VARIATIONS IN THE VASCULAR ANATOMY OF THE RABBIT KIDNEY AND ITS EXPERIMENTAL SIGNIFICANCE

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Abstract. The aim of the study was to describe rabbit’s kidney arteries and veins. Research was carried out on 40 New Zealand White Rabbits. The corrosion cast of the arterial and venous system was prepared by using Spofacryl. In 10% of the cases it was observed that the left renal artery was doubled. In one case the presence of an accessory renal artery in the right kidney was recorded. In 10% of the cases it was observed that the left renal vein was doubled. In 5% of the cases two left renal veins arose from the kidney and subsequently united to form a single vein about 1cm from the opening to the caudal vena cava. In 5% of the cases two left renal veins arose from the kidney and subsequently they united 1 cm away from the renal hilus. The anatomical knowledge of the renal arteries, veins and its variations are of importance in the experimental field.

Key words: corrosion casts, rabbit, renal vessels

INTRODUCTION

Knowledge of the variations of the renal vascular anatomy is important when it comes to exploration and treatment of renal trauma, transplantation, reno-vascular hypertension, renal artery embolization, angioplasty or vascular reconstruction of congenital and acquired lesions, surgery of abdominal aortic aneurysm and conservative or radical renal surgery. Numerous reports have appeared in the literature describing variations in renal vascular anatomy [Ross et al. 1961].

Variations in the renal vasculature have etiologic, diagnostic, and therapeutic implications. Etiologically, multiple renal arteries represent persisting mesonephric arteries. Diagnostically, failure of a kidney portion’s opacification at an arteriography raises the

Therapeutically, as each multiple renal artery is a terminal vessel, its lesion may produce segmental ischemia with subsequent hypertension. In traditional surgical procedures, besides haemorrhage and the loss of renal parenchyma, one of the consequences of a renal arterial lesion is the development of hypertension [Sampaio and Passos 1992]. The presence of multiple renal arteries increases the complexity of renal transplantation. It has been reported that kidneys presenting anatomic vascular variations are associated with a significantly higher failure rate than kidneys with a single artery [Fox and Yalin 1979, Sampaio and Passos 1992, Sansom et al. 1978].

The basic type of the vascular arrangement of kidneys has two vessels on each side: one artery and one vein for each kidney [Nejedly 1965, Popesko et al. 1990]. Although rabbits are laboratory animals relatively frequently used for studies, there is a considerable gap in angiologic literature regarding the issue of vascular variations of rabbit kidneys. Papers dealing with this issue have been published only sporadically [Mierzwa 1975]. Variations in the number of renal vessels have been described in other species. Quite often variations of renal arteries in dogs were observed [Sajjarengpong and Adirektaworn 2006] and compared with other species [Wiland and Indykiewicz 1999].

The aim of this study was to describe the origin, localisation and variations of kidney arteries and veins in the rabbit as this laboratory animal is frequently the subject of scientific studies, which will help to prevent various complications during experiments and subsequently to the acquisition of distorted or false results in experiments.

**MATERIAL AND METHODS**

The study was carried out on 40 adult (age = 140 days) New Zealand White rabbits (breed HY+) of both sexes (male n = 20, female n = 20), with weight range 2.5–3 kg in an authorized experimental laboratory at the University of Veterinary Medicine and Pharmacy in Kosice. The animals were kept in cages under standard conditions (temperature 15–20°C, relative humidity 45%, 12 h light period) and fed with a granular feed mixture (O-10 NORM TYP). Drinking water was available for all animals ad libitum. Twenty rabbits of both genders were used to prepare corrosion casts of the kidney arterial system. Another group of the same size and composition served to investigate the venous system. The animals were euthanized by intrapulmonary injection with a T-61 solution. Immediately after euthanasia, the vascular network was perfused with physiological solution. The arterial system was injected manually through ascending aorta while the right atrium of heart was opened in order to lower the pressure in the vessels to ensure good injection. Before injecting the venous system, we the valves were fixed by means of 10% formaldehyde solution injected through the caudal vena cava, to prevent their reverse closure. Fixation of the venous system was maintained for three hours. Subsequent injection was carried out through the caudal vena cava. 35 ml of Spofaeryl (SpofaDental, Czech Republic) was used as a casting medium. Maceration was carried out in 2–4% KOH solution for 5 days at 60–70°C.

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RESULTS

The renal arteries, as paired organ arteries supplying the kidneys, arose from lateral aorta walls. The left renal artery (a. renalis sinistra), was longer than the right renal artery (a. renalis dextra), which was related to more lateral localisation of the left kidney. It was observed that in all cases the right renal artery originated more cranially than the left renal artery (Fig. 1). In 75% of the cases the beginning of the renal arteries was located at the level of the third lumbar vertebra and in the remaining 25% of the cases the right renal artery branched off at the level of the second lumbar vertebra. The renal arteries were originated between the second and third lumbar vertebrae in 20% of cases. In 95% of the cases the beginning of the renal arteries was located caudally from the cranial mesenteric artery (a. mesenterica cranialis). Only in one case the right renal artery begun at the same level as the cranial mesenteric artery. In 10% of the cases it was observed that the number of right renal artery was doubled (Fig. 2), both originating at the level of the third lumbar vertebra. In one case the accessory renal artery (a. renalis accessoria) was recorded in the right kidney (Fig. 3). It begun from the ventral wall of the aorta between the fourth and fifth lumbar vertebra and entered the kidney at its caudo-medial margin. After entering the renal hilus (hilus renalis) the renal artery divided into interlobar arteries (aa. interlobares).

The cranial abdominal artery (a. abdominallis cranialis) was a paired artery originating from the renal artery. In 65% of the cases the right cranial abdominal artery (a. abdominallis cranialis dextra) originated from the right renal artery, ahead of the left cranial abdominal artery (a. abdominallis cranialis sinistra) originating from the left renal artery. In 30% of the cases they both originated from the renal arteries at the same level. In one case they begun directly from the wall of the abdominal aorta (aorta abdominallis), cranially from the beginning of the renal arteries.

The localisation and the opening frequency of the renal veins into the caudal vena cava (v. cava caudalis) were coincident with the origin of the renal arteries from the abdominal aorta. The renal veins were situated more caudally than the renal arteries. The left renal vein (v. renalis sinistra) was longer than the right renal vein (v. renalis dextra) (Fig. 4). The left cranial abdominal vein (v. abdominallis cranialis sinistra) opened into the left renal vein in all of the cases while the right cranial abdominal vein (v. abdominallis cranialis dextra) opened into the right renal vein in 65% of the cases. In 35% of the cases the right cranial abdominal vein opened into the caudal vena cava. In 10% of cases it was observed that the number of the right renal vein was doubled. In 5% of the cases two left renal veins arose from the kidney and subsequently, about 1 cm from the opening to the caudal vena cava, they united to form a single vein. The right cranial abdominal vein also joined this common vein. The left cranial ureteral vein (v. ureterica cranialis sinistra s. ramus uretericus a. renalis sinistra) opened into one of the left renal vein (Fig. 5). In 5% of the cases two of the left renal veins arose from the kidney and subsequently, approximately 1 cm away from the renal hilus, they united into one vein. The right cranial abdominal vein and the left cranial ureteral vein also opened into this common vein (Fig. 6). The left cranial ureteral vein opening into the left renal vein was observed in 20% of cases.

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Fig. 1. Macroscopic image of the renal arteries are branches of the abdominal aorta. The right renal artery (a. renalis dextra) originating more cranially than the left renal artery (a. renalis sinistra). Both cranial abdominal arteries (aa. abdominales craniales) are branches from the renal arteries (aa. renales). Dorsal view


Fig. 2. Macroscopic image of the double left renal artery (a. renalis sinistra). Ventrolateral view

Ryc. 2. Obraz makroskopowy podwójnej tętnicy nerkowej lewej (a. renalis sinistra). Widok do-brzuszno-boczny
Fig. 3. Macroscopic image of the accessory renal artery (*a. renalis accessoria*) in the right kidney. Dorsolateral view

Ryc. 3. Obraz makroskopowy tętnicy nerkowej dodatkowej (*a. renalis accessoria*) w nerce prawej. Widok dogrzbietowo-boczny

Fig. 4. Macroscopic image of the renal veins (*vv. renales*) opened into the caudal vena cava (*v. cava caudalis*) and the cranial abdominal veins (*vv. abdominales craniales*) opened into the renal veins (*vv. renales*). The cranial ureteral vein (*v. ureterica cranialis*) is a single tributary of the caudal vena cava (*v. cava caudalis*). Ventral view

Ryc. 4. Obraz makroskopowy żył nerkowych (*vv. renales*) dołączających do żyły głównej doogonowej (*v. cava caudalis*) oraz żył brzusznych doczaszkowych (*vv. abdominales craniales*) odchodzących od żył nerkowych (*vv. renales*). Żyła moczowodowa doczaszkowa (*v. ureterica cranialis*) jest pojedyncza i łączy się z żyłą główną doogonową (*v. cava caudalis*). Widok dobrzuszny
Fig. 5. Macroscopic image of two left renal veins (vv. renales sinistriæ) arose from the kidney and subsequently, about 1 cm from opening to caudal vena cava (v. cava caudalis), they united to form a single vein. Ventrolateral view

Ryc. 5. Obraz makroskopowy dwóch lewych żył nerkowych (vv. renales sinistriæ), które łączą się w jedno naczynie na około 1 cm, zanim dołączą do żyły głównej doogonowej (v. cava caudalis). Widok dobrzuszno-boczny

Fig. 6. Macroscopic image of two left renal veins (vv. renales sinistriæ) arose from the kidney and subsequently, approximately 1 cm away from the renal hilus (hilus renalis), they united into one vein. Ventral view

Ryc. 6. Obraz makroskopowy dwóch lewych żył nerkowych (vv. renales sinistriæ) opuszczających nerkę i następnie w pobliżu, na około 1 cm od wnęki nerkowej (hilus renalis), łączących się ze sobą. Widok dobrzuszny
DISCUSSION

Last study about the renal vasculature in New Zealand adult rabbits was carried out by Shalgum et al. [2012]. They observed only the one renal artery which was divided in two, dorsal and ventral branches into the renal hilus. Furthermore, they found branching pattern for intrarenal arteries (I, II, and III type). This division depends on the division renal artery. According to Sindel et al. [1990], the first renal artery division in the domestic rabbits take place into the renal hilus.

Senecail et al. [2003] described that the left anomalies of the renal vein may represent real traps in the interpretation of the abdominal imaging, particularly in CT scanning, where they are not always recognized, or in magnetic resonance. The abnormal imaging may be the source of technical difficulties in diagnostic or therapeutic angiography [Gil-\i lot 1978] and may modify the values obtained by catheter sampling for suprarenal hormonal levels [Satyapal et al. 2001, Senecail et al. 2003].

An angiographic evaluation of the renal arterial supply must be carried out routinely before donor nephrectomy, in order to identify any arterial variants or covert parenchymal disease artery [Fox and Yalin 1979, Sampaio and Passos 1992, Sansom et al. 1978].

The anatomical knowledge of the renal arteries, veins and its variations are of extreme importance for the surgeon that approaches the retroperitoneal region, mainly in face of the current frequency of the renal transplant surgeries, as well as, these anatomical variations should be kept in mind by clinicians and academics that may work within this anatomical area [Fernandes et al. 2005].

In 10% of the cases it was observed that the number of the left renal artery was doubled. For example, in the dog the left renal artery was doubled in 20% of cases [Sajjarengpong and Adirektaworn 2006] or in 9.72% of the cases and in the mink in 20.7% [Wiland and Indykiewicz 1999]. The double right renal artery in the rabbit was not present like in the dogs [Sajjarengpong and Adirektaworn 2006, Wiland and Indykiewicz 1999]. The presence of a thin accessory renal artery of the right kidney with more caudal origin was found only in one case.

The aim of the study, which pointed to double the number of both renal arteries and the renal veins, were obtained using relatively significant statistic set of data which can lead to distorted or insufficient results of experiments in this field.

The accuracy of preoperative evaluation using digital subtraction angiography was 91–95% and while using CT angiography was 95–97% [Hänninen et al. 2005]. But the accuracy of intra-operative findings and in the described study, by preparing corrosive casts, was 100%.

Such variations in the renal arteries of each kidney are an important anatomical feature and they are required to be known by surgeons, during removal, translocation or transplantation of the kidney [Sajjarengpong and Adirektaworn 2006].

Morphological variations observed here could have been linked to environmental processes [Wiland and Indykiewicz 1999] or embryonic development [Sajjarengpong and Adirektaworn 2006].
REFERENCES


ZRÓZNICOWANIE ANATOMICZNE
W UNACZYNIENIU NERKI KRÓLIKA
I ZNACZENIE TYCH WARIANCJI W DOŚWIADCZENIACH

Streszczenie. Celem pracy była charakterystyka tętnic oraz żył nerkowych królików nowozelandzkich białych. Badań dokonano na 40 osobnikach, u których wykonano korozję naczyń, posługując się Spofacrylem. Zabberowano, że u 10% badanych osobników występowały dwie tętnice nerkowe lewe. Natomiast w jednym przypadku odnotowano tętnicę nerkową dodatkową prawą. Stwierdzono także, iż żyła nerkowa lewa, podobnie jak tętnica, także u 10% osobników była parzysta. Obi naczynia w 5% ulegały połączeniu na około 1 cm przed dołączeniem do żyły
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Słowa kluczowe: badania korozyjne, królik, naczynia nerkowe

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