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Importance of B-type Natriuretic Peptide (BNP) Analysis and Hemogram Evaluation in Cats wıth Pericardial Effusion Detected on

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ABSTRACT

This study aimed to measure plasma N-terminus pro-B-type natriuretic peptide (NT-proBNP) levels and hemogram parameters in 20 cats diagnosed with pericardial effusion by echocardiographic examination and to determine whether NT-proBNP could be used as a cardiac biomarker in the confirmation of pericardial effusion.

The study was conducted on 40 cats, consisting of a patient group of 20 cats of different ages, breeds and genders diagnosed with pericardial effusion by echocardiographic examination at the Cat Hospital Animal Hospital, and a control group of 20 healthy cats in terms of heart diseases. Blood samples were taken from the patient group and the control group cats for total blood count and NT-proBNP analysis. NT-proBNP values were determined from the prepared serum samples using the Vcheck200 – BIONOTE device. Total blood count was performed using the IDEXX ProCyte Dx TM Hematology Analyzer. After pericardial effusion was detected in echocardiography examination, M-mode measurement parameters such as left ventricular free wall thickness (LVPW) in systole and diastole, interventricular septum wall thickness (IVSD) in systole and diastole, end-diastole and end-systole left ventricular internal diameter (LVID), left atrium internal diameter (LA), aortic diameter (AO), LA/AO ratio, left ventricular ejection fraction (EF), and fractional shortening (FS) were evaluated.

In conclusion, in the statistical analysis of the data obtained in this study, while no statistically significant difference was observed between the groups in total blood count, it was determined that NT-proBNP increased significantly in cats with pericardial effusion. Therefore, it was concluded that NT-proBNP may be a good biomarker in terms of evaluating the wall stress caused by the fluid accumulated in the pericardium in cats with pericardial effusion.

Key words: cat, echocardiography, N-terminus pro-B-type natriuretic peptide, pericardial effusion

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INTRODUCTION

Pericardial effusion refers to an increase in the physiological fluid level within the pericardial sac and may cause cardiac tamponade (Davidson et al., 2008). Pericardial effusion is the most frequently detected pericardial disorder. Pericardial effusion causes hemodynamic disorders at various levels after an increase in intrapericardial pressure (Ware, 2011). Effusions and decreased cardiac output affect both the cardiovascular picture and the general condition of cats. In other words, if the fluid volume in the pericardial sac increases and intrapericardial pressure increases, it can lead to cardiac tamponade and gradually decreasing cardiac output, followed by signs of right heart failure. The symptomatic condition indicates a poor prognosis (Cote et al., 2011).

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Pericardial effusion has been reported to develop secondary to common diseases including hypertrophic cardiomyopathy (HCM), neoplasia, feline infectious peritonitis (FIP), peritoneopericardial diaphragmatic hernia (PPDH), anemia, uremia, systemic infections and idiopathic pericarditis (Hall et al., 2007; Davidson et al., 2008; Ciaravolo et al., 2022). In one study, pericardial effusion secondary to HCM, DCM, RCM or mitral valve disease was detected in 28% of cats (Stokol et al., 2008).

Clinical findings resulting from pericardial effusion are due to changes in cardiac function. They depend on the rate of fluid accumulation and the severity of cardiac tamponade (Owens, 1977). Since clinical signs are not specific in cats with pericardial effusion, it is important to evaluate any cat with abdominal breathing for pericardial disease. Weakness and exercise intolerance are also important findings. Pericardial effusion can be detected in cats with small volume levels without any clinical signs (French, 2010). Regular monitoring and imaging of cats for heart disease is the recommended approach by physicians (Little and Freeman, 2006).

In asymptomatic patients, radiographic and echocardiographic examination is an important method in the diagnosis of heart diseases. The heart and respiratory system should be evaluated together in the examination (Krüger et al., 2016). In echocardiographic examination, pericardial effusion appears as a non-echoic space around the heart. If a cat has a concomitant pleural effusion, the pericardium gives a hyperechogenic thin white image at the base of the heart (Stokol et al., 2008). Echocardiography is a more reliable tool in the diagnosis of heart diseases. However, echocardiography is a more time-consuming and expensive procedure. For this reason, the evaluation of cardiac biomarkers is recommended for diagnosis with faster results and more affordable costs (Gavazza et al., 2021).

Cardiac biomarkers are useful in evaluating asymptomatic cats for cardiomyopathy, assessing prognosis, and distinguishing between cardiogenic and noncardiogenic causes in cats with respiratory findings. Cardiac biomarkers, particularly natriuretic peptides, have gained increasing acceptance over time as sensitive, specific, and safe tools useful in identifying patients with heart failure and determining its severity (Fox et al., 2009; Hsu et al., 2009).

The aim of this study was to measure plasma NT-proBNP levels and hemogram parameters in 20 cats diagnosed with pericardial effusion by echocardiographic examination and to determine whether NT-proBNP could be used as a cardiac biomarker in the confirmation of pericardial effusion

MATERIAL AND METHODS

The presented study was conducted in accordance with the decision of Kırıkkale University Animal Experiments Local Ethics Committee dated 15/11/2023 and numbered E-217201.

Animal material

The animal material of the study consists of a total of 40 cats, 20 cats (Patient group) and 20 healthy cats

Table 1. Individual information of cats in the Patient and Control groups

Patient Group (with pericardial effusion) (n=20)			**Control Group (Healthy) (n=20)**		
Age	Gender	Breed	Age	Gender	Breed
1	Female	Scottish Fold	1	Male	Tabby
1.5	Male	Britishshorthair	1	Female	Britishshorthair
2	Female	Britishshorthair	1	Female	Britishshorthair
2	Female	Scottish Fold	2	Male	Tuxedo
2	Male	Britishshorthair	3	Female	Tabby
2	Male	Britishshorthair	3	Female	Tabby
2	Male	Tabby	3	Female	Scottish Fold
3	Female	Scottish Fold	6	Male	Tabby
3	Male	Scottish Fold	6	Male	Sarman
3	Male	Britishshorthair	6	Male	Chinchilla
6	Female	Tabby	6	Female	Tabby
8	Male	Sarman	6	Female	Scottish Fold
8	Female	Tabby	6	Female	Britishshorthair
9	Male	Britishshorthair	7	Female	Tabby
9	Male	Britishlonghair	7	Female	Tabby
10	Male	Tabby	8	Male	Tabby
11	Male	Tuxedo	9	Male	Tabby
12	Male	Tabby	11	Female	Britishlonghair
13	Male	Persian	11	Male	Sarman
13	Female	Tabby	14	Female	Angora cat

(Control group), aged between 1-14 years, of different breeds and genders, diagnosed with pericardial effusion at Cat Hospital Animal Hospital (Table 1).

Sampling procedures

In order to perform the necessary blood evaluation from the patient group and the control group, 1 ml of blood was taken from the vena cephalica antebrachii into EDTA tubes and 3 ml of blood into tubes without anticoagulant. Serum was prepared by centrifuging the blood taken into empty tubes for 5 minutes at 3200 rpm without wasting time (LC – 04B, HASVET). NT-proBNP values were determined from the prepared serum samples quickly with the commercial kit Vcheck Feline NT-proBNP, BIONOTE and Vcheck200 – BIONOTE device.

Hemogram analysis from blood samples taken in anticoagulant tubes was performed with IDEXX ProCyte Dx TM Hematology Analyzer. In the study, Mindray brand DC-N3model ultrasonography device and 3.0 – 7.0 MHz P7-3 Phased Array transducer probe belonging to the device were used for echocardiographic examination. The right parasternal 4th and 5th intercostal region of the cats that were laid on the examination table in the right laterolateral position was lightly shaved. The cats were kept calm without using any sedatives. Afterwards, 2D, M mode and B mode imaging were performed in the long and short axis.

In echocardiographic examination, priority was given to pericardial effusion visualization and measurement. Additionally, left ventricular free wall thickness (LVFW) in systole and diastole, interventricular septum wall thickness (IVSD) in systole and diastole, left ventricular internal diameter end-diastole and end-systole (LVID), left atrium internal diameter (LA), aortic diameter (AO), LA/AO ratio, left ventricular ejection fraction (EF), fractional shortening (FS) parameters were measured.

Table 2. Clinical findings of the cats in the patient group.

	Symptoms					
Case No.	Exercise intolerance	Dyspnea	Abdominal breathing	Friction sound on auscultation	Muffled heart sound on auscultation	Ascites
1			x		x	
2						
3		x		x	x	
4		x	x	x		
5			x		x	
6	x	x				
7					x	x
8						
9	x					
10						
11			x		x	
12	x	x		x	x	x
13	x		x			
14						
15						
16						
17	x		x			
18	x			x		
19		x	x		x	x
20						

Statistical significance between groups was taken as $P<0.05$.

Statistical analyses

In this study, hematological, BNP and cardiac parameters were examined in patient and healthy groups. Normality tests were applied to evaluate the differences in hematological, cardiac and BNP parameters between healthy and patient groups and Mann-Whitney U test was used as a non-parametric test. Spearman correlation analysis was applied to examine the relationships between the parameters. In addition, interaction analyses were performed to evaluate the interactions between demographic variables such as disease status, race, age and gender on certain hematological and cardiac parameters. In these analyses, the effects of the interactions between disease status and race, age and gender on hematological, BNP and cardiac parameters were examined. In these analyses, partial eta-squared was calculated to evaluate how much of the variance in these parameters was explained by the interactions. All analyses were performed using SPSS 16.0 package program (Coakes et al., 2009).

RESULTS

Clinical findings

It was determined that the healthy cats in the control group did not have any findings of heart disease in their clinical examination and had normal values in the cardiac biomarker reference assessment. The cats with pericardial effusion, which constituted the patient group of the study, were also evaluated in terms of clinical examination findings and cardiac biomarkers. In the clinical examination of these cats, it was determined that 11 cats were asymptomatic, 6 cats had muffled heart sounds in auscultation, 4 cats had friction rubs in auscultation, 5 cats had respiratory distress, 6 cats had exercise intolerance, 3 cats had ascites, and 7 cats had abdominal breathing (Table 2).

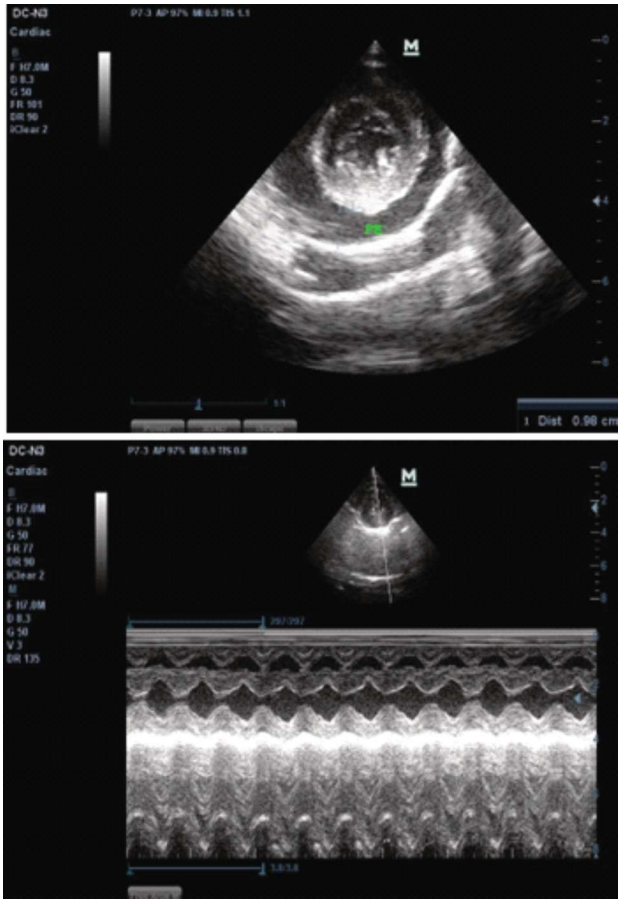

Figure 1. Echocardiography image of a case with severe pericardial effusion resulting in cardiac tamponade.

Complete blood count findings

Of the 20 cats with pericardial effusion in the patient group, anemia was detected in 3, leukocytocytosis in 3, neutrophilia in 5, monocytosis in 5, and thrombocytopenia in 3. As can be seen, although changes were detected in some blood parameters individually in cats with effusion, it is noteworthy that there is no statistically significant difference with the control group values (Table 3).

Echocardiographic examination findings

Echocardiographic imaging was performed on 20 cats diagnosed with pericardial effusion and 20 cats in the control group used in the study. Based on the clinician's perspective, of the 20 cats diagnosed with pericardial effusion, 2 had severe pericardial effusion, 5 had moderate pericardial effusion, and 13 had mild pericardial effusion. Of the moderate pericardial effusion cases, 1 had peritoneal pericardial diaphragmatic hernia, 5 had hypertrophic cardiomyopathy, and 11 had left atrial

Table 3. Total blood count results of the patient and control groups

Parameter	Patient group		Control group		
	n	Mean ± Standard Deviation	n	Mean ± Standard Deviation	P
RBC (M/µL)	20	9.98 ± 3.15	20	10.52 ± 1.60	0.74
HCT (%)	20	42 ± 12	20	43 ± 0.83	0.66
Hb (g/dL)	20	13.79 ± 4.08	20	14.32 ± 2.48	0.73
MCV (fL)	20	43.15 ± 10.22	20	41.08 ± 4.90	0.31
MCH (pg)	20	14.31 ± 2.65	20	13.63 ± 1.43	0.44
MCHC (g/dL)	20	32.22 ± 1.93	20	33.25 ± 1.56	0.08
RDW (%)	20	25 ± 4	20	26 ± 3	0.40
Reticulocyte (K/ µL)	20	24.72 ± 17.19	20	29.02 ± 22.25	0.74
WBC (K/ µL)	20	11.34 ± 7.11	20	9.74 ± 5.02	0.80
Neutrophil (K/ µL)	20	6.48 ± 5.13	20	4.91 ± 4.33	0.40
Lymphocyte (K/ µL)	20	3.66 ± 2.74	20	3.71 ± 1.58	0.28
Monocyte (K/ µL)	20	0.81 ± 1.02	20	0.46 ± 0.43	0.50
Eosinophil (K/ µL)	20	0.32 ± 0.31	20	0.56 ± 0.40	0.02
Platelet (K/ µL)	20	313.55 ± 192.28	20	248.30 ± 123.95	0.33
MPV (fL)	20	17.05 ± 1.78	20	16.88 ± 1.94	0.91

Table 4. Echocardiographic findings of cats in the patient group

Case No.	Echocardiographic changes								
	IVSd ↑	LVIDd ↓	LVPWd ↑	IVSs ↑	LVIDs ↓	LVPW ↑	Left atrial dilatation (LA/AO) ↑	EF ↓	FS ↑
1				x					
2			x				x		
3	x	x	x	x	x	x	x		
4	x	x	x		x		x		x
5			x				x		
6									
7			x	x		x			
8									
9	x		x	x	x	x			x
10			x			x			
11	x			x			x		
12	x		x	x		x			
13	x	x	x	x		x	x	x	
14	x			x	x		x		x
15							x		
16			x	x		x			
17			x				x		
18	x		x	x		x	x		
19	x		x	x	x	x	x		x
20									

Tablo 5. Individual values obtained in echocardiographic examination of both groups

Groups	Breed	Age	IVSd	LVIDd	LVPWd	IVSs	LVIDs	LVPWs	EF	FS	LA	AO	LA/AO
		(year)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)		(cm)	(cm)	(cm)	
Patient	B. Shorthair	1.5	0.42	1.54	0.39	0.76	0.76	0.73	0.92	0.64	1.38	1.07	1.28
Patient	Tabby	6	0.35	1.3	0.53	0.5	0.7	0.71	0.82	0.47	1.43	0.81	1.76
Patient	B.Shorthair	3	0.8	1.06	0.8	0.92	0.39	0.97	0.94	0.63	1.46	0.77	1.89
Patient	B. Shorthair	2	0.73	1.12	0.6	0.64	0.36	0.7	0.96	0.68	1.35	0.76	1.77
Patient	Tabby	8	0.42	1.72	0.51	0.51	0.86	0.64	0.83	0.49	1.35	0.77	1.75
Patient	Smokin	11	0.38	1.87	0.44	0.68	0.71	0.64	0.92	0.62	1.31	0.93	1.4
Patient	Mix	8	0.33	2.35	0.45	0.82	0.59	0.85	0.8	0.48	1.17	1.5	0.78
Patient	B.Shorthair	2	0.38	1.42	0.39	0.67	0.82	0.6	0.77	0.43	1.14	0.92	1.23
Patient	B. Shorthair	9	0.65	1.36	0.56	0.96	0.36	1.01	0.97	0.73	1.51	0.99	1.52
Patient	Scottish Fold	3	0.47	1.36	0.54	0.67	0.67	0.94	0.86	0.51	1.17	1.06	1.1
Patient	Tabby	10	0.6	1.42	0.39	0.79	0.7	0.7	0.86	0.51	1.37	0.78	1.75
Patient	Persian	13	0.7	1.46	0.59	0.94	0.8	0.95	0.8	0.46	1.43	1.01	1.41
Patient	Tabby	21	0.91	1	0.48	0.94	0.79	1	0.48	0.21	1.54	0.63	2.44
Patient	B.Shorthair	2	0.51	1.21	0.33	0.71	0.35	0.7	0.96	0.71	1.34	0.73	1.83
Patient	Tabby	13	0.36	1.34	0.35	0.55	0.62	0.67	0.87	0.53	1.44	0.85	1.69
Patient	Scottish Fold	1	0.45	0.72	0.56	0.8	0.78	0.92	0.91	0.59	1.35	1.07	1.26
Patient	B. Longhair	9	0.44	1.88	0.52	0.7	0.76	0.63	0.95	0.67	1.54	0.86	1.79
Patient	Scottish Fold	3	0.67	2.3	0.54	0.91	1.3	0.91	0.72	0.44	2.02	1.17	1.72
Patient	Tabby	9	0.51	1.3	0.82	0.88	0.18	0.97	1	0.86	1.35	0.7	1.92
Patient	Scottish Fold	2	0.38	1.5	0.42	0.6	0.6	0.64	0.91	0.6	1.34	0.89	1.5
Control	Tabby	6	0.33	0.91	0.48	0.54	0.3	0.42	0.95	0.67	1.04	0.9	1.15
Control	Mix	6	0.49	1.15	0.36	0.68	0.77	0.36	0.96	0.68	0.9	0.79	1.13
Control	Tabby	8	0.48	1.12	0.45	0.51	0.51	0.51	0.88	0.54	0.75	0.71	1.05
Control	Angora cat	14	0.57	1.84	0.39	0.76	1.39	0.42	0.52	0.25	1.33	0.82	1.62
Control	Tabby	7	0.57	1.42	0.54	0.73	0.45	0.79	0.96	0.68	1.3	0.91	1.42
Control	Tabby	9	0.35	1.51	0.44	0.74	0.38	0.76	0.98	0.75	1.14	0.92	1.23
Control	Mix	11	0.51	1.21	0.42	0.64	0.42	0.67	1	0.88	1.25	0.73	1.71
Control	Chinchilla	6	0.57	1.09	0.42	0.64	0.42	0.67	0.93	0.51	1.03	0.62	1.66
Control	B. Longhair	11	0.56	1.35	0.54	0.83	0.39	1.04	0.96	0.71	1.15	0.95	1.21
Control	Scottish Fold	3	0.33	0.91	0.48	0.54	0.3	0.42	0.95	0.67	1.04	0.89	1.16
Control	Tabby	6	0.41	1.25	0.45	0.71	0.3	0.95	0.98	0.76	1.3	0.84	1.54
Control	Tabby	3	0.45	1.18	0.45	0.57	0.48	0.67	0.91	0.59	1.15	0.86	1.33
Control	Tabby	7	0.64	1.54	0.51	0.97	0.24	0.54	0.99	0.84	1.26	0.81	1.55
Control	Tabby	1	0.42	1.03	0.45	0.73	0.42	0.7	0.95	0.66	1.17	1	1.17
Control	Smokin	2	0.45	1.41	0.33	0.71	0.6	0.54	0.89	0.57	0.8	0.69	1.15
Control	B.Shorthair	1	0.36	1.12	0.39	0.64	0.39	0.48	0.95	0.65	1.19	0.86	1.38
Control	B.Shorthair	1	0.47	0.94	0.48	0.64	0.94	0.56	0.87	0.54	1.29	0.91	1.41
Control	Tabby	3	0.48	1.09	0.36	0.57	0.57	0.64	0.83	0.47	1.21	0.73	1.65
Control	Scottish Fold	6	0.32	1.31	0.33	0.54	0.55	0.59	0.91	0.58	1.14	0.9	1.26
Control	B. Shorthair	6	0.51	1.78	0.39	0.79	0.77	0.83	0.89	0.57	1.55	1.04	1.49

British Shorthair (B. Shorthair), British Longhair (B. Longhair)

dilatation. Cardiac tamponade was noted in 1 of the cases with severe pericardial effusion (Table 4, Figure 1).

In echocardiographic examination, a statistically significant difference was found between the LA/AO, LVPWs, LAIDd and EF values of cats with pericardial effusion and the control group ($P<0.05$) (Table 6). No statistically significant difference was found between the study group and the control group in other parameters (IVSd, IVSs, LVIDd, LVIDs, LVPWd, FS and AO) ($p>0.05$) (Table 5, Table 6). In this study, the left ventricular end-diastolic diameter was measured as 0.88 cm in 1 case with severe pericardial effusion. Afterwards, the right ventricular end-diastolic diameter was evaluated considering the possibility of cardiac tamponade. RVIDd was measured as 0.24 cm. It was found that there was a decrease in the internal diameter of both ventricles, left and right ventricular filling was limited and this finding was compatible with cardiac tamponade (Table 5).

NT-proBNP findings

Information including NT-proBNP values of cats with pericardial effusion and cats in the control group used in the study is shown in Table 7.

A significant difference was found in the statistical analysis of the NT - proBNP parameter between the groups (p = 0.009). This finding showed that the disease status had an effect on BNP levels (Table 7).

DISCUSSION and CONCLUSION

Pericardial effusion refers to an increase in the physiological fluid level within the pericardial sac (Davidson et al., 2008). Pericardial effusion is the most commonly detected pericardial disorder (Ware, 2011). Pericardial effusion causes hemodynamic disorders at various levels after an increase in intrapericardial pressure. If the increase in fluid volume within the pericardial sac causes an increase in intrapericardial pressure, it can lead to cardiac tamponade and gradually decreasing cardiac output, followed by symptoms of right heart failure (Ware, 2011). The symptomatic condition indicates a poor prognosis (Cote et al., 2011).

Pericardial effusion has been reported to develop secondary to common diseases including hypertrophic cardiomyopathy (HCM), neoplasia, feline infectious peritonitis (FIP), peritoneopericardial diaphragmatic hernia (PPDH), anemia, uremia, systemic infections and idiopathic pericarditis (Tilley et al., 1975; Hall et al., 2007; Davidson et al., 2008; Hsu et al., 2009; Yousaf et al., 2023). In one study, pericardial effusion secondary to HCM, DCM, RCM or mitral valve disease was detected in 28% of cats (Stokol et al., 2008). In our study, it was determined that 25% of the cases with pericardial effusion were due to HCM. In the study conducted by Hall et al. (2007), it was stated that the primary factor in 21.9% of pericardial effusion in cats was neoplasia. In our study, it was determined that effusion due to neoplasia was 5%, fusion due to PPDH was 5% and pericardial effusion where the primary factor was anemia was 15%. These rates indicate the diversity of the primary etiology of pericardial effusion, parallel to the literature data.

It has been determined that some cat breeds are more prone to heart diseases. Maine Coon, Ragdoll, Scottish, British, Persian and Siamese cats are among these breeds (Boeykens et al., 2024). Among the cats included in this study, 7 were British, 4 were Scottish, 1 was Persian and 6 were mixed breeds, a similarity is striking. Their ages ranged from 1 to 13 years old and 7 of these cats were female and 13 were male. Since the study was conducted with a limited number of cases, no significant results were found in the statistical evaluation related to gender, breed and age predisposition.

Table 6. Statistical analysis of echocardiographic findings

Parameter	Patient group		Control group		P
	n	Mean ± Standard Deviation	n	Mean ± Standard Deviation	
IVSd (cm)	20	0.52 ± 0.16	20	0.46 ± 0.09	0.42
LVIDd (cm)	20	1.46 ± 0.40	20	1.25 ± 0.26	0.66
LVPWd (cm)	20	0.51 ± 0.12	20	0.43 ± 0.06	0.39
IVSs (cm)	20	0.74 ± 0.14	20	0.67 ± 0.11	0.12
LVIDs (cm)	20	0.65± 0.24	20	0.52 ± 0.26	0.60
LVPWs (cm)	20	0.79 ± 0.14	20	0.62 ± 0.18	0.005
EF (%)	20	0.86 ± 0.11	20	0.91 ± 0.10	0.05
FS (%)	20	0.56 ± 0.14	20	0.62 ± 0.13	0.08
LA (cm)	20	1.39 ± 0.18	20	1.14 ± 0.18	0.000
AO (cm)	20	0.91 ± 0.19	20	0.84 ± 0.10	0.35
LA/AO	20	1.58 ± 0.36	20	1.36 ± 0.20	0.01

Statistical significance between groups was taken as $p<0.05$.

Table 7. NT-proBNP Values of Cats in Patient and Control GroupsClinical findings resulting from pericardial effusion

Parametre	Patient group		Control group		P
BNP (pmol/L)	n	Mean ± Standard Deviation	n	Mean ± Standard Deviation	
	20	564.060 ± 61.292	20	57.085 ± 10.68	0.007 (p<0.05)

Statistical significance between groups was taken as $p<0.05$.

are due to changes in cardiac function. It depends on the rate of fluid accumulation and the severity of cardiac tamponade (Owens, 1977). The heart and respiratory systems should be evaluated together during examination (Krüger et al., 2016). In our study, it was determined that 11 cats were asymptomatic, 6 cats had muffled heart sounds on auscultation, 4 cats had friction rubs on auscultation, 5 cats had respiratory distress, 6 cats had exercise intolerance, 3 cats had ascites, and 7 cats had abdominal breathing (Table 2).

In a study conducted in dogs with endocarditis, thrombocytopenia and leukocytosis were detected in approximately 90% of patients in the total blood count. However, there are very few studies in cats (Sykes et al., 2006). Hematological abnormalities characterized by neutrophilia and a regenerative left shift, a marker of mild toxicity, were reported in clinical case of endocarditis caused by Bartonella henselae in a cat (Chomel et al., 2003; Perez, 2010).

Finally, in a series of 13 cats with infectious endocarditis, inflammatory neutrophilia was observed in seven patients and anemia in six patients (Palerme et al., 2016). In our study, in line with literature data, anemia was

detected in three of the 20 cats in the patient group, leukocytosis in three, thrombocytopenia in three, neutrophilia in five, and monocytosis in five. However, although individual changes were observed in the patient group, no statistically significant difference was detected with the control group (Table 3). This may be attributed to the small number of patients studied and the fact that pericardial effusion may be caused by different etiological factors such as inflammatory and non-inflammatory.

In cats with no clinical signs, small-volume pericardial effusions can be detected by echocardiography (French, 2010). In asymptomatic patients, radiographic and echocardiographic examinations are important methods for the diagnosis of heart diseases. In echocardiographic examination, pericardial effusion appears as a non-echoic space around the heart (Stokol et al., 2008). In our study, in parallel with the literature data, out of 20 cats diagnosed with pericardial effusion, 2 had severe pericardial effusion, 5 had moderate pericardial effusion, and 13 had mild pericardial effusion (Figure 1).

After pericardial effusion, severe intrapericardial pressure occurs, causing increased pressure in the RA and RV, and this condition is defined as cardiac tamponade (Turgut, 2017). It is emphasized that pericardial effusion will compress the heart from the outside and limit RV and LV filling over time (Linney, 2014; Turgut, 2017). In this study, in a case with severe pericardial effusion, ventricular diastolic expansion was severely impaired, both ventricles had a reduced internal diameter (Table 4, Table 5), and left and right ventricular filling was limited. This condition was interpreted as echocardiographic findings confirming ventricular collapse and cardiac tamponade. Echocardiography is preferred because it is not an invasive tool in the diagnosis of pericardial effusion and its sensitivity is very high. However, since echocardiographic examination requires more time and is an expensive procedure, evaluation of cardiac biomarkers is recommended for diagnosis in terms of faster results and more affordable costs (Ward et al., 2018; Gavazza et al., 2021). In a retrospective study, Machen et al. (2014) showed that NT-proBNP measurements performed in 146 cats were useful in determining whether pleural effusion in cats was related to heart disease. Cardiac biomarkers, especially natriuretic peptides, have become increasingly accepted as sensitive, specific, and safe tools useful in identifying patients with heart failure and determining its severity (Fox et al., 2009; Hsu et al., 2009). In our study, NT - proBNP values were found to be significantly increased in cats with pericardial effusion and there was a highly significant difference in statistical analysis between the groups ($p = 0.009$).

In conclusion, the results obtained in the study revealed that NT-proBNP can be used as an important cardiac biomarker in confirming the diagnosis of pericardial effusion in cats (Table 7).

ETHICAL APPROVAL

The presented study was conducted in accordance with the decision of Kırıkkale University Animal Experiments Local Ethics Committee dated 15/11/2023 and numbered E-217201.

AUTHOR CONTRIBUTIONS

This study was derived from the Master's Thesis of the same name of the first author, conducted under the supervision of the second author.

CONFLICT OF INTEREST

There is no situation that would cause a conflict of interest between the authors.

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