Brazilian Journal of Veterinary Research and Animal Science (2003) 40 (supl):163-169
ISSN *printed*: 1413-9596
ISSN *on-line*: 1678-4456

Some segmental structural features of the aortic wall of domestic chicken (*Gallus domesticus*)

Algumas características morfológicas segmentares da parede da aorta de galo doméstico (*Gallus domesticus*)

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Recebido para publicação: 13/12/2002
Aprovado para publicação: 19/02/2004

Abstract

The segmental structure of the aortic wall at the thoracic and abdominal levels were studied in domestic chicken by light microscopy (LM) and scanning electron microscopy (SEM). Selected histological sections were submitted to histomorphometric studies using image analysis methods. The variables studied were the thickness of the aortic layers in the three segments investigated: ascendant thoracic, descendant thoracic and abdominal parts as well as the tubular diameters and the mean number of elastic lamellae in the medial layer of each analyzed segment. The aortic wall of the chicken had a predominately elastic structure in the thoracic portions, that decrease gradually in relative number of elastic lamellae towards the abdominal aorta in which smooth muscle cells predominated. Vascular diameters decreased gradually to the ascendant aorta from the descendant thoracic portion and to the last from the abdominal aorta.

Key-words:
Aortic wall.
Structure.
Microscopy.
Histophysiology.
Domestic chicken.

Introduction

In domestic birds the thoracic and abdominal portions of the aorta had been characterized as elastic vascular segments by Lauper et al.[1] The elastic lamellae of the medial layer alternate with connective tissue and smooth muscle cells. About 25 to 30 elastic lamellae have been detected in the aortic media of pigeon, and similar results were obtained for aorta of chicken[2] and swan.[3] The inner and outer elastic lamellae of the aorta were poorly defined or nonexistant in domestic birds.[2,4,5] The aortic elastic lamellae in these species tend to form cylindrical structures disposed around the vessel wall.[1,2,3,5] Also, the layers of connective tissue present in the wall of avian elastic vessels consisted of mixed networks of collagen and elastin[3], as well as of some cells of the proper connective tissue.[2,3]

On the other hand, there was a relative scarcity of specific descriptions on the vascular wall structure in domestic birds of high zootechnic importance. So, the aim of this study is to describe some segmental structural characteristics of the aortic wall of *Gallus domesticus* using histological analysis at the LM and SEM levels. Moreover, morphometric analyses of the aortic wall in the thoracic tract (ascendant and descendant parts) and in abdominal aorta were made, in order to demonstrate small but significant differences among the thickness of the vascular layers and vascular diameters, respectively.

Materials and Methods

The ascendant and descendant thoracic parts and the abdominal part of the aorta of 10 adult Leghorn chicken aged 50 days and weighing on average 1.5 kg were studied. After sacrifice by ether inhalation, 10 chickens were submitted to arterial perfusion through the left cardiac ventricle with neutral formalin solution in 0.1 M phosphate buffer, pH 7.2, for the LM studies, and 2 animals were submitted to arterial perfusion with Karnovky's[6] fixative for SEM study.

Immediately after arterial perfusion with formalin, the following aortic segments were collected from 8 chickens: (1) ascendant segment corresponding to the vascular portion located at an intermediate level between the aortic annulus and the emergence of the brachiocephalic arteries, (2) descendant thoracic segment corresponding to the intermediate portion located between the emergence of the third intercostal arteries, and (3) descendant abdominal segment, corresponding to the portion located at an intermediate level between the emergence of the cranial mesenteric artery and the external iliac artery. The vascular fragments were dissected under a stereomicroscope, cut into circular and longitudinal rings, and immersed in formalin for 24 hours, to complete the histological fixation.

The materials were prepared for histological analyses, and the vascular portions were embedded in paraplast. Sections of 5 to 7mm thick were cut and stained by HE, Weigert resorcin-fuchsin (Van Gieson), and Masson and Calleja trichromes.[7] The histomorphometry of the intimal, medial and adventitial layers of the aortic wall and of the diameters of each aortic portion, and counts of the elastic lamellae of the medial layer were performed using an image analysis system (Zeiss KS-300, Carl Zeiss, Germany), and also the Optimas 4.10 software (IBM, USA). Data were analyzed statistically by analysis of variance of the mean profiles.[8]

The thickness of the layers and the number of lamellae of the medial layer in the three selected aortic portions of the chicken were measured, or counted, in 12 fully randomized measurements made in 5 transverse 7mm-thick histological sections stained with Masson and Calleja trichromes. The diameters of the three aortic portions were measured in a stereomicroscope Olympus SZ (Olympus, Japan), with the use of a graduate reticulum in the same 5 transverse sections of each aortic portion.

Transverse and longitudinal segments of the descendant thoracic and abdominal portions of the aorta from three chickens were fixed in Karnovsky's[6] fixative and routinely processed for scanning electron microscopy. The tissues were dehydrated and taken to the critical point (Balzers CPD-010, Germany), sputtered with colloidal gold (Balzers SCD-040, Germany), and analyzed and photographed in a Philips SEM 515 (Philips, The Netherlands).

Results

The intimal layer of the chicken aorta was thin in the three portions analyzed (Figure 1), showing 3.21mm of mean average, and consisted of the surfacial endothelium and by circularly organized elastic fibers which formed the inner limiting elastic lamina (Figures

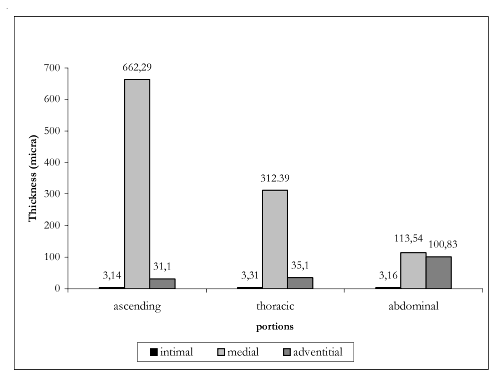

Figure 1
Mean thickness (mm) of the intimal, medial and adventitial layers of the aortic portions of the domestic chicken (see graphic)

2 and 3).

The aortic medial layer was the thickest coat in the three portions analyzed, showing mean average of 362.4mm (Figure 1). In the ascendant and descendant thoracic portions were noted the major amount of elastic fibers and lamellae disposed between collagen fibers and smooth muscle cells (Figures 2, 4 and 5). Elastic fibers of the aortic portions were also clearly visible in the region closer to the adventitia, and were intimately intermingled and arranged in a circular disposition, forming a well defined outer elastic lamina (Figure 3).

At the core of the aortic media the elastic fibers were intermingled, but had a predominant spiral arrangement. Closer to the intimal layer, the elastic fibers were distributed separately or in groups of small longitudinally arranged bundles (Figure 5). The number of elastic lamellae of the medial layer decreased progressively from the ascendant aorta to the abdominal aorta (Figure 6).

In the abdominal part of the aorta was observed a predominance of smooth muscle cells intermingled with more discrete elastic and collagen fibers and lamellae, which occurred mainly in the medial layer level. The outer elastic lamina showed a serpentiform aspect and was clearly seen in the abdominal aorta (Figure 3).

The adventitial layer was relatively narrow in all the aortic portions in chicken

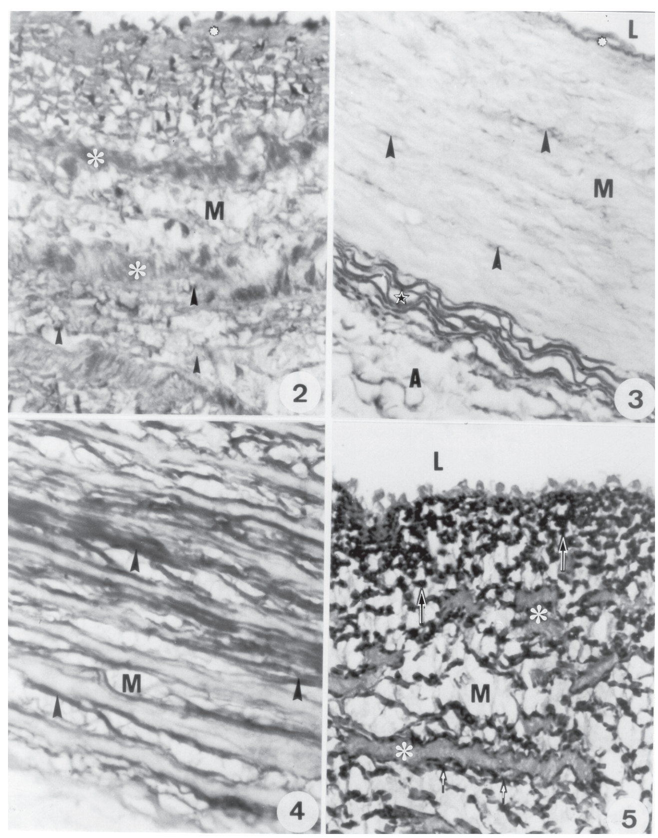

Figure 2-5
Histological structure of chicken aorta in the portions descendant thoracic in figure 2, abdominal in figure 3, and ascendant thoracic in figure 4 and figure 5, x400. The following structures are showed: lumen (L), medial layer (M), adventitia (A), smooth muscle cells (*), collagen fibers (short ?), inner elastic lamina (*), elastic lamellae of the middle layer (large *), outer elastic lamina (), elastic fibers in longitudinal arrangement (large ?), elastic fibers in spiral arrangements (small ?), enveloping a smooth muscle cell (*). Figure 2: Masson's trichrome; Figures 3 and 4: Calleja's trichrome and Figure 5: Weigert resorcin fuchsin

(Figure 1), and predominately consisted of irregularly arranged collagen fibers intermingled with some elastic fibers and few smooth muscle cells (Figure 3).

Concerning the intimal layer appearance at SEM, it showed discrete but conspicuous longitudinal intimal folds observed at the endothelium level (Figure 7).

The vascular diameter of the chicken aorta decreased gradually to the ascendant aorta from the abdominal aorta. (Figure 8). The descending portion of the abdominal aorta showed, comparatively to the thoracic portions, a less thick medial layer and a thicker adventitia, with mean averages of 113.54mm and 100.83mm respectively (Figure 1).

Discussion

Our observations differed from those reported by some authors[2,4,5] regarding to their statement that there was no inner elastic lamina in aortic wall of domestic birds. The inner elastic lamina in domestic chicken aorta was clearly defined at LM (see Figure 3), and showed a folded aspect at SEM level (see Figure 7).

On a comparative base[9] it was hypothesized that the intimal folds, which were seen in the endothelium surface of chicken aorta, were formed in order to expand the size of the vascular lumen and also may act as a reserve for the arterial wall viscoelasticity, property that was revised in large elastic vessels.[10]

The medial layer was thicker (see Figure 1) in the ascendant and descendant portions of the chicken aorta, where a large amount of elastic fibers was observed forming defined elastic lamellae. The lamellae naturally tend to be larger in the ascendant aorta, which is direct submitted to the thrust of the ventricular systolic pressure.[11]

Elastic organization of the aortic media in the ascendant and descendant thoracic parts of aorta showed a mixed pattern with circular (transverse) and longitudinal disposition of the elastic lamellae

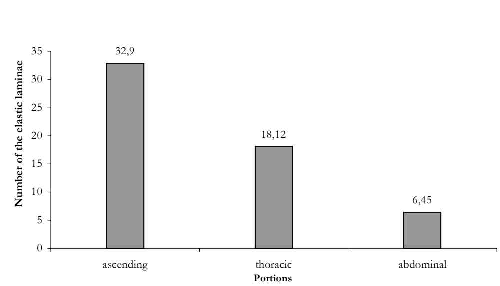

Figure 6
Mean values of elastic lamellae number at the medial layer of the aortic portions in chicken (see graphic)

Figure 7
SEM of the aortic wall structure in chicken, at the abdominal portion of the aorta, showing folds in the intimal (I) layer. View by the endothelium layer, x264

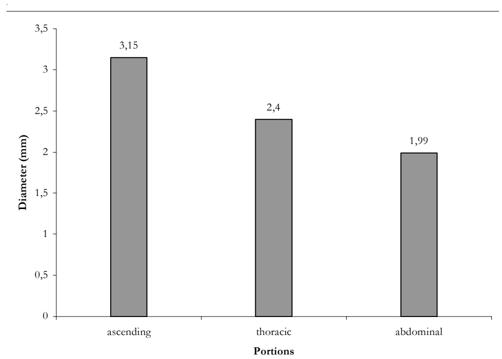

Figure 8
Mean total diameter (mm) of the aortic portions in chicken (see graphic)

and fibers. Comparatively to Mello[12] observations, in rat and guinea pig's aortas, the circular elastic arrangement is assumed to provide tonicity to the wall, whereas the longitudinal arrangement may perhaps facilitate propulsion forward of the blood stream. Thus, we did not visualize the cylindrical or semicylindrical spatial configurations of the elastic lamellae described for the aorta of domestic birds[5], including in our three-dimensional observations at SEM.

With reference to the amount of elastic lamellae present in the aortic media of chicken, our results showed the occurrence of a mean average of 32.9 elastic lamellae for the ascendant thoracic portion of the chicken aorta (see Figure 6). This result is similar to that reported for the aortas of pigeons; chickens themselves and swans.[1,2,3]

The medial layer of the abdominal segment of the aorta in chicken showed smaller amount of elastic lamellae (see Figure 6), when compared to the thoracic portions. These elastic lamellae were also found to be interspersed with collagen fibers and smooth muscle cells, in agreement with previous descriptions[2,3] for avian elastic vessels.

Although, our data differed from the results reported for the pigeon's aortic wall[1], in which the elastic lamellae were described as separate units. Actually, they formed "myo-elastic-fibrous unites" in chicken aorta, similarly to the pattern described in mammals[13] as: "contractile-elastic units of the medial layer".

We observed that the abdominal aorta of *Gallus domesticus* had an arterial wall pattern of transitional or mixed structural type, however few elastic lamellae were present (see Figure 1). Actually, a predominance of smooth muscle cells occurred in the medial layer architecture of the abdominal aorta in this species. Similar findings were described in abdominal aortas of mini pig[14]; albino rat[15], and rabbit.[16]

Furthermore, it was known that smooth muscle cells mainly present in the aortic medial structure, act on the contractility of the vascular wall, controlling the vascular diameter and consequently the blood stream towards the peripheral regions of the body, including in chicken aorta. Thus, the smooth muscle cells, and more adequately the presence of aortic "smooth muscle cells-elastic fibers units"[13] provided through the aorta branching an adequate blood supply to all the body tissues, as comparatively discussed in aortas of mammals.[13,15,17,18,19]

The predominance of smooth muscle cells in the aortic media of the posthepatic and juxtarenal portions of the abdominal aorta may be hypothetically correlated with a natural decrease in arterial pressure in this descendant aortic segment.[5] The possible reason for this last theoretical inference could be the previous emission of the visceral abdominal branches of the abdominal aorta, such as the coeliac, mesenteric and renal arteries. This occurred before the relative decrease of the elastic components, that possibly insure a more rapid blood flow in the more cranial vascular segments.[12]

Moreover, the emission of the parietal branches of the abdominal aorta as the external iliac arteries and the emission of the ischiatic arteries occurred more caudally, at the abdominal segment of the avian aorta.[5] Perhaps, for comparative physiological reasons the blood might penetrate at a naturally decreased pressure in the vessels that irrigate the pelvic limbs, in which a laminar pattern of blood flux was described, whose relative predominance of erythrocytes in this blood stream had been characterized.[11]

The diameter of the vascular wall in chicken aorta progressively decreased in caliber towards the descendant abdominal aorta, supporting the notion of the progressive distributive nature of arterial blood through the aorta and its branches, as commented upper.

Collagen fibers were found in the entire vascular wall, but they were especially noted in the adventitia, and also have a relative predominance in the aortic adventitia of mammals, as a comparative support.[19,20] These fibers support tension strengths and keep together morphological groups of "myo-connective or myo-stromal" structural elements.[13]

As conclusion, we may state once again that the fibers and lamellae of collagen and elastin present in the adventitia of elastic arteries, as the aorta, also in avian blood vessels, exherted function similar to a "sheath".[12] It prevents exaggerate distention of the aortic wall during the vascular pulse and the progression of the systolic pressure wave.[19]

Acknowledgements

We thank the "Centro de Microscopia Eletrônica, UNESP, Botucatu, SP" for technical assistance, and we also thank the CNPq, Brasília, Brazil (Grant 30.1242/80, 08/98) and FAPESP, São Paulo, Brasil (Grant 96/09970-2) for financial support.

Resumo

A estrutura segmentar da parede aórtica foi estudada em galo doméstico, em níveis torácico e abdominal, nas dimensões de microscopias óptica e eletrônica de varredura. Secções histológicas selecionadas foram submetidas a estudos histomorfométricos usando métodos de análises de imagens. As variáveis analisadas foram as espessuras das túnicas da parede aórtica em três segmentos investigados, compreendendo as porções ascendente torácica; descendente torácica e abdominal, bem como os diâmetros tubulares, em cada porção, e o número médio de lamelas elásticas na túnica média de cada segmento analisado. A parede aórtica do galo doméstico apresenta estrutura predominantemente elástica nas porções torácicas, cujo número relativo de lamelas elásticas decresce gradualmente para a parte abdominal da aorta, onde células musculares lisas predominam. Os diâmetros aórticos decrescem também gradualmente, e progressivamente, da porção torácica ascendente para a porção torácica descendente, e desta para a porção abdominal da aorta.

Palavras-chave:
Parede aórtica.
Estrutura.
Microscopia óptica.
Histofisiologia.
Galo doméstico.

References

1. LAUPER, N. T. et al. Anatomy and histology of aorta of white carneau pigeon. **Lab. Invest.**, v. 32, p. 536-551, 1975.
2. MOSS, N. S.; BENDITT, E. P. Spontaneous and experimentally induced arterial lesions: an ultrastructural survey of the normal chicken aorta. **Lab. Invest.**, v. 22, p. 166-183, 1970.
3. BUSSOW, H. Zur Wandstruktur der Großen Arterien der Vögel. **Z. Zellforsch. Mikrosk. Anat.**, v. 142, p. 263-288, 1973.
4. BERRY, C. L.; GERMAIN, J.; LOVELL, P. Comparison of aortic lamellar unit structure in birds and mammals. **Atherosclerosis,** v. 19, p. 47-59, 1974.
5. KING, A. S.; McLELLAND, J. **Form and function in birds**. London: Academic Press., v. 2, p. 251-259, 1981.
6. KARNOVSKY, M. J. A formaldehyde-glutaraldehyde fixative of high osmolality for use in electron microscopy. **J. Cell. Biol.**, v. 27, p. 137-138, 1965.
7. GANTER, P.; JOLLES, G. **Histochimie normale et pathologique**. Paris: Gauthier-Villars, 1970. t. 2, p. 925-1003, 1970.
8. MORRISON, D. F. **Multivariate statistical methods**. 2. ed. Tokyo: Mc Graw-Hill Kogakusha, 1976. 415 p.
9. TINDALL, A. R.; SVENDSEN, E. Intimal folds of the rabbit aorta. **Acta Anat.** v. 113, p. 169-177, 1982.
10. STEHBENS, W. E. Structural and architectural changes during arterial development and the role of hemodynamics. **Acta Anat.**, v. 157, p. 261-274, 1996.
11. MELBIN, J.; DETWEILER, D. K. Sistema cardiovascular e fluxo sangüíneo. In: SWENSON, M. J.; DUKES, W. O. R. **Fisiologia dos animais domésticos**. Rio de Janeiro: Guanabara Koogan, 1996. cap. 5, p. 57-222.
12. MELLO, J. M. **Estrutura da aorta e artéria ilíaca externa de cobaia:** aspectos comparativos com o rato albino e ave doméstica. 1999. 100 f. Tese (Doutorado em Ciências Biológicas) – Instituto de Biociências, Universidade Estadual Paulista, Botucatu, 1999.
13. DAVIS, E. C. Smooth muscle cell to elastic lamina connections in developing mouse aorta: role in aortic medial organization. **Lab. Invest.**, v. 68, p. 89-99, 1993.
14. TANIGAWA, M.; ADACHI, J.; MOCHIZUKI, K. Histological study on the arterial wall of Gottingen miniature pig. **Exp. Anim.**, v. 35, p. 35-45.
15. AWAL, M. A.; MATSUMOTO, M; NISHINAKAGAWA, H. Morphometrical changes of the arterial walls of main arteries from heart to the abdomino-inguinal mammary glands of rat from virgin

through pregnancy, lactation and post-weaning. **Vet. Med. Sci.,** v. 57, p. 251-256, 1995.
16.VIEGAS, K.A. et al. Caracteristicas estructurales de la aorta del conejo (*Oryctolgus cuniculus*). **Rev. Chil. Anat.,** v. 19, p. 131-137, 2001.
17.DINGMANNS, K. P.; JANSEN, N.; BAKER, A. E. Ultrastructure of the normal human aortic media. **Virchows Archs. Pathol. Anat.,** v. 392, p. 199-216, 1981.
18.DUBREUIL, G.; LACOSTE, A. Histophysiologie des parois vasculaires arterielles et veineuses de l'homme. **Ann. Anat. Pathol.,** v. 8, p. 988-1041, 1931.
19.HAM, A. W.; CORMACK, D.H. Sistema circulatório. In: ______. **Histologia**. 8. ed. Rio de Janeiro: Guanabara Koogan, 1983. cap. 19, p. 555-575.
20- WILLIAMS, P. L.; WARWICK, R.; DYSON, M.; BANNISTER, L. H. Angiologia. In: ______. **Gray anatomia**. 37. ed. Rio de Janeiro: Guanabara Koogan, cap. 6, p. 635-807, 1995.