Abstract

The doctoral thesis entitled *„Research regarding the diagnostic value of electrocardiography in canine cardiac diseases"* was motivated by the study of electrocardiographic changes and characteristics during different endocardial, myocardial and pericardial diseases. The originality of this thesis is based on the statistical study of the electrocardiographic changes and the emphasis of the differences found between cardiac diseases. Moreover, with the statistical analysis of the data, the decision tree graphics were able to highlight the diagnostic value of some findings, our results being compared with those form the Department of Veterinary Medicine of Naples. The last study of the thesis comes forward through the cardiologic characterisation of the healthy Bucovina Shepherd dogs, proposing the reference ranges for vertebral heart scale, echocardiographic and electrocardiographic measurements. Another novelty is represented by the report of two cardiac pathologies such as dilated cardiomyopathy in one Bucovina Shepherd dog and the pericardial defect with right atrial herniation in a dog.

The thesis consists of 181 pages, comprising two main parts, according to proposed guidelines, the first part, the bibliographic study, representing 24% (43 pages) and the second part, 76% (138 pages) represented by the personal research. The results are supported by a number of 42 tables, 36 figures and 42 graphics.

The first part of the thesis, entitled *„The current state of knowledge"* represents the short bibliographic study of the cardiac anatomy, physiology and rhythmology in dogs. This part is structured in two main chapters that describe the electrophysiological mechanisms and electric activity of the heart and the clinical electrocardiography including the recording, reading and interpretation of the diagnostic.

The first chapter, entitled *„Morphophysiological aspects of the canine heart"* extends over two subchapters, the first shortly describing the heart anatomy, highlightening the anatomy and morphology of the nodal tract, while the second concentrating on the electrophysiology of the heart. The second subchapter presents a series of physiological mechanisms such as cellular membrane activity, action potential, and the correlations between action potential and the electrocardiographic phases. Furthermore, the functional parameters of the heart represented by excitability, rhythmicity, conductibility, contractility and tonicity are described. Finally, the electrical conduction within the myocardial cell is presented.

The second chapter, entitled *„Electrocardiography in dog"* extends over three subchapters and comprises the basic mechanism of the electrocardiographic recording, the technique, reading and interpretation. Finally, the most common arrhythmias in dogs are described. The first chapter entitled *„Basics of electrocardiography"* begins with a short history of the veterinary cardiology and electrocardiography and then continues with basic electrophysiology describing concepts such as electrical field, mechanism of cardiac depolarisation and the dipole theory.

The second subchapter entitled *„Electrocardiographic examination in dog"* presents the technique of classic and ambulatory (Holter) electrocardiography, this chapter being dedicated for explaining the process from the cardiac electrical activity to the electrocardiographic paper. Thereby, the derivation leads, practical technique, measurements of the electrocardiographic tracing, rhythm and heart rate determination are explained. Finally, the correlation between each electrocardiographic sector and structural and pathological changes of the heart are described. Also, within this chapter, the morphological changes of the waves, segments and intervals are discussed from the clinical point of view. The specific aspects of the electrocardiographic tracing in dilatation, hypertrophy, hypoxia, ischemia, electrolyte disturbances and specific patterns during respiratory and pericardial diseases are described.

The third subchapter, entitled *„Arrhythmias in dog"* describe, on the basis of a classification proposed by *Santilli and Perego, 2014*, the most common arrhythmias in dogs. These arrhythmias are summarized in one table and classified by heart rate in tachyarrhythmias and bradyarrhythmias, by localisation in supraventricular and ventricular arrhythmias, and by frequency in beats and ectopic rhythms. Subsequently, the rhythm changes are described by electrophysiological mechanism, correlated with pathologies and finally electrocardiographic characterisation is presented.

The second part of the thesis, entitled *„Personal research"* extends over four chapters comprising the results and discussions of the research performed during four years.

The third chapter represents the main aim of the thesis, followed by the personal objectives proposed for the research. At the end, the research activities performed for achieving the objectives proposed are presented.

The fourth chapter, entitled *„Material and methods"* begins by describing the two institutions where the research was performed: Faculty of Veterinary Medicine from Iași and the Department of Veterinary Medicine from Naples, Italy. Furthermore, the biological material represented by the group of dogs taken into study is described and the inclusion

criterias are presented. Then, the methods used for the diagnostic, such as physical examination, imaging and electrocardiographic methods and blood tests used are described. The fourth chapter closes with the description of the statystical analyses used for the data interpretation.

The fifth chapter, entitled *„Results and discussions"* is the largest chapter extended over four subchapters, each representing a study characterizing the electrocardiography of different cardiac diseases. From a didactic point of view, the patients were distributed according to anatomical localisation of the lesion in: patients with endocardial diseases, patients with myocardial diseases, patients with pericardial diseases and patients with nodal tract disorders. Each category represents a stand-alone study structured acording to the proposed guidelines in introduction, material and methods, results, discussions and conclusions.

Subchapter 5.1 entitled *„Endocardial diseases in dogs"* presents the results of the cardiac diseases developed by endocardial changes. Due to the fact that 96% of the dogs were diagnosed with chronic valvular disease, the electrocardiographic characterisation was based on this particular disease. This study included 26 dogs, 25 being diagnosed with chronic valvular disease. The diagnostic protocol included history, physical and special examinations such as echocardiography, X-ray and electrocardiography. In the results section we present and describe the symptoms related to mitral valve disease, vertebral heart scale values, the electrocardiographic and echocardiographic measurements and summarize the most common arrhythmias and morphological changes of the electrocardiographic tracing. Heart rate had large ranges, but the group mean was within normal ranges and the rhythm was sinusal in all patients. Rhythm analysis showed sinus tachycardia in 32,1%, followed by sinusal arrest in 7,7% of the dogs, but also ventricular rhythm and 2^{nd} degree atrio-ventricular block were infrequently diagnosed. Morphological analysis of the ECG tracing showed signs consistent with myocardial ischemia, left cardiomegaly and left atrial dilatation. Furthermore, the results were tested for correlations with various physical, radiographic and echocardiographic changes. Subsequently, the results are discussed and explained, being in the same time compared with the literature. Within the discussion section we included decision tree graphics to highlight the most important measurements and to ease the diagnostic protocol. The subchapter finishes with a series of conclusions.

Subchapter 5.2 entitled *„Myocardial diseases in dogs"* present the results of the cardiac diseases developed by myocardial changes. Out of 17 patients, 13 dogs, representing 76,5% were diagnosed with dilated cardiomyopathy. For this reason, the electrocardiographic

characterisation was based on this particular disease. The diagnostic protocol included history, physical and special examinations such as echocardiography, X-ray, electrocardiography, complete cell blood count and biochemical analyses. Within the result section we present the frequency of the clinical signs, vertebral heart scale values, echocardiographic and ECG measurements. Heart rate showed wide ranges and the group mean value over the upper normal limit. This measurement showed a strong negative correlation with the RR interval only. The sinusal rhythm was diagnosed in 50% of the dogs, while the rest of the patients had a non-sinusal rhythm represented mainly by atrial fibrillation. Also, atrial flutter, jonctional rhythm, ventricular tachycardia and ventricular premature complexes were diagnosed. The analysis of the ECG tracing showed an augmentation of the P-wave and QRS duration, over the normal reference ranges. The ECG tracing measurements were tested for correlations with different physical, radiographic, echocardiographic and blood tests results. The morphologic changes of the ECG tracing were consistent with myocardial hypoxia, left cardiomegaly and more uncommon for myocardial ischemia. At the end of this section, a study regarding the electrocardiographic changes that influence the survival time on dogs with dilated cardiomyopathy was performed. The analysis showed that only higher heart rate had a negative influence on the survival time. Subsequently, the results are discussed and explained, being in the same time compared with the literature. Within the discussion section we included decision tree graphics to highlight the most important measurements and to ease the diagnostic protocol. The subchapter finishes with a series of conclusions.

Subchapter 5.3 entitled *„Pericardial diseases in dogs"* present the results of the cardiac diseases developed by pericardial changes. Eight dogs were included in this group, seven diagnosed with neoplastic and non-neoplastic pericardial effusion and one dog with pericardial defect and right atrial herniation. The diagnostic was based on the same protocol, the echocardiographic examination being the most important tool for detecting the pericardial fluid. Also, pericardiocenthesis was used for treatment and cytological diagnostic. In the results section we present the symptoms of the patients with pericardial disease, radiologic, echocardiographic and ECG tracing measurements. The electrocardiographic tracing was examined for detecting the rhythm and morphological changes. Heart rate showed the highest values of all groups, with the mean over the normal reference ranges. Fifty percent of the patients were diagnosed with sinus tachycardia. Sinus rhythm was present in all patients diagnosed with pericardial effusion, while one patient with pericardial defect and right atrial herniation had a supraventricular rhythm represented by atrial flutter. The morphology of the

ECG tracing showed low voltage of the waves, and the T wave greater than ¼ of the R wave amplitude. Changes of the tracing were consistent with myocardial hypoxia, hipovoltage and electrical alternance. Furthermore, the results were discussed and compared with the literature findings. Also, in the discussion section, decision tree graphics were included to highlight the most important measurements and to ease the diagnostic protocol. This subchapter is finished with a series of conclusions.

Subchapter 5.4 entitled *„Electrocardiographic results in canine heart diseases"*describe the rhythm and morphological disturbances diagnosed in all dogs subjected to electrocardiographic examination. Also, in this subchapter, there are performed a series of comparrisons between ECG tracing among groups with different cardiac diseases. The result section is focused on summarizing the rhythm disturbances in all dogs examined during the doctoral period. Heart rate is analyzed among groups distributed by gender, breed and heart disease. The main rhythm was sinusal in 92% of the patients and in 8% was non-sinusal, represented mostly by atrial fibrillation and more infrequent by atrial flutter, jonctional rhythm, ventricular tachycardia and premature complexes and atrio-ventricular dissociation. Hereinafter the arrhythmias diagnosed were described and discussed. The results section continues with the analysis of each electrocardiographic measurement comparing the results among groups distributed by gender, breed and cardiac pathology, results carrdied by graphics and tables. This section is continued by summarizing the morphological diagnostic of the ECG tracing. Furthermore, the results are discussed and compared with the literarure, including also decision tree graphics. This subchapter ends with a series of conclusions.

The sixth chapter, entitled *„Study on electrocardiography in Bucovina Shepherd dogs"* was aimed on proposing radiological, echocardiographic and electrocardiographic reference ranges in this breed. Twenty client-owned Bucovina Shepherd dogs were included in the study. All dogs were free cardiac disease. History and physical examination were performed in all dogs to exclude any signs of heart disease. For the cardiologic measurements, the dogs were subjected to thoracic X-ray, echocardiography and electrocardiography. The result section present the obtained values expressed by minimum, maximum, mean±standard deviation. The group values distributions were pointed out through box-plot graphics. The chapter continues with the discussion of the results and comparrison with different breed proposed values. The sixth chapter ends with the most important conclusions of the study.

The seventh chapter, entitled *„General discussions"* brings a debate of the results obtained in the previous chapters, highlightening the electrocardiographic differences among

cardiac pathologies, comparing, in the same time with the results stated by other researchers. In this section, graphics and tables are included to facilitate the interpretation of the ECG tracing and to mark out the differences between heart diseases. Within this chapter, authors performed a comparative discussion regarding the results obtained due to cardiac examination in two teaching hospitals: the Faculty of Veterinary Medicine of Iași and the Department of Veterinary Medicine from Naples, Italy. This discussion is closed with a series of conclusions, observing some demographic and social differences regarding the importance of small animal cardiology and some similarities regarding the diagnostic approach and the obtained results. Chapter VIII ends the thesis with a series of final conclusions and recommendations regarding the results obtaind from the performed studies and the originality of the research are presented.

The thesis finishes with the reference list (220 titles from national and international literature) used during the research period.