10.4322/rbcv.2020.023

Determination of the value of vertebral heart size regarding the weight and body area in canines*

Determinação dos valores do vertebral heart size em relação ao peso e área corporal canina

Juliana Dall'Antonia Garbelini,** Julia Pompeo Rocha,** Jessica Aparecida Colombo,** Daniel De Bortoli Teixeira,*** Milena Friolani,**** Rodrigo Prevedello Franco*****

Abstract

The vertebral heart size is a method used to measure the cardiac dimension in order to identify the remodeling of the chambres in heart disease. This study aims to determinate the vertebral heart size values at right lateral and ventrodorsal radiographs views relating to canines weight and body area variations. For the purpose of the study 40 healthy dogs within the age of 1 to 6 years, males and females, with deep or intermediated thorax were selected, brachycephalic dogs were not included in the study; the dogs were separated in four groups: group 1(n=9) compound of dogs up to 5 kg; group 2 (n=8) with dogs from 5,1 to 10 kg; group 3 (n=12) with dogs from 10,1 to19 kg and group 4 (n=11) with dogs weighing more than 19,1 kg. The values of body score, body mass index and the thorax configuration where previously measured, as well as the vertebral heart size and the depth width ratio from the radiographs. The results demonstrated intervals of right lateral-lateral vertebral heart size 9.9 to 10.4v and ventro-dorsal vertebral heart size of 9.8-10.3v. The study results show that the vertebral heart size numbers did not correlate with weight or body area, regardless the type of radiography view. Therefore, it can be concluded that the vertebral heart size in right lateral and ventrodorsal radiography can be used to rate the cardiac area, not suffering influence by the dog's weight or body area.

keywords: cardiomegaly, radiography, body weight, dog.

Resumo

O *vertebral heart size* é um método utilizado para mensurar a dimensão cardíaca visando identificar os remodelamentos das câmaras nas cardiopatias. O objetivo do estudo foi determinar os valores de *vertebral heart size* nas projeções radiográficas latero-lateral direita e ventro-dorsal conforme as variações do peso e área corporal. Para isso, foram selecionados 40 cães hígidos com idade entre 1 e 6 anos, machos e fêmeas, com padrão torácico intermediário e profundo, com exclusão dos braquicefálicos; os cães foram divididos em quatro grupos: grupo 1 (n=9) composto por cães de até 5 kg; grupo 2 (n=8) com cães de 5,1 a 10 kg; grupo 3 (n=12) com cães de 10,1 a 19 kg e grupo 4 (n=11) com cães acima de 19,1 kg. Os valores de escore corporal, índice de massa corporal e conformação torácica foram previamente mensurados, bem como os valores dos *vertebral heart size* a relação profundidade/largura torácica das radiografias. Os resultados demonstraram intervalos de *vertebral heart size* latero-lateral 9.9 a 10.4v e *vertebral heart size* ventro dorsal de 9.8-10.3v. Os valores não apresentaram correlação com o peso e área corporal nos grupos estudados, independente das projeções estudas. Assim, pode-se concluir que método *vertebral heart size* nas projeções estudadas é aplicável na avaliação da área cardíaca, não sofrendo influências do peso e área corporal canina.

Palavras-chave: cardiomegalia, radiografia, peso corporal, cão.

Introduction

Cardiovascular evaluation is primordial in the diagnosis of canine heart diseases (THRALL, 2014). Currently the search for new diagnostic methods that could precociously identify heart deseases has lead to the implementation of digital radiography, computed tomography and magnetic resonance imaging in the routine of pets. Alves *et al.* (2015) reported that, despite the improvement in the resolution of the images, computed tomography and magnetic resonance imaging present reduced availability due to the complexity of the installation and execution of the exam, radiation and high costs. Therefore, digital radiography is still the most used method for assessing cardiac chambers and their remodeling, pulmonary parenchyma and vascular abnormalities (WOOLLEY *et al.*, 2007; BAHR, 2014). However, the radiographic examination is not accurate in the

*Recebido em 8 de agosto de 2020 e aceito em 21 de setembro de 2020.

**Student of Veterinary Medicine at Universidade de Marília – UNIMAR. Ave. Higino Muzi Filho, 1001, Marília, SP 17525-902, Brasil. E-mail: juliarocha.pompeo@gmail.com; jessica.colombo384@gmail.com; + Corresponding author, E-mail: juliana.garbelini@hotmail.com.

***Course Professor of Veterinary Medicine at Universidade de Marilia – UNIMAR. Agronomist, DSc, Center of Agrarian Sciences, UNIMAR, Ave. Higino Muzi Filho, 1001, Marília, SP 17525-902, Brasil.

****Course Professor of Veterinary Medicine at Universidade de Marilia – UNIMAR. Veterinarian, DSc, Center of Agrarian Sciences, UNIMAR, Ave. Higino Muzi Filho, 1001, Marília, SP 17525-902, Brasil.

*****Course Professor of Veterinary Medicine at Universidade de Marilia – UNIMAR. Veterinarian, DSc, Center of Agrarian Sciences, UNIMAR, Ave. Higino Muzi Filho, 1001, Marília, SP 17525-902, Brasil.

evaluation of cardiovascular morphology, since the cardiac area is three-dimensional and the radiographic position can modify the formation of the image (LAMB *et al*., 2000).

In 1995, Buchanan and Bücheler described the quantitative method of measuring the heart in radiographs, the *vertebral heart size*, using a vertebral unit system comparing the cardiac dimensions with the length of the thoracic vertebrae, therefore reducing the difficulty in observing cardiomegaly. An action that allowed to identify and evaluate the evolution of cardiac diseases earlier, as well as to follow the results of treatments performed, consequently maximizing the accuracy of the radiographic diagnosis. An advantage of the method was the determination of distinct points that enable to measure cardiomegaly in an objective way (HANSSON, 2005; GLANBER *et al*., 2005) and to follow the remodeling after the instituted therapy (BUCHANAN & BÜCHELER, 1995; SOARES *et al*., 2004; CASTRO *et al*., 2011; BIRKS *et al*., 2017). However, studies reveal the need to consider other factors such as breed, hemithorax, radiographic projection, chest conformation, phases of the respiratory and cardiac cycles, variations in the measurement axes, interpretation and overlapping ribs (BUCHANAN & BÜCHELER, 1995; SPASOJEVIĆ *et al*., 2007; GHADIRI *et al*., 2010).

Regarding the diversity of breed sizes, Ghadiri *et al*. (2010) found differences in the vertebral heart size values of right lateral-lateral and left lateral-lateral radiographs in dogs native from Iran. For all dogs proposed by Buchanan e Bücheler (1995) the limit value of the vertebral heart size is ≤10.5v, however Lamb *et al*. (2001) determined values of 10v for the breed Dobermann, 10.8v for Labrador Retriever, 11.6v for Boxer and 10.6v for Cavalier King Charles Spaniel. For the breed Yorkshire Terrier, Lamb *et al*. (2001) and Castro *et al*. (2011) obtained vertebral heart size values higher than the proposed reference; with the exception in the dorsoventral projection in relation to the body weight of the studied dogs. Birks *et al*. (2017) found no significant differences between body score and conformation of the chest in the studied dogs. However, aiming at the applicability of the method studied , Woolley *et al*. (2007) sought to determine the values of vertebral heart size and its monthly increase (Δ vertebral heart size unity / month) to perform the previous diagnosis of congestive heart failure in 94 dogs of the breed Cavalier King Charles Spaniel with degenerative mitral valve disease, demonstrated that the values increase progressively as the congestive heart failure advances. Thus, due to the variations in body weights and scores of the different dog breeds, the aim of the present study is to determine the vertebral heart size values according to the variations in body weight, with subsequent indexing of the values in the canine body area.

Material and method

The project was analyzed by the ethics committee on animal use, in addition to the consent of the tutors to perform the exams and use the results. For this, 40 adult dogs, male and female, regardless of racial size, aged one to six years old, were selected from outpatient clinics at the Veterinary Hospital for Small Animals, and their weight and body score were determined using the Laflamme scale (1997), body mass index as proposed by Muller (2008) and body area determined by the formula described by Rosenthal (1995).

The dogs underwent several clinical evaluation, such as measurement of systolic blood pressure using the doppler method. And complementary tests: complete blood cell count, serum biochemistry of renal function - urea and creatinine; and liver function - aspartate transaminase and alkaline phosphatase (THRALL, 2007). In addition, electrocardiography was performed in order to rule out the presence of cardiac, respiratory, infectious, hemodynamic changes and arrhythmias. The selected dogs had a deep or intermediate pattern chest (BUCHANAN & BÜCHELER, 1995), not being included in the evaluations and in the present study, dogs of the brachycephalic breeds with barrel-shaped chest, with cardiac, respiratory, infectious and hemodynamic conditions that could interfere with cardiovascular function. After the clinical evaluations, the dogs were subdivided into groups according to body weight, as described below:

- G1 = dogs weighing up to 5 kg (n = 9);
- G2 = dogs weighing from 5.1 to 10 kg (n = 8);
- G3 = dogs weighing 10.1 to 19 kg (n = 12)
- G4 = dogs weighing more than 20 kg (n = 11).

For the characterization of the chest conformation in deep or intermediate, as well as the calculation of the vertebral heart size, the methodology used was proposed by Buchanan and Bücheler (1995) and applied to radiographs obtained in conventional X-ray equipment (for veterinary use) A7602224, Toshiba / KXO-15R, 640 mA 150 KPV, belonging to the Diagnostic Imaging Sector of the university's Veterinary Hospital. The animals were manipulated and physically restrained with the help and consent of their guardians, being positioned in the right lateral decubitus position to perform the right lateral-lateral projection and dorsal decubitus for ventro-dorsal projection, thus generating two images to be evaluated; sedative or anesthetic drugs were not used to contain the selected dogs. The images obtained were analyzed for quality and a caliper and a ruler were used to determine the measurements. Subsequently, the images were evaluated by experienced veterinarians in the field of cardiology and radiology.

For the classification of the deep chest, the right lateral-lateral radiographic projections were used, marking the distance between the cranial margins of the xiphoid process and the ventral margin of the spine, which was defined by a line perpendicular to the spine in the ventro-dorsal projection, from the distance between the medial margins of the eighth rib, with its lateral curvatures, respectively, as shown in figure 1. They were classified as deep standard thorax, when the ratio between the depth and the width of the thorax is greater than or equal to 1.25. For the long chest, the value was less than or equal to 0.75 and for the intermediate chest, between 0.75 and 1.25. The dogs that presented a long chest (≤ 0.75) considered by Jepsen-Grant et al. (2012) as a chest in a barrel, were excluded from the selection because most of them belong to brachiocephalic breeds and present anatomical changes, as well as respiratory conditions that lead to cardiac remodeling.

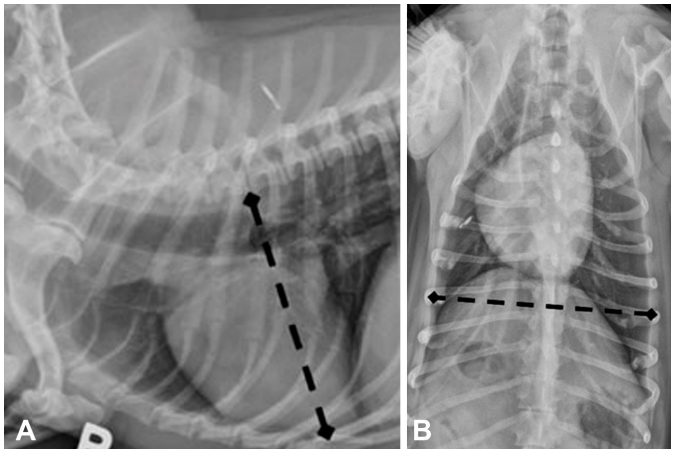

Figure 1: A) Thoracic depth measurement, measurement of the xiphoid process perpendicular to the spine. Source: adapted from Jepsen-Grant et al. (2012). B) Measurement of the width of the chest, measured from the inside of the eighth ribs. Source: adapted Jepsen-Grant et al. (2012).

To calculate the vertebral heart size, the right lateral-lateral projection was analyzed, with the long cardiac axis starting at the ventral edge of the tracheal carina (under the left main bronchus) and ending at the most distal ventral point of the cardiac apex. The measurement of the short cardiac axis represents the central cardiac third, perpendicular to the long cardiac axis. The values obtained in centimeters were converted into a vertebral unit, with an approximation of 0.1 vertebra, when repositioned on the thoracic spine, starting at the cranial margin of the fourth thoracic vertebra. The sum of the values of the axes in thoracic unit corresponds to the value of the vertebral heart size of each canine. In the ventro-dorsal projections, the vertebral heart size was obtained by determining the long cardiac axis and short cardiac axis with a caliper and ruler in a similar way to the latero-lateral, with the measurement of the vertebrae also obtained in the projections, starting in the same way at the cranial margin. of the fourth thoracic vertebra, as shown in figure 2 (BUCHANAN & BÜCHELER, 1995; BIRKS *et al.*, 2017).

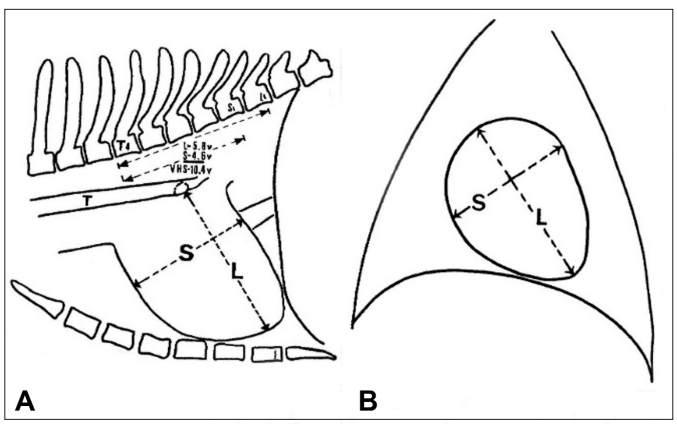

Figure 2: A) Side view diagram of a dog's chest illustrating the method of measuring the size of the vertebral heart. The dimensions of the long axis (L) and the short axis (S) of the heart are transposed to the spine and recorded as the number of vertebrae. Source: Buchanan and Bücheler (1995). B) Dorsoventral diagram illustrating the dimensions of the short (S) and long (L) axis of the heart that were measured on ventrodorsal and dorsoventral radiographs. Source: adapted from Buchanan and Bücheler (1995).

The values of vertebral heart size adopted as normal for the canine species are 9.7 ± 0.5v in direct lateral-lateral projection and 10.2 ± 0.8v in ventro-dorsal projection, with the value of ≤10.5v as the upper limit in most cases. breeds, with exceptions for dogs with a short chest that may have a normal 11v vertebral heart size (BUCHANAN & BÜCHELER, 1995).

The tabulated data underwent statistical analysis in order to verify the presence of differences in the values of the vertebral heart size between the groups, relating to body weights, body score, body mass index, thoracic conformation and age of the animals. The averages were compared using the Tukey test at 5% probability, Dunn's test at 5% probability and then the normality values for the vertebral heart size were estimated based on the mean of each group.

Results and discussion

Forty dogs were evaluated according to the groups previously described, all mean values obtained from the vertebral heart size were similar to those proposed by Buchanan and Bücheler (1995), below 10.5v, regardless of the projections analyzed, the values are shown in Table 1. It was obtained a 95% confidence interval, being 9.9v to 10.4v for right lateral-lateral projections and 9.8v to 10.3v for ventro-dorsal. The mean weight of the patients was 14.67 ± 10.3 kg, with dogs in group 1 (n = 9) weighing 3.39 ± 0.97kg, those in group 2 (n = 8) 6.93 ± 1.6kg, group 3 (n = 12) of 15.43 ± 3.18kg and group 4 (n = 11) 27.6 ± 6.22kg. However, weight did not show a positive correlation with vertebral heart size in both projections.

Table 1: Vertebral Heart Size values at right laeral-lateral (RLLVHS) and ventro-dorsal (VDVHS) radiographs of dogs according to their body weight

GROUPS	RLLVHS	VDVHS
G1 (≤ 5 kg)	9.87±0.82v	9.98±0.83v
G2 (de 5,1 a 10 kg)	10.28±0.45v	10.05±0.79v
G3 (de 10,1 a 20 kg)	10.12±0.95v	10.14±0.89v
G4 (≥ 20,1 kg)	10.31±0.66v	10.1±1.07v

In the research by Lamb et al. (2001), values were found for Yorkishire Terrier, Doberman, Boxer, Labrador Retriever, German Shepherd Dog and Cavalier King Charles Spaniel dogs obtaining mean values of vertebral heart size ≤10.5v in Yorkishire Terrier (9.7v), Dobermans (10v) and German Shepherd Dog (9.7v), which shows that the averages acquired are similar to the current study. Emphasizing that, still in the study by Lamb et al. (2001) the Boxer breed has a cardiac silhouette with average values of vertebral heart size of 11.6v due to the barrel-shaped chest pattern. Greco et al. (2008) studying the correlation between the vertebral heart size in the projections of the right lateral and left lateral lateral used a sample with varied races and mixed breed animals, varied sizes of animals and with prevalent intermediate thoracic conformation, reporting values of vertebral right side-to-side heart size of 9.8 ± 0.6v, with these approximate to that obtained in the present study, reaffirming the use of the generic value stipulated by Buchanan and Bücheler (1995).

On the other hand, Castro et al. (2011) studying Yohshire Terrie dogs with similar weights and ages, reported the presence of a

correlation between the values of vertebral heart size and body weight, with the values of the right side-to-side projections being 9.9 ± 0.6v with a correlation coefficient r = 0.42 and ventro-dorsal of 10.1 ± 0.6, with a correlation r = 0.40, considered significant when Person's correlation coefficient r≥0.40. They justified the results due to the homogeneous sampling of dogs, a fact that differs from the methodology of the present work, where the values demonstrated the absence of correlation of the vertebral heart size with the canine body weight and the use of less homogeneous sampling, since animals were used separated by weight and not by race. Bodh et al. (2016) when they studied the values of vertebral heart size in dogs of the Indian Spitz breeds (10.03 ± 0.11vr = -0.077), Labrador Retriever (10.22 ± 0.2vr = 0.034) and without a defined race (9.62 ± 0.25vr = 0.038), concluded that racial type and body weight do not interfere in the values, obtaining the mean values of the right latero-lateral vertebral heart size of 9.96v and 10.14v ventro-dorsal, within the recommended range and similar to those obtained in the present study, where the the value of the right lateral-lateral projections was 10.15v ventro-dorsal 10.07v, as shown in figures 4 and 5.

In the present study, the presence of a significant correlation between the body score and the vertebral right side-to-side heart size (r = 0.644, P <0.05) and the vertebral heart size ventro-dorsal (r = 0.608, P <0.05) was observed in dogs of the group 4, as illustrated in figure 6. What makes us suggest that variations in body score may alter the values of vertebral heart size, especially in giant dogs, obese and with increased fatty tissue in the rib cage and at the pericardial sac region. Tôrres et al. (2008) studying the relationship between weight gain and the vertebral heart size in mixed breed dogs with 15% more of the initial body weight, when comparing the cardiac silhouettes before and after the weight gain program, they observed an increase in 8.54% in the values of the vertebral heart size and related to the achieved obesity index. They concluded that there is a need to consider obesity when measuring the vertebral heart size.

In addition, Cardoso et al. (2011) studying dogs of the American Pitbull Terrier breed found significant values of the vertebral heart size right lateral-lateral of 10.9 ± 0.4v being above the value suggested for the breed of ≤11v. Justifying that the chest muscle mass, standard of the breed, can influence the values of canine muscle mass index in heavier dogs, as well as the increase in cardiac muscle mass due to the athletic activity of the dogs of the breed (company or athlete) can influence in the values of vertebral heart size. This may explain the correlation found in the present study between the body score values of dogs in group 4 in both projections of the studied vertebral heart size.

Differentiated values of the vertebral heart size in large dogs were described by Lamb et al. (2001), giving 10.8v to the Labrador Retriever and 10.6v to Cavalier King Charles Spaniel; as well as in the research by Gugjoo et al. (2013), where the values of vertebral heart size right lateral-lateral in Labrador Retriever dogs were equal to 10.29 ± 0.04v, even with variations in body weight, increase in vertebrae and internal organs according to age and development

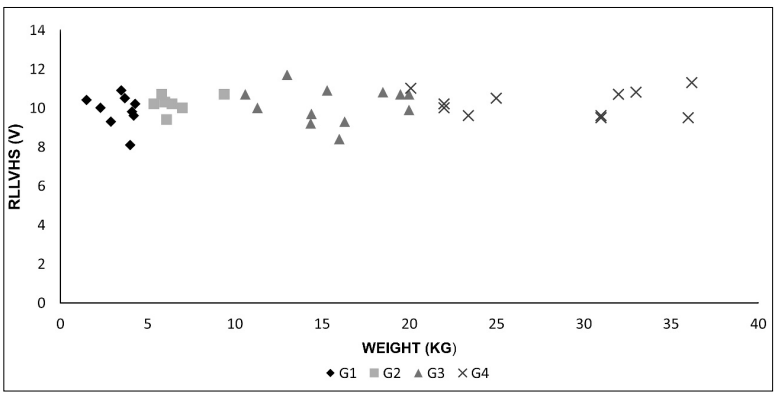

Figure 4: Demonstration of the values of the right lateral-lateral Vertebral Heart Size - RLLVHS (v) according to the body weight of groups of clinically healthy dogs separated by weight groups (G).

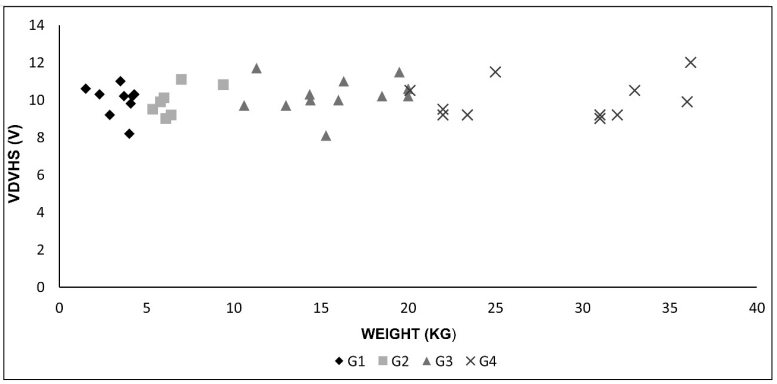

Figure 5: Demonstration of the values of the ventro-dorsal Vertebral Heart Size - VDVHS (v) according to the body weight of groups of clinically healthy dogs separated by weight groups (G)

of the animal. Ghadiri et al. (2010) and Bodh et al. (2016) in studies with large dogs, stated that the difference in the values of the vertebral heart size is not statistically significant, but suggest identifying the correlation with obese animals. Previous facts, can justify the data found in the present work represented in figure 6.

In small dogs, Jepsen-Grant et al. (2012) in their study with Pug, Pomeraniam, Yorkshire Terrier, Dachshund, Bulldog, Shih-Tzu, Lhasa Apso and Boston terrier breeds concluded that the increase in body score could produce a false positive in the diagnosis of cardiomegaly, even with a low correlation found with the studied breeds (r = 0.03). Alves et al. (2015) studied Poodle dogs and concluded that the body score can influence the values of the vertebral heart size, especially in obese dogs due to the strong correlation found. Thus, emphasizing the importance of identifying the body score in relation to the values of the vertebral heart size according to racial size.

Another result obtained was the significant correlation in Pearson's coefficient (r = 0.891; P <0.05) of the vertebral ventro-dorsal heart size in relation to the body mass index in dogs in group 2 (Figure 7), justified by the lower homogeneity between size and weight of the dogs evaluated. Fact described by Cardoso et al. (2011) when they studied a specific breed of dog (American Pitbull Terrier) describing that the increase in the skeletal muscle mass of dogs can interfere with the values of the vertebral heart size.

Regarding the values of the vertebral heart size correlated with the chest pattern and body area, no significant correlation was observed in the present study, justified in terms of the homogeneous pattern of the intermediate chest in all dogs. Similar results were observed by Greco et al. (2008) in a study with dogs, regardless of racial size, with mean values in the right lateral-lateral projection for a deep chest of 9.8 ± 0.72V, an intermediate chest of 9.7 ± 0.6V and a broad chest of 9.9 ± 0.60v, absent of differences significant. Castro et al. (2011) studying Yorkshire Terrier dogs with intermediate thorax pattern, also found no significant correlation between the vertebral heart size and thoracic conformation. Recently, Jepsen-Grant et al. (2012) and Bodh et al. (2016) found no significant correlation between chest pattern, body area and vertebral heart size, explaining their results due to the exclusion of animals with deep thorax. Which justifies the values obtained in the present study. However, Jepsen-Grant et al. (2012) point out that in small dogs there are variations in the length of the vertebral body in relation to body size, requiring a study directed to this assessment.

Regarding the age and sex of the dogs evaluated, no correlation was observed with the values of the vertebral heart size, as previously described by Buchanan (2000), Sleeper and Buchanan (2001), Gülamber et al. (2005) and Bohd et al. (2016). However, Lamb et al. (2001) justified the possibility of correlation of the vertebral heart size with age due to the predisposition of races to

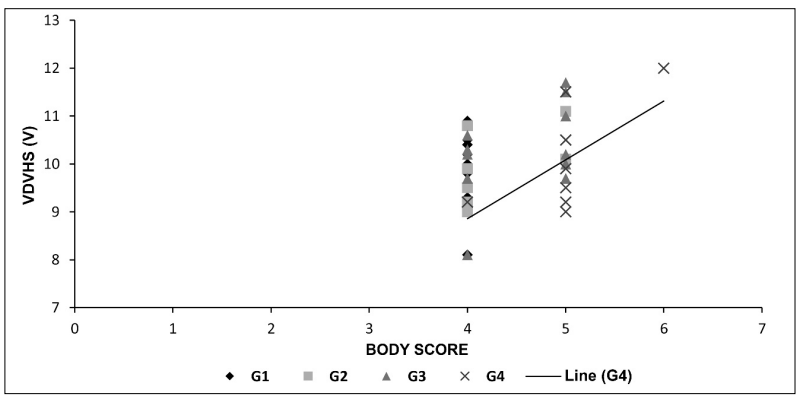

Figure 6: Demonstration of the correlation between Vertebral Heart Size in ventro-dorsal projection – VDVHS (v) and body score of clinically healthy dogs separated by weight groups (G).

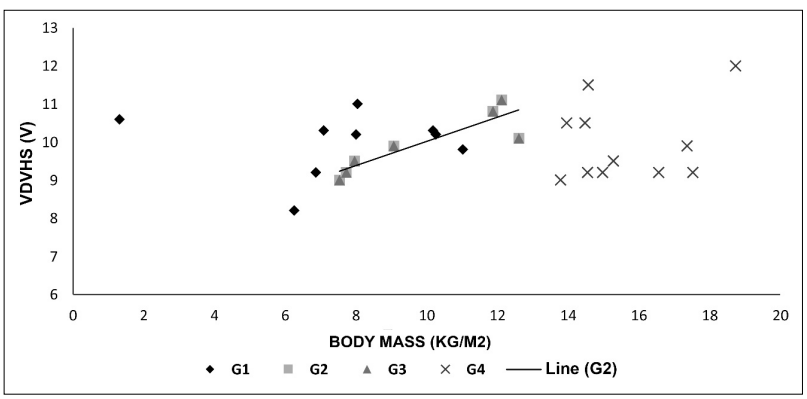

Figure 7: Demonstration of the correlation between Vertebral Heart Size in ventro-dorsal projection – VDVHS (v) and canine body mass index of clinically healthy dogs separated by weight groups (G).

the development of heart diseases. In 2008, Choisunirachon and Kamonrat studying dogs of the shih-tzu breed observed different values between dogs younger than one year of age, with those of older ages, recommending further research. When cataloging the vertebral heart size by specific breeds without encompassing mixed-breed animals, most authors agree with the need to index values by race, not only due to pre-existing physiological structural changes, but also due to the homogeneity of the studied group. Differing from the indication, in the present study, mixed breed and multi-breed animals were used, only separated by weight, canine body mass index, age, thoracic conformation and body area, obtaining the basis, through statistical studies, for the statement that the generic value of vertebral heart size with an upper limit of ≤10.5v is valid and applies to all breeds, except for dogs with a short chest as proposed in the study by Buchanan and Bücheler (1995), considered as a reference. In addition, the study provides an assessment basis for mixed breed animals that are excluded from racial studies.

Conclusion

Subsequently, the data analysis showed that the vertebral heart size method in the right lateral-lateral and ventro-dorsal projection is applicable in the evaluation of the cardiac dimension according to previous studies, with the values obtained not being influenced in relation to weight and body area for dogs up to 20kg. However, in dogs over 20kg the values of ESR may vary according to the body score.

References

Alves F.R., Pessoa G.T., Sousa F.C.A, Rodrigues R.P.S., Diniz A.N., Sanches, M.P., ... Fontenele R.D. 2015. Estudo comparativo entre o vertebral heart scale (VHS) e índice cardiotorácico (ICT) em cães hígidos da raça poodle. *Trabalho apresentado em V Simpósio Internacional de Diagnóstico por Imagem Veterinário.* Disponível em: <https://proceedings.science/sindiv/5sindiv/papers/estudo-comparativo-entre-o-verterbral-heart-scale--vhs--e-indice-cardiotoracico--ict--em-caes-higidos-da-raca-poodle?lang=pt-br#>.

Bahr R. (2014). O coração e os vasos pulmonares. In: Thrall D.E. *Diagnóstico de radiologia veterinária.* (p.585-607) 6rd. Rio de Janeiro: Elsevier.

Birks R., Fine D.M., Leach S.B., Clay S.E., Eason B.D., Britt L.G. & Lamb K.E. 2017. Breed-Specific Vertebral Heart Scale for the Dachshund. *Journal of the American Animal Hospital Association*, 53(2): 73-79.

Bodh D., Hoque M., Saxena A.C., Gugjoo M.B., Bist D. & Chaudhary J.K. 2016. Vertebral scale system to measure heart size in thoracic radiographs of indian spitz, labrador retriever and mongel dogs. *Veterinary world*, 9(4): 371-376. Disponível em: <www.veterinaryworld.org/Vol.9/April-2016/7>.

Buchanan J.W. 2000. Vertebral scale system to measure hearth size in radiographs. Veterinary clinics of North America: small animal practice, 30(2): 379-393.

Buchanan J.W. & Bücheler J. 1995. Vertebral scale system to measure canine heart size in radiographs. *Journal of the American Veterinary Medical Association*, 206(2): 194-199.

Cardoso M.J.L., Caludino, J.L., Melussi, M. 2011. Mensuração do tamanho cardíaco pelo método VHS (vertebral heart size) em cães sadios da raça American Pit Bull Terrier. *Ciência Rural,* 41(1): 127-131. Disponível em: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-84782011000100020&lng=en&nrm=iso>.

Castro M.G., Tôrres R.C.S., Araújo R.B., Muzzi R.A.L. & Silva E.F. 2011. Avaliação radiográfica da silhueta cardíaca pelo método Vertebral Heart Size em cães da raça Yorkshire Terrier clinicamente normais. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, 63(4): 850-857. Disponível em: <http://www.scielo.br/pdf/abmvz/v63n4/09.pdf>.

Choisunirachon N. & Kamonrat P. 2008. Vertebral scale system to measure heart size in radiographs of Shih-Tzus. *Thai Journal of Veterinary Medicine*. 38: 60.

Ghadiri A., Avizeh R. & Fazli G. 2010. Vertebral heart scale of commonlarge breeds of dogs in Iran. *International Journal of Veterinary Research*, 4(2): 107-111.

Greco A., Meomartino L., Raiano V., Fatone G. & Brunetti A. 2008. Effect of left vs. right recumbency on the vertebral heart score in normal dogs. *Veterinary Radiology & Ultrasound*, 49(5): 454-455.

Gugjoo M.B., Hoque M., Zama M.M.S., Saxena A.C., Pawde A.M. Ansari M.M. & Bhat S.A. 2013. Vertebral scale system to measure heart size on thoracic radiographs of Labrador retrivier dogs. *The Indian Veterinary* Journal, 90(2): 71-73.

Gülanber E.G, Gönenci R., Kaya U., Aksoy O. & Biricik H.S. 2005. Vertebral scale system to measure heart size in thoracic radiographs of Turkish Shepherd (Kangal) dogs. *Turkish Jornal of Veterinary and Animal Sciences.* 29(2005): 723-726.

Hansson K., Häggström J., Kvart C. & Lord P. 2005. Interobserver variability of vertebral heart size measurements in dogs with normal and enlarged hearts. *Veterinary Radiology & Ultrasound*, 46(2): 122-130.

Jepsen-Grant K., Pollard R.E., Johnson L.R. 2012.Vertebral heart scores in eight dog breeds. *Veterinary Radiology & Ultrasound*, 00(0): 1-6.

Laflame D.P. 1997. Development and validation of a body condition score system for dogs. *Canine Practice*, 22: 10-15.

Lamb C.R., Tyler M., Boswood A., Skelly B.J. & Cain M. 2000. Assessment of the value of the vertebral heart scale in the radiographic diagnosis of cardiac disease in dogs. *The Veterinary Record*, 146: 687-690.

Lamb C.R., Wikeley H., Boswood D. & Pfeiffer D.U. 2001. Use of breed-specific ranges for the vertebral heart scale as an aid to the radiographic diagnosis of cardiac disease in dogs. *The Veterinary* Record, 148: 707-711.

Muller D.C.M., Schossler J.E., Pinheiro M. 2008. Adaptação do índice de massa corporal humano para cães. *Ciência Rural*, 38: 1038-1043.

Rosenthal R.C. (1995). Quimioterapia. In: Ettinger S.J., Feldman E.C. (Ed) *Textbook of Internal Medicine*, Diseases of Dog and Cat. 4rd. Filadélfia: Saunders.

Sleeper M.M. & Buchanan J.W. 2001. Vertebral scale system to measure heart size in growing puppies. *Journal of the American Veterinary Medical* Association, 209(1): 57-59.

Soares E.C., Larsson M.H.M.A & Pinto A.C.B.C.F. 2004. Aspectos radiográficos da doença valvar crônica. *Ciência Rural*, 34(1): 119-124. Disponível em: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-84782004000100018&lng=en&nrm=iso>.

Spasojević K.L., Krstić N. & Trailović R.D. 2007. Comparison of three methods of measuring Vertebral Heart Size in German Shepherd dogs. *ACTA Veterinaria Beograd*, 57(2-3): 133-141. Disponível em: <https://www.researchgate.net/publication/47740339_Comparison_of_three_methods_of_measuring_vertebral_heart_size_in_German_Shepherd_dogs>.

Thrall D.E. (2014). Princípios da interpretação Radiográficas do Tórax. In:_____. *Diagnóstico de Radiologia Veterinária* (p.474-488) 6rd. Rio de Janeiro: Elsevier.

Thrall M.A., Weiser G., Allison R.W. & Campbell T.W. (2007). *Hematologia e bioquímica clínica veterinária*. São Paulo: Roca.

Tôrres A.C.B., Mesquita R.G., Silva L.H., Oliveira S.C, Silva C.S.B. & Oliveira R.A.2008. Avaliação radiográfica da silhueta cardíaca de cães submetidos a um programa nutricional de ganho de peso.

Woolley R., Smith P., Munro E., Smith S., Swift S., Devine C., ... French A. 2007. Effects of treatment type on vertebral heart size in dogs with myxomatous mitral valve disease. *Intern. Journal. Appl. Res. Vet. Med.*, 5(1): 43-48.