Ultrasonographic evaluation of the renal dimensions in captive tigers

Somkiat HUAIJANTUG1), Komsan MANATPREPREM2), Sukhumarn MANATPREPREM3) and Paranee YATMARK3)*

1)Department of Clinical Sciences and Public Health, The Faculty of Veterinary Science, Mahidol University, 999 Phuttamonthon 4 Road, Salaya, Nakhon Pathom 73170, Thailand
2)The Faculty of Veterinary Science, Mahidol University, 999 Phuttamonthon 4 Road, Salaya, Nakhon Pathom 73170, Thailand
3)Department of Pre-Clinical and Apply Animal Science, The Faculty of Veterinary Science, Mahidol University, 999 Phuttamonthon 4 Road, Salaya, Nakhon Pathom 73170, Thailand

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ABSTRACT. Ultrasonographic measurements of kidney size are useful in the practical diagnosis of kidney diseases in animals. In tigers, there is a lack of information regarding the ultrasonography methods used to measure the kidney size of the tiger. Thirty-three healthy captive tigers (Panthera tigris) were placed in lateral recumbency for ultrasonography. The measurements obtained from the ultrasonography were computed, and the results showed that there was a statistically significant difference between genders in terms of body weight and renal length. The length of the right kidney was significantly different from that of the left kidney (10.23 ± 0.76 cm in males versus 9.94 ± 0.80 cm in females; P<0.05). Interestingly, this study demonstrated that kidney length was statistically significantly associated with the body weight, and it also had an positive linear relationship with the body weight. Therefore, ultrasonographic renal dimensions could prove to be beneficial and modality for use in the evaluation of kidneys in unconscious tigers. However, kidney size evaluation must be performed using not only ultrasound but other clinical forms of technology and parameters.

KEYWORDS: aorta, captive tiger, renal dimensions, ultrasonography

Ultrasonography has become an essential imaging tool for identifying abnormalities caused by several kidney diseases in human and veterinary medicine [2–3, 18]. Ultrasonoscan could be practical to assess the kidneys for important anatomic information concerning the size, shape and internal architecture [1]. Several kidney diseases may be associated with changes in renal dimensions or resistance index; this has been reported in dogs and cats due to acute inflammation, obstruction renal diseases and acute or chronic renal failure [12, 16]. End-stage kidneys are usually small and irregular [14] and nephritis, renal abscesses and renal failure leading to morphological changes are not usually diagnosed via radiographs or blood and urinary examination, whereas ultrasonography could be used for its detection.

In practice, ultrasonography must be performed on unconscious tigers, and the technique used to evaluate kidney size must be quick, simple and reliable. As for ratios comparing renal length with vertebrae in radiographs, relating ultrasonographic renal dimensions to obtain some indicators of body size could justifiably fulfill these conditions. The aortic diameter used as reliable landmark for ratio studies to quantify left atrial enlargement [8] was used to evaluate portal vein diameter in portosystemic shunt diagnosis [6]. It is also affirmed by other studies that relative changes in renal allograft size could be easily monitored by ultrasound [17]. Other studies have also reported the same could be done to obtain the renal dimensions and resistive index in other species including healthy dogs [5, 15], cats [20] and horses [13], and captive cheetahs with glomerulosclerosis and Iberian lynx with glomerulonephritis [4]. Although, there was a single case of pyelonephritis reported in a Siberian tiger [11], so far, no studies have investigated renal dimensions in healthy tigers. Therefore, the aim of this study was to evaluate the renal dimensions (height, length and width) and the aortic diameter in captive tigers using ultrasonography with the main purpose of generating information to establish reference intervals that could be used in practice and to analyze the basic factors that affect kidney size.

MATERIALS AND METHODS

Animal preparation and anesthesia: All 33 captive tigers (Panthera tigris) (21 females and 12 males) were used. Tigers are kept in The Bungchawak Zoo in Supanburi, Thailand and The Khao Prathap Chang Zoo in Ratchaburi, Thailand. Healthy adult captive tigers (Panthera tigris) were recruited into the present study, only if results from the physical examination were unremarkable. The complete blood count, serum and biochemical electrolyte values were normal for all tigers. The age and body weight were recorded for analyzing the relationship with renal dimensions. The protocol used in this study was approved by the Faculty of Veterinary Science-Animal Care and Use Committee, Mahidol University of Thailand. Each tiger was fasted for 12 hr prior to general anesthesia. The tigers were anesthetized...
RESULTS

The effects of gender on renal dimensions and luminal diameter of the aorta in tigers: The age and body weight of the male and female tigers are presented in Table 1. There was a statistically significant difference between genders with males having a higher body weight than females (161.91 ± 38.43 versus 110.99 ± 18.72 kg; P<0.05).

Table 1. The effects of gender on renal dimensions and luminal diameter of the aorta in tigers

| Variables        | Sex  | Range     | Mean ± SD  | P-value |
|------------------|------|-----------|------------|---------|
| Age (years)      | Male | 1.08–5.33 | 3.25 ± 1.50 | 0.274   |
|                  | Female | 1.08–10.00 | 4.13 ± 2.82 |         |
| Body weight (kg) | Male | 111–222  | 161.91 ± 38.43 | 0.002b) |
|                  | Female | 80–169 | 110.99 ± 18.72 |        |
| Rt length (cm)   | Male | 9.60–11.95 | 10.63 ± 0.76 | 0.017a) |
|                  | Female | 9.00–11.55 | 10.01 ± 0.64 |        |
| Rt width (cm)    | Male | 5.10–7.40  | 6.22 ± 0.76  | 0.292   |
|                  | Female | 4.90–8.50 | 5.91 ± 0.82  |        |
| Rt height (cm)   | Male | 4.90–7.65  | 6.20 ± 0.81  | 0.325   |
|                  | Female | 4.90–7.50 | 5.94 ± 0.62  |        |
| Lt length (cm)   | Male | 8.00–12.00 | 10.32 ± 0.86 | 0.039a) |
|                  | Female | 8.50–10.80 | 9.72 ± 0.70  |        |
| Lt width (cm)    | Male | 5.20–7.00  | 6.21 ± 0.61  | 0.183   |
|                  | Female | 4.80–7.90 | 5.87 ± 0.70  |        |
| Lt height (cm)   | Male | 5.00–7.65  | 6.51 ± 0.77  | 0.078   |
|                  | Female | 4.90–7.10 | 6.05 ± 0.61  |        |
| Ao transverse (cm)| Male | 1.00–1.40  | 1.18 ± 0.11  | 0.507   |
|                  | Female | 0.90–2.00 | 1.13 ± 0.23  |        |
| Ao dorsal (cm)   | Male | 0.98–2.00  | 1.21 ± 0.26  | 0.326   |
|                  | Female | 0.90–1.80 | 1.13 ± 0.20  |        |

Rt=Right kidney, Lt=Left kidney, Ao transverse=luminal diameter of the aorta measured on transversal planes, Ao dorsal=luminal diameter of the aorta measured on longitudinal planes. a) Statistically significant at the 0.05 level (P-value). b) Statistically significant at the 0.01 level (P-value).

Ultrasound imaging of the kidney length as shown in Fig. 1A, the luminal diameter of the aorta was measured on transverse (Fig. 1B) and longitudinal (Fig. 1C) planes. Males had a greater renal length than females (right renal length 10.63 ± 0.76 cm versus 10.01 ± 0.64 cm; P<0.05 and left renal length 10.32 ± 0.86 cm versus 9.72 ± 0.70 cm; P<0.05, respectively). On the other hand, there was no statistically significant difference in width, height and diameter of the aorta found between the genders.

Comparisons of renal dimensions between right and left kidneys in tigers: Renal measurements of every tiger were performed on both sides (see Table 2). The mean length of the right kidney was significantly larger than that of left kidney (10.23 ± 0.76 cm versus 9.94 ± 0.80 cm; P<0.05), but the mean width and height were not different between the right and left kidneys. In addition, as the aortic diameter was constant within each tiger, there was no statistically significant difference between length/aortic transverse and length/aortic dorsal ratios and between those of the right and left kidneys.

Relationship of body weight to renal dimensions in tigers: The length of the left and right kidneys showed the significant correlation with body weight in male tigers (r=0.641, P<0.05 and r=0.677, P<0.01, respectively), except for the length of the left and right kidneys in female (r=0.411, P<0.05 and r=0.312, P=0.08, respectively), (Fig. 2). Spearman correlation indicates the direction of association between the length of kidney and the body weight of every tigers (left kidney; r=0.58, P<0.01 and right kidney; r=0.544, P<0.01, respec-
tively), (Fig. 3), but not with the aorta diameter. However, the age did not relate with body weight or renal dimensions in this study.

**DISCUSSION**

The results revealed that the kidney size of the adult captive tigers was related to body weight and corresponded to the findings in domestic cats [20]. The kidney length and body weight were different between male and female tigers. The larger kidneys in males than females may be due to increased body weight, but the size of the kidney may also correlate with other factors associated with androgens. According to some authors, kidneys of adult male mice were larger than those of females, because of both the cellular hyperplasia and hypertrophy due to the influence of androgens [10]. In addition, the length of the right kidney was greater than that of the left kidney, but opposing to those reported in dogs (the cranial margin of the right kidney was not clearly outlined for measurement in all dogs) [15]. Measuring the renal dimensions was difficult in tigers, because most of the tigers in our study had larger body size and high body condition scores (3.5–4). This can be overcome using the dorsal plane measurement and a low frequency transducer.

The present study used a ratio comparing renal length with aorta diameter, because the weight ranges of the tigers were significantly different, thus creating a relationship between the ultrasonographic renal measurements and the large body weight discrepancies in this species. However, no relation between the kidney length and the aorta diameter of the tigers in this study was different from previous studies conducted using other species [19]. Furthermore, kidneys

| Renal dimension          | Right kidney     | Mean ± SD | Left kidney     | Mean ± SD |
|--------------------------|------------------|-----------|-----------------|-----------|
| Length (cm)              | 9.00–11.95       | 10.23 ± 0.74 | 8.00–12.00      | 9.94 ± 0.80 |
| Width (cm)               | 4.90–8.50        | 6.03 ± 0.80 | 4.80–7.90       | 6.01 ± 0.68 |
| Height (cm)              | 4.90–7.65        | 6.05 ± 0.70 | 4.90–7.65       | 6.24 ± 0.70 |
| Length/Ao transverse     | 5.78–10.89       | 9.06 ± 1.09 | 5.10–10.91      | 8.82 ± 1.21 |
| Length/Ao dorsal         | 5.88–10.65       | 9.01 ± 1.17 | 5.68–10.70      | 8.76 ± 1.22 |

Ao transverse=luminal diameter of the aorta measured on transversal planes, Ao dorsal=luminal diameter of the aorta measured on longitudinal planes. a) Statistically significant at the 0.01 level ($P$-value).
Fig. 2. Correlation between body weight and the length of the left and right kidneys in male and female tigers.

Fig. 3. Correlation between body weight and the length of the left and right kidneys in total tigers used in this study. The regression equation of the length of the left and right kidneys and body weight are $y=24.59x–118$ and $y=30.44x–184$, respectively.
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could be abnormal without a significant alteration in size [7]. Therefore, a ratio comparing renal length with aorta diameter should only be used to indicate abnormal renal size and only as one parameter in the ultrasonographic evaluation of kidney disease. Other clinical forms of technology and parameters should be considered to assess renal function and abnormal structures.

Regarding limitations, it is noted that although the measurement method of the present study could be reproducible by experienced sonographers, the level of experience required to reliably obtain these values was not examined. However, authors believe that these renal dimensions could be used as reference in tigers. Additionally, the population used in this study was dominated by a high female-to-male ratio, and therefore, the results obtained from this population may be lower than expected. It is therefore suggested that an equal number of adult male and female tigers be considered for further investigation.

In conclusion, ultrasonographic renal dimensions could prove to be beneficial and modality for use in the evaluation of kidneys in unconscious tigers. Kidney size evaluation must be performed using not only ultrasound but other clinical forms of technology and parameters. This study found that kidney length of tigers was associated with body weight, but not aorta diameter, and could be a reference interval used in ultrasonography in this feline species.

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