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EVALUATION OF THE ELASTIC COMPONENT IN THE ADVENTITIA OF THE DESCENDING ABDOMINAL AORTA AND ITS COLLATERALS IN THE GOAT (*Capra hircus*)

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Abstract

Fragments of the descending abdominal aorta and its main branches were collected from 8 goats that died following accidents, for histological investigations. Verhoeff staining was used, which specifically highlights the elastic components. It was found that all the arteries taken in the study contain well-represented elastic tissue at the level of the adventitia, the least in the descending abdominal aorta and the renal artery, and the most in the external iliac arteries. We believe that these fibroelastic adventitia constitute an elastic sleeve that provides resistance and elasticity to the arteries to cope with the external demands given by the amplitude of the volume changes undergone by the organs in the abdominal cavity, which train and the vessels that serve them. They appeared as adaptive structures mainly due to the presence of prestomachs which undergo extensive and frequent changes during digestion processes.

Key words*: adventitia, arteries, Capra hircus, elastic tissue.*

INTRODUCTION

Arteries have a wall consisting of three tunics, which from the inside to the outside are the intima, the media, and the adventitia (Miclăuș, 2006). The dynamic tunic of the vessel is the media (Gal & Miclăuş, 2020) and it adapts structurally and functionally to the internal demands, given by the pressure with which the blood circulates through their lumen. In the case of arteries, the media is the thickest tunic, even if there are differences depending on the type of arteries.

The adventitia represents the protective tunic of the arteries, giving it the necessary resistance and the ability to adapt to external demands in the anatomical area it serves (Aughey & Frye, 2001; Ihuț et al., 2024). The adventitia differs greatly in thickness from one type of vessel to another, being generally thin in the case of elastic arteries and much thicker in the case of muscular ones, where it can approach the tunica media in thickness. In the vast majority of cases, the adventitia consists of loose connective tissue, in which the collagen fibers have a longitudinal or oblique arrangement and the cells are relatively few (Raica et al., 2004). The vast majority of arteries also contain elastic fibers in the adventitia, but in most cases, they are present in small or very small amounts. According to their diameter, they are classified into large, medium, and small arteries, and according to the structural elements that predominate in their middle tunic, they are called elastic arteries and muscular arteries. From a structural point of view, the large arteries are elastic, and the medium and small ones, are muscular arteries (Pușcașiu et al., 1999). Between the two main types of arteries are interposed segments of passage called transition arteries or mixed arteries. At their level, the ratio between the average's elastic and the muscular component changes gradually, reaching a certain point of equality, and then the muscular component exceeds the elastic one (Gal & Miclăuş, 2020). This category includes, in most species of animals, the collaterals of the abdominal aorta, carotid, axillary, external iliac, etc. (Cornilă, 2000). In ruminants, most of the large-caliber arteries show a structure more similar to the transitional arteries (ascending aorta, pulmonary arterial trunk, aortic cross, brachiocephalic arterial trunk, thoracic descending aorta artery, bicarotid arterial trunk, left sub clavicular artery, sub clavicular artery right). The media of these arteries contains islands of smooth muscle cells separated from each other by elastic lamellae (Gal & Miclauș, 2020).

MATERIALS AND METHODS

This study used eight goats that died following accidents as biological material. The Bioethics Commission of USAMV Cluj-Napoca approved the investigation by decision no. 403 of 29.09.2023 and the recommendations of the World Organization for Animal Health were respected.
Anatomical dissection was performed to create access to the abdominal cavity and fragments of the following arterial segments were collected for histological investigations: descending abdominal aorta, celiac trunk, mesenteric, gastric, splenic, hepatic, rumen, omasal, abomasal, renal arteries and iliac. Fixation of the collected samples was done in 10% formalin for 5 days, after which they were dehydrated with increasing concentrations of ethyl alcohol, clarified with 1-Butanol, and embedded in paraffin. Sections with a thickness of 5 µm were made, which, after spreading on slides, were stained by the Verhoeff method. For the examination of the histological preparations, we used an Olympus BX41 microscope, equipped with an Olympus E-330 digital camera, to capture the images.

RESULTS AND DISCUSSIONS

The abdominal descending aorta (Figure 1) differs from the previous segments in that its media does not contain smooth muscle islands. The elastic laminae can be distinguished, and the elastic sheets appear wavy and of somewhat comparable thickness throughout the media. The adventitia is thicker than in the previous segments and is predominantly composed of collagen fibers, but it also contains significantly more elastic fibers than the thoracic descending aorta. Overall, we can say that the abdominal descending aorta falls into the category of typical elastic arteries.

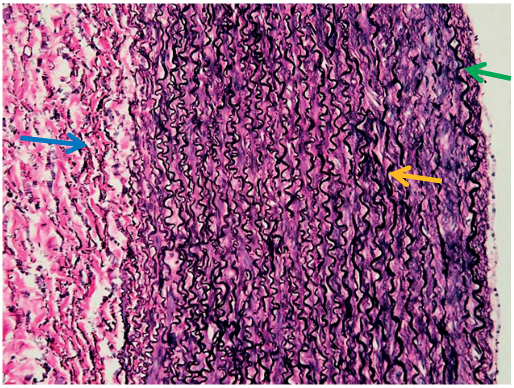

Figure 1. Abdominal descending aorta: yellow arrow – elastic lamellae in the media; green arrow – internal limiting membrane; blue arrow – adventitia (original photo; Verhoeff, obj. 20X)

The celiac trunk (Figure 2) is the first branch of the abdominal aorta, and its thickest tunic is the media. It has a relatively thin intima, a thick and wavy internal elastic lamina, while the external elastic lamina is noticeably thinner. The media is predominantly composed of smooth muscle cells, mostly arranged in a circular pattern, though some muscle bundles with an approximately longitudinal orientation can be found in peripheral areas near the adventitia.

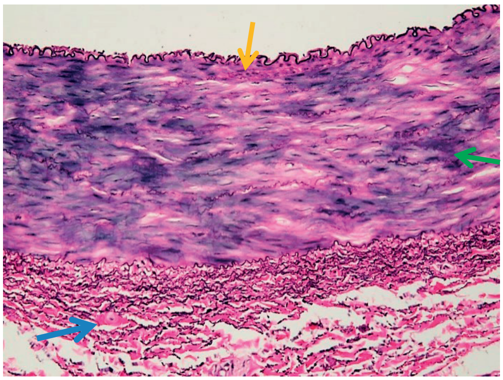

Figure 2. Celiac trunk: yellow arrow – internal limiting membrane; green arrow – media; blue arrow – elastic lamellae in the adventitia (original photo; Verhoeff, obj. 20X)

Scattered throughout the media, thin elastic fibers are evident, mostly arranged in a circular pattern, but some are transversely or obliquely oriented, giving the impression of anchoring the muscle bundles together. Based on the structure of its intima and media, this artery falls into the category of muscular arteries. However, the adventitia contains significantly more elastic tissue than the media. This elastic tissue is represented by wavy elastic lamellae arranged circularly, mimicking the distribution of elastic lamellae in the media of elastic arteries. The adventitia's high amount of elastic tissue distinguishes this artery from classic muscular arteries. For this reason, we classify the goat celiac trunk as a transitional, musculo-elastic artery.

This structural pattern is largely found in the other branches of the abdominal descending aorta, including the splenic (Figure 3a), gastro-ruminal (Figure 3b), renal (Figure 4a), iliac (Figure 4b), hepatic, omasal, abomasal, and mesenteric arteries.

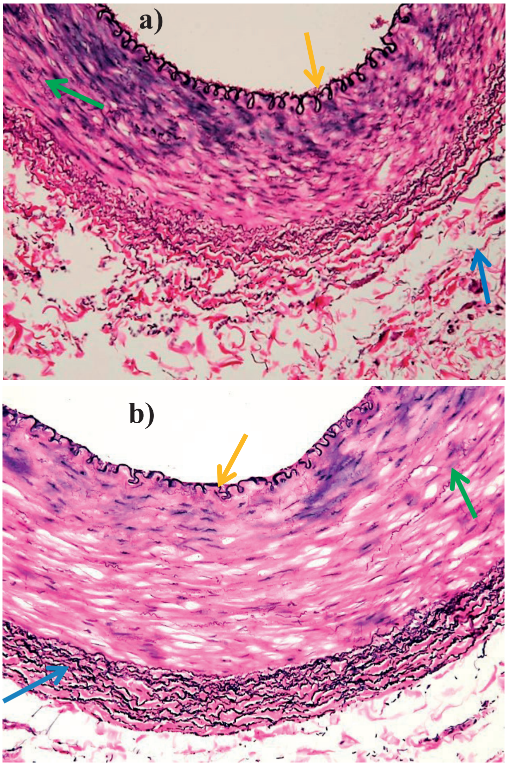

Figure 3. **a)** Splenic artery: yellow arrow – internal limiting membrane; green arrow – media; blue arrow – elastic lamellae in the adventitia (original photo; Verhoeff, obj. 20X); **b)** Gastro-ruminal artery: yellow arrow – internal limiting membrane; green arrow – media; blue arrow – elastic lamellae in the adventitia (original photo; Verhoeff, obj. 20X)

All branches of the abdominal descending aorta exhibit a fibroelastic adventitia, although there are some differences in the amount of elastic tissue present in the adventitia. Most of these arteries contain an amount of elastic tissue comparable to that of the celiac trunk, except the renal and iliac arteries.

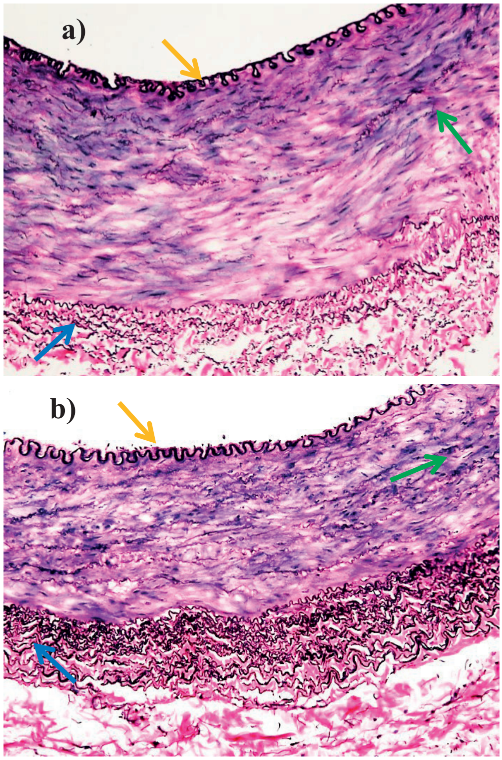

Figure 4. **a)** Renal artery: yellow arrow – internal limiting membrane; green arrow – media; blue arrow – elastic lamellae in the adventitia (original photo; Verhoeff, obj. 20X); **b)** External iliac artery: yellow arrow – internal limiting membrane; green arrow – media; blue arrow – elastic lamellae in the adventitia (original photo; Verhoeff, obj. 20X)

The renal arteries contain slightly less elastic tissue, while the external iliac arteries contain noticeably more.

Nevertheless, all branches of the abdominal descending aorta in goats are classified as transitional, musculo-elastic arteries.

The tunica adventitia of blood vessels varies in thickness from one segment to another, depending on the vessel's position relative to the heart and the region it supplies. Structurally, its main components are collagen and elastic fibers. Evaluating the adventitia of large arteries in lambs from a structural perspective, Csibi et al. (2015) found that some arteries contain a small number of elastic fibers (ascending aorta, aortic arch, thoracic descending aorta, bicarotid trunk, left subclavian artery), while others have a slightly higher amount (abdominal descending aorta, left and right internal iliac arteries, brachiocephalic trunk, subclavian artery). However, in some arteries, the amount of elastic tissue in the adventitia is so significant that it clearly exceeds that found in the tunica media (external iliac arteries, common carotid arteries).

The authors suggest that this high amount of elastic tissue in the adventitia appears to be an adaptation to the external mechanical stresses that these arteries experience in the anatomical regions they serve.

The abdominal descending aorta in goats has an adventitia comparable to that reported by Csibi et al. (2015) in lambs, in the sense that its elastic fibers are more abundant than in the previous segments. Due to the presence of numerous elastic lamellae in the media, it is classified as an elastic artery. However, among elastic arteries, it has the thickest adventitia with the highest amount of elastic tissue. In other words, among aortic segments, the abdominal descending aorta is the only one that contains a substantial amount of elastic tissue both in the media and the adventitia, whereas the previous segments have a thinner adventitia with very little elastic tissue. This situation changes significantly in the case of its branches, including the celiac trunk, mesenteric, hepatic, splenic, ruminal, reticular, omasal, abomasal, gastric, renal, ileocolic, external iliac, and internal iliac arteries.

For all these arteries, we found that their adventitia contains a well-represented amount of elastic tissue, clearly exceeding the level found in the adventitia of the abdominal aorta.

The elastic tissue present in the adventitia of these arteries is not only well represented but also has a specific arrangement. It consists of wavy elastic lamellae, primarily arranged in a circular pattern, closely resembling the organization of elastic lamellae in the media of elastic arteries. There are differences among the mentioned arteries regarding adventitial thickness and, especially, the amount of elastic tissue within it. However, in all cases, the quantity is sufficient to justify classifying these arteries as transitional arteries.

Among the arteries described, the external iliac artery has the thickest adventitia and the highest number of elastic lamellae, while the renal arteries have the lowest amount. The presence of a fibroelastic adventitia in these transitional arteries - and, more importantly, the remarkably high number of transitional arteries in goats - is not coincidental but rather a necessity dictated by the type of animal and its specific diet.

The arteries in the abdominal cavity are subject to extensive movement due to the presence and activity of digestive organs. Compared to monogastric animals, goats have three large digestive organs: the rumen, reticulum, and omasum (Marina et al., 2023). These organs undergo significant volumetric changes due to their function. Their activity, along with that of the other abdominal organs, generates frequent and extensive movements that also affect the blood vessels supplying them.

For optimal blood circulation and to protect the vessels from the magnitude of these movements, these arteries have developed adaptive structures that provide both resistance and elasticity. The resistance is primarily ensured by the collagen fibers in the adventitia, but in this specific case, it is also reinforced by the well-represented elastic component with its unique arrangement, which grants exceptional elasticity to the walls of the abdominal blood vessels.

In the case of the external iliac arteries, the presence of a highly developed fibroelastic adventitia may be attributed to the fact that goats are energetic and active animals, often covering long distances, especially during food-gathering periods. Additionally, they frequently forage from elevated sources, such as leaves and twigs from shrubs and young trees. During these activities, goats often stand on their hind legs, relying solely on them for support, which places significant strain on these limbs.

During movement and particularly in demanding postures, the blood vessels supplying the hind limbs are subjected to external pressures. To prevent these pressures from compromising the integrity and function of the vessels, these arteries have developed thick fibroelastic adventitia. This structure acts as an elastic cushion, ensuring both flexibility and protection, allowing the blood vessels to withstand mechanical stress without impairing circulation.

In some animal species, the adventitia of transitional arteries contains a large number of elastic lamellae arranged in a particular manner around the tunica media, as observed in Japanese pigs (Awal et al., 1997) and dogs (Awal et al., 1998). However, this characteristic was not present in guinea pigs (Awal et al., 2001) or in Bengal black goats (Awal et al., 1999).

Regarding the elastic tissue in the tunica adventitia, other researchers have reported different findings from those of Awal in Bengal black goats. For instance, Ogeng'o et al. (2010) observed a cranio-caudal increase in the thickness and elastic fiber content of the adventitia in goats. In the ascending aorta, aortic arch, and thoracic descending aorta, the adventitia was thin, containing only a few scattered elastic fibers running in different directions. However, in the abdominal descending aorta, the adventitia was thicker and contained significantly more elastic tissue than in the previous segments. Based on these findings, they argued that the adventitia of the abdominal aorta in goats is fibroelastic, similar to that found in dogs (Hass et al., 1990; Orsi et al., 2004), guinea pigs, and albino rats (Mello et al., 2004).

These observations highlight differences among researchers regarding findings within the same species. Awal et al. (1999) reported that Bengal black goats had an insignificant amount of elastic tissue in the adventitia of aortic segments, whereas Ogeng'o et al. (2010) found a gradual increase in elastic tissue, culminating in a fibroelastic adventitia in the abdominal descending aorta of goats. Our results also indicate a gradual increase in elastic tissue across aortic segments, aligning more closely with the findings of Ogeng'o et al. (2010).

A particularly interesting aspect was reported by Raica et al. (2004) in humans, where the authors described the media of transitional arteries as having two distinct zones: an internal muscular layer and an external elastic layer. Examples of such arteries included abdominal aortic branches, external carotid arteries, axillary arteries, and common iliac arteries. However, our findings on the abdominal descending aorta and its branches in goats do not resemble those reported by Raica et al. (2004) in humans. While they claimed that the media of abdominal aortic branches contains both a muscular internal zone and an elastic external zone, in goats, the media is entirely muscular, with well-represented elastic tissue found in the adventitia. This suggests either that the abdominal aortic branches in goats are structurally different from those in humans or that Raica et al. (2004) may have interpreted the elastic tissue-rich adventitial region as part of the media.

As a general observation, we found fibroelastic adventitia in arteries located in anatomical regions subjected to external mechanical stresses, due to their proximity to structures exerting pressure or traction at certain times, depending on their presence and function. In other words, fibroelastic adventitia represents an adaptive structure that has developed in response to external stresses, just as the media of elastic arteries is adapted to internal stresses caused by blood column pressure and turbulent flow in the initial segments emerging from the heart.

CONCLUSIONS

The abdominal descending aorta and its branches contain well-represented elastic tissue in the adventitia, arranged in a specific manner, which justifies classifying them as having a fibroelastic adventitia. This type of structure acts as an elastic cushion, protecting blood vessels located in anatomical regions exposed to external factors such as significant pressure and traction.

Fibroelastic adventitia is an essential structural adaptation that has developed in response to mechanical stress caused by the proximity of large organs that undergo significant volume changes depending on the phases of digestion. This adaptation helps maintain the integrity and functionality of the arteries under high mechanical strain, ensuring efficient blood circulation in highly stressed abdominal regions.

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