PAROXYSMAL ATRIAL ARRHYTHMIAS AS A CAUSE OF SYNCOPE IN A BOXER DOG – A CASE REPORT

AGNIESZKA NOSZCZYK-NOWAK, JACEK GAJEK1, URSZULA PASŁAWSKA, JERZY RABCZYŃSKI2, AGNIESZKA SŁAWUTA1, AND JÓZEF NICPOŃ

Department of Internal and Parasitic Diseases with Clinic for Horses, Dogs and Cats, University of Environmental and Life Sciences, 50-366 Wroclaw, Poland
1Department and Clinic of Cardiology, 2Department of Pathological Anatomy, Medical University, 50-367 Wroclaw, Poland
agnieskann@poczta.onet.pl

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Abstract

The aim of the presented electrophysiological and histological study was the investigation of unexplained syncopal spells in a dog of Boxer breed. The dog underwent non-invasive procedures, which turned out to be insufficient for a complete diagnosis. Invasive procedures showed paroxysmal atrial fibrillation. In post-mortem examination, intensive extravascular fibrosis in the both atria, mostly in the endocardium, as well as a local loss of the cross-striation in cardiomyocytes, the presence of giant nuclei, and penetration of adipose tissue, especially in the left ventricle, were found. These changes might be the cause of arrhythmias. Paroxysmal atrial arrhythmias can be the mechanism of syncope in dogs. The electrophysiological properties of the myocardium predispose to both supraventricular and ventricular arrhythmias in dogs. Invasive electrophysiological study is a valuable diagnostic tool in dogs with syncope.

Key words: dog, arrhythmia, electrophysiological examination.

Heart diseases have emerged as a major clinical entity in dogs (9). The diagnosis of arrhythmias is more effective but their pathogenic mechanisms in dogs are still unclear. Many studies on human population give satisfactory insight into the pathology of arrhythmias, whereas the reports on the pathophysiology and mechanisms of arrhythmias in dogs, especially in the predisposed breeds, are sparse. The reason of this status quo is a limited access to invasive cardiological procedures in veterinary medicine and the fact that autopsy and histopathological examination are still not common. Invasive electrophysiological study (EPS) in the form of programmed electrical stimulation enables the estimation of the conduction properties by measuring intracardiac potentials, effective refraction periods, and intracardiac conduction time (8). The method, very useful in cardiac arrhythmias, consists in recording of intracardiac electrograms and stimulation of selected sites of the heart with multipolar electrodes (2, 17). EPS is a very useful prognostic and diagnostic tool, which begins and closes every radiofrequency catheter ablation - the treatment option in cardiac arrhythmias (1, 3, 4, 14). This method is one of diagnostic procedures in the investigation of some unexplained symptoms, including syncope (12). In Poland, the first programmed electrical stimulation for experimental purposes was conducted in a swine with hyperthyreosis (6). The aim of the study was to estimate the changes of conduction properties of the heart in hyperthyreosis, which is the well-known background of cardiac arrhythmias in humans (6, 7). In veterinary medicine, electrical stimulation was performed on dogs providing accurate diagnosis and facilitating a right choice of a therapeutic approach (13, 15, 16), but the procedure has not been used in Poland yet.

The aim of the electrophysiological and histological study was the investigation of unexplained syncopal spells in a dog from a Boxer breed. The dog underwent non-invasive procedures, which turned out to be insufficient for a complete diagnosis.

Material and Methods

In a male dog from a Boxer breed at the age of 8 years, weighing 38 kg, the owner observed recurrent syncopal spells. After clinical examination, the blood tests (aspartate and alanine aminotransferases, urea, creatinine, alkaline phosphatase, K⁺, Na⁺, Mg²⁺, Ca²⁺, Cl⁻) were performed. The dog underwent electrocardiogram and echocardiogram with the ambulatory 24 h electrocardiography recording (ECG Holter monitoring), performed according to the established clinical practice. Disposable self-adhesive electrodes were placed on dog’s shaven chest skin and the recorder was fixed with a bandage on its back, between the shoulder blades. After analysis of the results of non-invasive procedures, the cardiac
The first stage of the procedure was to set a threshold of stimulation for the every paced site. The stimulation was performed with a stimulus twice higher than the previously measured threshold. A stimulation protocol consisted of drive train of paced beats (S1 beats) and stimulation with a premature beat S2 (a drive train of 8 S1 and S2 in a decremented interval). The stimulation protocol included the atrial and ventricular effective refractory periods at the normal sinus rhythm rate and at two fixed rates (150 and 180 bpm), measurement of the Wenckebach cycle length and the sinus node recovery time after pacing at a rate 150 bpm for 30 s. The ventricular effective refractory period is defined as the longest S1-S2 interval where S2 fails to capture the ventricle. The atrial effective refractory period (AERP) is the longest interval from the last sinus beat (S1-S1) and the single extrastimulus (S2) that fails to capture the atrium prematurely. The A-V nodal effective refractory period (AVNERP) is the longest interval S1-S2 without conduction of stimulus to the ventricle. The Wenckebach cycle length is the lowest stimulation rate at which dropped ventricular beats occur, which means Wenckebach type of atrioventricular block. The sinus node recovery time (SNRT) is the period between the last paced stimulus and the first spontaneous atrial depolarisation with features typical of sinus node origin.

After 24 h of fasting, anaesthesia was induced by premedication (2 mg/kg of azaperone and 10 mg/kg of ketamine i.m.) and sodium pentobarbital (8-10 mg/kg as the initial dose). The anaesthetic agents used in the experiment have minimal effect on the electrophysiological properties of cardiac myocytes and they are commonly applied during EPS in animals (6). Pacing protocol consisted of the ventricular effective refractory period (VERP), the AV nodal effective refractory period (AVNERP), the atrial effective refractory period (AERP) at underlying sinus rate and at a fixed rate (100 bpm, 130 bpm, 150 bpm, 180 bpm), the Wenckebach CL (cycle length), and the sinus node recovery time (SNRT). The range of procedures was actually different because some parameters were omitted, e.g. refractory periods at the rate 100 bpm in case of sinus tachycardia >100 bpm present in some animals with hyperthyreosis. After the invasive EP study, unfractionated heparin at a dose of 100 i.m./kg was administered intravenously, as well as a broad spectrum and long-acting antibiotic subcutaneously.

An autopsy was performed 2 d later. The decision for euthanasia was taken because of multiple injuries caused by the car accident. Paraffin sections stained with haematoxylin-eosin and by van Gieson’s method were prepared from tissue samples taken from the both ventricles, both atria, and the interventricular septum.

**Results**

The clinical examination revealed normal colour of the mucous membranes, capillary filling time below 2 s, normal strength and contour of the pulse, which was regular - 130 bpm. In auscultation, the heart sounds were normal, regular, without any murmurs. There were not any abnormalities in the clinical examination. The results of all blood tests were within normal ranges (Table 1).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Results</th>
<th>Norm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspartate aminotransferases (U/L)</td>
<td>89</td>
<td>100</td>
</tr>
<tr>
<td>Alanine aminotransferases (U/L)</td>
<td>68</td>
<td>100</td>
</tr>
<tr>
<td>Urea (mg/dL)</td>
<td>34</td>
<td>25-70</td>
</tr>
<tr>
<td>Creatinine (mg/dL)</td>
<td>1.4</td>
<td>0.2-2.0</td>
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<tr>
<td>alkaline phosphatase (U/L)</td>
<td>57</td>
<td>61</td>
</tr>
<tr>
<td>K⁺ (mEq/L)</td>
<td>4.4</td>
<td>3.5–5.1</td>
</tr>
<tr>
<td>Na⁺ (mEq/L)</td>
<td>149</td>
<td>142-158</td>
</tr>
<tr>
<td>Mg²⁺ (mg/dL)</td>
<td>2.4</td>
<td>2-3</td>
</tr>
<tr>
<td>WBC (10³/uL)</td>
<td>13</td>
<td>8-19</td>
</tr>
<tr>
<td>RBC (10⁶/uL)</td>
<td>8.9</td>
<td>4.95-10.6</td>
</tr>
<tr>
<td>Hb (g/dL)</td>
<td>13.2</td>
<td>8-15</td>
</tr>
<tr>
<td>Ht(%)</td>
<td>39</td>
<td>25-42</td>
</tr>
</tbody>
</table>

Electrocardiogram showed sinus rhythm regular, 120 bpm, with P-wave duration 0.03 s, P-wave amplitude + 0.2 mV, PQ interval duration 0.08 s, QRS complex duration 0.05 s, R wave amplitude =1.0 mV, ST segment duration 0.16 s, QT interval =0.21 s, mean vector in vectorcardiogram was 34°. In echocardiography, left atrium (LA) diameter was 3.2 cm, aorta diameter 2.4 cm. Left ventricle enddiastolic diameter (LVd) was 4.42 cm, endsystolic 3.02 cm. The systolic diameter of interventricular septum (IVSs) was 1.6 cm, diastolic (IVSd) 1.4 cm. Left ventricle posterior wall diameter in diastole was (LWd) 1.7 cm and in systole (LWs) 1.5 cm. Ejection fraction (EF) of the left ventricle calculated on the basis of systolic and diastolic parameters of the left ventricle amounted 57.8%. The animal underwent ambulatory 24 h electrocardiography recording (Holter monitoring), which revealed the highest sinus rate 210 bpm during exercise and lowest 41 bpm during a sleep. Mean sinus rate was 93 bpm. In Holter recordings, we observed 14 single supraventricular premature complexes, 2 episodes of paroxysmal supraventricular tachycardia with heart rate 150 bpm lasting 12 s, and 4 single ventricular premature complexes (Fig. 1).
Fig. 1. Episodes of paroxysmal supraventricular tachycardia in Holter recordings.

Fig. 2. The atrial fibrillation after an extrastimulus at a coupling interval 130 ms.
In EPS, the ventricular and atrial stimulation was carried out. In stimulation at a sinus rate 8, sinus beats were followed by 1 additional premature beat at a decreasing cycle length (CL). The stimulation at a fixed rate consisted of pacing of the ventricle and the atrium at a rate 150 bpm and 180 bpm with an extrastimulus at a decrementing coupling interval. The ventricular effective refractory period (VERP) at a sinus rate was 180 ms, the ventricular effective refractory period at a fixed rate 150 bpm was 130 ms, and at 180 bpm – 110 ms. The atrioventricular nodal effective refractory period (AVERP) at a sinus rate was 160 ms; at a fixed rate 150 bpm - 130 ms, at the rate 180 bpm - 110 ms. The atrial effective refractory period (AERP) at a sinus rhythm and a fixed rate has not been measured as the atrial tachycardia was induced after an extrastimulus at a coupling interval 180 ms and the atrial fibrillation after an extrastimulus at a coupling interval 130 ms (Fig. 2). The Wenckebach CL and the sinus node recovery time could not be estimated because of the recurrent atrial fibrillation.

Post-mortem examination did not reveal any essential organ changes. No macroscopic changes were found in the brain. The height of the heart was 10.0 cm, breadth 8.8 cm, cardiac mass 200 g. Dimensions of the right atrium were 3.1 cm and 4.0 cm, and of the left atrium 2.0 x 1.6 cm. The right ventricular dimensions were 5.3 x 4.4 cm, and the left ventricular ones were 5.2 x 4.2 cm, a thickness of the right ventricular muscle was 0.3 cm, left free wall 1.1 cm, the interventricular septum 1.4 cm. There was neither any change in appearance of the epicardium and endocardium of the atria and ventricles nor any blood clots present in the cardiac chambers. The atrioventricular, pulmonary artery, and aortic valves were glistening, smooth, and of reduced transparency.

In the histopathological examination, intensive extravascular fibrosis in the both atria, mostly in the endocardium was found. A local loss of a cross-striation in cardiomyocytes, the presence of giant nuclei, and penetration of adipose tissue was found, especially in the left atrium (Fig. 3). The examination did not reveal any hypertrophy of coronary vessels wall, perivascular fibrosis around coronary vessels, hyperaemia, and cellular infiltrations.

**Discussion**

The identifying of aetiology of syncope in animals differs markedly from a standardised diagnostic methods used in humans (6). In human pathology, orthostatic hypotonia, dysautonomic syndrome, and reflex syncope predominate (1). These mechanisms, although possible in animals, cannot be properly verified because of lack of the fundamental diagnostic tool - head-up tilt test. Obviously, in case of an animal, the upright position cannot determine a mechanism of syncope (1). Although the causes mentioned above must be different in animals and humans, arrhythmias and blood flow disturbances in structural heart diseases are equally probable.

Since in the examined dog, a significant valvular stenosis or intensive hypertrophy of the interventricular septum capable of producing an obstruction to LVOT (left ventricle outflow tract), especially during exercise, were excluded echocardiographically, we presumed that the underlying
mechanism of syncope must be either intermittent atrioventricular block or fast ventricular or supraventricular rhythm. In human pathology, a dysfunction of the atrioventricular conduction is usually the effect of four basic reasons, three of which can be easily excluded in the presented case. The animal was neither treated with drugs affecting atrioventricular conduction, nor had symptoms of myocardial ischaemia, nor underwent any cardiac surgery. A possibility of intermittent atrioventricular block as the result of aging process was unlikely because of lack of such abnormalities in Holter monitoring, high heart rate variability and, what is crucial, parameters of atrioventricular node function during the electrophysiological examination were within normal limits.

Dogs from the Boxer breed are especially predisposed to ventricular arrhythmias (5). The possible background of that fact are particular electrophysiological properties of canine myocardium; a relatively short refractory period attributable to a density of potassium channels, as compared to human or porcine heart, which was expressed in our previously published studies (5). A short repolarisation phase of a single cardiomyocyte results in a short repolarisation time of the whole structure, which manifests itself in a short QT interval in the electrocardiogram. Presumable in such conditions processes inducing creation of regions of slowed conduction (e.g. hypertrophy, fibrosis) cause a profound increase in dispersion of repolarisation, as compared to other species and thus increasing the susceptibility for ventricular arrhythmia, this can be the cause of transient loss of consciousness or even sudden cardiac death. In the presented case, there was no evidence for such a hypothesis because of the result of Holter monitoring, which was negative for significant ventricular arrhythmia, as well as no ventricular arrhythmia was induced during programmed ventricular stimulation.

The most probable mechanism of syncope in the examined dog was paroxysmal atrial arrhythmia – fast atrial tachycardia and atrial fibrillation with ventricular rhythm 300-400 bpm. It is consistent with a presence of those arrhythmias in Holter recordings and their repeated induction during the electrophysiological study. The presence of multiple atrial premature complexes in 24 h electrocardiography recording, relatively short refraction period of atrial myocardium or regional fibrosis of the stroma are sufficient to expect paroxysmal focal atrial tachycardia or atrial fibrillation in a given case.

The paroxysmal atrial arrhythmia with fast atrioventricular conduction is the underlying mechanism of presyncope and syncope in humans. The extreme example is atrial fibrillation in patient with an accessory pathway. As the matter of fact, even slower ventricular rate during arrhythmia is not sufficient to exclude such a background of syncope. The lack of contractile function of the atria decreases effective volume by 15%-25%, which does not affect minute heart volume; furthermore, this parameter can rise with higher ventricular rate. However, the rise of the latter results in deterioration of diastolic function in the form of impaired relaxation, especially of the left ventricle. Extremely fast rhythm, which is possible in dogs as mentioned above, leads to decrease in stroke volume manifesting as syncope.

In conclusion, paroxysmal atrial arrhythmias can be the cause of syncope in dogs. The electrophysiological properties of the myocardium predispose to both supraventricular and ventricular arrhythmias in dogs. Invasive electrophysiological examination is a valuable diagnostic tool in dogs with syncope.

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