

Radiographic cardiopulmonary changes in dogs with heartworm disease

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NICULAE TUDOR, LUCIAN IONITA, DANA TAPALOAGA, POLIANA TUDOR, CARMEN IONITA, CONSTANTIN VLAGIOIU

*USAMV Bucharest – Faculty of Veterinary Medicine
Splaiul Independentei 105, sector 5; 050097, Bucharest, Romania
nghudor@yahoo.com*

Abstract

*Canine dirofilariasis or heartworm disease caused by *Dirofilaria immitis* is a serious animal life threatening disease. Adult worms live in the lung arteries and right heart, causing cardiovascular and pulmonary parenchyma changes. The aim of this study was the radiographic evaluation of the dogs' thorax naturally infected with *D. immitis* in southern Romania. Medical records of 83 dogs (45 males and 38 females), diagnosed positive for *D. immitis* with thorax radiographs have been reviewed. Fifty-six (67.47%) were pure breeds and 27 (32.53%) mongrels, aged between 2 and 16 years (7.51 years average). Sixty-two dogs (74.70%) presented cardiopulmonary radiographic changes and 21 dogs (25.30%) were without radiographic signs. Sixty dogs (72.29%) had vascular radiographic changes, 51 dogs (61.44%) had pulmonary parenchymal changes, 39 dogs (46.99%) had changes in heart shape and silhouette, and 2 dogs (2.41%) had pleural effusions. On lateral radiographs, the average VHS rate on the evaluated dogs was higher than the reference. The obtained results suggest that thoracic radiography represents a useful tool in assessing the presence and severity of cardiopulmonary changes in dogs infected with *D. immitis*.*

Keywords: dogs, heartworm disease, thoracic radiography

1. Introduction

Cardiopulmonary dirofilariasis usually called heartworm disease is a parasitic disease caused by *Dirofilaria immitis* species, affecting domestic and wild canines and felines and also human population. (J.A. MONTOYA & al. [1]). The parasite is widely distributed throughout the world, particularly in tropical, subtropical and temperate regions. In Romania, previous studies have reported the presence of the parasite *D. immitis* in dogs in almost all areas of the country, GH. CUCU and V. FOCSĂNEANU [2] have shown the existence of the parasite in the east side of the country (Tulcea county), P. TUDOR & al. [3] in the south (Bucharest and surrounding areas), R. CIOCAN & al. [4] in the west side (Timis county), D. ACATRINEI & al. [5] in north-east (Iasi county), V. MIRCEAN & al. [6], in the center of the country.

Heartworm infection is a severe disease endangering the life of the host (dog), due to the presence of adult worms in the pulmonary arteries and right heart ventricle, also due to the presence of circulating microfilariae (G. GRANDI & al. [7]). Although its name suggests a primary cardiac involvement, the main location of the first alterations and worms presence are pulmonary arteries, which causes the subsequent development of pulmonary and cardiac pathology. The disease evolution is usually chronic, with a varied clinical picture, in which the signs of the disease appear gradually (L. VENCO [8]). Without being considered an effective screening test, thoracic radiography is an important method for the diagnosis of cardiopulmonary disease, offering the possibility of establishing the severity of the disease and assessing cardiovascular and lung parenchyma changes [C. ATKINS [9]]. The aim of this

study was to evaluate the cardiopulmonary radiographic status of dogs naturally infected with *D. immitis*.

2. Material and methods

A retrospective study of the radiographic images in the cases of canine heartworm disease has been carried out in order to investigate the cardiopulmonary changes. For this, the medical records from the Clinic of Faculty of Veterinary Medicine Bucharest were reviewed for dogs positive for *D. immitis* who had thoracic radiographs performed using a digital radiography system (Philips Optimus) between January 2012 and January 2014.

A complete record was kept for each animal, including identification (breed, age, gender) and their origin (indoor/outdoor). Dogs were of various ages (range 2-16 years) and breeds: Mongrels (n=27), German shepherd (n=15), German Shorthaired Pointer (n=9), Rottweiler (n=7), Doberman (n=8), Boxer (n=6), American Pit Bull Terrier (n=5), Labrador Retriever (n=5), and Cocker Spaniel (n=1). The history revealed that 65 dogs were working dogs and kept outdoors and 18 were pets, but they were held both indoors and outdoors.

Radiographic examination included, in each case, the standard diagnostic procedure (lateral and dorsoventral/ventrodorsal thoracic radiographs). Radiographs were obtained in full inspiration as possible and at a distance from the source to the image of 100 cm. Thoracic radiographs were evaluated mainly for size and shape of the heart, pulmonary vascular and parenchymal changes, and the presence of pleural effusion. Evaluation of heart size (except with pleural effusions) was performed on a thoracic radiograph obtained from incidence of right side using the Vertebral Heart Score (VHS) method developed by J. BUCHANAN & J. BÜCHELER [10]. To obtain long axis and short axis dimensions of the heart, electronic calipers were used. Appearance of pulmonary vessels was assessed by comparing the diameter of the right cranial lobe and caudal artery with 4th rib width (in the proximal third) respectively with 9th rib (where the artery is superimposed on the rib), from the lateral right incidence and respectively ventrodorsal, as previously described (R. BAHR [11]). Parenchymal changes were classified as alveolar, interstitial or mixed pattern.

There was made a statistical analysis in MS Excel using metric measurements, the data being expressed as mean \pm SD. The Student's t-test was also used for the statistical analysis requiring group comparisons, the statistical significance set at $p < 0.05$.

3. Results

Of the 83 dogs enrolled, 45 (54.22%) were males and 38 (45.78%) were females. Fifty-six (67.47%) were pure breeds and 27 (32.53%) were mongrels, 81.93% were kept outdoors and 18.07% were kept both outdoors and indoors. Age of dogs ranged from 2 to 16 years with an average of 7.51 years (7.59 years for males and 7.47 years for females). Of these, 34 (40.97%) were 2-6 years, 49 (59.04%) were over 6 years.

Radiographic examination of the thorax revealed various combinations of cardiopulmonary abnormalities in 62 dogs (74.70 %) and 21 dogs (25.30%) were without radiographic signs. Two of the dogs with thoracic radiographic changes (2.41%) had pleural effusions, making impossible to accurately assess the heart, pulmonary vessels and lung parenchyma. Sixty dogs (72.29%) presented radiographic changes compatible with dog heartworm disease, represented by the widening arteries of lung lobes with tortuous appearance (Fig. 1) and dilatation of the main pulmonary artery.

Changes in the lung parenchyma were observed in 51 dogs (61.44%). These changes were complex and varied in severity, represented by interstitial infiltration, with focal or multifocal appearance in 44 cases and mixed pattern (alveolar and interstitial) in 7 cases.

Changes in the size and shape of the heart silhouette were observed in 39 dogs (46.99%), the enlargement of the right ventricle being found (Fig. 2). Average VHS on the evaluated dogs (n=81) was 10.59 ± 0.88 (mean \pm SD) vertebrae (v) the scope of the right side, being significantly higher than the reference values (9.7 ± 0.5 v [mean \pm SD], n = 100). The data from all heart measurements and reference values are presented in Table 1.



Figure 1. Left lateral thoracic radiograph of a dog with heartworm disease. It emphasizes the enlargement of the right cranial pulmonary artery comparative with vein.



Figure 2. Ventrodorsal thoracic radiograph of dog with heartworm disease. The “D reverse” classical shape of the cardiac silhouette indicates the enlargement of the right heart is noticed.

Table 1. Heart measurements in dogs with heartworm disease from lateral view

Breed	No. of animals	VHS of heartworm infected group (Average \pm SD vertebrae)	Reference value (Average \pm SD vertebrae)	Reference
Mongrels	25	10.34 ± 0.82 v	9.5 ± 0.43 v	AL.G. NEAGU et al. [23]
German Shepherd	15	10.34 ± 0.85 v	9.7 ± 0.7 v	C.R. LAMB et al. [22]
German Shorthaired Pointer	9	11.0 ± 1.02 v	10.56 ± 0.69 v	N. TUDOR - unpublished data
Doberman	8	10.22 ± 0.76 v	10.0 ± 0.6 v	C.R. LAMB et al. [22]
Rottweiler	7	10.55 ± 0.59 v	9.8 ± 0.1 v	L. MARIN et al. [24]
Boxer	6	11.45 ± 0.65 v	11.6 ± 0.8 v	C.R. LAMB et al. [22]
Labrador	5	10.92 ± 0.68 v	10.8 ± 0.6 v	C.R. LAMB et al. [22]
American pit bull terrier	5	11.18 ± 0.45 v	10.9 ± 0.4 v	M.J.L. CARDOSO et al. [25]
Cocker Spaniel	1	10.90 v	11.05	PINTO et al. [26]
Total	81	10.59 ± 0.87 v	9.7 ± 0.5 v	J. BUCHANAN and J. BÜCHELER [10]

4. Discussions

Analysis results reveal the presence of infestations in pure breed and mongrels dogs, but predominantly in the first category, without a breed predisposition, but rather correlate with their use (security, defense, hunting, etc.). Because most dogs (81.93%) were kept exclusively outside, risk of exposure to vectors was greater than of the others, and these eventually had access outside, sometimes being moved with owners trips to endangered areas (lakes, forests). Regarding the age of the animals, the highest percentage was recorded in animals aged >6

years. This can be explained by the fact that age is an important risk factor in the disease, older animals having a longer period of exposure to mosquito bites and more likely to develop the disease (M.E. BOLIO-GONZALEZ & al. [12]).

Heartworm disease is a severe cardiovascular disease and it's characterized by several different clinical signs (G. GRANDI & al. [7]), severity of the disease is mainly determined by the number of adult worms present, the immune response of the host during infection and the intensity of the dog activity (dog exercise levels) (D.D. BOWMAN & C. ATKINS [13]). Life cycle of the nematode *D. immitis* is quite long (6-7 months), and the clinical course of heartworm disease in dogs is commonly chronic so that some infected dogs do not show any symptoms of the disease for months or even years (L. VENCO [8]), the signs gradually developing. Our results indicated the existence of a diverse array of thorax images in dogs with heartworm disease, in correlation with previous studies (Z.S. POLIZOPOULOU & al. [14]). Although all the dogs were diagnosed positive for *D. immitis*, 25.30% of them showed no cardiopulmonary radiographic changes in the assessment. This may be due to either to a recent infestation or to the presence of a small number of worms or a sedentary life, issues that may delay the onset of cardiopulmonary changes. According to a study of 200 dogs with heartworm disease, J.M. LOSONSKI & al. [15] identified that only 14% of the dogs had no cardiopulmonary changes, differences could be attributed to the intervention of various abiotic factors (habitat) and biotic (dog type population, host-parasite relationship, lifestyle) involved in the installation and development of the disease.

Vascular changes were found in 72.29% of dogs evaluated by us, representing the largest percent of cardiopulmonary changes. This is due to the biological cycle that follows the parasite during its development in the body host. Thus, after infestation, larvae that reached the body host (dog) started to molt and migrate, moving to the pulmonary arteries, particularly in the caudal pulmonary arteries (L. VENCO [8]). At this level, preadults worms begin to grow rapidly, increasing in size and develop into adults, and as a result of mechanical and toxic aggression, they produce significant damage to the pulmonary artery wall and tighten the vessels (endarteritis) and elasticity alteration (F. SIMÓN & al. [16]). As the disease progresses, the pulmonary arteries are enlarged and tortuous with thickened walls (R.J. BAHR [11]). In the cases examined, we observed typical aspects of the heartworm disease in the pulmonary artery (C.A. RAWLINGS & al. [17]; C.A. CALVERT & al. [18]), with various degrees of severity depending on the stage of the infection. Incidence of side lobe cranial artery enlargement was found as while the incidence of DV showed tortuous appearance and enlarged diameter of the artery as the caudal lobe. Also, the incidence of VD radiographic images reveal the origin of the main pulmonary artery, these changes occur consecutively to the migration of adult worms in the main pulmonary artery (L. VENCO [8]).

Over time, the pathologic process can progress, and vascular changes involve alterations of lung parenchyma. According to previous studies (C.A. CALVERT & C.A. RAWLINGS [18]), pulmonary arteries impairing, characterized by an increased permeability of blood vessel walls, allows the extravasation (leakage) of fluid and proteins from the bloodstream resulting in perivascular edema and inflammation of the lung parenchyma. Also, the presence of microfilariae contributes to the pathogenesis of parasitic pneumonia (G. GRANDI & al. [7]). In the present study, 61.44% of infected dogs showed changes in lung parenchyma, varying in scope and design, and with vascular changes led to a radiographic image that was characteristic to heartworm disease. In the evaluation of thoracic radiographs, it was found the presence of interstitial infiltrate and perivascular and parenchymal density increase localized focal or multifocal, the appearance of the parenchymal pattern being mild, moderate or severe depending on the stage of the disease. The presence of interstitial or mixed lung pattern falls

within the typical heartworm disease changes, reported in previous studies (D.E. THRALL & al. 1980 [19]).

As it is known, heartworm disease term is misnomer as adult worms live in the pulmonary arteries (where they produce the first changes) and only in later stages of disease [L. VENCO [8]) or when large numbers of them (D. BOWMAN & C. ATKINS [13]) migrate to the right heart, resulting in cardiac changes. In this study, cardiac changes were detected in 46.99% of the evaluated dogs, while J.M. LOSONSKY & al. [15] and Z.S. POLIZOPOULOU & al. [14] identified the enlargement of the right ventricle in 60%, respectively 41.76% of the dogs with heartworm disease. The alteration of heart shape and size has different aspects, perhaps due to the load of parasitic infestation duration and intensity of effort consecutive to pulmonary hypertension, created by the presence of adult worms in the pulmonary arteries (A.R. DILLON & al. [20]).

While changing the size and shape of the heart has not occurred in all dogs examined by us, measurement of heart by VHS method showed an average value of $10.59 \pm 0.87v$, a slight increased value than the average reference (J. BUCHANAN & J. BÜCHELER [10]). Our results were consistent with those previously reported by A. LITSTER & al. [21], after the evaluation of 25 different breeds of dogs infected with *D. immitis*.

To avoid obtaining erroneous results, evaluating a patient cardiac silhouette should be made by comparing the images obtained from normal individuals of the same breed (C.R. LAMB & al. [22]) because VHS values may be affected by some factors such as interracial (interbreeds) differences or sex, C.R. LAMB & al. [22] finding values of VHS greater in males compared to females. Thus, analyzing the results presented in Table 1, discussing each breed separately, there were found elevated VHS average values on 7 of the 9 breeds examined compared with breed-specific reference average values. The largest group was represented by mongrels (n=27), the average value VHS was $10.34 \pm 0.82v$ (n=25), being higher than the reference average value of $9.5 \pm 0.43 v$ (AL.G. NEAGU & al. [23]).

German Shepherd was the second breed as weight (n=15), with an average value VHS of $10.34 \pm 0.85v$, is higher than the breed average reference ($9.7 \pm 0.7v$) (CR LAMB & al. [22]), similar results were recorded also for Rottweiler breed ($10.55 \pm 0.59v$ versus $9.8 \pm 0.1v$) (L. MARIN & al. [24]), German Shorthaired Pointer ($11.0 \pm 1.02v$ versus $10.56 \pm 0.69v$) (N. TUDOR unpublished data), and the American Pit Bull Terrier ($11.18 \pm 0.45v$ versus $10.9 \pm 0.4v$) (MJL CARDOSO & al. [25]). A slightly moderate VHS value, higher than the breed reference mean was registered at Doberman and Labrador (Table 1). Boxer breed average value obtained was smaller than the average reference, but all the values obtained were within normal limits established previously (CR LAMB & al. [22]). Cocker Spaniel breed was represented by a single specimen, and the radiographic image did not revealed any changes in the cardiac silhouette. The differences in the values obtained for each breed separately and the mean of the entire group of animals, suggested the necessity of using average values of VHS breed-specific in the process of heart size evaluation, idea suggested also by C.R. LAMB & al [22]. Practical usefulness of the VHS method for heart size measurements offers the possibility to discover and evaluate some heart diseases progression, such as heartworm disease.

Two of the 83 cases presented pleural effusion that made impossible to assess heart and lung parenchyma. According to previous studies, pleural effusion is uncommon in dogs with heartworm disease, being the result of development of congestive right heart failure (F. SIMÓN & al [16]) and less the result of pulmonary eosinophilic granulomatosis associated with bronchial lymphadenopathy (D. BOWMAN & C. ATKINS [13]).

5. Conclusions

The results of this study revealed a varied picture of thorax imaging in dogs naturally infected with *D. immitis*, represented by changes of pulmonary artery, pulmonary parenchyma, shape and size of the heart in different proportions. Vascular changes dominated the lesion picture, followed by parenchymal changes, lesion severity being correlated with the evolution of the disease process. Measurement of cardiac dimensions showed a higher mean value of VHS infected dogs than the normal average. Thorax radiography represents an useful tool in assessing disease severity in dogs with heartworm disease.

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