

## RADIOGRAPHIC EVALUATION OF CAUDAL VENA CAVA AND AORTA SIZE IN APPARENTLY HEALTHY SMALL BREED DOGS

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### ABSTRACT

The present study was conducted on six apparently healthy small breed dogs free from cardiothoracic diseases to generate the reference values of diameters of the caudal vena cava (CVC), the diameter of the aorta (AO), length of the thoracic vertebra (T4) and the width of the fourth rib (R4). Mean±SE values of the aorta (AO) diameter, caudal vena cava (CVC) diameter, length of the fourth thoracic vertebra (T4) and the width of the fourth rib (R4) were 1.09±0.09 (0.88-1.5) cm, 1.02±0.05 (0.9-1.2) cm, 1.32±0.05 (1.2-1.54) cm and 0.46±0.03 (0.34-0.55) cm, respectively. Except for CVC/AO and CVC/R4, all mentioned parameters were negatively correlated with age and excluding T4 and R4, the rest of the parameters were positively correlated with body weight. These reference values may help in the diagnosis and future studies of cardiovascular disease in small breed dogs.

**Keywords:** Dogs, Heart, Thoracic radiography

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Thoracic radiography is used for diagnosing small animal cardiovascular and respiratory disorders. It is fairly reliable for the evaluation of left-sided affections (Saini *et al.*, 2017) and right-sided congestive heart failure. Dilation of the CVC is often listed as a radiographic finding suggestive of heartworm disease (Litster *et al.*, 2005), pericardial diseases (Gidlewski and Petrie, 2005), pulmonic stenosis (Hashiyama *et al.*, 2006), tricuspid valve regurgitation, and cardiomyopathy (Lehmukhl *et al.*, 1997). Size variability between dogs constraints comparison of absolute CVC size, but ratios of the CVC size to other anatomic structures may be useful to provide a quantitative assessment of CVC size (Lehmukhl *et al.*, 1997). Therefore, quantitative evaluation was performed to compare the average diameter of the CVC with the diameter of the aorta, length of the 4<sup>th</sup> thoracic vertebra (Hashiyama *et al.*, 2006) and diameter of the fourth rib (Lehmukhl *et al.*, 1997) in dogs. The ratio of the CVC to the aorta (AO), the ratio of the CVC to the length of the fourth thoracic vertebra, and the ratio of CVC to the width of the right fourth rib (R4) were estimated in the present study for small breed dogs.

### MATERIAL AND METHODS

The present study was carried out on six apparently healthy small breed dogs (1 Beagle, 1 Pomeranian, 4 Spitz) with 6-15 kg body weight and 18-72 months of age free from cardiothoracic diseases based on history, absence of abnormalities on physical examination, cardiac auscultation, normal thoracic radiographs and electrocardiograms. X-ray machine (Heliophos-D, Siemens Healthineers India) and computed radiography system (Regius Model 110 S

with Regius direct digitizer 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 9.5-13 mAs and 55-65 KVP. The cassettes (14x17 inches) were oriented horizontally for complete visualization of the thorax from spine to sternum and first rib to diaphragm. The length of the fourth thoracic vertebra (T4) was determined by measuring from the mid-point of the cranial endplate to the mid-point of the caudal endplate and the width of the right fourth rib (R4) just ventral to the spine. The greatest diameter of the caudal vena cava and aorta was measured perpendicular to the long axis of the vessel at the 5<sup>th</sup> intercostals space (Lehmukhl *et al.*, 1997) (Fig. 1). From these measurements, the CVC/AO, CVC/T4, CVC/R4, AO/T4, AO/R4 ratios were calculated. Mean±standard error and ranges were calculated for each measurement. Bivariate Pearson's correlation test was used to establish the correlation of various cardiothoracic parameters with age and body weight of animals (Snedecor and Cochran, 1994). The level of statistical significance was set at P<0.05 and P<0.01.

### RESULTS AND DISCUSSION

Mean±SE values of the aorta (AO) diameter and caudal vena cava (CVC) diameter, length of the fourth thoracic vertebra (T4) and the width of the fourth rib (R4) were 1.09±0.09 (range 0.88-1.5) cm, 1.02±0.05 (0.9-1.2) cm, 1.32±0.05 (1.2-1.54) cm and 0.46±0.03 (0.34-0.55) cm, respectively. Measurement of the CVC has been applied to assess right heart function (Aycock *et al.*, 2014) and to monitor the effectiveness of therapy in patients with

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**Table 1. Mean ± S.E. values of various cardiac parameters and their ratio in right lateral thoracic radiographs**

Case no.	AO (cm)	CVC (cm)	T4 (cm)	R4 (cm)	CVC/ AO	CVC/ T4	CVC/ R4	AO/ T4	AO/ R4
1.	1.5	1.2	1.3	0.55	0.8	0.92	2.1	1.15	3
2.	1.1	0.9	1.4	0.5	0.8	0.64	1.8	0.78	2.2
3.	0.98	1.2	1.24	0.37	1.22	0.94	3.24	0.79	2.6
4.	0.88	1	1.24	0.34	1.13	0.80	2.94	0.70	2.58
5.	0.92	0.92	1.54	0.55	1	0.59	1.67	0.59	1.67
6.	1.2	0.9	1.2	0.45	0.75	0.75	2	1.00	2.66
Mean ± S.E.	1.09±0.09	1.02±0.05	1.32±0.05	0.46±0.03	0.95±0.08	0.77±0.05	2.29±0.26	0.83±0.08	2.45±0.18
Correlation with age	-0.568	-0.570	-0.203	-0.436	0.159	-0.328	0.081	-0.378	-0.292
Correlation with bodyweight	0.347	0.66	-0.285	-0.069	0.210	0.640	0.357	0.383	0.569

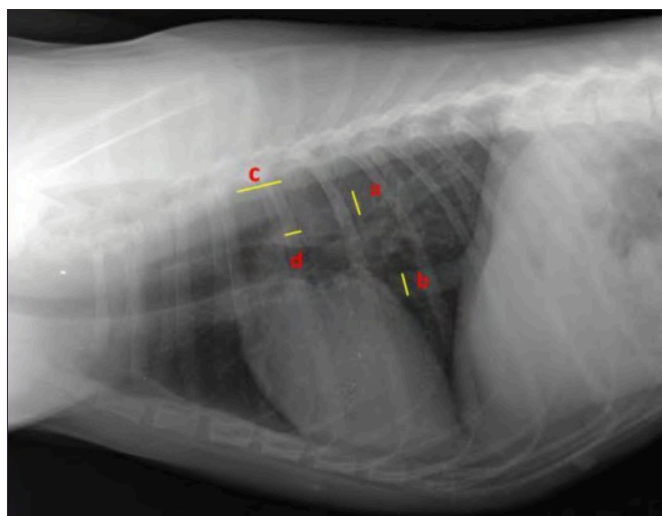


Fig. 1. Right lateral thoracic radiograph showing the measurements landmarks (a) diameter of aorta, (b) diameter of caudal vena cava, (c) length of T4 and (d) width of R4.

congestive heart failure (Kaufman *et al.*, 2005). Radiography correlates to elevated right-sided cardiac pressures and a dilated, tortuous or more radiopaque caudal vena cava (Dew *et al.*, 2005) as rising central venous pressure dilated CVC because failing right atrium cannot accommodate the systemic venous return. Studies by Losonsky *et al.* (1983) found that the CVC/R4 ratio was more confirmatory for heartworm infestation as a normal-appearing caudal vena cava sometimes misleading for right heart failure. The ratio of the CVC to the descending aorta, thoracic vertebra length and fourth rib width on a right lateral radiograph were useful indicators of right heart disease (Kumar *et al.*, 2019). The present study showed Mean±SE values of CVC/AO, CVC/T4 and CVC/R4 as 0.95±0.08 (0.8-1.22), 0.77±0.05 (0.59-0.94) and 2.29±0.26 (1.8-2.94), respectively.

According to Kwak *et al.* (2018), by ultrasound, the CVC/AO ratio can be used for identifying the presence of a dehydrated state in normal beagle dogs. The reverse ratio i.e. AO/CVC can also be used to detect the presence of systemic hypertension and prompt evaluation of blood pressure ultrasonographically (Holland *et al.*, 2020). As

per Vosugh and Nazem (2019), CVC/AO and CVC/R4 ratios were sensitive in Domestic shorthair cats with right heart failure compared to healthy ones. According to Lehmukhl *et al.* (1997), the ratio of CVC/AO may also be increased by a small aorta due to decreased cardiac output associated with the underlying cardiac disease other than an enlarged CVC.

The ratio of the diameter of caudal vena cava to the length of T4 is a valuable parameter in the radiographic evaluation of the heart since elevated values are suggestive of right-sided congestive heart failure (Hashiyama *et al.*, 2006). Lehmukhl *et al.* (1997) documented that the dogs with right heart disease had larger caudal vena cava size than normal dogs as determined by the ratios CVC/AO, CVC/VL and CVC/R4. Lehmukhl *et al.* (1997) also identified certain cut off values for these ratios that distinguish between normal and abnormal dogs i.e. CVC/AO < 1.00, CVC/VL < 0.80, or CVC/R4 < 2.25 would indicate a dog without right-sided heart disease; whereas, CVC/AO > 1.50, CVC/VL > 1.30, or CVC/R4 > 3.75 would be considered positive for right-sided heart disease. The present study values lie within the normal ranges as suggested by Lehmukhl *et al.* (1997). In the present study, mean±SE values of AO/T4 and AO/R4 were 0.83±0.08 (0.59-1.15) and 2.45±0.18 (1.67-3), respectively. These ratios are helpful in evaluating cardiac diseases. Lehmukhl *et al.* (1997) found that the AO/VL ratio was smaller in dogs with right heart disease.

Aortic diameter (AO), Caudal vena cava, CVC/T4, AO/T4 and AO/R4 were positively correlated with age and negatively correlated with body weight. A negative correlation with age and body weight was evident with T4 and R4 and a positive correlation was identified with CVC/AO and CVC/R4, respectively. The findings of R4 with age and body weight were in accordance with Kumar *et al.* (2019), T4 with Kumar *et al.* (2019) and CVC/AO, CVC/R4 and AO/T4 were in compliance with the findings of Mishra (2019).

In conclusion, radiographic evaluation of CVC, AO, R4 and T4 and their respective ratios can be considered valuable parameters and in future studies, they may provide a diagnostic value to evaluate cardiac diseases in dogs.

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