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# Assessing the Elastic Components of the Aortic Media in Goats (*Capra hircus*)

**Evaluación de los Componentes Elásticos de la Aorta en Cabras (*Capra hircus*)**

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**CRET, C. R.; MICLAUS, V.; OANA, L.; DRAGOMIR, M. F.; OBER, C.; RATIU, C. & DAMIAN, A.** Assessing the elastic components of the aortic media in goats (*Capra hircus*). *Int. J. Morphol., 42(4)*:999-1004, 2024.

**SUMMARY:** Samples were collected from five goats (*Capra hircus*) from the ascending aorta, aortic arch, descending thoracic aorta, and descending abdominal aorta. These samples were histologically processed to reveal elastic structures in their media. The mean number of elastic lamellae discovered was 91.5 in the mean ascending aorta, 78.5 in the mean aortic arch, 66 in the mean descending thoracic aorta, and 31.7 in the mean descending abdominal aorta. Because they all have a large number of elastic laminae on average, they all fall into the elastic artery category, but not all are typical elastic arteries. Thus, the ascending aorta, the aortic arch, and the descending thoracic aorta contain, on average, in addition to elastic tissue, polymorphous muscle islands, which distinguishes them from typical elastic arteries, which is why we call them particular elastic arteries. The descending abdominal aorta contains no such islands so that it can be classified as a typical elastic artery. The goat aortic segment is the only one comparable in structure to the elastic arteries of humans, which is why we suggest that it is the only one suitable for studying aortic disease in humans.

**KEY WORDS: Aorta; *Capra hircus*; Elastic blades; Goat.**

## INTRODUCTION

The arteries have a wall made up of three tunics, which, from the inside to the outside, are the intima, media, and adventitia. The arterial wall comprises elastic laminae, smooth muscle fibers, and connective tissue. Based on the proportion of these components, arteries are classified into three types: elastic, muscular, and transitional. The aorta and its main branches are examples of elastic arteries, with some variations across species. The media of elastic arteries play a vital role in hemodynamics through their Windkessel function, which is influenced by systolic pressure and turbulent blood flow during ventricular systole (Mello *et al*., 2004, 2009; Martonos *et al*., 2021).

The goat is a particular animal with a digestive system adapted for herbivorous feeding and possibly using cellulose, which most animals cannot digest. However, the degradation of cellulose requires special processing because it cannot be broken down by enzymatic digestion. To degrade it, the goat has developed particular organs in which microbial degradation of cellulose takes place, and the material thus processed passes on to compartments where enzymatic digestion, comparable to that of other mammals, takes place. Microbial digestion occurs in specialized organs called pre-stomachs, represented by the rumen, the grid, and the fovea, in a complex and very demanding process.

The combined capacity of these organs in the goat is up to 25 liters, occupying a large part of the abdominal cavity. These large organs require a significant blood supply because of their size and very active involvement in the first phase of digestion, i.e., microbial digestion. This requires extra effort from the circulatory system, which must pump more blood compared to a monogastric animal of similar size.

At the same time, the presence of these extra-large organs means that the peripheral capillary network has a much larger surface area than in monogastric animals. To meet these additional demands, the goat's arterial system must work harder than that of a monogastric animal of similar size.

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The study aimed to evaluate the elastic component in the mean of each aortic segment in the goat to see how they adapted to the particular stresses given by the presence of pre-stomachs and a more extensive peripheral network than in monogastric.

## MATERIAL AND METHOD

Five adult common breed goats, slaughtered by their owners following accidents, were used as biological material. The study was approved by the Bioethics Commission of USAMV Cluj-Napoca, according to decision no. 403 of 29.09.2023. The working procedure follows the recommendations of the OIE (World Organization for Animal Health) permanent working group on the slaughter of animals and the AVMA guidelines for the humane slaughter of animals.

Fragments from all aorta segments, i.e., ascending aorta, aortic arch, descending thoracic aorta, and descending abdominal aorta, were harvested for histological investigations. For histological fixation, specimens were immersed in 10 % formalin solution for 6 days, when the fixative solution was changed twice. At the end of the fixation period, the specimens were dehydrated in ethyl alcohol baths of increasing concentration (70 %, 96 %, and absolute), then clarified with 1-butanol and embedded in paraffin. Parts were sectioned at 5 mm thickness using a LEICA RM 2125 RT rotary microtome. Histological sections were stained by the Verhoeff method and then examined under an Olympus BX41 microscope. Image capture was done with a digital camera, Olympus model E-330, provided with a microscope.

## RESULTS

The ascending goat's aorta is an artery in which the media is the predominant layer, occupying more than 80 % of the arterial wall thickness. The predominant component in the media is the elastic component, which has a particular disposition in the inner third compared to the middle and outer thirds.

The inner third has certain structural peculiarities related to the elastic lamellae's arrangement, density, and orientation. At the boundary with the intima, there is no thick, wavy elastic band comparable to that of the muscular arteries. However, there is an agglomeration of medium-thickness lamellae arranged near the intima, which may constitute an internal elastic band together. The following layer has a not-very-thick area with more sparse elastic laminae and a more longitudinal and oblique orientation. The rest of the inner third is occupied by undulated elastic lamellae of medium thickness and predominantly circular arrangement (Fig. 1).

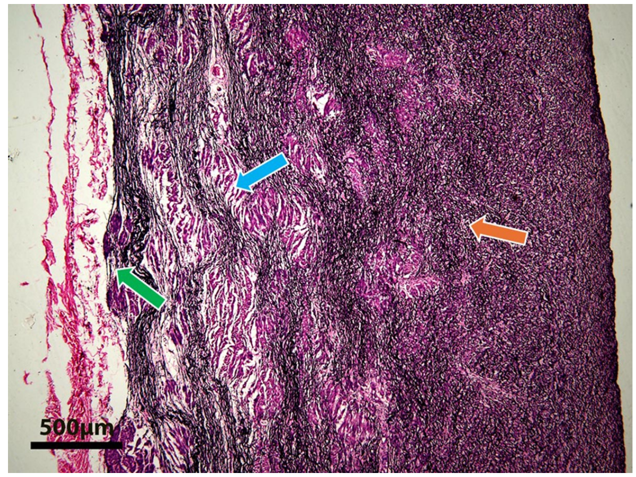

Fig. 1. The ascending aorta; Arrows: green-thin layer of adventitia, blue-area of muscle islands, orange-elastic laminae layer.

In the vicinity of the inner third, the elastic blades become slightly thicker, and their circular orientation is sharper.

The middle third contains relatively thick, circularly oriented elastic blades with a medium degree of undulation. From place to place, the elastic laminae in the middle third appear interrupted by smooth muscle cells grouped as polymorphic islands and distributed without a strict order. A limited number of fibers partially traverse some of the islands, obviously thinner than those between the islands.

The outer third has a very particular structure. Here, the muscular islands interrupting the elastic laminae are much more numerous and prominent than those in the middle third. The surface area of the islands varies significantly from one area of the outer third to another. It can be estimated to occupy between 20 and 75 % of the thickness of the outer third. It should be noted that some islands are so peripherally arranged that they are separated from the adventitia by only one or two elastic blades. An external elastic boundary cannot be distinguished. However, in the portions where the islands are not in the vicinity of the adventitia, a closer arrangement of elastic lamellae is observed so that we can interpret that there is a kind of external elastic boundary but a discontinuous one. The adventitia is thin (no more than 15 % of the wall thickness) and is collagenous structurally. The mean number of elastic lamellae in the ascending aorta was 91.5.

The aortic arch contains a discrete and discontinuous elastic boundary. Specifically, here, we find densification of lamellae in the subendothelial zone only in certain portions and a lower number of lamellae than in the ascending aorta. Otherwise, the situation is quite similar in terms of the elastic laminae's thickness and arrangement and the presence of muscular islets, their size, and distribution. The adventitia are comparable both in thickness and structure. The mean number of elastic lamellae in the aortic arch was 78.5 (Fig. 2).

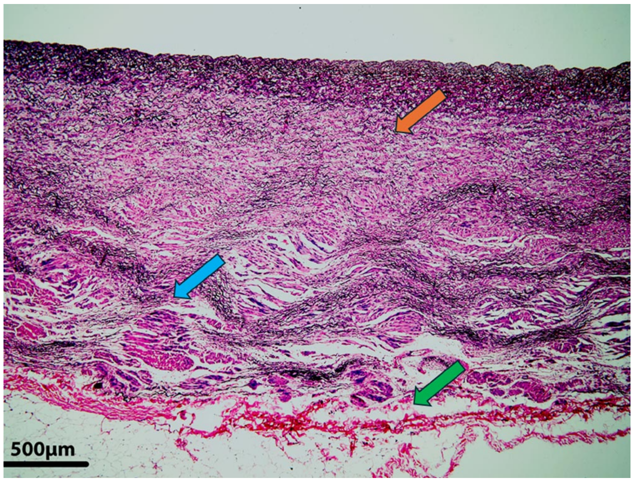


Fig. 2. The aortic arch; Arrows: green-thin layer of adventitia, blue-area of muscle islands, orange-elastic laminae layer.

The descending thoracic aorta shows a continuous, relatively thick, and wavy internal elastic boundary. In the thickness of the media, muscular islands are also present, but they are smaller in size than in the anterior segments and appear arranged only in the outer half of the media. The external elastic boundary can be appreciated and appears to be formed of 2-3 elastic laminae, obviously thinner than the internal boundary. The adventitia is thicker than the previous segments, occupying about 20-25 % of the wall thickness. It consists mainly of collagen fibers, among which there are also several elastic fibers. The average number of elastic lamellae in the descending thoracic aorta was 66 (Fig. 3).

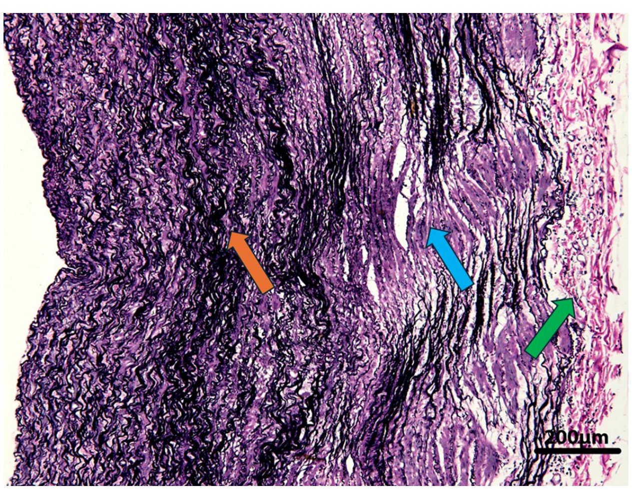


Fig.3. The descending thoracic aorta; Arrows: green-a thicker layer of adventitia, blue-area of smaller muscle islands, orange- elastic laminae layer.

The descending abdominal aorta differs markedly from the anterior segments because its media does not contain smooth muscle islands. Elastic margins are well represented and easily distinguishable, and the elastic laminae appear wavy and of somewhat comparable thickness throughout the thickness of the media. As regards the density of the elastic lamellae, there are some differences between the inner and outer half of the stocking in that in the inner half, the distance between the lamellae is somewhat greater. The adventitia is thicker than in the anterior segments, occupying 30-35 % of the arterial wall thickness. It consists predominantly of collagen fibers but contains noticeably more elastic fibers than in the thoracic descending. In a general assessment, the descending abdominal aorta is the only one with a structure that fits the typical elastic arteries. The mean number of elastic lamellae in the abdominal descending aorta was 31.7 (Fig. 4).

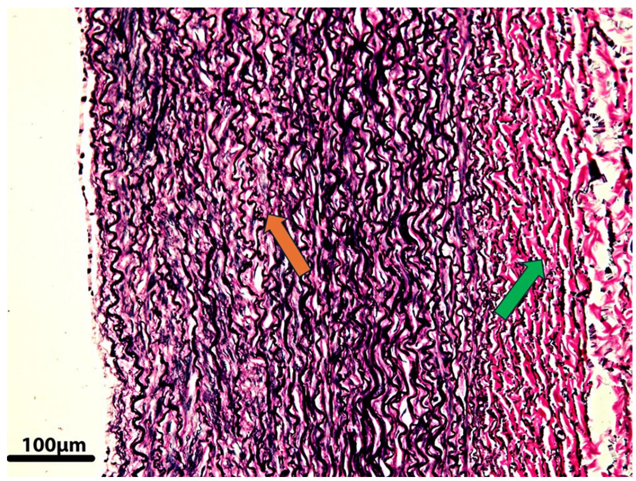


Fig. 4. The descending abdominal aorta; Arrows: green-thicker layer of adventitia, orange-elastic laminae layer.

## DISCUSSION

The middle of the elastic arteries contains concentrically arranged fenestrated elastic lamellae that anastomose to form complex elastic networks. The media is flanked by two elastic boundaries (inner and outer), indistinguishable from elastic lamellae in structure and arrangement (Gal & Miclaus, 2020).

In the goats we studied, the internal elastic limitation was the thickest and most folded in the descending abdominal aorta, a situation that has also been reported in goats (Ogeng'o *et al*. 2010), in the rabbit (Svendsen, 1985) and the dog (Orsi *et al*., 2004). According to some authors, the folding of the internal elastic limitation may contribute to the resistance of the aorta to dilatation during systole but also constitutes a reserve of the intima, which relaxes during systole to increase the circumference of the vessel lumen. This folding may also enhance the Windkessel mechanism, usually attributed only to elastic laminae in the tunica media (Svendsen, 1985).

It should also be noted that the number of elastic lamellae differs between domestic and laboratory animals (Awal *et al*., 1995, 1999). The number of elastic laminae in the elastic arteries differs from species to species depending on the size of the animal and the physiological parameters characteristic of each species. Moreover, even within the same species, their number differs from author to author. Thus, some authors claim that the number of elastic laminae in the human aorta is 40-60 (Leeson *et al*., 1985; Ross & Reith, 1985); others, it is 30-50 (Raica *et al*., 2004), 50-60 (Adlersberg *et al*., 1955), 40-70 (Junqueira *et al*., 1998). Some authors argue that the number of elastic laminae is not the same throughout life but increases with age (Junqueira *et al*., 1998; Raica, 2004). Thus, it is argued that in humans, the number of lamellar units in the newborn is 40 and increases with age, reaching up to 52 lamellar units.

In the goats we studied, the mean number of elastic lamellae in the ascending aorta was 91.5; in the aortic arch, it was 78.5; in the descending thoracic aorta, it was 66; and in the descending abdominal aorta, it was 31.7 (Fig. 5). Comparing the number of elastic laminae in the human aorta with those in the first aortic segments of the goat, we find that the goat aorta contains significantly more elastic laminae. However, the goat's waist size is smaller than a human's, demonstrating that the wall of the goat's aorta is more elastic, robust, and efficient than that of humans because the arterial system of the goat is more stressed than that of man and is the result of the additional stress given by the existence of three additional large organs (rumen, meshwork, phiosis) and higher peripheral resistance.

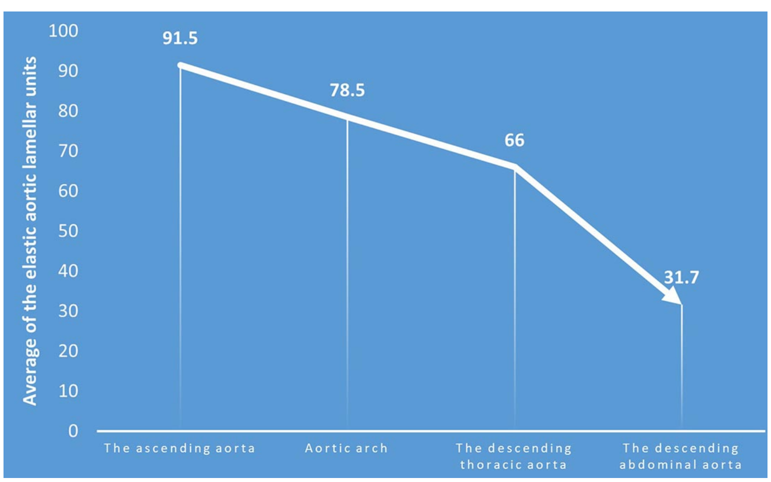


Fig. 5. Graphic exposing the mean number of elastic lamellae and their gradual decrease due to the position of each arterial segment concerning the heart, in direct relation to the blood pressure, which is highest in the ascending aorta and decreases gradually with each segment as it moves away from the heart.

In studies on black Bengal goats, it was found by Awal *et al*. (1999), that the number of elastic laminae in the tunica media was 85-90 in the ascending aorta, 70-75 in the aortic arch, 25-30 in the thoracic aorta, 15-20 in the abdominal aorta. When studying the number of elastic lamellae in the mean descending thoracic aorta in decani sheep and bird goats, Sharanagouda *et al*. (2016), found a comparable number in the two species, ranging from 20-22. Comparing the number of elastic laminae reported by different authors in the aortic segments in goats, we find larger or smaller differences from one author to another.

The number of elastic laminae identified by us in the Hircus goat is comparable to that identified by Awal *et al*. (1999), in black Bengal goats in the ascending aorta and aortic arch but different from that in the descending thoracic and abdominal aorta. It also differs from the number reported in the descending thoracic aorta in deccani sheep and bidri goats, 20-22 (Sharanagouda *et al*. 2016), whereas we identified 25-30.

The differences between species are significant and are primarily due to differences in body size and type of animal. Studying the elastic component in aortic segments in chinchillas, Martonos *et al*. (2019), found that the average number of lamellae is somewhat constant, being 18-19 in the ascending aorta, aortic arch and thoracic descending, while in the abdominal descending the average was 14 lamellae. Examining the mean of the chicken aorta, Mello *et al*. (2003), found an average number of 32.9 elastic lamellae, results close to those reported in pigeons where the mean was 25-30 lamellae for the thoracic portion. Studying the structure of the arteries in the guinea pig (*Cavia porcellus*), Awal *et al*. (2001), found that in this species, the average number of elastic lamellae in the tunica was 20-30 in the ascending aorta, 20-24 in the aortic arch, 10-15 in the thoracic aorta, 6-8 in the abdominal aorta. Similar results were obtained in guinea pigs by Mello *et al*. (2004), who identified 29.31 elastic lamellae in the ascending aorta, 15.53 elastic lamellae in the descending thoracic aorta and 7.87 lamellae in the descending abdominal aorta. The same authors studied the number of elastic lamellae in the rat aorta, where they identified in the ascending aorta 11 lamellae, in the descending thoracic aorta 8.78, and 7 in the descending abdominal aorta.

Comparing the segments of the aorta in the goats studied by us, we found a gradual decrease in the number of elastic lamellae concerning the position of each aortic segment relative to the heart so that the most lamellae were found in the middle of the ascending aorta and the fewest in the descending abdominal aorta. The number of lamellae is directly related to the blood pressure in the lumen of the aortic segments, which is highest in the ascending aorta and gradually decreases with each aortic segment. A more marked decrease in the number of elastic laminae was found in the rat where 29 were identified in the ascending aorta, 15 in the thoracic descending, and only 8 in the abdominal descending, and in the rat where 12 elastic laminae were found in the ascending aorta, 9 in the thoracic aorta and 7 in the abdominal aorta (Awal *et al*., 1995). A significant decrease was also found in the dog, which contains 30-40 elastic lamellae in the ascending and descending thoracic aorta and decreases to 15 in the descending abdominal aorta (Martonos *et al*., 2019). The authors state that the number of elastic laminae in the tunica media depends on the animal's size, the diameter of the artery, and the disposition of the arterial segment we refer to relative to the heart. The authors argue that the type of arterial wall does not depend on the size or diameter of the arteries but is related to the relative distance from the heart. The vessel closest to the heart has the most significant number of elastic lamellae and can withstand relatively high blood pressure (Awal *et al*., 1999). Other authors argue that the gradual decrease in elastic laminae is directly related to the stress given by blood pressure (Orsi *et al*., 2004). The blood propelled from the heart stresses the ascending aorta, then in the aortic arch and the proximal portion of the descending thoracic aorta. The structure of the walls of these aortic segments provides an elastic recoil that causes blood flow to become continuous and under significantly low pressure in the descending abdominal aorta (Orsi *et al*., 2004).

As a type of arteries, Raica *et al*. (2004), state that in humans, all segments of the aorta are classified as typical elastic arteries, while branches arising from the aorta (collaterals of the abdominal aorta, carotid, axillary, and common iliac arteries) are classified as transitional or mixed arteries that can only be done partially if we are referring to the possibility of using goats in experiments on vessels that can be extrapolated to humans. Even though the segments of the aorta of the goat are also classified as elastic arteries, not all are similar to those of humans. Thus, the ascending aorta, the aortic arch, and the descending abdominal aorta contain muscular islands in goats, whereas in humans, these are missing. Their presence alters hemodynamics in these segments in a way not seen in humans. The only aortic segment similar to that in humans is the descending abdominal aorta, which does not contain muscle islands in goats either. Considering these aspects, we consider that among the aortic segments of the goat, the only one suitable as a model for studying aortic disease in humans is the descending abdominal aorta. Being adapted to lower blood pressure than the anterior aortic segments, the abdominal descending aorta of the goat is structurally weaker than the thoracic aorta, making it more vulnerable (prone) to atherosclerosis and aneurysm formation than the thoracic descending (Ogeng'o *et al*., 2010). However, conditions such as penetrating atherosclerotic ulcers occur more frequently in the thoracic descending than in the abdominal descending (Cho *et al*., 2004).

## CONCLUSIONS

Due to the high content of elastic lamellae in the tunica media, the ascending aorta, the aortic arch, the descending thoracic aorta, and the descending abdominal aorta fall into the category of elastic arteries. The presence of muscular islands in the media of the first three segments leads us to call them particular elastic arteries so that the descending abdominal aorta is the only typical elastic artery in the goat. The mean number of elastic laminae in these arteries was 91.5 in the ascending aorta, 78.5 in the aortic arch, 66 in the thoracic descending aorta, and 31 in the abdominal descending aorta. The gradual decrease in the number of elastic laminae is due to the position of each arterial segment concerning the heart, in direct relation to the blood pressure, which is highest in the ascending aorta and decreases gradually with each segment as it moves away from the heart.

**CRET, C. R.; MICLAUS, V.; OANA, L.; DRAGOMIR, M. F.; OBER, C.; RATIU, C. & DAMIAN, A.** Evaluación de los componentes elásticos de la aorta en cabras (*Capra hircus*). *Int. J. Morphol., 42(4):*999-1004, 2024.

**RESUMEN:** Se recogieron muestras de cinco cabras (*Capra hircus*) de la aorta ascendente, el arco aórtico, la aorta torácica descendente y la aorta abdominal descendente. Estas muestras se procesaron histológicamente para revelar estructuras elásticas en sus capas. El número medio de laminillas elásticas descubiertas fue de 91,5 en la aorta ascendente, 78,5 en el arco aórtico, 66 en la aorta torácica descendente y 31,7 en la aorta abdominal descendente. Debido a que todas tienen en promedio una gran cantidad de láminas elásticas, caen en la categoría de arterias elásticas, pero no todas son arterias elásticas típicas. Así, la aorta ascendente, el arco aórtico y la aorta torácica descendente contienen, en promedio, además de tejido elástico, islas de músculos polimorfos, lo que las distingue de las arterias elásticas típicas, por lo que las llamamos arterias elásticas particulares. La aorta abdominal descendente no contiene tales islas, por lo que puede clasificarse como una arteria elástica típica. El segmento aórtico de cabra es el único comparable en estructura a las arterias elásticas de los humanos, por lo que sugerimos que es el único adecuado para estudiar la enfermedad aórtica en humanos.

**PALABRAS CLAVE: Aorta;** *Capra hircus*; **Cuchillas elásticas; Cabra.**

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