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Research Article

Comparative analysis of Buchanan vs. Ljubica method of Vertebral Heart Score (VHS) in apparently healthy German Shepherd dog

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Abstract

Vertebral heart score (VHS) in thoracic radiography measures the heart size by comparing it to the length of the thoracic vertebrae. The present study compared and established the reference values of the vertebral heart score using the Buchanan and Ljubica method. A total of seventeen healthy German Shepherd dogs aged 36-72 months and body weight 22-33.2 kg and free from cardio-thoracic diseases were selected. Non-significant ($p>0.01$) negative correlation was found in the values of the long axis (LA) and short axis (SA) with age, body weight, and T4. The vertebral heart scores calculated by these two methods were non-significant ($p\geq0.05$) and negatively correlated with age and body weight.

Keywords: Buchanan, Cardio-thoracic, Ljubica, Vertebral Heart Score

Highlights

- The values of the Vertebral Heart Score obtained via the Ljubica method were slightly lower than those obtained using the Buchanan and Bucheler methods in clinical practice.
- The values of the vertebral heart score by the Buchanan and Bucheler method and by the Ljubica method were non-significant ($p\geq0.05$) and negatively correlated with age and body weight.

INTRODUCTION

Radiographic cardiac silhouette abnormalities are detected if normal radiographic parameters are known and to this end, numerous studies about the radiographic assessment of the cardiac size have been carried out in a variety of species, including ferrets (Stepien *et al*., 1999), rabbits (Onuma *et al*., 2010), cattle (Jilintai *et al*., 2006), cats (Ghadiri *et al*., 2008), monkeys (Harada *et al*., 2009), llamas (Mattoon *et al*., 2001), pscittacines (Straub *et al*., 2002) and alpacas (Nelson *et al*., 2011). Radiographic examination (Liliana *et al*., 2007) and thoracic radiology (Hansson, 2004) are considered the most important diagnostic tools to evaluate cardiovascular disease in dogs. The present study provides the standard cardiothoracic data to evaluate cardiothoracic abnormalities and to evaluate whether there are significant differences between methods of VHS measurement to determine the most reliable method for further radiographic evaluation in German Shepherd dogs.

MATERIALS AND METHODS

The present study was carried out in the Teaching Veterinary Clinical Complex (TVCC), Kothari Veterinary Hospital, College of Veterinary Science and Animal Husbandry, U.P. Pandit Deen Dayal Upadhyaya Pashu-Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan (DUVASU), Mathura (U.P.).

Selection of animals

The current study focused on clinically healthy dogs. The study was conducted on seventeen apparently healthy medium-sized German Shepherd dogs (GSD) free of cardiothoracic illnesses, with an average age of 4 years (2-6 years) and body weight of 20 kg (15-35 kg).

All dogs were evaluated by clinical examination including anamnesis, physical examination (Table 1), thoracic radiography, electrocardiography (Mishra *et al.*, 2021), and echocardiography (Mishra *et al.*, 2020). All examinations were performed with manual restraint of the animals without the use of sedation or anaesthesia.

Thoracic radiography

The X-ray machine (Heliophos-D, Siemens Health Engineers India) and computed radiography system (Regius Model 110 S with Regius Direct Digitiger Software, Konica Minolta Healthcare, India) were used to obtain good quality radiographs. Right lateral radiographs were taken on fixed 90 cm focal film distance (FFD) and 320 mA, 9.5-13 mAs, and 58-63

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Table 1. Physical examination of the animals

Case no.	Body weight (kg)	Age (months)	Temperature (^{O}C)	Respiratory system		Cardiovascular system			
				Respiratory rate (breaths/min)	Lung auscultation	Heart rate	Rhythm	Pulse rate (bpm)	Pulse quality
1.	33.2	72	100.5	34	NAD	88	Regular	96	Regular, Strong
2.	24.9	54	101.4	39	NAD	84	Regular	93	Regular, Strong
3.	23.8	48	101.2	26	NAD	90	Regular	86	Regular, Strong
4.	22	36	100.8	29	NAD	79	Regular	88	Regular, Strong
5.	29.3	60	101.0	26	NAD	74	Regular	85	Regular, Strong
6.	29	58	100.6	33	NAD	86	Regular	91	Regular, Strong
7.	26.7	56	100.4	31	NAD	86	Regular	93	Regular, Strong
8.	25.5	56	101.4	35	NAD	84	Regular	93	Regular, Strong
9.	29.8	54	100.9	32	NAD	84	Regular	92	Regular, Strong
10.	25.6	59	101.4	33	NAD	86	Regular	93	Regular, Strong
11.	24.7	54	101.4	36	NAD	86	Regular	88	Regular, Strong
12.	24.09	60	101.4	27	NAD	89	Regular	84	Regular, Strong
13.	30.2	72	100.7	29	NAD	77	Regular	84	Regular, Strong
14.	26.6	55	100.4	32	NAD	85	Regular	92	Regular, Strong
15.	28.12	62	101.4	35	NAD	88	Regular	91	Regular, Strong
16.	22.2	69	101.4	34	NAD	82	Regular	86	Regular, Strong
17.	28.6	66	101.2	38	NAD	83	Regular	83	Regular, Strong
Mean ± S.E.	26.72 ± 0.007	58.00 ±2.14	101.02 ±0.09	32.94 ± 0.94	-	84.17 ±4.24	-	89.29 ±4.02	-

KVP. The cassettes (14 × 17 inches) were horizontally orientated to provide a comprehensive view of the thorax from the spine to the sternum and the first rib to the diaphragm (Fig. 1A).

Vertebral heart size (VHS)

Vertebral Heart Score was measured as described by Buchanan and Bucheler (1995) and Ljubica *et al*. (2007).

VHS- Buchanan and Bucheler (1995) method: The long axis (LA) of the cardiac silhouette was measured from the ventral border of the carina to the most distant ventral contour of the heart.

The short axis (SA) is located at the widest point of the cardiac profile and runs perpendicular to the long axis. Transfer LA and SA measurements to the vertebrae segment of the radiograph, initiating from the cranial or anterior edge of 4th thoracic vertebra (T4), and count the number of consecutive vertebrae that fit within the caliper points (Fig. 1A). VHS was calculated using the formula: VHS = LA+SA.

VHS- Ljubica *et al*. (2007) method: The length of the body of the fourth thoracic vertebrae (T4) was measured from its cranial edge to the caudal disc. The long axis (LA) and short axis (SA) of the heart were measured as described in the previous method. Then LA and SA of the heart were divided by the length of the body of T4, and the obtained values were summed up to get the vertebral heart size of each animal (Fig. 1).

VHS = LA/T4 +SA/T4

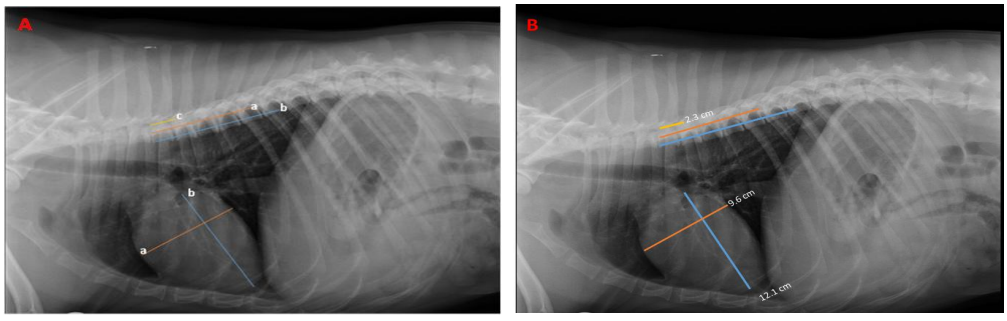

Fig. 1. (A & B) Right lateral thoracic radiograph showing the measurement landmarks of cardiac long axis (a), cardiac short axis (b) and T4 (c)

Statistical analysis

The mean and standard error calculated for radiographic parameters were calculated by using SPSS software version 16.0, one-way analysis of variance (ANOVA). The bivariate Pearson's correlation test was employed to determine the relationship between various radiographic measures, animal body weight, and age (Snedecor and Cochran, 1994). Statistical significance was defined at P>0.05 or p>0.01.

RESULTS

Determination of heart size is necessary to evaluate the patients with a cardiac anomaly. VHS provides the ratio of the heart size in comparison to the thoracic vertebra, which is helpful in the evaluation of cardiac diseases. VHS was analyzed in the right lateral thoracic radiograph.

Mean ± S.E. values of long axis (LA), short axis (SA), T4 were measured 12.076±0.21(range 10.9 - 13.4) cm, 9.11±0.22(range 7.4 - 11) cm, 2.09±0.03(range 1.8 - 2.3) cm, respectively (Fig. 1B; Table 2). Based on these measurements, the vertebral heart score was calculated by Buchanan and Bucheler method (1995) and by Ljubica *et al*. (2007) method (VHSL).

Results of the VHS measurements, mean ± S.E. values, and coefficients of variation are shown in Table 2 and Fig. 2. There were no significant differences between values in two different methods of VHS

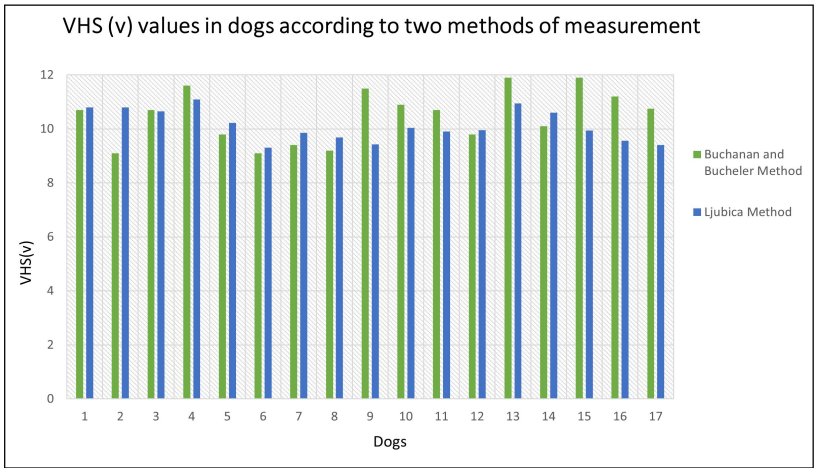

Fig. 2. VHS values (v) in dogs according to Buchanan and Ljubica methods of VHS measurement

Table 2. Mean ± S.E. values of vertebral heart score (VHS) in right lateral thoracic radiographs in dogs

Case no.	LA (cm)	SA (cm)	T4 (cm)	VHS = LA+SA (Buchanan and Bucheler, 1995) method	VHS = LA/T4 + SA/T4 (Ljubica *et al*., 2007) method
1.	11	8.5	1.8	10.7	10.8
2.	12.8	9.9	2.1	9.1	10.8
3.	13.1	8.2	2	10.7	10.65
4.	13.4	11	2.2	11.6	11.09
5.	12	10.5	2.2	9.8	10.22
6.	11.1	8.5	2.1	9.1	9.3
7.	11	8.7	2	9.4	9.85
8.	11	7.4	1.9	9.2	9.684
9.	12.1	9.6	2.3	11.5	9.43
10.	12.9	9.2	2.2	10.9	10.04
11.	11.7	9.1	2.1	10.7	9.90
12.	12.8	9.1	2.2	9.8	9.95
13.	13.2	8.7	2	11.9	10.95
14.	10.9	8.2	1.8	10.1	10.6
15.	12.6	9.3	2.2	11.9	9.94
16.	11.8	10.2	2.3	11.2	9.56
17.	11.9	8.8	2.2	10.75	9.4
Mean ± S.E.	12.076 ± 0.211	9.11 ± 0.221	2.094 ± .037	10.44 ± 0.221	10.127 ± 0.141
		Correlation with age		-0.211	-0.260
		Correlation with B.W.		-0.409	-0.304
		CV%		9.2	5.75

* Correlation is significant at the 0.01 level, ** Correlation is significant at 0.05 level

measurement. VHS was found to be10.44±0.22 (range 9.1 - 11.9) vertebrae by Buchanan and Bucheler method (1995) and 10.12±0.14 (range 9.3 - 11.09) vertebrae by Ljubica *et al*. (2007) method (VHSL). The vertebral heart scores calculated by these two methods were non-significant ($p \geq 0.05$) and were negatively correlated with age and body weight.

In German Shepherd dogs, the threshold value for heart illness is 10.2v. In the Buchanan method, ten dogs (dogs 1, 3, 4, 9, 10, 11, 13, 15, 16, and 17) showed values higher than 10.2v, while it was less than 10.2v in the other seven dogs (dogs 2, 5, 6, 7, 8, 12, and 14) than the two other methods of measurement. In the Ljubica method, eleven dogs (dogs 5, 6, 7, 8, 9, 10, 11, 12, 15, 16 and 17) showed lower values, while it was higher in the other six dogs (dogs 1, 2, 3, 4, 13, and 14). Most of the values were in the normal range for this breed (8.7 – 11.2v) while some showed high VHS values but were found healthy on echo or electrocardiographic examination.

DISCUSSION

According to the two measurement techniques under study, variations in VHS values were attributed to disparate reference points for the heart's long (LA) and short (SA) axes, as well as by comparing the lengths of the two cardiac axes to either the number of vertebrae they covered or a single thoracic vertebrae's length. The values of VHS were slightly lower in Ljubica *et al*. (2007) method in compared to Buchanan and Bucheler (1995) method in clinical practice. Buchanan and Bucheler (1995) suggested a normal VHS value in dogs as 9.7±0.50 vertebrae; however, a higher VHS value for German Shepherds (10.50±0.10) was reported by Liliana *et al*. (2007), but for the same breed, it was reported as 9.7±0.8 by Lamb *et al*. (2001). In the present study, vertebral heart score by Buchanun and Bucheler (1995) method and by Ljubica *et al*. (2007) method values were non-significantly ($p \leq 0.05$) negatively correlated with age and body weight. It was lesser than the VHS reported by Liliana *et al*. (2007) but higher than the VHS values suggested by Lamb *et al*. (2001). This may be due to the higher body weight and size of the animals in the present study.

Variations in VHS measurement were observed in the present study when comparing the subjective evaluation of radiographs with VHS measurements. While VHS values ranged from 8.7v to 11.2v, dogs 2, 5, 6, 7, 8, 9, 11, 12, 15, and 17 had VHS values that were lower than 10.2v. According to Lamb *et al*. (2001), this value was regarded as the threshold for diagnosing cardiac conditions in German Shepherd dogs. In our study, these canines were female. According to earlier studies (Lamb *et al*., 2001), female VHS values are lower than males.

Bodh *et al*. (2016) determined VHS reference values for Labrador Retriever, Indian Spitz, and Mongrel dogs using lateral radiographs. The study found that Labrador Retrievers had the highest VHS values among all three in both LL and RL radiographs (10.22±0.20v and 10.39±0.19v, respectively), while Mongrel dogs (9.62±0.25v and 9.82±0.21v) had the least, and the values of VHS in Spitz lies in between (10.03±0.11v and 10.21±0.13v, respectively). In Mongrel dogs, cardiac LA and SA measurements were significantly ($p<0.05$) lower than in the other two breeds. Equivalent findings were also reported by Ghadiri *et al*. (2008), who observed that native dogs had the lowest VHS and Doberman dogs had the greatest VHS, followed by German Shepherds and mixed breed dogs. The discrepancy in VHS measurement among different dog breeds could be linked to differences in breed thoracic conformation.

Bhargavi *et al*. (2018) established reference values of VHS in Chippiparai, an indigenous canine breed of Tamil Nadu. The Vertebral Heart Score (VHS) was measured in both left and right thoracic radiographs. The mean VHS on right and left lateral radiographs were found to be 8.63±0.23, 8.95±0.13 and 8.67±0.33, 8.97±0.1 in young and adult dogs, respectively. No significant variations were identified between the VHS of young and adult Chippiparai canines.

However, individual breed-wise VHS was reported earlier by different workers. VHS for non-descript dogs was 9.7±0.67v, as reported by Kumar *et al*. (2011). Again, 11.06±0.56v was reported by Gugjoo *et al*. (2014) in Labrador Retriever and by Grant *et al*. (2013) in Pugs 7±0.9v. VHS in Rottweiler was 9.8±0.1v, as reported by Liliana *et al*. (2007). Whereas VHS in Pomeranian dogs was 10.5±0.9v, as reported by Grant *et al*. (2013) and 10.0±0.6v, as reported by Liliana *et al*. (2007) in Doberman.

These variations can be attributable to the phenotypic diversity among breeds found in various geographical domains. According to Grant *et al*. (2013), Pugs, Pomeranians, Bulldogs, and Boston Terriers had VHS values that were much higher than the 9.7±0.5 standard range set by Buchanan and Bucheler (1995). Factors affecting VHS could be breed-specific variations in vertebral body length relative to overall body size. Higher VHS in Labrador Retrievers, Boxers, and Cocker Spaniels compared to other breeds could be attributed to somewhat shorter vertebrae (Lamb *et al.*, 2001). Many dogs with cardiac diseases had VHS values within the

normal reference ranges (Buchanan and Bucheler, 1995). Also, there were many normal dogs with VHS values above the normal reference ranges (Lamb *et al*., 2000). Studies performed on German Shepherd dogs observed a trend for cardiac diseases, but not linked with respiratory disease, to have a higher mean value on the VHS scale than normal dogs of the same breed. The diagnostic accuracy of the VHS measurement was 75% in this breed (Lamb *et al*., 2001).

In conclusion, while calculating VHS in dogs, consider the breed and recumbent side of the radiography in order to avoid any erroneous interpretation of cardiac enlargement. Objectiveness, simplicity of measurements and calculation, and independence of clinical experience give an advantage to this method compared with subjective analyses of radiographs. This is particularly the case for the second method of VHS measurement i.e. Ljubica method.

Conflict of interest: All the authors confirmed that there was no conflict of interest regarding the publication of this manuscript.

Author's contribution: MM, SP: Conception and design, acquisition of data; MM, SP, RPP: Performed statistical analysis of data and performed interpretation of the results.

Data availability statement: All the data supporting the research findings have been presented in this paper. The corresponding author is willing to provide the raw data upon reasonable request.

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