

# 3D Echocardiographic Imaging and Modeling: Towards the Patient-Specific Virtual Mitral Valve

Emiliano Votta, Marco Stevanella, Laura Fusini, Federico Veronesi, Gloria Tamborini, Mauro Pepi, Francesco Maffessanti, Francesco Alamanni, Alberto Redaelli and Enrico G Caiani\*

Politecnico di Milano  
Biomedical Eng. Dpt., Milan, Italy

Finite element models (FEMs) represent an innovative approach for dynamic cardiac structures biomechanical analysis. We recently proposed to obtain a realistic FEM of normal mitral valve (MV), simulating closure from end-diastole (ED) to systolic pressure peak, by gathering patient-specific information about the mitral annulus (MA) and papillary muscles from transthoracic (TTE) real-time 3D echocardiography (RT3DE). Our aims were to apply this strategy to 3 normals (NL) and 3 patients (MVP) with organic MV prolapse, to test for differences in FEM quantitative parameters, and to validate FEM morphology in MVP by comparison with transesophageal (TEE) RT3DE data. **Methods.** TTE RT3DE (iE33, Philips) in full-volume mode was performed in all subjects, and also by TEE during surgery in MVP patients. The MA ED position was defined in 3D space from TTE data, and then tracked frame-by-frame by custom software. The obtained dynamic annular profile was integrated in the patient-specific FEM, where time-dependent pressure up to 120 mmHg applied on the leaflets simulated closure. TEE data were separately analyzed (QLab, Philips) to obtain 3D MV reconstructions for comparison. **Results.** Compared to NL, at systolic peak, in MVP leaflets maximum principal stresses showed an asymmetric distribution, larger in the anterior annular region than posterior, and decreasing towards the free margin, with the most stress focused in the fibrous trigones. Both papillary muscles tension and MA reaction forces at trigones increased by 50% in MVP, consistent with abnormal anchorage associated to MV insufficiency. FEM morphology captured with reasonable approximation the position and extent of regurgitant areas, compared to TEE-derived 3D MV. **Conclusions.** The adopted FEM strategy seemed flexible enough to reproduce different pathological scenarios and inter-subject variability, providing quantitative biomechanical parameters useful to interpret the effects of organic MV insufficiency. This approach represents the basis for the development of a patient-specific virtual modelling tool.