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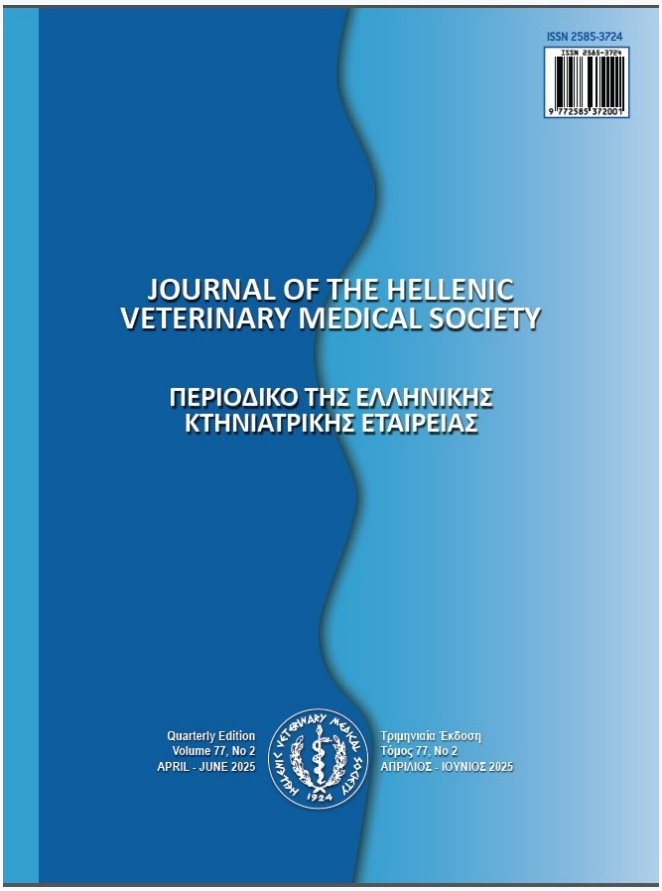

Diagnostic Importance of Serum Neopterin, Procalcitonin and Some Acute Phase Proteins in Cattle with Lung Hydatid Cyst

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Research article
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Diagnostic importance of serum neopterin, procalcitonin and some acute phase proteins in cattle with lung hydatid cyst

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ABSTRACT: In this study, it was aimed to determine the diagnostic importance of serum neopterin, procalcitonin, and some acute phase proteins in cattle with lung hydatid cysts. In the study, 30 cattle aged 2-8 years, Simmental or crossbred, constituted the patient group, and 10 healthy cattle in the same characteristics and age range constituted the control group. The cattle were included in the study after being diagnosed with lung hydatid cyst as a result of clinical, anamnesis, auscultation, radiographic examinations, laboratory and histopathological findings. Neopterin (21.60 nmol/L) and procalcitonin concentrations (146.77 ng/L) were significantly increased in the disease group compared to the control group (respectively: 7.22 nmol/L, 47.76 ng/L) (P<0.001). Haptoglobin (P<0.001) and ceruloplasmin (P=0.047) of the acute phase proteins werehigher in the patient group compared to the control group, while albumin was found to be lower (P=0.028). In conclusion, the evaluation of serum neopterin, procalcitonin, and some acute phase proteins in cattle with lung hydatid cysts was found to be important. Since hydatid disease is a zoonotic disease, it will be important to perform radiography scans and confirm the diagnosis with relevant biomarkers and take new protective measures. We think that the diagnosis will be strengthened by investigating neopterin and procalcitonin levels, especially in cattle with suspected lung cysts in radiographic findings.

Keyword: Cattle; Echinococcus; lung; neopterin; procalcitonin.

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INTRODUCTION

Very common worldwide, the hydatid disease is an important zoonotic disease affecting animals and humans (Kumar et al., 2016, Maleki et al. 2023). It occurs very frequently, particularly in regions where agriculture and animal husbandry are intense, and environmental health and preventive medicine practices are not carried out regularly (Cardona and Carmena, 2013). The disease is caused by a parasitic agents called *Echinococcus granulosus*. While the adult form of *Echinococcus granulosus* lives in the small intestines of carnivores; the cyst form lives in the tissues and organs of many living things such as ruminants, horses, and humans (Nisbet et al., 2008; Gökce et al., 2009). Dog feces are the main source of infection in humans and animals. Food and water contaminated with dog feces are the main cause of transmission. Contamination is common in places where husbandry is performed unconsciously, slaughtering of animals is done in an uncontrolled manner, cystic organs are fed to dogs, and animals are not given regular antiparasitic drugs (Nisbet et al., 2008). The incubation period varies and may take several years. There is no obvious symptom of lung hydatid cyst (Sayır and Çobanoğlu, 2013). Imaging techniques and serological tests are used in suspected cases (Gökce et al., 2009). In the radiological image, the cysts are smooth, sharply circumscribed, and oval in shape. Tomography is needed to distinguish it from other nodular lesions radiologically (Turgut et al., 2009). Radiological examination helps identify some cases of hydatid disease. Besides, tests such as the indirect hemagglutination test, ELISA, and immunoelectrophoresis are used in diagnosis (Sayır and Çobanoğlu, 2013). In addition to clinical and laboratory findings in the diagnosis of diseases, biomarkers have started to be used in recent years (Köse and Maden, 2013).

Neopterin is mostly released from macrophages and dendritic cells stimulated by cytokines in inflammatory conditions (Michalak et al., 2017; Pergialiotis et al., 2018; Akyüz and Gökce, 2021, Bozukluhan et al., 2023). Although it is widely used in human medicine to provide information about the prognosis of diseases, its use in veterinary medicine remains limited. Plasma neopterin concentration is actually an indicator of circulating active monocytes and macrophage activation. Neopterin plasma concentration alteration can be considered as a direct reflection of the activation of monocytes and macrophages against the disease (Ruokonen et al., 2002). As a result of macrophage or T-cell activation, there may be increases in blood neopterin levels, particularly in viral infections, inflammatory conditions, autoimmune diseases, neurodegenerative disorders, and some cancer types. Neopterin levels can be useful to evaluate the prognosis of various pathological conditions and the activity of diseases (Zuo et al., 2018; Ünüvar and Aslanhan, 2019, Bozukluhan et al., 2023).

Procalcitonin is an important protein and is used in the diagnosis of inflammatory conditions. Procalcitonin production during inflammation is associated with bacterial endotoxin and inflammatory cytokines (Ruokonen et al., 2002, Akyüz and Gökce 2021, Akyüz et al., 2022). Procalcitonin is normally secreted from the thyroid gland. However, it is also synthesized by neuroendocrine cells in the lungs or intestines during inflammation (Camacho and Losa, 2014, Neumann et al., 2023). Procalcitonin is synthesized from the C cells of the thyroid gland and its amounts in the blood are low under normal conditions. Procalcitonin is a protein consisting of 116 amino acids and is the precursor of calcitonin produced in the thyroid gland. It is produced by specific proteolytic enzymes in the C cells of the thyroid gland. Procalcitonin and calcitonin are synthesized by preprocalcitonin (Muller et al., 2001, Matur et al., 2017, Bozukluhan et al., 2023).

In this study, it was aimed to determine the diagnostic importance of serum neopterin, procalcitonin, and some acute phase proteins in cattle with lung hydatid cysts. Due to the lack of a clear symptom specific to lung hydatid cyst, the need for tomography to distinguish it from other nodular lesions radiologically, and the difficulties in accessing tomography in veterinary medicine; we think that the diagnosis will be strengthened by examining neopterin and procalcitonin levels, particularly in cattle with suspected lung cysts in radiographic findings.

MATERIALS AND METHODS

This study was approved by the Local Ethics Committee of Kafkas University (Kafkas University-HADYEK/2021-027).

Animals

A total of 40 cattle admitted to Hospital of the Faculty of Veterinary Medicine, KafkasUniversity were used in the study. In the study, 30 cattle (18female, 12 male) aged 2-8 years, Simmental or crossbred, constituted the patient group, and 10 healthy cattle (6 female, 4 male) in the same characteristics

and age range constituted the control group. Cattle with clinical signs such as anorexia, and weight loss, and those with pathological mass in the lung radiography were included in the study. Cattles that were determined to have different diseases in the clinical examinations performed in the Patient group were not included in the study. Animals that were determined to be completely healthy because of general physical and radiographic examinations were included in the study. First of all, clinical, anamnesis, auscultation, radiographic and laboratory examinations were performed on the cattle. Cattle diagnosed with lung hydatid cyst as a result of histopathological findings were included in the study. Cattle with suspected hydatid cyst diagnosis were slaughtered in the slaughterhouse unit of our university and destroyed in accordance with the procedure after samples were taken. The definitive diagnosis was determined by histopathological examination of the cysts in the lung tissue of cattle in the laboratory of KafkasUniversity, Faculty of Veterinary Medicine, Department of Pathology.

Procedures

Taking Blood Samples

Blood samples were taken from patient cattle before any practice was performed. Only one blood sample was collected from the patient and control groups, from the jugular vein into serum tubes with gel (BD Vacutainer®, BD, UK) and tubes with K_2EDTA (BD Vacutainer®, BD, UK) from all cattle.

Biomarkers, Biochemical and Hematological Analyses

Blood samples in K_2EDTA (BD Vacutainer®, BD, UK) were assessed for total leukocyte count (WBC $x10^3/\mu L$) and other hematological parameters using a complete blood count device (VG-MS4e®, Melet Schloesing, France). Complete blood count was measured within 10 minutes immediately after blood taking. Blood samples taken for serum were kept at room temperature for about 1 h and centrifuged at 20 × g for 10 min (Hettich Rotina 380R®, Hettich, Germany). All serum samples were stored at -20°C until analysis. Alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma-glutamyl transferase (GGT), lactate dehydrogenase (LDH), total protein (TP), glucose, iron, total bilirubin (Tbil), albumin, cholesterol, magnesium, creatinine, urea, and creatine kinase (CK) were measured with a fully automatic biochemistry device (Mindray BS120®, Mindray Medical Technology İstanbul, Türkiye) and commercial kits (Mindray Medical Technology, İstanbul, Türkiye). Haptoglobin and ceruloplasmin levels were measured in serum samples using methods reported in the literatüre (Colombo and Richterich, 1964, Skinner et al., 1991). Bovine neopterin (Bovine Neopterin ELISA Kit®, Cat No: E0121Bo, BT Lab, China) and bovine procalcitonin (Bovine Procalcitonin ELISA Kit®, Cat No: E0085Bo, BT Lab, China) were measured with ELISA kit. Albumin was measured colorimetrically (Epoch, Biotek, USA) with a commercial test kit (Biolabo, France).

Histopathological Examinations

Lung tissue samples taken after systemic necropsy of animals were fixed in 10% buffered formaldehyde solution. After routine tissue follow-up procedures, serial sections of 5 µm thickness were taken from the prepared paraffin blocks. Hematoxylin & Eosin staining was performed on the sections to detect histopathological changes. Sections were examined and photographed under a light microscope.

Radiographic Imaging

All of our cases were evaluated in the Radiology Unit of the Department of Surgery, Faculty of Veterinary Medicine, Kafkas University. Radiological evaluation was performed using 35x43 cm cassettes, in the right or left L/L position, at doses of 80-85 kV and 20-25 mAs, and radiographic images were taken with a computed radiography (CR)device (Fujifilm FCR Prima T2 Veterinary Set®, Medical Technology, Türkiye).

Statistical Analysis

Statistical analysis of the data was performed using SPSS® (SPSS 26.0, Chicago, IL, USA) software. The statistical differences between the groups with normal distribution according to the Shapiro-Wilk test were compared by the independent sample *t*-test. Pearson correlation coefficients were calculated to define the correlation between the variables. The obtained results were given as mean ± standard error of the mean (SEM). $P<0.05$ was considered statistically significant in the evaluation of the results.

RESULTS

As a result of the anamnesis, it was determined that all the sick cattle were anorexia, weight loss and lethargic. As a result of clinical examinations, the cough finding was determined in 40% (12/30) of patient cattle, lethargy in 50% (15/30), dyspnea in 23% (7/30), and cyanosis (5/30) in 16%. No statistical difference was found between the patient and

control groups in physical examination findings, respiratory rate and pulse rate per minute, and rectal temperature (P>0.05, Table 1).

Among the hematological parameters, the granulocyte count was found to be higher in the patient group compared to the control group (P=0.029), while no statistical difference was found in other hematological parameters (Table 1). In serum biochemistry, AST (P=0.015), GGT (P=0.005), urea (P=0.008), and LDH (P<0.001) levels were found to be significantly higher in the patient group compared to the control group, while TP (P=0.008), albumin (P=0.028), and cholesterol (P<0.001) levels were found to be lower (Table 2).

Lateral direct thoracic radiography revealed single or multiple cystic nodular lesions of round or irregular shape, widely localized in the lung, and showing radiopacity. The smallest of the existing cysts was 2.49 cm in diameter and the largest was 6.45 cm in diameter (Figures 1A and 1B).

Cystic formations of different sizes, which had a hard consistency when palpated and spread to all lobes of the lung, were detected in different regions. In places, hyperemic areas were observed around the cysts. When the contents of the cysts were examined, it was determined that the interior of the large cysts was filled with clear fluid, and the interior of the small cysts was calcified (Figures 2A and 2B).

In the histopathological examination of the lungs, atelectatic areas were observed especially near the cyst. The contents of the cysts, which are macroscopically small and with a harder consistency, were also calcified microscopically. It was observed that the cysts were surrounded by a fibrous capsule and there was a concentric lamellated cyst wall just below the fibrous capsule; in the pericystic region, an inflammatory cell line consisting of lymphocytes, histiocytes, and plasma cells was detected. It was observed that there were foreign body giant cells, whose nuclei were localized in the opposite direction of the cyst and did not have a distinct shape, in the region close to or adjacent to the cyst wall. In the cases examined, scolex was not found in the cyst walls and it was concluded that the cysts were sterile cysts (Figure 3a, 3b, 3c, 3d).

Neopterin concentration in the patient group (21.6 nmol/L) was significantly higher than in the control (7.22 nmol/L) (P<0.001, Figure 4A). Procalcitonin concentration in the patient group (146.77 ng/L) was significantly higher than in the control (47.76 ng/L) (P<0.001, Figure 4B). Haptoglobin concentration in the patient group (0.28 g/L) was

Table 1. Patient and control group physical examination findings and hematology

Parameters	Patient Group (n: 30)	Control Group (n: 10)	P value
	Mean ± SEM		
Rectal temperature (°C)	38.73 ± 0.37	38.01 ± 0.13	0.171
Breaths/min	21.87 ± 1.77	19.80 ± 2.82	0.525
Heart beats/min	67.20 ± 2.99	71 ± 2.80	0.362
Total leukocytes count (×10³/μL)	12.36 ± 1.80	8.35 ± 0.50	0.212
Lymphocytes count (%)	42.91 ± 2.89	48.18 ± 5.32	0:375
Monocytes count (%)	3.52 ± 0.29	6,89 ± 1.47	0.051
Granulocytes count (%)	53.21 ± 2.87	44.89 ± 6.47	0.187
Lymphocytes count (x10³/μL)	6.17 ± 1.70	4.03 ± 0.55	0.478
Monocytes count (x10³/μL)	0.38 ± 0.03	0.59 ± 0.15	0.190
Granulocytes count (x10³/μL)	5.82 ± 0.49	3.73 ± 0.57	0.029
Red blood cell count (x10⁶/μL)	7.80 ± 0.33	7.77 ± 0.48	0.959
Mean red cell volume (fL)	45.58 ± 1.33	43.50 ± 2.88	0.467
Hematocrit (%)	34.74 ± 1.13	32.20 ± 1.90	0.293
Hemoglobin (g/dL)	11.13 ± 0.42	10.30 ± 0.49	0.295
Platelet count (x10³/μL)	675.50 ± 96.44	525.40 ± 103.44	0.405

The expression P<0.05 is statistically significant. n: refers to the number of animals in the group.

Table 2. Patient and control group serum biochemistry findings

Parameters	Patient Group (n: 30)	Control Group (n: 10)	P value
	Mean ± SEM		
Alanine aminotransferase (IU/L)	56.36 ± 8.96	31.88 ± 3.07	0.128
Aspartate aminotransferase (IU/L)	137.45 ± 14.34	71.02 ± 12.42	0.015
Gamma glutamyl transferase (IU/L)	21.98 ± 1.52	16.34 ± 1.09	0.005
Creatine (mg/dL)	1.58 ± 0.29	1.23 ± 0.06	0.487
Urea (mg/dL)	68.66 ± 6.12	38.62 ± 2.62	0.008
Total bilirubin (mg/dL)	0.16 ± 0.02	0.15 ± 0.03	0.681
Lactate dehydrogenase (IU/L)	1329.33 ± 124.32	270.80 ± 25.49	<0.001
Glucose (mg/dL)	77.07 ± 9.63	61.70 ± 4.52	0.157
Total protein (g/dL)	5.82 ± 0.36	6.95 ± 0.18	0.008
Albumin (g/dL)	2.44 ± 0.07	3.01 ± 0.12	0.028
Creatine kinase (IU/L)	362.51 ± 130.91	103.96 ± 10.92	0.266
Iron (mg/dL)	1.04 ± 0.07	1.19 ± 0.08	0.232
Cholesterol (mg/dL)	77.58 ± 6	132.92 ± 7.80	<0.001
Magnesium (mg/dL)	3.43 ± 0.20	2.67 ± 0.41	0.073

The expression P<0.05 is statistically significant. n: refers to the number of animals in the group.

significantly higher than in the control (0.09 g/L) (P<0.001, Figure 4C). Ceruloplasmin concentration in the patient group (12.22 mg/dL) was significantly higher than in the control (9.29 mg/dL) (P=0.047, Figure 4D). In addition, the Pearson correlation of neopterin, procalcitonin, haptoglobin, ceruloplasmin and albumin parameters in the study is given in Table 3. A positive correlation was determined between neopterin, procalcitonin and haptoglobin (Table 3).

DISCUSSION

Causing significant economic losses and public health problems worldwide, hydatidosis is one of the important zoonotic and parasitary problems of do-

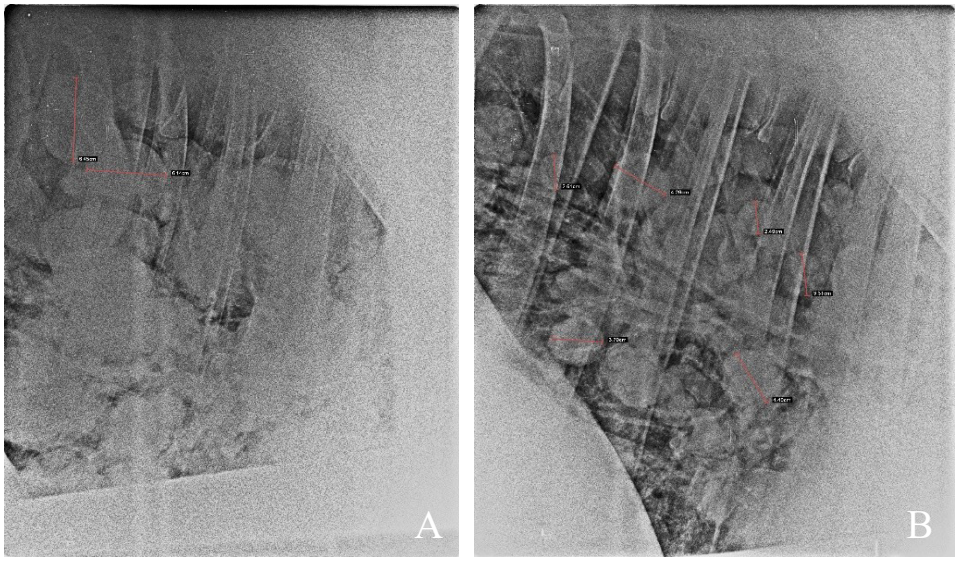

Figure 1. Radiographs of two cattle in the patient group. Lateral direct thoracic radiography showed single or multiple cystic nodular lesions of round or irregular shape, widely localized in the lung and showing radiopacity. A: Cysts larger than 6 cm, B: Cysts smaller than 6 cm.

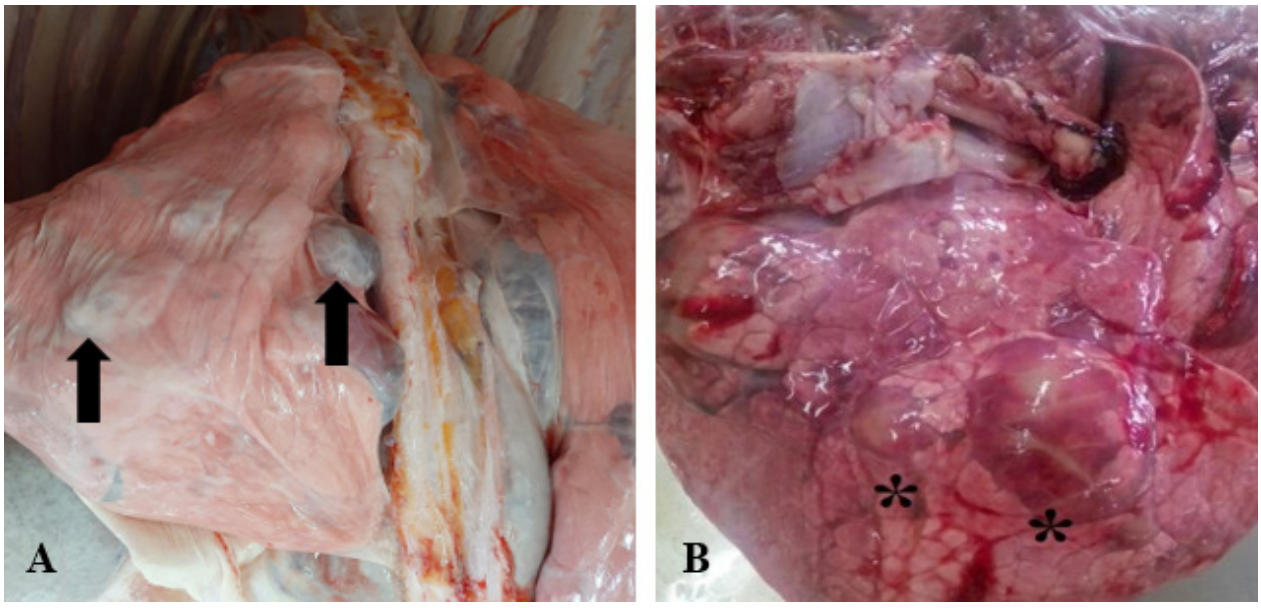

Figure 2. Macroscopic view of lung spread cysts of two different cattle lung in the patient group (A, black arrow; B, star).

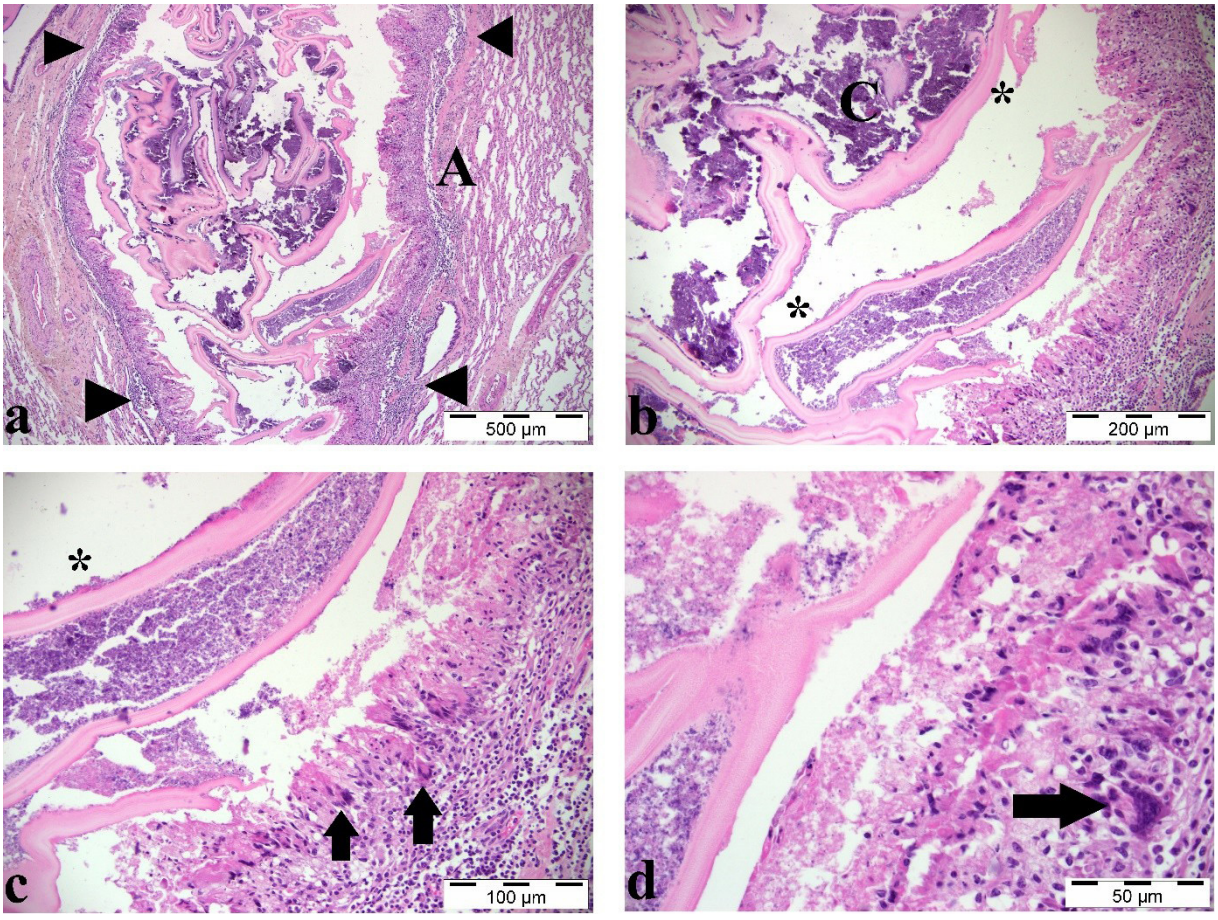

Figure 3. Lung tissue, H&E, **a:** Atelectasis (A) and granuloma structure in the area surrounded by arrowheads, **b:** Cyst wall with calcification (C) and concentric lamellation (asterisks), **c:** Cyst wall with concentric lamellation (asterisk) and foreign body giant cells (arrows), **d:** Higher magnification, foreign body giant cell (arrow).

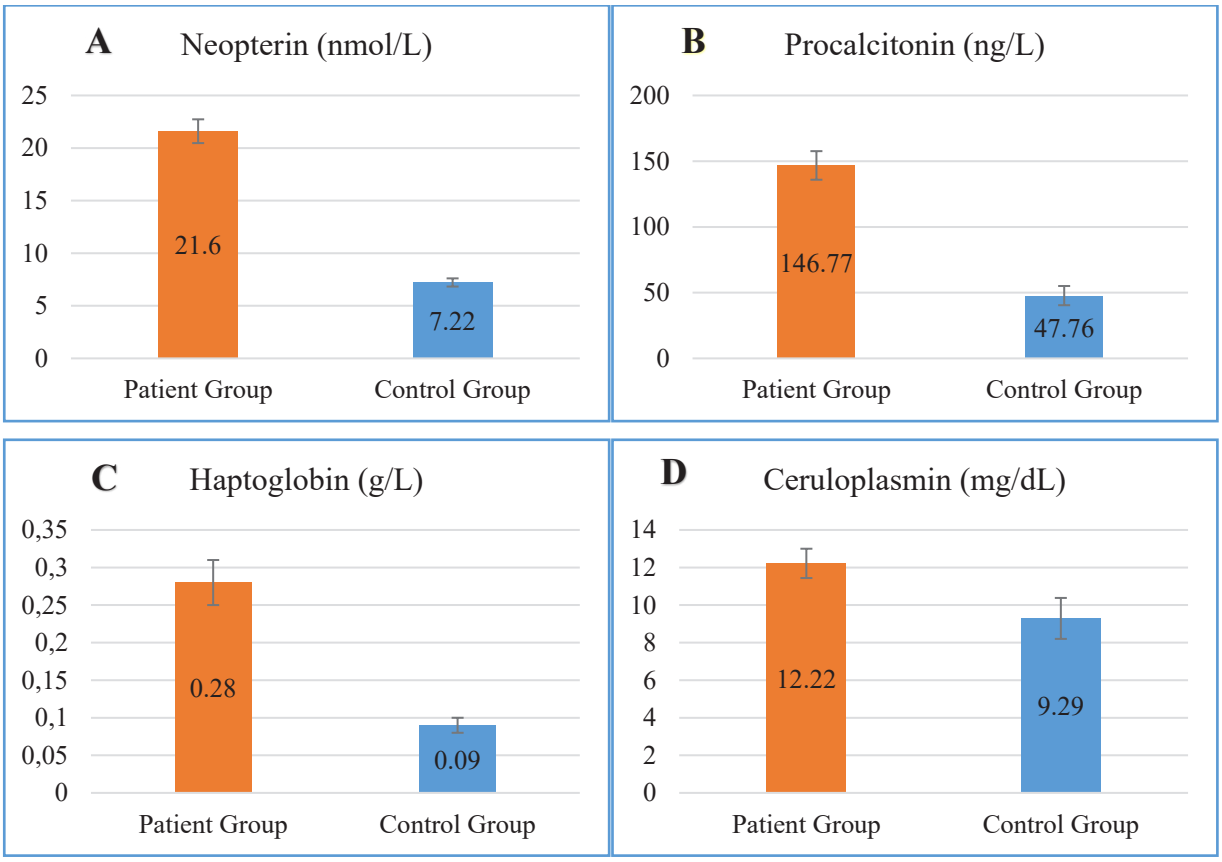

Figure 4. Comparison of mean values of serum neopterin, procalcitonin, haptoglobin, and ceruloplasmin levels of patient group and control group cattle. The expression P<0.05 is statistically significant. **A.** Comparison of mean serum neopterin level of cattle in patient group and control group (P<0.001), **B.** Comparison of mean serum procalcitonin level of cattle in patient group and control group (P<0.001), **C.** Comparison of mean serum haptoglobin level of cattle in patient group and control group (P<0.001), **D.** Comparison of mean serum ceruloplasmin level of cattle in patient group and control group (P=0.047).

mestic animals (Eckert and Deplazes, 2004). The destruction of all patient cattle in our study in terms of threatening public health caused a serious economic loss. Symptoms vary according to the location and size of the cyst, and the number and developmental stage of the cyst (Gökce et al., 2009). In our study, there was no statistical difference in physical examination findings, rectal temperature, respirations per minute, and pulse rates in the patient group. Dyspnea, cough, and anorexia findings were observed in some of the patient cattle as clinical symptoms. There may be changes in the serum biochemistry of cattle with hydatid cysts (Abdel-Rbhrnan et al., 2011). In the study we presented, changes in serum biochemistry were determined in AST, GGT, urea, LDH, TP, albumin, and cholesterol levels. The ran-

Table 3. Person correlation of some important parameters in the study

Parameters	Neopterin (nmol/L)	Procalsitonin	Haptoglobin	Ceruloplasmin
Procalsitonin (ng/L)	0.496**	-	-	-
Haptoglobin (g/L)	0.313*	0.369*	-	-
Ceruloplasmin (mg/dL)	0.094	0.110	0.137	-
Albumin (g/dL)	-0.022	-0.220	-0.175	-0.147

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

dom distribution and different sizes and round-oval structures of the cysts in the lung radiography findings in our study are similar to the study of Kumar et al., (2016). In the histopathological examination of the lungs of cattle with hydatid cysts, fibrous tissue reaction (capsules), necrosis, cellular reaction and collapse of all parts of the lung tissue adjacent to the cyst wall are observed. Additionally, mononuclear cells and neutrophils are the inflammatory cell types that most frequently infiltrate the area (Albermani and Al-Dabhawi, 2022). Histopathological examination findings in our study were also found to be compatible with the results of the study of Albermani and Al-Dabhawi, (2022).

During the course of infectious diseases, neopterin, the end product of pteridine metabolism, is released from monocytes and macrophages by interferon-gamma stimuli released from T lymphocytes (Berdowska and Zwirska-Korczala, 2001; Akyüz et al., 2022). Neopterin is used as an indicator of many cell-mediated immune activations in infections associated with the activation of T-lymphocytes and natural killer cells (Eisenhut, 2013). It has been reported that the increase in parasitic neopterin concentration is due to the activation of the cellular immune system (Rokos et al., 1991). There is a strong correlation between neopterin levels and endothelial damage (Ruokonen et al., 2002). In our study, the neopterin concentration was found to be statistically higher than the control. One of the possible reasons for this increase may be the activation of alveolar macrophages and lymphocytes stimulated in the patient group. Although there was no statistical difference in the hemogram, the increased lymphocyte count in the patient group compared to the control supports this. In addition, the increase in neopterin concentration as a result of cellular immunity activation in parasitic disease (Rokos et al., 1991) may have produced a similar result in our study. It has been reported that there is severe endothelial damage in the lung tissue as a result of aspiration in calves with pneumonia and that the neopterin concentration is increased compared to the control (Akyüz et al., 2022). Neopterin concentration may have increased in the patient group due to endothelial damage caused by cysts in the lung, activation of alveolar macrophages, and activation of cellular immunity.

Procalcitonin is produced in parafollicular cells in the thyroid gland. It also begins to be produced by parenchymal cells during infections or in some pathological conditions. Since parenchymal tissues are quite common, it is abundantly secreted during inflammation (Christ-Crain et al., 2007). The pancreas, liver, spleen, adrenal gland, lungs, kidneys, stomach, and white blood cells are the main sources of extrathyroid production (Matur et al., 2021). In this presented study, procalcitonin may have been secreted abundantly from the parenchyma cells in the lung due to the inflammation caused by the cysts. The release of procalcitonin during inflammation occurs as a result of direct stimulation by the toxins of microorganisms or as a result of stimulation by a cellular-mediated host response caused by cytokines (Nakamura et al., 2013). The stimulation of some pro-inflammatory cytokines as a result of inflammation and the cellular-mediated host response caused by this may have increased the procalcitonin concentration in the patient group. Besides, the increase in positive acute phase proteins haptoglobin and ceruloplasmin supports that the inflammation is severe. The increase in oxidative stress load as a result of the disease may have increased the procalcitonin level by activating the cytokines of inflammation and disease factors or toxic products caused by cysts in the lung parenchyma.

Those that increase after infection or severe inflammatory conditions, such as haptoglobin and ceruloplasmin, are called positive acute phase proteins, and those, on the other hand, that show a decrease, such as albumin, are called negative acute phase proteins. The task of haptoglobin is to prevent iron loss after complex structures formed by binding hemoglobin (Erkılıç et al., 2019). An increase in haptoglobin levels is observed in cases of inflammation, trauma, and infection (Mcgrotty et al., 2003). Haptoglobin concentration, which increased in the patient group compared to the control group, may have increased as a result of inflammation or secondary infection due to the pathological condition in the lung. The fact that hemoglobin and iron levels remained within normal limits in the patient group may have been shaped as a result of increased haptoglobin preventing hemoglobin and thus iron loss. Similarly, the decrease in albumin concentration in the patient group compared to the control may be due to the negative acute phase protein characteristics as a result of inflammation or secondary infection due to the pathological condition in the lung.

Ceruloplasmin is a positive acute-phase protein synthesized from the liver (Murata et al.,2004). Ceruloplasmin plays a role in the antioxidant system and protects cells against oxidative damage. De-

creased serum ceruloplasmin levels mean decreased phagocytosis and antimicrobial activity. As a result, the need for this enzyme increases in inflammatory conditions (Cerone et al., 2000; Kaya et al., 2016). In this presented study, oxidative stress load will increase if cysts disrupt normal lung functions (such as insufficient ventilation due to dyspnea) in patient cattle, and therefore, ceruloplasmin concentration may be increased in the patient group compared to the control, due to the protection of cells against oxidative damage. In addition, ceruloplasmin level may have contributed to this increase due to the stimulation of the lung macrophage system.

As a result of the inflammation caused by the hydadic cyst, relevant biomarkers and acute phase proteins increased compared to the control. This increase comes into play through a complex mechanism such as a response of cellular immunity, activation of defense systems, fight of the organism, and repair of endothelial damage. Evaluation of radiographic imaging, clinical and laboratory findings, and relevant biomarkers together provides important information for differential diagnosis. In addition, a positive correlation was determined between procalcitonin, neopterin and haptoglobin. The possible reasons for this positive correlation are that the relevant biomarkers give an acute phase reaction because of the inflammation. Lung inflammation caused by hydatid disease, stimulated macrophage activity, and lung endothelial damage caused by cysts may cause the elevated procalcitonin, neopterin and haptoglobin concentrations to give a positive correlation among themselves.

CONCLUSION

As a result, it is very difficult to diagnose hydatid cyst during antemortem examinations. We think that the presented study will be important in terms of contributing to current diagnostic methods for this disease. Radiographic imaging methods are helpful in the differential diagnosis of hydatid cysts. Radiological imaging may have different pathological masses (such as cancer mass), which may cause incorrect results. In addition, there are difficulties in accessing tomography in veterinary medicine. In our study, neopterin, procalcitonin, haptoglobin, and ceruloplasmin concentrations were found to be statistically higher in the patient group than in the control group. Hematology, radiography, and neopterin, procalcitonin, haptoglobin, and ceruloplasmin levels of cattle with lung hydatid cysts will be important in antemortem examination in the differential diagnosis.

Conflicts of interest

The authors have declared that there are no conflicts of interest associated with this study or its results.

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