The Development of a Building Block for a Structural Artery Model

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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 [2], myocardium [3], 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 [4].

This lecture will 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 and the myocardium in health and disease, e.g., an aortic dissection. Based on the building block for a structural artery model, 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 [5]. We have several needs and challenges for the next decade. For example, multiscale models must take into account the microstructure, which changes over the course of the disease and is best analyzed by multimodal experimental studies [6]. For the future, mechanics and natural sciences, represented by, e.g., biophysics, biochemistry, mathematics, etc., then engineering sciences must have an even stronger interaction/interrelation with medicine. In order to achieve clinically relevant results, mechanics and natural sciences will have to interact even more closely with medicine in the future.

References

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