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MULTISCALE TECNIQUES FOR THE COUPLING OF 3D-1D FSI EQUATIONS SYSTEM IN COMPLIANT VESSELS

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In this paper we present a multiscale model for the analysis of fluid structure interaction which couples the three-dimensional vessel equations with an appropriate monodimensional system representing a linked circuit. This approach allows the study of transient phenomena with a remarkable reduction of computational complexity. This model, when large displacements are taken into account, is of considerable interest for time-dependent simulations of blood flow in components such as large arteries or blood vessels. The vessel simulation consists of two interacting fluid-structure regions. The motion in the fluid region is described by the multidimensional Navier-Stokes system while in the solid by the structural mechanics equations. Due to the computational cost of fully three-dimensional fluid-structure interaction problems and the complexity of the cardiovascular system, this multi dimensional models can only be applied to selected regions of interest. According to this multiscale approach the rest of the blood circuit is represented by a mono dimensional formulation of the Navier-Stokes system. In particular, the monodimensional model has to describe properly the wave propagation nature of blood flow and, when coupled with the rest of geometry, must act as a proper absorbing and generating device for the exiting waves inside the computational domain. The mono-three dimensional interface and the multi dimensional geometry of components such as heart valves add complexity to the treatment of inflow and outflow boundaries, where one would like to have a correct representation of the traveling waves, without spurious reflections which may compromise the stability of the solution. In this work we study the propagation of fluid waves into a multidimensional geometry solving fully coupled fluid-structure problem with multiscale approach and present the results of different configuration.

REFERENCES

[1] L. Formaggia, J.F. Gerbeau, F. Nobile, A. Quarteroni, *On the coupling of 3D and 1D NavierStokes equations for flow problems in compliant vessels*, Computer Methods. *Applied Mechanics and Engineering*, Vol. **191** (6-7), pp. 561-582 (2001).

[2] J. De Hart, G.W.M. Peters, P.J.G. Schreurs and F.P.T. Baaijens, *A three-dimensional computational analysis of fluid-structure interaction in the aortic valve*, *Journal of Biomechanics*, Vol. **36** (1), pp. 103-112 (2003).

[3] K. Takizawa and T.E. Tezduyar, *Multiscale spacetime fluidstructure interaction techniques*, *Computational Mechanics* Vol. **48** (3), pp. 247-267 (2011).

[4] A. Quarteroni, M. Tuveri, and A. Veneziani, *Computational vascular fluid dynamics: problems, models and methods*, *Computing and Visualization in Science*, Vol. **2** (4), pp.163-197 (2000).

[5] E.J. Weinberg, D. Shahmirzadi, and M.R.K. Mofrad, *On the multiscale modeling of heart valve biomechanics in health and disease*, *Biomechanics and modeling in mechanobiology*, Vol. **9** (4), pp. 373-387 (2010).

[6] J. Hron and S. Turek, *A monolithic FEM/multigrid solver for an ALE formulation of uid-structure interaction with applications in biomechanics*, *Fluid-Structure Interaction: Modelling, Simulation, Optimization*, Springer, Berlin (2006).