11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

FLUID-STRUCTURE INTERACTION ANALYSIS UTILISING A COMPREHENSIVE MITRAL VALVE MODEL

Milan Toma[1], Daniel R. Einstein[2,3], Ajit P. Yoganathan[1], Richard P. Cochran[4] and Karyn S. Kunzelman[4]

[1] Department of Biomedical Engineering, Georgia Institute of Technology, Technology Enterprise Park, Suite 200, 387 Technology Circle, Atlanta GA, 30313-2412, U.S.A., toma@gatech.edu; ajit.yoganathan@bme.gatech.edu

[2] Computational Biology & Bioinformatics, Pacific Northwest National Laboratory, Richland WA, 99352, U.S.A., daniel.einstein@pnnl.gov

[3] Department of Mechanical Engineering, University of Washington, Stevens Way, Box 352600, Seattle WA, 98195, U.S.A.

[4] Department of Mechanical Engineering, University of Maine, 219 Boardman Hall, Orono ME, 04469-5711, U.S.A., {richard.cochran; karyn.cochran}@maine.edu

Key words: *Fluid-Structure Interaction, Mitral Valve, Comprehensive Model, Chordal Structure, Computational Model.*

Computational models of heart valves are important for understanding and characterising the dynamics of healthy and diseased human valves. This work encompasses efforts to make the current model of the heart valves more comprehensive and accurate.

The mitral valve (MV) is comprised of two leaflets, annular attachment at the atrioventricular junction, tendinous chords and the papillary muscles (PMs), see Fig. 1. The two leaflets of the MV are noticeably different in structure; the terms anterior and posterior leaflets are commonly used by clinicians. The posterior leaflet is narrow and extends two-thirds of the way around the left atrioventricular junction within the inlet portion of the ventricle.

Mitral regurgitation (MR) is an increasingly prevalent disorder of the heart in which the MV does not close properly causing blood to flow backward (leak) into the upper heart chamber when the left lower heart chamber contracts. MR is the most common type of heart valve insufficiency, often requiring open-heart surgical repair. After age 55, some degree of MR is found in almost 20% of men and women. See [1] for more detailed review on the mechanics of healthy and functionally diseased MV.

MV repair is considered superior to mitral valve replacement, and there are many surgical techniques utilised to address differing pathologies. One approach to assess the effects of pathology and proposed surgical repair is to utilise a computational model, in which

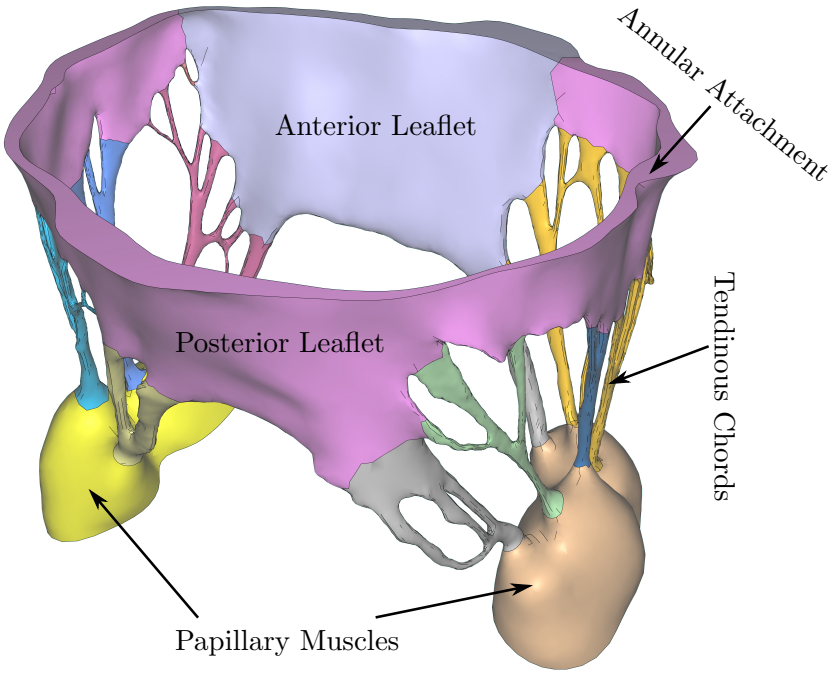

Figure 1: The mitral valve comprises two leaflets, annular attachment at the atrioventricular junction, tendinous chords and the papillary muscles.

pathologic or surgical alterations can be assessed systematically. However, current models are limited by assumptions related to geometry and material properties and importantly, none have been validated with detailed experimental data.

In the present work, an advanced fluid-structure interaction (FSI) model of the MV system is utilised without the limitation to geometry and material properties that allows analysis of the valve in the normal, diseased, or repaired states [2].

REFERENCES

[1] J.-P.M. Rabbah, N. Saikrishnan, A.W. Siefert, A. Santhanakrishnan and A.P. Yoganathan. Mechanics of healthy and functionally diseased mitral valves: a critical review. *J. Biomech. Eng.*, Vol. **135**(2), 21007:1–16, 2013.

[2] D.R. Einstein, F. DelPin, X. Jiao, A.P. Kuprat, J.P. Carson, K.S. Kunzelman, R.P. Cochran, J.M. Guccione, M.B. Ratclifee. Fluid-structure interactions of the mitral valve and left heart: Comprehensive strategies, past, present, and future. *Comm. Num. Meth. Eng.*, Vol. **26**(3-4), 348–380, 2010.