A partitioned and a monolithic approach to fluid-composite structure interaction

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ABSTRACT

We study a nonlinear fluid-structure interaction (FSI) problem between an incompressible, viscous fluid and a composite elastic structure consisting of two layers: a thin layer (membrane) in direct contact with the fluid, and a thick layer (linearly elastic structure) sitting on top of the thin layer. The coupling between the fluid and structure, and the coupling between the two structures is achieved via the kinematic and dynamic coupling conditions modeling no-slip and balance of forces, respectively. The coupling is evaluated at the moving fluid-structure interface with mass, i.e., the thin structure. To solve this nonlinear moving-boundary problem in 2D a partitioned approach based on Lie's operator splitting was developed [1], while a monolithic method was used for 3D problems [2]. Both methods are combined with an Arbitrary Lagrangian-Eulerian (ALE) approach to deal with the motion of the fluid domain.

This class of problems and its generalizations are important in e.g., modeling FSI between blood flow and arterial walls, which are known to be composed of several different layers, each with different mechanical characteristics and thickness. By using this model we show how multi-layered structure of arterial walls influences the pressure wave propagation in arterial walls, and how the presence of atheroma and the presence of a vascular device called a stent, influence intramural strain distribution throughout different layers of the arterial wall.

REFERENCES

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