**Fluid-Structure Interaction in the Aortic Heart Valve**

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**Introduction**

The opening and closing behavior of the valve is a delicate interaction between blood flow and geometrical and stiffness properties of the heart valve leaflets and aortic root. Numerical analysis of the opening and closing behavior is complicated by the three-dimensional finite motion of the very flexible leaflets in a compliant system of fluid and structure. Fluid-structure interaction models of the heart valve have been developed before, e.g. see Peskin & McQueen [1] and Horsten [2]. However, none of these models was able to analyse the physiological condition in which the valve functions because of numerical artefacts. The Fictitious Domain/Arbitrary Lagrange-Euler method is introduced, which allows numerical modeling of valves under physiological conditions.

**Methods**

In modeling fluid-structure interaction, the fluid domain is most conveniently described with respect to an Eulerian reference frame while a Lagrangian formulation is more appropriate for the structure domain. However, these formulations are incompatible. A solution to this problem is the use of an Arbitrary Lagrange-Euler (ALE) formulation. It involves a continuous adaptation of the fluid mesh without modifying its topology. This method is used to describe the expansion of the aortic wall caused by internal fluid pressures. However, with respect to the large leaflet motion within the computational fluid domain it is generally difficult, if not impossible, to adapt the fluid mesh in such a way that a proper mesh quality is maintained without changing the topology. Alternatively, remeshing can be performed, either continuously, using a Lagrangian formulation, or in conjunction with an ALE formulation, where remeshing is performed if the mesh quality has degenerated too much. Remeshing, however, not only introduces artificial diffusivity, it also may be difficult to perform with sufficient robustness and accuracy for three-dimensional problems. To solve this problem a Fictitious Domain method is used where the fluid is described in an Eulerian setting, and the structure in a Lagrangian setting, allowing the use of commercial available software. The method is based on the imposition of velocity constraints associated with moving internal boundaries by means of Lagrange multipliers.

**Results**

The method of Fictitious Domain (FD) has been tested on a two-dimensional model of the aortic valve [3]. The model has been validated experimentally using Laser Doppler Anemometry and digitized High-Speed video recordings to visualize the fluid flow and leaflet motion in corresponding geometries. Results show that both the fluid and leaflet behavior are well predicted for a different range of leaflet thickness. The implementation towards three-dimensional valve models of flexible leaflets within a compliant aortic root, using this new combined FD/ALE technique, is currently under investigation.

**References**