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Mechanical Characterization and Constitutive Modeling of Rabbit Aortas in Health and Diabetes

Zhi Zhang[1] and Jianhua Tong[1, *]

Abstract: Diabetes is a major risk factor to cause macrovascular diseases and plays a pivotal role in aortic wall remodeling. However, the effects of diabetes on elastic properties of aortas remain largely unknown. Thirty adult rabbits (1.6-2.2 kg) were collected and the type I diabetic rabbit model was induced by injection of alloxan. A total of 15 control and 15 diabetic rabbit (abdominal) aortas were harvested. Uniaxial and biaxial tensile tests were performed to measure ultimate tensile strength and to characterize biaxial mechanical behaviors of the aortas. A material model was fitted to the biaxial experimental data to obtain constitutive parameters. Histological and mass fraction analyses were performed to investigate the underlying microstructure and dry weight percentages of elastin and collagen in the control and the diabetic aortas. No statistically significant difference was found in ultimate tensile strength between the control and the diabetic aortas. Regarding biaxial mechanical responses, the diabetic aortas exhibited significantly lower extensibility and significantly higher tissue stiffness than the control aortas. Notably, tissue stiffening occurred in both circumferential and axial directions for the diabetic aortas; however, mechanical anisotropy does not change significantly. The material model was able to fit biaxial experimental data very well. Histology showed that a number of isolated foam cells were embedded in the diabetic aortas and hyperplasia of collagen was identified. The dry weight percentages of collagen within the diabetic aortas increased significantly as compared to the control aortas, whereas no significant change was found for that of elastin. The results suggest that the diabetes impairs elastic properties and alters microstructure of the aortas and consequently, these changes may further contribute to complex aortic wall remodeling.

Keywords: Diabetic aorta, biomechanical behavior, constitutive modeling, microstructure.

[1] Institute for Biomedical Engineering and Nano Science, Tongji University School of Medicine, Shanghai, 200092, China.

[*] Corresponding Author: Jianhua Tong. Email: tongjh@tongji.edu.cn.