their ongoing growth processes, with the intrauterine development of their fetus and with subsequent lactation against the background of decreased appetite after calving [27].
Currently, there is a high interest in free radical processes that can disrupt the course of many metabolic transformations in cows, including in the transition period. Normally, the body is able to actively fight the excess formation of free radicals using a number of antioxidation mechanisms. The levels of malondialdehyde and total antioxidant protection in cows before and after calving can reflect the state of equilibrium during this physiological period [28]. The results of our study indicate that the amount of malondialdehyde was significantly higher in the postpartum period, in first-heifers and in re-calving cows. Previous observations by other authors suggest similar results. Due to the fact that the mobilization of non-esterified fatty acids in lactating cows is combined with an increase in the production of free radicals. Under these conditions, there is an increase in the level of malondialdehyde in the body's media [29].

In the study, the overall antioxidant protection was taken into account to register the balance between the levels of pro-oxidants and the capabilities of antioxidants. The determination of the total antioxidant protection was used for an approximate assessment of the antioxidant system. This observation revealed a slight increase in the overall antioxidant protection after calving in cows calving repeatedly. Also, as in the previous work, it was not possible to trace correlations between the levels of oxidizing substances and the capabilities of antioxidants in cows after calving. At the same time, the highest level of total antioxidant protection was noted in cows during the eighth week of the lactation process. These animals are considered to be highly predisposed to the development of oxidative stress, which can negatively affect all health parameters. This may explain why the synthesis of peroxides is higher than the functional capabilities of the anti-oxidation system. The state of oxidative stress can occur as a result of a strong release of oxidants and/or a decrease in antioxidant protection [30]. Having conducted our own research, it is necessary to emphasize the great importance of the level of oxidative processes and metabolic processes in cows after calving and consider these parameters as important for assessing the metabolic status.

The situation may be caused by the appearance of endometritis, ketosis and non-discharge of the placenta after calving the cow. In the conducted observation, it was not possible to detect significant differences in haptoglobin levels between the observation groups. In previous studies, a significant increase in the level of haptoglobin was noted during the week after calving. At the same time, previous studies are consistent with the results we obtained and revealed a slight increase in haptoglobin after calving. Also, differences may appear in view of the individual variability of any physiological reactions after calving. This is confirmed by the fact that some cows do not have an increase in haptoglobin levels immediately after calving. Also, the previous study suggested that the first calves calving spontaneously may have a slight injury to the cervix and vagina during calving, which often goes unnoticed, but leads to the development of the inflammatory process and to an increase in the level of haptoglobin [31]. At the same time, other researchers believed that the increase in haptoglobin levels may mainly be associated with the appearance of acute infection, and not with trauma, including after normal childbirth in normal conditions that do not affect the concentration of haptoglobin [32].

5 Conclusion

The end of pregnancy, calving and the beginning of lactation are always accompanied by a number of changes in metabolic and oxidative processes in the body in first-born heifers and in cows that are calving repeatedly. At the same time, the first heifers react more to the development of a negative energy balance during the transition period, which is accompanied by a higher increase in the level of free non-esterified fatty acids in their blood compared to cows calving repeatedly. In both categories of cows, a weakening of the
antioxidant protection of the body was noted, which indicates the need for them to systematically prevent the development of oxidative cell damage in dairy cows during the transition period, regardless of the number of previous pregnancies.

References

1. S. Praveen, et al., Int. J. Sci. Environ, 7(3), 950-954 (2022)
18. I. Medvedev. Lecture Notes in Networks and Systems 354 LNNS, 538-543 (2022)
20. N. Vorobyeva, I. Medvedev. Lecture Notes in Networks and Systemsthis link is disabled, 354 LNNS, 476-484 (2022)
30. I.N. Medvedev, O.N. Makurina, G.S. Mal. AIP Conference Proceedingsthis link is disabled, 2467, 070044 (2022)