The effect of dystocia on oxidative stress, colostral antibody/passive immune status, and blood gases in Damascus goats and their kids

Abstract: The present study was conducted to investigate the effect of dystocia on oxidative stress, venous blood gases and colostrum and serum immunoglobulins G (IgG) in Damascus goats and their kids, respectively. The study sample comprised a total of 40 Damascus goats with of their own 40 kids separated into 2 groups according to type of birth. Group 1 consisted of goats with eutocia (n=20) and their kids (n=20) and Group 2 consisted of goats with dystocia (n=20) and their kids (n=20). Blood samples were taken from the goats and their kids in both groups to measure oxidative stress within one hour after kidding, and from the kids to evaluate serum IgG levels 24 hours after kidding. Following blood gas and acid/base status were determined immediately after blood collection, colostrum samples were taken before the kids were sucked. Malondialdehyde (MDA), lactate dehydrogenase (LDH), ischemia modified albumin (IMA) and total oxidant capacity (TOC) levels were significantly higher in the dystocia group than in the eutocia group ($p<0.05$). Glutathione peroxidase (GSH-Px), superoxide dismutase (SOD), and total antioxidant capacity (TAC) were significantly lower in the dystocia group than those in the eutocia group ($p<0.05$). In addition, the serum IgG levels of kids were significantly lower in the dystocia group than those in the eutocia group ($p<0.05$). In the kids, partial pressure of oxygen (pO_2), pH, bicarbonate (HCO_3), base excess (BE) and glucose levels were significantly lower in the dystocia group than those in the eutocia group ($p<0.05$); whereas, partial pressure of carbon dioxide (pCO_2), potassium (K) and calcium (Ca) levels were significantly higher in the dystocia group than those in the eutocia group ($p<0.05$). In the goats, oxygen pressure (pO_2) was significantly higher in the dystocia group than that in the eutocia group ($p<0.05$); whereas, bicarbonate (HCO_3)

was significantly lower in the dystocia group than that in the eutocia group (p<0.05). There was a significant correlation between IMA and serum IgG in kids in Group 1 (r=0.611, p<0.05). A statistically significant correlation was observed between MDA and colostrum IgG levels in goats in Group 2 (r=0.464, p<0.05). In conclusion, current results could reveal that dystocia caused oxidative stress in both goats and kids. Present study elucidate that dystocia resulted in hypercapnia and hypoxia in kids, negatively affected blood gases, and decreased serum IgG levels in kids. It was revealed that oxidative stress increased and colostrum IgG level did not change in goats in the dystocia group.

Keywords: Blood gases, dystocia, goat, kid, oxidative stress, IgG

1. Introduction

Dystocia increases maternal and offspring mortality, and the incidence of puerperal disease, culling rates and infertility, leading to significant economic losses [1]. In small ruminants, the rate of dystocia is low (3%) due to the anatomic structure of the birth canal [2]. However, the rate of death due to dystocia is quite high [3].

Oxidative stress occurs through the imbalance of reactive oxygen and nitrogen species and the antioxidant system towards oxidation. It is a natural process, with specialized mechanisms keeping this stress under control. When these mechanisms are insufficient, oxidative damage occurs [4]. When the antioxidant systems are not sufficient to counteract oxidative stress, the oxidative damage in cells progresses, leading to deteriorated cell functions [5]. Hydroxyl radical is the most reactive of ROS and can damage proteins, lipids, carbohydrates, and DNA [6]. High oxidative stress is common in organs and tissues with high metabolic and energy demands, including skeletal and heart muscle, the liver, and blood cells [7].

The neonatal period is critical for newborn offspring to adapt to the extrauterine environment [8]. This period is highly affected by the pregnancy, type of birth and postpartum care, and prolonged hypoxia during birth can result in neonatal death [9]. During this period, adaptation processes known as cardiovascular, respiratory, thermoregulatory, metabolic and hemostatic mechanisms are completed [8]. The metabolic status of newborns is highly variable. During this period, various changes occur in different organ systems (acid-base balance and respiratory functions) [8].

Passive transfer is among the most important factors that affect the health of offspring in the neonatal period. Since ruminants have epitheliochorial placentas, the passage of immunoglobulins in the womb is minimal. Therefore, the offspring are born agammaglobulinemic/hypogammaglobulinemic and need colostrum as soon as possible [10]. Offspring with passive transfer failure do not have good protection against infectious diseases, so they are more likely to catch diseases, with an increased death rate [11]. The main immunoglobulin in the colostrum is IgG and there is a correlation between low serum IgG levels and neonatal diseases in newborns [12]. Dystocia causes decreased neonatal viability in farm animals and increased morbidity has been associated with decreased IgG absorption [13]. In particular, studies in calves have shown that dystocia-induced respiratory acidosis and hypercapnia are followed by decreased absorption of IgG [14]. This inhibition of uptake may occur both at the level of initial endocytotic capacity in intestinal cells and by an earlier induction of intestinal closure. Nevertheless, it remains unclear whether dystocia alone can influence IgG absorption and to which extent this is directly or indirectly related to postnatal acidosis and hypercapnia [15].

Therefore, the aim of this study was to reveal the effect of dystocia on passive immune status (serum IgG), oxidative stress and venous blood gases in Damascus goats and kids, and to determine whether there is an effect of dystocia on maternal colostrum IgG.

2. Materials and methods

2.1. Animal selection and experimental protocol

The study material consisted of 40 Damascus breed goats and 40 kids born from them, aged between 3-5 days (Group 1: 3.95; Group 2: 4.05), selected with the random sampling method. All the animals were receiving the same feed (goat milk feed; 2.700 kcal/kg metabolic energy, 18% protein, 87.50%-88.00% dry matter, 18.00-18.50% crude protein, 7.20-7.60% crude cellulose, 3.00-3.50% crude oil, 7.00-7.50% crude ash, 28.00-29.00% starch, 2560-2580 kcal/kg metabolic energy and corn silage, hay and straw were given) and management conditions on a private farm in Eyyübiye District of Şanlıurfa province, Turkey. The anamneses of the goats revealed that they had normal births, with no postpartum problems and only animals with singleton gestation were included to objectively evaluate the parameters. The births occurred in January-February and the research was carried out between September and April, when the goats had the highest synchronization and birth season. The goats were divided into 2 groups according to type of birth. Group 1 consisted of goats with eutocia (n=20) and their kids (n=20) and Group 2 consisted of goats with dystocia (n=20) and their kids (n=20). Dystocia was defined as the total time to birth exceeding 90 min or rupture of the fetal membranes and no progression for 30 min [16]. The kids consumed 50 mL/kg of colostrum in the first hour and 250 mL/kg of colostrum in 24 hours with a bottle. Although the sucking reflexes of the kids born as a result of difficult delivery were weak, it was ensured that the specified amounts of colostrum were taken.

2.2. Blood and colostrum samples

Determination of oxidative status (malondialdehyde, lactate dehydrogenase, glutathione peroxidase, ischemia modified albumin, superoxide dismutase, total oxidant capacity, total antioxidant capacity) was applied to both goats and kids within 1 hour after birth in both study groups and serum IgG was determined 24 hours after birth in the blood samples of the kids. Blood samples taken from the *v. jugularis* into tubes containing 5 mL coagulation activator, then transported to the laboratory under cold chain conditions. The samples were centrifuged at 3000 rpm for 10 min and the serum was removed and stored at -80˚C until analysis. Blood samples were also taken from goats and kids into blood gas injectors within 1 hour after birth to determine venous blood gas levels; pH, partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO_2), bicarbonate (HCO_3-), base excess (BE), sodium (Na^+), potassium (K^+), calcium (Ca^{++}), chlorine (Cl^-), glucose (Glu), lactate (Lac). Finally, colostrum samples from goats were taken into centrifuge tubes (Conical Bottom Screw Cap Tubes, Isolab, 15 mL) before the kids sucked and centrifuged at 3000 rpm for 10 min. Samples were taken from the supernatant and stored at -80˚C until analysis.

2.3. Biochemical analysis

Venous blood gas measurements were performed using an Epoc® Blood Analysis System device (Siemens Healthcare™, Ottawa, Canada). A blood gas injector (Safe Pico, Denmark) was used for the analysis and measurements were made within the first 10 min. Serum MDA (Elabscience, Houston, United States), LDH (Elabscience, Houston, United States), GSH-Px (Elabscience, Houston, United States), IMA (Rel Assay, Gaziantep, Turkey), SOD (Cayman, Michigan, USA), TAC (Rel Assay, Gaziantep, Turkey), and TOC (Rel Assay, Gaziantep, Turkey) levels were determined spectrophotometrically

(Molecular Device SpectraMax M5 Plate Reader, Pleasanton, CA, USA) using a commercial kit. Maternal colostrum IgG (Goat colostrum IgG Elisa kit, Eagle biosciences, USA) and kid serum IgG levels were determined with the ELISA method using a commercial kit (Goat IgG Elisa kit, Mybiosource, USA). OSI=([TOS {mmol/L}]/[TAC {mmol} Trolox equivalent]/l×100) [17].

2.4. Statistical analysis

Statistical analysis of the data was performed using the Statistical Package for the Social Sciences (SPSS for Windows; version 24.0) packaged software. The conformity of the variables to normal distribution was examined using visual (histogram and Q-Q Plot) and analytical methods (Shapiro-Wilk tests). Descriptive analyses were reported as mean ± standard error of the mean (SEM) values for normally distributed variables. Since the data showed conformity to normal distribution, they were compared between groups using the Independent Samples t-test. The homogeneity of variances was determined using the Levene test. Pearson correlation coefficients were calculated to reveal the correlations between measurements. A value of $p<0.05$ was accepted as statistically significant for all analyses, and $p<0.001$ was also used to emphasize significance.

3. Results

3.1. Measurements of kids according to birth type

The oxidative status parameters and serum IgG levels are shown in Table 1 and blood gas/acid-base findings in Table 2. The MDA, LDH, IMA, TOC and OSI values were significantly higher in the dystocia group than in the eutocia group ($p<0.05$). The GSH-Px, SOD, TAC and serum IgG levels were significantly lower in the dystocia group than in the eutocia group ($p<0.05$). The pH, pO_2, HCO_3, BE and glucose levels were significantly lower in the dystocia group than in the eutocia group ($p<0.05$). The pCO_2, K and Ca levels were significantly higher in the dystocia group than in the eutocia group ($p<0.05$). No significant difference was determined in respect of Na, Cl and lactate levels.

The results of the analysis of the correlations between the parameters are shown in Table 3. There was a significant correlation between IMA and serum IgG levels in kids in Group 1 ($r=0.611$, $p<0.05$). A significant correlation was found between MDA and SOD levels in kids in Group 2 ($r=0.548$, $p<0.05$).

3.2. Measurements of goats according to birth type

The oxidative status parameters and colostrum IgG levels are shown in Table 4 and blood gas/acid-base findings in Table 5. The MDA, LDH, IMA, TOC and OSI levels were significantly higher in the dystocia group than in the eutocia group ($p<0.05$). The GSH-Px, SOD and TAC were significantly lower in the dystocia group than in the eutocia group ($p<0.05$). No significant difference was determined in maternal colostrum IgG levels according to type of birth. Evaluation of blood gas and acid/base measurements; pO_2 levels were significantly higher in the dystocia group than in the eutocia group; HCO_3 levels were significantly lower in the dystocia group than in the eutocia group ($p<0.05$), and there was no significant difference in the other measurements.

The correlation analyses of these parameters are presented in Table 6. There was a significant correlation between MDA and TAC levels in goats in Group 1 ($r=-0.601$, $p<0.01$). This indicated that as MDA increases, TAC decreases. A statistically significant correlation was observed between MDA and colostrum IgG levels in goats in Group 2 ($r=0.464$, $p<0.05$). This indicated that as MDA increases, colostrum IgG increases. There were significant correlations between GSH Px - SOD ($r=0.473$, $p<0.05$), IMA - TOC (r=0.492, p<0.05) and IMA - colostrum IgG (r=0.480, p<0.05). Similarly, the observed correlated values increased in parallel with each other.

4. Discussion

Previous studies of lambs, calves and foals have investigated dystocia in correlation with the parameters examined in this study [9,18-20]. However, no studies were found to focus on kids, and the previous studies did not evaluate the offspring or the effect of mothers on dystocia.

Research on oxidative stress is a current issue and many studies have been carried out on this subject [21-35]. Research on buffaloes revealed significantly higher MDA levels in dystocia groups than in eutocia groups [23-25]. Another study reported that MDA levels were higher in dystocia than in eutocia albeit with no significant difference [26]. Aydogdu et al. [16] reported higher plasma MDA levels in dystocia lambs than eutocia lambs. In the current study, MDA was found to be higher in the dystocia group compared to the eutocia group, similar to the findings in literature. Obstetric operations in difficult labor are very stressful and increase adrenaline and glucocorticoid levels. It was thought that excessive ROS production caused peroxidation of placental membrane lipids, especially polyunsaturated fatty acids, and increased MDA level. Although not to a significant level, serum LDH levels have been found to be higher in cows with dystocia than in those with eutocia, which was reported to stem from tissue damage due to prolonged birth [30]. In the current study, LDH levels were higher in the dystocia group in both goats and kids, in line with the literature. In the dystocia group, it was thought that the serum LDH level increased as a result of the muscle damage in the genital tract due to the prolongation of the delivery period, thereby increasing the muscle enzyme activities. In recent years, the determination of changes in serum albumin structure in ischemia conditions has enabled the discovery of a new serum ischemia marker. Studies have shown increased maternal IMA levels associated with stress in recurrent pregnancy loss [31] and early pregnancy loss [32]. In the present study, IMA was found to be higher in the dystocia group than in the eutocia group, which was thought to be due to hypoxia and free radical damage caused by dystocia. SOD is another oxidative state marker; stress causes the oxidation of oxyhemoglobin to methemoglobin, leading to the formation of superoxide ions (O_2), which increase SOD activity [27]. Previous research has noted that buffaloes with dystocia had higher SOD activity than those with eutocia [25-26]. However, some studies have reported significantly lower SOD levels in buffaloes with dystocia [23-24]. In the current study, the SOD levels of goats and kids were determined to be higher in the eutocia group. These two different views in the literature can be attributed to the ration used, care-nutrition, and environmental conditions. GSH-Px is another oxidative status marker. The production of reactive oxygen products during dystocia causes a decrease in selenium uptake [36]. A decrease in selenium intake causes a relative insufficiency of GSH-Px concentration and thus oxidative stress [36]. GSH-Px levels have been reported to be significantly lower in buffaloes, cows and lambs with dystocia than in these respective animals with eutocia [16,23-26,28]. Although there is no direct study on GSH-Px levels in goats and kids with respect to dystocia, results of previous studies in literature [16,23-26,28] could give an idea about the course of dystocia on GSH-Px levels in different species. In our study, GSH-Px was found to be lower in the dystocia group compared to the eutosia group in goats and kids. It has been suggested that ROS production during dystocia may lead to a decrease in selenium uptake by erythrocytes, leading to a deficiency of GPx concentration, leading to the emergence of oxidative stress. It has been stated that the measurement of antioxidants separately does not fully reflect the antioxidant capacity of the body and therefore, the TAC colorometric value, which reflects the sum of all antioxidants in the biological system, can be measured for this purpose [33]. Several previous studies have reported that TAC and TOC levels will vary according to the measurement method [34] and nutritional differences [35]. In the current study, all the goats were under the same feeding and management conditions and uniformity was ensured by using the same analytical method in the TAC-TOC measurements. Serum TAC levels have been found to be lower in cows with dystocia than in those with eutocia although not at a significant level [30]. In the present study, the TOC level was found to be higher in the dystocia group than in the eutocia group, whereas the TAC level was found to be higher in the eutocia group than in the dystocia group. In human medicine, it has been reported that oxidative stress increases in pathological pregnancy [36]. It has been reported that plasma TAC activity is lower in preeclampsia and there is an imbalance between lipid peroxidase and antioxidants in preeclampsia [37]. In addition, OSI values were found to be significantly higher in women with preeclampsia [38]. In our study, the OSI value was found to be higher in the dystocia group in goats and kids, which is in line with the literature, where the level increased in case of oxidative stress.

IgG absorption has been reported to decrease due to dystocia [15]. One study on the passive transfer status of lambs found serum IgG concentrations to be 28.4±6.6 mg/dL immediately after birth, 2695±2290 mg/dL at the 24th h and 2634±1980 mg/mL at the 48th h [39]. In a similar study, serum IgG concentrations of lambs were 289.1±220.44 mg/dL immediately after birth, 2121.2±350.03 mg/dL at the 24th h and 2401.2±230.99 mg/dL at the 48th h [40]. In the present study, the serum IgG levels of the kids born as a result of dystocia were found to be lower at the 24th hour after the birth than those of the eutocia group. Furthermore, the mean serum IgG levels of both groups were above 800 mg/dL at the 24th hour (1720.10±6.42 in Group 1 and 1669.75±8.41 in Group 2), with sufficient passive transfer in all kids.

It has been reported that hypoglycemia in newborn lambs may be due to a serious decrease in fetal circulation during birth [41]. In the present study, glucose levels were measured to be low in kids in both groups and it was observed that this amount was lower in the dystocia group than in the eutocia group. This finding is in line with the results of the Aydogdu et al [16] study on lambs.

It has been reported that pCO_2 high and BE low in newborn lambs after birth [41]. In the current study, pCO_2 level is higher and BE is lower in the kids of the dystocia group compared to the eutocia group. This was thought to be due to hypercapnia caused by the prolonged stay in the birth canal in dystocia. In the goats, there was no difference between the groups in terms of BE or pCO_2 measurement. Detection of BE in venous blood is a valuable indicator for the detection of metabolic-respiratory acidosis [42]. In the current study, the increased pCO_2 values in dystocia were thought to be due to impaired excretion of CO_2 from the lungs and the development of respiratory acidosis. Vannucchi et al. [43] reported that blood pH and BE in calves were significantly lower in the dystocia group than in the normal birth group. This finding is in parallel with the results of the current study. The authors of the previous study associated the low pO_2 levels in newborn lambs with decreased oxygen exchange between alveoli and pulmonary capillaries in the placenta at birth [41]. Uterine contractions during birth cause compression of the uterine artery and umbilical cord, leading to a major reduction in placental and umbilical blood flow [44]. In the present study, pO_2 levels were found to be lower in kids with dystocia, and there was also a difference in the pO_2 levels of the goats, with lower levels determined in Group 1. Another study reported no significant difference in pH, pCO_2, pO_2 and HCO_3 levels at 0 and 24 hours in calves with dystocia [9]. Kimura et al. [20] reported that foals with dystocia had low pH, HCO_3 and BE levels with similar improvement in blood gases on day 1. In the same study, it was reported that the lactate level measured immediately after birth was significantly higher, and according to the results of the study it had negative effects on the blood gases of foals born as a result of dystocia [20]. In the present study, pH and HCO_3 were found to be low in the kids of both groups and it was observed that this amount was lower in the dystocia group than in the eutocia group. In pH measurements in the goats, no difference was observed between the groups, whereas HCO_3 was lower in the dystocia group than in the eutocia group. It has been reported that an increase in lactate level is observed in the formation of anaerobic metabolism in hypoxia [45]. In the current study, the lactate measurements in kids and goats were found to be higher in the dystocia group, but no difference was observed. Aydogdu et al. (16) reported that the Ca levels of the lambs born as a result of dystocia were higher than the eutocia group. This situation which is found in our study which is similar to the literature, when the blood pH decreases the binding of ionized calcium to albumin decreases and an increase in the blood ionized calcium level can be observed [46]. The K value of the kids in the dystocia group was determined to increase and this was thought to be related to the increase in plasma K level in acute metabolic acidosis due to the fact that a large amount of hydrogen (H) ions pass into the cell as a buffer [47]. Early intervention in dystocia has been predicted to be the reason for this. In general, blood gas and acid-base conditions were not affected much in goats but substantial differences were observed in kids. Particularly in newborns, the adaptation processes known as cardiovascular, respiratory, thermoregulation, metabolic, and hemostatic mechanisms, were considered to be the reason for this situation.

In the literature, colostrum IgG concentrations have been determined as 115.1±10.1 mg/mL at birth and 101.21±7.24 (50-164) mg/mL before suckling in lambs [48]. IgG was found to be 148.2±19 mg/mL in the colostrum taken immediately after birth in Honamlı goats [49]. In a different study conducted in goat colostrum, it was reported that the amount of IgG in the first colostrum was 41.2 mg/mL [50]. In another study, it was reported that the colostrum IgG value was at the level of 65 mg/mL [51]. In the presented study, colostrum IgG level is numerically similar to the literature data, but there was no difference between the groups. However, the absence of difference suggested that colostrum production is shaped over a long period of time before birth and may be minimally affected by undesirable conditions during the birth.

5. Conclusion

In conclusion, current result could elucidate that dystocia could cause oxidative stress in both goats and kids, cause hypercapnia and hypoxia in kids, negatively affect blood gases, and decrease serum IgG levels in kids. It was revealed that oxidative stress increased and colostrum IgG level did not change in goats in the dystocia group. Evaluation of oxidative stress and antioxidant status should remain a keystone of veterinary obstetric research as it is quantitative information that provides insight into the state of animal health during oxidative stress. The increased oxidative stress in goats and kids affected by dystocia could be associated with any injury to the birth canal or uterus due to obstetric intervention. Decreased antioxidant enzymes and increased lipid peroxidation metabolite levels led to the progression towards the disruptive effect of various reactive oxygen metabolites and oxidative stress produced during birth. Further studies are needed to monitor oxidative stress in depth. Therefore, it is recommended that dystocia should be addressed as early as possible to avoid oxidative stress and further complications, with monitoring of antioxidant parameters as a critical care issue. It could be assumed that general knowledge of these differences depending on the type of birth in general could result in healthier offspring with higher survival rates with the necessary supplements administered to goats and kids after birth.

Approval of the Ethics Committee

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Table 1. Oxidative status and passive immune status (serum IgG) levels in kids according to the type of birth.

Oxidative status and serum IgG	Eutocia group (n=20)		Dystocia group (n=20)		*P
	Mean	SEM	Mean	SEM	
MDA (micromol/L)	7.30	0.09	7.60	0.07	0.001
LDH (U/L)	24.58	2.00	33.92	2.15	0.001
GSH-Px (ng/ml)	34.56	1.81	29.59	2.46	0.001
IMA (ng/ml)	439.98	15.69	613.75	22.94	0.001
SOD (u/mg)	1.95	0.09	1.57	0.09	0.001
TAC (mmol/L)	2.00	0.06	1.79	0.06	0.001
TOC (micromol/L)	12.77	0.09	15.56	0.16	0.001
OSI	6.37	0.04	8.70	0.07	0.001
Serum IgG	1720.10	6.42	1669.75	8.41	0.001

*Significance levels according to Independent T-test results. Malondialdehyde (MDA), lactate dehydrogenase (LDH), glutathione peroxidase (GSH-Px), ischemia modified albumin (IMA), superoxide dismutase (SOD), total antioxidant capacity (TAC), total oxidant capacity (TOC), Oxidative Stress Index (OSI).

Table 2. Blood gas/acid-base levels in kids according to the type of birth.

Blood gas/acid-base	Eutocia group (n=20)		Dystocia group (n=20)		*P
	Mean	SEM	Mean	SEM	
pH	7.32	0.01	7.30	0.01	0.001
pCO_2 (mmHg)	56.73	0.13	59.39	0.33	0.001
pO_2 (mmHg)	22.39	0.33	17.33	0.26	0.001
HCO_3 (mmol/L)	31.43	0.29	28.41	0.25	0.001
BE (mmol/L)	-2.34	0.30	-5.53	0.26	0.001
Na (mmol/L)	133.45	0.28	133.50	0.29	0.616
K (mmol/L)	3.79	0.06	4.14	0.06	0.001
iCa (mmol/L)	1.46	0.06	1.52	0.07	0.023
Cl (mmol/L)	111.35	1.95	111.85	2.43	0.478
Glucose (mg/dl)	43.34	0.28	35.50	0.30	0.001
Lactate (mmol/L)	4.22	0.04	4.24	0.04	0.266

*Significance levels according to Independent T-test results. Power of Hydrogen (pH), partial pressure of carbon dioxide (pCO_2), Partial pressure of oxygen (pO_2), bicarbonate (HCO_3), base excess (BE), sodium (Na), potassium (K), calcium (Ca), chlorine (Cl).

Table 3. Correlation analysis in kids in the eutocia and dystocia groups.

Correlation analysis		MDA	LDH	GSH-Px	IMA	SOD	TAC	TOC	Serum IgG
LDH									
Eutocia	r	0.163							
Dystocia		0.206							
GSH-Px									
Eutocia	r	0.265	-0.032						
Dystocia		0.302	-0.007						
IMA									
Eutocia	r	-0.108	-0.308	0.078					
Dystocia		-0.074	-0.190	0.093					
SOD									
Eutocia	r	0.037	0.305	0.199	0.171				
Dystocia		**0.548***	0.233	0.360	0.056				
TAC									
Eutocia	r	-0.196	-0.004	-0.203	-0.077	0.077			
Dystocia		-0.030	-0.187	-0.373	0.038	-0.351			
TOC									
Eutocia	r	-0.097	-0.061	-0.300	0.075	-0.140	0.257		
Dystocia		-0.026	-0.038	0.095	0.183	-0.053	0.025		
Serum IgG									
Eutocia	r	-0.261	-0.344	0.328	**0.611****	0.238	0.023	-0.139	
Dystocia		-0.252	-0.014	-0.082	0.173	-0.087	-0.168	-0.288	

*p<0.05, **p<0.01, r: Pearson correlation coefficients. Malondialdehyde (MDA), lactate dehydrogenase (LDH), glutathione peroxidase (GSH-Px), ischemia modified albumin (IMA), superoxide dismutase (SOD), total antioxidant capacity (TAC), total oxidant capacity (TOC), Oxidative Stress Index (OSI).

Table 4. Oxidative status and colostrum IgG levels in goats according to the type of birth.

Oxidative status and colostrum IgG	Eutocia group (n=20)		Dystocia group (n=20)		*P
	Mean	SEM	Mean	SEM	
MDA (micromol/L)	2.94	0.14	4.56	0.19	0.001
LDH (U/L)	24.47	2.00	32.84	2.24	0.001
GSH-Px (ng/ml)	29.85	1.56	24.75	1.35	0.001
IMA (ng/ml)	445.21	16.46	594.69	19.41	0.001
SOD (u/mg)	1.92	0.07	1.53	0.08	0.001
TAC (mmol/L)	2.31	0.07	2.09	0.05	0.001
TOC (micromol/L)	12.42	0.11	14.45	0.15	0.001
OSI	5.38	0.04	6.93	0.04	0.001
Colostrum IgG (mg/ml)	125.74	6.06	126.11	5.64	0.839

*Significance levels according to Independent T-test results. Malondialdehyde (MDA), lactate dehydrogenase (LDH), glutathione peroxidase (GSH-Px), ischemia modified albumin (IMA), superoxide dismutase (SOD), total antioxidant capacity (TAC), total oxidant capacity (TOC), Oxidative Stress Index (OSI).

Table 5. Blood gas/acid-base levels in goats according to the type of birth.

Blood gas/acid-base	Eutocia group (n=20)		Dystocia group (n=20)		*P
	Mean	SEM	Mean	SEM	
pH	7.42	0.01	7.42	0.02	0.679
pCO_2 (mmHg)	50.35	1.65	49.56	1.42	0.114
pO_2 (mmHg)	25.23	0.26	25.49	0.27	0.004
HCO_3 (mmol/L)	26.40	0.28	25.51	0.26	0.001
BE (mmol/L)	-4.39	0.23	-4.43	0.26	0.578
Na (mmol/L)	130.39	0.26	130.46	0.30	0.408
K (mmol/L)	3.76	0.04	3.76	0.06	0.880
iCa (mmol/L)	1.40	0.07	1.40	0.06	0.866
Cl (mmol/L)	111.75	1.94	112.50	2.54	0.301
Glucose (mg/dl)	45.44	0.31	45.40	0.27	0.701
Lactate (mmol/L)	2.83	0.15	2.87	0.05	0.233

*Significance levels according to Independent T-test results. Power of Hydrogen (pH), partial pressure of carbon dioxide (pCO_2), Partial pressure of oxygen (pO_2), bicarbonate (HCO_3), base excess (BE), sodium (Na), potassium (K), calcium (Ca), chlorine (Cl).

Table 6. Correlation analysis in goats in the eutocia and dystocia groups.

Correlation analysis		MDA	LDH	GSH-Px	IMA	SOD	TAC	TOC
LDH	r							
Eutocia		0.340						
Dystocia		0.135						
GSH-Px	r							
Eutocia		0.128	-0.025					
Dystocia		-0.183	-0.239					
IMA	r							
Eutocia		-0.263	-0.134	-0.272				
Dystocia		0.054	-0.074	-0.292				
SOD	r							
Eutocia		-0.233	-0.358	0.369	0.092			
Dystocia		-0.016	0.188	**0.473***	-0.421			
TAC	r							
Eutocia		**-0.601****	-0.263	-0.225	0.147	0.087		
Dystocia		-0.165	-0.008	-0.333	0.246	-0.313		
TOC	r							
Eutocia		0.176	0.195	0.335	0.126	0.094	-0.160	
Dystocia		-0.287	-0.219	0.087	**0.492***	-0.076	-0.047	
Colostrum IgG	r							
Eutocia		0.100	-0.374	-0.143	0.404	0.254	-0.073	0.073

Dystocia		**0.464***	-0.098	-0.189	**0.480***	-0.191	-0.202	0.251

*p<0.05, **p<0.01, r: Pearson correlation coefficients. Malondialdehyde (MDA), lactate dehydrogenase (LDH), glutathione peroxidase (GSH-Px), ischemia modified albumin (IMA), superoxide dismutase (SOD), total antioxidant capacity (TAC), total oxidant capacity (TOC), Oxidative Stress Index (OSI).