LETTERS

Evaluation of mitral valve regurgitation according to Carpentier's classification and development of 3D FEM models

Dear Editor,

Computational modeling of the mitral valve (MV) is a useful tool for physicians' training and understanding the mitral regurgitation (MR) mechanisms. It is also helpful for the further interpretation and evaluation of MV kinematics after repair or replacement, for example, the use of the annuloplasty ring or the percutaneous mitral repair with the MitraClip. Nevertheless, MV modeling is challenging due to geometric non-linearity, material non-linearity described using hyperelastic constitutive equations, temporal boundary conditions, and its complex anatomical structure[1,2]. This study aims to employ the Finite Element Method (FEM) to simulate the multi-component MV apparatus and kinematics.

More specifically, using computer-aided design, a detailed three-dimensional (3D) MV geometry was implemented by measurements performed on two-dimentional (2D) transthoracic echocardiography (2D-TTE) of 100 individuals (80 patients with MR and 20 healthy volunteers). MR patients were further categorized according to the Carpentier's anatomical classification into Type I, Type II, and Type III. For each type, representative MV geometrical models have been parametrically designed, while the simulation of the MV function was performed in Abaqus/Explicit (Figure 1).

To the best of the authors' knowledge, most of the existing MV models are based on data from limited size samples by transesophageal, 3D-echo, and cardiac magnetic resonance. This study is innovative because the 3D MV geometry construction is based on real MR patients' data obtained with 2D-TTE from a large sample size.

The clinical significace of this translational study is that the developed 3D models could be used for: 1. Interactive education and training of medical students, cardiologists and cardiothoracic surgeons, 2. Improvement of percutaneous and surgical techniques and preprocedural planning, 3. Optimization of devices and artificial implants for MR.

To conclude, according to Carpentier's classification, the developed MV models showed that robust patient-specific modeling can be effectively realized by 2D-TTE measurements (simple, cheap, and easily reproducible), parametric computer aided design and computational analysis.

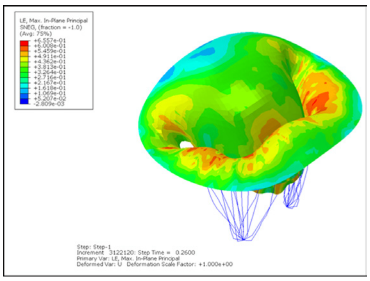

Figure 1: Finite Element Method model of a normal mitral valve at the systolic peak (p =100 mmHg); The colorbar represents the maximum principal logarithmic strain (LE).

Keywords: Mitral valve, regurgitation, Carpentier's classification, finite element method, 2D transthoracic echocardiography measurements, 3D geometrical modeling

Conflict of interest

None declared by all authors.

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