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The transitional zone of the renal artery in cats

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Summary

The length and structure of the transitional zone in the tunica media in the renal artery of adult male cats were investigated. In addition, the volume of the lumen and different layers in transitional and non-transitional zones in the right and left sides were also determined. Morphometrical, histological and stereological studies were performed on 16 renal arteries of 8 adult male cats. After perfusion and morphometrical measurement, 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 haematoxylin and eosin and orcein. In the morphometrical measurement, the right renal arteries were longer than the left ones with a mean value of 22.0 ± 0.2 and 18.8 ± 0.1 mm, respectively. Despite the fact that the right renal artery is commonly longer, the length of transitional zone was 7 mm in both renal arteries of adult male cats. The artery has a structure between muscular and elastic type at its origin with several elastic layers in the tunica media which is gradually changed to a muscular type at the distal section after 7 mm from origin of aorta. Transitional zone has an arrangement of parallel elastic fibers which become rare and fragmented towards the non-transitional zone. The volume of tunica intima, tunica media, tunica adventitia and lumen of the artery decrease from transitional zone towards the non-transitional zone and the volume of these areas in both transitional and non-transitional zones in the right renal artery is more than the left one. The volume of the lumen in transitional zone differs significantly compared to non-transitional zone, in both sides ($P<0.05$). Also there is a significant difference in the volume of the lumen in non-transitional zone between right and left renal arteries ($P<0.05$).

Key words: Histology, Stereology, Transitional zone, Renal artery, Cat

Introduction

The main function of the arterial system is to distribute blood from the heart to the capillary throughout the body (Janzen *et al*., 2001). Elastic arteries including the aorta and the common carotid arteries have an important function during the diastole to maintain the arterial forward flow (Janzen *et al*., 2000). The transition from elastic to muscular arteries is not abrupt (Inderbir and Jaypee, 2002). Renal arteries are branch of abdominal aorta and classified as muscular type arteries. The microscopic transitional zone is a segment of arterial tree where the elastic-type wall architecture is relayed by one of the muscular types (Janzen, 2004). It has been studied that in human, the transitional zone in the carotid tripod was localized only in the post-bifurcational segments (Janzen *et al*., 2000), and the length has been demonstrated in the internal and external carotid and renal arteries (Janzen *et al*., 2000, 2001).

In 1978, the transitional structure in proximal renal artery has been reported in rat (Osborn-Pellegrin, 1978). Ball *et al*. (1963) reported that there was different ratio of smooth muscle cells along the media in the visceral branch of the aorta. Roach (1987) showed that the histological structure of the proximal and distal lips of the abdominal aortobranch junction was quite different, and running the bundles of elastin along the branch of aorta have been observed (Baardwijk *et al*., 1985).

Aortic wall thickness, cross-sectional area of aortic media and total number of vascular smooth muscle cells were determined by unbiased stereological technique in nephrectomized rats (Amann *et al*., 1997) and the volume relationship between the smooth muscle cells and their nucleus was determined in elastic and muscular type arteries in dogs by this method (Levicky and Dolezel, 1980). Osborn-Pellegrin (1978) demonstrated the cell surface and cell volume in the aorta and renal artery.

The aim of the present study was to determine and demonstrate the length and structure of the transitional zone in the renal arteries in adult cat. The volume of the tunica intima, tunica media, tunica adventitia and lumen were determined in transitional zone and compared with those in non-transitional zone of the right and left renal arteries.

Materials and Methods

In this study, 16 renal arteries were obtained from 8 clinically healthy adult male cats after vascular perfusion.

Our study was performed by morphometrical, histological and stereological methods. In morphometrical measurement, the length of renal artery was defined from abdominal aorta up to the hilus of the kidney with ruler. For histological studies, both renal arteries from 8 adult cats were examined. The renal arteries were separated from the perfused animals with 10% buffered formalin solution. The fixed specimens were dehydrated in a graded series of alcohol, cleared in xylol, embedded in paraffin and each specimen was serially sectioned at 5 μm thickness. Sections were mounted carefully and were stained with haematoxylin and eosin and orcein (Luna, 1968). Histological studies were carried out using light microscope. Serial sections were taken from the origin to the end of the renal artery at the hilus of the kidney and the number of sections with transitional structure was counted. Considering the thickness of the sections, the length of the transitional zone was defined.

Stereological studies on the serial sections were carried out using Bausch and Lomb microscope and volume of lumen, tunica intima, tunica media and tunica adventitia were determined using Cavalieri method and point counting method (Haward and Reed, 1998). For this study, each specimen was serially sectioned with a distance T $(T = \frac{\text{length of specimen}}{10})$ and ten sections were collected from each specimen with 5 μm thickness and sections were stained with orcein. The volume of lumen and different layers were demonstrated by:

$$V = \frac{\sum P.a\,(P).T}{m^2} \quad \text{and} \quad a\,(P) = \Delta X.\Delta Y$$

∑P: A number of points landing within the lumen and different layers
T: Distance between sections
m: Magnification
a(P): Area associated with each point
ΔX: Width between points
ΔY: Length between points

All data were finally analysed by paired Student's t-test, using SPSS software and compared with each other.

Results

The length of the right and left renal arteries in adult cat varied from 20 to 25 mm and 17 to 20 mm with mean values of 22.0 ± 0.2 and 18.8 ± 0.1 mm, respectively.

The histological studies of the arterial specimens showed that the length of transitional zone is 7 mm in the right and left renal arteries.

Histological results are shown in Figs. 1 to 3. It is obvious that the artery has a structure between muscular and elastic at its origin with the presence of several elastic fibers in the tunica media which change gradually to a muscular type at the distal section after 7 mm from origin of aorta. In transitional zone, tunica media has an arrangement of parallel elastic fibers at its origin (Fig. 1). These fibers decreased and become fragmented from transitional zone towards the non-transitional zone (Fig. 2). In contrast to the transitional zone, the non-transitional zone has a typical morphologic feature of muscular artery (Fig. 3).

The stereological results for both zones are demonstrated in Figs. 4 to 7. It can be

seen that the volume of the lumen, tunica intima, tunica media and the tunica adventitia decreased from transitional zone towards the non-transitional zone in the right and left renal arteries (Figs. 4 and 5).

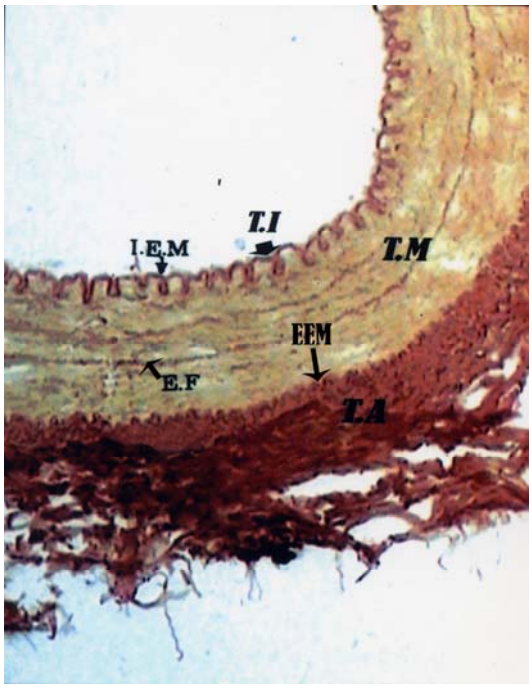

Fig. 1: Photomicrograph of the origin of transitional zone showing parallel elastic fibers in the tunica media of renal artery in adult male cat. Tunica intima (TI), tunica media (TM), tunica adventitia (TA), internal elastic membrane (IEM), elastic fibers (EF) and external elastic membrane (EEM), (Orcein stain, ×200)

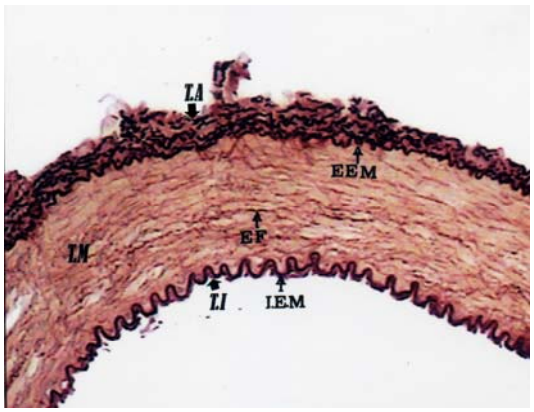

Fig. 2: Photomicrograph of the end of transitional zone showing fragments of elastic fibers in the tunica media. Tunica intima (TI), tunica media (TM), tunica adventitia (TA), internal elastic membrane (IEM), elastic fibers (EF) and external elastic membrane (EEM), (Orcein stain, ×200)

The volumes of the lumen in transitional zone in the right and left renal arteries were 94.4 ± 24.4 and 66.1 ± 19.0 μm^3, respectively which were higher than those for the non-transitional zone (i.e., 78.4 ±

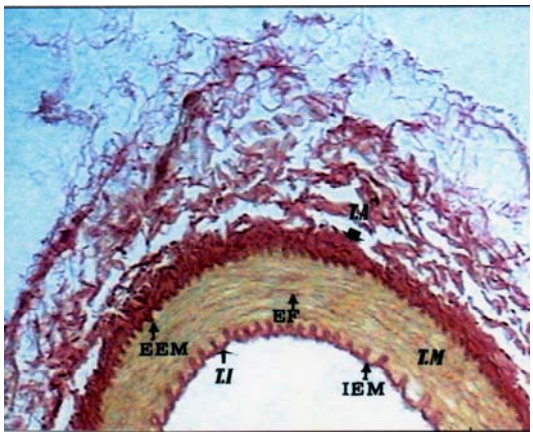

Fig. 3: Photomicrograph of non-transitional zone. Typical aspect of a muscular artery. Tunica intima (TI), tunica media (TM), tunica adventitia (TA), internal elastic membrane (IEM), external elastic membrane (EEM) and elastic fibers (EF), (Orcein stain, ×200)

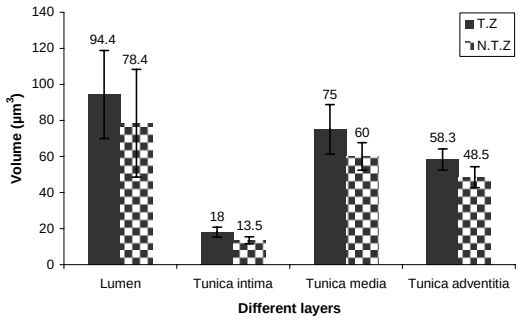

Fig. 4: Comparison of the mean volume and standard error of lumen and different layers of transitional zone and non-transitional zone in the right renal artery in adult male cat

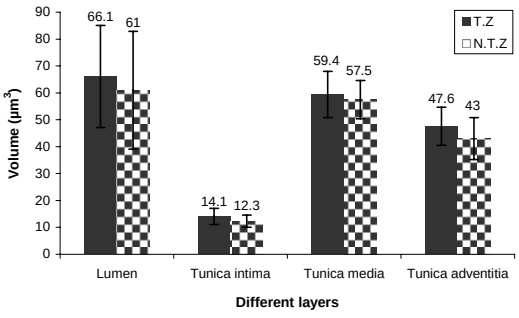

Fig. 5: Comparison of the mean volume and standard error of lumen and different layers of transitional zone and non-transitional zone in the left renal artery in adult male cat

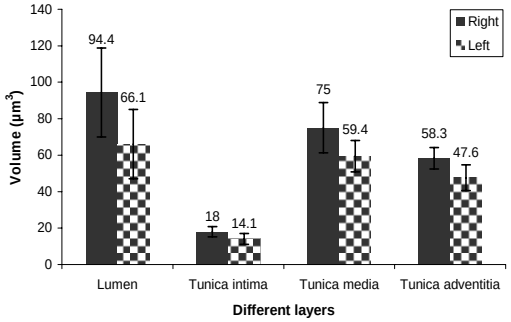

Fig. 6: Comparison of the mean volume and standard error of lumen and different layers of transitional zone in the right and left renal arteries in adult male cat

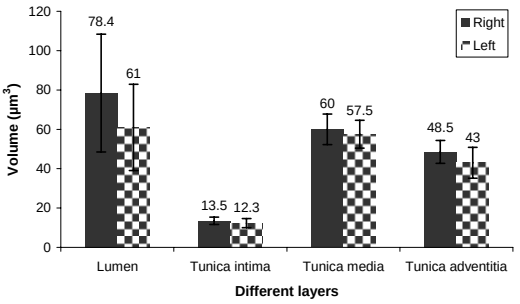

Fig. 7: Comparison of the mean volume and standard error of lumen and different layers of non-transitional zone in the right and left renal arteries in adult male cat

29.9 and 61.0 ± 21.9 μm^3 for the right and left arteries, respectively) with $p<0.05$.

Comparison of the volumes in both zones reveals an increase in the right side (Figs. 6 and 7).

However, a significant difference in volume of different parts in the right renal artery was not observed compared to the left one in both zones, except for lumen in non-transitional zone on the right side which had a significant difference compared to the left side with $p<0.05$.

Discussion

The results of the present study indicate that the right renal arteries are longer than the left ones and the average length of the transitional zone is 7 mm in both sides. A microscopic transitional zone in renal and carotid arteries in human has been described and the average length of transitional zone has been reported 10 mm in the renal arteries and between 5 and more than 20 mm in internal and external carotid arteries (Janzen *et al*., 2000, 2001).

The results show that renal artery in the origin of abdominal aorta, has an arrangement of parallel elastic fibers and distal to the origin, elastic fibers become fragmented and are gradually replaced by smooth muscle cells. In non-transitional zone a typical muscular morphology is present in each side. However, rare remnants of elastic fibers are found in this region between the smooth muscle cells. In the previous studies, running the bundle of elastin from the aorta to its branches has been reported. Light microscopic studies showed differences in the elastic pattern on the proximal and distal lips of the aorto-branch junction in sheep and dogs (Roach, 1987) and it has been established that the bundles of elastin appeared to be continuous from the aorta into its branches in sheep and lambs (Baardwijk *et al*., 1985). The proximal renal artery shows structural characteristics which are intermediate between those of the aorta and distal renal artery (Osborn-Pellegrin, 1978).

These studies are in accordance with the finding of Janzen (2004) who reported that in renal and carotid arteries transitional zone exist and the transition from elastic artery to muscular artery is gradual.

During relaxation phase (diastole), elastic rebound of large arteries helps to maintain arterial pressure, and affluence of blood to the organ to be controlled by contracting or relaxing the smooth muscle cells of the tunica media (Fourman and Moffat, 1971; Junqueira *et al*., 2003). Existence of more elastic fibers at the proximal part of renal artery compare to the distal part of renal artery and replacing of elastic fibers by smooth muscle cells at the distal part of renal artery can be normal. This irregularity between elastic fibers and smooth muscle cells from proximal to the distal part of renal artery can be important in vascular disease.

It was observed that the volume of the lumen, tunica intima, tunica media and tunica adventitia of the artery decreased in transitional compared to non-transitional zones and from left to right renal arteries. This is due to the fact that the size of artery from elastic to muscular type is decreased

and therefore the volume of artery decreases from transitional to the non-transitional zones.

Aortic wall thickness, cross-sectional area of aortic media and total number of vascular smooth muscle cells were determined by unbiased stereological technique in nephrectomized rats by Amann *et al*. (1997) and they observed that all these variables increased after subtotal nephrectomy. The relationship between the volume of smooth muscle cells and its nucleus in elastic and muscular type arteries was determined in dog by a stereological point counting method by Levicky and Dolezel (1980). These authors stated that relative elastic tissue volume fell from the aorta towards the peripheral arteries, from 22.6% in the ascending aorta to 4.6% in the smallest arteries. Osborn-Pellegrin (1978) by stereological method, demonstrated that in the rat, there was an average of 2.7 μm^2 of cell surface for 1 μm^3 of cell volume in the aorta compared to 1.6 $\mu m^2/\mu m^3$ in the renal artery.

The clinical implications of the transitional zone and its length have not yet been fully understood. It is possible that an abnormal length of arterial transitional zone could be associated with clinical syndromes of some diseases as kinking, coiling and megadolicho arteries (Janzen, 2004). Changing histological architecture within the transitional zone may be responsible for a mechanical mismatch related to atherogenesis (Janzen *et al*., 2000).

Arterial transitional zone are often sites of atherosclerosis and non-atherosclerosis lesion (Janzen, 2004). Atherosclerotic lesions are characterized by focal thickening of the intima and media (Junqueira *et al*., 2003). Atherosclerotic plaque occurs at discrete locations in the arterial system and involves the proliferation of smooth muscle cells together with imbalance of the extra cellular matrix elements and elastic fiber in particular. Elastin is a critical regulatory molecule that regulates the phenotypic modulation, proliferation and migration of smooth muscle cells. The relationship between cell proliferation and elastin expression may be changed in atherosclerosis (Seyama and Wachi, 2004). The carotid bifurcation and internal carotid artery are predilection sites for atherosclerosis (Mackinnon *et al*., 2004) and the transitional zone in the medial structure of carotid artery tripods is exclusively located in the internal and external carotid arteries not in the common carotid artery (Janzen *et al*., 2000). In conclusion, we confirm that in the renal artery a transitional zone, an arterial segment with transition from elastic to muscular type, does exist with 7 mm length. The volume of different parts of artery decreases from transitional zone to non-transitional zone and the volumes of these parts in the right renal artery are more than the left one. The involvement of special structures in atherosclerosis is suggested.

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