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Radiographic Mensuration of Caudal Vena Cava, Aorta, Vertebral Length and Fourth Rib Width and Ascertaining their Ratios in Healthy Dogs

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ABSTRACT

Background: Caudal vena cava generally travels from the abdominal cavity to the right atrium and visible on lateral thoracic radiograph. Dilation of Caudal vena cava is generally considered as an abnormality for diagnosis of right-side heart failure. Normal range of ratio of caudal vena cava to associated structures can help in differentiating normal dogs from abnormal dogs. The present study was aimed to find such ratio in normal dogs and their clinical relevance.

Methods: The present study was conducted on 19 healthy dogs of either sex belonging to different age-groups presented to the Department. They were anaesthetized and subjected to thoracic radiography in standard positions. The width of caudal vena cava (CVC), the descending aorta (AO), right fourth thoracic rib (R4) and the length of thoracic vertebrae (VL) were measured in left lateral (LeL) radiographic views to calculate ratios like CVC/AO, CVC/VL, CVC/R4, AO/VL, AO/R4.

Result: The results revealed a wider range of some of such ratios than those reported so far by other workers for healthy dogs. Moreover, a wide variation in shape of CVC and size of R4 was noticed in individuals. It is concluded that the existing range of such ratio needs to be modified for better clinical relevance and overall such ratios do not represent a sensitive diagnostic modality.

Key words: Aorta, Caudal vena cava, Dogs, Fourth rib, Vertebral length.

INTRODUCTION

The right-side heart disease causing pooling of blood in right atrium is associated with increased pressure in the vessels delivering blood to the right atrium and the body's veins and capillaries. Dilation of the caudal vena cava (CVC) had been reported as a radiographic finding suggestive of right-sided congestive heart failure (Suter and Lord, 1984). Thus, measurement of CVC size and its ratio with other fixed-sized surrounding structures can help in detection of right-side heart disease in dogs.

Traditionally, radiographic measurements of CVC diameter have been compared with the length of vertebrae at the level of tracheal bifurcation, the descending aorta and the width of 4th rib to calculate their ratios whose normal range have been suggested for healthy dogs to help detecting right-sided heart diseases. However, based on the previous clinical experience at the present institute, it was hypothesized that measurements of such structures may not conform to the previously defined limits for healthy dogs in a normal manner. Therefore, the present study was undertaken to test such hypothesis and also to generate the regional baseline data of such ratios in healthy dogs and to ascertain the utility of such exercise.

MATERIALS AND METHODS

The present study was conducted on 19 healthy dogs of either sex belonging to different age-groups presented to the Department of Veterinary Surgery and Radiology, DGCN College of Veterinary and Animal Sciences, CSKHP Agricultural University, Palampur, India for various elective surgeries.

The objective of the study was to ascertain the range of ratio of caudal vena cava (CVC), the descending aorta (AO), right fourth thoracic rib (R4) and the length of thoracic vertebrae (VL) in the thoracic radiographs of normal healthy dogs.

No dog showed any symptom of cardiac enlargement and were free from cardiac murmurs. All the dogs were

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subjected to thoracic radiography under anaesthesia after obtaining permission from their owners. All dogs were premedicated with induced with Inj. Atropine @ 0.04 mg/kg (Tropine, Neon Laboratories Ltd., India) BW SC and induced with Inj. Xylazine (Xylaxin, Indian Immunologicals Ltd., India) @ 1.5-2 mg/Kg and Ketamine (Aneket, Neon Laboratories Ltd., India) @7.5-10 mg/Kg IM. After ascertaining the normal shape and size of their heart as per vertebral heart score (VHS) in right lateral (RtL) and cardio-thoracic ratio (CTR) in dorsoventral (DV) radiographic views, the left lateral (LeL) thoracic radiographs were utilized to measure the greatest diameter of CVC not overlapping the heart or diaphragm; the diameter of the AO at the same intercostal space; diameter of the R4 just ventral to the spine and the VL over tracheal bifurcation as per Lehmkuhl *et al.* (1997).

The diameters of the vessels were measured perpendicular to their long axis and the thoracic vertebral lengths were measured (in mm) at their mid-body levels (Plate 1) using digital scale. The mean (± SD) ratios of CVC/VL, CVC/R4, CVC/AO, AO/VL and AO/R4 were calculated and their range recorded. These were compared with previously established ratios and ranges for healthy dogs.

RESULTS AND DISCUSSION

The mean and range of different ratios like CVC/AO, CVC/VL, CVC/R4, AO/VL, AO/R4 are given below in Table 1. Out of 19 radiographs, the CVC and AO measurements could not be taken in one different case each due to inadequate radiographic sharpness at the particular segment. Therefore, the CVC/AO ratio was eventually calculated in 17 cases and the remaining ratios in 18 cases.

Table 1: Ratios of the diameters of caudal vena cava, aorta, vertebral length and fourth rib width in healthy dogs.

	Range	Mean±SD
CVC/AO (Nos.17)	0.42-1.30	0.79±0.22
CVC/VL (Nos. 18)	0.34-1.11	0.68±0.21
CVC/R4 (Nos. 18)	0.65-2.2	1.63±0.44
AO/VL (Nos. 18)	0.71-1.18	0.84±0.12
AO/R4 (Nos. 18)	1.53-2.59	2.05±0.32

Mean CVC/AO ratio was calculated to be 0.79±0.22 with a range of 0.42-1.30. Similarly, mean CVC/VL ratio was 0.68±0.21 (range: 0.34-1.11); CVC/R4 was 1.63±0.44 (range: 0.65-2.2); AO/VL was 0.84±0.12 (range: 0.71-1.18) and AO/R4 was 2.05±0.32 (range: 1.53-2.59).

Measurement of caudal vena cava size and its ratio with other surrounding structures can provide information about pathogenesis of right-side heart disease. Lehmkuhl *et al.* (1997) suggested ratio of CVC/AO > 1.50, CVC/VL > 1.30, or CVC/R4 > 3.50 as a strong indicator of right-sided heart abnormality in dogs whereas, dogs having ratio of CVC/AO < 1.00, CVC/ VL < 0.80, or CVC/R4 < 2.25 could be considered normal definitively. In another study on 200 dogs, Losonsky *et al.* (1983) reported mean CVC/R4 ratio as 2.07±0.69 in normal sized hearts of dogs. Whereas, it was 2.25±0.64 in cases of moderately enlarged hearts and 2.60±.68 in severely enlarged hearts. Similarly, Thrall and Calvert (1983) reported CVC/R4 ratio as 2.95±0.76 in 28 dogs with history of heartworm disease and right heart failure. However, their study showed that normal caudal vena cava size was an insensitive indicator of heart worm induced right heart failure in dog.

In the present study, though the higher range of these ratios remained less than those indicative of right-sided heart abnormality as per both of the above-mentioned studies, yet the range of CVC/AO and CVC/VL exceeded the levels suggested to consider the dogs normal in a definitive manner. However, overall, the mean values remained within the normal range. Moreover, in one case, the CVC/R4 ratio was found to be quite close to the mean reported by Losonsky *et al.* (1983) in cases of moderately enlarged hearts in dogs, whereas, the heart size in that particular dog was considered normal on the basis of VHS and other parameters and it did not show any clinical signs

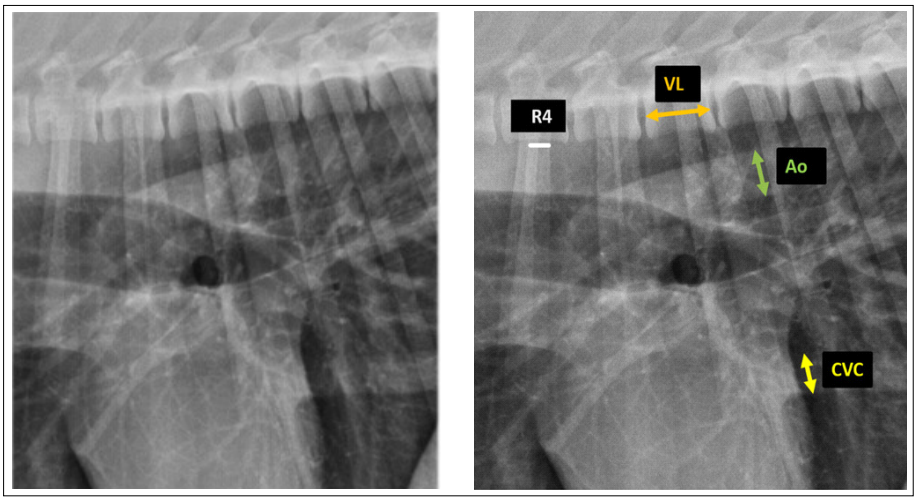
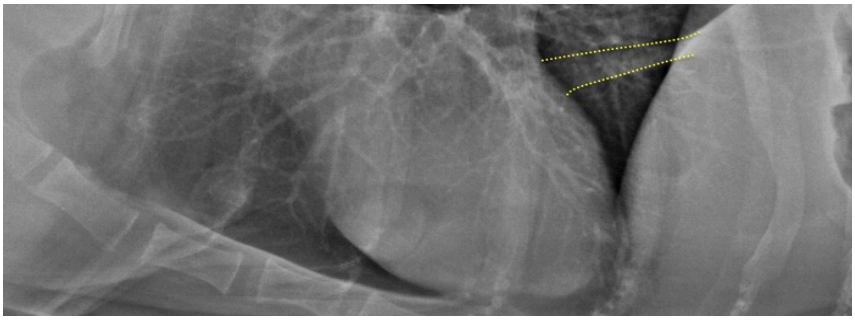


Plate 1: Measurements of caudal vena cava, aorta, vertebrae and rib in left lateral thoracic radiograph of dog.

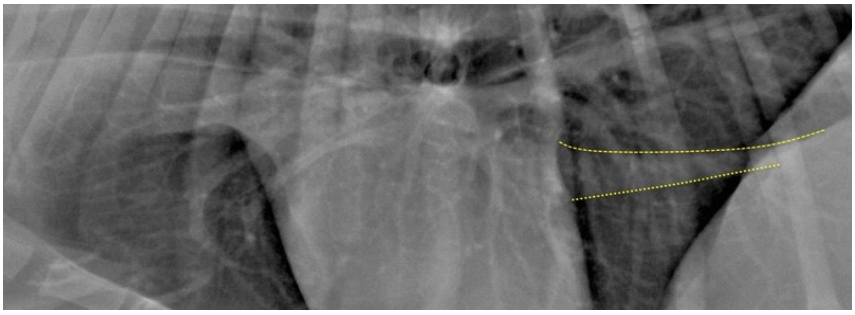
associated with cardiomegaly. This signifies a much greater individual variations of such radiographic biometric parameters in healthy dogs than those reported by Lehmkuhl *et al.* (1997) or Losonsky *et al.* (1983). It was also admitted by Lehmkuhl *et al.* (1997) that such parameters were likely to help only a minority of clinical patients as most patients would fall outside their range.

In a similar yet limited study in the same geographical area, Sharma (2018) reported range of mean ratio of CVC/VL from 0.66±0.11 to 0.97±0.10 and to that of CVC/R4 from 1.56±0.26 to 2.03±0.16 in different breeds of dog. There were significant differences ($P<0.05$) in CVC/VL ratios in between different breeds of dogs though no direct correlation was found in between the size of dogs and this ratio. For example, the CVC/VL ratios of Pugs and Rottweilers were found significantly greater than Pomeranians, German Shepherds and mongrels. On the other hand, no significant difference was found in CVC/R4 ratio in different breeds of dogs implying that this ratio might be more useful than CVC/VL for clinical relevance. However, as the mean CVC/VL ratios in that study were found to be higher than collective mean CVC/VL ratio in the present study, it can be concluded that a greater range exists in such measurements in a normal manner.

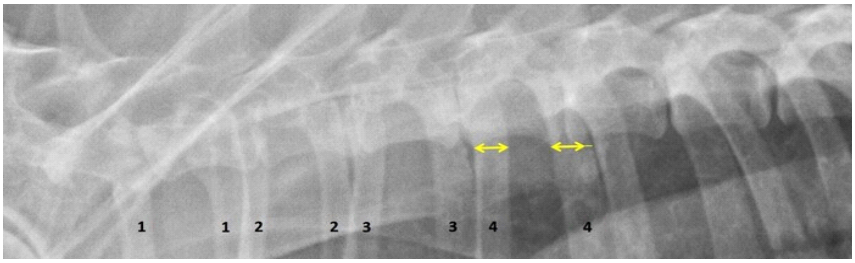
As regards to AO/R4 ratio is concerned, Lehmkuhl *et al.* (1997) reported insignificant difference in this ratio in between healthy (2.36±0.52) and right-side heart disease (2.22±0.42) dogs. However, mean AO/VL ratios were found to be lesser in dogs with right side heart disease (0.80 ±0.10) than that seen in healthy ones (0.90±0.15). Similarly, Vosugh and Nazam (2017) reported low AO/VL ratio in domestic short haired cats with right heart failure (0.68±0.050) as compared to that recorded in healthy subjects (95±0.03). In the present study, the AO/VL ratio of healthy dogs remained in between the mean values for healthy and the ones with right side heart disease as reported by Lehmkuhl *et al.* (1997).



Conical shape of CVC in cases where heart is in relatively tilted position with greater contact with sternum



Stretching of CVC due to manual inflation of lungs in anaesthetized dog



Non-uniform width of left and right R4 at the same level in cases of too much arched rib conformation

Plate 2: Effect of thoracic conformation and inflation of lungs on measurements of CVC and R4 in healthy dogs.

In the present study, the diameter of CVC showed a wide range of measurements from 6.14 to 19.45 mm in different dogs. The shape and size of CVC differed greatly with in same dog depending upon various factors. Generally, in cases where the heart remained in relatively upright position in thorax, the diameter of CVC remained uniform from heart to diaphragm. Whereas, in cases where it was titled a bit more or there was greater contact of heart with sternum due to normal body conformation, the CVC assumed a somewhat conical shape with lesser diameter towards diaphragm and greater towards heart sometimes with as much as 3 times difference in between them. Similarly, when the lungs were inflated to its fullest extent, the CVC stretched and its diameter reduced greatly (Plate 2). Besides, the margins of CVC weren't found uniformly clear in all radiographs across its visible segment and hence, the measurements were taken from the clear sections which might not be always truly reflective of their greatest diameters.

Similarly, differences were found in the measurements of R4 width with in the same animal at different segments of R4. Though for maintaining uniformity the measurements of R4 were taken just underneath the vertebrae but in some animals with wide chest where the ribs were too much arched at their origin, the measurements of right and left ribs were not found equal at this level. And, this augment didn't represent the most proximal aspect of rib as well.

CONCLUSION

It was concluded that the thoracic radiographic biometry utilizing measurements of CVC, VL, AO or R4 was not a sensitive tool for diagnostic inference or perhaps not unless identical conditions were maintained with regards to radiographic positions of the subject, inflation of lung and the site of measurement of CVC in different thoracic radiographs.

Further, there was much greater regional or individual variation in the range of CVC/AO and CVC/VL ratios in healthy dogs than those reported earlier to qualify them normal in a definitive manner.

Conflict of interest

All authors declare that they have no conflict of interest.

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