Multi-scale, multi-physics modelling of fibrosis effects on atrial function.

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Atrial fibrillation (AF) is a significant public health problem, with an estimated 15 million patients with AF in Europe by 2030. Patients with AF are at an increased risk of developing left atrial (LA) thrombosis, with a corresponding increase in the risk of stroke. Fibrotic atria are more prone to thrombosis, but the specific mechanisms are not well understood. Possible causes for atrial motion impairment due to fibrosis include electrical, structural and contractile effects.

To address this gap of knowledge, we present a computational framework that enables personalized analysis of LA hemodynamics, leveraging a multi-physics, multi-scale framework that incorporates electrophysiology, biomechanics and hemodynamics simulations. The framework uses medical images to generate a patient specific model of the heart. In this talk, we will present the numerical framework and discuss a case study, in which we model a LA contraction against a constant pressure in 4 patient-specific anatomies with different fibrotic burdens. We consider separately the effect of fibrosis on the tissue's passive stiffness and on the peak tension generated by the cardiomyocytes, evaluating the impact of these mechanical properties on blood transport. We will conclude the talk by discussing the potential applications of this framework to improve our understanding of atrial function and to personalize cardiovascular care.