



ORIGINAL ARTICLE

Radiological Assessment of the Ratio of Kidney Length to the Length of Lumbar Vertebrae in Cats Referred to Tehran-Pet Clinic

Reza Behmanesh ¹, Zahra Sorouri ²

¹ Department of Radiology, Faculty of Veterinary Sciences, Islamic Azad University, Garmsar Branch, Garmsar, Iran. ² Graduated from Faculty of Veterinary Sciences, Islamic Azad University, Garmsar Branch, Garmsar, Iran.

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ABSTRACT

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This study includes the measurement of both kidneys and lumbar vertebrae (from L1 to L7) using radiography of 38 adult cats, including 22 male cats and 16 female cats in the ventrodorsal (VD) view. Radiographs were prepared in DICOM format. Then we obtained the ratio of the length of each of the right and left kidneys to each of the lumbar vertebrae. Two independent two-sample t-test and Pearson's test were used to check the relationship between the variables. The results showed that out of 38 cats included in this study, 16 cats, 42.1% of them were female and 22 cats, 57.9% of them were male. It was observed that among the vertebrae, on average, L1 had the shortest length and L5 had the longest length. The male and female groups had statistically significant differences in terms of the average length of the right and left kidney as well as the length of the L1 vertebra. The length of the left and right kidneys as well as the length of the L1 vertebra in male cats were significantly higher than in female cats. The average ratio of the length of the right kidney to the L1 to L7 vertebrae in male cats was significantly higher than these ratios in female cats. The two groups of male and female cats do not have a statistically significant difference in terms of the average ratio of the length of the left kidney to the L1 to L7 vertebrae. The length of the right and left kidneys has a direct and significant statistical relationship. It was also observed that the length of the right kidney in cats has a direct and significant statistical relationship with the length of the L1 vertebra.

Introduction

Radiographs are useful for detecting changes in the size and final shape of the kidneys and for diagnosing diseases of the extraperitoneal areas. Radiopaque kidney stones are also recognized by x-ray. In cases of suspicion of urinary tract obstruction, radiography should always be done because. Plain radiographs should always be obtained if there is a history of trauma to the abdomen or pelvis with urinary tract involvement or if there is a mass in the dorsoabdominal region. The left kidney is often completely defined by fat, while in many cats only the posterior end of the right kidney is visible. The anterior pole of the right kidney is often not clearly visible because

it is covered by the caudal lobe of the liver. The right kidney is usually located at the level of the 13th rib. The left kidney is usually more posterior, and in animals with a large amount of extraperitoneal fat, it is located more ventrally.¹ In the dorsoventral view, the right kidney is often superimposed by the liver and other abdominal organs, while the left kidney is typically visible posterior to the fundus of the stomach and the posterior-median region to the superior end of the spleen. Kidneys are usually seen on a plain radiograph of the cat's abdomen. Feline kidneys are round or oval. In lateral radiographs, the posterior pole of the right kidney may overlap with the anterior pole of the left kidney. This radiographic

 Corresponding author. Email: dr.rezabehmanesh@yahoo.com

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view may be imagined. A mistake of the presence of a small round kidney or an extraperitoneal mass. In cats, the absence of kidneys in a simple radiograph means the need for more abdominal examinations.¹

Excretory urography is a method for diagnostic imaging of the urinary tract, in which contrast media containing iodized compounds are used. If these contrast media are used by injection; it enters the renal glomeruli through the blood stream and through the kidney are filtered and thus accumulate in the kidney tissue and makes the kidney parenchyma tissue, urinary tract, ureter and bladder to be seen more clearly.² Also, this is a diagnostic imaging method of the urinary system that helps the radiologist to appropriately understand the anatomy and function of the kidney, examine the ureters and bladder and if changes in body fluids and dehydration can be prevented. Urography with larger amounts of contrast media is acceptable and routinely is performed in diagnostic examinations of small animals.^{3,4} With the urography method, some disorders and abnormalities of the urinary system can be detected, such as kidney stones, the presence of tears in the urinary tract, tumors or masses related to the kidney, ureters, bladder, surgical effects on the urinary system, and congenital disorders such as ectopic ureter.⁵

The measurement of kidneys is a very important factor for examining kidney diseases in dogs and cats, and since the size of animals is different, therefore, the absolute measurement of kidneys alone cannot be confirmed and analyzed during ultrasound evaluation. The right kidney is more anterior than the left kidney and is in close contact with the caudal lobe of the liver, and due to its location in the chest or the back area of the intestinal loops, its examination is more difficult. Both kidneys are symmetrical and lobular in shape and size in cats. Kidneys can be measured at different stages and their size can also be estimated. In cats, the exact measurements should be based on the total body weight because there is a lot of racial diversity.⁶

Background knowledge of normal renal dimension (RD) may help in the diagnosis of renal diseases. Changes in kidney dimensions in nephropathies occur due to hypertrophic and/or atrophy process, therefore, it is necessary to determine the pattern of normal kidney dimensions.⁷ In cats and dogs, relationships between kidney length and the presence of renal pathology are well documented through the use of diagnostic imaging. Determining the size and normal morphology of the kidney allows identifying changes that may indicate pathological and chronic processes.⁸ Lee and Leowijuk based on both plain radiograph and urographic studies estimated the normal kidney size in cats to be $2.95 \pm 0.04 \times L2$ for the right kidney and $2.46 \pm 0.05 \times L2$ for the left kidney.⁹

In dogs and cats, the ratio of the length of the kidney to the length of the body of the radiographic kidney size is determined by comparing kidney length to the length of the second lumbar vertebra (K/L2), and a ratio of 2.5–3.5 has been accepted as normal in adult dogs and is commonly used in general practice.⁹

Radiographic measurement of kidney size is quick and simple and less likely to be influenced by the operator's skill. In addition, a study showed that the radiographic length of the kidney is better than the ultrasonographic length of the kidney with its actual length.¹⁰

This study was aimed to perform radiological evaluation of the ratio of kidney length to the size of all lumbar vertebrae in order to obtain the best index in cats referred to Tehran clinics.

Materials and Methods

Animals

This study was a cross-sectional observational analytical study. The study included measurements of both kidneys and lumbar vertebrae from L1 to L7 using radiography of 38 adult cats, including 22 male cats and 16 female DSH cats in the ventrodorsal (VD) view. In this study, cats that had normal kidneys based on history, physical examination and radiology standards were used. The cats were placed in one age group above one year and two sex groups (male and female). The state of the gonads in terms of sterilized and non-sterilized was not investigated. Radiographs were prepared using digital radiography with a device (DR, Vivix South Korea). Radiographic images were saved in DICOM format and from one DICOM viewer (Sante DICOM Viewer 3D pro). Caliper size was 1 mm to measure the kidney (Figures 1 and 2). The maximum length (both right and left kidneys) and the maximum distance between the anterior and caudal poles were recorded. To measure the vertebrae, the maximum length of each body of the lumbar vertebrae from L1 to L7 that is, from the front to the caudal end plate, was measured separately. Then we obtained the ratio of the length of each of the right and left kidneys to each of the lumbar vertebrae, and 14 different ratios were obtained in each radiograph. In this way, the length of the left kidney was compared to the length of L1 to L7 and the length of the right kidney was compared to L1 to L7.

Data Analysis

Data were analyzed using SPSS version 22 software. The significance level in the tests was considered 0.05. The results were reported as mean \pm standard deviation for quantitative data and as number percentage for qualitative data. To investigate the relationship between variables, two independent t-tests and Pearson was used. Descriptive and inferential statistics methods were used to analyze and describe statistical data.



Figure 1. Abdominal ventrodorsal (VD) radiographic view in cats.

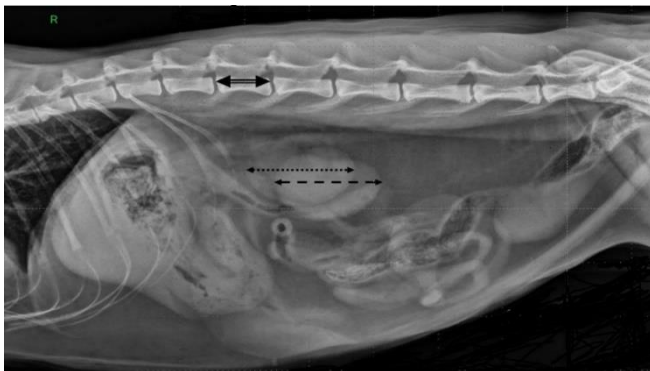


Figure 2. Abdominal lateral (LAT) radiographic view in cats.

Results

The average length of the right kidney in cats was 4.04 cm with a standard deviation of 0.38 cm, and the average length of the left kidney was 3.96 cm with a standard deviation of 0.39 cm. It was observed that among the vertebrae, L1 had the shortest length and L5 had the longest length.

The results of the two-sample independent t-test showed that the male and female groups had a statistically significant difference in terms of the average length of the right and left kidneys as well as the length of the L1 vertebra ($p < 0.05$). It was observed that the length of the left and right kidneys, as well as L1 vertebra in male cats were significantly higher than female cats. The average ratio of the length of the right kidney to the L1 to L7 vertebrae in male cats was significantly higher than these ratios in female cats ($p < 0.05$). It was observed that the two groups of male and female cats do not have a statistically significant difference in terms of the average ratio of the length of the left kidney to the L1 to L7 vertebrae ($p > 0.05$).

The results showed that the average ratio of the length of the right kidney to L1 to L7 vertebrae in male cats was significantly higher than these ratios in female cats. Also, the two groups of male and female cats do not have a statistically significant difference in terms of the average ratio of the length of the left kidney to the L1 to L7 vertebrae (Table 1).

The results of Pearson's correlation test to investigate the linear relationship between these variables showed that the length of the right and left kidneys have a direct and significant statistical relationship ($p < 0.001$) and it was also observed that the length of the right kidney in cats to the L1 vertebra has a direct and significant statistical relationship ($p = 0.026$).

Table 1. The ratio of the length of the right and left kidneys to the vertebrae in female cat.

Ratio	Female	Male
Right kidney/L1	2.52	2.77
Right kidney/L2	2.30	2.56
Right kidney/L3	2.12	2.35
Right kidney/L4	1.96	2.19
Right kidney/L5	1.87	2.10
Right kidney/L6	1.96	2.17
Right kidney/L7	2.39	2.71
Left kidney/L1	2.53	2.68
Left kidney/L2	2.30	2.48
Left kidney/L3	2.12	2.27
Left kidney/L4	1.96	2.12
Left kidney/L5	1.87	2.03
Left kidney/L6	1.96	2.09
Left kidney/L7	2.39	2.62

Discussion

This study showed that there is a correlation between radiological findings of kidney length and lumbar vertebrae. The radiological method has been adapted for use in the United States to assess kidney size in dogs.¹¹

Based on the studies conducted in dogs, cats, squirrels, rabbits, and other animals, it has been determined that the right kidney is more anterior than the left kidney, nevertheless, the location of the kidneys of different animals is located near different vertebrae.¹²

According to the findings of this study, the relationship of right and left kidneys with gender and L1 vertebra length with gender was significant, in other cases no significant relationship was observed. Based on the above

data, it can be concluded that the ratio of the length of the right kidney was larger than the left. In studies conducted by ultrasound, the right kidney was significantly longer than the left kidney.^{6,13} Also, in the present study, the length of the kidneys and the length of the vertebrae were larger in male cats than in females. Previous studies also showed that male cats had longer kidneys and vertebrae.^{6,14,15} This can be influenced by body weight, as males weigh more than females. On the contrary, there are other studies in which kidney size did not differ between sexes.^{9,16} In other studies, spayed cats showed longer kidneys and vertebral bodies than intact animals, which was considered significant for vertebral bodies. Also, sex hormones (estrogen and testosterone) have a positive effect on kidney size in the respective sexes.⁹ Therefore, intact animals showed longer kidneys. However, there are other studies that show that neutered cats have longer kidneys regardless of gender without significant differences.¹³ Previous ultrasound studies have reported that the normal size of the cat kidney varies between 3.0 and 4.3 cm and its length can reach 5.3 cm.^{6,15-17}

The results also showed that the length of the right and left kidneys have a direct and significant relationship and it was also observed that the length of the right kidney in cats has a direct and significant relationship with the length of the L1 vertebra. These results are not fully in agreement with other studies, which can be due to differences in age, race, and environmental factors including diets. Also, it does not match with the results of another study that was conducted using CT scan.¹⁹

Based on the results of the present study, there were differences in the size of the length of the kidneys and the length of the vertebrae. These differences between males and females were significant in some cases. Also, these dimensions were larger in males than in females. The precise standards obtained in the present study can be used in the interpretation of results and clinical decisions to determine the normal and abnormal size of the kidneys and the length of the vertebrae and their ratio to each other in cats.

Conflict of Interest

None to declare.

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