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Histomorphometric Study of the Aorta and Brachiocephalic Artery in Neonate and Adult Cat

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Knowledge of the structure of the aorta and brachiocephalic artery is important for properly functioning arteries. Morphometrical and histological studies were performed on 20 cats (10 adults and 10 neonates). After euthanizing, routine tissue processing was carried out by autotechnicon. The processed tissues were embedded in paraffin and sectioned serially into 5 μm thickness. The sections were stained with Masson's trichrome and orcein. Sections were measured with special digital microscope. In both ages, aorta and brachiocephalic artery were of elastic type and the number of elastic lamellae in the tunica media of aorta was more than brachiocephalic artery. In both arteries diameter of artery and thickness of tunica intima, media and adventitia were more in adult than neonate. In both ages the diameter of artery and thickness of tunica intima and media were more in aorta compared with brachiocephalic artery but tunica adventitia in brachiocephalic artery was thicker than in aorta.

Key words: Morphometric, aorta, brachiocephalic trunk, cat, adult, neonate

The aorta is the largest artery in the body and arises from the left ventricle of the heart. Most major arteries branch off from the aorta. The aorta gives off branches that go to the head and neck, the arms, the major organs in the chest and abdomen, and the legs. In its journey from the heart to the tissues, the blood passes through channels of six principal types: elastic arteries, muscular arteries, arterioles, capillaries, venules and veins. All arteries are comprised of three distinct layers, intima, media and adventitia, but the proportion and structure of each varies with the size and function of the particular artery (Eurell *et al*., 2006).

In cats arterial system starts with aorta that is the largest artery in the body. The initial part is known as the ascending aorta. It makes a U-turn dorsocaudally and to the left as the aortic arch. The remainder of the aorta, from the arch to the terminal iliac branches, is the descending aorta.

Brachiocephalic artery and left subclavian artery are two large vessels that branche off the aortic arch in cat.

The structure and morphometric study of arteries has interested researchers for a long time (Machida *et al*., 1988; Monnereau *et al*., 2005; Ocal *et al*., 1997; Parchami *et al*., 2009; Popescu *et al*., 2013; Rahmanifar *et al*., 2014; Szpinda M., 2007; Silver *et al*., 2003; Jyothirmayi *et al*., 2014).

Aorta and brachiocephalic artery are elastic artery with thick tunica media. In these arteries tunica media consists primarily of concentrically arranged, fenestrated elastic laminae. Elastin and elastin associated proteinare synthesized and secreted by vascular smooth muscle cells and are the major extracellular matrix

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component deposited in the vascular wall. Elastic fiber may be a key factor in the pathophysiology of hypertensive or atherosclerotic vascular remodeling (Wachi H, 2011). So, knowing the structure of these arteries is important and can be used in medicine.

In the United States, domestic cats are among the most widely used model organisms in comparative or mammalian anatomy courses, as well as in experimental research of both human and veterinary medicine. Such a popularity is due to cats exhibiting a rather unspecialized body plan that is very similar to that of the human (Fishbeck and Sebastiani, 2008), and specimens are also readily available and fairly inexpensive. Preserved specimens can be commercially purchased at relatively low costs and, despite limitations, used as substitutes for human dissection when human cadavers are unavailable or cost prohibitive (Waters *et al*., 2005).

In this study it was decided to compare, using morphometric techniques, the architecture of aorta and brachiocephalic artery in neonate and adult cat. There is little information regarding the morphometric variation in this group of animals.

MATERIALS AND METHODS

For this study 20 cats (10 adults and 10 neonates) clinically healthy, mixed breed, native adult male cats in two sexes were used. The chosen cats were normal size and between 3 and 4 years old. The aorta and brachiocephalic artery was dissected from cats that were euthanized with an overdose of thiopental sodium .At first, specimens were washed with normal saline to flush out remaining blood and then fixed in 10% formalin. After dehydration through graded alcohols, the samples were cleared in xylol and embedded in paraffin wax. Sections were cut at 5 µm serially and stained with Green Masson's Trichrom and orcein before examination. Sections were analyzed with a special digital microscope for measurement of sections.

By transferring the image from the microscope to the computer screen, by dino kilcher software, diameter of artery and thickness of the intimal plus medial layer and adventitial layer in each vessel in two ages were determined

Elastic lamellae were counted (40 slides for each arterial segment) by using higher

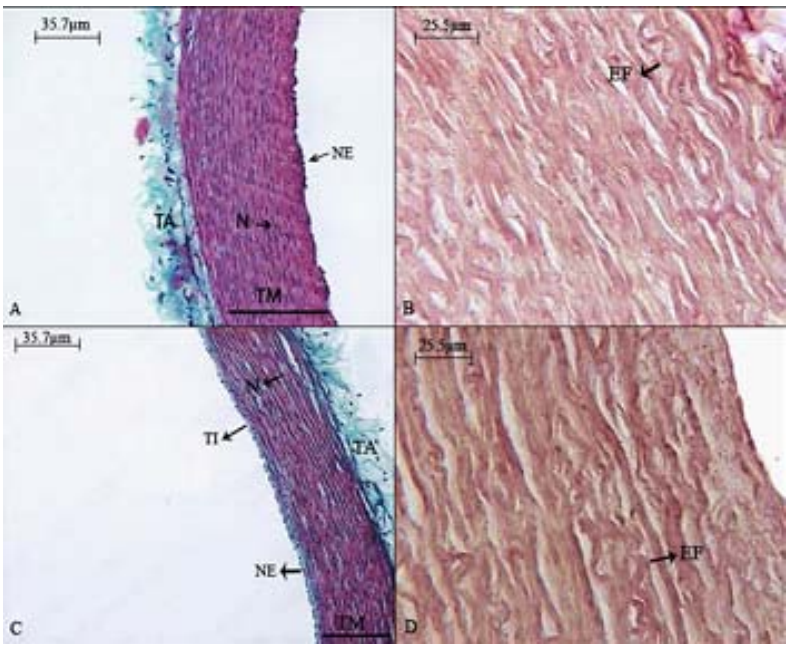

Fig. 1. Photomicrograph – Aorta in neonate cat with masson trichorom staine (A) and , orcein stane (B) and Brachiocephalic artery in neonate cat with masson trichorom stane (C) and orcein staine (D) (TI) Tunica Intima, (TM) Tunica Media, (TA) Tunica Adventitia, (NE) Endothelial cell nucleus, (EF) Elastic Fibers, (N) Smooth muscle cell nucleus.

magnification and from the enlarged microphotographs (Awal *et al*., 1995)

The means of histometric parameters for aorta and brachiocephalic artery were compared using the statistical method Student's t test (SPSS version 16.0). The means of histometric parameters of arteries on different ages were compared between groups using one-way analysis of variance. Differences were considered significant for $P \leq 0.05$.

RESULTS AND DISCUSSION

Histological results are shown in Figs. 1 and 2.The histological studies of the arterial specimens showed that there are three layers consist of tunica intima, tunica media and tunica adventitia in the arterial structure. The tunica intima of aorta and brachiocephalic artery in both ages made up of one layer of endothelial cells are in direct contact with the blood flow. Subendothelial layer as a thin layer of connective tissue was observed under the endothelium in the intima. The internal elastic lamina was absent.

In all specimens the tunica media was the thickest of the three layers. In both ages the tunica media of aorta and brachiocephalic artery had the highest percentage of arterial wall, extending between the tunica intima and media (fig 3, 4). It was composed of concentric elastic lamellae separated by layer of concentrically-arranged smooth muscle cells and collagen fibers. The number of lamellae increased with age and more in aorta than in brachiocephalic artery. The number of elastic lamellae in the tunica media of neonate cat aorta was 20, in adult cat aorta 29, in neonate cat brachiocephalic artery 14, in adult cat brachiocephalic artery 21, respectively. As we proceed away from the heart gradually muscularity of an artery increases and elasticity decreases (Kumar K, 2001) so it is acceptable for the number of elastic lamellae to be more in aorta compared with brachiocephalic artery. The clear external elastic membrane didn't observe in all specimens.

The thin tunica externa was the outermost tunica and composed of collagen fibers and smooth muscle cells.

These structures showed that in two ages, aorta and brachiocephalic artery with a large number of elastic lamellae are as elastic artery. This finding is similar to the arterial segments from the ascending aorta to thoracic aorta in miniature swine

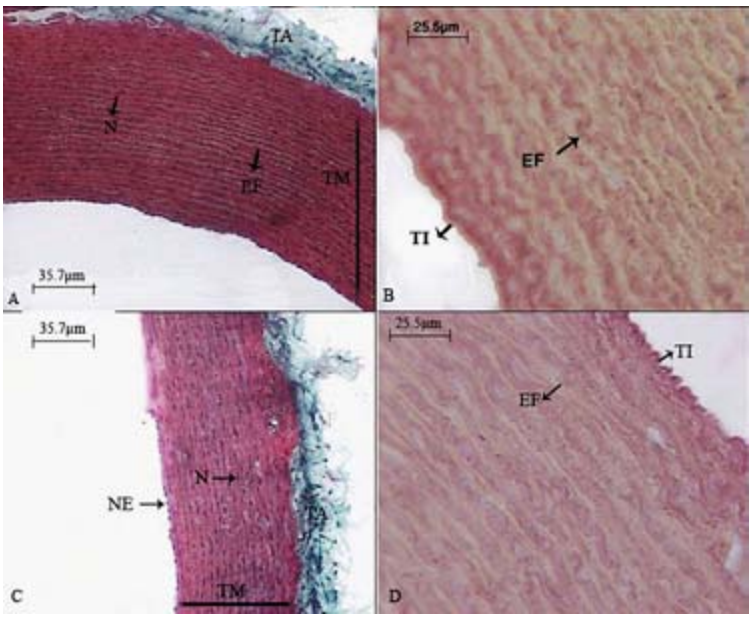

Fig. 2. Photomicrograph – Aorta in adult cat with masson trichorom staine (A) and , orcein stane (B) and Brachiocephalic artery in adult cat with masson trichorom stane (C) and orcein staine (D) (TI) Tunica Intima, (TM) Tunica Media, (TA) Tunica Adventitia, (NE) Endothelial cell nucleus, (EF) Elastic Fibers, (N) Smooth muscle cell nucleus.

(Tanigawat *et al*., 1985), and black Bengal goats(AWAL *et al*., 1999) and the arterial segments from ascending aorta to the abdominal aorta in Wistar rats (AWAL *et al*., 1995) that were recognized as elastic type.

Morphometric observations of the diameter of artery and thickness of tunica intima, tunica media, tunica adventitia of aorta and brachiocephalic artery in neonate and adult cat demonstrated that the diameter of the artery and thickness of the tunica intima, tunica media and tunica adventitia increase from neonate towards the adult in the aorta and brachiocephalic artery (Table 1). There was a significant difference in the diameter of the artery and thickness of the tunica media and tunica adventitia between the neonate and adult (P≤0.05). According to the morphometric study we found that the diameter of artery and thickness of layers increase from neonate towards adult. Several studies have been performed on increasing of arterial wall with grow (Borovic *et al*., 2013 Popescu *et al*., 2013). The increased thickness of layers and artery in adult compared with neonate perhaps relate to the increasing of food needs and blood volume in adult compared with neonate. Also with growth the organs and blood vessel evolve (Guyton and Hall, 2000).

In neonate and adult cat the diameter of artery and thickness of tunica intima and media were more in aorta compared with brachiocephalic artery and these differences between tunica media were statistically significant (P≤0.05). But tunica adventitia in brachiocephalic artery was thicker than in aorta and these differences in adult were statistically significant (P≤0.05) (table 2). Wall thickness of an artery is directly proportional to pulsatory power of that artery. Arterial segments having equal length and equal pulsatory power have equal number of smooth muscle fibres in their tunica media (Kumar K, 2002). We know that during

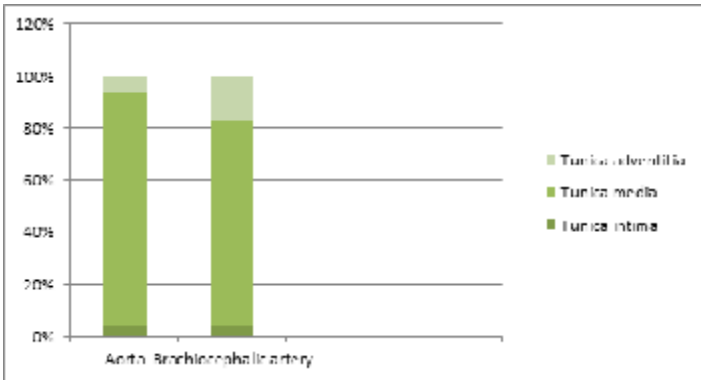

Fig. 3. Comparison of the percentage of the intima, media, and the adventitia as compared with the total wall thickness in aorta and brachiocephalic artery in neonate cat

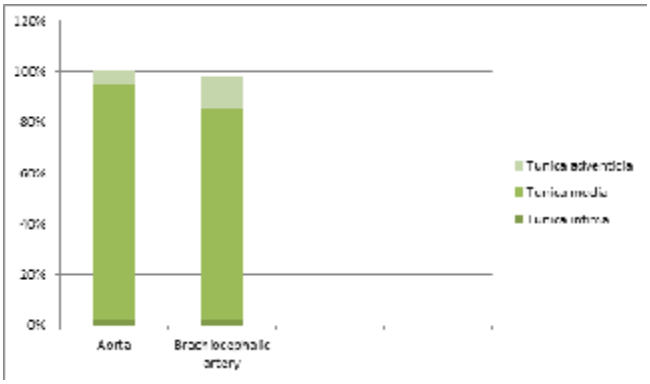

Fig. 4. Comparison of the percentage of the intima, media, and the adventitia as compared with the total wall thickness in aorta and brachiocephalic artery in adult cat

Table 1. Comparison of mean±standard deviation of diameter of artery and thickness of different layers of neonate and adult cat in two arteries

Type	Age	Diameter of artery	Tunica intima	Tunica media	Tunica adventitia
aorta	neonate	157.01± 13.57*	. 0.58± 0.31*	15.86± 3.00*	1.15± 0.35*
	adult	170.45± 18.32*	0.65± 0.40*	24.28± 4.28*	1.28± 18.32*
Brachioccephalic artery	neonate	126.96± 13.23*	0.51± 0.13*	10.43± 2.18*	.21± 0.54*
	adult	167.96± 18.163*	0.60± 0.38*	19.83± 3.33*	.17± 1.02*

* statistically significant difference between both ages (P<0.05).

Table 2. Comparison of mean±standard deviation of diameter of artery and thickness of different layers of the aorta and brachiocephalic artery in two ages

Age	Type	Diameter of aorta	Tunica intima	Tunica media	Tunica adventitia
Neonate	Aorta	157.01± 13.57*	0.58±0.31	15.86± 3.00*	1.15± 0.35
	Brachiocephalic artery	126.96±13.23*	0.51± 0.13	10.43 ± 2.18*	2.21± 0.54
Adult	Aorta	170.45± 18.32	0.65± 0.40	24.28±4.28*	1.28±18.32*
	Brachiocephalic artery	167.96± 18.16	0.60± 0.38	19.83± 3.33*	3.17± 1.02*

* statistically significant difference between both arteries (P<0.05).

systole the blood enters the large elastic arteries with considerable force and that these arteries distend. They are able to do so because of the large amount of elastic tissue in their walls. During diastole the arteries return to their original size because of the elastic recoil of the walls. The flow of blood to the organ is controlled by the contraction or relaxation of the smooth muscle cells of the tunica media (Junqueira *et al*., 2005).Elasticity of an artery depends upon the density of elastic fibres in its tunica media and muscularity of an artery depends upon the density of smooth muscle fibres in its tunica media. Proceeding towards the heart gradually elasticity of an artery increases and muscularity decreases. So as we proceed away from the heart gradually muscularity of an artery increases and elasticity decreases (Kumar K, 2001). These findings are well in agreement with our reports. The tunica media in aorta consisted of more elastic lamellae and was thicker compared with brachiocephalic artery, and this is related to the pulse pressure and proximity of this part of the heart.

CONCLUSION

In this study it was observed that in both ages, aorta and brachiocephalic artery were elastic artery and the number of elastic lamellae in the tunica media of aorta was more than in that of brachiocephalic artery. Tunica media formed the highest percentage of arterial wall. In both arteries diameter of artery and thickness of tunica intima, media and adventitia were more in adult than neonate. In neonate and adult cat the diameter of artery and thickness of tunica intima and media were more in aorta compared with brachiocephalic artery but tunica adventitia in brachiocephalic artery was thicker than in aorta.

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