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Reduced fluid structure interaction modeling of the aortic valve including leaflets curvature

Ivan Fumagalli*,1, Luca Dede'1 and Alfio Quarteroni1,2

[1] MOX – Department of Mathematics, Politecnico di Milano, piazza Leonardo da Vinci 32, 20133 Milano, Italy, ivan.fumagalli@polimi.it, luca.dede@polimi.it, alfio.quarteroni@polimi.it

[2] Mathematics Institute, Ecole Polytechnique Fédérale de Lausanne, Av. Piccard, CH-1015 Lausanne, Switzerland (*Professor Emeritus*)

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In the study of cardiac hemodynamics, a relevant role is played by the interaction between the blood flow, cardiac wall deformation, and valves dynamics. Different approaches can be found in the literature, to model such interaction, ranging from CFD with prescribed displacement for the moving geometry to full fluid-structure interaction simulations. In this work, we introduce a novel lumped-parameter model for the aortic valve dynamics, including elastic effects associated to the leaflets' curvature [1]. This model is coupled with 3D Navier-Stokes equations describing the blood flow, where the moving valve leaflets are immersed in the fluid domain by a resistive method [2]. The resulting reduced fluid-structure interaction problem has a computational cost that is comparable with the solution of a prescribed-motion fluid dynamics problem. Computational results show the suitability of the system in representing the leaflets motion, the blood flow in the ascending aorta, and the pressure jump across the leaflets. The effectiveness of the proposed model is assessed in terms of its ability to reproduce phenomenological and pathological conditions, and it is compared with a known phenomenological model from the literature [3]. Extensions of the model to other cardiac valves and to different fluid conditions will be discussed.

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