A Case Report of Long-Term Wireless Electrocardiographic Monitoring in a Dog with Dilated Cardiomyopathy

M. Brložnik*, V. Avbelj**

* Small animal clinic, Veterinary faculty, University of Ljubljana, Slovenia  
** Department of Communication Systems, Jožef Stefan Institute, Ljubljana, Slovenia  

Correspondence: viktor.avbelj@ijs.si

Abstract – Wireless electrocardiographic (ECG) sensor attached to the skin and connected to a smart device via low power Bluetooth technology has been used to record more than 500 hours of ECG data in a German shepherd dog with dilated cardiomyopathy (DCM). Wireless ECG monitoring has been used for a period of 6 months. With the wireless body electrodes, the ECG data were obtained while the dog was resting, walking, playing and eating. Atrial fibrillation, ventricular premature complexes, occasional ventricular tachycardia and multiform ventricular beats were observed. Numerous standard 6-lead ECG recordings have been compared to the recordings obtained with wireless body electrodes. Instantaneous and average heart rates and standard duration measurements evaluated with the two devices were identical in all cases. The extended ECG monitoring time with the wireless device increased the diagnostic yield of arrhythmias.

The dog was treated with diuretics, positive inotropes, ACE inhibitor and antiarrhythmics for 2 years. Influence of various drugs, dog’s activities, and environmental factors on ECG data was investigated. During the 6 months period dog’s condition was changing substantially and long term ECG monitoring excluded arrhythmias as the cause for dog’s weakness. The wireless device, which proved to be reliable and simple to use, enables an excellent option of long-term monitoring of canine cardiac rhythm in real-world environment.

I. INTRODUCTION

Canine dilated cardiomyopathy (DCM) is a primary myocardial disease characterized by chamber dilation and a decrease in myocardial contractility. Beside the predominant systolic dysfunction of one or both ventricles, diastolic dysfunction is also present. DCM is the most common form of canine cardiomyopathy. It is an inherent disease of large and medium sized dogs [1 - 6]. In dogs with DCM arrhythmias occur commonly. Due to their intermittent nature a long-term electrocardiographic (ECG) monitoring in real-world environment is most suitable for the diagnostics [7 - 9]. Arrhythmias frequently require treatment. Treatment success and possible adjustment of dosages is best evaluated with follow-up long-term electrocardiographic monitoring.

In this case report we present a German shepherd dog with DCM and various arrhythmias, which were recorded with a wireless ECG sensor. This wireless device was described and used previously [7, 8, 10, 11].

Fig. 1: A 10-year old German Shepherd Srečko

The frequency of atrial fibrillation lowered to 180 beats per minute. To further lower heart rate diltiazem (30
mg/8h) was added to therapy. Heart rate reduced to 130-150 beats per minute. Dog’s condition appeared stable, but ECG measurements revealed occasional slow solitary ventricular premature contractions (VPCs). Later, also VPC couplets and triplets were observed with standard ECG. Atenolol and sotalol were administered, but were not tolerated. Half a year into DCM diagnosis, surgery had to be performed due to gastric torsion. In following months frequent weakness, depression and anorexia have been observed and long-term electrocardiographic monitoring of cardiac rhythm was advised to exclude arrhythmia like ventricular tachycardia as a possible cause. Long term ECG monitoring was unavailable for another year, when a possibility of wireless ECG monitoring was introduced. Wireless ECG sensor described previously [7, 8, 10, 11] consists of an electronic module with battery and two self-adhesive electrodes with a distance of 9 cm (Fig. 2).

The ECG sensor records one bipolar lead. Wireless communication with the sensor via low power Bluetooth technology allows the display of the ECG signal on a smart device (tablet or smart phone), which records real-time data from the electrodes. Evaluation of the ECG recordings was performed with VisECG software (Jožef Stefan Institute, Ljubljana). The software can also extract the respiration rate based on the amplitude changes of QRS complexes [12]. The device was used to record more than 500 hours of ECG data over a period of 6 months. To prevent detachment, the ECG sensor was occasionally bandaged (Fig. 3). With the wireless body electrodes, the ECG data were obtained while the dog was resting, walking, playing and eating. Numerous standard ECG recordings were compared to the recordings obtained with wireless body electrodes. Influence of various drugs, dog’s activities, and environmental factors on ECG data was investigated. During the 6 months period dog’s condition was changing substantially and the purpose of long term ECG monitoring was to exclude arrhythmias as the cause of debilitating condition.

Fig. 2: Wireless body ECG sensor placed on the left side of the thorax, negative electrode near atria and positive electrode at the apex of the left ventricle.

Fig. 3: Wireless body ECG sensor during activities in real time environment

B. Results

Heart rate and rhythm from the wireless ECG data were compared with the data from the standard ECG. Instantaneous and average heart rates measured with both devices were identical in all cases. Whenever compared standard duration measurements (P wave width, QRS width, PR interval and QT interval) were congruent. All arrhythmias documented with standard ECG were observed with wireless sensor. The extended ECG monitoring time of the wireless device increased the diagnostic yield of arrhythmias. Atrial fibrillation (Figs. 4 – 9), fusion beats, VPCs (Figs. 5 – 8), and ventricular tachycardia (Fig. 9) were observed. VPCs were solitary (Fig. 5), couplets (Fig. 8), bigemini (Fig. 7), and multiform (Fig. 6). Atrial QRS complexes were usually notched, which represents an indication of an asynchronous depolarization of ventricles. The notches are clearly visible in Fig. 4.

Fig. 4: Atrial fibrillation with a dominant frequency of approx. 650 fibrillations/min (see 90 ms cycle length) and ventricular frequency of approx. 130 beats/min. Presumably, every 5th fibrillation in the vicinity of atrio-ventricular node is conducted to the ventricles. Note the notched QRS complexes (arrows).

It was estimated that approximately 10% of the recordings were composed of artifacts (motion artifacts or loss of signal). During strenuous physical activity
(running, jumping, etc.) interpretation of ECG signal was not possible.

Due to frequent bouts of non-sustained ventricular tachycardia, dog’s condition did not seem to worsen. However, an interesting observation was made with wireless ECG sensor: in first two months of measurements all ventricular arrhythmias were very frequent, while in the last months of dog’s life heart rhythm appeared more steady and slower, and only solitary VPCs were documented.

Due to cardiac cachexia and kidney failure the owner opted for dog’s euthanasia 2 years after diagnosis of DCM (6 months after initiation of wireless ECG monitoring).

C. Discussion
Diagnosis of DCM is based on the identification of myocardial dysfunction and myocardial eccentric hypertrophy with the exclusion of other congenital or acquired cardiac disease [2 - 4]. Patients with DCM frequently present with decreased exercise tolerance, as was the case in this dog. Other frequent clinical manifestations are poor appetite, lethargy, generalized weakness, cough and syncope [1, 2, 5, 6]. The primary morphologic change in DCM is ventricular eccentric hypertrophy. This occurs in response to a functional systolic contractile failure. Histopathological findings in canine DCM include fatty infiltration with degeneration and/or attenuated wavy fibers [2]. Atrial fibrillation is a common arrhythmia in patients with DCM and was noted at the presentation of this case. The dog presented with congestive heart failure (CHF). CHF most commonly develops at a certain stage of the disease and is mostly present at the time of diagnosis [1, 2]. The pathophysiology of CHF is no longer considered a mere haemodynamic consequence of a pump dysfunction, but a complex clinical syndrome with release of many neurohormones, which are believed to have impact on the progression of the disease [3]. The diagnosis of overt DCM is usually straightforward [4]. Therapy of the dogs with DCM and heart failure consists of inotropic support (pimobendan, digoxin), ACE inhibitors, diuretics, and antiarrhythmics, if indicated [4]. In this case the frequency of atrial fibrillation was initially decreased with digoxin, but diltiazem had to be added. Therapy for ventricular arrhythmias was either not tolerated (sotalol, atenolol) or was declined by the owner (carvedilol, amiodarone or mexillette) due to possible side effects.

Prognosis of DCM is likely to depend on the underlying cause. In one study, the median survival time in the dogs was 19 weeks, with the survival rate at one year 28% and at two years 14% [1]. In another study survival time ranged from 2 to 1108 days with median survival time 671 days [6]. Certain negative predictors of survival time were proposed including age, breed, pleural effusion, pulmonary edema, ascites, arrhythmias, severely increased end-systolic volume and ejection fraction, a restrictive pattern of transmural flow, increased duration of QRS, etc. [5, 6, 13]. In our case, pulmonary edema, ascites, severely enlarged heart with poor contractility, various arrhythmias, and prolonged QRS (88 ms, reference < 60 ms) were identified. However, the dog was living a quality life for two years after diagnosing DCM, which is a favorable outcome.
considering the negative prognostic factors. Long-term ECG monitoring can prolong survival of the patients with cardiac diseases, because it can exclude or diagnose arrhythmias as the cause for debilitating condition. Although the condition of this dog was worsening over the last few months of his life, wireless sensor showed that heart rhythm was more steady and slower with less arrhythmias compared to the first months of wireless ECG measurements. This enabled more confident approach to treatment and support.

Wireless ECG devices have been used in animals previously [7, 8, 14 – 18]. In this case the results of wireless ECG monitoring were compared with numerous standard ECG recordings and a conformation was made that the device is accurate and highly reliable. All arrhythmias documented with standard ECG were also documented with wireless sensor. Instantaneous and average heart rates, and standard duration measurements, determined with the two devices, were identical in all cases. This has been reported for the device previously [7, 8, 10]. Furthermore, the accuracy of this device has been confirmed with the synthesis of a 12-lead ECG [19 - 22]. Other devices to monitor ECG wirelessly have also proved to be accurate and reliable [23 – 32].

A higher diagnostic yield of arrhythmias was documented with wireless sensor due to prolonged monitoring. This has been reported previously in veterinary medicine for standard Holter and Event monitors [9, 33, 34], and also for the used wireless device [7, 8]. In human medicine the wireless devices were compared to 24-hour Holter monitoring and these reports are emphasizing the advantage of wireless devices to diagnose arrhythmias due to possibility of extended monitoring [23 - 25]. Longer monitoring is enabled with wireless devices due to their wearing comfort (they are waterproof, suitably small, and there are no wires attached to the body). Low power consumption of these devices contributes not only to prolonged lifetime, but also to system miniaturization, because the size of the battery occupies most of the system volume [31, 32, 35]. It is reasonable to expect that further development of electronics will enable even more monitoring of vital functions in clinical and home settings [36, 37] and that the wireless devices will become an important tool in human and veterinary medicine.

Beside the heart rate, duration measurements and arrhythmia recognition, the wireless device was also able to identify details like notched QRS complexes and predominant frequency of atrial fibrillation. This is another indicator of device’s precision and it suggests that wireless sensor might have additional diagnostic value and might not be used as a mere heart rate and rhythm monitor.

Atrial fibrillation (AF), which was the prevailing heart rhythm of the dog in our case, most commonly occurs secondary to serious underlying cardiac disease. The onset of AF usually coincides with deterioration in clinical status and AF is associated with a high mortality rate [38, 39]. Different mechanisms of AF have been proposed, including a single focus firing rapidly and causing fibrillatory conduction, and multiple re-entrant wavelets with random propagation over the atria [40]. In persistent AF, the prevailing theory regarding its mechanism involves coexistence of multiple random wavelets of activation, which create a chaotic cardiac rhythm [41]. Dominant frequency analysis of atrial electrograms has been used to understand the pathophysiology of AF and it has been shown that the dominant frequency of AF is an effective tool in estimating activation rate during AF condition. In our case the dominant frequency of approximately 650 fibrillations/min was observed with the wireless sensor. It is noteworthy that dominant frequency of AF is different at various localized atrial sites, which has been shown with spectral analysis and dominant frequency mapping of AF [41 – 43].

III. CONCLUSIONS

Wireless long term ECG monitoring was beneficial in diagnostics and treatment of the dog in our case, because arrhythmias were excluded as the cause of dog’s debilitating condition. This enabled more confident approach to treatment.

The wireless device used in this case report is now readily available [44]. With additional validation, software development, and experts offering readings and interpretation, the wireless devices might replace conventional Holter and Event monitors in human and veterinary medicine in due course.

ACKNOWLEDGMENT

This work was partially supported by the Slovenian Research Agency under grant P2-0095 (V. Avbelj).

REFERENCES


