Histological Study of the Elastic Artery, Muscular Artery, and Their Junction in Neonate Dog

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ABSTRACT

Introduction: We did this study because there were a few studies about aorto-branch junction.

Methods: Four light microscope and electron microscope study, the abdominal aorta, renal artery, and the adjoining right and left renal arteries were dissected out from 4 neonate dogs.

Results: Based on the results, there is only one cell type in the tunica intima of endothelium in both arteries. In abdominal aorta, there were open connective tissue spaces, containing elastic fibers between the internal elastic membrane and endothelium. In renal artery, endothelial cells were attached directly to the internal elastic membrane. In the abdominal aorta tunica media, layers of smooth muscle cells alternating with elastic lamellae were observed, but in renal artery, the smooth muscle cells were close to each other and a small quantity of collagen and elastic fibers were found between them. There were more dense bodies in the renal artery smooth muscle cells compared to the abdominal aorta. The adventitia of the both arteries consisted of scattered fibroblasts and elastic fibers in tunica adventitia of renal artery were more than those in abdominal aorta. There were 2 orientations of smooth muscle cells at the junction of renal artery; circular form in tunica media and longitudinal form in the outer part of tunica media and tunica adventitia and it was similar to the structure of muscular veins.

Conclusion: aorta and renal artery in neonate dogs show some differences. These differences presumably reflect adaptation to the function of these 2 arteries.

Key Words:

Elastic fibers, Collagen, Smooth muscle cell, Dog, Junction

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1. Introduction

Aorto-branch junction is always important as a site for arterial diseases such as atherosclerosis. There are many reports about development of vascular diseases in aorto-branch junction. According to the reports the structure of cerebral artery bifurcation in rat changes with increasing the age and it can be a major predisposing factor in the formation of cerebral artery aneurysm [1].

Carotid bifurcation and internal carotid artery have been known as a site for atherosclerosis [2]. Based on the studies about atheroma distribution in aorta, they were mostly spotted around the origin of the intercostals and lumbar arteries [3].

Furthermore, in the hypercholesterolemic rabbits, atherosclerotic lesions initially occur in the ascending aorta, thoracic aorta, especially at the distal and lateral sides of the orifices of dorsal intercostals arteries [4]. Also, there are marked differences in the elastin pattern at aorto-branch on the proximal and distal lips of the junctions, both in small elastic and large muscular branches arising from the abdominal aorta [5].

In the study of collagen fibers in brain arteries and bifurcation region, a narrow band of collagen was observed along the apex of the flow divider that provides strength and stiffness in that region [6]. Generally, the structure of the aortic wall and renal artery is defined as elastic and muscular [7]. In all animals, the only cell type in the aorta tunica media is smooth muscle cells, but in the avian species not only smooth muscle cells but also connective tissue cells as second major cell type are found [8]. In domestic swine renal artery, the internal elastic membrane shows an expressed degree of wrinkliness. Also, a great quantity of mast cells is found in the middle shell [9]. Aorta and renal artery in several species have been described [10-12], but there has been no report about the structure of renal artery in the junction of abdominal aorta in neonate dog. In this report, we compare the structural feature of the abdominal aorta and renal artery as well as the structure of renal artery in its junction from aorta in neonate dogs based on morphological analyses using transmission electron microscopy.

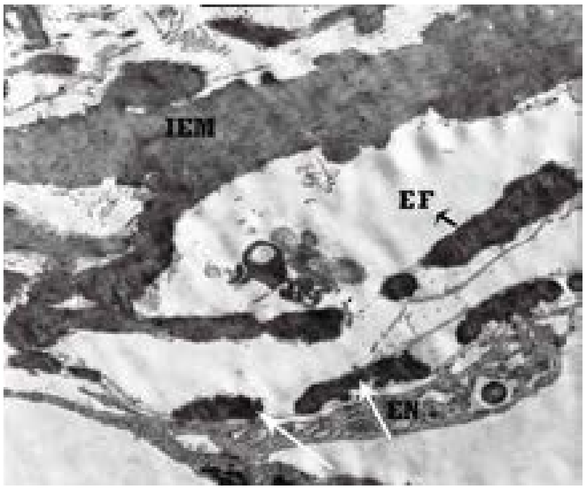
2. Materials and Methods

Four neonate dogs were used in this study. The dogs were euthanized with an overdose of anesthetic drug (thiopental sodium). For light microscope study, the abdominal aorta, renal artery, and the adjoining right and left renal arteries were dissected out from 2 dogs and stored in 10% formalin solution. After 48 hours, the specimens were transferred in 4% formalin. After dehydrating samples through graded alcohols, they were cleared in xylol and embedded in paraffin so that serial longitudinal could be cut at 6 µm. The slides were then stained with Green Masson's trichrome and smooth muscle cells at the junction of renal artery were investigated.

The materials for electron microscope study were taken immediately after killing 2 dogs. The abdominal aorta, renal artery, and the adjoining right and left renal arteries were dissected out and the specimens of junction of renal artery from abdominal aorta were separated. The specimens were fixed in glutaraldehyde and post fixed in OsO_4. The later treatment was carried out through bathing dehydration, adding propylene oxide and embedding in resin. Semi-thin sections were mounted on glass slides and stained with toluidine blue. Thin sections were stained with lead citrate and examined in electron microscope.

3. Results

The only cell type found in the tunica intima was endothelium in both abdominal aorta and renal artery (Figures 1, 2). In the abdominal aorta, the internal elastic membrane was a thick sheet of elastin. There was open connective tissue space between the main mass of the internal elastic membrane and the endothelium. Such space contained elastic fibers that are branchs of internal elastic membrane. In the internal elastic side of endothelium, areas of elastic fibers were observed that probably showed in progress elastin formation (Figure 1). In renal



ANATOMICAL SCIENCES

Figure 1. Photomicrograph–Abdominal aorta tunica intima in neonate dog. Abbreviations: IEM: Internal Elastic Membrane; EN: Endothelium; EF: Elastic Fibers. Arrows: Elastin formation. ×5610. Scale bar: 1.78 µm.

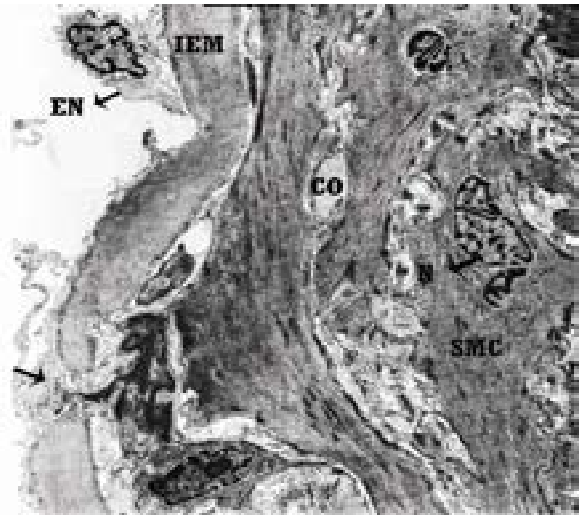


Figure 2. Photomicrograph–Renal artery tunica intima in neonate dog. Abbreviations: IEM: Internal Elastic Membrane; EN: Endothelium; CO: Collagen Fibers; SMC: Smooth Muscle Cells; N: Nucleus. Arrows: Interrupt. ×2950. Scale bar: 3.38 µm.

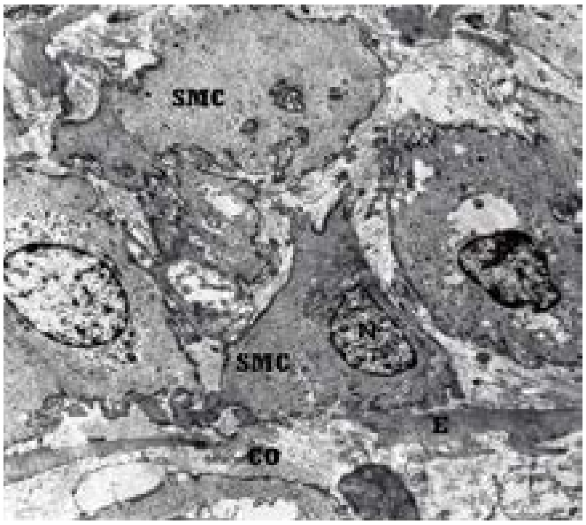


Figure 3. Photomicrograph–Abdominal aorta tunica media in neonate dog. Abbreviations: CO: Collagen Fibers; SMC: Smooth Muscle Cells; N: Nucleus; E: Elastic lamellae; MF: Myofilaments; DB: Dens Bodies. ×3900. Scale bar=2.56 µm.

artery, a thick internal elastic membrane was observed that endothelial cells attach directly to it. In some places, the internal elastic membrane was interrupted for as much as a few microns. In the vicinity of such fenestrations, collagen, island of elastin, and even extrusions of muscle cell protoplasm were seen (Figure 2).

The only cell type which was found in the abdominal aorta and renal artery tunica media was smooth muscle cells. Myofilaments were found throughout most of the cytoplasm of the smooth muscle cells. Smooth muscle cells in the walls of these 2 arteries contained conspicuous dens bodies which underlie the cell surface and lie between myofilaments. In contrast, dens bodies were more numerous in the smooth muscle of the renal artery than in abdominal aorta (Figures 3, 4). In the tunica media of renal artery, the smooth muscle cells were close to each other and a small quantity of collagen and elastic fibers were found between them. In the space between smooth muscle cells, collagen fibers were more than elastic fibers (Figure 4). In the abdominal aorta tunica media, layers of smooth muscle cells was observed that alternate with elastic lamellae. These elastic lamellae

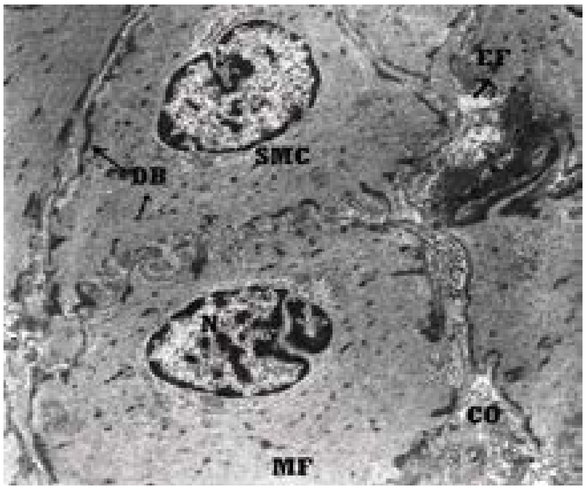


Figure 4. Photomicrograph–Renal artery tunica media in neonate dog. Abbreviations: EF: Elastic Fibers; CO: Collagen Fibers; SMC: Smooth Muscle Cells; N: Nucleus; MF: Myo-Filaments; DB: Dens Body. ×5200. Scale bar: 1.92 µm.

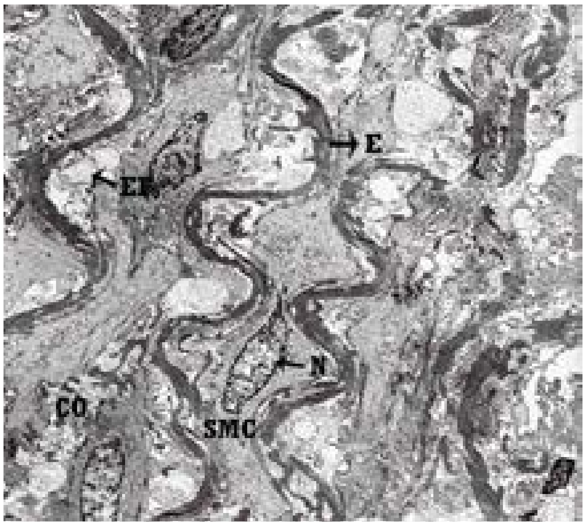


Figure 5. Photomicrograph–Abdominal aorta tunica media in neonate dog. Abbreviations: EF: Elastic Fibers; CO: Collagen Fibers; SMC: Smooth Muscle Cells; N: Nucleus; E: Elastic lamellae. ×1650. Scale bar: 6.06 µm.

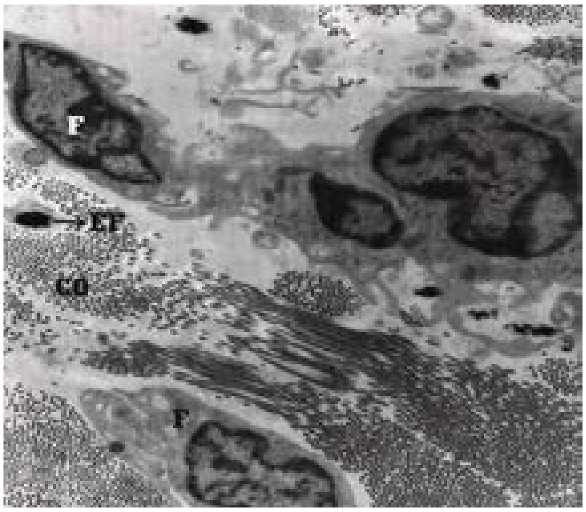


Figure 6. Photomicrograph–Abdominal aorta tunica adventitia in neonate dog. Abbreviations: EF: Elastic Fibers; CO: Collagen Fibers; F: Fibroblast. ×5200. Scale bar: 1.92 µm.

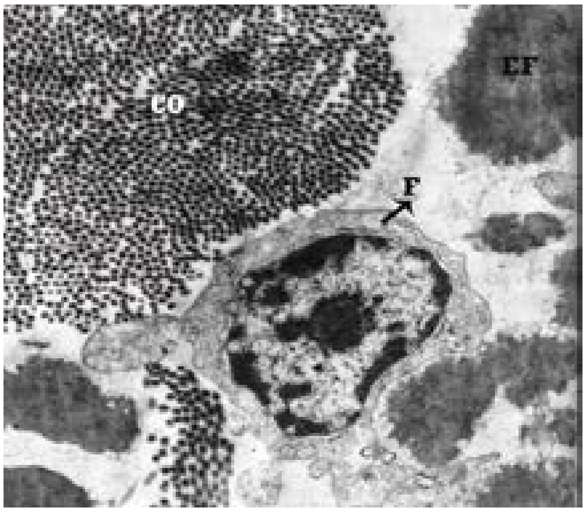


Figure 7. Photomicrograph–Renal artery tunica adventitia in neonate dog. Abbreviations: EF: Elastic Fibers; CO: Collagen Fibers; F: Fibroblast. ×11500. Scale bar: 0.86 µm.

were essentially continuous sheets with considerable thickness. Adjacent to their surface, there were connective tissue space containing collagenous fibers quantity (Figure 5).

The adventitia of the abdominal aorta and renal artery consisted of scattered fibroblasts among bundles of collagen and elastic fibers. Elastic fibers in tunica adventitia of renal artery were more than abdominal aorta (Figures 6, 7).

At the junction of renal artery, we observed 2 orientations of smooth muscle cells; circular and longitudinal form. Also, at this junction, tunica media consisted of several layers of smooth muscle cells, which were commonly arranged in circular fashion with associate collagen and elastic networks. In outer tunica media and tunica adventitia, there were smooth muscle cells in longitudinal form (Figure 8). Circular and longitudinal forms of smooth muscle cells were also observed in electron microscopy. There were collagen and elastic fibers between smooth muscle cells in extracellular space (Figure 9).

4. Discussion

In this histological study, we were able to show the open connective tissue space between the main mass of

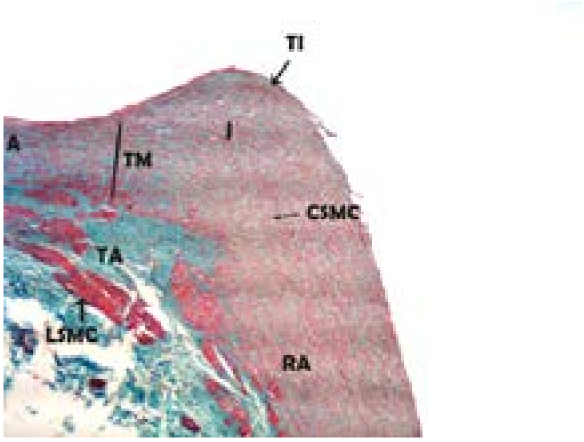


Figure 8. Microscopic aspect of the junction of right renal artery in neonate dog at 175x magnification. Scale bar: 57.14 µm. Abbreviations: TI: Tunica Intima; TM: Tunica Media; TA: Tunica Adventitia; A: Aorta; RA: Renal Artery; J: Junction; CSMC: Circular Smooth Muscle Cells; LSMC: Longitudinal Smooth Muscle Cell. Green Masson's trichrome stain.

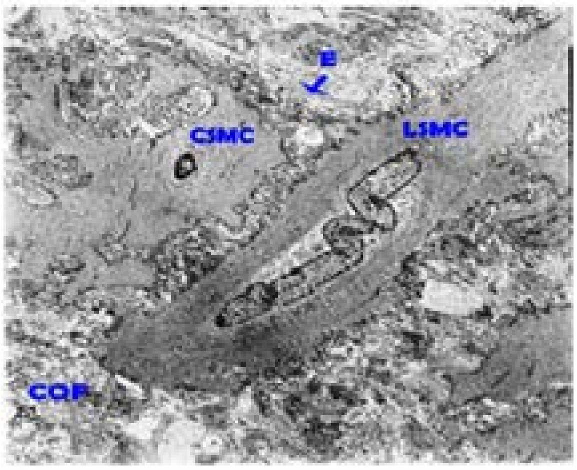


Figure 9. Transmission electron micrographs of tunica media at the junction of right renal artery in neonate dog. Abbreviations: E: Elastin; COF: Collagen Fibers; CSMC: Circular Smooth Muscle Cells; LSMC: Longitudinal Smooth Muscle Cell. ×2200. Scale bar: 4.54 µm.

the internal elastic membrane and the endothelium in abdominal aorta. This space has been previously observed in aorta wall of the rats [13]. In tunica intima of renal artery, there was an interruption in some place of internal elastic membrane. There were not similar fenestrations in the abdominal aorta of neonate dogs. However, similar fenestrations have been observed in the aorta of other animals by light microscopy as well as in smaller vessels by electron microscopy [14, 15].

The cytoplasm of the smooth muscle cell in tunica media of renal artery and abdominal aorta consisted of numerous myofilaments and dens bodies. These dens bodies in the cytoplasm and the cell membrane serve as anchor site for the myofilaments. These bodies have been previously observed in smooth muscle cells in varying details by Parker [15] and Mark [16]. Previously, it was reported that they are attachment devices, anchoring the system of myofilaments to the cell surface [17]. The number of dens bodies in smooth muscle cells of renal artery were more compared to that of the abdominal aorta and it may be because of the function of these cells in the renal artery. In a large artery like abdominal aorta, arterial pressure is maintained by elastic fibers but in a muscular artery such as renal artery, the pressure remains high by contraction and relaxation of smooth muscle cells and action of these cells in renal artery is more than abdominal aorta. Also in abdominal aorta tunica media, the rows of elastic fibers between smooth muscle cells were more numerous as opposed to the renal artery. In the walls of an artery, especially in large arteries, elastic rebound helps to maintain arterial pressure [18].

We know that during systole, blood enters the large elastic arteries with considerable force, and these arteries distend. They are able to do so because of the large amount of elastic tissue in their walls, and during diastole the arteries return to their original size because of the elastic recoil of their walls. The flow of blood to the organ is controlled by the contraction or relaxation of the smooth muscle cells of the tunica media [7]. Therefore, the existence of more elastic fibers in the abdominal aorta tunica media as opposed to the renal artery, and the replacement of elastic fibers by smooth muscle cells in the renal artery can serve as a physiological process.

Although the number of elastic fibers in tunica media of abdominal aorta was more than that of renal artery, but these fibers in renal artery tunica adventitia was more compared to the abdominal aorta. It is probably due to the function of elastic fibers for helping to maintain arterial pressure [19]. Also, the existence of more elastic fibers in the renal artery tunica adventitia convince us that they probably play a role in maintaining arterial pressure. This research showed that at the junction of renal artery with abdominal aorta in male adult dogs, there were 2 orientations of smooth muscle cells; circular form in tunica media and longitudinal form in the outer of tunica media and tunica adventitia.

However, the fact that the orientations of smooth muscle cells at the junction of renal artery with abdominal aorta in dogs are similar to the muscular vein is of special interest. The veins are dilatable when contain more elastic and collagen fibers than smooth muscle cells in their wall and they are contractile if contain more smooth muscle cells in their walls. The contractile state of the vein wall plays an important role in blood flow [19]. The significance of bifurcation in the arterial walls is not clear yet, but they may be mobile physiological structures for regulating blood flow [20]. However, the observation of circular and longitudinal form of smooth muscle cells at the junction of renal artery convince us that they probably play a role in regulating blood flow and control of its affluence from the aorta to the kidney.

In conclusion, aorta and renal artery in neonate dogs show some differences. These differences presumably reflect adaptation to the function of these 2 arteries. Junction of renal artery, tunica media, consisted of several layers of smooth muscle cells, which are arranged in circular fashion and in outer tunica media and tunica adventitia there were smooth muscle cells in the longitudinal form. They probably have a role in blood flow and control of blood affluence to renal artery.

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Conflict of Interest

The authors of this study declared no conflict of interests.

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