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Computational fluid-structure interaction: methods and application to a total cavopulmonary connection. (English) Zbl 1398.92056

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Summary: The Fontan procedure is a surgery that is performed on single-ventricle heart patients, and, due to the wide range of anatomies and variations among patients, lends itself nicely to study by advanced numerical methods. We focus on a patient-specific Fontan configuration, and perform a fully coupled fluid-structure interaction (FSI) analysis of hemodynamics and vessel wall motion. To enable physiologically realistic simulations, a simple approach to constructing a variable-thickness blood vessel wall description is proposed. Rest and exercise conditions are simulated and rigid versus flexible vessel wall simulation results are compared. We conclude that flexible wall modeling plays an important role in predicting quantities of hemodynamic interest in the Fontan connection. To the best of our knowledge, this paper presents the first three-dimensional patient-specific fully coupled FSI analysis of a total cavopulmonary connection that also includes large portions of the pulmonary circulation.

MSC:

92C35 Physiological flow
74F10 Fluid-solid interactions (including aero- and hydro-elasticity, porosity, etc.)
76Z05 Physiological flows
76M10 Finite element methods applied to problems in fluid mechanics
74L15 Biomechanical solid mechanics

Keywords:

blood flow; Fontan surgery; fluid-structure interaction; variable wall thickness; hyperelasticity; wall shear stress

Full Text: DOI

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