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Research Article

Gross Morphological Study of Kidneys and Urinary Bladder in Adult Domestic Cats (*Felis catus*)

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ABSTRACT

Introduction: The urinary system of domestic cats has important anatomical and clinical relevance in veterinary medicine. The present study aimed to characterize the gross anatomy and morphometry of the right and left kidneys and urinary bladder of adult (1-2 years) male and female domestic cats (*Felis catus*).

Materials and methods: For the present study, ten healthy adult domestic cats of both genders (5 males and 5 females), with a mean body weight of 4300.0 ± 0.4 grams, were used. The cats were local domestic cats collected in Babylon Province, Iraq, and examined at the College of Veterinary Medicine, Al-Qasim Green University, Iraq. Although both sexes were included, the present study did not conduct a separate sex-based comparison because the main objective was to explain the general gross morphology and morphometry of the kidneys and urinary bladder in adult domestic cats. General anesthesia was induced by intramuscular injection of xylazine hydrochloride 2% (20 mg/mL) at a dose of 1 mg/kg and ketamine hydrochloride 10% (100 mg/mL) at a dose of 10 mg/kg. Laparotomy was performed through the midline approach to expose both right and left kidneys and the urinary bladder to evaluate their gross morphology and morphometry.

Results: The urinary system included two kidneys, ureters, urinary bladder, and urethra, as in mammals. The kidneys were bean-shaped, paired retroperitoneal organs located in the lumbar region. The right kidney occupied a more cranial position and appeared more fixed than the left, which appeared more caudal and mobile. The kidneys had a smooth surface, were unilobar and unipapillary, with an obvious renal crest and hilus. They were covered with a thin fibrous capsule and perirenal fat. As a result of morphometric analysis, the right kidney was slightly larger than the left in terms of weight, length, and thickness. The internal structure consisted of three zones, including the renal cortex, renal medulla, and renal pelvis. The renal medulla contained medullary tissue that converged into a single renal papilla, a feature specific to cat kidneys. The urinary bladder appeared as a smooth, muscular, hollow organ located mainly in the pelvic cavity when empty and extending cranially into the abdominal cavity when distended. It was pear-shaped and consisted of an apex, body, and neck.

Conclusion: In the present gross examination, no obvious gross morphological differences were observed in the external morphology of either the kidneys or the urinary bladder between the sexes.

1. Introduction

The urinary system is essential because it maintains homeostasis by regulating water content, electrolyte balance, and acid-base balance[1]. The urinary system excretes metabolic waste products, thereby maintaining an optimal internal environment necessary for normal cellular function[2]. Development of the urinary system occurs through the intermediate mesoderm, following a well-conserved developmental pattern in mammals. However, some variations in developmental timing and morphology were observed among mammalian species[3,4]. Moreover,

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morphological adaptations in the urinary system may occur according to the animal's habitat and functional specialization[5]. The urinary system comprises four parts, including the kidneys, ureters, urinary bladder, and the urethra. Kidneys act as filters of blood, removing nitrogenous wastes from the bloodstream and regulating the composition of body fluids, while the urinary bladder serves as a storage site for urine before excretion through the urethra[6,7].

The urinary tract in domestic cats (*Felis catus*) is anatomically and clinically significant due to the high incidence of diseases affecting the kidneys and lower urinary tract. In addition, cats can be considered suitable cases for comparative anatomy studies. It is therefore necessary to study gross morphology and morphometry of the kidneys and urinary bladder in domestic cats as basic data for veterinary anatomy[7,8]. Several physiological adaptations associated with the diet and hydration in felines can be identified in their urinary physiology. In particular, kidney function in felines includes the ability to produce concentrated urine, characterized by efficient water conservation, and may depend on the cat's hydration level[9,10]. This renal concentrating capacity is clinically important because urine concentration and hydration status are closely related to lower urinary tract health in cats[2,8].

The kidney is a vital organ that not only filters and excretes metabolic waste but also regulates blood pressure, maintains electrolyte balance, and produces hormones such as erythropoietin[10]. Anomalies in structure or function within the kidneys result in systemic disturbances, underscoring the need for an in-depth understanding of the organ's anatomy and histology[2,6,11]. Approximately 20% of the cardiac output reaches the kidneys due to their higher metabolic activity[12,13]. The renal cortex receives almost all of this flow because nephrons are located there and perform filtration. In turn, 1% of the total blood supply goes to the medulla, where it plays a role in urine concentration and water reabsorption via juxtamedullary nephrons[13].

The urinary bladder is a distensible muscular structure that stores urine before urination[1]. The urinary bladder of domestic cats usually has a pear-like shape and a thick muscular wall, which facilitates expansion and contraction[14,15]. The inner layer of the urinary bladder is composed of transitional epithelial cells that confer elasticity on the tissue but do not affect its permeability[15]. On the other hand, the functions of the lower urinary system are continence and micturition, which depend on the interaction between the urothelial barrier and the central and peripheral nervous systems[1,16]. These processes (continence and micturition) depend not only on individual functions but also on coordination among the different components. Since the anatomical and structural characteristics of organs such as the kidneys and urinary bladder influence urine formation, storage, and micturition, a precise description is essential for subsequent evaluation[17,18]. Given the limited scientific literature on the urinary system of local cats and the physiological importance of the kidneys and urinary bladder in maintaining body fluid balance, excretion, and overall homeostasis, this study was conducted. The present study aimed to characterize the gross anatomy and morphometry of the right and left kidneys and the urinary bladder of adult male and female domestic cats (*Felis catus*) collected in Babylon Province, Iraq.

2. Materials and methods

2.1. Ethical approval

All procedures involving animals were conducted in accordance with institutional guidelines for animal care and use. Ethical approval was obtained from the relevant committee at the College of Veterinary Medicine, Al-Qasim Green University, Iraq.

2.2. Animals

Ten healthy adult domestic cats, aged 1-2 years and of both sexes (5 males and 5 females), with an average body weight of 4300.0 ± 0.4 grams, were sourced from private owners in Al-Hilla city, Babylon Governorate, Iraq. Cats were subjected to the present study to investigate the gross morphology of the kidneys and urinary bladder. All animals were subjected to routine clinical examination selection by assessing general body condition, activity, mucous membranes, hydration status, rectal temperature, heart rate, abdominal palpation, and external urogenital inspection. Before selection, assessments were performed to confirm the absence of systemic or urinary tract diseases[19], to ensure consistent physiological conditions, and to minimize variation in bladder distension. The animals were fasted for 24 hours before the anesthesia and laparotomy.

2.3. Anesthesia and gross anatomical examination

General anesthesia was induced by intramuscular injection of xylazine hydrochloride 2% (20 mg/mL) at a dose of 1 mg/kg, followed by ketamine hydrochloride 10% (100 mg/mL) at a dose of 10 mg/kg[20]. Adequate depth of anesthesia was confirmed by their response before the procedure, and then the animals were euthanized under deep anesthesia. Death was confirmed by the absence of heartbeat and respiration. Following that, an abdominal midline incision was made to enter the abdominal cavity[21.] In the abdominal cavity, the kidneys and urinary bladder were visualized in relation to other organs, including the vertebrae, adrenals, ureters, and the stomach. The gross morphology of the kidneys in terms of form, size, location, surface, margins, poles, and renal hilum was observed and noted. The urinary bladder was examined for shape, location, and its division into apex, body, and neck.

2.4. Morphometric measurements

Body weight was recorded before anesthesia using an electronic balance and expressed in kilograms (kg). After dissection, the kidneys and urinary bladder were gently separated from surrounding connective tissue, blotted with filter paper to remove excess fluid, and weighed using an electronic balance. The organ weights were expressed in grams (g). Linear measurements of the

kidneys were taken using a digital caliper and expressed in millimeters (mm). Kidney length was measured from the cranial pole to the caudal pole, whereas kidney thickness was measured at the widest dorsoventral point. Each measurement was taken three times by the same observer, and the mean value was used for statistical analysis to improve accuracy and reproducibility.

2.5. Data analysis

The normality of data was evaluated using the Shapiro–Wilk test ($p > 0.05$). Because the right and left kidneys were from the same animals, a paired-samples t-test was employed to compare their weight, length, and thickness. Statistical significance was defined at a p-value less than 5% ($p < 0.05$), and 95% confidence intervals (CI) were calculated. An independent-samples t-test confirmed that there were no significant sex-related differences in any of the measured parameters. Data were reported as mean ± standard error (SE). For the unpaired urinary bladder, descriptive statistics (mean ± SE) were used.

3. Results

The urinary system of the domestic cat consists of two kidneys, renal pelvis, ureters, urinary bladder, and urethra, arranged in the typical mammalian pattern. The kidneys were paired, encapsulated, retroperitoneal organs located in the lumbar region, lateral to the vertebral column. The right kidney was situated more cranially and firmly attached, whereas the left kidney was positioned slightly more caudally and exhibited greater mobility (Figures 1 and 2).

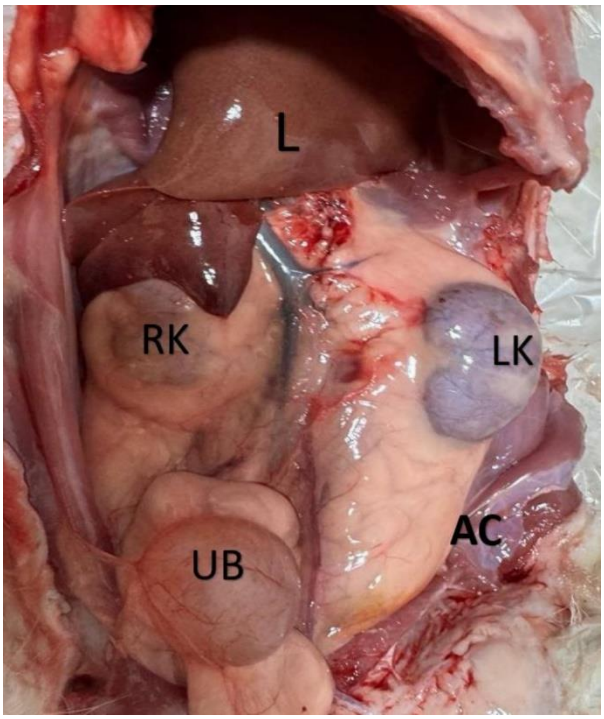

Figure 1. Ventral view of the abdominal cavity of an adult local cat. RK: Right kidney, LK: Left kidney, L: liver, UB: Urinary bladder, AC: Abdominal cavity

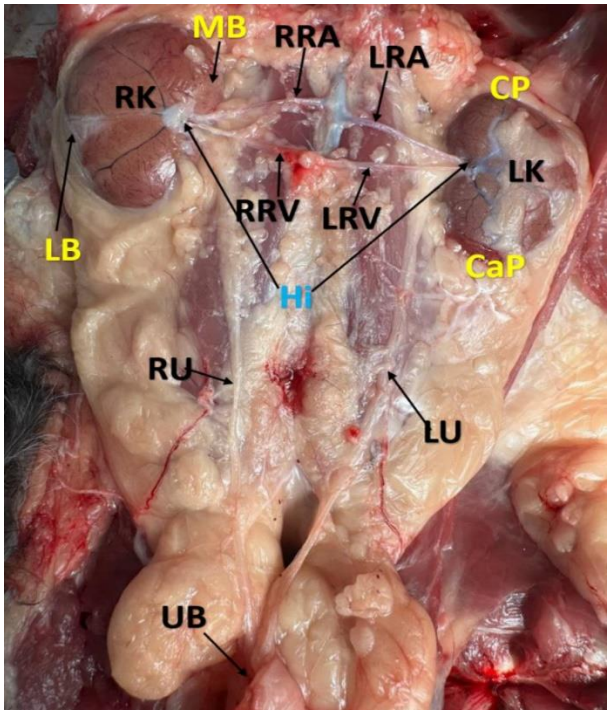

Figure 2. Ventral view of the abdominal cavity of an adult local cat with more details. RK: Right kidney, LK: Left kidney, LU: Left ureter, RU: Right ureter, MB: Medial border, LB: Lateral border, CP: Cranial pole, CaP: Caudal pole, LRV: Left renal vein, RRV: Right renal vein, LRA: Left renal artery, RRA: Right renal artery, UB: Urinary bladder, Hi: Hilum

Macroscopically, the kidneys were bean-shaped, smooth, unilobar, and unipapillary, with a well-developed renal crest. The cranial pole appeared larger than the caudal pole. Each kidney presented dorsal and ventral surfaces, convex lateral and concave medial borders, and distinct cranial and caudal poles. The medial concave border formed the renal hilum, which served as the passage for the renal artery, renal vein, nerves, and ureter. The kidneys were externally surrounded by a fibrous renal capsule and perirenal fat capsule, providing structural protection and positional stability.

Morphometric analysis demonstrated that the mean body weight of the examined cats was 4300.0 ± 0.4 g. The mean weight of the left kidney was 13.38 ± 0.17 g, while the right kidney had a slightly higher mean weight of 14.15 ± 0.18 g. The mean length of the left kidney was 36.31 ± 0.27 mm, whereas the right kidney was 38.71 ± 0.29 mm. The average thickness of the left kidney was 18.86 ± 0.09 mm, while the right kidney measured 19.40 ± 0.07 mm. The relative weight of the right kidney to body weight was 0.35 ± 0.006%, slightly higher than that of the left kidney (0.33 ± 0.005%). The right kidney was significantly heavier (mean difference = 0.77 g, 95% CI: 0.45-1.09, $p = 0.008$), longer (mean difference = 2.40 mm, 95% CI: 1.85-2.95, $p = 0.003$), and thicker (mean difference = 0.54 mm, 95% CI: 0.38-0.70, $p = 0.002$) than the left kidney (Table 1). No significant sex-related differences were observed in any renal or bladder parameters ($p > 0.05$).

Table 1. Thickness, length, and weight of the kidneys of 1-2-year-old local cats

Parameters	Left kidney	Right kidney	P value
Weight (g)	13.38 ± 0.17	14.15 ± 0.18	0.008
Length (mm)	36.31 ± 0.27	38.71 ± 0.29	0.003
Thickness (mm)	18.86 ± 0.09	19.40 ± 0.07	0.002

Data are presented as mean ± SE. The p-values derived from the paired-samples t-test for the total number of cats (n = 10).

Internally, the kidney consisted of an outer cortex, a centrally located medulla, and a renal pelvis situated at the hilum. The medullary tissue was arranged in pyramid-like forms where its apex converged to form one renal papilla extending to the renal pelvis. Each renal lobe comprises a medullary pyramid surrounded by cortical tissue (Figures 3 and 4).

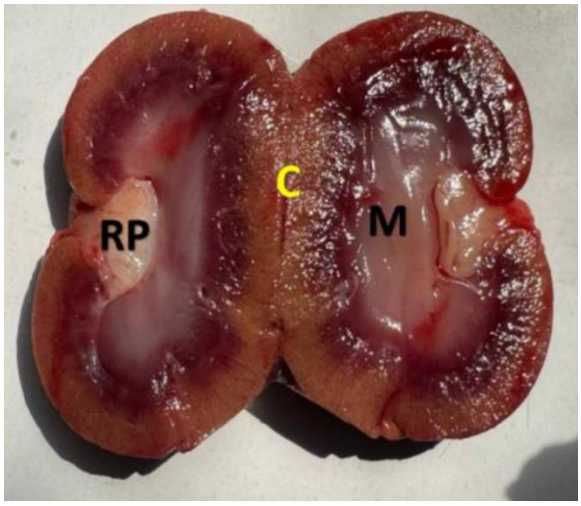

Figure 3. Longitudinal section of the left kidney of an adult local cat aged 1-2 years. C: Cortex, M: Medulla, RP: Renal pelvis

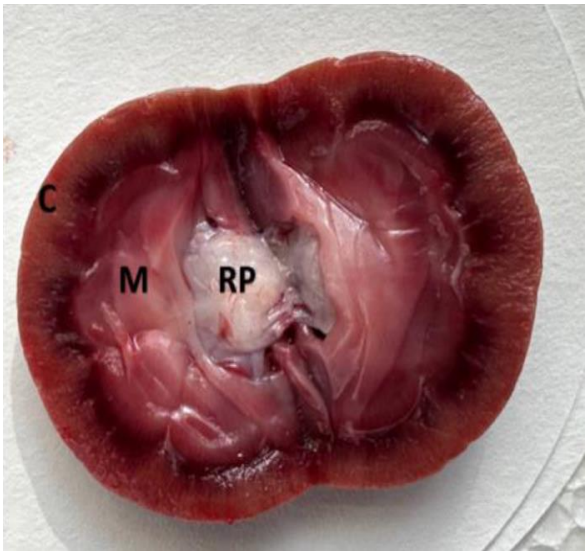

Figure 4. Longitudinal section of the right kidney of an adult local cat aged (1-2) years. C: Cortex, M: Medulla, RP: Renal pelvis

The urinary bladder was a pear-shaped muscular sac situated predominantly within the pelvic cavity when empty; however, upon distension, it extended into the abdominal cavity, extending cranially. The urinary bladder was emptied prior to weighing, ensuring that the recorded weight reflected the bladder wall alone and excluded urine contents. The cranial part (apex), middle part (body), and caudal part (neck) were clearly distinguishable (Figures 1 and 5). The mean urinary bladder weight was 3.09 ± 0.05 g, with a relative urinary bladder weight to body weight of 0.072 ± 0.001%.

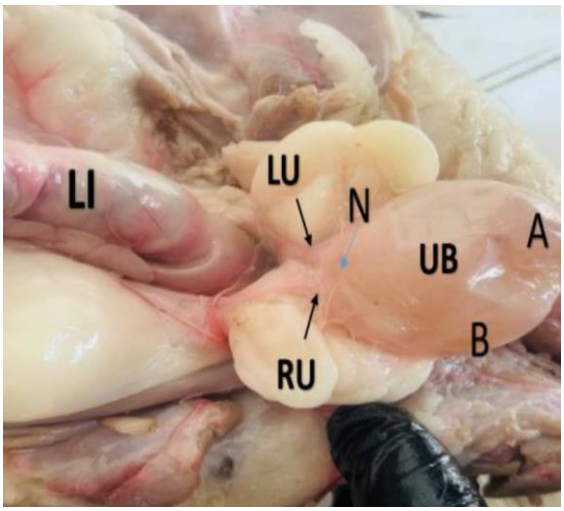

Figure 5. Ventral view of the urinary bladder of an adult local cat aged 1-2 years. B: Bladder, LU: Lift ureter, RU: Right ureter, LI: large intestine

Table 2. Length and weight of the body and urinary bladder of 1-2-year-old local cats

Parameters	Measurement
Urinary bladder weight	3.09 ± 0.05 (g)
Body weight	4300.0 ± 0.4 (g)
Body length	460.4 ± 3.6 (mm)

Data are presented as mean ± SE (n = 10). No statistical comparison was performed for the urinary bladder, as it is a single, unpaired organ

4. Discussion

The current results demonstrated that the kidneys and urinary bladder of the adult domestic cats followed the general anatomical arrangement described for the urinary pattern of domestic mammals. The kidneys were paired, bean-shaped, smooth, unilobar, unipapillary organs located retroperitoneally in the lumbar region. The right kidney was positioned more cranially and appeared more fixed, whereas the left kidney was located slightly more caudally and demonstrated greater mobility. This arrangement was consistent with standard descriptions of feline and carnivore anatomy reported in veterinary anatomical references[15,22,23].

The topography of the kidneys relative to other abdominal structures, such as the vertebral column, adrenal glands, and surrounding muscles, was also observed. The observation of the medial concave surface, where the renal vessels and ureter enter the kidney, was in agreement with classical anatomical descriptions[23]. Moreover, the retroperitoneal position and the presence of the renal capsule and perirenal fat were consistent with classical anatomical reports in the literature[16,23]. The morphometric measurements in the present study regarding kidney weight and size were within the normal range for domestic cat

anatomy. The normal renal length in cats is approximately 3.0-4.5 cm and can reach up to 5.3 cm[24]. The slightly greater weight and size of the right kidney compared with the left indicated renal asymmetry. The comparison between the right and left kidneys revealed notable differences in weight, length, and thickness, which are common in carnivorous animals such as cats and dogs. The relationship between body weight and kidney weight observed in the present study may indicate normal organ development in small carnivorous mammals, because renal size and weight generally increase in proportion to body size when the animals are clinically healthy and no gross renal abnormalities are observed[24].

The kidney structure consisted of three main regions, including the cortex, medulla, and renal pelvis. These parts corresponded to the anatomical pattern of an unipyramidal kidney. The presence of medullary pyramids converging into a renal papilla directed toward the renal pelvis was typical of cats[6,25]. Moreover, the medullary layer was relatively large, which may be related to the kidney's urine-concentrating function[3,1]. Compared with the findings of Maher et al.[7], the kidney weights in the current study were lower. The current study reported right kidney weight of 14.15 ± 0.18 g and left kidney weight of 13.38 ± 0.17 g, whereas Maher et al.[7] reported the right kidney as 17 g and the left as 15 g. In the present study, the right kidney was marginally longer (38.71 ± 0.29 mm) than the left (36.31 ± 0.27 mm). These measurements were slightly higher than those reported by Maher et al.[7], who reported 36.5 mm and 34.2 mm for the right and left kidneys, respectively. The thickness of the kidneys was smaller than that reported by Maher et al.[7]

The urinary bladder was examined in both males and females. In the present study, the urinary bladder was described grossly in both sexes as part of a general anatomical observation; however, sex-based morphometric comparisons were not performed[1,17]. The urinary bladder had the typical appearance of a pear-shaped, distensible muscular sac, which was situated mainly in the pelvic cavity when empty of urine and extended into the abdominal cavity when distended with urine. The clear division of the bladder into apex, body, and neck observed in the present study was consistent with standard anatomical descriptions[1,13,19]. The changes in bladder position observed at different filling volumes are consistent with the storage function of the urinary bladder[1,13]. The parameters obtained from measuring bladder weight and its ratio to body weight were within the expected range and may indicate normal bladder capacity. The structure of the urinary bladder wall was characteristic of organs involved in distension and contraction, which makes it suitable for urine storage and excretion.

Similar to carnivores overall, especially dogs, the domestic cat's urinary system shares the same fundamental structure, with only minor quantitative differences variations[22,15]. The absence of special renal adaptations, compared with those of other mammals, indicated that the feline kidney retains the general anatomical features of the carnivore renal system and performs its specific functions.

5. Conclusion

The urinary system of adult domestic cats (*Felis catus*) consisted of paired kidneys and a urinary bladder arranged according to the typical mammalian pattern. The kidneys were bean-shaped, smooth, unilobar, and unipapillary, with a renal cortex, medulla, and renal pelvis. The right kidney was located more cranially and demonstrated slightly higher morphometric values than the left kidney. The urinary bladder appeared as a pear-shaped, distensible muscular organ located mainly in the pelvic cavity when empty and extending cranially into the abdominal cavity when distended. These findings provided baseline gross anatomical and morphometric data for the kidneys and urinary bladder of adult domestic cats. The present study was limited by the small sample size and the lack of detailed comparisons by sex, breed, and age. In addition, bladder urine volume was not measured, which may affect the interpretation of urinary bladder weight. The urethra was not included in the present gross anatomical and morphometric examination. Future studies should include a larger number of cats from different ages, breeds, and sexes, with statistical analysis and additional imaging or histological examination to provide more detailed reference data for the feline urinary system.

Declarations

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Availability of data and materials

The data supporting the findings of the present study are available from the corresponding author upon reasonable request.

Authors' contributions

Moamel Mohsen Salman AL-Tufaily designed the study, collected the samples, performed the anatomical measurements, and drafted the manuscript. Salim Salih Ali AL-Khakani supervised the study, contributed to data interpretation, and revised the manuscript. Both authors read and approved the final edition of the manuscript.

Competing interests

The authors declared that they have no competing interests.

Ethical considerations

The author has addressed all ethical concerns such as plagiarism, consent to publish, data fabrication, and falsification prior to publication. An AI-based tool, Grammarly v.1.2.259.1886, was used solely for language

editing and to improve the clarity of the manuscript. The authors reviewed and approved all edited text and take full responsibility for the content of the manuscript.

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