Acta Scientiarum

http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-863X
Doi: 10.4025/actascibiolsci.v40i4.38801

ZOOLOGY

Renal artery in tufted capuchin monkey: structure and morphometry

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ABSTRACT. The objective was to describe the structure of the renal artery in capuchin monkey at the level of the proximal and distal arterial segments. Morphometric analysis was performed referring to the thickness and quantification of tissue elements of the renal artery tunica media in both segments. Renal arteries of eight adult capuchin monkeys were collected for histological analysis of the two segments, being the proximal part branched from the abdominal aorta, and the distal part localized next to the renal hilus. The quantification of smooth muscle cells and connective elements was carried out in transversal sections of the two segments; for the tunica media, it was used the volume densities of smooth muscle cells, collagen and elastic fibers. Considering these volume densities obtained for each segment, it was verified that the proximal segment showed a marked myoconnective architecture, while the distal segment was characterized by a single muscular artery. Apparently, the mixed architecture of the proximal segment could be related to a blood flow control at the aortic emergence of the renal artery, which helped to guarantee a priority flow of enriched plasma into the kidney parenchyma.

Keywords: anatomy and histology; blood vessels; mammals.

Artéria renal do macaco prego: estrutura e morfometria

RESUMO. O objetivo foi descrever a estrutura da artéria renal no macaco prego ao nível dos segmentos arteriais proximal e distal. Uma análise morfométrica foi realizada, tendo como parâmetros a espessura e a quantificação dos elementos constituintes da túnica média da parede vascular, nos dois segmentos. Foram coletadas as artérias renais de oito macacos pregos adultos para estudos histológicos dos dois segmentos, sendo o segmento proximal a parte originária da aorta abdominal e o segmento distal a parte arterial junto ao hilo renal. A quantificação de células musculares lisas e de elementos conjuntivos da matriz extracelular foi realizada em secções transversais dos dois segmentos, sendo empregadas para a túnica média as densidades de volumes (DV), dos componentes musculares e das fibras elásticas e colágenas. Tendo por base estas densidades de volumes obtidas para cada segmento arterial verificou-se que o segmento proximal apresentou estrutura mioconjuntiva marcante, enquanto que o segmento distal foi caracterizado como uma artéria muscular padrão. Aparentemente, a arquitetura mista do segmento proximal estaria relacionada com o controle de fluxo sanguíneo na emergência aórtica da artéria renal, garantindo um direcionamento prioritário de fluxo de plasma sanguíneo enriquecido para dentro do parênquima renal.

Palavras-chave: anatomia e histologia; vasos sanguíneos; mamíferos.

Introduction

The renal artery had been mainly characterized as a typical muscular artery, similar to the other visceral branches from the abdominal aorta. Its role of blood distribution to specific parts of the body presents histo physiological compatibility with a mural muscular architecture (Melbin & Detweiler, 2007; McGrath et al., 2005; Tortora & Grabowisky, 2012).

On the tunica media structure of the muscular arteries occurred concentric layers of smooth muscle cells assuming helical arrangement (Gartner & Hiatt, 2007), being mainly intermingled by variable amounts of extracellular matrix elements, such as elastic and collagen lamellae and fibers (McGrath et al., 2005). The muscular arteries also presented two limiting elastic laminas. The inner elastic lamina, marking the transition between the end of the tunica media and the beginning of the tunica adventitia (Gartner & Hiatt, 2007).

Although, between the elastic and muscular arterial types (Gartner & Hiatt, 2007; Tortora & Grabowisky, 2012), it was observed an intermediary arterial type whose tunica media presented a myoconnective architecture. This pattern was verified in the abdominal segment of aorta in some mammals (Mello, Orsi, Padovani, Matheus, & Eleutério, 2004;Orsi, Stefanini, Crocci, Simões, & Ribeiro, 2004; Viegas, Orsi, Simões, & Crocci, 2004a; Viegas, Orsi, Simões, Domeniconi, & Natali, 2004b; Mello et al., 2007),including the tufted capuchin monkey (Mello, Orsi, Domingues, Molinari, & Araujo, 2009).According to these authors, in distal aortic wall, a minor amount of extracellular matrix components was found, with a proportional equilibrium with the occurrence of smooth muscle cells. Perhaps, it could be associated with a lesser diameter of the aorta in this distal segment (Orsi, Domeniconi, Mello, & Spilla, 2015).

Theoretically, other visceral distributive arteries could be formed by an intermediary structure, with a muscular composition in the tunica media. Regarding the architecture of the renal artery, there was a motivation for the analysis of this vessel in the tufted capuchin that was the objective of this study. The capuchin monkey has restricted geographical distribution (Costa, Leite, Mendes, & Ditchfield, 2005; Alves et al., 2007), which, among other factors, may have restricted the knowledge of some anatomical characteristics of this species. In addition, the renal artery, terminal branch, plays several roles through renal hemodynamics, such as: blood dialysis; control of the blood pressure; ionic and water balance and other functions related to homeostasis (Melbin & Detweiler, 2007; Koeppen & Stanton, 2009).

Material and methods

The right renal artery was collected from 8 adult tufted capuchin monkeys (*Cebus apella*) without specific sexual distinction. The monkeys were provided from the "Tufted Capuchin Monkey Breeding Center", localized at the UNESP Campus of Araçatuba, State of São Paulo, Brazil. The primates were euthanized by anesthetic saturation using an intravenous injection of ketamine hydrochloride® (15 mg kg^{-1}), followed by barbiturate salt™ (30 mg kg^{-1}), into the peritoneal cavity.

All the monkeys suffered initially arterial perfusion with an adequate volume of neutral saline solution followed by perfusion with buffered formalin (0.1 M sodium borate buffer, pH 9.5) at 4ºC.The arterial tree perfusion occurred throughout a continuous flow in all the monkeys. Afterwards, the proximal and distal segments of the right renal artery were collected, which were destined for light microscopy studies. The proximal segment of the renal artery was characterized by fragments collected from the arterial part branched from the abdominal aorta. The arterial distal segment was represented by fragments collected from the renal artery localized next to the renal hilus.

The histological routine was followed by embedding the arterial fragments in paraplast™, obtaining transverse and semi serial histological sections with 5 to 7 μm thickness. Slides were stained by the methods of Resorcin-fuchsin from Weigert-Van Gieson and Masson trichrome (Lillie, 1965).

The histological sections were analyzed and documented photographically in a video microscope system, an Olympus BX 50® photomicroscope, coupled to an image capture system - "Image Pro Plus™ software, using 10 and 20x objective. The histological slides with cross sections were used for counting the elastic laminae and the thickness of the arterial tunica media, and the slides were analyzed and documented in the BX® microscope with a 20x objective. To perform the morphometry, the measurement of the tunica media was made, with analyses of four different regions, of the same section, the regions being located in opposite diameters to obtain greater precision in the study. From the collected data, the arithmetic averages were calculated. Quantification of the fibromuscular components was performed in the tunica media, also in cross sections, using volume density (Vv) of smooth muscle, and collagen and elastic fibers. For each animal, nine histological sections were analyzed, focused on random microscopic fields. The analysis of the volume density was performed using a score of points, using a test system with 36 points.

The present research was approved by the Animal Research Ethics Committee of the Prego Monkeys Procreation Center of the Faculty of Odontology of Araçatuba - FOA 087/95.

Results and discussion

Few studies show the structure of the renal artery wall in humans. Renal arteries are usually in number of two and responsible for the supply of blood to the kidneys. Approximately 1,200 to 2,000 liters of blood are passed through the adult human kidneys each day from these arteries (Sodré, Costa, & Lima, 2007). Studies show that 90% of renal artery lesions have atherosclerotic etiology and their prevalence increases with age, because during the aging process the arteries lose their elasticity and their walls become stiffer, thicker. There is still a loss of elastic tissue, connective tissue accumulation and calcium deposit (Safian & Textor, 2001; White, 2006).

The general structure of the right renal artery of the tufted capuchin monkey presented a thin inner tunica, which was separated from the larger tunica media by a circumferential inner elastic lamina (Figures 1, 2 and 3). At the tunica media architecture were found smooth muscle cells mainly arranged circularly, except near the adventitia coat whose tunica media smooth muscle cells were arranged longitudinally (Figures 1 to 4). Fibrous and lamellar collagen of the tunica media was seen intermingled with the smooth muscle cells and the elastic lamellae (Figure 4). The tunica adventitia (AT) appeared closely related to the tunica media architecture. AT was mainly formed by loose connective tissue with some sparse smooth muscle cells and extracellular matrix elements. They appeared scarce when the adventitia limits were more distant from the tunica media coat, and an outer elastic lamina surrounded the limiting border of the tunica adventitia. This general renal arterial architecture was similar to that described in histological texts (Gartner & Hiatt, 2007; Junqueira & Carneiro, 2013).

Concerning the architecture of the proximal segment and distal segments of the right renal artery, it was verified some distinction in parameters such as: number of elastic lamellae; volume density (%) of collagen elements; volume density (%) of smooth muscle cells and volume density (%) of elastic materials, shown in table 1.

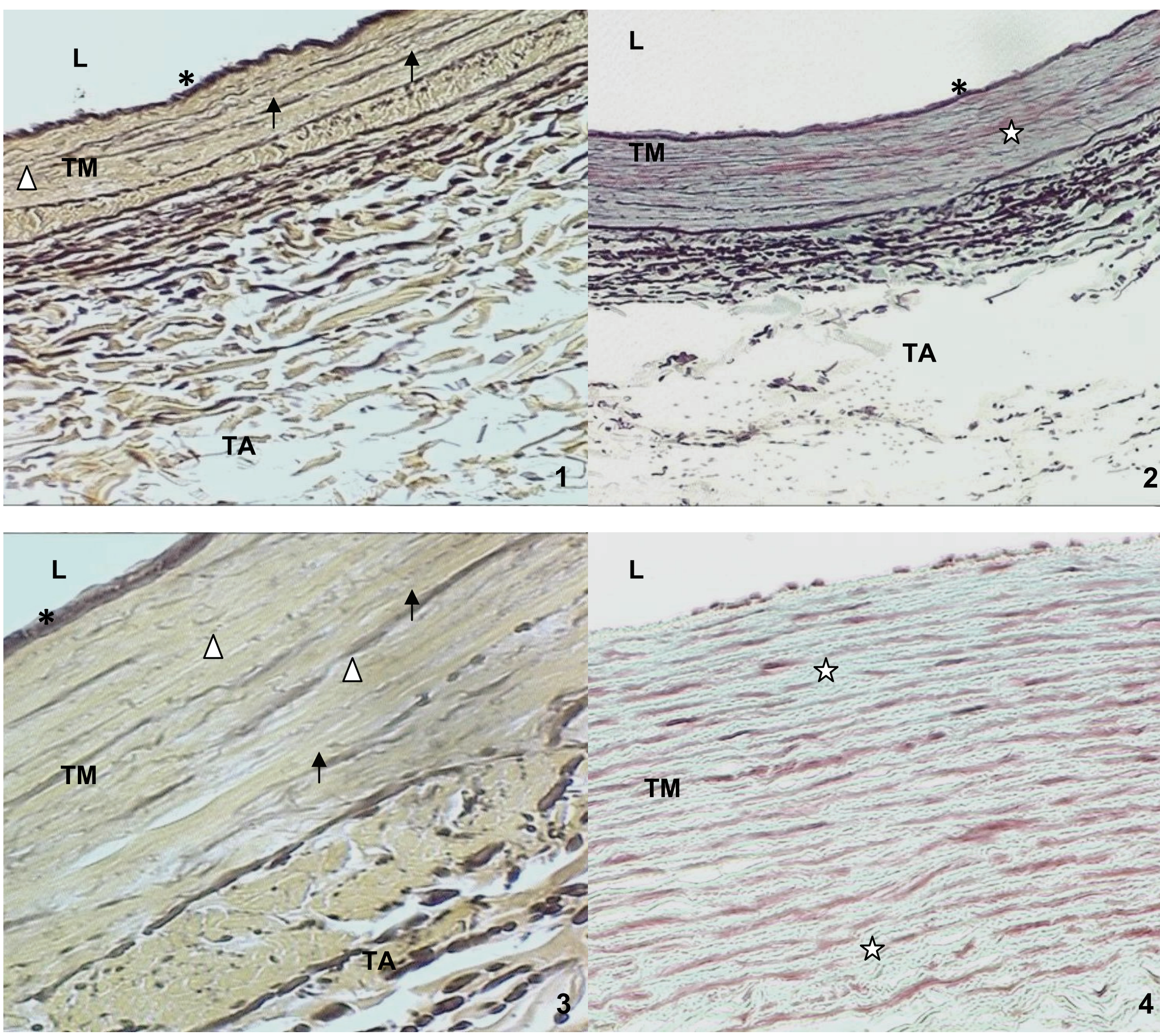

Figure 1 to 4. Architecture of the wall of the renal artery of *Cebus apella* monkey. 1 and 2: proximal segment (ad aortic)- (1–fuchsin 100 x, 2 –Masson's trichrome 100 x); 3 and 4: distal segment (*ad renal hilus*)- (3 – fuchsin 400x, 4–Masson's trichrome 200 x). Indications of vascular lumen (L), tunica media (TM), tunica adventitia (TA), internal limiting elastic membrane (*),elastic lamina of the tunica media(arrow), smooth muscle fibers of the tunica media(Δ), collagen fibers of the tunica media(stars).

Table 1. Quantitative analysis of the tunica media focusing on the proximal segment (*ad aortic*), and the distal segment (*ad renal hilus*) of the right renal artery of *Cebus apella* monkey.

Tunica media components (Measurements)	Proximal Segment	Distal Segment
Number of elastic lamellae[1]	4 to 5	2 to 4
Volume density (Vv%) of collagen[2]	36.01	30.64
Volume density (Vv%) of smooth muscle[2]	33.32	46.68
Volume density (Vv%) of elastin[2]	30.67	22.86

Observation: median values[1], arithmetic mean values[2].

The values in Table 1 evidenced some distinction between the median values of elastic lamellae presented in the proximal (*ad aortic*), and distal (*ad hilus*) segments of the right renal artery of the tufted capuchin monkey. Also, the arithmetic mean from the densities of volumes verified between the smooth muscle tissue and the extracellular matrix components, formed by collagen and elastin fibers and lamellae (McGrath et al., 2005), showed small differences in both the segments (see Table 1).

There was a greater number of elastic lamellae in the proximal segment, whose architecture of the arterial wall showed similar values of densities of volumes observed for smooth muscle and extracellular matrix components (see Table 1). These observations allow classifying this *ad aortic* part of the right renal artery as a mixed, or myoconnective, type. This arterial pattern was somewhat similar to the mural architecture of the abdominal aorta, as was described in some mammals (Viegas et al., 2004a; b; Mello et al., 2004; 2007; 2009; Orsi et al., 2004; 2015), obviously regarding the dimension and extension of each vessel.

Also, in terms of vascular histophysiology, the *ad aortic* segment of the *Cebus apella* renal artery could be related to a blood flow control at the aortic emergence of the renal artery. Similar to a small functional "valve", mainly formed at the tunica media level, it guarantees a priority flow of enriched plasma into the kidney parenchyma. It is a fundamental function in terms of the renal circulation dynamics with physiological support (Melbin & Dteweiller, 2007), referring on the presence of a preferential enriched blood plasma flow destined from the abdominal aorta to the renal parenchyma. This plasmatic flow was made by the renal artery (Young, Lowe, Stevens, & Heath, 2007).

Another consideration could be made from the muscular structure of the distal segment (*ad renal hilus*) of the right renal artery, whose tunica media coat composition presented marked smooth muscle density of volume (Vv = 46.68%, see Table 1). The general architecture of the distal segment wall presented some similarity to that observed in the left vertebral artery of the dog. The distributive role of part of the blood stream to the neural system throughout the vertebral artery was discussed (Orsi et al., 2015). Theoretically, the distal segment of the right renal artery, being a muscular distributive vessel, assured the continuous plasmatic inflow to the renal parenchyma supporting the hemodynamic basis for the renal dialysis, and other renal functional roles.

Conclusion

Based on the volume density obtained in each segment, it was verified that the proximal segment showed a marked myoconnective architecture, while the distal segment was characterized as a standard muscular artery.

Acknowledgements

The authors thank Professor Dr. Rogerio Leone Buchain for assuring the ethical procedure to utilize the tufted capuchin monkeys.

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Received on September 4, 2017.
Accepted on June 8, 2017.