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Evaluation of total sialic acid, paraoxonase activity, and malondialdehyde in cows with subclinical paratuberculosis

E. Akyüz^{1,a,*}, A. Kükürt^{2,b}, M. Makav^{3,c}, E. Gökçe^{1,d}, H.A. Eroğlu^{4,e},
H.A. Deveci^{5,f}, G. Gökçe^{1,g}, M. Karapehlivan^{6,h}

¹Department of Internal Medicine, Faculty of Veterinary Medicine, Kafkas University, Kars, Türkiye

²Department of Biochemistry, Faculty of Veterinary Medicine, Kafkas University, Kars, Türkiye

³Department of Physiology, Faculty of Veterinary Medicine, Kafkas University, Kars, Türkiye

⁴Department of Physiology, Faculty of Medicine, Çanakkale Onsekiz Mart University, Çanakkale, Türkiye

⁵Department of Nutrition and Dietetics, Faculty of Health Sciences, Gaziantep University, Gaziantep, Türkiye

⁶Department of Biochemistry, Faculty of Medicine, Kafkas University, Kars, Türkiye

ABSTRACT: This study was aimed to evaluate total sialic acid (TSA), paraoxonase activity (PON1), malondialdehyde (MDA), and some serum biochemical parameters in cows with subclinical paratuberculosis. Paratuberculosis (PT) test was performed on 500 cows aged 2-6 years by ELISA method. Twenty-four cows diagnosed with paratuberculosis constituted the PT group and 12 healthy cows constituted the control group. According to the results, alanine aminotransferase (ALT), aspartate aminotransferase (AST), and urea levels were found to be statistically higher ($p < 0.05$) in the group with paratuberculosis compared to the control group. Iron (Fe) levels were found to be lower than the control group ($p < 0.001$). Compared to the control group, there was a decrease in PON1 ($p < 0.001$) activity and a significant increase in TSA ($p < 0.001$) and MDA ($p = 0.002$) levels in the PT group. In conclusion, in subclinical paratuberculosis infection, the long incubation period and the absence of clinical findings until advanced stages constitute a handicap. However, our findings show that the determination of lipid peroxidation (MDA), PON1 activity, and TSA concentration caused by the inflammatory and oxidative stress state caused by the infection can be used as new biomarkers for this infection.

Keywords: Paratuberculosis, Malondialdehyde, Total sialic acid, Paraoxonase activity

Corresponding Author:

Enes Akyüz, Department of Internal Medicine, Faculty of Veterinary Medicine,
Kafkas University, 36100, Kars, Turkey
E-mail address: enesakyuz_44@hotmail.com

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INTRODUCTION

Paratuberculosis (PT) can be seen in many parts of the world. The disease is known as Johne's or Hohnesche Krankheit disease. The causative agent of the disease is *Mycobacterium avium subsp. paratuberculosis*. PT is an infectious disease that causes economic losses due to a decrease in meat and milk yield and a decrease in reproductive efficiency, as well as causing chronic enteritis. Although the disease causes severe cachexia, it is also important as a zoonosis (Makav and Gökçe, 2013; Li et al., 2017; Davis and Park, 2018; Karatay et al., 2020). Although the disease is mostly seen in older ages, it generally occurs between the ages of 2-6. The disease can also be seen in calves at an earlier age (Karakas and Civelek, 2018). Because the incubation period of the disease is quite long, infected animals may start to spread bacteria with feces 15-18 months before clinical symptoms are observed (Mecitoğlu and Demir, 2012). In the subclinical period, variations occur in the antigen response to paratuberculosis and the immune response due to increased gamma interferon levels (Strickland et al., 2005). Paratuberculosis causes serious productivity losses in animals. In addition, its role in the etiology of Crohn's disease makes paratuberculosis important (Çetinkaya et al., 1997; Diéguez et al., 2009; Osterstock et al., 2010; Karatay et al., 2020).

Sialic acids, which are derivatives of N-acetyl neuraminic acid, are found in the structure of macromolecules and receptors as terminal carbohydrate residues of the oligosaccharide side chain of polysaccharides, glycoproteins, and mucoproteins (Varki and Varki, 2007; Uzlu et al., 2010). Determination of total sialic acid (TSA) is indicated to be a valuable marker for the diagnosis and prognosis of inflammatory diseases (Uzlu et al., 2010; Deveci et al., 2017). As a response to an inflammatory stimulus, free radicals or reactive oxygen species (ROS) are released from dendritic cells, neutrophils, and macrophages (Kostadinović et al., 2016). The produced ROS should be sustained in balance with the antioxidant system in the cell. An increase in ROS levels in cells can cause oxidative stress, which has an important role in the pathophysiology of diseases (Kara et al., 2016; Kükürt et al., 2020; Kostadinović and Lević, 2018).

Paraoxonase enzyme activity (PON1) is an antioxidant enzyme found in the serum, liver, kidney, and intestine (Kuru et al., 2020). PON1 coexists with high-density lipoprotein in plasma and plays a role in preventing oxidation of the plasma lipoproteins.

Because peroxidized lipids are metabolized by this enzyme, the accumulation of lipid peroxides in both high-density lipoprotein and low-density lipoprotein is inhibited (Deveci et al., 2017). Malondialdehyde (MDA), which is the result of non-enzymatic oxidative lipid peroxide degradation, shows toxic effects by binding to nucleic acids, phospholipids and amino groups of proteins (Puvača et al., 2015). It is measured as an indicator of lipid peroxidation in oxidative stress (Cenesiz et al., 2016). MDA is a lipid peroxidation product and is a biomarker that generally indicates oxidative stress. In cases where oxidative stress increases, its level increases (Aguiar et al., 2012; Çevik et al., 2012; Giera et al., 2012).

It has been reported that there may be changes in PON1 (Kuru et al., 2020), TSA, and MDA levels as a result of inflammation caused by the existing infection (Uzlu et al., 2010; Deveci et al., 2017). Although ELISA is the most commonly used method for subclinical paratuberculosis diagnosis, this method has disadvantages (Duran and Çenesiz, 2019). Because, in subclinical paratuberculosis infection, the long incubation period and the absence of clinical findings until advanced stages constitute a handicap. ELISA has a low (about 45%) sensitivity for subclinical paratuberculosis (Collins, 1996). Therefore, alternative methods are sought to increase the accuracy of the diagnosis. In this context, it was aimed to determine total sialic acid, paraoxonase activity, malondialdehyde, and some serum biochemical parameters in cows with subclinical paratuberculosis.

MATERIALS AND METHODS

Animals

The presented study was carried out after the approval of the Kafkas University Animal Experiments Local Ethics Committee (KAÜ-HADYEK/2020-099). For the study, 500 clinically healthy cows (2-6 years old, middle lactation, semi-intensive fattening, under the same care and feeding conditions, Simmental cows), whose basic physical examination findings (rectal temperature, breathing per minute, and pulse rate) were within normal limits, were selected in Kars province. ELISA test was performed from blood samples collected. Twenty-four animals with positive ELISA test constituted the subclinical paratuberculosis group and 12 animals with negative ELISA test constituted the control group.

Blood samples taken from the jugular vein were kept at room temperature for about 1 hour and then

centrifuged at 3000 rpm for 10 minutes (Hettich Rotina 380R®, Hettich, Germany) to obtain serum samples. Serum samples were stored at -20 °C until analysis.

Diagnosis of Paratuberculosis

The serum samples were tested with paratuberculosis using a commercial antibody ELISA kit (IDEXX, Montpellier SAS, France) at 450 nm wavelength by a spectrophotometer (PowerWave XS, BioTek, USA). The percentage results for the obtained OD values were calculated with the following formula:

$$\text{Result (\%)} = \frac{(\text{OD}_{\text{samples}} - \text{OD}_{\text{negative}})}{(\text{OD}_{\text{positive}} - \text{OD}_{\text{negative}})}$$

According to the formula above, from the obtained results; 55% and above are considered positive, 45-55% are considered as suspected and 45% and below are considered negative.

Biochemical analysis

Serum TSA levels were measured colorimetrically using a spectrophotometer (Power Wave XS®, BioTek, USA) according to the method described by Sydow (1985), the results were presented in mg/dL. The MDA concentration was determined according to the method reported by Yoshioka et al.(1979). The resulting MDA forms a pink-coloured complex with thiobarbituric acid (TBA) and the absorbance of this solution is measured spectrophotometrically at 535 nm (PowerWave XS®, Biotek, USA) to determine the degree of lipid peroxidation. MDA levels were calculated as µmol/L. PON1 activity was determined by measuring the absorbance of the colored composite caused by 4-nitrophenol (an enzymatic product of paraoxon-ethyl (Sigma®, London, UK) at 412 nanometers

with a spectrophotometer (PowerWave XS®, Biotek, USA) and the results were recorded as U/L (Eckerson et al., 1983). Serum Alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma-glutamyl transferase (GGT), creatinine (CREA), UREA, total protein (TP), lactate dehydrogenase (LDH) and iron (Fe) levels were determined with a commercial kit by an automated analyzer (Mindray BS120®, Mindray Medical International Limited Istanbul, Turkey).

Statistical analysis

Biochemical parameter values in the study were given as mean ± standard deviation (SD). Since the groups (control and paratuberculosis) showed normal distribution according to the Shapiro-Wilk test, they were compared with the independent samples t-test. SPSS® (SPSS Version 18.0, Chicago, IL, USA) program was used for all statistical analyses. In terms of parameters examined, differences between groups were considered significant at the p<0.05 level.

RESULTS

According to the data, when being statistically compared with the control group, it was determined that there was a significant decrease (p<0.001) in PON1 in the PT group. However, it was determined that there was a significant increase in TSA (p<0.001) and MDA (p=0.002) levels (Table 1).

In the PT group, a significant increase was found in ALT (p<0.001), AST (p=0.002), and UREA (p<0.001) according to the results obtained from the analyses. A significant decrease was observed in Fe (p<0.001). CREA, GGT, TP and LDH concentrations were not statistically significant between groups (p>0.05 Table 2).

Table 1. PON activities, TSA and MDA levels of the control and PT groups.

Parameters	Groups	N	Mean value ± SD	P value
PON1 (U/L)	Control	12	41.23 ± 5.47	<0.001
	PT	24	21.83 ± 3.74	
TSA (mg/dL)	Control	12	43.38 ± 3.05	<0.001
	PT	24	58.72 ± 3.42	
MDA (µmol/L)	Control	12	3.64 ± 0.81	0.002
	PT	24	7.53 ± 0.59	

Notes: PON1: paraoxonase activity, MDA: malondialdehyde, TSA: total sialic acid, PT: paratuberculosis group, control: healthy group, N: number of animals in the group.

Table 2. Some biochemical parameters levels of the control and PT groups.

Parameters	Groups	N	Mean value \pm SD	P value
ALT (U/L)	Control	12	15.73 \pm 0.37	<0.001
	PT	24	25.36 \pm 0.63	
AST (U/L)	Control	12	45.72 \pm 1.27	0.002
	PT	24	83.61 \pm 3.87	
GGT (U/L)	Control	12	13.16 \pm 0.49	NS
	PT	24	14.25 \pm 0.72	
CREA (mg/dL)	Control	12	1.27 \pm 0.04	NS
	PT	24	0.98 \pm 0.07	
UREA (mg/dL)	Control	12	283.1 \pm 4.27	<0.001
	PT	24	835.2 \pm 6.32	
TP (g/dL)	Control	12	7.62 \pm 0.23	NS
	PT	24	8.11 \pm 0.34	
LDH (U/L)	Control	12	643.58 \pm 19.02	NS
	PT	24	697.71 \pm 12.55	
Fe (μ mol/L)	Control	12	47.38 \pm 2.72	<0.001
	PT	24	21.17 \pm 1.62	

Notes: NS: not significant, ALT: alanine aminotransferase, AST: aspartate aminotransferase, CREA: creatinine, TP: total protein, LDH: lactate dehydrogenase, Fe: iron, PT: paratuberculosis group, control: healthy group, N: number of animals in the group.

DISCUSSION

Reactive oxygen species (ROS) are required for the defense system against pathogenic microorganisms. Macrophages and neutrophils generate large amounts of ROS as a result of oxidation. (Kuru et al., 2018a, 2020). Free radicals, which are the most important products of antimicrobial activity in the host, are difficult to measure due to their short life and high reactivity. Therefore, methods are used by which the end products of various reactions are measured. MDA, which is an indicator of lipid peroxidation, is the most common of these (Valko et al., 2007). *Mycobacterium paratuberculosis* sustains its life in macrophages after passing the intestinal barrier. There, they come across reactive oxygen and nitrogen species in cellular defense (Ehrt and Schnappinger, 2009). An antioxidant-oxidant defense mechanism develops between the host and the bacteria. With this aim, we determined the serum MDA concentration to evaluate lipid peroxidation and observed a significant increase ($p < 0.05$) when compared with the control group. These findings are consistent with the results of the studies performed (Cenesiz et al., 2016; Qasem, 2016). The reason for its high in our study was attributed to the increase in oxidative stress associated with the disease.

Paraoxonase is an endogenous antioxidant produced by liver cells. It has protective properties against lipid peroxidation caused by free radicals on cell sur-

faces (Aguiar et al., 2012; Çevik et al., 2012; Giera et al., 2012; Deveci et al., 2017). In the PT group, PON1 activity was found to be lower compared to the control group. The decrease in PON1 activity suggested that it was the result of liver function loss. The increase in ALT and AST levels may indicate that the disease may cause hepatocyte destruction. The decrease in PON1 activity also suggested that it was the result of hepatocyte destruction.

Sialic acid is an acute-phase protein that forms the terminal sugar of carbohydrates in the glycoprotein structure (Karapehlivan et al., 2007). It has been suggested that sialic acid is an antioxidative agent responsible for removing oxygen from the vascular system in living organisms. It has also been reported that oxidative stress can initiate the release of sialic acid from oligosaccharides on the cell surface without sialidase activity or induction (Eguchi et al., 2005). In the presented study, it was found that TSA levels differed significantly compared to the control group. These results confirm that sialic acids are important during paratuberculosis-induced stress. It has been reported that serum levels of TSA are increased in inflammatory conditions or such conditions (Uzlu et al., 2010). In our study, it was concluded that the high TSA level of the PT group may be the result of infection-induced inflammation.

Malondialdehyde is a lipid peroxidation product and is a biological biomarker that generally indicates

oxidative stress. In cases where oxidative stress increases, its level increases (Aguiar et al., 2012; Çevik et al., 2012; Giera et al., 2012; Kuru et al., 2018b). In a study, MDA levels of the PT group were found to be statistically higher than the control group (Qasem, 2016). In bacterial infections or inflammation, oxidative stress has been reported in different studies (Akyüz et al., 2017; Kuru et al., 2018a, 2018b; Kükürt et al., 2020). It is thought that the high level of MDA in the presented study following the literature may be due to the increase in oxidative stress with infection.

In a study, it was reported that the PT group had higher ALT levels and lower AST levels compared to the control group (Abdelaal et al., 2019). ALT and AST enzyme levels may increase in liver damage (Cebra et al, 1997; Stojević et al, 2005; Akyüz and Gokce, 2021). In our study, ALT and AST levels were found to be higher than in the control group. It was thought that the reason for this might be liver function loss due to infection. The high ALT level in both studies compared to the control group was found to be consistent with the literature. The amount of UREA in the blood may vary depending on the type of protein in the diet, and kidney and liver function. UREA is converted into ammonia in the liver (Sosa et al., 2010). In the presented study, we think that the reason for high UREA in the PT group might be a malfunction

in conversion to ammonia as a result of impaired liver function, and therefore its level increased. No statistical significance could be determined for other parameters in serum biochemistry.

CONCLUSION

As a result, a decrease in PON1 activity and an increase in MDA, TSA, ALT, AST, and UREA concentrations were determined with PT, which may show a hidden course despite the absence of any clinical findings. For the diagnosis of PT, alternative methods are sought to increase the accuracy of the diagnosis. In conclusion, in subclinical PT infection, the long incubation period and the absence of clinical findings until advanced stages constitute a handicap. However, our findings show that the determination of lipid peroxidation, PON1 activity, and TSA concentration caused by the inflammatory and oxidative stress state caused by the infection can be used as new biomarkers for this infection. Also, these data may cause a loss of yield by revealing the harmful effects of inflammation in the long term. Besides, we think that the data obtained from the presented study will contribute to new studies in this field.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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