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Research Article

Electrocardiographic changes in chronic valvular disease and dilated cardiomyopathy in dog

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Abstract
Introduction: Two of the most common acquired cardiac diseases in dogs are chronic valvular disease and dilated cardiomyopathy. Morphological and structural changes in the myocardium during disease progression may induce alterations of the nodal system resulting in arrhythmias. Electrocardiography is the golden method for detecting arrhythmias. The aim of this study is to discuss the most frequent electrocardiographic changes in chronic valvular disease and dilated cardiomyopathy and to underline the electrocardiographic diferences between the two pthologies. Materials and method: Twenty-seven client-owned dogs distributed in two groups according to diagnostic were included in the study. Eighteen dogs were diagnosed with chronic valvular disease and nine dogs with dilated cardiomyopathy. Dogs have been submitted to a physical examination, electrocardiography and cardiac ultrasonography. Results: Within chronic valvular disease group, 9 dogs had signs of left cardiomegaly, 3 dogs had sinus tachycardia, 2 dogs had signs of myocardial hypoxia, one dog had sinus arrest, one had ventricular tachycardia and ventricular premature complexes and 2 dogs had normal ECG trace, while in the dilated cardiomyopathy group 4 dogs had atrial fibrillation, 3 dogs had generalised cardiomegaly signs with sinusal rhythm, 1 dog had atrial fibrillation with ventricular premature complexes and 1 dog had sinus rhythm with presence of ventricular premature complexes. A significant difference ($p<0.05$) was found between the duration of the QRS complex in the two groups (mean±SD of 68.16±10.72 in CVD group and 85.88±15.33 in DCM group). Conclusion: Supraventricular rhythm was the most common rhythm disturbance in dilated cardiomyopathy group, while in chronic valvular disease the sinus rhythm is predominant. The duration of QRS complex was significanly higher in dilated cardiomyopathy group.

Key Words: arrhythmia, dog, electrocardiography, QRS duration;

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Introduction

The two most common acquired cardiac diseases in dogs are chronic valvular disease (CVD), affecting mostly small breed dogs and dilated cardiomyopathy (DCM), affecting mostly large and giant breed dogs. Chronic valvular disease is estimated to account for 75% of all cardiac diseases in dogs (Atkins et al 2009). Regarding the dilated cardiomyopathy, the prevalence is 0.5% among the general population of dogs, but most studies in this field have concentrated over breed characteristic DCM (Ettinger&Feldman 2005). According to literature, some predisposed breeds to DCM appear to have high prevalence, such as Doberman pinschers, Newfoundlands, or Great Danes (Tidholm 1996; Tidholm et al 2001; Stephenson et al 2012). Electrocardiography (ECG) is widely used as a diagnostic tool for cardiac diseases in both, human and veterinary medicine, allthough, ECG was not recommanded as a specific diagnostic tool neither in diagnosis of canine chronic valvular disease nor in dilated cardiomyopahty in dogs (Dukes-McEwan et al 2003; Atkins et al 2009). The aim of this study is to discuss the most frequent electrocardiographic changes in CVD and DCM and to underline the electrocardiographic differences.

Materials and methods

The study was conducted under the ethical recommendations for the accomodation and animal handling and the owners were orally informed regarding the procedures. All dogs were presented to our teaching hospital for medical reasons. Twenty-seven cliend-owned dogs have been retrospectively included in the study, distributed in two groups according to diagnostic. The CVD group, comprise eighteen dogs, with age between 4 and 15 years with a median of 12 years (IQR 9.5 to 13.25), 8 males and 10 females, with body weight between 3.6 and 50 kg with a median of 9 (IQR 6 to 13.95), from different breeds: 5 Caniche, 3 mix breed, 3 Cavalier King Charles, 2 Dachshund, 2 Bichon maltese and one of each breed Cocker Spaniel, German shepherd and Boxer. The DCM group comprise nine dogs, with age beetween 4 and 14 years with a median of 8 (IQR 5.5 to 11), 8 males and one female, with body weight between 13 and 60 kg with a median of 36 (IQR 19.5 to 40), from different breeds: two mix breed and one from each breed Caucasian shepherd, Mioritic shepherd, Cocker spaniel, Pointer, Giant schnauzer, German shepherd and Doberman pinscher. Dogs have been submitted to physical examination, electrocardiography and

cardiac ultrasonography. Physical examination have been performed in the same manner for each patient and concerned the history, cough, exercise intolerance, apetite, weight loss, dispnoea, syncope, heart rhythm and presence or absence of heart murmur. A 5 minutes, six lead electrocardiography have been performed in right lateral recumbency in each patient, with the PolySpectrum 8E/8V ECG machine and the trace interpretation have been performed with a dedicated software (PolySpectrum Neurosoft digital ECG system Software ver. 4.8.131). The electrocardiographic tracing was analised concerning the rhythm, heart rate, respiratory arrhythmia, wandering pacemaker, mean electrical axis and presence of any abnormal rhythm. The morphology of the ECG resided from the measurement of P wave, PR interval, QRS complex, R wave, ST segment and T wave. Cardiac ultrasound was performed with the Esaote AU5 ultrasound machine, using a phased-array 2-5 MHz tranducer, in left and right lateral recumbency acording to ACVIM recommendations (Thomas et al 1993). The diagnostic of chronic valvular disease have been established according to ACVIM consensus statement for diagnostic of mitral valve disease, (Atkins et al 2009). For CVD group, thickening or prolapse of the mitral valve leaflets and colour Doppler identification of the mitral valve regurgitant jet were used as inclusion criteria. The diagnostic of dilated cardiomyopathy have been established according to the scoring proposed in DCM diagnostic guidelines in dogs (Dukes-McEwan et al 2003). In one patient from the DCM group, cardiac ultrasonography was not available, but the diagnostic was set due to rhythm disturbances.

Statistics: A computer programe (IBM SPSS statistics v. 21) was used for all statistical analyses. Normal distribution data are presented as mean ± standard deviation and non-parametric data distribution are presented as median and interquartile range (Q1 to Q3). The Saphiro-Wilk test was used to verify the normal distribution of the data. A student t-test was used to evaluate the differences between normally distributed groups and Mann-Whitney U test for non-parametric normal distribution. A p value less than 0.05 was considered statistically significant.

Results

Eighteen dogs were diagnosed with CVD and nine dogs were diagnosed with DCM. Within the CVD group, according to physical examination, six dogs had signs of cough, two dogs had mild, three had moderate and four had severe exercise intolerance, six dogs had apetite loss, weight loss, signs of dispnoea and two dogs had history of syncope. In auscultation two dogs had 1st degree murmur, seven dogs had 3rd degree murmur, three dogs had a 4th degree murmur, six dogs had a 5th degree murmur and one dog had 6th degree murmur. Electrocardiographical changes have been analysed and the most important changes have been taken in consideration. Within the CVD group, seventeen dogs had sinus rhythm. Nine dogs had signs of left cardiomegaly, 3 dogs had sinusal tachycardia, two dogs had signs of myocardial hypoxia, one dog had sinusal arrest, one dog had ventricular tachycardia and ventricular premature complexes (VPC) and two dogs had normal ECG trace.

The DCM group included 9 dogs. Clinical examination was not available in one patient. Only two dogs presented signs on cough, seven dogs had severe effort intolerance, loss of apetite, weight loss and dispnoea and none of the dogs presented history of syncope. In auscultation, four dogs had a sinus rhythm and five dogs had a non-sinusal rhythm. Four dogs had no audible murmur, two dogs had a 2nd degree murmur, one dog had a 4th degree murmur, and one dog had a 5th degree murmur. Electrocardiographic changes revealed atrial fibrillation in 4 dogs, generalised cardiomegaly signs with sinus rhythm in 3 dogs, atrial fibrillation with VPCs in one dog, and sinus rhythm with presence of VPCs in one dog.

Electrocardiographic measurements of the P-QRS-T waves, segments and intervals were performed in all patients within the two groups and statistical difference was assessed. Minimum, maximum and mean±SD, along with the statistical significance are shown in table 1.

Among the electrocardiographic measurements assessed, a significant difference ($p<0.05$) was found only between the duration of the QRS complex in the two groups. Differences were found also between heart rate, P-wave duration and R wave amplitude, but with no significant difference (Table 1).

Table 1. Values of the electrocardiography variables in the chronic valvular disease group (CVD) and dilated cardiomyopathy group (DCM) expressed as minimum, maximum and mean±SD and the value of the difference between groups

	CVD group			DCM group			P
	Min	**Max**	**Mean±SD**	**Min**	**Max**	**Mean±SD**	
HR (bpm)	100	200	137.22±28.03	80	250	160±66.14	0.216
P (mV)	0.11	0.40	0.22±0.08	0.13	0.35	0.2±0.09	0.649
P (msec)	32	85	58±13.85	53	80	65.7±13.74	0.323
R (mV)	0.59	4.06	1.62±0.87	0.41	2.44	1.09±0.68	0.054
QRS (msec)	52	88	68.16±10.72	64	110	85.88±15.33	0.002
ST (mV)	-0.25	0	-0.11±0.08	-0.29	0.11	-0.05±0.12	0.138
T (mV)	-1.12	0.66	0.01±0.42	-0.34	0.33	0.07±0.23	0.433

Cardiac ultrasound was performed in all patients within CVD group and in 8 dogs out of 9 in DCM group. In both groups, monodimensional and bidimensional measurements have been performed. For assessing the left atrium size, the left atrium to aorta ratio in bidimensional mode has been used. Variables for assessing the left ventricle systolic and diastolic function such as shortening and ejection fraction, end-diastolic and end-systolic volume interventrcular and left ventricle free wall thickening fraction and left ventricle diameter in systole and diastole indexed to body weight were calculated.

Between the CVD and DCM groups, significant difference was found in end diastolic and end systolic volume volume indexed to body surface area and left ventricle diameter in diastole and systole indexed to body weight ($p<0.05$). Other measurements such as shortening and ejection fraction, left atrium to aorta ratio, interventricular septum and left ventricle free wall thickening ratio did not show statisticaly significant difference (Table 2).

Table 2. Values of the echocardiography variables in the chronic valvular disease group (CVD) and dilated cardiomyopathy group (DCM) expressed as minimum, maximum, median and interquartile range and the value of the difference between groups.

	CVD group			DCM group			P
	Min	Max	Median (IQR)	Min	Max	Median (IQR)	
LA/Ao	1.18	3.10	1.32 (1.22-1.85)	1.35	2.29	1.86 (1.44-2.04)	0.150
SF%	23.50	45.00	30.5 (26-38.75)	8.10	46.00	18.1 (12.9-37.25)	0.081
EF%	47.00	79.00	60 (53-75.5)	18.00	84.00	37 (27.75-69.2)	0.106
EDVi	21.43	241.00	61 (32.6-99.4)	45.59	307.95	138.9 (110.2-223.3)	0.035
ESVi	7.96	78.73	21.42 (14.09-44.77)	13.11	207.35	90.68 (31.8-141.7)	0.012
IVS%	0.00	117.00	32.5 (10.5-68.75)	0.00	70.00	41 (8.75-63.75)	0.911
LVW%	13.00	192.00	32.5 (19-53.5)	11.00	85.00	32 (15.25-39.75)	0.637
LVDd-BW	0.94	2.49	1.39 (1.09-1.7)	1.21	2.77	1.95 (1.76-2.39)	0.046
LVDs-BW	0.63	1.45	0.87 (0.74-1.19)	0.66	2.20	1.5 (0.96-1.87)	0.022

Discussion

Chronic valvular disease and dilated cardiomyopathy are considered the most frequent acquired cardiac diseases in dogs (Tidholm et al 2001; Atkins et al 2009). Chronic valvular disease is characterised by nodular degeneration or thickening of the valve leaflets and sometimes lengthening of the cordae, leading to valvular coaptation deficit and mitral valve incompetence (Smith et al 2016). These changes lead to hemodinamic and neuro-hormonal disturbances and in return, to myocardial structural changes. Dilated cardiomyopathy is a muscular disease characterised by enlargement of the left, or both ventricles along with the thinning of the myocardial walls and severe systolic dysfunction (Richardson et al 1996). Electrocardiography is the test of choice for detecting arrhythmias and can be helpfull in detecting heart chambers enlargement (Smith et al 2016). History and clinical examination in the dogs taken in study helped orientate the diagnostic of cardiac disease. Later, the diagnostic was confirmed and the dogs have been distributed according to test results into CVD and DCM group.

In the CVD group, cough, loss of apetite, weight loss and dispnoea was present in 6 out of 18 dogs, exercise intolerance was present in 9 dogs, syncope in 2 dogs and all dogs had a sinusal rhythm. Auscultation revealed a systolic apexian left sided murmur of different degrees in all dogs. Similarily, in a study, all previous clinical signs were found in CVD and showed to be associated with cardiac mortality, except dispnoea (Lopez-Alvarez et al 2015). Electrocardiography in CVD group showed sinusal rhythm in 17 dogs, but only 2 had a normal trace of ECG. Nine dogs had morphological changes associated with left cardiomegaly. This finding occurs because of the chronic hemodinamic changes and left atrium and ventricle dilatation. Left atrium chamber is the first subjected to internal pressure increase, because of the regurgitant jet, while the left ventricle size deteriorates progresively with the cardiac overload. The mitral P wave is associated with the dilatation of the left atrium while an increase of QRS duration or R wave amplitude is associated with left ventricle dilatation (Santilli and Perego 2014). Three dogs presented sinus tachicardia, without any other rhythm or morphological changes. Sinus tachicardia is an early sign of cardiac compensation. Higher heart rate occurs due to early neuro-hormonal activation during the begining stage of the disease (Oyama 2009). In two patients, electrocardiography changes were consistent with myocardial hypoxia. The myocardial muscle is very sensitive to arterial oxygen concentrations and permanent alterations of the myocardium may emerge early, first with repolarisation alteration, followed by more malignant arrhythmias (Santilli and Perego 2014). One dog presented sinusal arrest, showing a disturbance of sinusal electrical impulse production. This abnormality appear secondary to an increase of vagal tone, neuro-hormonal disturbances or a structural sinusal dysfunction. In one patient, synusal rhythm was discontinued by runs of ventricular tachycardia and ventricular premature complexes.

In the DCM group, only 2 presented signs of cough, exercise intolerance, apetite loss, weight loss and dispnoea was present in 7 dogs and none of them had history of syncope. Auscultation reavealed absence of murmur in 4 dogs. Mitral valve murmur in dilated cardiomyopathy is consistent with a regurgitating jet caused by the atrio-ventricular ring enlargement and ventricular dilatation resulting in a coaptation deficit of the mitral valve leaflets. Four dogs had a synusal rhythm and 5 dogs had a non-synusal rhythm. Electrocardiography revealed atrial fibrillation in 4 dogs, signs of cardiomegaly in 3 dogs, atrial fibrillation and VPCs in one dog and synusal rhythm with presence of VPCs in one dog. Similarily, according to literature, atrial fibrillation is the most common arrhythmia in dogs with DCM (Dukes-McEwan et al 2003; Borgarelli et al 2006). Signs of cardiomegaly are also common because dilated cardiomyopathy is a progressive disease that develop atrial and ventricular enlargement. Ventricular premature complexes are spontaneous ventricular depolarisations that may occur from any ventricular area and are currently found in dilated cardiomyopathy, being included in the diagnostic scoring as major criteria (Dukes-McEwan et al 2003; Petric and Tomsic 2008; Santilli and Perego 2014).

Concerning the morphology, all ECG traces have been measured. The P-wave was absent in 5 dogs from the DCM group because of the presence of atrial fibrillation, while in the rest of the cases, from both groups have been measured, but no significant difference have been found between the two groups. Amplitude of R wave was found to be higher in CVD disease than DCM, but aswell, without significant difference. Increased amplitude of R wave may be consistent with left ventricle dilatation or interventricular conduction disturbances. Between the two groups, the left ventricle internal diameter in systole and diastole indexed to body weight was found greater in DCM group (see Table 2), demonstrating that the reason for higher R wave amplitude in CVD was the presence of a most severe

interventricular conduction disturbance. It is also known, that during chronic cardiac disease, changes such as myocardial remodelling, arrhythias, haemorrage, vascular and myocardial fibrosis may occur, which may also produce myocardial conduction disturbances (Pouchelon et al 2015). The QRS duration is also associated with ventricular dilatation and conduction disturbances (Santilli and Perego 2014). Between the QRS duration in the 2 goups in this study, a statistically singificant difference was found, DCM group showing a higher duration (Figure 2). One study found that a QRS duration ≥ 60 msec was associated with a reduced survival time. Moreover, an increase of 1 msec had a HR of 1.015 (Pedro et al 2011). The mean QRS duration in DCM group in our study was 85.88 msec. Between the ST segment and T wave in the two groups no significant difference was found.

The study was limited because of the small number of dogs in the two groups, but, according to literature, the groups were representative concerning the electrocardiographic changes. Also, a Holter ECG recording was not available dor the DCM patients, so the number of VPCs and VT runs could not be calculated. The patients in the CVD group were not distributed according to ACVIM chronic valvular disease diagnostic recommendations and the result interpretations were based only on the chronic valvular disease diagnostic.

Conclusion

Between the two groups, a difference was found concerning the rhythm, and rhytm disturbances. Supraventricular rhythm was the most common disturbance in dilated cardiomyopathy group, while in chronic valvular disease, all patients had a sinus rhythm except one. Moreover, patients in dilated cardiomyopathy group had more malignant rhythm disturbances. Concerning the morphology, only the duration of QRS complex was significanly higher in dilated cardiomyopathy group. Studies are required on larger groups in order to understand better the electrophysiological changes between the two most common cardiac diseases in dogs.

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