A Building Block for a Structural Artery Model: Application for Patient-Specific Computational Modeling of Aortic Dissection

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More than two decades ago, we published a constitutive framework for arterial wall mechanics that served as a building block for a structural model formulated in the context of fiber-reinforced composites [1]. It has served as a basis for mechanical analysis of various types of biological materials, including arteries in health and disease, myocardium, heart valves, corneas, lens capsules, ligaments, temporomandibular joint disc, cartilage, intervertebral discs, etc. The basic building block for a structural model is also used to describe mechanical responses, e.g., of engineered materials such as textile composites and anisotropic hyperelastic solids in general. Since we know that several soft biological tissues have distributed collagen fiber orientations, we extended our model with two additional scalar structural parameters that characterize the non-symmetrically dispersed collagen fiber orientation [2].

This lecture will very briefly summarize the development of a building block over the last two decades and focus on the challenges of modeling fibrous soft tissues such as artery walls, e.g., aortic dissections. The morphology and structure of cardiovascular tissues in health and disease is explained. In particular, a patient-specific computer model of aortic dissection including fluid-structure interaction will be demonstrated, which enables the system behavior to be better understood and analyzed based on specific parameter changes [3]. We have several needs and challenges for the next decade. For example, computational modeling must take into account the microstructure, which changes over the course of the disease and can best be analyzed through multimodal experimental studies [4].

References

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