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Role of pericardial effusion in dogs with and without cardiac neoplaesia

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Summary

In this research, LV systolic functions of the 14 mature dogs with idiopathic pericardial effusion (IHPE) and cardiac neoplaesia (CN) were examined. The dogs were between 1-16 years old, generally large breed and male. Signs of cardiomegaly were observed in the chest radiography and low amplitude QRS complexes in electrocardiograms. Pericardial effusion, cardiac masses and paradoxical motion were detected by 2D echocardiography. Left ventricle (LV) systolic functions were detected with M mode echocardiographic examinations. A statistical significance ($p<0.001$) was found between echo-free pericardial Space (EPS) and fractional shortening (FS%), ejection fraction (EF%), velocity of circumferential fiber shortening (VcF), in the dogs with IHPE. A distinction was also found between EPS and EF in the dogs with CN ($p < 0.001$). FS, EF and VcF were significantly decreased in the dogs with IHPE in contrast to the dogs with CN.

It was detected that the systolic function of the left ventricle could be considerably disturbed by the excessive volume of the pericardial effusion, even if no cardiac tamponade occurred.

Keywords: echocardiography, cardiac tumor, dog

The pericardial disorders accounts for about 1% of all cardiovascular diseases in animals (22). The most common pericardial disease is the pericardial effusion (PE) (7, 16). PE is the accumulation of an abnormal amount of fluid within the pericardial sac that covers the heart. Although the cause of a PE is often associated with an underlying disease, it may be difficult to establish in many cases (4). By the characteristic of the fluid, PE is classified as transudation, exudation and haemorrhagic (16). Hemorrhagic pericardial effusion (HPE) is very common in dogs. HPE is occurred with the complicated situations as a result of the neoplastic and idiopathic reasons (5, 6, 14). The cardiac tamponade is occurred by the increase of the intrapericardial pressure because of the PE. Diastolic collapse is occurred by the cardiac tamponade in the right ventircule (RV) and the right atrium (RA) with the thin muscles and low pressure (6, 22). Although it was reported that the cardiac tamponade was resulted in RV failure (4, 8, 22), there is limited information about the effect on the left ventricle (LV) functions (6, 7).

This research was made to detect the effect of the volume of the fluid within the pericardial sac on the LV systolic functions in dogs with the idiopathic haemorrhagic pericardial effusion and the cardiac neoplasia.

Material and methods

All echocardiograms performed in dogs admitted to the Istanbul University, Faculty of Veterinary Medicine, Clinics of Internal Medicine Department between April 1999 and July 2003 were screened retrospectively for the presence of the pericardial effusion. From July 2003 to May 2005, the same information was collected prospectively, with the subsequent review of the medical records. Between 1-16 years old and 13-62 weighed, 2 female and 12 male dogs in different breeds were used in this research (tab. 1). After a systemic examination, complete blood cell counts, AST, ALT, CK, LDH, total protein and urea levels were detected from the blood samples taken from the dogs. The chest radiography (L-L, D-V) and the electrocardiogram were performed in each dog. All dogs had M-mode and 2-dimensional studies performed from standard right and left parasternal planes with Shimadzu SDU-350A apparatus, equipped with micro convex transducer (3.5-4.5 MHz). The echocardiograms (2-D and M-mode) obtained without sedative drug administration were analysed for any abnormalities of atrial and ventricular dimensions, inter ventricular septal motion and atypical mitral and aortic valvular patterns and for separation of the visceral and parietal pericardia.

The dogs were held firmly in the left lateral position and the diagnostic pericardiocentesis was performed in each dog by use of an i.v. catheterization set with the guidance of two-dimensional echocardiography. The pericardiocentesis was performed from the surgically site on the right hemi-thorax between the 4^{th} and 6^{th} intercostals spaces on costo-condral joint. Anaesthetic drug was injected to this site locally. The catheter was placed into the pericardial sac and haemorrhagic pericardial fluid was obtained.

After the echocardiographic examination and the diagnostic pericardiocentesis, the patients were divided into two groups. The first group consisted of dogs with the cardiac neoplaesia (CN). The second group consisted of dogs with the idiopathic haemorrhagic pericardial effusion (IHPE) without cardiac neoplaesia. EPS, FS, EF, VcF and SV of the dogs were calculated with the formula written below.

Echo-free Pericardial Space (EPS) was measured of distance between free wall of left ventricle and pericardium during

Tab. 1. Dates of dogs with cardiac neoplaesia and haemorrhagic pericardial effusion and statistical analysis of changes between size of echo-free pericardial space and systolic functions of left ventricle

Group	Breed	BW (Kg)	EPS (mm)	FS (%)	EF (%)	VcF (Circ/sn)	SV (ml)
Cardiac Neoplaesia (CN)	G. Shepherd	35	34	69	95	3.40	22
	Doberman	21	30	65	92	3.08	34
	Terrier	13	26	56	97	2.90	28
	Groenendeal	30	51	54	85	2.71	30
	Means ± SD		35.2 ± 10.99$^{ns\alpha}$	61 ± 7.1**	92.2 ± 5.25$^{*\alpha}$	3.02 ± 0.293^{ns}	28 ± 2.6*
Idiopathic Haemorrhagic Pericardial Effusion (IHPE)	G. Retriever	22	56	4	14	0.41	42
	G. Shepherd	28	62	9	20	0.46	51
	E. Setter	26	43	16	23	0.70	78
	Rotweiller	42	53	10	21	0.70	40
	G. Shepherd	26	52	14	29	0.98	61
	Boxer	30	41	14	22	0.94	54
	G. Shepherd	29	31	20	40	1.08	44
	S. Bernard	62	72	18	48	1.00	72
	Karabach	38	44	18	28	1.02	45
	G. Retriever	26	47	12	24	0.82	68
	Means ± SD		50.1 ± 11.60 $^{ns§,¥,†,‡}$	13.5 ± 4.88**§	26.9 ± 10.10 *¥	0.81 ± 0.237 $^{ns\,†}$	46.2 ± 8.73*^{ns}

Explanation: BW – body weight, FS – fractional shortening, EF – ejection faction, VcF – vlocity of circumferential fiber shortening, SV – stroke volume, EPS – echo-free pericardial space. * The statistical significance of the same parameters between the groups ($p < 0.01$). ** The statistical significance of the same parameters between the groups ($p < 0.001$). α – The statistics of the parameters inside the group ($p < 0.01$). §, ¥, †, ‡ – The statistics of the parameters inside the group ($p < 0.001$). Symbols in the line of means ± sd shows the statistical significant of the parameters inside the group

diastole. LV Fractional Shortening (FS %) was calculated by formula LV diameter in diastole (LVDd) – LV diameter in systole (LVDs)/(LVDd) × 100. Teicholz formula (7 – $LVDs^3$/2.4 + LVDs) were used for Ejection Fraction (EF%). The velocity of the circumferential fiber shortening (VcF) was calculated by the formula SF%/time from aortic valve opening to aortic valve closure. The stroke volume (SV) was determined using the formula diastolic volume of LV – systolic volume of LV.

Continuous data were presented as means ± SD. The proportions of the categorical variables between the different groups and within the same group were compared using the one way analysis of variance (ANOVA) test.

Results and discussion

From April 1999 to May 2005, 224 dogs underwent echocardiography. 14 of them were identified with cardiac neoplasia (n = 4) or idiopathic haemorrhagic pericardial effusions (n = 10). Of these, 8 were identified retrospectively. The group with effusions without cardiac neoplasia includes 10 dogs (10 [%100] male, age 6.7 ± 5.3 [range 1 to 12], and the group with cardiac neoplasia effusion includes 4 dogs (2 [%50] male, age 11.2 ± 4.6 [range 7 to 16].

There were the signs of anorexia, depression and abdominal distension in all dogs. Cough and periferal oedema also detected in the dogs with cardiac neoplaesia. Hyperaemia and cyanosis in the mucous membranes, dyspnoea/tachypnoea, jugular distension, irregular and weak arterial pulse, increase in capillary refilling time, ascites, expansion of the percussion area of the heart, tachycardia and muffled heart sounds were detected in the physical examination of dogs in both CN group and IHPE group. One case in CN had had a mammary neoplaesia operation 4 months ago.

Non-regenerative anaemia (41%) and leukocytosis (28%) were detected in the complete blood cell counts and no specific alterations were seen in blood chemistry. In chest radiography disappearing and extending of the heart margins, restriction of the angle of the trachea-vertebra, distension of the vena cava caudalis, and in the abdominal radiography loss of details were determined. In ECG, QRS with lower voltage were detected. Black coloured hypo echoic (echo-free) area in various sizes between the endocardium and the pericardium in 14 patients (100%), swinging motions in RV muscle and mass in 4 patients (28%), and pericardial fibrosis (57%) were demonstrated in the echocardiographic examinations of the cases. During the echocardiographic evaluation, the intra cardiac masses placed in the right atrium (9.5 × 12.2 mm), and the pericardium (4.1-10.3 and 3.4 × 6.6 mm) and between the pericardium and the right atrium (1.5 × 3.1 mm) were easily imagined. Thoracic radiograph, electrocardiogram and echocardiograms from these dogs are presented in fig. 1.

The statistical evaluation of the parameters of EPS and the systolic function of the group of the dogs with CN and IHPE was shown in tab. 1. FS % was detected as 61 ± 7.1 in the dogs with CN and 13.5 ± 4.88 in the dogs

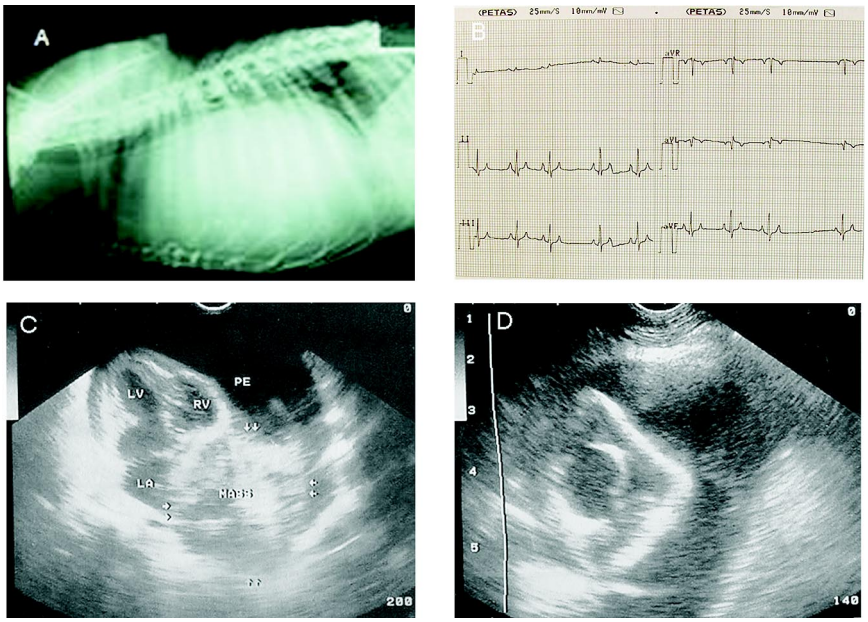

Fig. 1. Thoracic radiograph, electrocardiogram and echocardiograms from dogs with pericardial effusion. A. Lateral projection. Cardiac silhouette assumes a spherical shape, massive cardiomegaly and tracheal elevation is apparent. B. Electrocardiogram taken with paper speed 25 mm/sec and 1 cm = 1 mV. QRS amplitudes are reduced (less than 1 mV) and there is a mild beat to beat variation in the wave amplitude of both the *R* and *S* waves. C. Echocardiogram taken from a dog with the cardiac tumour. Left apical parasternal four-chamber view shows a large soft tissue mass (9.5 × 12.2 mm) cranial to the left atrium and dorsal to the right atrium. Notice the large amount of pericardial fluid. D. Echocardiogram taken from a dog with the idiopathic haemorrhagic pericardial effusion. Right parasternal short-axis echocardiographic image from the level of the aortic valve. Severe pericardial effusion and cardiac tamponade can be seen. Notice diastolic collapse in right ventricle

with HPE. The statistical consideration of this parameter among the groups was $p < 0.001$. EF % was detected as 92.2 ± 5.25 in the dogs with CN and 26.9 ± 10.10 in the dogs with HPE. SV was detected as 28.2 ± 0.09 in the dogs with CN and 46.2 ± 8.73 in the dogs with HPE. The statistical consideration of EF % and SV among the groups was $p < 0.01$. It was also detected that the statistical considerations of EPS and VcF among the groups were insignificant.

The distinction between EPS and EF% was statistically significant in the dogs with CN ($p < 0.01$). In the other hand no statistical significance between EPS and FS%, and between VcF and SV was found in this group. The statistical considerations between EPS and FS%, and between EF% and VcF were found significant in the dogs with IHPE ($p < 0.001$).

Hemangiosarcoma, mesothelioma, adenocarcinoma, and myxoma were determined histopathologically. The dog with mesothelioma had also testis neoplasia.

The pericardial effusions occur rarely in the animals and are seen about 1% of all the cardiovascular diseases (22). The pericardial diseases are the congenital and acquired disorders that cause PE and interpericardial masses (3, 8). The pericardial effusions in the dogs are associated with the congestive heart failure, infectious, toxic, traumatic, metabolic, neoplastic or idiopathic disorders (16, 22).

The most common reasons of the HPE are the trauma, especially ruptur of LA, the idiopathic pericarditis, and the pericardium and the heart base neoplastic masses (16). But the cardiac neoplasia is not one of the most common cardiac disorders. They take origin from the myocardium, vessels and connected tissues and localize within the walls or lumen of various cardiac chambers and pericardium (1, 19). Hemangiosarcoma is commonly seen. It localizes in RA. German shepherd dog and Golden Retriever dog predispose to that kind of the neoplastic masses (1, 12, 14). The aortic neoplaesia as chemodectoma and nonchromaffin paraganglioma are secondarily seen cardiac neoplaesias and it is clear that the brachiocephalic breed have predisposition to these neoplaesias (16, 17). The heart base ectopic thyroid carcinoma, mesothelioma in the pericardium, metastatic carcinoma, lymphosarcoma, fibroma, fibrosarcoma and myxoma in the myocardium rarely localize in the heart of the small animals (2, 21). The most sensitive test for the evaluation of the acquired pericardial disorders of the dogs is the echocardiography (7, 15, 20). In the echocardiographic examination, echo free space image between the epicardium and the pericardium is the pathognomic sign for the diagnosis of PE (11). PE was detected as a result of the 2-D echocardiographical examination and the pericardiocentesis from the dogs evaluated in this research. The various types of the echoic/hyperechoic masses connected with RA, pericardium and fibrosis were observed inside the pericardial sac.

It is reported in the previous researches that the large breed dogs are predisposed to the pericardial disorders and the cardiac neoplaesia (12, 18, 19). In this report, all of the dogs were large breed except one. Twelve of the dogs of this study were male (12/14). In addition to these, sex can also be a predisposition factor because both testis and cardiac neoplaesia (mesothelioma) were determined in a 16 year old male Groenendeal dog.

The intrapericardial fluid pressure increases out of control due to the PE. This case is resulted in the cardiac tamponade. The mechanism of the cardiac tamponade is the decrease of the amount of the blood ejected from the heart and the existence of the congestive heart failure (8). The considerable signs of the tamponade are the positive intrapericardial pressure, diastolic collapse of RA and sometimes RV, decrease of the amount of the blood flowing from the ventricules to the veins, and the arterial hypotension. If the accumulation of the fluid in the pericardium occurs slowly, then pericardium expands and becomes thick. The intrapericardial pressure doesn't increase considerably. The amount of the blood filling up the ventricules does not alter. On the contrary to the accumulation of the fluid in the pericardium occurs in a short time, the ventricules will get compressed and the

cardiac tamponade will occur. So as a result of the elevation of the intracardiac and the jugular venous pressure and the decrease of the arterial pressure, the amount of the blood in the circulation reduces. The primary effected part is the right side which has thinner muscles and lower pressure in the cardiac tamponade. Right side is affected worse than the left side (13, 16). In this research, although there was no statistical difference between the values of EPS among the two groups, the value of EPS was higher in the IHPE group than the CN group. However, Right ventricular swinging motion was observed in four dogs with CN. The detection of the diastolic collapse of RA and RV and paradoxial motion of the interventricular septum (IVS) by the echocardiography prove the existence of the cardiac tamponade (7). We detected the diastolic swinging motion of the RV anterior wall easily by using the parasternal images of the heart. As a result of the accumulation of the fluid in abdomen, the heart was pushed forward and changed direction anticlockwise. It was promoted by the echocardiograms taken from the human beings and the animals with PE that the anterior wall of the PE and posterior wall of IVS and LV moved with the same direction and that occurred because of the alteration of the position of the heart (7, 9). It occurs in right ventricular volume overload (10).

When the amount of the outflow blood is inadequate, the heart begins to move faster. But the increase in the velocity of the heart does not accompany with the increase in the contraction of the myocardium. Inadequate outflow blood and increase in the velocity of the heart result in decrease in ejection time. In this research, SF% was found higher in the CN group than in the IHPE group ($p < 0.001$). In IHPE group, in spite of the higher heart rate there was a lower fractional shortening of the myocardium. However, EF% and VcF of the same group were lower than the other group ($p < 0.01$). We think that in spite of the higher amount of the pericardial effusion in IHPE group, the reason of the decreasement in SF%, EF%, and VcF of the left ventricule was the congestive heart failure developing as a result of the severe pericardial effusion, even if no cardiac tamponade had occurred. In the dogs with IHPE, Statistical significance were found between EPS and FS% and found between EF% and VcF ($p < 0.001$). Although moderate effusion and cardiac tamponade were detected in the dogs with CN, the effect of the EPS on the functions of the left ventricule was insignificant. On the other hand, no statistical significance was found between EPS and FS% and between VcF% and SV in this group. In the 4 dogs of the CN group, as there were normal blood parameters despite of the cardiac tamponade and inflammation signs, no underlying disorder was detected. The leukocytosis unrelated with the other disorders was a result of the CN. The majority of the animals with the cardiac neoplasms are middle-age to geriatric, although younger animals are occasionally affected (14, 15). In this research, the dogs with cardiac neoplaesia were between 7 and 16 years old.

Clinical, radiological and electrocardiographic examination can be used in the diagnosis of the pericardial disorders. But the echocardiography has importance in the determination of the prognosis according to the cardiac tamponade and the grade of the congestive heart failure. The echocardiographical examination is more reliable and non-invasive method than the other techniques, although invasive methods have indication in the pericardial disorders.

The most significant signs of this research were some of the clinical signs and the severe effusion, without the cardiac tamponade, unrelated with the other disorders in the dogs with IHPE. It was the cardiac tamponade and the inflammation despite of the moderate effusion in the dogs with CN.

It was detected that there was a relationship between the amount of the fluid collected in the pericardium and the LV systolic functions and the excessive amount of the pericardial effusion could cause disturbance in the LV systolic functions and provide the congestive heart failure developed even if no cardiac tamponade had occurred.

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