Age-related Morphologic Changes in Human Renal Arteries and Their Influence on Mechanical Behavior

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INTRODUCTION: The geometry and morphology of the arterial wall change with age. Age related changes in the relative amounts and variations in the structure of the load bearing components of the arterial wall (elastin fibers, collagen fibers, smooth muscle cells (SMC)), likely lead to changes in the arterial wall's mechanical properties. The objective of this study was to examine the age-related morphologic changes and to examine their influence on mechanical behavior in human renal arteries.

METHODS: Human renal arteries (age range of 2 to 86 years) were harvested during routine autopsy and stored at 4°C in L-15 solution. Arteries with obvious cardiovascular diseases were excluded. Specimens were divided into five age groups: 0~15, 16~30, 31~45, 46~60, and 60 years over. Loose surrounding tissue was removed. Part of each artery was prepared for mechanical testing (previously reported [1]) and a section of each specimen that was tested was prepared for histological examination. Each specimen was placed in a chemical fixative (4% formaldehyde 1% gluteraldehyde) for at least 24 hours to ensure complete fixation prior to further micro-structural analysis. All specimens were subjected to standard histology preparation: paraffin wax embedding, sectioning and staining. Three histology slides, with the wall cross-section exposed, were prepared for each specimen: one slide was stained with Hematoxylin and Eosin (H&E) stain to identify SMC, one with elastin stain to identify elastin fibers, and one with Trichrome stain to identify collagen fibers. Tissues were examined under a microscope and digital images were made at several locations (at least 12) for each slide. The relative content of elastin, collagen fibers and SMC in each layer for the five age groups was determined using morphometric analysis and expressed as mean ± standard deviation. Differences between age groups were assessed with the Student's t test, with a significance level of $p<0.05$

RESULTS AND DISCUSSION: The morphology of the arterial wall changed with age. The average number of SMCs decreased with age until 60 years old and then remained fairly constant (Figure 1). The collagen/elastin ratio was fairly constant up to 30 years old, and then increased (Figure 2). Other researchers also reported the decrease of SMC and increase of collagen/elastin ratio with the increase of age [2]. In the arterial wall of adolescents and young adults, elastin and collagen fibers were still developing and being deposited. After 30 years old, elastin fibers were no longer developed and started to degrade and fragment; the relative amount of elastin fibers decreased. The deposition of collagen fibers continued and the relative amount of collagen fibers increased. Thus, the collagen/elastin ratio increased with age. The variation of fiber content with age led to the change of mechanical behaviors. For specimens up to 30 years old, mechanical properties (e.g., stiffness) were not significantly different [1]. However, the increase of the collagen/elastin ratio after 30 years old caused increase of stiffness and loss of extensibility in the arterial wall. Moreover, the aging progress was different for each layer. In the media, the collagen/elastin ratio decreased slightly to the 15~30 yr group, and then increased (Figure 3). In the adventitia, the average collagen/elastin ratio was fairly constant up to 45 years old and then increased gradually with age. Aging affected the media more than the adventitia. Further study is necessary to understand the effects of different morphology change on mechanical behavior for each layer due to aging.

REFERENCES: [1] Yuan, Y, Topoleski, LDT, Mergner, WJ, Li, L, Trans 31st SFB, p.389, 2005.
[2] Humphrey, JD, Mechanics of the Arterial Wall: Review and Directions, Crit Rev Biomed Engg, **23(1-2)**:1-162, 1995.

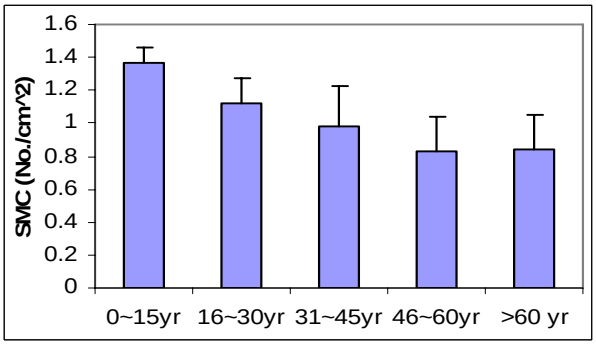

Figure 1: The concentration of SMC in the media.

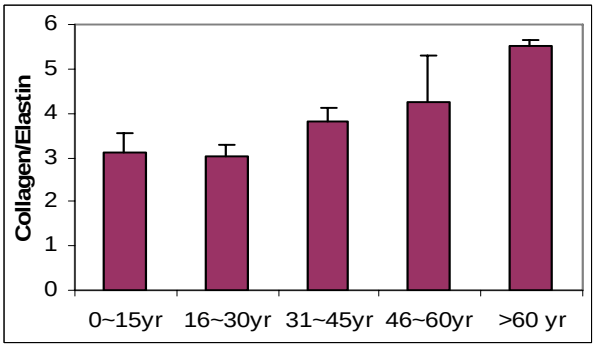

Figure 2: The collagen/elastin ratio in the arterial wall.

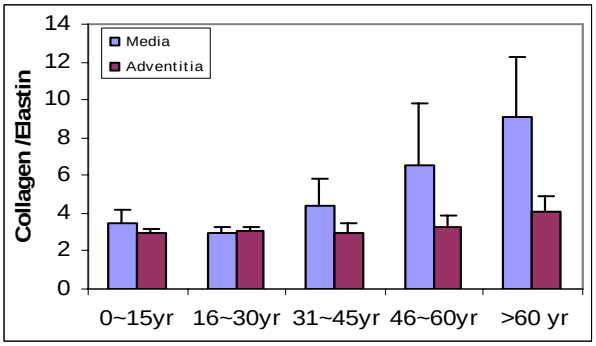

Figure 3: The collagen/elastin ratio in each layer.