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RESEARCH ARTICLE

Iron Metabolism and Haematological Changes in Ewes During The Periparturient Period

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Abstract

This study sought to evaluate changes in plasma iron (Fe), unsaturated iron-binding capacity (UIBC), and hematocrit (Hct) levels in pregnant ewes before and after parturition. Blood samples were collected 10 days before and 10 days after birth, and concentrations of Fe, UIBC, and Hct were evaluated. The results indicated a substantial reduction in plasma iron levels postpartum (p=0.042) and a considerable elevation in UIBC levels (p=0.004). No statistically significant variation in Hct level was observed between the prepartum and postpartum periods (p=0.531). The reduction in plasma iron levels may be linked to heightened physiological requirements for iron and bleeding associated with parturition. Increased UIBC levels indicate changes in transferrin binding capacity during the postpartum period. Hct levels remained consistent postnatally, signifying the preservation of hematopoietic equilibrium.

Key Words: Ewes, iron, unsaturated iron-binding capacity

Koyunlarda Periparturient Periyotta Demir Metabolizmasi ve Hematolojik Değişiklikler

Öz

Bu çalışma, gebe koyunlarda doğum öncesi ve sonrası plazma demir (Fe), doymamış demir bağlama kapasitesi (UIBC) ve hematokrit (Hct) seviyelerindeki değişimleri değerlendirmek amacıyla gerçekleştirilmiştir. Çalışmada, doğumdan 10 gün önce ve doğumdan 10 gün sonra alınan kan örneklerinde Fe, UIBC ve Hct düzeyleri analiz edilmiştir. Elde edilen bulgular, doğum sonrası dönemde plazma Fe seviyelerinin anlamlı bir şekilde azaldığını (p=0.0425), buna karşılık UIBC seviyelerinin belirgin bir artış gösterdiğini (p=0.0004) ortaya koymuştur. Hematokrit seviyelerinde ise doğum öncesi ve sonrası dönemler arasında istatistiksel olarak anlamlı bir fark bulunmamıştır (p=0.531). Plazma Fe seviyelerindeki azalma, doğum sırasında meydana gelen kan kaybı ve artan fizyolojik demir ihtiyacı ile ilişkilendirilebilir. UIBC seviyelerindeki artış ise doğum sonrası transferrin bağlanma kapasitesindeki değişiklikleri yansıtmaktadır. Hct seviyelerindeki stabil durum, doğum sonrası hematopoetik dengenin korunduğunu göstermektedir.

Anahtar Kelimeler: Demir, doymamış demir bağlama kapasitesi, koyun

INTRODUCTION

Iron (Fe) is an essential component of hemoglobin (Hb), as well as numerous enzymes and proteins, and it is continuously recycled within the erythrocyte cycle. Following the breakdown of aging erythrocytes, the released Fe can be stored in the form of ferritin or hemosiderin by the mononuclear phagocyte system or can bind to transferrin and be released into the plasma for use in the production of new erythrocytes (1,2). The capacity of transferrin to transport iron is defined as the total iron-binding capacity (TIBC) and is measured by the transferrin saturation. The unsaturated iron-binding capacity (UIBC) is calculated by subtracting the bound iron capacity from the total serum iron concentration (1). TIBC increases in cases of iron deficiency in humans, horses, cattle, and pigs, while it does not show significant changes in dogs. Additionally, it has been reported that TIBC is elevated in malnourished sheep, whereas it remains low or at the lower limit of the normal range in inflammatory diseases (2,3).

Iron deficiency leads to a reduction in hemoglobin (Hb) synthesis, resulting in increased erythrocyte division and the development of microcytosis (3,4). Typically, mean corpuscular volume (MCV) and mean corpuscular hemoglobin concentration (MCHC) are found at lower levels; however, in some cases, MCHC may remain within the normal range (2). Although microcytosis is primarily associated with iron deficiency but it can also be observed in other pathophysiological conditions (5). In anemias caused by chronic blood loss, iron depletion can lead to erythropoiesis suppression and normocytic anemia, whereas in inflammatory processes, iron retention results in decreased plasma iron levels (6,7). During pregnancy, anemia poses serious health risks, including fetal growth retardation (8).

In the evaluation of iron metabolism, parameters such as erythrocyte count (RBC), hematocrit (HCT), hemoglobin concentration (Hb), serum iron level (Fe), total iron-binding capacity (TIBC), unsaturated iron-binding capacity (UIBC), and transferrin saturation (TS%) are considered fundamental biochemical markers (6,9). Additionally, copper (Cu) deficiency can negatively impact erythropoiesis, leading to anemia (10). Although iron deficiency is relatively rare in ruminants, factors such as nutritional deficiencies, blood loss, or increased iron demand can contribute to its development (11). In anemia resulting from chronic blood loss, iron stores are initially depleted, and as the condition progresses, erythropoiesis is affected, leading to a decline in hemoglobin synthesis (12).

Total iron-binding capacity (TIBC), unsaturated iron-binding capacity (UIBC), and transferrin saturation percentage (%TS) are key parameters associated with iron deficiency and metabolic adaptations (13). However, long-term, controlled studies investigating iron metabolism and hematological changes in pregnant ewes during pre- and post-partum periods remain limited. In this study, the effects of pregnancy on iron metabolism were investigated by evaluating Fe, UIBC, and Hct levels in blood samples collected from ewes two weeks before and after parturition.

MATERIAL AND METHODS

Animals and Housing Conditions

This study was conducted at the Ewes Husbandry Unit of Kastamonu University İhsangazi Vocational High School. Twelve clinically healthy Anatolian Merino ewes, confirmed to be negative for parasitic infections via flotation and sedimentation parasitological tests, were included in the study. The ewes were between 2 and 5 years of age, had optimal body condition, and were maintained under identical housing and feeding conditions. The study was carried out during the thermoneutral period of the year. The animals were grazed on pasture during the day, and upon being housed in the barn, their diet was supplemented according to the nutritional value of the pasture. Their ration was enriched with a commercial concentrate mixture containing alfalfa, wheat bran, sunflower meal, soybean meal, ground corn, barley, calcium carbonate, and a vitamin premix. All ewes had ad libitum access to drinking water.

Experimental Design and Blood Sampling

This study collected blood samples from the same ewes at two different time points: before and after parturition. The first blood samples were obtained 10 days (±2 days) before the expected lambing date, while the second sampling was performed 10 days (±2 days) postpartum. All blood samples were collected under sterile conditions via jugular venipuncture.

Biochemical Analyses

Blood samples collected in Vacusera 4 mL lithium heparin tubes (Türkiye) were centrifuged to separate the plasma, which was then stored at -20°C until analysis. Plasma iron (Fe) and unsaturated iron-binding capacity (UIBC) measurements were performed using the DiaSys respons® 910 Vet desktop biochemistry analyzer (DiaSys Diagnostic Systems, USA, Wixom, MI).

Hematological Analyses

Blood samples were drawn from the same vein and placed in 2 mL EDTA-coated vacutainer tubes (Hema&Tube®, Türkiye) for hematological analysis. The samples were examined within two hours of being drawn. Hematocrit (Hct) was manually measured using the microhematocrit method. During blood sampling, special attention was given to minimizing the risk of contamination by shaving the phlebotomy site and disinfecting it with an antiseptic solution. The samples were transported to the laboratory in cold storage containers with ice and analyzed on the same day. This study did not include a control group but aimed to assess changes occurring in the prepartum and postpartum periods. No baseline values were established before blood collection.

Statistical Analysis

The statistical analyses of the obtained data were performed using MedCalc (Ostend, Belgium) statistical software. The normality assumption of the measured parameters was assessed using the Shapiro-Wilk test. Changes in plasma iron (Fe), UIBC concentration, and Hct level during the prepartum and postpartum periods were analyzed using the Wilcoxon singed rank test. Graphs were generated using GraphPad software. A p-value of <0.05 was considered statistically significant.

RESULTS

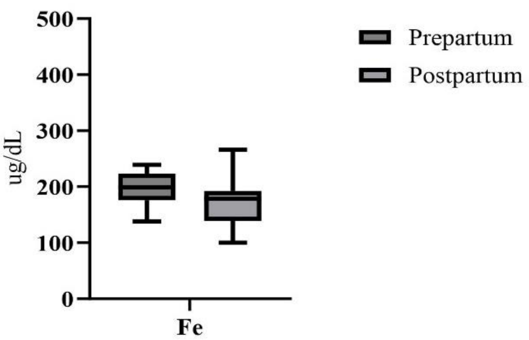
This study examined changes in plasma Fe, UIBC, and Hct parameters during the prepartum and postpartum periods. The findings were analyzed to assess the effects of parturition on iron metabolism and hematological adaptation processes in the postpartum period (Table 1).

Table 1. Prepartum ve postpartum dönemde plazma Fe, UIBC ve Hct değerleri. Data were expressed as mean ± standard deviation (95% CI). Fe: Iron, UIBC: Unsaturated Iron Binding Capacity, Hct: Hematocrit.

Variable	Prepartum (n=12)	Postpartum (n=12)	Significance
Fe (ug/dL)	204±27 (191-223)	171±44 (139-192)	p=0.0425
UIBC (ug/dL)	215±49 (185-246)	304±58 (267-342)	p=0.0004
Hct (%)	37±4 (34-39)	38±2 (36-39)	p=0.5315

According to the obtained data, the Fe level was measured as 204±27 µg/dL in the prepartum period, whereas it decreased to 171±44 µg/dL in the postpartum period. This reduction in Fe levels was found to be statistically significant (p=0.042). The observed decline in the postpartum period may be associated with changes in maternal iron metabolism. The decrease in plasma iron levels can be explained by increased erythropoiesis, blood loss during parturition, and heightened iron demand in the postpartum period. The changes in plasma iron (Fe) levels during the prepartum and postpartum periods are presented graphically (Chart 1).

Chart 1. Box plot of prepartum and postpartum serum Fe concentrations in ewes. The horizontal line inside the box represents the median value, the box boundaries indicate the 25th and 75th percentiles, and the vertical lines (whiskers) show the minimum and maximum values. A statistically significant decrease in Fe levels was observed in the postpartum period (p = 0.042).



UIBC levels increased significantly from 215±49 µg/dL in the prepartum period to 304±58 µg/dL in the postpartum period (p=0.004). This significant rise in UIBC levels may reflect changes in transferrin binding capacity and reduced circulating free iron during the postpartum period. Additionally, the impact of postpartum inflammatory processes on iron metabolism could also contribute to the observed increase in UIBC levels. Chart 2 presents the changes in UIBC levels during the prepartum and postpartum periods.

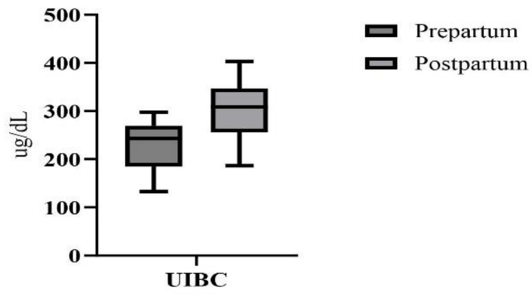
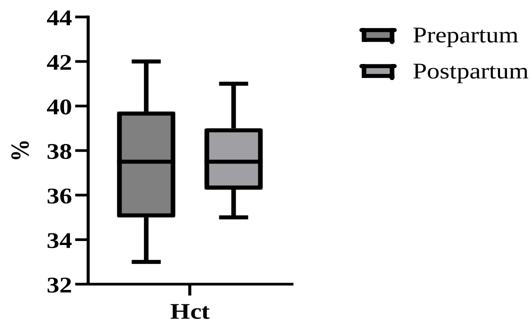


Chart 2. Box plot of serum UIBC levels measured in ewes during the prepartum and postpartum periods. The horizontal line inside the box represents the median value, the box boundaries indicate the 25th and 75th percentiles, and the vertical lines (whiskers) show the minimum and maximum values. A statistically significant increase in UIBC levels was observed in the postpartum period (p = 0.004).

Hct levels were measured at 37±4% in the prepartum period and 38±2% in the postpartum period. This change in Hct levels was not statistically significant (p=0.531). This result suggests that hematopoietic balance is maintained in the postpartum period and that the circulating erythrocyte mass remains largely preserved. Chart 3 illustrates the changes in Hct levels during the prepartum and postpartum periods.

Chart 3. Box plot of Hct levels measured in ewes during the prepartum and postpartum periods. The horizontal line inside the box represents the median value, the box boundaries indicate the 25th and 75th percentiles, and the vertical lines (whiskers) show the minimum and maximum values. No statistically significant difference was observed in Hct levels between the prepartum and postpartum periods (p = 0.531).



These findings indicate that plasma iron levels significantly decrease in the postpartum period, whereas UIBC levels show a statistically significant increase. On the other hand, the observed changes in hematocrit levels were not statistically significant, suggesting that parturition does not have a pronounced effect on hematocrit levels.

DISCUSSION AND CONCLUSION

In this study, changes in plasma Fe, UIBC, and Hct parameters were evaluated in pregnant ewes during the prepartum and postpartum periods. Our findings revealed a significant decrease in plasma iron levels in the postpartum period and a notable increase in UIBC levels. In contrast, no statistically significant change was observed in Hct levels.

The obtained results are significant in understanding the effects of parturition on iron metabolism and the changes in hematological parameters during the postpartum period. In particular, the decline in plasma iron levels postpartum may be associated with the redistribution of maternal iron metabolism and increased physiological demands. The increase in UIBC levels could be linked to alterations in transferrin saturation and an elevated free iron-binding capacity during the postpartum period.

Significant changes in iron metabolism occur during the postpartum period. As shown in Figure 1, plasma iron levels postpartum exhibited a statistically significant decrease compared to the prepartum period ($p \leq 0.05$). This decline may be associated with physiological blood loss during parturition, increased erythropoiesis, and the heightened iron demand in the postpartum period. Additionally, the initiation of lactation and the subsequent utilization of iron for milk production could be another contributing factor to the reduction in plasma iron levels. These findings are consistent with previous studies (14-17) and support that iron homeostasis undergoes a postparturient reorganization, with maternal body resources adapting to changing physiological demands. Similarly, some studies have reported a decline in iron levels postpartum, suggesting that this reduction may be linked to postpartum inflammatory processes and iron metabolism regulation via hepcidin.

In the present study, the UIBC level was determined as 215±49 µg/dL in ewes sampled 10 days before parturition and 304±58 µg/dL in those sampled 10 days after parturition. In a study conducted on healthy Awassi sheep and sheep with iron deficiency anemia, UIBC levels were reported as 149±5 µg/dL in non-pregnant ewes, 175±7 µg/dL during the prepartum period, and 154±9 µg/dL in the postpartum period (18). Similarly, in a study on Akkaraman sheep, the mean prepartum UIBC level was reported as 157.2±5.3 µg/dL (6). A study conducted on cows also reported a prepartum UIBC level of 185.35±9.78 µg/dL (19).

On the other hand, UIBC levels reported in a different study (3) were found to be higher than those obtained in the three previously mentioned studies. In our study, the UIBC levels were higher than those reported previously (6,18,19), but lower than those reported in another study (3). These variations suggest that prepartum and postpartum UIBC levels may vary across different sheep breeds and cattle, as reported in studies on different species. At the same time these discrepancies may be attributed to genetic variations among sheep, differences in analytical methods, dietary regimens, environmental factors, and iron metabolism changes associated with pregnancy. In particular, physiological alterations in iron-binding capacity during pregnancy and lactation may contribute to the differences observed across studies.

In this study, no statistically significant difference was found in hematocrit (Hct) levels between the prepartum and postpartum periods ($p=0.531$). This finding suggests that hematopoietic balance is maintained postpartum and that erythropoiesis may have compensated for potential blood loss. Additionally, the stability of plasma volume could have contributed to the limited changes observed in hematocrit levels. In this study, the Hct level was found to be consistent with those reported in pregnant ewes in earlier studies (3,20). However, lower values were observed compared to those reported in previous studies (21,22). These variations among studies may be attributed to differences in breed, dietary regimens, and environmental conditions (23,24).

In this study, changes in plasma Fe, UIBC, and Hct levels were evaluated in pregnant ewes before and after parturition. The results indicated a significant decrease in plasma iron levels postpartum, whereas UIBC levels showed a notable increase. However, no significant difference was detected in Hct levels between the prepartum and postpartum periods. The decline in plasma iron levels may be associated with blood loss during parturition and an increased physiological demand for iron. The increase in UIBC levels could reflect changes in transferrin binding capacity in the postpartum period. Meanwhile, the stability of Hct levels suggests that hematopoietic balance was maintained. These findings contribute to a better understanding of the effects of parturition on hematological parameters and iron metabolism. Future studies may investigate these changes in different breeds and under varying environmental conditions to provide a more comprehensive analysis.

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CONFLICT OF INTEREST

The authors assert that the research was performed without any commercial or financial affiliations that could be perceived as a potential conflict of interest.

AUTHOR CONTRIBUTIONS

OD: Data curation, Writing – original draft, Methodology. SB: Writing–review & editing. BIS: Writing–original draft. AS: Writing–original draft. TS Writing–review & editing. KCT: Formal analysis, Methodology, Resources, Writing–original draft.

ETHICAL STATEMENT

All procedures were conducted in accordance with the Animal Welfare Guidelines, and the study was approved by the Kastamonu University Animal Experiments Ethics Committee (21/2025).

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