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# Correlation of Canine Kidney Autopsy to Renal Diseases: Pathological Insights

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**ABSTRACT**

Kidneys play a vital role in regulating fluids, electrolytes, hormones, and metabolic waste in canines. This study aimed to enhance the understanding of the correlations between canine kidney autopsy findings and renal diseases. A total of 194 domestic dog samples, including 153 males and 41 females with an average age of 3.88 years (ranging from 1 to 7 years), were physically examined using post-mortem evaluations to understand the prevalence and characteristics of kidney diseases, focusing on both external and internal examinations of the kidneys. Key parameters such as kidney size, texture, and coloration were measured to provide insights into the overall kidney health of the canine population in Vietnam. Results indicated that 22.68% of the dogs had kidney cysts, 29.38% showed signs of external hemorrhage, and 52.06% of the cases exhibited internal hemorrhage, proving to be a condition linked to increased renal vascular resistance and further potentially contributing to renal dysfunction. No evidence of necrosis was detected, and the majority of renal capsules (90.98%) were easy to peel off for further analysis. Kidney size and weight varied obviously in dogs presenting with specific hemorrhagic conditions. This study emphasized the importance of external and internal kidney evaluations in diagnostic measurements and treatment protocols for canine renal diseases while also providing further insights into the current status of the canine population in Vietnam.

**Keywords:** Dog, Hemorrhage, Kidney, Post-mortem, Renal disease

## INTRODUCTION

The kidneys play an important role in maintaining a dog's well-being through the regulation of fluids, electrolytes, and waste management. Healthy kidneys ensure that homeostasis is achieved in both humans and animals (Mitrakou, 2011). Additionally, kidneys release certain hormones such as renin, which aid in blood pressure regulation and fluid volume control (Castrop et al., 2010). Furthermore, erythropoietin has been proven to accelerate wound healing processes (Haroon et al., 2003) and promote the brain's response in the presence of neural injury (Sirén et al., 2001). However, with such complex and critical roles, kidneys are also susceptible to various renal diseases that severely compromise an animal's well-being. Changes such as cortical echogenicity or loss of corticomedullary differentiation are indicative of renal diseases (Bragato, 2017).

Some of the most common diseases occurring in old canine patients are chronic kidney disease and acute kidney injury (Bartges, 2012). Chronic kidney disease is characterized by the gradual loss of kidney function and is one of the leading causes of morbidity (Kalantar-Zadeh et al., 2021). Acute kidney injury, on the other hand, is defined as the sudden onset of loss of renal function (Ross, 2011). In Vietnam, renal diseases account for 42.11% of urinary tract complications (Nguyen et al., 2020). These diseases not only affect a patient's quality of life but also lead to life-threatening complications if not properly diagnosed and treated. Physical examination of the kidneys has been shown to provide critical findings regarding chronic kidney disease (Polzin, 2011). Additionally, research has established correlations between the effects of hemorrhage on renal blood flow (Kennard et al., 2024) and the ratio of kidney length to lumbar vertebrae (Barella et al., 2012). Access to accurate and detailed information is crucial for understanding the current health status of a population, as demonstrated in this study, which focuses on the canine population in Vietnam.

Therefore, the present study aimed to collect and analyze data to interpret the status of renal health in Vietnamese canines and its correlation with renal diseases.



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## MATERIALS AND METHODS

### Ethical approval

The study was conducted through post-mortem examination, kidney observation, and measurements according to the procedures of the Animal Welfare Council, Hutech University, Ho Chi Minh City, Vietnam. The authors considered ethical concerns and consent, animal welfare, and safety procedures before conducting the study.

### Sample collection and macroscopic examination

A post-mortem examination was performed on 194 dogs aged 1–7 years, comprising 153 males (78.87%) and 41 females (21.13%). The gender imbalance was acknowledged as a factor influencing the generalization of findings and correlations to gender. Afterward, a macroscopic examination of lesions was conducted, which recorded kidney measurements, texture, appearance, and status. After opening the abdominal cavity, the location and the signals of the kidneys were checked. The left kidney is slightly more caudal than the right kidney (Nyland et al., 2015). The kidneys were then removed from the body by cutting the renal vessels. To differentiate the left and right kidneys, a small transverse cut was made into the parenchyma of the right kidney. The kidneys were immediately evaluated after sectioning. Firstly, the renal capsule was removed to examine the external aspects of both kidneys (McDonough and Southard, 2016). The adhesion of the renal capsule was evaluated based on the difficulty of peeling the capsule. The appearance (smooth or spotty) and color (light, dark, or blue-gray) of the kidney surfaces were documented. Then, the consistency of the kidneys was assessed through gentle palpation of the kidneys. Additional signs, such as hemorrhage, necrosis, and tumors, were recorded before the examination of the internal aspects of the kidneys. Longitudinal sectioning was performed to examine the internal features of the kidneys. Abnormal findings on the cut surface of the kidneys, internal hemorrhage, and necrosis were also recorded.

### Measurement protocols

The thickness of the renal cortex and medulla of each kidney was measured. Renal cortical thickness was defined as the maximal distance from the cortex-perirenal fat interface to the cortex-pyramidal base (Su et al., 2019). The thickness of the cortex varies depending on whether it is measured at the top or a lower point of the scallop. However, the cortex is thicker than the outer medulla zone beneath it (Bulger et al., 1979). The inner medulla is thicker than both the cortex and the outer medulla in healthy kidneys. The length, width, and weight of each kidney were separately recorded. Renal length was measured as the longest distance between the superior and inferior poles on the longitudinal section. Renal width was determined as the maximum transverse diameter at the hilum under healthy conditions (Su et al., 2019). Renal medulla thickness was defined as the distance from the corticomedullary junction to the tip of the medullary papilla (Beuchat, 1990). Gender and hemorrhage status were noted in all cases to evaluate their impacts on kidney measurements. A digital caliper was used for all measurements, with the unit of measurement being centimeters (cm).

### Statistical analysis

Data were analyzed using mean values and standard deviations (SD) calculated in Microsoft Excel, version 2016.

## RESULTS

When examining externally, there were only two main differentiations, whether the layer was smooth or not. Of the 194 dogs, 150 had a smooth layer on the kidney's surface (77.32%). Meanwhile, 44 of the 194 dogs had spots on them (22.68%, Table 1). Regarding the color of kidneys, there were three types of coloring recorded: 184 (94.85%) cases were reported to be light-colored, 9 (4.64%) cases were reported to be deep-colored, and 1 (0.52%) case was reported to be blue-gray. The samples provided showed three distinct types of consistency: 191 cases showed normal consistency (98.45%), 2 were tough cases (1.03%), and 1 was a soft case (0.52%). Other lesions that could be observed were the presence of hemorrhage on the outer shell, with 57 cases showing hemorrhage (29.38%). However, the other 137 (70.62%) cases did not present any signs of bleeding outside the kidney (Table 1).

While external factors may provide insights into the rough outline of underlying conditions, internal factors provide insights into the main roots of the complications. When evaluating bleeding conditions in the samples, 52.06% of the cases were found to have internal hemorrhage in the kidneys, while the other 47.94% showed no signs of bleeding during the dissection process. Necrosis is a kidney disorder involving damage to the cells of the kidneys. Necrosis is also a major factor in renal health: 100% of the cases showed no signs or progression of necrosis when examined. Out of 194 pairs of kidneys, 178 right kidneys and 175 left kidneys were reported to be easy to peel off, while the rest proved to be difficult to peel off for further inspection (Table 2).

Based on the results, the average thickness of the renal cortex was 0.47 ± 0.11 cm on the right kidney, while the average thickness of the renal cortex on the left kidney was 0.45 ± 0.12 cm. The renal medulla had an average thickness of 0.76 ± 0.23 cm on the right kidney and 0.74 ± 0.22 cm on the left kidney. When measuring the length of both kidneys, the average length was found to be 4.72 ± 0.50 cm on the right kidney and 4.81 ± 0.52 cm on the left kidney. The same right and left difference also applies to measuring the width of the kidneys, averaging 2.27 ± 0.38 cm on the right kidney while having an average of 2.28 ± 0.39 cm on the left kidney. When weighing individual kidneys, the average weight was 23.70 ± 4.97 g on the right kidney and 23.73 ± 5.29 g on the left kidney. It should also be noted that a total of 30 out of 194 cases (15.46%) had not been weighted properly due to unforeseen circumstances (Table 3).

**Table 1.** Examining external aspects of canine kidneys in domestic dogs (153 males and 41 females).

| Variable | Criteria | Number of cases | Percentage |
|---|---|---|---|
| Appearance | Smooth | 150 | 77.32 |
| | Spots | 44 | 22.68 |
| Color | Light colored | 184 | 94.85 |
| | Deep colored | 9 | 4.64 |
| | Blue-gray | 1 | 0.52 |
| Consistency | Normal | 191 | 98.45 |
| | Hard | 2 | 1.03 |
| | Soft | 1 | 0.52 |
| Other problems | Hemorrhage | 57 | 29.38 |
| | None | 137 | 70.62 |

**Table 2.** Examining internal aspects of the canine kidney in domestic dogs (153 males and 41 females).

| Variable | Criteria | Number of cases | Percentage |
|---|---|---|---|
| Bleeding | Internal hemorrhage | 101 | 52.06 |
| | None | 93 | 47.94 |
| Necrosis | Absent | 194 | 100.00 |
| | Present | 0 | 0.00 |
| Renal capsule | Easy to peel (Right) | 178 | 91.75 |
| | Easy to peel (Left) | 175 | 90.21 |
| | Difficult to peel (Right) | 16 | 8.25 |
| | Difficult to peel (Left) | 19 | 9.79 |

**Table 3.** Average measurements of the canine kidney in domestic dogs (153 males and 41 females).

| Renal parameters | Number of samples | Mean ± SD (cm) | Mean ± SD (g) |
|---|---|---|---|
| Renal Cortex (Right) | 194 | 0.47 ± 0.11 | - |
| Renal Cortex (Left) | 194 | 0.45 ± 0.12 | - |
| Renal Medulla (Right) | 194 | 0.76 ± 0.23 | - |
| Renal Medulla (Left) | 194 | 0.74 ± 0.22 | - |
| Length (Right) | 194 | 4.72 ± 0.50 | - |
| Length (Left) | 194 | 4.81 ± 0.52 | - |
| Width (Right) | 194 | 2.27 ± 0.38 | - |
| Width (Left) | 194 | 2.28 ± 0.39 | - |
| Weight (Right) | 164 | - | 23.70 ± 4.98 |
| Weight (Left) | 164 | - | 23.73 ± 5.29 |

SD: Standard deviation

**Table 4.** Gender difference in average measurements of canine kidneys in domestic dogs (153 males and 41 females).

| Mean ± SD (cm) | Renal cortex | | Renal medulla | | Length | | Width | |
|---|---|---|---|---|---|---|---|---|
| | Right | Left | Right | Left | Right | Left | Right | Left |
| **Male** | 0.47 ± 0.11 | 0.44 ± 0.11 | 0.77 ± 0.25 | 0.76 ± 0.24 | 4.74 ± 0.47 | 4.82 ± 0.48 | 2.26 ± 0.36 | 2.27 ± 0.37 |
| **Female** | 0.48 ± 0.11 | 0.49 ± 0.13 | 0.73 ± 0.13 | 0.69 ± 0.14 | 4.67 ± 0.61 | 4.76 ± 0.67 | 2.30 ± 0.46 | 2.33 ± 0.48 |

SD: Standard deviation

**Table 5.** Correlation of hemorrhage to average measurements of the canine kidney in domestic dogs (153 males and 41 females).

| External Hemorrhage | Internal hemorrhage | Number of cases | Renal cortex (cm) | | Renal medulla (cm) | | Length (cm) | | Width (cm) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Right | Left | Right | Left | Right | Left | Right | Left |
| No | No | 75 | 0.50 | 0.49 | 0.75 | 0.75 | 4.67 | 4.78 | 2.28 | 2.33 |
| Yes | No | 16 | 0.44 | 0.41 | 0.83 | 0.73 | 4.81 | 4.84 | 2.35 | 2.29 |
| No | Yes | 60 | 0.46 | 0.44 | 0.80 | 0.77 | 4.76 | 4.81 | 2.28 | 2.29 |
| Yes | Yes | 41 | 0.45 | 0.40 | 0.72 | 0.71 | 4.71 | 4.82 | 2.23 | 2.26 |

The thickness of the renal cortex showed slight differences between males and females. In males, the right and left renal cortices measured 0.47 ± 0.11 cm and 0.44 ± 0.11 cm, respectively, while in females, these values were reported as 0.48 ± 0.11 cm and 0.49 ± 0.13 cm, respectively (Table 4). Conversely, the renal medulla thickness was greater in the male canines. For males, the right and left medulla were 0.77 ± 0.25 cm and 0.76 ± 0.24 cm, respectively. For females, the measurements of the renal medulla were recorded as 0.73 ± 0.13 cm and 0.69 ± 0.14 cm for the right and left kidneys, respectively. Kidney length was, on average, greater in males, measuring 4.74 ± 0.47 cm on the right and 4.82 ± 0.48 cm on the left, as compared to females, whose kidneys measured 4.67 ± 0.61 cm on the right and 4.76 ± 0.67 cm on the left. Conversely, females exhibited slightly wider kidneys compared to males. The right and left kidney widths in females were 2.30 ± 0.46 cm, respectively, while in males, the measurements were reported as 2.26 ± 0.36 cm (right) and 2.27 ± 0.37 cm (left).

Upon further inspection, the study isolated cases of bleeding for deeper analysis, which led to four different results: No hemorrhage present in either the external or internal regions of the examined kidneys; external hemorrhage present but no internal hemorrhage; internal hemorrhage present but no external hemorrhage; and both external and internal hemorrhage present. When external hemorrhage was present, the average thickness of the right and left renal cortex was lower than the average, at 0.47 cm and 0.45 cm, respectively (Right: 0.44 cm without internal hemorrhage and 0.45 cm with internal hemorrhage present, Left: 0.41 cm without internal hemorrhage and 0.40 cm with internal hemorrhage present). In cases where internal hemorrhage was observed without the presence of external hemorrhage, kidney dimensions were generally larger than the average measurements. The thickness of the renal medulla increased, with the right medulla measuring 0.80 cm compared to the average of 0.75 cm and the left medulla measuring 0.77 cm compared to the average of 0.74 cm. Additionally, kidney length showed slight variations, with the right kidney measuring 4.76 cm, surpassing the average of 4.72 cm, while the left kidney remained consistent at 4.81 cm, aligning with the average. Moreover, kidney width displayed marginal increases, with the right kidney measuring 2.28 cm compared to the average of 2.27 cm and the left kidney measuring 2.29 cm compared to the average of 2.28 cm (Table 5). These results highlight subtle differences in kidney dimensions under these specific conditions.

## DISCUSSION

### Kidney's appearance

Evaluation criteria included external aspects such as appearance, color, texture, and other problems with the kidney, as well as internal aspects such as bleeding, necrosis, and the renal capsule. Recognizing these external and internal conditions is crucial for understanding the kidney's function and structure. Of 194 dogs, 144 were found to have "spots" on their kidneys. Kidney cysts are responsible for these "spots" appearing externally on the kidneys. Kidney cysts are complex, requiring careful diagnosis and early detection of symptoms to manage them effectively (Bergmann et al., 2018). Timely identification is crucial for developing an appropriate treatment plan and improving disease management outcomes. In particular, 22.68% of dogs had spots on their kidneys from the results (Van Dyck et al., 2018). This is alarming when taking into account the total population and its local implications. Abnormal colors were also observed, which indicate underlying chronic kidney disease conditions (Chetan et al., 2019). However, it should be noted that these dissections were performed post-mortem, so the color of the kidney might not reflect the overall health when the dog was alive. On the other hand, texture is also an important criterion to evaluate when dissecting, as it can indicate whether or not chronic renal failure is developing (Sebastian, 2009).

### Internal functions of the kidney

Whereas external factors may provide a general understanding of underlying conditions, internal factors reveal the root causes of the complications. When examining, 52.06% of the samples were recorded to have experienced bleeding. This is a concerning percentage, as the presence of renal hemorrhage can also contribute to an increase in renal vascular

resistance (Sordi et al., 2024). Furthermore, increased renal vascular resistance correlates with a higher prevalence of renal dysfunction (Derchi et al., 2005).

**Kidney sizes and measurements**

Other aspects of the kidney, such as the thickness of the renal cortex and renal medulla, kidney length and width, and kidney weight, were measured, and the averages were calculated (Table 3). Accurate kidney size measurements are essential for assessing renal health (Hoey et al., 2016). In humans, kidney size has been found to correlate with kidney disease in some cases, especially when these parameters are correlated with other important diagnostic criteria such as serum creatinine concentration and creatinine clearance (Jovanović et al., 2013). Whether or not these findings can be applied to canine patients will depend on more thorough research with larger sample sizes to eliminate any irregularities and subclinical renal disease.

**Correlation of gender with kidney size**

When analyzing the differences between both genders, no definitive conclusion about kidney sizes could be drawn based on gender factors alone in this canine population. However, one notable finding was that males had longer kidneys on average as compared to females. This finding aligns with those of Kalucki et al. (2020), which were previously observed in humans but appear to apply to the canine population sample as well. Further research is required to draw more definitive conclusions.

**Hemorrhage and its effects on renal measurements**

Further analysis of external hemorrhage suggests that the difference in measurements may be because hemorrhage can lead to hypovolemia (Mattson et al., 2006), which decreases blood supply and results in less vascularized tissue, leading to reduced thickness. Conversely, in cases of internal hemorrhage, it is hypothesized that fluid accumulation leads to kidney enlargement, eventually resulting in measurements that are greater than average.

**Accurate practices and understanding of renal diseases**

Further investigation acknowledges that additional tests, such as biomarker analysis (Lippi et al., 2021), could have provided a more detailed overview and additional insights. Nevertheless, this study demonstrates that canine renal disease in Vietnam is a significant issue that requires attention. It is important to acknowledge that some of the data was compromised due to inadequate practices during the collection process. Therefore, it is essential to recognize this limitation and make improvements in future efforts.

## CONCLUSION

After performing a physical examination of the kidneys, it is clear that all criteria and aspects are interconnected, forming a complex web of diseases and dysfunctions that negatively impact a dog's well-being. To tackle renal diseases, it is important to pay attention to all symptoms and abnormalities of the kidney. This is the key to accurate renal disease diagnosis and treatment. Future studies are encouraged to better understand and provide updates regarding this matter.

## DECLARATIONS

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**Author contributions**

Loan Vu Thuy Hong Nguyen and Thuong Thi Nguyen conceptualized, designed, and supervised the research. Loan Vu Thuy Hong Nguyen, Thuong Thi Nguyen, and Nhung Thi Tran collected samples and conducted experiments. Thuong Thi Nguyen, Loan Vu Thuy Hong Nguyen, and Nguyen Tran Phuc Nguyen analyzed and interpreted the data generated. Thuong Thi Nguyen, Loan Vu Thuy Hong Nguyen, Nhung Thi Tran, and Nguyen Tran Phuc Nguyen critically reviewed the study. All authors revised and approved the submitted manuscript.

**Competing interests**

The authors declare no conflicts of interest.

**Availability of data and materials**

The authors of this article confirm that all data supporting the findings of this research are available upon reasonable request.

**Ethical considerations**

This article was written originally without copying from previously published manuscripts, such as articles and books.

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