Original Article

THE VARIATIONS AND PATTERNS OF RENAL ARTERIES IN DOGS

Kriengyot Sajjarengpong* Adisorn Adirektaworn

Abstract

Kriengyot Sajjarengpong* Adisorn Adirektaworn

THE VARIATIONS AND PATTERNS OF RENAL ARTERIES IN DOGS

288 kidneys complete with renal arteries and abdominal aorta, were collected from 144 dogs (75 males and 69 females), dissected and studied according to the number, branch, length and position of the renal arteries bifurcation. The positions of the left and right renal arteries were also observed. Double renal arteries were noted in 14 of 144 dogs (9.72%) but only on the left side. Single renal arteries had one to six branches. Most kidneys had 2 (39.42%) or 3 (33.58%) branches. The bifurcation mostly occurred in the middle of the renal artery (60.61%). Only ten kidneys (3.65%) were supplied by a renal artery that had no branch. The patterns of double renal artery were single - single (21.43%); single - branched (57.14%) and branched - branched (21.43%). The right renal arteries, departing from the aorta, were higher, or at the same level, and longer than the left.

Keywords : kidney, dog, renal artery, branch.

Department of Veterinary Anatomy, Faculty of Veterinary Science, Chulalongkorn University. Henry Dunant Rd. Pathumwan, Bangkok 10330, Thailand.

***Corresponding author**

บทคัดย่อ

เกรียงยศ สัจจเจริญพงษ์* อดิศร อดิเรกถาวร

ความผันแปรและรูปแบบของ renal artery ในสุนัข

ไตพร้อมเส้นเลือดส่วน renal artery และ abdominal aorta จำนวน 288 ข้าง ถูกเก็บมาจากสุนัขจำนวน 114 ตัว (เพศผู้ 75 ตัว และเพศเมีย 69 ตัว) นำมาชำแหละและศึกษาจำนวน แขนง ความยาวและตำแหน่งของการแตกแขนงของ renal artery นอกจากนี้ยังศึกษาตำแหน่งของ renal artery บน abdominal aorta ทั้งด้านซ้ายและด้านขวา Renal artery ที่มีจำนวนสองเส้นที่ไปไตข้างเดียว (double renal artery) พบในสุนัข 14 จาก 144 ตัว (9.72%) และพบเฉพาะข้างซ้ายเท่านั้น Renal artery ที่มีแขนงเดี่ยวไปที่ไตข้างเดียว (single renal artery) พบการแตกแขนงตั้งแต่ 1 ถึง 6 เส้น โดยส่วนใหญ่จะพบ 2 และ 3 แขนง (39.42% และ 33.58%) การแตกแขนงของ renal artery พบว่าเริ่มต้นมากที่สุดบริเวณตรงกลาง (60.61%) มีเพียง 3.65% ของ renal artery ที่ไม่มีการแตกแขนง รูปแบบของ renal artery ที่มีจำนวนสองเส้นที่ไปไตข้างเดียว (double renal artery) พบได้ 3 แบบ คือ เส้นเดี่ยวทั้งคู่ (21.43%) เส้นเดี่ยวและแขนง (57.14%) และแขนงทั้งคู่ (21.43%) Renal artery ข้างขวาจะออกจาก aorta ที่ตำแหน่งสูงกว่าข้างซ้ายหรือที่เดียวกันและยาวกว่าข้างซ้าย

คำสำคัญ : ไต สุนัข renal artery แขนง

ภาควิชากายวิภาคศาสตร์ คณะสัตวแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย ปทุมวัน กรุงเทพฯ 10330
***ผู้รับผิดชอบบทความ**

Introduction

Kidneys are paired structures located in the abdominal cavity. Normaly each kidney in the dog has only a single renal artery arising from the abdominal aorta. Christensen (1952), Reis and Tepe (1956), Shively (1978) and Wiland and Indykiewicz (1999) studied renal arteries in dogs and found that some dogs had more than one renal artery supplying each kidney. Multiple renal arteries to each kidney were also found in some other species: man, cat, guinea pig (Shively, 1978) and mink (Wiland and Indykiewicz, 1999). Such variations in the renal arteries to each kidney are an important anatomical feature and are required to be known for surgery, such as removal, translocation or transplantation of the kidney.

During embryonic development, the dorsal, lateral and ventral branches arise from the aorta. The renal artery develops from the lateral branch, that is paired (Noden and de Lahunta, 1985). Commonly the renal artery bifurcates into dorsal and ventral branches which supply the cranial and caudal portion of the kidney (Fuller and Heulke, 1973; Evans and Christensen, 1993). The branching variations involving single or double renal arteries ranges from a single to numerous branches (Evans and Christensen, 1993). The end arteries from the branches of the renal artery, which are found inside kidney, are interlobar, arcuate, interlobular arteries and finally become glomeruli via the afferent arterioles (Evans and Christensen, 1993; Smith, 1999).

The aim of this paper was to study the variations and patterns of renal arteries in dogs, including the position of the left and right single renal arteries, which depart from the abdominal aorta, and the bifurcation point of single renal arteries. Additionally, we measured the length of the renal arteries.

Materials and Methods

A total of 288 kidneys, including abdominal aorta and renal arteries, were collected from 144 dogs of various ages (Mongrel breeds, 75 male and 69 female). Approximately 60 dogs came from preserved specimens used for gross dissection in an anatomy laboratory and the remainder came from fresh specimens, used for practice in a surgery laboratory. Kidneys, renal arteries and their branches were dissected systematically.

The number, position of left and right single renal arteries from the aorta and the bifurcation of single renal

arteries were recorded. The length of renal arteries was measured from abdominal aorta to the hilus of the kidney.

Results

In this study, 130 dogs had a single renal artery to each kidney and 14 dogs (9.72%) had double renal arteries. Double renal arteries could be found in both sexes, but only on the left side (Table 1). In Table 2, the number of branches from the single renal arteries is shown to be, one to six. Some kidneys (39.42%) had two branches for each kidney. Only one kidney had six branches from the renal artery. Ten kidneys (3.65%) were supplied by renal arteries that did not bifurcate before entering the renal hilus (Fig. 1). In most dogs (69.23%), the right renal arteries departed from the abdominal aorta before the left renal arteries, whereas in 40 dogs (30.76%), the left and right renal arteries arose from the abdominal aorta at the same level (Table 3).

Table 1 The number of renal arteries is classified by sex and position.

Number of renal arteries	Number of dogs	Male		Female		%
		Right	Left	Right	Left	
Single	130	63	63	67	67	90.28
Double	14	-	12	-	2	9.72

Table 2 The number of branches from the single renal artery is classified by sex and position.

Sex	Position	Number of branches from the single renal artery					
		1	2	3	4	5	6
Male	Right	4	20	22	10	8	1
	Left	1	30	20	9	4	-
Female	Right	4	30	21	23	1	-
	Left	1	28	29	8	-	-
Total	274	10	108	92	50	13	1
(%)	(100)	(3.65)	(39.42)	(33.58)	(18.25)	(4.74)	(0.36)

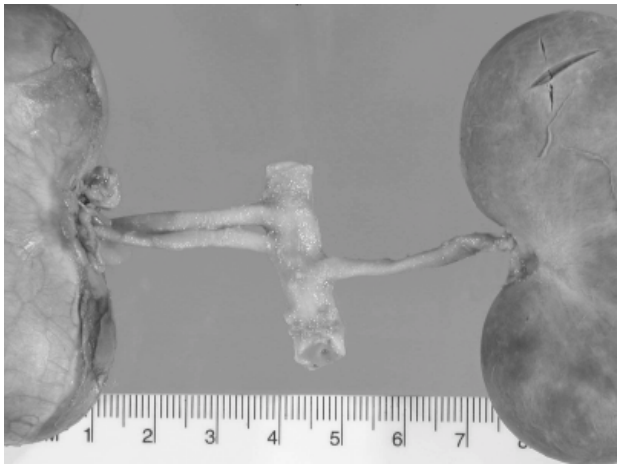
Table 3 The positions where the left and right single renal artery leaves the abdominal aorta.

Positions	Total (%)
right higher than left	90 (69.23)
right and left level	40 (30.76)

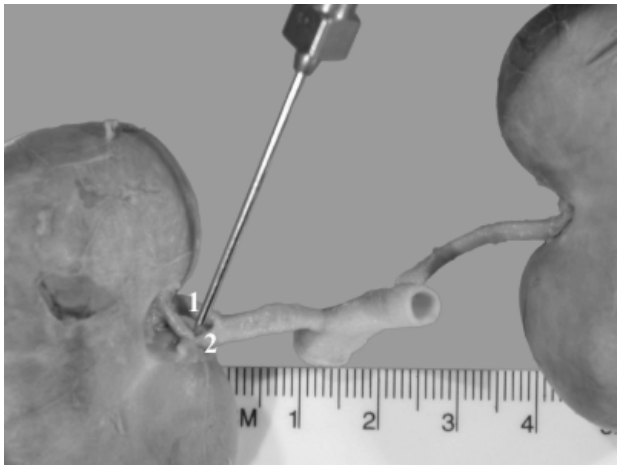
The patterns made by the double renal arteries were single-single; single-branched; and branched-branched (Fig. 2). In the majority of cases, the pattern of the double renal artery was single-branched (57.14%). The number of double renal arteries, which had single-single and branched-branched pattern, was similar (Table 4).

Table 4 The patterns of double renal arteries, classified by sex.

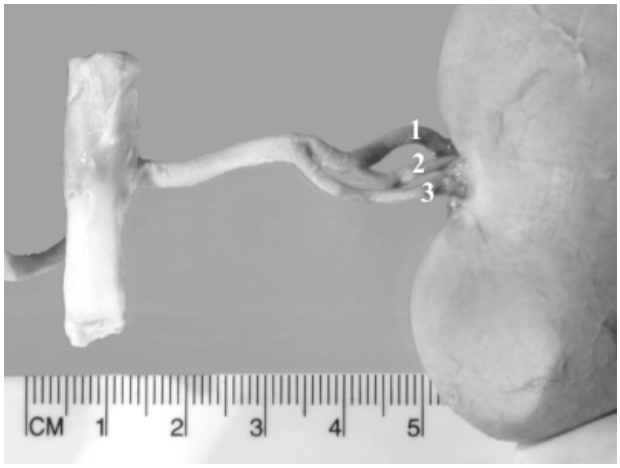
Patterns of double renal arteries	Male	Female	Total (%)
Single-single	2	1	3 (21.43)
Single- branched	7	1	8 (57.14)
Branched- branched	3	-	3 (21.43)



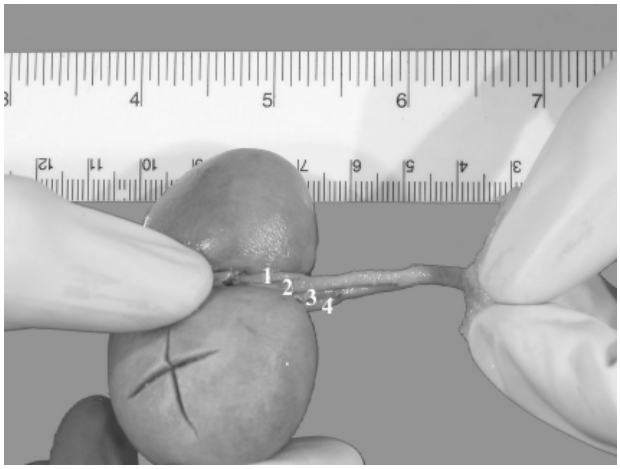
Single



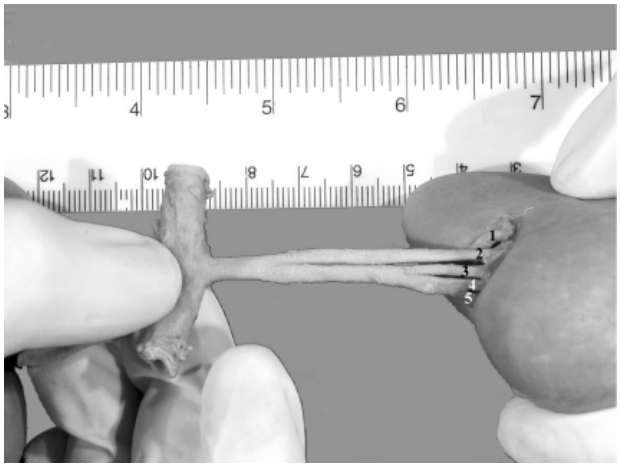
Branched (2)



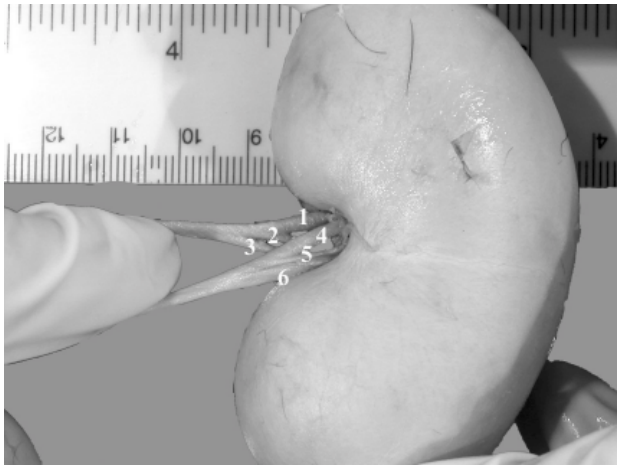
Branched (3)



Branched (4)



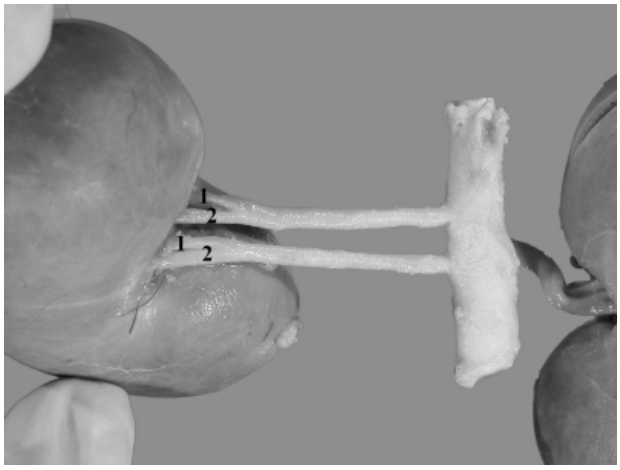
Branched (5)



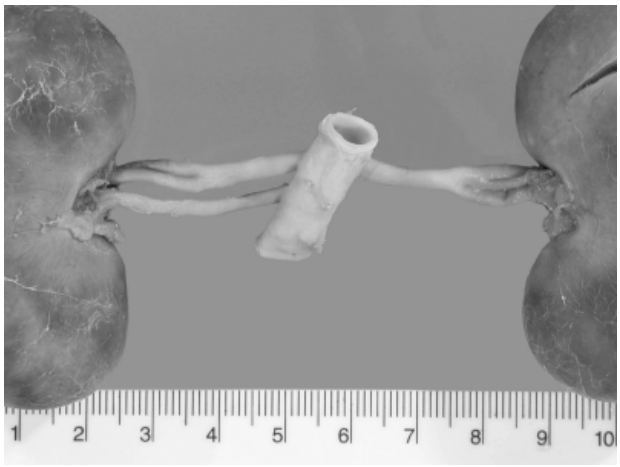
Branched (6)

Figure 1 The patterns of the single renal artery in dogs.

Single-single



Branched-branched



Single-branched

Figure 2 The patterns of double renal arteries in dogs.

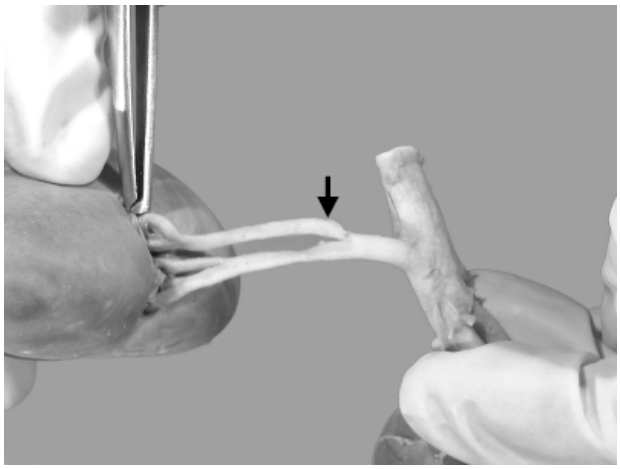
The positions of the bifurcation of the single renal artery were proximal, middle and distal (Fig. 3). In Table 5, 160 renal arteries had the position of the bifurcation in the middle (60.61%) and proximal (12.12%). From this study (Table 6), we found that the right renal arteries were longer than the left one, in both sexes.

Table 5 The positions of the bifurcation of the single renal artery were classified by sex and position.

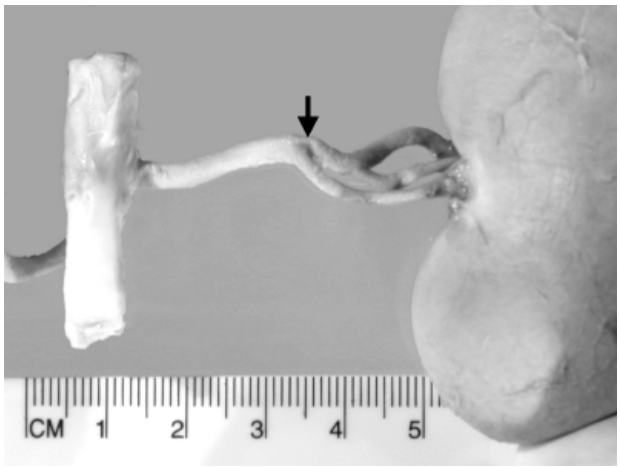
Sex	Position	Positions of the bifurcation of the single renal artery		
		Proximal	Middle	Distal
Male	Right	3	47	24
	Left	11	39	14
Female	Right	4	37	20
	Left	14	37	14
Total (%)	264 (100)	32 (12.12)	160 (60.61)	72 (27.27)

Table 6 The length of the renal arteries (in cm) from abdominal aorta to the kidney was classified by sex and position.

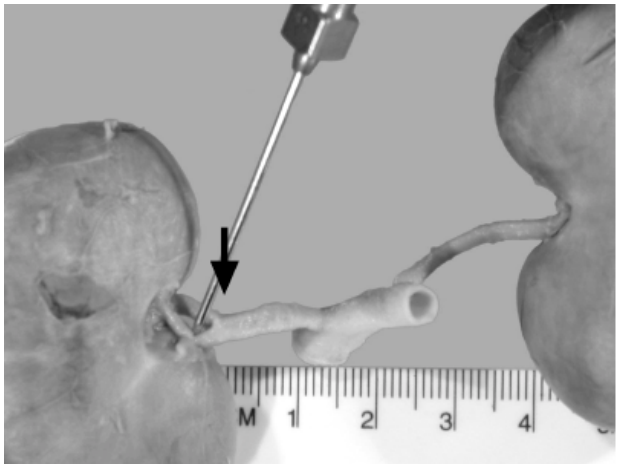
Sex	Position	Length of renal arteries (mean ± SD)
Male	Right	4.01 ± 0.86
	Left	3.98 ± 0.96
Female	Right	3.66 ± 0.81
	Left	3.56 ± 0.95



Proximal bifurcation



Middle bifurcation



Distal bifurcation

Figure 3 The positions of the bifurcation that occur in a single renal artery in dogs.

Discussion

Normally each canine kidney is supplied by one single renal artery. The incidence of double renal arteries in dogs has been shown to be 24.79% (29 from 117 kidneys) (Christensen, 1952), 12.80% (64 from 500 dogs) (Reis and Tepe, 1956), 13.40% (67 from 500 dogs) (Shively, 1978) and 20% (7 from 35 dogs) (Wiland and Indykiewicz, 1999). In this study, the incidence of double renal arteries was 9.72% (14 from 144 dogs) and they were only on the left side, whereas Christensen (1952), Reis and Tepe (1956), Shively (1978) and Wiland and Indykiewicz (1999) found double renal arteries on the both sides, although they reported that the incidence of double renal arteries was more on the left side than on the right side. We hypothesize that the presence of double renal arteries may be due to two events during development. Firstly, the lateral aortic branch does not degenerate and the renal artery develops from the lateral aortic branch. In the fetus, multiple lateral branches supply the mesonephros and as the mesonephros degenerates, the lateral aortic branch also degenerates (Noden and de Lahunta, 1985). Secondly, the double renal arteries come from dorsal and ventral branches which arise directly from abdominal aorta. Normally the renal artery departs from the abdominal aorta and bifurcates into a dorsal and a ventral branch (Fuller and Heulke, 1973; Evans and Christensen, 1993). According to the second hypothesis, the patterns of a double renal artery can be single-single; single-branched and branched-branched. It appears that these double renal arteries could have arisen from the dorsal and ventral branches of the aorta. Triple renal arteries have also been found in dogs (Reis and Tepe, 1956; Shively, 1978), but they were not observed in this investigation.

This study showed that the number of branches from a single renal artery was 1 to 6 while Christensen (1952) reported 1 to 7 branches. The position of the bifurcation from a single renal artery occurred mostly in the middle. The minimum position of the bifurcation of single renal artery was proximal. This position in some dogs was close to the aorta. Most kidneys had 2 branches, which appeared to be dorsal and ventral branches (Fuller and Heulke, 1973; Evans and Christensen, 1993).

In this investigation, the right renal artery departed from the aorta before the left and the right was longer than the left renal artery, due to the position of the right kidney which was higher than the left one. The position of the right and left kidneys is at the 12^{th} or 13^{th} thoracic vertebrae - 2^{nd} or 3^{rd} lumbar vertebrae and the 1^{st}-3^{rd} lumbar vertebrae, respectively (Smith, 1999). In some dogs (40 from 120) the right and left renal arteries arose from the aorta at the same level. Christensen (1952) reported that the right renal artery was invariably longer than the left, whereas the left renal vein was longer than the right one.

In conclusion, the variations in the renal arteries in this study was single (90.28%) and double (9.72%). Double renal arteries were found in both sexes but only on the left side. Branches from the single renal arteries were one to six and most kidneys had 2 to 3 branches. However, 10 kidneys had no branch at all. The position of the bifurcation was in the middle, distal and proximal sections. The patterns of double renal arteries were single-single (21.43%); single-branched (57.14%) and branched-branched (21.43%). The left renal arteries departed from the aorta at a lower position, or at the same level, and were shorter than the one on the right.

Acknowledgments

We would like to thank the Department of Veterinary Pathology, Faculty of Veterinary Science, Chulalongkorn University for permission to use the dissection room and Assoc. Prof. Payatra Tantilipikara for advice. We thank Assoc. Prof. Dr. Weerapong Koykul for his critical reading of the manuscript. This study was supported by a Development Grant for new Faculty/ Researchers.

References

Christensen, G.C. 1952. Circulation of blood through the canine kidney. Am. J. Vet. Res. 13: 236-245.

Evans, H.E. and Christensen, G.C. 1993. Urogenital system. In: Miller's Anatomy of the Dog. 3rd ed. H.E. Evans (ed.). Philadelphia: W.B Saunders Company. 494-500.

Fuller, P.M. and Heulke, D.F. 1973. Kidney vascular supply in the rat, cat and dog. Acta Anat. 84: 516-522.

Noden, D.M. and de Lahunta, A. 1985. The Embryology of Domestic Animals. G. Stamathis (ed.). Baltimore: Williams &Wilkins.219.

Reis, R.H. and Tepe, P. 1956. Variation in the pattern of renal vessels and their relation to the type of posterior vena vava in the dog *(Canis familiaris)*. Am. J. Anat. 99: 1-15.

Shively, M.J. 1978. Origin and branching of renal arteries in the dog. J. Am. Vet. Med. Assoc. 173: 986-989.

Smith, B.J. 1999. Canine Anatomy. Philadelphia: Lippincott Williams. 441-446.

Wiland, C. and Indykiewicz, P. 1999. Multiple renal arteries *(Aa. renales)* in mink and dog. EJPAU. 2: 1-4.