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Assessing Cardiomegaly in Anatolian Shepherd Dogs Utilizing Cardio-Thoracic Ratio (Ctr) and Vertebral Heart Score (Vhs)

Amanj M. Ahmed[1], Rizgar Rahim Sulaiman[1] and Othman Jalal Ali [2]

[1]*Department of Internal Medicine, College of Veterinary Medicine, University of Sulaimani, Sulaymaniyah 46001, Kurdistan Region, Iraq.*

[2]*Department of Surgery and Theriogenology, College of Veterinary Medicine, University of Sulaimani, Sulaymaniyah 46001, Kurdistan Region, Iraq.*

Abstract

THE study aimed to assess the diagnostic efficacy and discriminative ability of a method for calculating the Cardiothoracic Ratio (CTR) on X-rays, utilizing the Vertebral Heart Scale (VHS) as the standard radiographic technique for heart size in dogs, distinguishing between normal heart size and cardiomegaly. The study comprised 51 local Anatolian dogs, collected at Sulaymaniyah province, Iraq, consisting of 21 females and 30 males aged between 1 and 5 years. Physical, radiographic, and electrocardiographic examinations were conducted, utilizing 102 radiographs to assess CTR and compare it with the VHS. A significant correlation existed between VHS and CTR for the entire study cohort (r^2=0.764, p<0.01). The mean (±SD) CTR on lateral radiographs of normal dogs was 28.41% ±0.71% at the points of peak inspiration and 30.67% ±1.10% at the peak of expiration. The cutoff value of the CTR for diagnosing cardiomegaly on lateral radiographs was 29.42% (inspiration) and 32.21% (expiration). It is concluded that CTR measurements provide a clinically useful technique for assessing heart size and can discriminate between normal heart size and cardiomegaly in Anatolian shepherd dogs.

Keywords: Heart, Vertebral Heart Scale (VHS), Cardiothoracic Ratio (CTR), Dogs, Cardiomegaly, Canine Radiography.

Introduction

Thoracic radiography is a cost-effective, non-invasive, and easily accessible diagnostic and screening technique for thoracic organs, especially for cardiovascular evaluation in small animals [18, 20]. The circulatory systems of both dogs and cats are complex and employing fundamental identifying patterns is crucial for precise radiography evaluation [19]. Utilizing optimal radiography is crucial for assessing the evolution of congestive heart failure and monitoring the disease's progress or reactions to further therapies [9]. Various diagnostic techniques have been employed to assess cardiac dimensions, including thoracic radiography, echocardiography, and electrocardiography. Radiography is still considered an initial recognized approach for cardiac assessment; nevertheless, a normal heart size does not necessarily exclude the existence of cardiovascular diseases [4]. Numerous methodologies are utilized to evaluate cardiac conditions in an X-ray image by statistical anatomical landmarks. A practical technique utilized for rapid cardiac assessment is measuring the cardiac short axis length at the 2.5 and 3.5 intercostal spaces in deep-chested and wide-chested dogs, respectively [10]. Changes in cardiac silhouette measurements indicate enlargement of certain cardiac chambers, and the diagnosis of right and left-sided congestive heart failure, can only be definitively established through radiography [12]. In 1995, Buchannan developed a criterion for assessing heart size in dogs,

*Corresponding authors: Othman J. Ali, E-mail: othman.ali@univsul.edu.iq, Tel.: 009647701484700
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known as the Vertebral Heart Scale (VHS), which is regarded as the most widespread and precise method in veterinary medicine [7]. The Cardiothoracic Ratio (CTR), a novel approach for evaluating heart size in veterinary medicine developed by Torad and Hassan [21] , is determined by calculating the ratio of the thoracic area to the cardiac area [21]. Assessing cardiac size using the full cardiac silhouette could be a helpful method for identifying both overall cardiac enlargement and small changes in cardiac size. Simultaneously, electrocardiography exclusively reveals the heart's functional condition, but not its mechanical status [23]. The ECG demonstrates restricted sensitivity in detecting cardiac hypertrophy, although its specificity is generally increased. ECG identify only those structural changes in the heart that lead to significant abnormalities in the direction and duration of the electrical current wavefront. Therefore, it is beneficial to utilize this method alongside radiography, but it should not serve as a substitute for accurately assessing heart size [17]. Therefore, this study aimed to determine the correlation between Cardiac Thoracic Ratio (CTR) and Vertebral Heart Scale (VHS) and assessing the discriminative ability of CTR for evaluating dogs with normal heart size or cardiomegaly in relation to their ages, weight and sex in Anatolian shepherd dogs.

Material and Methods

Animals

Fifty-one stray local Anatolian local breed dogs (30 males and 21 females), with their ages ranging from 1 to 5 years and their weights from 25.5kg - 49.4kg, were collected and transported to Sulaimani Private Veterinary Hospital in Sulaymaniyah province, Iraq, for physical and radiographic assessment. All dogs were captured using a blowpipe anesthetic immobilization method, administering an intramuscular injection of a combination of 2% xylazine and 10% ketamine, at a dosage of 1 mg/kg and 15 mg/kg as a single bolus injection.

Ethical approval

This study was approval by the Veterinary College Research Ethics Committee (VMUS.EC. Doc 6-2025) at the University of Sulaimani, in partial fulfillment of the requirements for the Master of Science degree in Veterinary Small Animal Internal Medicine.

Study design

After complete immobilization, complete physical examinations were performed, including temperature, pulse rate, mucous membrane examination, capillary re-fill times, cardiac assessment using stethoscope and finally thoracic radiography were performed. The exclusion criteria encompassed conformation defects, diaphragmatic hernia, any pulmonary pathology obstructing heart silhouette, and dogs with non-cardiac systemic disorders. All the dogs were prepared for complete physical examination, two radiographic views for heart assessment and ECG.

Cardiac Physical Examination

Precordial palpation was utilized to assess apical impulse intensity, while cardiac auscultation focused on identifying abnormal heart sounds, murmurs, rate, rhythm, and intensity. Additionally, the evaluation of pulse quality and character was conducted. The grading system for heart murmur is not universally recognized; it is defined here as follows: I/VI denotes a soft murmur audible only in quiet surroundings following a duration of focused auditory attention at the specific location on the chest where the murmur is detected. II/VI is a soft murmur that is detectable immediately upon proper placement of the stethoscope chestpiece at the point of maximal impulse (PMI). An II/VI murmur does not radiate much from the location on the chest where it is optimally auscultated. III/VI is louder, audible from a considerable distance from its point of (PMI), however typically inaudible on the contralateral side of the chest. IV/VI designates a loud murmur that radiates widely, frequently encompassing the contralateral side of the thorax, yet lacks an accompanying palpable precordial thrill. V/VI indicates a markedly loud murmur accompanied by a palpable precordial thrill, consistently identifiable at its (PMI) on the chest wall. VI/VI indicates an exceptionally loud murmur that is accompanied by a palpable precordial thrill and can be auscultated without a stethoscope or with the stethoscope withdrawn from the chest wall [14].

Radiographic Measurements

Animals were positioned on the lateral recumbency, right lateral radiographs were taken for each dog, includes radiographs taken during the peak expiration and inspiration. Peak expiration was indicated by the lumbo-diaphragmatic angle being cranial to the 11th thoracic vertebra (T11), whereas peak inspiration happens when the angle was caudal to the 12^{th} thoracic vertebra (T12) [21]. Accurate radiographic positioning was ensured through a standardized technique, through Positioning a sandbag on the neck with sand evenly distributed at both ends to prevent airway and vascular compression, extending the forelimbs forward and securing them with sandbags or ties to prevent overlap with the cranial thorax, and placing a sandbag over the hindquarters or encircling the pelvic limbs. Carefully extend the head and neck to prevent positional displacement of the trachea, ensuring that the sternum and vertebrae are aligned; a foam positioning wedge beneath the sternum and/or back may be necessary based on the patient's conformation. Position the X-ray beam at the caudal region of the scapula and two-thirds of this distance

ventrally across the thorax. Collimation must encompass the thoracic inlet and the entire diaphragm, including a portion of the liver. Place a left or right marker in the collimated area, typically in the axillary region, to denote the patient's recumbency. In most cases, radiographic exposure should occur during full inspiration[18] . For radiography Computed Radiography (CR) system was used. The machine (PCMAX-40H, POSKOM Co., EXAMION GmbH, Germany) and Cassette with (0.2 -35 -43 cm) dimensions were used, settings at 60-70 kVp and 2.5 mAs with a focal film distance of an about 60 - 80 cm. Analogue radiographs of all dogs were examined and scanned using a Computed Radiography reader (EXAMION, AGFA HEALTHCARE N.V, Mortsel-Belgium, Germany) to measure VHS and CTR. The standard value for detecting cardiomegaly is a VHS of 9.74 (range: 9.10-10.50) according to the reported literatures [22].

All radiographs were accurately labeled and randomized for blind evaluation. Radiographic assessments of the VHS and CTR were conducted utilizing commercial software (Digimizer_ 5.4.9.0 image analysis software, MedCalc Software bvba, Ostend, Belgium). The VHS measurement was conducted in accordance with [7] in the lateral radiographs, the long axis is defined as the distance from the base (ventral edge of the carina) to the apex (L), whereas the short axis denotes the width of the heart measured perpendicularly to the length, often at the ventral margin of the caudal vena cava (S). The dimensions of the two axes were compared to the vertebrae, commencing at the cranial border of the Fourth thoracic vertebra (T4), with the program's "unit" measuring tool, with the results articulated in units of vertebral length. Then the total of the two axes equals the VHS value (Fig. 1).

The CTR measurements according to Torad and Hassan [21]required the manual delineation of the thoracic region by tracing a line from the right crura of the lumbo-diaphragmatic recess, following the diaphragm cupola to the sterno-diaphragmatic angle, advancing along the dorsal aspect of the sternum to the cranial edge of the first sternebra, encompassing the thoracic inlet and the ventral border of the thoracic vertebral bodies, and returning to the right crura of the lumbo-diaphragmatic recess. The assessment of cardiac area involves delineating the outline of the cardiac silhouette along the cranial border, waist, apex, caudal border, waist, base, and returning to the cranial border (Fig. 2). The calculation of CTR is derived from the cardiac area (CA) and the thoracic area (TA) using the formula (CA*100/TA) [1].

Electrocardiograms (ECG)

Electrocardiograms were taken on the right lateral recumbency on a table equipped with an insulating mattress, using an ECG300G-VET, 6-lead ECG amplifier (Contec Medical Systems Co., Qinhuangdao, Hebei, China). The limbs were positioned perpendicular to the body's longitudinal axis, and electrodes were attached to the skin of each limb using alligator clips. ECG tracings (lead II) were evaluated for changes in heart rate, rhythm, or QRS morphology.

Statistical Analysis

The data is shown as mean ± standard deviation for a normal distribution. A scatter plot was utilized to analyze the correlation between VHS and CTR, with a P value of less than 0.05 indicating statistical significance. Person correlation coefficients for the connection between VHS or CTR with age or weight in both the normal heart group and the cardiomegaly group. Receiver operating characteristic (ROC) curve analysis was used to determine the diagnostic accuracy and the cutoff values of the CTR of normal dogs and those with cardiomegaly based on the measurement of Vertebral Heart Score (VHS) using graphing software.

Results

The age, sex, weight, body condition score, temperature, heart rate, heart murmurs, precordial palpation, pulse character, VHS, CTR, and electrocardiogram findings are summarized in Table 1. A robust, positive, linear correlation ($r^2=0.764$, $p<0.01$) was identified between the VHS and CTR for all dogs, as illustrated in Figure 3.

In radiological assessment, the VHS was regarded as the gold standard for assessing cardiac silhouette on X-ray. The normal and abnormal condition of heart sizes were determined based on vertebral heart score values (VHS), Consequently, the complete cohort of dogs was categorized into two groups: the normal heart size group and the cardiomegaly group. The prevalence of cardiomegaly was determined when the values of VHS exceeding 10.5. From a total of 51 dogs, 22 dogs (43.13%) were found that the VHS was exceeding 10.5 and they were identified as cardiomegaly condition, whereas the remaining 29 dogs were showed normal VHS sizes. In dogs with normal cardiac size based on subjective radiographic using VHS, the mean (±SD, minimum to maximum) CTR on lateral radiographs of normal dogs was 28.41% ±0.71% (27 – 29.89) at the points of peak inspiration and 30.67% ±1.10% (29.30 – 33.72) at the peak of expiration. While for the cardiomegaly group was 30.78% ±1.20% (29.40 – 32.99) at the points of peak inspiration and 33.99% ±1.09% (32.18 – 36.22) at the peak of expiration. Additionally, a relationship between VHS and the CTR between normal and abnormal heart size were calculated. Statistically, a significant relationship between VHS and CTR in normal heart size group ($r^2=0.428$; $p<0.01$) and cardiomegaly group ($r^2=0.483$, $p<0.01$) was observed, they are summarized in Table 2.

The proportion of sex in both groups is illustrated in Figure 4, in which males were more overrepresented in the cardiomegaly group; males were 14 (27.45%) and females were 8 (15.69%). The proportion of heart murmurs in both the normal heart group and the cardiomegaly group is shown in Figure 5, where abnormal murmurs were more in the cardiomegaly group. The mean values of VHS in both males and females were the same (10.1) in the normal heart group, while for the cardiomegaly group, the mean of VHS was 0.1 bigger than female (10.8) and (10.7), respectively, as illustrated in Figure 6.

The correlation test was also conducted for VHS and CTR with age or weight in both the normal and cardiomegaly groups (Table 3); in the normal heart group, there was a statistically significant moderate positive correlation between VHS and age *($p<0.05$, $r=0.385$)*, while no statistically significant correlation was found between VHS and weight *($p=0.1$, $r=0.309$)*. However, for the cardiomegaly group, the association between VHS and both age or weight; no statistically significant correlation was found between VHS and age *($p=0.3$, $r=0.221$) ($p=0.3$, $r=0.212$)*, respectively.

For CTR, the correlation with age or weight in both the normal and cardiomegaly groups was conducted (Table 3); in the normal heart group, a statistically significant moderate positive correlation between CTR and age and weight *($p<0.01$, $r=0.501$) ($p<0.05$, $r=0.423$)* was found, respectively. We found no statistically significant correlation between CTR and either age or weight *($p=0.2$, $r=0.256$) or $p=0.3$, $r=0.230$)* in the cardiomegaly group. According to ROC curve analysis, at inspiration phase a CTR cutoff value of 29.42% had a sensitivity of 86% and a specificity of 86% for discrimination between cardiomegaly and normal heart size, with an AUC of 0.969, where at expiration a CTR cutoff of 32.21% had a sensitivity of 90% and a specificity of 89% for discrimination between normal heart size and cardiomegaly, with an AUC of 0.981.

Discussion

This study, utilized the Cardiac Thoracic Ratio (CTR) referenced values, to assess cardiac size in relation to thoracic size, with a view to establish an objective diagnostic tool for evaluating cardiac size in Anatolian Shepherd (ASH) dogs. Variations in radiographic cardiac size resulting from uneven animal placement or respiratory phase were minimized by employing a single evaluator, ensuring uniformity in radiographic positioning, and accounting for the respiratory phase. A notable constraint of traditional measuring equipment and graded rulers in VHS measurement is the necessity to approximate ratios when heart length and width do not correspond with full vertebral counts [21]. In this study, we addressed this issue by employing a software program that computed the precise heart length and width, thereafter expressed in vertebral length units. The strong correlation ($r^2=0.764$, $p<0.01$) between vertebral heart scale measurements and cardio-thoracic ratio indicates similar results from both approaches. Both methodologies utilize a variable measurement (the heart) calibrated against a fixed reference, with the VHS using the body length of the thoracic vertebrae and the CTR employing the thoracic area. The VHS serves as a standard for assessing cardiac silhouette on X-ray. Consequently, the complete cohort of dogs was categorized into two groups: the normal heart size group and the cardiomegaly group. In dogs with normal cardiac size based on subjective radiographic using VHS, the mean (±SD, minimum to maximum) CTR on lateral radiographs of normal dogs was 28.41% ±0.71% (27 – 29.89) at the points of peak inspiration and 30.67% ±1.10% (29.30 – 33.72) at the peak of expiration. While for the cardiomegaly group was 30.78% ±1.20% (29.40 – 32.99) at the points of peak inspiration and 33.99% ±1.09% (32.18 – 36.22) at the peak of expiration. The prevalence of cardiomegaly was determined using vertebral heart scale values exceeding 10.5, resulting in a diagnosis of cardiomegaly in 22 dogs (43.13%). This finding supports the adverse conditions experienced by street dogs, along with insufficient nutrition, which are linked to the development of heart diseases [13, 24]. Authorities should implement measures to protect dogs from harmful conditions by creating modern shelters, supplying adequate food, and guaranteeing medical care for sick dogs. According to ROC curve analysis, at inspiration phase a CTR cutoff value of 29.42% had a sensitivity of 86% and a specificity of 86% for discrimination between cardiomegaly and normal heart size, with an AUC of 0.969, where at expiration a CTR cutoff of 32.21% had a sensitivity of 90% and a specificity of 89% for discrimination between normal heart size and cardiomegaly, with an AUC of 0.981. This provide an objective diagnostic tool and discriminative ability for evaluation of cardiac size in the Anatolian shepherd breed and could be considered an early indicator of subtle changes in cardiac size. A statistically significant relationship was observed between VHS and CTR in both normal heart size ($r^2=0.428$; $p<0.01$) and cardiomegaly groups ($r^2=0.483$; $p<0.01$), suggesting that CTR is a reliable indicator of VHS values in both categories. The cardiothoracic ratio represents a novel method that employs planar assessment instead of linear techniques, which omit certain areas of the heart, such as left atrium dilation [1, 5]. The proportion of gender in both groups was illustrated in Figure 4; the proportion of males was higher in the cardiomegaly group, which agrees with other studies [11]. This finding suggests a potential link between male gender and the prevalence of cardiomegaly, highlighting the need for further research to explore underlying biological or behavioral factors.

Additionally, understanding these gender disparities could inform targeted prevention strategies and treatment approaches. While for cardiac murmurs, the proportion was higher in the cardiomegaly group, as illustrated in Figure 5, which is an increase mostly consistent with cardiovascular disease. This finding underscores the importance of thorough cardiac evaluations in patients with cardiomegaly [22]. Electrocardiography findings are summarized in Table 1. The result was varied even in normal dogs, although ECG is considered a main part of cardiac assessment but mostly evaluates cardiac electrical function and not anatomical structural changes, and it has a low sensitivity and specificity for the diagnosis of cardiac chamber overload as mentioned in previous studies [6]. As such, additional diagnostic tools, including echocardiography and advanced imaging techniques, are often necessary to provide a comprehensive assessment of cardiac health. These modalities can help identify subtle structural abnormalities that may not be apparent on an ECG alone.

Regarding gender, as illustrated in Figure 6, the means of VHS values among the normal cardiac group showed no difference between males and females, which aligns with the previous study by Buchanan and Bücheler [7]. However, in the cardiomegaly group, a difference in the means of VHS was observed between males and females, where males over presented which agrees with other studies [16]. Our study agrees with former studies. Clearly, interbreed differences, and possibly sex, should be taken into account when evaluating the possibility of cardiomegaly on the basis of the vertebral heart scale [15].

In terms of the association between VHS and age or weight (Table 3) in the normal heart group, there was a statistically significant moderate positive correlation between VHS and age *($p<0.05$, $r=0.385$)*, as mentioned in the previous study [2]. This suggests that as age increases, the VHS also tends to rise, indicating potential changes in cardiac structure or function over time , while no statistically significant correlations were found between VHS and weight *($p=0.1$, $r=0.309$)* as mentioned in previous studies [3, 16]. However, for the cardiomegaly group, there was no statistically significant correlation between VHS and age or weight *($p = 0.3$, $r = 0.221$, $p = 0.3$, $r = 0.212$)*, respectively.

For CTR, the correlation with age or weight in both the normal and cardiomegaly groups was conducted (Table 3); in the normal heart group, a statistically significant moderate positive correlation between CTR and age and weight *($p<0.01$, $r=0.501$) ($p<0.05$, $r=0.423$)* was found, respectively. While in the cardiomegaly group, the correlation between CTR and age or weight showed no statistically significant correlation *($p=0.2$, $r=0.256$) ($p=0.3$, $r=0.230$)*, respectively. These findings suggest that while age and weight are important considerations in the normal heart population, they may not be as predictive in cases of cardiomegaly. It is the first study that showed correlation between this CTR method and age or weight.

The primary limitations of VHS are that pulmonary edema or pleural effusion might obscure the contours of the cardiac profile, hindering precise assessment of heart size and morphology [8]. While the primary limitation of utilizing CTR is in the challenge of applying this metric to canines with pericardial effusion, perihilar pulmonary edema, or moderate to severe pleural effusion, as fluid accumulation obscures the anatomical elements of the thoracic cavity [21]. The application of CTR is contraindicated in dogs with pneumothorax, as the thorax seems overinflated due to the presence of expelled air, potentially resulting in false results. The study's limitations encompass the utilization of analog radiographs, necessitating scanning before incorporation into the computer system [21]. The study concentrated solely on one dog breed (ASH); additional research is necessary to establish breed-specific normative parameters before the CTR for heart size evaluation can be applied more generally.

Conclusions

The cardio-thoracic ratio is a reliable Method that shows a significant correlation with the Vertebral Heart Scale in Anatolian shepherd dogs. The CTR assessment evaluates cardiac size in dogs, distinguishing between normal heart size and cardiomegaly. This method effectively evaluates the entire heart outline, including all regions of the organ. This method could be applied to consistently measure and monitor changes in heart size during the progression of diseases without the use of ultrasound technology. The notable prevalence of altered heart size in stray dogs reflects their adverse environmental conditions and various stressors. Authorities should establish measures to safeguard dogs from harmful conditions through the construction of modern shelters and the provision of medical care for sick dogs.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical approval

This study was approval by the Veterinary College Research Ethics Committee (VMUS.EC. Doc 6-2025) at the University of Sulaimani, in partial fulfilment of the requirements for the Master of Science degree in Veterinary Small Animal Internal Medicine.

TABLE 1. Shows the clinical, cardiologic and electrocardiographic findings in examined dogs.

Parameters	Captured dogs
Age (Years) (median)(range)	1.5 (1-5)
Weight(kg) (mean and range)	32.57 ± 0.88 (25.5 – 49.4)
Sex	30 males; 21 females
Body Condition Score (1 -5)	3 (90.2%) 4 (7.8%) 2 (2%)
Temperature in °C (mean and range)	38.53 (37 – 39.8)
Precordial Palpation	Normal 34 (66.7%) Strong 11 (21.6%) Weak 6 (11.8%)
Heart Rate (beats / min) (mean and range)	95 ± 3.20 (60 – 170)
Pulse Character	Normal 37 (72.5%) Pulsus paradoxus 7 (13.7%) Hyperkinetic 3 (5.9%) Pulsus parvus et tardus 2 (3.9%) Corrigan 2 (3.9)
Heart Murmur (I – VI)	No murmur 38 (74.5%) II 6 (11.8 %) III 5 (9.8%) IV 2 (3.9%)
ECG Findings	Sinus Rhythm 31 (60.8%) Sinus Bradycardia 5 (9.8%) SA Block 4 (7.8%) 1st degree AV block 3 (5.9%) Ischemia 3 (5.9%) 3rd degree AV block 2 (3.9%) Sinus Tachycardia 1 (2%) Sinus Arrhythmia 1 (2%) LVH 1(2%)
VHS (mean and range)	10.3 ± 0.05 (9.3 – 11.2)
CTR at peak of inspiration (mean and range)	29.43 ± 0.21 (27 – 32.99)
CTR at peak of expiration (mean and range)	32.11 ± 0.27 (29.30 – 36.22)

TABLE 2. Correlation between VHS and CTR utilizing the VHS method between normal and cardiomegaly groups on the bases of cardiac size.

Groups	R^2	*P*
Normal heart size group	*0.428*	*p<0.01*
Cardiomegaly group	*0.483*	*p<0.01*

TABLE 3. correlation between VHS or CTR and Age or Weight in both normal and cardiomegaly group.

Groups	Age	Weight
VHS in normal heart group	*(p<0.05, r=0.385)*	*(p=0.1, r=0.309)*
CTR in normal heart group	*(p<0.01, r=0.501)*	*(p<0.05, r=0.423)*
VHS in cardiomegaly group	*(p=0.3, r=0.221)*	*(p=0.3, r=0.212)*
CTR in cardiomegaly group	*(p=0.2, r=0.256)*	*(p=0.3, r=0.230)*

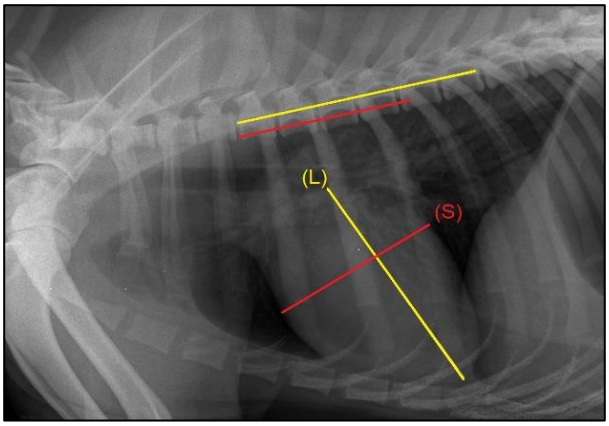

Fig. 1. A right-lateral radiograph illustrates Vertebral Heart Scale (VHS) measurements. The short axis shows the width of the heart perpendicular to the length measurement, usually at the ventral margin of the caudal vena cava (S), whereas the long axis is the distance between the base (ventral edge of the carina) and the apex (L). These two axes' dimensions were compared to those of the vertebrae, beginning at the fourth thoracic vertebra's (T4) cranial edge.

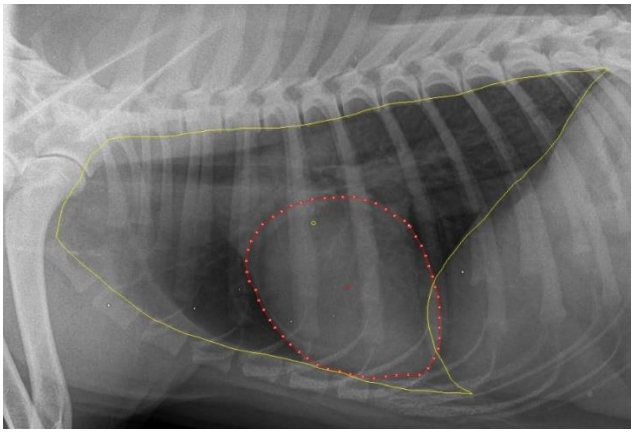

Fig. 2. Right lateral radiograph of an Anatolian dog illustrating measurements of the Cardiothoracic Ratio (CTR) at peak inspiration. The cardiac silhouette is evaluated at the cranial cardiac boundary, waist, apex, caudal border, base, and once again at the cranial border. The thoracic cavity is delineated by a closed boundary comprising the ventral margin of the thoracic vertebrae, the lumbo-diaphragmatic angle, the right crura of the diaphragm, the sterno-diaphragmatic angle, the dorsal margin of the sternum, the thoracic inlet, and concludes at the ventral margin of the thoracic vertebrae.

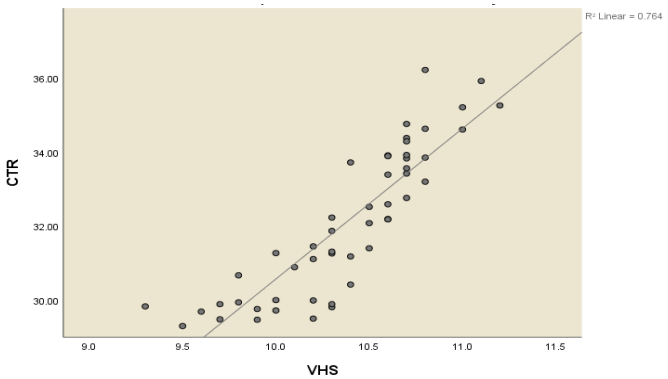

Fig. 3. Scatterplot illustrating the relationship between vertebral heart scale and cardiothoracic ratio for the entire study. A significant positive linear correlation ($r^2=0.764$, $p<0.01$) was observed between the VHS and CTR across all dogs.

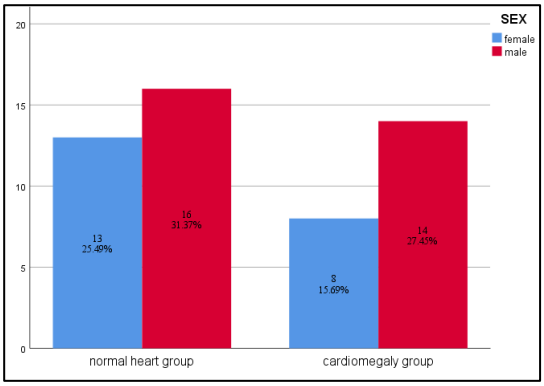

Fig. 4. Illustrate gender distribution (Male and Female) between normal and the cardiomegaly group.

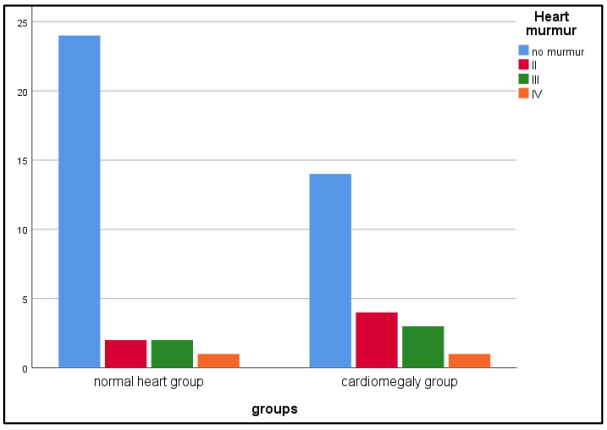

Fig. 5. Illustrate proportion of the cardiac auscultation results (no murmur, grade I-VI) in normal heart group and the cardiomegaly group.

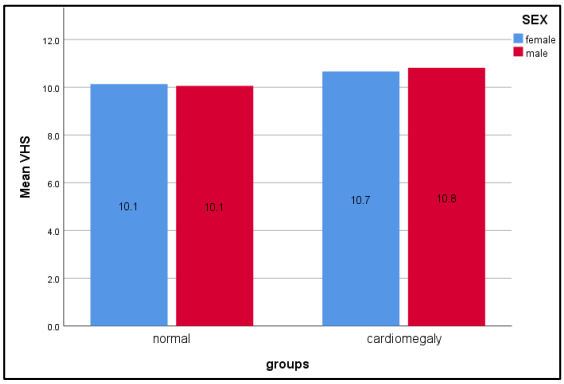

Fig. 6. illustrate the mean values of VHS between female and males in both normal and cardiomegaly group.

References

1. Andrei, B., Diana, M., Oana, B. and Vulpe, V., The diagnostic value of Cardio-thoracic ratio for detecting the heart size changes in dogs. *Rev. Rom. Med. Vet.*, **26**(3), 5-9 (2016).

2. Azevedo, G., Pessoa, G., Moura, L., Sousa, F., Rodrigues, R., Sanches, M., Fontenele, R., Barbosa, M. A .P. S., Neves, W., Sousa, J. and Alves, F. Comparative Study of the Vertebral Heart Scale (VHS) and the Cardiothoracic Ratio (CTR) in Healthy Poodle Breed dogs. *Acta Scientiae Veterinariae*, **44**, 81108 (2016). DOI: http://dx.doi.org/10.22456/1679-9216.81108.

3. Baisan, R. A. and Vulpe, V. Vertebral heart size and vertebral left atrial size reference ranges in healthy Maltese dogs. *Vet. Radiol. Ultrasound.*, **63**(1),18-22(2022). DOI: https://doi.org/10.1111/vru.13027.

4. Bashir, M., Hoque, M., Zama, M. and Amarpal , A. Vertebral Scale System to Measure Heart Size in Dogs in Thoracic Radiographs. *Advances In Animal And Veterinary Sciences*, **1**, 1-4.(2012

5. Bîrsan, O., Andrei, B., Diana, M. and Vulpe, V. Cardio-Thoracic Ratio Evaluation of Cardiac Sihlouette Compared with the Vertebral Heart Scale in Cats. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Veterinary Medicine*, **37**(1) **73**2016(2016). DOI: https://www.cabidigitallibrary.org/doi/pdf/10.5555/20163189263.

6. Bombardelli, M., Champion ،T., Fischborn, J. and Gusso, A. Diagnostic Accuracy of the Electrocardiogram for Detection of Atrial and Ventricular Overloads in Dogs. *Acta Scientiae Veterinariae*, **49,** 105274 **(**2021). DOI: http://dx.doi.org/10.22456/1679-9216.105274.

7. Buchanan, J. W. and Bücheler, J. Vertebral scale system to measure canine heart size in radiographs. *J Am Vet Med Assoc*, **206**(2), 194-9(1995). DOI: https://doi.org/10.2460/javma.1995.206.02.194.

8. Ettinger, S. J., Feldman, E. C. and Cote, E., *Ettinger's Textbook of Veterinary Internal Medicine - eBook: Ettinger's Textbook of Veterinary Internal Medicine - eBook*. 2024: Elsevier. 3992.

9. Fuentes, V. L., Johnson, L. R. and Dennis, S., *BSAVA Manual of Canine and Feline Cardiorespiratory Medicine*. British Small Animal Veterinary Association. 47-48(2010).

10. Hecht, S., *Diagnostic radiology in small animal practice*. second ed. 2020: 5m Publishing Ltd. 156-175.

11. Inoue, M., Hasegawa, A., Hosoi, Y. and Sugiura, K. Association between breed, gender and age in relation to cardiovascular disorders in insured dogs in Japan. *J. Vet. Med. Sci.*, **78**(2), 347-350(2016). DOI: 10.1292/jvms.15-0171.

12. Jr., E. D., *Cardiology for Veterinary Technicians and Nurses*. 2017: JohnWiley & Sons, Inc. 111.

13. Kaplan, J. L., Stern, J. A., Fascetti, A .J., Larsen, J. A., Skolnik, H., Peddle, G. D., Kienle, R. D., Waxman, A., Cocchiaro, M., Gunther-Harrington, C. T., Klose, T., LaFauci, K., Lefbom, B., Machen Lamy, M., Malakoff, R., Nishimura, S., Oldach, M., Rosenthal, S., Stauthammer, C., O'Sullivan ،L., Visser, L. C., Williams, R. and Ontiveros, E. Taurine deficiency and dilated cardiomyopathy in golden retrievers fed commercial diets. *PLoS One*, **13**(12), e0209112(2018). DOI: https://doi.org/10.1371/journal.pone.0209112.

14. Keene, B. W., Smith, F .W. K., Tilley, L. P. and Hansen, B., *Rapid Interpretation of Heart and Lung Sounds: A Guide to Cardiac and Respiratory Auscultation in Dogs and Cats*. 2014: Saunders.

15. Lamb, C., Wikeley, H., Boswood, A. and Pfeiffer, D. Use of breed-specific ranges for vertebral heart scale in dogs as an aid to radiographic diagnosis of cardiac disease. *The Veterinary Record*, **148**, 707-11(2001). DOI: http://dx.doi.org/10.1136/vr.148.23.707.

16. Parkan Yaramış, Ç., Erdikmen, D., Altundağ, Y., Ozkan, E. and Güzel, B .Examination of the Vertebral Heart Scale and Anatomical Structure of Different Dog Breeds by Computed Tomography. *Kafkas Universitesi Veteriner Fakultesi Dergisi*, in press, ID:30599 (2024). DOI: http://dx.doi.org/10.9775/kvfd.2023.30599.

.17 Santilli, R., Moïse, S., N. , Pariaut, R. and Perego, M., *Electrocardiography of the dog and cat diagnosis of arrhythmias* 2018: Edra S.p.A.

.18 Schwarz, T. and Johnson, V., *BSAVA manual of canine and feline thoracic imaging*. second ed. 2024: British Small Animal Veterinary Association.21-1,6 .

.19 Seiler, G. S. and Thrall, D. E., *Thrall's textbook of veterinary diagnostic radiology*. Eight ed. 2025: Elsevier. 2932.

.20 Smith, K., W., Francis., Tilley, P., Larry., Oyama, A., Mark., and Sleeper, M., Meg., *Manual of Canine and Feline Cardiology*. 2016: Elsevier, Inc. 25.

.21 Torad, F. A. and Hassan, E. A. Two-dimensional cardiothoracic ratio for evaluation of cardiac size in German shepherd dogs. *J. Vet. Cardiol.*, **16**(4), 237-244(2014). DOI: https://doi.org/10.1016/j.jvc.2014.08.001.

.22 Turgut, K., Naseri, A., Ince, M. E., Süleymanoğlu, H., Ertan, M., Sağmanligil, V. and Sen, I. Clinical and cardiologic assessment of Anatolian shepherd dogs with asymptomatic degenerative mitral valve disease. *International Journal of ADVANCED AND APPLIED SCIENCES*, **6**, 29-35(2019). DOI: https://doi.org/10.21833/ijaas.2019.07.004.

23. Varshney, J., P. , *Electrocardiography in Veterinary Medicine*. 2020: Springer Nature singapore.

24. Zaitsev, S. Y., Stepanova, M. V. and Sotnikova, L. F. Mineral imbalance and cardiovascular disease in animals of the canine (Canidae) and feline (Felidae) families: a study in Russian zoos. *Animal Diseases*, **4**(1), 38(2024). DOI: https://doi.org/10.1186/s44149-024-00143-w.

تقييم تضخم القلب في كلاب الراعي الأناضولي باستخدام نسبة القلب إلى الصدر (CTR) ومقياس الفقرات القلبية (VHS)

أمانج محمدامين احمد[١]، عثمان جلال علي[*٢]و رزگار رحيم سليمان [١]

[١]فرع السريريات والطب الباطني، كلية الطب البيطري، جامعة السليمانية، السليمانية، العراق.

[٢]فرع الجراحة والتناسل، كلية الطب البيطري، جامعة السليمانية، السليمانية، العراق.

الملخص

هدفت الدراسة إلى التحقيق في الحالات القلبية وتقييم الفعالية التشخيصية والقدرة التمييزية لطريقة حساب نسبة القلب والصدر (CTR) على الأشعة السينية، باستخدام مقياس القلب الفقري (VHS) كمعيار لحجم القلب في الكلاب، والتمييز بين حجم القلب الطبيعي وتضخم القلب. شملت الدراسة 51 كلبًا محليًا من الأناضول، جُمعت في محافظة السليمانية بالعراق، باستخدام إجراء الكيتامين/زيلازين، وتتكون من ٢١ أنثى و٣٠ ذكرًا تتراوح أعمارهم بين ١ و٥ سنوات. أُجريت فحوصات بدنية وشعاعية وكهربائية للقلب، باستخدام ١٠٢ صورة شعاعية لتقييم نسبة القلب والصدر ومقارنتها مع VHS. كان هناك ارتباط كبير بين VHS و CTR لمجموعة الدراسة بأكملها ($r^2=0.764$) ، ($p<0.01$). يُعد CTR طريقة فعالة للتمييز بين المرضى الذين يعانون من تضخم القلب وأولئك الذين لديهم حجم قلب طبيعي. يشير الانتشار الكبير لتغير حجم القلب لدى الكلاب الضالة إلى الظروف البيئية القاسية والضغوطات العديدة التي تواجهها؛ لذلك، يجب على السلطات تنفيذ التدابير اللازمة لحماية الكلاب من الظروف السيئة من خلال بناء ملاجئ حديثة وتقديم العلاج الطبي للكلاب المريضة.

الكلمات الرئيسية : القلب، مقياس القلب الفقري ، نسبة القلب والصدر ، الكلاب، تضخم القلب، التصوير الشعاعي للكلاب.