

ORIGINAL ARTICLE

ARTERIAL WALL OF THE ALBINO RAT: MORPHOMETRIC STRUCTURE AND GENERAL MORPHOPHYSIOLOGY

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ABSTRACT

The histological structure and some morphometric parameters referring the aortic architecture of the adult albino rat were focused from the three segmental parts of the aorta comprising the thoracic ascendant and thoracic descendant parts, and the abdominal part of aorta immediately caudal to the renal arteries emergency. Slides containing transversal samples of aortic segments stained by Masson's trichromes were studied and morphometrically analyzed through a Zeiss KS 300[®] system. The abdominal aortic segment showed a mixed pattern from the mural building formed by similar amounts of smooth muscle cells and connective matrix elements, being represented by collagen and elastic lamellae and fibers. However a classic elastic mural pattern was verified in the thoracic segments of the rat aorta, an intermingled pattern mainly occurred between the smooth muscle cells and matrix elements in all the segments of the rat aorta. The thickness of the aortic wall showed a numeric progressive lower from the ascendant part to the abdominal part of aorta. Similar pattern was verified for the number of elastic lamellae, which the major lamellar number observed could be related with the luminal vortex flow observed inside the ascendant aortic part. Also the aortic diameters verified decreased progressively from the ascendant to the abdominal part of aorta.

Keywords: Aorta, Mural structure, Morphophysiology, Rat.

INTRODUCTION

Anatomic texts when described the mural aortic architecture and referred on the

large aortic ramifications classify these vessels with an elastic pattern. The large arteries directly branching from aorta, such as the carotid and subclavian arteries were formed by several elastic lamellae and fibers in their structural coats (HEBEL; STROMBERG, 1986; EVANS, 1993; MARTINI et al., 2009; TORTORA; GRABOWISKY, 2012). Moreover, the parietal and visceral collaterals originated from those vessels such as the vertebral and external iliac arteries, presented a relative major number of smooth muscle cells in their parietal coats (VIEGAS et al., 2004; MARTINI et al., 2009; TORTORA; GRABOWISKY, 2012).

On the other hand, some papers suggested presence of a mixed structure from the abdominal part of aorta, in which was verified equilibrium on the mural distribution of smooth muscle cells and connective matrix components, occurring a minor number of elastic lamellae and fibers (VIEGAS et al., 2001; ORSI et al., 2004; MELLO et al., 2004; 2007; 2009). The apparent wall fragility of the abdominal aortic wall composition had been considered one of the causes from the abdominal aortic aneurysm pathophysiology (MAC SWEENEY et al., 1992; HENNEY et al., 1993).

Concerning to the mural aortic architecture of rat had been observed presence of membranous elastic tissue also disposed as lamellae and fibers (MELLO et al., 2004). The predominance of aorta elastic tissue in mammals was accomplished by interconnections formed between elastic lamellae and connective dense lamellae throughout connective dense fibers. Furthermore, was seen complex networks including smooth muscle cells intermingled with elastic and connective dense lamellae and

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fibers, mainly disposed into the aortic medial layer structure (TINDALL; SVENDSEN, 1982; CLARK et al., 1985; HASS et al., 1991; AWAL et al., 1995; VIEGAS et al., 2001; ORSI et al., 2004; MELLO et al., 2004; 2007; 2009).

Special correlations between the medium thicker of the aortic layers and the medium number of elastic lamellae presented into the medial aortic layer according to segmental transit pattern had not been related, specifically, in rat. Furthermore, a theoretical complementary register could be made between aortic mural structure and blood flow pattern inside the aorta luminal compartment, as was described recently from the dog aorta (ORSI et al., 2015). So, this paper described these aspects under a morphophysiological knowledge, and aimed to provide some base for other studies.

MATERIAL AND METHODS

Aortic samples were collected from the ascendant aorta (T2-T3 level, 1th position or P₁), descendant thoracic aorta (T6-T7 level, 2th position, or P₂), and abdominal aorta (L4-L5 level, 3th position or P₃), using ten albino *Wistar* rats (*Rattus norvegicus albinus*), of both sexes, weighing 120 g of medium average. The rodents were housed at UNESP Campus of Botucatu, and afterwards were destined from laboratorial studies.

The rodents suffered euthanasia using an overdose of anesthetic formed by a mixture of ketamine hydrochloride (20 mg/kg) and xylazine hydrochloride (1.5 mg/kg)*. After dissections of the thoracic and abdominal cavities fragments of the aortic segments were collected and immediately fixed in 10% buffered formalin during 24 hours and processed to embedded in Paraplast™ (Oxford Labware, St. Louis, USA).

Five to seven micrometers sections were taken and stained with HE, Van Gieson picrofuchsin, hydrochloric orcein, and Calleja and Masson trichromes (LILLIE, 1965). A part of the microscopic materials being four histological sections from the aorta, focusing the three positions (P₁, P₂, and P₃), was considered in all the rats, whose data were submitted at random measurements from the aortic thickness. Three conditions (C₁ and C₃) were adopted from the measurements of the arterial walls, referring the thickness of the inner layer and of the medial layer (C₁ and C₂,

respectively), and the thickness of the adventitial layer (C₃).

The thickness of the aortic layers was measured considering the three conditions (C₁ and C₃), and established taking transverse histological sections (5 μm), stained with Masson trichrome from each aortic segment (positions P₁ from P₃), using a 10x ocular micrometer and a 20x objective under an Olympus BH-2 microscope, and also using an image analysis system (Zeiss KS-300).

The Zeiss KS-300® system was also used for elastic lamellae counts made in aortic arterial segments, following measurements of the aortic diameters realized in regular round shaped samples of each segmental part analyzed. The numerical data obtained concerning the segmental thickness of the aortic wall layers were employed to yield arithmetic medium values from the arterial mural layer thickness.

RESULTS AND DISCUSSION

The medial layer of the rat aorta was thicker than the other layers and showed the major thickness in the ascendant thoracic segment (Table 1), such as was described in other mammals, also including the own aorta of albino rat (VIEGAS et al., 2001; ORSI et al., 2004; MELLO et al., 2004; 2007; 2009; ORSI et al., 2015). The aortic lumen next to the heart emergency apparently showed a luminal blood flow assuming a vortex pattern as a consequence of the left ventricular systolic pressure, as was previously described (MELBIN; DETWEILER, 1998; GUYTON; HALL, 2000).

An intermediary mural thickness was verified from the aortic descendant thoracic segment, followed by a lesser mural thickness observed in the aortic abdominal part (Table 1). The last two aortic segments showed a lamellar blood flow into the aorta luminal compartment, in which blood cells formed spatial arrangements surrounded by the blood plasma. Lamellar blood flow helps to guarantee an adequate renal perfusion, and permit efficacy on the visceral irrigation as a whole. However, the ascendant part of aorta presented a vortex flow with complete mixture of the figurative elements of the blood, previously to the emission of the arteries destined to supply the head and the thoracic limbs (MELBIN; DETWEILER, 1998).

Concerning to the architectural and morphometric findings verified in the medial layer from the aorta segments (C_2 condition, Table 1), similarly described for other mammals (VIEGAS *et al.*, 2001; MELLO *et al.*, 2004; 2009; ORSI *et al.*, 2004; 2015),

could be considered the radial distension verified in aortic wall, during the impact of the systolic pressure of the heart left ventricle (TINDALL; SVENDSEN, 1982; STHEBENS, 1996; MELBIN; DETWEILER, 1998; GUYTON; HALL, 2000).

Table 1 - Medium thickness in micrometers from the layers of rat aorta at the level of the segments P_1 to P_3 analyzed under the conditions C_1 and C_2 .

Layers or coats (C)	Inner layer (C_1)	Medial layer (C_2)	Adventitial layer (C_3)
Segments or parts (P)			
P_1 - ascendant	2.68 ± 0.31	87.34 ± 6.19	57.91 ± 6.13
P_2 - descendant (thoracic)	2.65 ± 0.32	71.59 ± 4.93	30.00 ± 1.69
P_3 - abdominal	2.79 ± 2.21	53.25 ± 2.21	65.69 ± 3.05

Notes: P_1 to P_3 represented the segmental levels in which aortic segments were studied, being P_1 - ascendant aortic segment; P_2 - descendant thoracic segment, and P_3 - aortic abdominal segment. C_1 represented the first condition referring the arterial layers studied being the thickness of the inner coat, C_2 was the thickness of the medial layer, and C_3 represented the thickness of the adventitial coat. Numerical data represented arithmetic medium value followed by the standard deviation.

Under structural terms, apparently had been prevalent the interrelations established among smooth muscle cells and connective lamellae and fibers, which formed an extracellular matrix (MCGRATH *et al.*, 2005). This matrix was disposed as a meshwork into the aortic medial and adventitial layers (WOLINSKY; GLAGOV, 1967; TINDALL; SVENDSEN, 1982; CLARK *et al.*, 1985; HASS *et al.*, 1991; AWAL *et al.*, 1995; VIEGAS *et al.*, 2001; ORSI *et al.*, 2004; 2014; MELLO *et al.*, 2004; 2007; 2009). Those intermingled connections formed among mural elastic and dense collagen fibers and elastic lamellae, and also with smooth muscle cells, help to guarantee the aortic mural integrity, besides the alternative mechanic impacts suffered by the aortic wall during the cardiac cycle (STHEBENS, 1996; MELBIN; DETWEILER, 1998; MULRONEY; MEYERS, 2010).

The medium value of elastic lamellae verified into the aortic medial layer decreased from the ascendant thoracic segment to the abdominal infra kidney segment. So, it was observed a median value of 11.8 ± 0.7 concentric elastic lamellae (position 1th, or P_1), into the medial layer of the ascendant aortic segment. This number was followed by 8.8 ± 0.6 elastic lamellae (position 2th, or P_2), localized into the medial layer of the descendant thoracic aorta, and a lesser number of 7.0 ± 0.9 elastic lamellae (position 3th, or

P_3), that occurred in the descendant abdominal part of aorta.

Furthermore, the aortic diameters accomplished a similar pattern, being median values of 1.7 ± 0.3 mm in the ascendant segment; 1.4 ± 0.2 mm in the descendant thoracic part, and 1.2 ± 0.1 mm in the abdominal segment of the aorta. The adventitial aortic layer in rat showed a variable thickness along the aortic segments focused, being thicker in the abdominal part of the aorta.

The adventitial layer was formed by lamellar and fibrous collagen and elastic tissue disposed with transverse, longitudinal and oblique orientations, with interconnecting elastic fibers that joined disperse elastic and collagen lamellae, whose general disposition had been observed as a framework composition. Similar pattern was described previously from other mammals. including the own rat (SONG; ROACH, 1985; VIEGAS *et al.*, 2001; ORSI *et al.*, 2004; 2015; MCGRATH *et al.*, 2005; MELLO *et al.*, 2004; 2007; 2009). Referring to the last histological pattern described, it had been generally verified in mammals, according to the last authors cited. However, had been considered from the aortic mural histology some species specific peculiarities, especially characterized from laboratory rodents (MELLO *et al.*, 2004); dog (SONG; ROACH, 1985; ORSI *et al.*, 2004), and the tufted capuchin monkey (MELLO *et al.*, 2009).

The occurrence of a minor number of elastic medial lamellae in the abdominal segment of aorta was previously verified in some mammals, including the own rat (VIEGAS et al., 2001; MELLO et al., 2004; 2009), the man (SIMIONESCU; SIMIONESCU, 1981), and the dog (ORSI et al., 2004; 2015). This fact could be associated with a lesser diameter of the aorta in this segment but no description made had considered this hypothesis. Nevertheless, a lesser number of elastic tissue in abdominal mural aorta building seemed to be related to the etiology of the human aortic aneurysm disease, as a consequence of a natural fragility of the distal wall from the ageing abdominal aorta (MAC SWEENEY et al., 1992; HENNEY et al., 1993).

As was described in the introductory part, concerning to the minor number of mural elastic lamellae observed in the abdominal (distal) part of the rat artery, similar finding had been made from the human aorta (SIMIONESCU; SIMIONESCU, 1981). This observation was increased by the decrease of the connective matrix elements and scarcity of smooth muscle cells arrangements into the medial layer formation. Perhaps, it could be one of the main causes from the distal aortic aneurysm etiology in the human being (MAC SWEENEY et al., 1992; HENNEY et al., 1993).

CONCLUSION

The aortic wall main structure in albino rat showed a classic elastic blood vessel building, especially characterized in their ascendant and descendant thoracic segments. However, the abdominal aortic part presented a mixed and equilibrated amount of smooth muscle cells and connective extracellular matrix in its delimiting vascular wall. Also, it was verified a lesser number of elastic lamellae and elastic and connective dense fibers in the abdominal aorta segment, comparatively to the precedent segments. This pattern presented certain similarity with the building of other muscular branching arteries whose origin was made from different segments of the own aorta.

ESTRUTURA E ASPECTOS MORFOFUNCIONAIS DA PAREDE DA AORTA DO RATO ALBINO

RESUMO

A estrutura histológica e alguns parâmetros morfométricos referentes à arquitetura da parede aórtica do rato albino foram estudados nos três segmentos aórticos, compreendendo a parte ascendente e a parte descendente torácicas e a parte abdominal infra-renal. Lâminas histológicas contendo amostras transversais dos três segmentos aórticos, coradas com tricrômico de Masson, foram estudadas e morfometricamente analisadas através de um sistema Zeiss KS-300®. O segmento aórtico abdominal apresentou padrão estrutural misto na arquitetura da parede sendo do tipo muscular lisa e conjuntivo. Ocorreu equilíbrio ponderal entre as fibras musculares lisas e o componente conjuntivo matricial mural. Embora um padrão mural predominantemente elástico fosse verificado nos segmentos torácicos da aorta do rato, ocorreu, de modo geral, um entrelaçamento entre as fibras lisas e os elementos matriciais colágeno-elásticos da parede em todos os segmentos da aorta. A espessura da parede aórtica mostrou um decréscimo numérico progressivo, partindo da parte ascendente torácica em direção ao segmento abdominal. Observação similar foi vista quanto ao decréscimo do número de lamelas elásticas, nos mesmos segmentos referidos. O maior número relativo de lamelas elásticas encontrado no segmento aórtico ascendente poderia se relacionar com um reforço mural local, conseqüente ao regime de fluxo turbilhonar presente no interior da luz vascular da aorta ascendente. Os diâmetros aórticos encontrados mostraram também um comportamento decrescente progressivo entre o segmento ascendente e o segmento abdominal da aorta deste roedor.

Palavras-chave: Aorta, Estrutura mural, Morfofisiologia, Rato.

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