

Hyperelastic Behavior of Porcine Aorta under Sub-Failure Inflation Loading

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ABSTRACT

While traumatic aortic rupture (TAR) continues to be a major cause of fatality in motor vehicle accidents, the underlying mechanisms of it are not well understood. A major step to gain an insight into this problem is to understand the mechanical behavior of aortic tissue under loading conditions that lead to the failure. Although the mechanical properties of blood vessels under physiological pressure and quasi-static or cyclic loading has been investigated and modeled by many researchers, it is not clear whether these models are capable of predicting the behavior of tissue under loading conditions that occur in automotive crashes. The goal of this study was two-folds. First we looked at the material properties of aorta under quasi-static sub-failure loading and then we investigated the effect of sinusoidal and impulse loading and determined the rate dependency of the material behavior. To this end, samples of porcine aorta were obtained and assembled in a custom-made inflation-extension test setup capable of generating pressures up to 70 kPa. Samples inner pressure were recorded with 2 fiber optic pressure sensors. The 3D deformation of aorta from 4 angles was captured using 2 high speed cameras and a front face mirror. Aorta was assumed to be an anisotropic thick-walled cylinder with a Fung-type exponential hyperelastic strain energy density function W and the material parameters were derived from least-square optimization, taking the convexity requirement of W into account. Comparing the results of this study with previously reported material parameters for physiological conditions suggests that the terms with individual normal strain components have a higher contribution in W . The oscillatory and impulse experiments showed the material was significantly stiffer in dynamic loading conditions leading to traumatic failure. The material rate dependency is described using a quasi-linear viscoelastic model.