International Journal of Anatomy and Research,
Int J Anat Res 2016, Vol 4(4):3194-98. ISSN 2321-4287
DOI: http://dx.doi.org/10.16965/ijar.2016.437

Original Research Article

A COMPARATIVE STUDY ON THE STRUCTURE AND FUNCTIONS OF AORTA IN MAN AND RUMINANT ANIMALS

N. Shakuntala Rao *[1], K. Sujatha [2], K Meera [3], H.R. Krishna Rao [4].

*[1] Professor, Department of Anatomy, P.E.S. Institute of Medical Sciences and Research, Kuppam, Andhra Pradesh, India.

[2]Assistant Professor, Department of Anatomy, P.E.S. Institute of Medical Sciences and Research, Kuppam, Andhra Pradesh, India.

[3] Assistant Professor, Department of Anatomy, P.E.S. Institute of Medical Sciences and Research, Kuppam, Andhra Pradesh, India.

[4] Professor and Head, P.E.S. Institute of Medical Sciences and Research, Kuppam, Andhra Pradesh, India.

ABSTRACT

Background: In large elastic arteries the media has elastin fibres and collagen fibres to maintain pressure during the cardiac cycles of systole and diastole. The contracting heart stretches the elastin in their walls and after the ventricle finishes contraction and the valve is closed the walls of the elastic arteries contract passively to maintain pressure for the short interval between filling and contraction. In contrast to the function of elastic arteries that maintain pressure the muscular arteries or distributing arteries have the function of supplying blood to different parts of the body under varied conditions. Since the domestic animals have a different set of branches from the aorta as was observed by the authors in a previous study comparing them with human aorta this study was undertaken to study the differences in the histological differences in the aorta of man and domestic animals.

Materials and Methods: The heart specimens of the domestic animals were obtained from the local butcher who had legal permission to sacrifice the animals for sale. The heart was removed carefully along with the arch and its branches and processed for the histological observations with use of standard histological slide preparation.

Results: It was found that the section of the aorta taken at the origin had elastic fibres in the mediassthe brachiocephalic trunk had muscle fibres arranged in bundles between the elastic fibres and the part of aorta going posteriorly to form the descending aorta also had muscle bundles in the

Conclusion: The arrangement of muscle fibres in the anterior aorta which supplies the head,neck upper limbs could be significant. The function of aorta to maintain pressure during the cardiac cycle of systole and diastole is taken care of by the elastic fibres. The distributive function of supplying blood according to the needs of the parts of the head is probably served by the muscle bundles present. This could be due to the continuous adaptation of the animals to the environment for feeding and locomotion towards and against gravity.

KEY WORDS: Elastic arteries, Muscular arteries , Aorta, Windkessel vessels.

Address for Correspondence: Dr. N. Shakuntala Rao, Professor, P.E.S. Institute of Medical Sciences and Research, Kuppam, Andhra Pradesh 517425, India. **E-Mail:** drshakuntala@gmail.com

Access this Article online

Quick Response code	Web site: International Journal of Anatomy and Research ISSN 2321-4287 www.ijmhr.org/ijar.htm	
DOI: 10.16965/ijar.2016.437	Received: 12 Oct 2016 Peer Review: 12 Oct 2016 Revised: None	Accepted: 17 Nov 2016 Published (O): 31 Dec 2016 Published (P): 31 Dec 2016

INTRODUCTION

In large elastic arteries the media has a markedly layered structure. Fenestrated layers of elastin alternate with smooth muscle cells which lie between the elastin layers and collagen fibres. Thus each elastic lamella and adjacent interlamellar zone is called one lamellar unit of the media. The number of lamellar units at new birth is 40 and it increases with age reaching upto 52 lamellar units each about 11µm in thickness. The smooth muscle cells produce the elastin and collagenic fibres.

When the left ventricle contracts it sends spurts of blood into the aorta around 70 per minute.There is a high pressure generated during the contractions. The ventricle. relaxes between contractions and the pressure falls to zero in the arterial system. To maintain a pressure between contractions the arteries that arise from the ventricle directly are formed of layers of elastic laminae. The contracting heart stretches the elastin in their walls and after the ventricle finishes contraction and the valve is closed the walls of the elastic arteries contract passively to maintain pressure for the short interval between filling and contraction.

The windkessel vessels are arteries that have wide diameters (2 cm) and they consist of 3 coats, Tunica intima, media and adventitia.

Tunica intima is an internal single layer of epithelium called vascular endothelium in direct contact with blood. It is silky and smooth.Lamina propria: External to the endothelial layer lies the lamina propria made up of mainly elastic fibres and a few collagen fibres. External to the lamina propria is a layer of elastic fibres called fenestrated membrane. It is also called subendothelial region. Tunica media lies external to the fenestrated membrane. It is a thick coat consisting of smooth muscles and plenty of elastic fibres. Tunica adventitia contains collagen fibres external to the media.

The elastic fibres in the media produce what is called the windkessel effect during ventricular systole and diastole. .During ejection the blood is injected into the aorta, the elastic fibres stretch and thus make the blood flux more uniform and reduce the pressure change. During ventricular relaxation the pressure in the ventricles reduces but the arterial pressure is maintained due to the elastic rebound. The arterial pressure and blood velocity decrease and become less variable as the distance from the heart increases.

In contrast to the function of elastic arteries that maintain pressure the muscular arteries or distributing arteries have the function of supplying blood to different parts of the body under varied conditions. For this the arteries must be capable of regulating the size of their lumina. This will allow blood to be delivered in appropriate amounts at any given time. The walls contain circularly disposed smooth muscle fibres. These muscle fibres are spirally arranged and they respond to nerve impulses and regulate the size of the lumen of the artery thus regulating the flow of blood according to the needs of the parts.

The study was undertaken to study the differences in the histological differences in the aorta of man and domestic animals.

MATERIALS AND METHODS

The heart specimens of the domestic animals were obtained from the local butcher who had legal permission to sacrifice the animals for sale. The heart was removed carefully along with the arch and its branches. 10% formalin was used to transport and preserve the specimens in glass jars. Tissues of the aorta were taken from the arch, Brachiocephalic trunk and descending aorta and fixed and processed using conventional histo-technique methods. They were embedded in paraffin wax and blocks were formed. Sections were cut using a rotary microtome and mounted on glass slides for staining procedure. Routine hematoxylin and eosin stain was used and the sections were viewed under the light microscope.

RESULTS

The sections of the arch, brachiocephalic trunk (anterior aorta) and posterior (descending) aorta had a well developed adventitial layer and contained muscle bundles interspersed within elastic fibres. The wall of the posterior or descending aorta was wider and the media was proportionately wider compared to the anterior aorta or the brachiocephalic trunk. (Fig. 1, Fig. 2 and Fig. 3)

Fig. 1: Showing the adventitial layer and contained muscle bundles interspersed within elastic fibres.

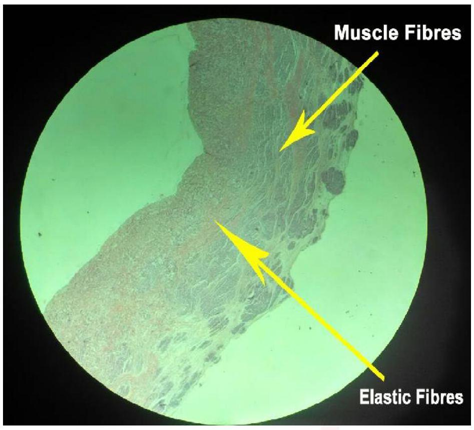


Fig. 2: Showing the adventitial layer and contained muscle bundles interspersed within elastic fibres.

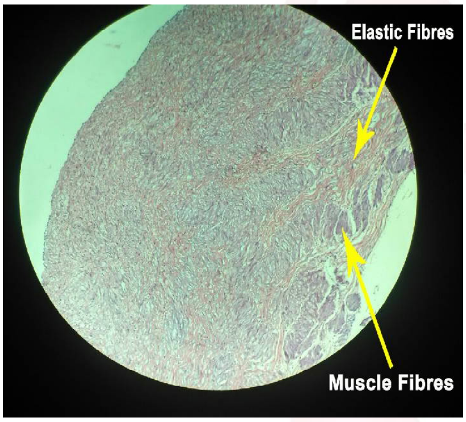
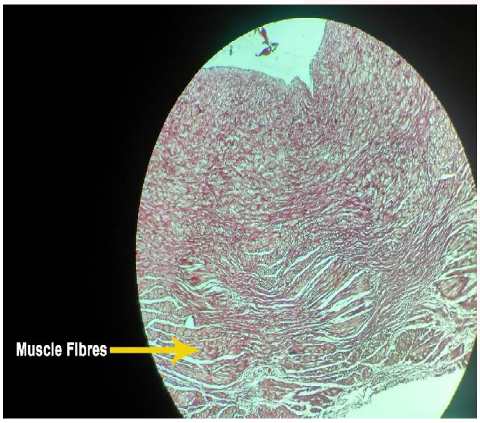


Fig. 3: Showing the adventitial layer and contained muscle bundles interspersed within elastic fibres.



DISCUSSION

In large elastic arteries the media has a markedly layered structure. Fenestrated layers of elastin alternate with smooth muscle cells which lie between the elastin layers and collagen fibres. Thus each elastic lamella and adjacent interlamellar zone is called one lamellar unit of the media. The number of lamellar units at new birth is 40 and it increases with age reaching upto 52 lamellar units each about 11µm in thickness. The smooth muscle cells produce the elastin and collagenic fibres [1].

The windkessel vessels are arteries that have wide diameters (2 cm) and they consist of 3 coats, Tunica intima, media and adventitia.The elastic fibres in the media produce what is called the windkessel effect during ventricular systole and diastole [2]. During ejection the blood is injected into the aorta, the elastic fibres stretch and thus make the blood flux more uniform and reduce the pressure change. During ventricular relaxation the pressure in the ventricles reduces but the arterial pressure is maintained due to the elastic rebound. The arterial pressure and blood velocity decrease and become less variable as the distance from the heart increases. In contrast to the function of elastic arteries that maintain pressure the muscular arteries or distributing arteries have the function of supplying blood to different parts of the body under varied conditions [3]. Since the domestic animals have a different set of branches from the aorta as was observed by the authors in a previous study comparing them with human aorta this study was undertaken to study the differences in the histological differences in the aorta of man and domestic animals.

A study by Julius A.Ogeng'o et al [4] described the tunica media of goat. They found that the tunica media comprised of concentric elastic lamellae. The lamellae of the adventitial side in the arch,ascending and descending portions they observed interlocked muscle nests which formed islands. Their additional finding was the presence of vasa vasora in the tunica media. They discussed that this feature correlates with an active vessel wall in regulating the amount of blood flow. The same is the finding in the present study that the muscle bundles present account for the numerous adaptive functions of the domestic animals to their environment. Harvey Wolinsky and Seymour Glagov [5] studied the lamellar units of mammalian aortic wall in 10 species. They found the interlamellar zones had fine elastin fibres which make up the interlamellar elastin net and circumferentially arranged smooth muscle cells. They discussed that the intimate association of elastin, with collagen fibresand smooth muscle cells gives the vessel wall high tensile strength andadequate distensibility. There is uniform distribution of stresses and viscoelastic responses are appropriate to pulsatile oscillations. The major factor for the viscoelastic response to pressure pulsation is probably the smooth muscle.

In a review study for arterial aneurysm models Rodrigo Argenta et al [6] found that the models that were available at the point of time of their study were not able to mimic all the features of the human aneurysms. They concluded that human disease cannot be mimicked precisely. In the present study the features present in the wall of the aorta was studied with an intention to discover if the vascular dynamics of man and animals are the same considering the difference in the posturing.

The presence of muscle bundles in the adventitia indicates a highly active aorta and that the smooth muscle cells.

Gibbons CA [7] et al compared the aorta from lower vertebrates with that of mammals. He concluded that the aorta is designed to suit the function of an elastic smooth component in the circulation. That the differences in pressure wave transmission characteristics in the two groups are not due to the dissimilar arterial walls but from the differences in the heart rate of the two groups was explained. The present study also has identified the differences in the walls of the aorta in man and ruminating animals (Fig1,2,3) and opines that the structure suits an active vascular wall dynamics.

In a previous study by the same authors the gross anatomy of the arch of aorta was compared with ruminating animals and some differences in the branching pattern were found. Such branching pattern similar to the one seen in cow,goat and sheep was not seen in man though some have termed it a bovine arch. K.F.Layton [8] argues that the use of the term bovine aortic arch in man is a misnomer and further clarifies that the aortic arch in ruminants does not resemble the arch in humans.According to the author when the left common carotid artery has a common origin with the origin of innominate artery it is described as a bovine aortic arch. A true bovine arch is one in which a single vessel originates from the aortic arch giving rise to right and left subclavian areteries and a common carotid trunk for the right and left carotid arteries.

The author has cited Habel RE, Budras KD [9] in his study for describing the true bovine arch.

In a study on the patterns of aortic arch in American white and Negro stocks by De Garis CF et al [10] 25% of blacks were found to have a common origin for innominate artery and left common carotid artery. The author has also reported an incidence of 10% in blacks where the left common carotid artery arises from the Innominate artery.

In all the specimens of the domestic animals like cow, goat, sheep it was observed that the arch was not as prominent as that in man. The arch was short and continuous with the vessel that was destined to supply the thorax and abdomen and was designated as the posterior aorta. The vessel to supply the head, neck, and limbs bifurcated from the aorta, and turned cranially to reach the various structures. What is notable here is that unlike in man where we have three different branches, in the animals we have one large trunk which gives off branches to the head and neck. This common trunk has been named by some authors the anterior aorta. Another feature to note is that the subclavian arteries are given off by the brachiocephalic trunk to the right and left limbs. In man only the right subclavian artery arises from the brachiocephalic trunk and the left subclavian artery arises directly from the arch of aorta. Both the carotids have again a common trunk in animals.

In a study by Christophe C et al [11] thoracic aorta and its branches were studied in mice they explained that the geometry of the branches of the murine aortic arch was similar to that of men and both these species had a sigmoidal curve of the first part of aorta comprising of ascending aorta,aortic arch and superior part of descending aorta. In both the ascending and descending aorta do not lie in a single vertical plane. Such an arrangement describes a non-planar aortic geometry. They concluded that this arrangement is in contrast to the planar aortic pattern in domestic mammals where the ascending and dscending aorta lie in a single vertical plane.

The studies describing the arch of aorta and its branches correlate with the histological structure of the vessels in that there is a need for a highly active elastic and distributive feature of the aorta in animals [8-11].

CONCLUSION

The arrangement of muscle fibres in the anterior aorta which supplies the head,neck upper limbs could be significant. The function of aorta to maintain pressure during the cardiac cycle of systole and diastole is taken care of by the elastic fibres. The distributive function of supplying blood according to the needs of the parts of the head is probably served by the muscle bundles present. This could be due to the continuous adaptation of the animals to the environment for feeding and locomotion towards and against gravity.

ACKNOWLEDGEMENTS

We are grateful to the department of pathology P.E.S Medical College for the assistance provided in making the slides for histological study. We are thankful to the faculty for providing their valuable opinions.

Conflicts of Interests: None

REFERENCES

[1]. Susan standring.The anatomical basis of clinical practice The cardiovascular and lymphatic systems. Elsevier Churchill Livingstone 2008; pp 137-38.

[2]. Arthur W.Ham, David H.Cormack. Histology The Circulatory system. J.B.Lippincott Company 8th Edition: pp 592-98

[3]. Sujit K.Chaudhuri . Concise Medical Physiology Vas cular System. NCBA 6 th edition 2007: pp214-215

[4]. Ogeng'O,J.A.;M.Mwachaka,P.M. & Olabu,B.O. Vasa vasora in the tunica media of goat aorta. Int.J.Morphol., 29(3):702-705,2011.

[5]. Harvey Wolinsky,M.D., and Seymour Glagov, M.D. ALamellar Unit of Aortic Medial Structure and Function in Mammals. Circulatory Research,Vol.XX, January 1967.

[6]. Rodrigo Argenta, Adamastor Humberto Pereira. Animal models of aortic aneurysm. J.vasc.bras.vol.8 no.2 Porto Alegre June 2009

[7]. Gibbons CA,Shadwick RE.Functional similarities in the mechanical design of the aorta in lower vertebrates and mammals. Experientia 1989 Dec 1;45(11-12):1083-8.

[8]. K.F.Layton, D.F. Kallmes, H.J Cloft, E.P.Lindell and V.S Cox. Bovine Aortic Arch Variant in Humans: Clarification of a Common Misnomer AJNR August 2006;27:1541-1542.

[9]. Habel RE,Budras KD. Thoracic cavity. In: Bovine Anatomy: An Illustrated Text. Hanover, Germany: Schlutersche GmbH & Co;2003:62-65.

[10]. De Garis CF, Black IB,Riemenschneider EA. Patterns of the aortic arch in American white and Negro stocks, with comparative notes on certain other mammals. J Anat 1933;67:599-618.

[11]. Christophe Casteleyn, Bram Trachet, Denis Van Loo and Daniel G H Devos. Validation of the murine aortic arch as a model to study human vascular diseases.J Anat.2010 May;216(5):563-571.

How to cite this article:

N. Shakuntala Rao, K. Sujatha, K Meera, H.R. Krishna Rao. A COMPARATIVE STUDY ON THE STRUCTURE AND FUNCTIONS OF AORTA IN MAN AND RUMINANT ANIMALS. Int J Anat Res 2016;4(4):3194-3198. **DOI:** 10.16965/ijar.2016.437