Mitral Valve Modelling in Ischemic Patients: Finite Element Analysis from Cardiac Magnetic Resonance Imaging

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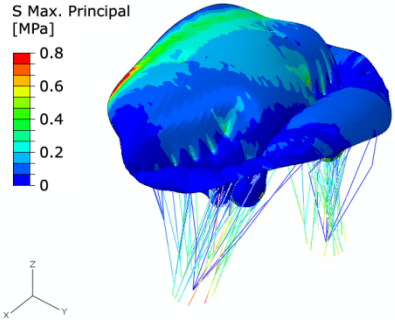
Introduction. Biomechanical data of the mitral apparatus could serve as a basis for finite element (FE) analyses of the mitral valve (MV) in ischemic patients. Previously FE models were mostly based on simplifying assumptions on MV symmetrical shape, idealized leaflets free-edge profile and neglected papillary muscles (PMs) contraction. To overcome these limitations, we aimed at developing a framework for the quantitative analysis of time-varying MV geometry from cardiac magnetic resonance (CMR) imaging, and to integrate these data in a patient-specific structural simulation of MV closure.

Methods. CMR imaging of 18 long-axis planes (one every 10 degrees) was performed on three ischemic patients with a temporal resolution of 55 time-frames per cardiac cycle. Three-dimensional MV annulus geometry, leaflets surface and PMs position were manually obtained using custom software. Leaflets extent and 3-D orientation were set consistently with the MRI-derived leaflets free-edge profile. Hyperelastic anisotropic mechanical properties were assigned to the MV tissues, and a physiological pressure load curve was applied to the leaflets.



Maximum principal stress distribution at peak systole.

Results. In the studied subjects, preliminary results concerning different aspects of MV biomechanics, such as valve dynamics, leaflets coaptation, leaflets strains and chordae tendineae tensions, were in good agreement with in vitro observations.

Conclusion. In this study, we introduced a novel approach for developing a FE model of the MV based on patient-specific data obtained from CMR. This technique allows for high time-resolution imaging in adequately large field of view, even in subjects with enlarged annulus due to MV pathologies. This approach could constitute the basis for accurate evaluation of MV pathologic conditions and for the planning of surgical procedures.