

Reference values for selected hematological and biochemical blood parameters from pre-pregnancy to advanced gestation in Angora cats

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Abstract: The aim of this study was to monitor some hematological and biochemical blood parameters from pre-pregnancy to advanced gestation in Angora cats. In the present study, 35 blood samples obtained before and during pregnancy from 7 adult cats were used. Blood was collected from cats before pregnancy and on days 15, 30, 45, and 55 of gestation. The blood samples were analyzed in terms of WBC, RBC, Hb, PCV, MCV, MCH, MCHC, GRA, MON, and LYM values. Additionally, serum ALT, AST, ALP, GGT, LDH, and CK activities and total cholesterol, glucose, triglyceride, urea, Ca, Mg, and Pi levels were measured. Levels of leukocytes, MCHC, MCH, and MCV were lower, and RBC, PCV, and Hb levels were higher before pregnancy than on day 55 of gestation. Monocyte and glucose levels were higher before gestation than during pregnancy. Total cholesterol levels were lower before gestation than during gestation. Triglyceride and Mg levels with LDH activity were higher in the late stages of pregnancy than before gestation. In conclusion, in this study changes in selected hematological and biochemical blood parameters have been determined before and during pregnancy in Angora cats for the first time. The data presented in this research may be a useful reference for veterinarians practicing in clinics.

Key words: Angora cats, pregnancy, biochemical, hematological

1. Introduction

Angora cats are one of the cat breeds of central Turkey and originate in the Ankara region. The length of pregnancy is usually between 58 and 63 days in these animals (1). During gestation, significant changes are observed in the cardiovascular, respiratory, and gastrointestinal systems and in the blood parameters of the animals (2). Several factors, including age, sex, animal breed, gestation, nutrition, and season have effects on the alterations observed in hematological and biochemical blood parameters (3–5). In veterinary medicine, blood parameters analysis is important in that it complements clinical findings and contributes to an accurate diagnosis. In order to ensure an accurate interpretation of analysis results, reference blood values should be available for each animal species (6,7).

Research has demonstrated the occurrence of alterations in certain parameters during gestation and the lactation period after birth (8,9). Özyurtlu et al. (10) reported that the availability of reference values for biochemical parameters in the periods before and after pregnancy would contribute to the monitoring of the reproductive period and the detection of irregularities

in Awassi sheep. In a study conducted on goats, it was determined that in advanced stages of gestation, hemoglobin (Hb) levels increased while leukocyte (WBC) numbers decreased (11).

Although hematological and biochemical parameters have been investigated in several animal species (9,10), no reference values are available for blood parameters before and during pregnancy in the Angora cat. Therefore, the aim of this study was to describe the values of selected biochemical and hematological blood parameters pertaining to the periods before and during pregnancy in the Angora cat.

The data obtained in this study will contribute to the diagnosis of various physiological and pathological cases encountered during gestation, the monitoring of the course of diseases, as well as future research on Angora cats.

2. Materials and methods

2.1. Animals

In this study, a total of 35 blood samples obtained before and throughout pregnancy from 7 healthy, vaccinated adult cats (1–3 years old) housed in Kırıkkale University

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were used. The length of gestational periods for these cats was between 58 and 63 days. Animals were fed with dry commercial cat food during the study.

The blood samples were collected before pregnancy and on days 15, 30, 45, and 55 of gestation from each cat in the morning before feeding. The animal care and use protocol was reviewed and approved by the ethics committee of Kırıkkale University (28.04.2008/19).

2.2. Hematological analysis

Blood samples for hematology were obtained through V. cephalica antebrachii puncture in vacuum tubes containing EDTA as an anticoagulant. Anticoagulated blood samples were used to determine WBC and erythrocytes (RBC) numbers; Hb; packed cell volume (PCV); mean corpuscular volume (MCV); mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC); and granulocytes (GRA), monocyte (MON), and lymphocyte (LYM) numbers by using commercial test kits on a blood counting machine (MS9-3; Melet Schloesing Laboratory, France). All samples were evaluated on the same day.

2.3. Biochemical analysis

Serum was separated from blood samples collected into sterile tubes by centrifugation at 3000 rpm for 10 min. The serum samples were stored at -30°C until analyzed. In the serum, alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), gamma glutamyl transferase (GGT), lactate dehydrogenase (LDH), and creatinine kinase (CK) activities and total cholesterol, glucose, triglyceride, urea, calcium (Ca), magnesium (Mg), and inorganic phosphor (Pi) levels were determined using commercial test kits (Biolabo, France) by spectrophotometer (Shimadzu UV-1700, Japan).

2.4. Statistical analysis

Data analysis was carried out by using the SAS 8.02 statistical program (SAS Inst.; Cary, NC, USA). The data were evaluated independently by general linear model (GLM) procedure. Fisher's least significant difference (LSD) test was used for differences between each group, with $P < 0.05$ considered significant. All results were presented as the arithmetic means \pm standard error of means (mean \pm SEM).

3. Results

3.1. Hematological parameters

Erythrocytes, PCV, and Hb levels were higher ($P < 0.05$) and MCH levels were lower ($P < 0.01$) before and during (on days 15, 30, 45) gestation in comparison to day 55 of pregnancy. Mean corpuscular volume ($P < 0.05$) and MCHC ($P < 0.01$) levels were lower in cats before and on day 15 of gestation than on day 55 of pregnancy ($P < 0.05$). Leukocyte levels were lower in nonpregnant cats

compared to levels on days 30 and 55 of gestation ($P < 0.05$). Significant differences in LYM levels were not observed when levels before pregnancy and during pregnancy were compared ($P > 0.05$). The monocyte level was higher and GRA level lower before gestation than on days 15 and 30 of pregnancy (Table 1; $P < 0.05$).

3.2. Biochemical parameters

There were no significant changes in serum ALT, AST, ALP, and CK activities and Ca levels when before-pregnancy levels were compared with levels throughout the pregnancy ($P > 0.05$). Gamma glutamyl transferase activity and Pi and Mg levels in serum were significantly lower on day 15 compared with day 55 of gestation ($P < 0.05$). Serum glucose levels were higher, while total cholesterol levels before gestation were lower than in pregnant cats, except on day 15 of pregnancy ($P < 0.05$). Triglyceride and Mg levels and LDH activity in the serum were higher on day 55 of pregnancy than before gestation ($P < 0.05$). This study also showed that serum urea levels on days 15 and 30 of gestation were lower than on days 45 and 55 of pregnancy (Table 2; $P < 0.05$).

4. Discussion

Hematological and biochemical blood parameters are of great importance to the veterinary practitioner as they provide valuable information that can contribute to the assessment of the health status of the animal and the monitoring of prognosis in pathological disorders (12). It is well known that multiple factors including age, nutrition, stress, temperature, gestation, muscle activity, and disease have effects on the changes observed in blood parameters (13,14).

In the present study RBC, PCV, and Hb values significantly decreased in the advanced stages of gestation ($P < 0.05$). This decrease was in agreement with the results of previous research conducted in other animal species, including sheep, horses, goats, dogs, and pigs (11,15,16). Such decreases, which occur close to the time of birth, may create a hemodilution effect resulting from an increased plasma volume. The hemodilution mechanism is of particular importance in animals as it enables increased oxygen and nutrient supply to the fetus by decreasing blood flow in the capillaries and increasing the blood flow in the placental capillaries (17). Furthermore, the MCV increased significantly in advanced stages of gestation. The increase observed in MCV could be related to the need for increased oxygen transport capacity of the blood resulting from decreased RBC numbers.

Leukocyte numbers significantly increased on day 55 of gestation ($P < 0.05$). It has been reported that WBC numbers increase towards the time of birth (16). These counts are generally above the standard values in most domestic animals (16). In the advanced stages of gestation,

Table 1. Selected hematological parameters before and during pregnancy in Angora cats (n = 7). Values represented as mean ± SEM in the table.

Parameters	Before pregnancy	During pregnancy				P value
		Day 15	Day 30	Day 45	Day 55	
RBC ($\times 10^6/\mu\text{L}$)	8.12 ± 0.6 ^a	7.61 ± 0.1 ^a	6.86 ± 0.2 ^a	6.83 ± 0.9 ^a	5.22 ± 0.3 ^b	P < 0.05
PCV (%)	33.47 ± 1.8 ^a	39.77 ± 3.9 ^a	33.78 ± 0.6 ^a	32.25 ± 3.6 ^{ab}	24.30 ± 1.2 ^c	P < 0.05
Hb (g/dL)	11.33 ± 0.7 ^a	11.27 ± 0.6 ^{ab}	9.7 ± 0.6 ^{ab}	9.76 ± 0.1 ^{ab}	9.15 ± 1.3 ^{bc}	P < 0.05
MCV (fL)	41.68 ± 0.6 ^c	46.59 ± 0.6 ^{bc}	50.71 ± 1.6 ^{ab}	55.57 ± 4.6 ^a	57.84 ± 2.4 ^a	P < 0.05
MCH (pg)	13.67 ± 0.4 ^b	14.49 ± 0.5 ^b	13.52 ± 0.3 ^b	13.33 ± 0.9 ^b	33.26 ± 2.9 ^a	P < 0.01
MCHC (%)	32.78 ± 0.7 ^b	31.17 ± 1.0 ^{bd}	27.42 ± 0.3 ^{cd}	24.47 ± 1.2 ^c	52.76 ± 2.8 ^a	P < 0.01
WBC ($\times 10^3/\mu\text{L}$)	11.41 ± 0.9 ^b	11.27 ± 0.4 ^b	16.4 ± 0.8 ^a	12.7 ± 1.0 ^{bc}	15.47 ± 1.8 ^{ac}	P < 0.05
LYM ($\times 10^3/\mu\text{L}$)	3.69 ± 0.3	2.95 ± 0.0	3.81 ± 0.5	3.86 ± 0.4	3.64 ± 0.2	NS
MON ($\times 10^3/\mu\text{L}$)	0.73 ± 0.1 ^a	0.39 ± 0.0 ^b	0.16 ± 0.0 ^c	0.32 ± 0.1 ^b	0.35 ± 0.0 ^b	P < 0.05
GRA ($\times 10^3/\mu\text{L}$)	5.57 ± 0.3 ^c	7.18 ± 0.2 ^a	6.66 ± 0.4 ^{ab}	6.16 ± 0.5 ^{bc}	5.99 ± 0.2 ^{bc}	P < 0.05

NS: not significant (P > 0.05). ^{a,b,c,d}: a letter in the same line means significantly different (P < 0.05; P < 0.01).

Table 2. Selected biochemical parameters before and during pregnancy in Angora cats (n = 7). Values represented as mean ± SEM in the table.

Parameters	Before pregnancy	During pregnancy				P value
		Day 15	Day 30	Day 45	Day 55	
ALT (U/L)	24.72 ± 5.4	37.62 ± 7.3	26.76 ± 8.8	23.63 ± 7.1	26.94 ± 4.4	NS
AST (U/L)	29.88 ± 2.9	24.05 ± 5.0	29.63 ± 1.6	27.44 ± 1.8	30.55 ± 4.1	NS
ALP (U/L)	42.54 ± 10.4	44.20 ± 7.9	41.77 ± 7.3	52.06 ± 9.3	60.16 ± 8.1	NS
GGT (U/L)	4.36 ± 0.5 ^{ab}	3.24 ± 0.6 ^b	5.27 ± 1.1 ^{ab}	5.06 ± 0.8 ^{ab}	5.55 ± 0.8 ^a	P < 0.05
LDH (U/L)	202.46 ± 35.6 ^b	263.40 ± 43.1 ^{ab}	211.26 ± 20.6 ^b	215.25 ± 41.4 ^b	325.41 ± 38.5 ^a	P < 0.05
CK (U/L)	154.54 ± 5.8	159.52 ± 18.8	140.44 ± 4.0	156.29 ± 39.7	166.64 ± 31.2	NS
Glucose (mg/dL)	154.60 ± 16.7 ^a	92.19 ± 6.9 ^b	90.83 ± 1.7 ^b	86.81 ± 2.5 ^b	88.20 ± 1.8 ^b	P < 0.05
Cholesterol (mg/dL)	118.13 ± 3.6 ^b	127.92 ± 3.6 ^b	155.55 ± 5.4 ^a	157.00 ± 13.5 ^a	159.27 ± 6.9 ^a	P < 0.05
Triglyceride (mg/dL)	39.38 ± 3.5 ^c	48.82 ± 5.9 ^{bc}	63.44 ± 13.8 ^{ab}	38.99 ± 4.7 ^c	83.36 ± 9.7 ^a	P < 0.05
Urea (mg/dL)	25.67 ± 3.9 ^{bc}	19.66 ± 2.8 ^c	22.54 ± 2.0 ^c	33.43 ± 4.6 ^{ab}	34.59 ± 4.0 ^{ab}	P < 0.05
Ca (mg/dL)	9.87 ± 0.3	10.04 ± 0.3	10.02 ± 0.3	10.17 ± 0.3	10.19 ± 0.2	NS
Pi (mg/dL)	5.38 ± 0.5 ^{bc}	4.55 ± 0.3 ^c	5.19 ± 0.5 ^{bc}	5.22 ± 0.3 ^{bc}	6.18 ± 0.5 ^{ab}	P < 0.05
Mg (mg/dL)	2.30 ± 0.1 ^{cd}	2.22 ± 0.1 ^d	2.51 ± 0.1 ^{bc}	2.59 ± 0.1 ^b	2.74 ± 0.1 ^{ab}	P < 0.05

NS: not significant (P > 0.05). ^{a,b,c,d}: a letter in the same line means significantly different (P < 0.05).

increased WBC numbers were associated with decreased MON numbers (P<0.05). The decrease observed in MON numbers was in compliance with the findings previously reported by Iriadam (18).

Biochemical blood parameters are commonly used in veterinary medicine for the clinical and metabolic assessment of animals when diagnosing diseases (19).

In pregnant animals the majority of biochemical blood parameters differ from values pertaining to the period before pregnancy (10).

In this study, AST activity was within the range of reference values reported for cats by Turgut (7). Data available for the impact of gestation on ALT and AST activity are unclear (20). It has been reported that the

transaminase enzymes play a significant role in the normal continuation of gestation (21). Macun et al. (22) detected that serum ALT activity showed a tendency to decrease in late gestation in the Angora cat. Similarly, in the present study it was ascertained that serum ALT activity had decreased on day 55 of gestation, in comparison to the value measured on day 15 of gestation.

The GGT enzyme is found in the endothelium of periportal blood vessels, the Kupffer cells of the liver, and the epithelium of bile ducts. The serum GGT activity before and during pregnancy in Angora cats remained within the reference value range for cats (7).

In this study, LDH activity determined before and throughout pregnancy was within the reference value range reported for cats (7). The increase observed in LDH activity on day 55 of gestation, compared to values before gestation, could be related to the breakdown of muscle tissue as a result of decreased protein intake (23).

As glucose is used as an energy source by cells, it needs to be maintained at a certain level in the blood. For this reason, glucose, which is the end product of carbohydrate digestion, is stored in the muscles and liver in the form of glycogen. When needed, glycogen is released from these tissues to maintain the plasma glucose levels (24). In agreement with the findings of Hamadeh et al. (25), it was ascertained that the serum glucose levels of nonpregnant cats were significantly higher than those of pregnant cats ($P < 0.05$). Atakişi et al. (26) reported that, in sheep, serum glucose levels were lower in the last 3 months of gestation compared to levels before pregnancy. These researchers attributed the decrease observed in blood glucose levels in late gestation to the increased use of glucose by the uterus, fetal tissues, and placenta.

Cholesterol, which is a component of the plasma membrane, is also the precursor of all steroid hormones, bile acids, and vitamin D in the body (6). Being a metabolic parameter, cholesterol is used to detect health problems that may be encountered during pregnancy and to assess the nutritional status of animals (27). In agreement with the results reported by Iriadam (18) and Poljicak-Milas et al. (28), the present study demonstrated that the serum total cholesterol levels on days 30, 45, and 55 of pregnancy

were higher than before pregnancy in cats ($P < 0.05$). This increase in serum cholesterol is due to estrogen stimulation during the pregnancy (29).

This study also showed that serum triglyceride levels were significantly higher on days 30 and 55 of gestation compared to the values before pregnancy ($P < 0.05$). The results obtained in the present study were in agreement with those reported in previous studies indicating that increased serum triglyceride levels were observed in the last months of gestation (25,30). The increase observed in serum triglyceride levels in late gestation could be related to the excessive intake of glucose to maintain body reserves for the supply of fetal energy requirements (26).

It is also known that blood mineral levels are affected by reproductive stages (31). The parathyroid hormone, calcitonin, and cholecalciferol are involved in the hemostasis of blood Ca and Pi concentrations. These hormones also have an effect on Mg metabolism (7). Serum Mg levels increased on day 55 of gestation, in comparison to the values before pregnancy, suggesting that mineral levels may change during pregnancy in relation to the prevailing hormonal circumstances. No significant change in Pi levels during gestation was recorded compared to the period before pregnancy. Findings in this study are similar to those reported previously in goats (29).

In conclusion, the results of the study showed that in pregnant cats hematological and biochemical parameters such as WBC, MCH, total cholesterol, triglyceride, and Mg levels and activity of LDH increased, while RBC, PCV, Hb, and glucose levels decreased in late gestation compared to nonpregnant cats. The present study provides the first report of changes in hematological and biochemical blood parameters before and during pregnancy in Angora cats and compares the blood parameters for these 2 periods. This study will contribute to the diagnosis of physiological and pathological cases that may develop during pregnancy, aid in monitoring of the course of diseases, and help to further research on Angora cats.

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