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Research Article

The Diagnostic Significance of Serum Troponin Levels Lambs with White Muscle Disease

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ABSTRACT

Objective: This study was carried out to determine the prognostic importance of troponin enzyme levels in lambs with White Muscle Disease (WMD).
Materials and Methods: This study consisted of 50 male and female lambs aged 0-3 months old, 30 of which had clinical white muscle disease (Group I) and 20 of which were healthy (Group II – Control Group). Group I was composed of lambs that showed clinical symptoms of the disease. The disease was also identified by laboratory analysis. The lambs in this group were treated and the course of the disease was followed for 15 days.
Results: Compared with the control group, the Group I before treatment results were as follows: AST, LDH, CK, CK-MB, Troponin I and T ($P<0.001$) were high, while GSH-Px ($P<0.001$), SOD ($P<0.01$), Se ($P<0.01$), Retinol and Tocopherol were low. Compared with the control group, the Group I After Treatment results were as follows: AST, CK, Troponin T ($P<0.001$) were high, LDH ($P<0.01$) was high and GSH-Px ($P<0.01$) was low. Comparing Group I Before Treatment and After Treatment results, AST, CK, CK-MB and Troponin I ($P<0.001$), as well as GSH-Px, SOD and Se ($P<0.01$) were high. It was determined that LDH decreased and Tocopherol increased. Whereas Vitamin D3 was determined to be insignificant in all three groups, the levels of CK-MB, Troponin I, Retinol, SOD and Se were insignificant in the After Treatment and control groups, and the Troponin T and retinol values were measured to be insignificant in the Before Treatment and After Treatment groups.
Conclusion: To conclude, measuring the AST, CK, CK-MB, LDH values as well as Troponin can be an important parameter for the identification and prognosis of WMD.

Key word: Lamb, White Muscle Disease, Cardiac Marker, Troponin.

INTRODUCTION

White Muscle Disease (WMD) or nutritional muscular dystrophy characterized by reluctance to move, difficulty in standing, stiff gait, arched back, and short and straight steps is a nutritional and

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enzootic disease of lambs, (farm animal species) by skeletal and cardiac muscle degenerations. It is most common in young, rapidly growing lambs, calves, goat kids and foals born from dams that have been fed for long periods, usually during winter months, on diets low in selenium (Se) and vitamin E (Vit E) (Radostits *et al*., 2006, Scott, 2015). Selenium and vitamin E appear to be synergistic in preventing WMD. Se deficiency is characterized by degeneration and severe necrosis in myocardial and skeletal muscles, resulting in acute heart failure and sudden death without prior clinical signs. Se and vitamin E deficiency induce lipoperoxidation in tissues, which results in muscle degeneration and calcification (Yavuz, 2017; Cooper and Valentine, 2016)

WMD can be diagnosed as clinically, laboratory and pathological findings. The blood biochemical profile should be determined in order to diagnose the disease, monitor the course of the disease, and follow up the response to the therapy. Blood parameters, such as aspartate aminotransferase (AST), lactate dehydrogenase (LDH), creatine kinase (CK), creatine kinase myocard band (CK-MB), glutathione peroxidase (GSH-PX), superoxide dismutase (SOD), Se, Retinol, and Tocopherol are among important biochemical parameters in determining the biochemical profile. These parameters are very essential regarding to diagnose, treatment and following up prognosis. Data regarding the pathogenesis and prognosis of the disease can be obtained from these parameters.

Clinical studies have indicated that serum cardiac troponins (cTns) are the earliest appearing biochemical markers in acute coronary disease of humans and that cardiac troponin-T (cTn-T) and cardiac Troponin I (cTn-I) are valuable biochemical indicators of myocyte degeneration. cTns are released into the blood circulation as a result of acute myocardial degeneration and necrosis (Mair et al., 1995).

Troponin is divided into three basic parts troponin I (Tn-I), troponin T (Tn-T) and troponin C (Tn-C), which make up the troponin complex. (Kaneko, 1997; Babuin and Jaffe 2005). Different isoforms of the troponin complex proteins are found in cardiac and skeletal muscles for Tn-T and Tn-I. The cardiac forms are indicated as cTn-T and cTn-I. Troponin-C is not a specific marker for cardiac cases because in the amino acid arrangement of Tn-C, there is no difference between cardiac and skeletal muscles (O'Brien *et al.*,1997; O'Brien *et al.*,1998; Babuin and Jaffe, 2005).

Especially in recent years in human and animal medicine (Gunes *et al*, 2005; Ataollahi *et al.*, 2013; Gunsolus *et al.,* 2018), that cTn-T and cTn-I are helpful biochemical indicators for determining the death of cardiac muscles. Studies have proven that cTn-T and cTn-I are emitted into circulation as a result of acute myocardial syndrome and necrosis (Bertsch *et al.*, 1997; M-Bardorff *et al.*, 1999; Azzazy and Christenson 2002; Murphy, 2004). It was asserted that Troponin I and T levels, which function in the contraction of cardiac and skeletal muscles, increase in human muscle degeneration (Christenson *et al.,* 1998; Panteghini, 2000; Boccara *et al.*, 2000). It was also stated that these proteins were found in the skeletal muscles of animals (O'Brien *et al.,* 1998; Fredricks *et al.*, 2001).

In this study the identification of serum troponin levels concurrent with muscle originated enzymes (AST, CK, CK-MB, LDH), as well as the determination of serum troponin levels as an indication of whether any cardiac muscle degeneration has occurred during the period when the clinical symptoms of the disease were observed, are considered significant in the diagnosis of cardiac muscle damage and the prognosis of the disease.

The aim of this study is to synchronically measure muscle originated enzymes and serum troponin (cTn-I and cTn-T) levels reported to be cardiac specific; and in the light of the data obtained, to determine the effectiveness of the observed changes in troponin levels on the identification of any possible cardiac damage that may occur due to the white muscle disease widespread in the region.

MATERIALS AND METHODS

The material of this study was composed of 50 male and female Akkaraman race lambs aged 0-3 months. The lambs, 30 of which had clinical white muscle disease and 20 of which were healthy, were obtained from Van and its districts. The lambs were diagnosed with clinical white muscle disease based on clinical symptoms (such as not being able to stand on legs, developmental retardation, stiff gait, arched back, and collapsing on hind legs) and laboratory analyses. In addition, a control group from the same region was formed of lambs that were healthy according to clinical examination and laboratory findings. A single dose of a combination of 1 mg sodium selenite and 60 mg vitamin E (Eselen®, Vetaş™, Turkey) was applied to the inside of the muscles of the lambs in the group with clinical white muscle disease. Blood samples were collected in non-anticoagulant tubes from the lambs with white muscle disease before treatment (0 day) and after treatment (7th day), and from healthy lambs only once. The blood samples were kept at room temperature for an hour, and then their serum was

removed by centrifuging them for 10 minutes at 3000 cycles (Rotofix 32®Hettich). The samples thus obtained were kept at -20°C until they were analyzed.

Serum AST (AS® 521/Randox/UK), LDH (LD® 401/Randox/UK), CK (CK® 110/Randox/UK), CK-MB, superoxide dismutase (SOD) (RANSOD®-SD125/Randox/UK) and glutathione peroxidase (RANSEL®-RS505/Randox/UK) levels were measured spectro-photometrically according to the procedures stated in the commercial test kits (Boehringer-Mannhein Photometer 5010, Mainhein-Germany).Vitamin A, D_3 and E levels and serum Se levels were analyzed by means of a high performance liquid chromatography device (HPLC 1100®-Agilent Technologies/USA) and an atomic absorption spectrophotometer (Solar AA Spectrometers®-ThermoElk. Co./UK), respectively. Serum cardiac troponin I and T concentrations were measured by means of ELISA (ELISA reader®-DAS) and an immunoassay device (Elecsys® 2010-Roche) according to the procedure stated in their commercial test kits.

To determine the changes in the serum values of the animals with white muscle disease before and after treatment, as well as for the control group, Student's t-test was applied using the SPSS software package.

RESULTS

Compared with the control group, the before-treatment results of the diseased animals were determined as follows: AST, CK, CK-MB, Troponin I and Troponin T were statistically high ($P<0.001$) while GSH-Px was considerably low ($P<0.001$). Furthermore, LDH was high ($P<0.001$) but SOD and Se ($P<0.01$) as well as Retinol and Tocopherol ($P<0.05$) were low.

Compared with the control group, the after-treatment results were as follows: AST, CK, Troponin T ($P<0.001$) were high, LDH ($P<0.01$) was high and GSH-Px ($P<0.01$) was low.

Comparing before-treatment and after-treatment results, AST, CK, CK-MB and Troponin I ($P<0.001$), as well as GSH-Px, SOD and Se ($P<0.01$) measurements were high. It was determined that LDH ($P<0.05$) decreased and Tocopherol ($P<0.05$) increased. Whereas Vit D3 was determined to be insignificant in all three groups, CK-MB, Troponin I, Retinol, SOD and Se were insignificant between after-treatment and control groups, and Troponin T and retinol values were insignificant between before-treatment and after-treatment groups.

DISCUSSION

White Muscle Disease is defined as an enzootic and nutritional disease characterized by reluctance to move, difficulty in standing, stiff gait, arched back, and short and straight steps (Or *et al.*,2003). Although animals have an appetite, due to degeneration in the muscles, they encounter problems in feeding and in later stages cardiac muscles are also affected, leading to the death of the animal (Or *et al.*,2003).

Laboratory and pathological findings are used in the identification of White Muscle Disease but identification by clinical findings is difficult since the clinical symptoms and observation time can be confused with those of many other diseases (Guns *et. al.* 2010; Aksoy 2012; Yüksek *et al*, 2017). In identification by pathological findings, difficulties can be encountered due to the variability of the affected muscle groups and the degree of the lesions. Vitamin E and/or Selenium deficiency plays a role in the etiology of the disease (Aytuğ *et al.*, 1990; Gunes *et al.*, 2010; Ataollahi *et al.*, 2013).

Vit E and Se deficiency leads to antioxidant deficiency and accordingly it increases free radicals so that degeneration occurs in muscle. Se enters the structure of the enzyme of glutathione peroxidase (GSH-Px) working in the body's antioxidant protection and acts on H_2O_2 or H_2O reduction (Radostits *et al.*, 2006). In the laboratory diagnosis of the disease, Vitamin E and/or Selenium levels, glutathione peroxidase activity and muscle originated enzymes (AST, CK, LDH, ALT) are used (Aytuğ *et al.*,1990; Nizamlıoğlu *et al.*,1991; Radostits *et al.*, 2006; Scott, 2015).

GSH-Px is prevents the oxidation of unsaturated fatty acid by making harmless of oxidants that known as reactive oxygen species pro-oxidants hydrogen peroxide etc. Vit E also makes similar task.

The increase in oxidants that results of Se and Vit E deficiency, leads to the hyaline degeneration and calcification of muscle fibers. The muscle degeneration is much more so than occurs in skeletal muscle because of high metabolic activity in skeletal muscle. Serum Lactate dehydrogenase (LDH), creatine kinase (CK) levels is increases in serum because muscular dystroph (Turgut 2000, Radostits *et al.*, 2006; Scott, 2015; Yüksek *et al*, 2017).

Or *et al.* (2003) established that GSH-Px enzyme activity is a diagnostic parameter in identifying white muscle disease; in addition, it is important that serum enzymes such as AST, ALT, LDH, ALP and CK are also measured in the sick lambs. They studied the

Parameters	Control Group (n=20)	White Muscle Disease Group (n=30)	
		Before Treatment	After Treatment
AST (IU/L)	51,86±9,2[a]	1892,07±205,6[d*]	138,44±25,3[d]
LDH (IU/L)	825,80±128,8[a]	1692,25±423,8[c†]	1464,58±100,6[c]
CK (IU/L)	213,52±42,8[a]	4384,91±829,8[d*]	357,80±39,91[d]
CK-MB (IU/L)	180,80±38,9[a]	991,59±123,5[d*]	221,25±27,6[a]
TroponinT(ng/ml)	0,0±0,0[a]	0,33±0,1[d]	0,2±0,03[d]
Troponin I (ng/ml)	0,56±0,2[a]	11,6±1,8[d*]	0,59±0,3[a]
Vitamin A(µg/ml)	0,67±0,04[a]	0,45±0,07[b]	0,57±0,04[a]
Vitamin D_3(µg/ml)	0,05±0,06[a]	0,054±0,03[a]	0,03±0,01[a]
Vitamin E(µg/ml)	2,5±0,37[a]	1,69±0,28[b†]	2,19±0, 35[a]
Se (ng/ml)	98,3±6,4[a]	22,6±2,8[c‡]	106,3±5,9[a]
GSH-Px (IU/g Hb)	65,8 ±6,3[a]	9,5±4,8[d‡]	24,5±5,6[c]
SOD (IU/g Hb)	768 ± 54,7[a]	213 ± 31,9[c‡]	628 ± 42,1[a]

*Table 1. Control group and before and after treatment values obtained in the case of white muscle disease in lambs. The statistical significance between the control group and before treatment; †p<0.05, ‡p<0.01 *p<0.001. The difference between the values shown with different letters in the same row is statistically significant.*

concentrations of some antioxidant vitamins in the

lambs with white muscle disease in our region and determined that the vitamin E and β-carotene levels of the sick lambs were significantly lower than those of healthy lambs. The findings and statistical evaluations of the study are presented in Table 1.

In this study, the AST values were measured as 51.86 (IU/L), 1892.07 (IU/L) and 138.44 (IU/L) for the control group, the before-treatment (BT) group and the after-treatment (AT) group, respectively. Kozat *et al.* (2011) measured AST levels as 252 (IU/L) BT and 135.2 (IU/L) AT. Sugen and Günes (2008) stated in their study that the AST level in lambs with white muscle disease was 126.4(IU/L). High BT AST concentrations can be related to the intensity of the disease; and the AT values are similar to those found by the researchers.

The level of CK enzyme, which is found in muscles as an indicator of muscle degeneration, in lambs with White Muscle Disease was measured by different researchers as follows: 429.57 (IU/L) by Or *et al.* (2003), 579.4 (IU/L) BT, 309.4 (IU/L) AT by Kozat *et al.* (2011), 261.16 (IU/L) by Tunca *et al.* (2009). In this study, the CK values were determined to be 213.52 (IU/L), 4384.91 (IU/L) and 357.80 (IU/L) for the control group, the before-treatment (BT) group and the after-treatment (AT) group, respectively.

The level of CK-MB in blood, which is one of the isoenzymes of the CK enzyme, also increases in muscle degeneration cases. The CK-MB level in lambs with White Muscle Disease was reported to be 216.2 (IU/L) by Sugen and Gunes (2008), and 214.16 (IU/L) by Or *et al.* (2003). The findings of this study are as follows: 180.80 IU/L in the control group, 919.59 IU/L before treatment and 221.25 IU/L after treatment.

Although the LDH values are low in trauma, necrosis, neoplasia and cardiac diseases that involve degenerative tissues, the levels increase in skeletal muscle degenerations, cardiac muscle diseases (myocardial infarction, bacterial endocarditis, diroflariasis, aortic thrombosis) and cellular liver diseases (Turgut, 2000). The results of this study are 825.8 IU/L in the control group, 1692.25 BT and164.58 IU/L AT. Tunca *et al.* (2009) found a mean LDH level of 228.77 (IU/L) in their study on lambs with White Muscle Disease.

Başbuğan *et al.* (2010) stated that Troponin T, which is found in the protein structure and increasesin muscle degeneration cases, is not found in the blood of healthy individuals. Schober and Kirbach (1999) established that cardiac Troponin T in healthy dogs was 0 ng/ml at minimum and 0 ng/ml at maximum levels. Başbuğan *et al.* (2010) reported that they measured the Troponin T level in the serum of all healthy ruminants as 0.010 ng/ml. The measurements in this study indicate the following levels of Troponin T: 0.0 ng/ml in the control group, 0.33 ng/ml in BT and 0.2ng/ml in AT.

In the study conducted with retinol (which plays an important role in the development of new cells, the maintenance and repair of tissues, and the development of bones and teeth), Vitamin A levels were measured as 0.67µg/ml, 0.45µg/ml and 0.57 µg/ml in control groups, BT and AT, respectively.

Nizamlıoğlu *et al.* (1991) stated that the average Tocopherol level in newborn lambs was 9.33 µg/100 ml and62.04 µg/100 ml in 5-month-old lambs, In the same study, the level was measured as 20.93 µg/100 ml in lambs with white muscle disease and 28.74µg/100 ml in healthy animals. In this study, tocopherol levels were measured as 2.5 µg/ml in the control group, 1.6µg/ml in BT and 2.9µg/ml in AT.

In their study, Or *et al*. (2003) measured the GSH-Px level as 67.9 IU/g Hb in the control group and 11.9 IU/g Hb in the group of lambs with white muscle disease. Kozat *et al*. (2011) measured the GSH-Px level as 77.6 IU/g Hb in the control group, 28.0 IU/g Hb in the BT group of lambs with subclinical white muscle disease, and 43.8 IU/g Hb in AT. In this study, tocopherol levels were measured as 65.8 IU/g Hb in the control group, 9.5 IU/g Hb in BT and 24.5 IU/g Hb in AT.

Troponin I, which is one of the cardiac troponins, is a protein that is specific to cardiac muscles. It was reported that the average Troponin I level was 0-0.04 ng/ml in healthy ruminants, 0.15 ng/ml in 0-to-6-month-old lambs, and 0.84 ng/ml in cattle with pericarditis (Başbuğan *et al.,* 2010). Tharwat et al., (2013) measured the mean cTnI concentration was 0.02±0.05 ng/mL in the control group (healthy goat kids) and 11.18±20.07 ng/mL in the goat kids with cardiac nutritional muscular dystrophy. In this study, Troponin I levels were measured as 0.56 ng/ml in the control group, 11.6 ng/ml in BT and 0.59 ng/ml in AT.

This study presents the levels of SOD, which functions as an antioxidant, as follows: 768 (IU/g Hb) in the control group, 213 (IU/g Hb) in the before treatment group, and 628 (IU/g Hb) in the after-treatment group.

In their study conducted on lambs with white muscle disease, Altuğ *et al.* (2006) determined the Se level as 106 ng/ml in the control group, 53.9 ng/ml in BT group, and 96.2 ng/ml in AT group. Radostits *et al.* (2006) stated that a Se level below 50 ng/ml is low, while 50-100 ng/ml is critical and above 100 ng/ml is normal. In this study, Se levels were measured as 98.3 ng/ml in the control group, 22.6 ng/ml in BT and 106.3 ng/ml in AT.

To conclude, in white muscle disease, which is known to cause degeneration of cardiac muscles and skeletal muscles, the identification of serum troponin levels concurrent with muscle originated enzymes (AST, CK, CK-MB, LDH), as well as the determination of serum troponin levels as an indication of whether any cardiac muscle degeneration has occurred during the period when clinical symptoms of the disease were observed are considerably significant in the diagnosis of cardiac muscle damage and the prognosis of the disease. It is believed that such information will also contribute to further studies.

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REFERENCES

Aksoy G. İz Element ve Vitamin Teminindeki Bozukluklar. In: Gül Y., Geviş getiren Hayvanların İç Hastalıkları. *Medipress matbaacılık yayıncılık Ltd.Şti. Malatya* 2012; pp: 511-533.

Altuğ N, Ağaoğlu ZT, Yüksek N, Kaya A, Keleş İ. Adenosine deaminase in the diagnosis of white muscle diseases in lambs. *Medycyna Wet* 2006; 62: 1007-1010.

Ataollahi F, Mohri M, Seifi HA, Pingguan-Murphy B, Wan Abas WAB, Abu Osman NA. Evaluation of copper concentration in subclinical cases of white muscle disease and its relationship whit cardiac troponin I. *Plos One* 2013; 8: 1-5.

Aytuğ CN, Alaçam E, Özkoç Ü, Yalçın B, Gökçen H, Türker H, 1990. Koyun-Keçi hastalıkları ve yetiştiriciliği, *Tüm. Vet. Hayvancılık Hizmetleri Yayını*. No:2, Teknoğrafik Matbaası, Istanbul 1990; 289-293.

Azzazy HME, Christenson RH. Cardiac markers of acute coronary syndromes: Is there a case for point of caretesting. *Clinical Chemistry* 2002; 35: 13–27.

Babuin L, Jaffe AL. Troponin: the biomarker of choice for the detection of cardiac injury. CMAJ 2005; 173,10, 1191- 1202.

Başbuğan Y, Ağaoğlu ZT, Yüksek N. An investigation on serum troponin concentration in healthy

ruminants. *Kafkas Univ. Vet Fak Derg* 2010; 16: 641-645.

Bertsch T, H Bleuel H, Aufenanger J. Comparison of cardiac troponin-T and cardiac troponin-I concentration in blood during orciprenaline induced tachycardia in rats. *Experimental toxicology and pathology* 1997; 49: 467–468.

Boccara G, Pouzeratte Y, Troncin R, Bonardet A, Boularan AM, Colson P, Mann C. Cardiac troponin I and ECG study. *Acta Anaesthesiol Scand* 2000; 44: 398–402.

Christenson RH, Apple FS, Morgan DL, Alonsozona GL, Mascotti K, Olson M, RT McCormack RT, Wians FH, Keffer JH, Duh SH. Cardiac troponin-I measurement with the Access immunoassay system: analytical and clinical performance characteristics. *Clinical Chemistry* 1998; 44: 52–60.

Cooper BJ, Valentine BA. Muscle and tendon in: *Maxie MG (editors), Jubb, Kennedy and Palmer's Pathology of Domestic Animals Volume 1. Elesvier Printing, China*. 2016; 214-218.

Fredricks S, Metron GK, Lerena MJ, Heining P, Carter ND, Holt DW. Cardiac troponins and ceratine kinase content of striated muscle in common laboratory animals. *Clinica Chimica Acta* 2001; 304: 65–74.

Gunes V, Erdogan HM, M. Citil M, Ozcan K. Assay of cardiac troponins in the diagnosis of myocardial degeneration due to foot and mouth disease in a calf. *The Veterinary Record* 2005; 156: 714–715.

Gunes V, Ozcan K, Citil M, Onmaz AC, Erdogan HM. Detection of myocardial degeneration with point-of-care cardiac troponin assays and histopathology in lambs with white muscle disease. *Vet J* 2010; 184, 3, 376-8

Gunsolus, I., Sandoval, Y., Smith, S. W., Sexter, A., Schulz, K., Herzog, C. A., & Apple, F. S. Renal dysfunction influences the diagnostic and prognostic performance of high-sensitivity cardiac troponin I. *Journal of the American Society of Nephrology*, 2018; 29.2: 636-643.

Kaneko JK. Clinical Biochemistry of Domestic Animals, *5th Edn., Academic Pres, San Diego*, 1997; 413 - 414.

Kozat S, Altuğ N, Yüksek N, Özkan C. Evaluation of the levels of homocysteine, troponin ı, and nitric oxide in lambs with subclinical white muscle disease *Kafkas Univ Vet Fak Derg* 2011; 17: 441-444.

Mair J, Morandell D, Genser N. Equivalant early sensitivities of myoglobin, creatine kinase MB mass, creatine kinase isoform ratios and cardiac traponins I and T for acute myocardial infarction. *Clin Chem* 1995; 41:1266-72.

M-Bardorff M, Hallermayer K, Schro A, Ebert C. Improved troponin T Elisa specific for cardiac troponin T isoform: assay devlopment and analytical and clinical validation. *Clinical Biochemistry* 1999; 26: 7035–7042.

Murphy AN. Another new targets troponin I. *Circulation Research* 2004; 95: 1043.

Nizamlıoğlu M, Tiftik AM, Turgut K, Traş B. Kuzuların beyaz kas hastalığında vitamin E, Glutamik Okzalasetik Transaminaz (GOT), Kreatin Kinaz (CK) ve Laktat Dehidrogenaz (LDH) Aktivitelerinin Araştırılması. *Doğa Türk Vet ve Hay Derg* 1991; 15: 59-64.

O'Brien PJ, Dameron GW, Berk ML. Differantial reactivity of cardiac and skeletal muscle from various species in two generations of cardiac troponin-T immunoassays. *Research in Veterinary Science* 1998; 65: 135–137.

O'Brien PJ, Lant Y, Landenson JH. Differantial reactivity of cardiac and skeletal muscle from various species in a cardiac troponin-I immunoassay. *Clinical Chemistry* 1997; 43: 2333–2338.

Or ME, Dodurka HT Kayar A. A diagnostic importance of erythrocyte glutathioneperoxidase (GSH-Px) activity and some serum parameters in lambs with white muscle disease. *Turk J Vet Anim Sci* 2003; 27: 1-6.

Panteghini M. Presenttissues in the determination of troponin sandothermarkers of cardiac damage. *Clinical Biochemitry* 2000; 33: 161–166.

Radostits OM, Gay CC, Hinchcliff KW, Constable PD. Veterinary Medicine: A Texbook of The Diseases of Cattle, Horses, Sheep, Pigs and Goats". *10th Ed. Bailliere Tindall, London* 2006; 1716-1748.

Schober KE, Kirbach B. Noninvasive assessment of myocardial cell injury in dogs with suspected cardiac contusioan. *Journal of Veterinary Cardiology* 1999; 1: 17-25.

Scott PR. Sheep Medicine. CRC Press, Second Edition, 2015; 334-336.

Sugen B. Gunes V. Beyaz kas hastalıklı kuzularda kalp kası hasarının teşhisinde kardiyak troponin kit analizleri ve serum enzim aktivitelerinin önemi. *Sağlık Bilimleri Dergisi (Journal of Health*

Sciences) 2008; 17: 144-149.

Tharwat M, Al-Sobayit F, El-Sayed M. Cardiac troponin I in healthy newborn goat kids and in goat kids with cardiac nutritional muscular dystrophy. *Acta Veterinaria Hungarica* 2013; 61(4): 442-453.

Tunca R, Erdoğan HM, Sözmen M, Çitil M, Devrim AK, Erginsoy S, Uzlu E. Evaluation of cardiac troponin I and inducible nitric oxide synthase expression in lambs with white muscle disease. *Türk Journal of Vetetinary Animal Science* 2009; 33: 53-59.

Turgut K. Veteriner Klinik Laboratuvar Teşhis. Bahçıvanlar Basım Sanayi Konya, 2000; 179-257.

Yavuz O. The Pathological Investigations on Nutritional Myopaty Causeing Lamb Deaths in Neonatal Period. *Journal of Bahri Dagdas Animal Research* 2017; 6(2): 1-8.

Yüksek N, Başbuğan Y, Altug, N. İz Element-Vitamin Yetmezlikleri ve Metabolik Bozukluklar. In: Yaran E. Koyun ve Keçi Hekimliği. Güneş Tıp Kitap Evleri Ostim Ankara. 2017; 511-531.