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A NEW METHOD FOR ULTRASONOGRAPHIC MEASUREMENT OF KIDNEY SIZE IN HEALTHY DOGS

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Abstract

Introduction**:** The authors propose a simple method for assessment of canine kidney size derived from the radiological technique described by Finco et al. in 1971.

Methods: In 26 healthy dogs ultrasonography was used to measure the length, height, and thickness of each kidney. These measurements were correlated with the lengths of the fifth and sixth lumbar vertebrae (L5 and L6), also measured by ultrasound. The resulting values were compared with the linear correlation method and the ratios defined using descriptive statistics.

Results: No significant differences were observed between the dimensions of the right and left kidneys. The length of both kidneys displayed significant correlation with both the length of L5 and that of L6. In both cases, the renal: vertebral length ratios ranged from 1.3 to 2.7.

Discussion: The ratio of kidney length to the length of L5 or L6 can be considered a useful parameter for assessing the size of the kidneys in healthy dogs. The normal range we identified in this study (from 1.3 to 2.7) is sufficiently narrow to allow sonographic detection of even limited changes in renal length.

Introduction

Ultrasonography is currently considered the first step in imaging assessment of the canine kidneys. The information it provides on the structure of the kidney is often nonspecific, but it is nonetheless a very useful diagnostic guide. However, evaluating the size of the organ is still problematic: reliable normal ranges for the canine kidney have never been precisely defined, largely because of the wide variation in this parameter related to breeds and canine morphology [1].

Mareschal et al. have proposed the kidney-to-aorta ratio (i.e., the ratio of the longitudinal diameter of the kidney to the diameter of the aorta during systole) as a tool for assessing renal size in dogs. Their experience indicates that ratios between 5.5 and 9.1 are indicative of a normal-sized kidney [2]. However, this reference range is fairly broad, and it may not allow the identification of minimal changes in kidney size.

The purpose of this study was to determine whether the radiological method proposed by Finco [3] can be adapted for use in ultrasonography. This method, which is still considered the only method for practical evaluation of renal size in dogs, is based on the relationship between the length of the kidney and that of the second lumbar vertebra (renal length / length of L2), and values ranging from 2.5 to 3.5 are regarded as normal.

Material and methods

The study population consisted of 26 clinically healthy dogs (aged > 1 year, weights 5-32 kg) with normal renal function (urea, creatinine) and normal urinalysis results (specimen collected by cystocentesis). Dogs were not included if they had any of the following: history of previous renal or vertebral disease; sonographic abnormalities of the kidneys; current drug therapy of any type; history of intravenous fluid administration during the 48 hours preceding the sonographic examination.

The animals were examined after a fast of at least 12 h, and no sedation was used. Scans were performed with an Esaote MyLab 70 X VISION scanner and multifrequency microconvex (3-9 MHz) and linear (4-12 MHz) probes. For each animal, the following ultrasound images were obtained: longitudinal sections of the right and left kidneys (RK, LK) passing through the renal pelvis, cross-sections of the RK and LK passing through the hilum, cross section of the aorta during diastole near the origin of the left renal artery, and longitudinal sections of L5 and L6.

The images of the RK and LK were obtained with the animal in the left and right lateral recumbent positions, respectively. For each kidney, we measured the maximum length (during the longitudinal scan through the renal pelvis) and the maximum width and depth (on the transverse scan through the pelvis) (Figs. 1-2).The aortic luminal diameter was measured in transverse plane just caudal to the origin of the left renal artery. Measurements were made from still images acquired at maximal luminal diameter, after reviewing cineloop frames to account for pulsation of the aorta. Measurement cursors were placed at the margins of the lumen, excluding the vessel walls (Fig. 3).

The images of the vertebrae were acquired with a linear probe during oblique scans done in the dorsal plane, ventral to the transverse processes of the lumbar vertebrae. We first identified the lumbosacral junction, which has a characteristic appearance, and then proceeded cranially, identifying in sequence L7, L6, and L5 (Figs. 4-5). Continuous scanning in the cranial direction to identify all the lumbar vertebra was not possible in all cases due to the obstacle represented by the proximal portion of the costal arch.

All measurements were recorded on a Microsoft Excel spreadsheet. Using the method proposed by Mareschal [2], we calculated the kidney:aorta ratio (longitudinal diameter of the kidney to the diameter of the aorta) for each kidney (Table 1). For each renal variable measured (length, width, thickness) we calculated the mean, median, and standard deviation (SD) (Table 2).

Using linear correlation analysis, we then performed a preliminary evaluation of the correlation between each renal parameter and the lengths of L5 and L6. For ratios that displayed a statistically significant linear correlation ($P < 0.05$), we used the Student's t-test (with 95% confidence intervals) to analyze the significance of our sample compared with the population. For this purpose, we used the ratios of mean (SD) kidney to mean (SD) vertebral parameters (e.g. mean RK length:mean L5 length, mean RK length: mean L6 length, etc.).

To determine whether a single reference range could be identified for the kidney:vertebra ratio, we used analysis of variance (ANOVA) to verify that there was no statistically significant ($P < 0.05$) difference between the sizes of the RK and LK.

The mean kidney:vertebra ratio (kidney size / size of L5 or L6) ± 2 SD was considered the reference range for the ratio of sonographically measured kidney dimensions (statistically significant in the tests cited above) and the lengths of L5 and L6.

Results

The 26 dogs included 9 males (1 of which was castrated) and 16 females (14 of which were spayed). Ten different breeds were represented (3 Labrador Retrievers, 2 Cocker Spaniels, 2 German Dachshunds, 2 Pitt Bull Terriers, 2 American Staffordshire Bull Terriers, 1 Miniature Doberman Pinscher, 1 Doberman Pinscher, 1 English Setter, 1 Italian Spinone, 1 Irish Setter), and there were also ten mixed breed dogs. Nine (34%) of the 26 dogs in the sample were intact males, 1 (4%) was a neutered male, 2 (8%) were intact females, and 14 (54%) were spayed females. Ages ranged from 1 to 11 years with an average of 5.9 years (SD: 3.3). Weights ranged from 5 to 32 kg with an average of 19 kg (SD: 9.12); 13 dogs (50%) weighed between 5 and 19 kg, and the other 13 (50%) had weights ranging from 21 to 32 kg.

Table 1 shows the renal length:aortic diameter ratios obtained as described by Mareschal et al. [2]. The mean values, SDs, and median values for each LK and RK dimension and for the lengths of L5 and L6 are reported in Table 2.

Significant linear correlations (P> 0.05) were observed for the following kidney/vertebra relationships: length of RK and L5 (r = 0.738, P <0.01); length of RK and L6 (r = 0.702, P <0.01); length of LK and L5 (r = 0.620, P <0.01); length of LK and L6 (r = 0.611, P <0.01); height of LK and L5 (r = 0.690, P = 0.046); height of LK and L6 (r = 0.563, P = 0.042). All other ratios had P values > 0.05. Because the height of the RK was not significantly correlated with L5 or L6, we also excluded the height of LK from subsequent analyses.

The relationships displaying significant correlation were then analyzed with the Student t-test (with 95% confidence intervals) to determine whether our sample could be considered significant for the population (Table 3).

ANOVA revealed that there was no statistically significant difference between the lengths of the right and left kidneys (P = 0.778). Therefore, it was possible to consider the lengths of both kidneys—right and left. The average of the two measurements (mean kidney length, Km) was then analyzed to identify its relationship with the lengths of L5 and L6. The reference ranges (± 2 SDs from the mean) thus obtained were: Km:L5 ratio = 1.33–2.65; Km:L6 ratio= 1.28–2.76.

Discussion

In veterinary radiology, the length of the kidney is compared with that of L2 or L3, but during ultrasonographic examinations, these vertebrae are not as easy to identify. To identify a lumbar vertebra, the transducer is placed over the lumbosacral junction and then moved cranially, maintaining contact with the skin surface. It was difficult to maintain scanning continuity all the way to L2 or L3, in part because cranial progression of the transducer was hindered by the presence of the costal arch. For this reason, we decided to use the last three lumbar vertebrae (L5, L6, and L7) as our references.

The lengths of L5 and L6 were measured as the distance between the two intersomatic surfaces, starting from the point of maximum contiguity with the intersomatic surface of the vertebrae immediately above and below the one being measured. In a future study, we intend to assess the correlation between the size of a canine vertebral body measured first with the radiological method and subsequently with sonographic described above. This will allow us to verify that the sizes of the structures measured radiologically are similar to those measured by ultrasound. This step was not carried out before the present study because we did not intend to compare our results directly with those obtained with the Finco method, but only to verify the applicability of our method.

Subsequently, we concentrated our attention solely on L5 and L6 in view of the anatomical changes that can affect L7 (heteromorphisms such as sacralization). In fact, reproducibility is a fundamental requisite for any measurement method used in clinical practice [2], so our term of comparison had to be easily identifiable. In the absence of relevant data in the literature that could help us, we then had to decide how the vertebral bodies would be measured. On scans carried out perpendicular to the longitudinal axis of the vertebrae (as much as possible), one can observe acoustic attenuation artifacts (acoustic shadows) related to the intersomatic spaces (Fig.1), and these can be useful for delimiting the extremes of the measurement. During image acquisition, the most frequently encountered problems were related to visualization of the cranial pole of the right kidney, which is situated more cranially than the left kidney. For this reason, it was not always immediately identifiable. Several scans had to be made to obtain a frame with an accurate, measurable image.

No problems were encountered acquiring transverse images of the aorta near the renal hilum in the systolic phase. It is important to note that, in the cases just mentioned, the kidney-to-aorta ratio is still close to the limits of the normal range. In only 9 cases, the ratio fell within the central portion of the reference range indicated by Mareschal [2]. A similar situation was observed in 3 cases for the left kidney alone and in one case only for the right kidney.

Although the borderline nature of the normal kidney-to-aorta ratios in the above-mentioned cases must be stressed, we were also surprised to find ratios in the central part of the Mareschal range [2] in only 9 cases.

Analysis of the linear correlations between renal dimensions (length, width and thickness) and the lengths of vertebrae L5 and L6 revealed significant correlation only for the lengths of the two kidneys ($P < 0.01$). Actually, the height of the left kidney also displayed significant correlation with the sizes of the lumbar vertebrae. However, this finding was not taken into consideration because the correlation regarded only the left kidney. Therefore, it could not be used to determine a normal range that could be used to assess both kidneys.

The Student t tests performed on the pairs of ratios mentioned above revealed strong statistical significance ($P < 0.01$), which indicates that our sample can indeed be considered representative of the population.

The results of our ANOVA show that there is no significant difference between the lengths of the RK and LK measured ultrasonographically: therefore, the ratios of kidney length to vertebral length can be considered reliable for both the RK and LK.

The reference ranges we established for these ratios, which spanned 2 standard deviations from the mean, are reported below:

Range: Km/L5 = 1.33 – 2.65

Range: Km/L6 = 1.28 – 2.76

The two intervals are clearly very similar—indeed, if the values were rounded to a single decimal place, the two ranges would be virtually identical (range: Km / Length of lumbar vertebrae (Lv) = 1.3–2.7, where Km indicates the mean length of the two kidneys and Lv indicates the length of L5 or L6.

From a speculative point of view, two main observations should be made.

The first regards the difference between our reference ranges and those described for radiologically measured ratios. A possible explanation for this difference is that the lumbar vertebrae we used (L5-L6-L7) are empirically (from a radiographic point of view) and significantly longer than L2 and L3.The ratio of kidney length to the length of a longer vertebra will naturally be smaller. The second observation relates to the similarity between the ratios based on of the lengths of L5 and L6. Indeed, both of these vertebrae can be used as a term of comparison. From a practical point of view, L6 is obviously easier to identify, but if the borders of this vertebra cannot be easily identified (owing, for instance, to the presence of spondylopathy), kidney size can still be reliably assessed in terms of its relation to L5.

Our sample was not sufficiently large to allow analysis of eventual sex-related differences, but there are no data in the literature indicating that the dimensions of the kidneys or the lumbar vertebrae are subject to such differences.

As for age, it is important to recall that in this study we examined only adult dogs. In the future, it will be interesting to see whether the rapid physical development that occurs in puppies has any influence the dimensional relationships we have identified.

Finally, it should also be noted that the size of our sample is identical to that proposed by Finco [3] to establish the radiological range of normality of the ratio between renal length and lumbar vertebrae.

Conclusions

On the basis of the data obtained in this study, calculating the ratio of kidney length to L5 or L6 length appears to be a useful method for evaluating the size of the canine kidney in clinical practice. In our opinion, this approach offers several advantages. First, the measurements used to calculate the ratio are sufficiently easy to obtain without complex reference tables like those reported by

Barrera et al. [1]. In the cases we examined, ultrasonographic images of the the last lumbar vertebrae were acquired without any particular difficulty.

The normal range for the ratio (1.3 to 2.7) is narrow enough to allow sonographic detection of even limited changes in the length of the kidney. In our opinion, the most significant objection that can be leveled against the method proposed by Mareschal [2] is the breadth of the range of "nonpathological" kidney-to-aorta ratios (from 5.5 to 9.1). Moreover, in several of the animals in our study—all clinically classified as free from kidney disease and in particular from conditions that could affect kidney size—the ratio of renal length/aortic diameter resulted outside of the reference values for normality indicated in that study.

However, there are also some critical issues that should be reported in relation to our method. First, the presence of severe, extensive lumbar spondylosis can make it difficult to identify the limits between the intersomatic surfaces of the vertebra, although in our experience the difficulty was never substantial enough to prevent measurement. Second, further investigation is needed to determine whether the reference values we identified are also valid for chondrodystrophic and/or brachymorphic breeds.

The authors have no conflict of interest to declare relative to the present article.

References

[1] Barrera R, Duque J, Ruiz P, Zaragoza C. Accuracy of ultrasonographic measurements of kidney dog for clinical use. Revista Cientifica 2009;6:576-83.

[2] Mareschal A, d'Anjou MA, Moreau M, Alexander K, Beauregard G. Ultrasonographic measurement of kidney-to-aorta ratio as a method of estimating renal size in dogs. Vet Radiol Ultrasound 2007;48(5):434–8.

[3] Finco DR, Stiles NS, Kneller SK, Lewis RE, Barrett RB. Radiologic Estimation of kidney size of the dog. J Am Vet Medic Assoc. 1971;159(8):995-1002.

Table 1. Ratios of kidney length to aortic diameter measured in each dog in our study

Dog	RK/Ao	LK/Ao
1	4.82	5
2	5.63	5.84
3	5.35	5.28
4	5.54	5.32
5	5.22	4.98
6	5.54	6.42
7	6.15	5.04
8	5.5	5.89
9	5.76	5.7
10	6.52	6.45
11	7.12	7.11
12	5.1	5.45
13	5.18	4.72
14	5.94	5.5
15	6.53	6.89
16	5.77	5.66
17	5.89	5.05
18	5.41	5.58
19	5.35	5.02
20	7.06	6.45
21	4.08	4.94
22	6.61	6.65
23	7.6	7.41
24	6.54	6.45
25	6.96	7.2
26	6.64	6.23

RK = right kidney, LK=left kidney; Ao = aorta

Table 2. Mean, medians, and standard deviations (SD) of renal and vertebral dimensions measured with ultrasound

	RK length	***RK height***	***RK thickness***	***LK length***	***LK height***	***LK thickness***	***L5***	***L6***
Mean	5.865 cm	3.277 cm	3.278 cm	5.785 cm	3.301 cm	3.329 cm	2.97 cm	2.95 cm
Median	5.77 cm	3.31 cm	3.41 cm	5.79 cm	3.3 cm	3.3 cm	2.96 cm	3 cm
SD	1.017	596	659	1.068	537	764	0.62	0.67

RK = right kidney; LK=left kidney; L5 = fifth lumbar vertebra; L6 = sixth lumbar vertebra

Table 3: Student t-test results for kidney-to-vertebra ratios with P values of <0.05.

Kidney-to-vertebra ratios	***P***	***Risultati***
RK length : L5	<0.01	95% CI for difference from 2.42 to 3.36; t = 12.673 with 50 degrees of freedom.
RK length : L6	<0.01	95% CI for difference from 2.43 to 3.39; t = 12.242 with 50 degrees of freedom.
LK length : L5	<0.01	95% CI for difference from 2.33 to 3.30; t = 11.680 with 50 degrees of freedom.
LK length : L6	<0.01	95% CI for difference from 2.34 to 3.33; t = 11.466 with 50 degrees of freedom.

RK = right kidney; LK=left kidney; L5 = fifth lumbar vertebra; L6 = sixth lumbar vertebra

Figure legends

Fig. 1. Example of renal measurements made on a retrocostal longitudinal scan. Mixed-breed intact male dog (age 11 years, weight 31 Kg).

Fig. 2. Example of renal measurements made on a retrocostal transverse scan. Mixed-breed intact male dog (age 11 years, weight 31 Kg).

Fig. 3. Measurements of the diameter of the aorta during diastole on a retrocostal transverse scan. Mixed-breed spayed female dog (age 1.5 years, weight 6 Kg).

Fig. 4. Measurement of the 6^{th} lumbar vertebra on a retrocostal longitudinal scan. Mixed-breed spayed female dog (age 9 years, weight 19 Kg).

Fig. 5. Measurement of the 5^{th} lumbar vertebra with artifacts caused by the intersomatic spaces. Retrocostal longitudinal scan.