15th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering
and
3rd Conference on Imaging and Visualization
CMBBE 2018
P. R. Fernandes and J. M. Tavares (Editors)

Abstract ID-34

NUMERICAL SIMULATION AND ANALYSIS OF THE FLOW PATTERNS IN AN AORTIC ROOT MODEL THROUGH A BI-LEAFLET MECHANICAL VALVE

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Keywords: CFD, Heart valve, vortical structure, DNS, LES

Summary: The aortic root (AR) is the region which connects the left ventricle (LV) to the ascending aorta that is the main artery which delivers oxygenated blood to the rest of the body.
The current work aims at providing a credible and cost-effective finite-volume based numerical simulations of the flow patterns within an aortic root model with the bi-leaflet mechanical valves in realistic conditions. The aortic model and the bi-leaflet mechanical valve is based on the experiment of Romano (2008) from which we acquire the geometry of the aortic model and the leaflets as well as the time dependent flow rate at inlet.
In first approach, the kinematics of the mechanical bi-leaflet is predefined from the experiments. Since the considered problem has two independently moving leaflets, proper meshing strategies need to be applied. In order to properly resolve the leaflet wall-boundary layers as well as the central region, the dynamic re-meshing and Chimera overset methods were applied. For approximately same total number of control volumes (~6M CVs) , the Chimera overset method was able to provide a better mesh quality (less skewed) in the proximity of leaflets compared to the dynamic re-meshing.
In second approach, the dynamics of the bi-leaflet is represented as a result of the fluid-structure interactions (FSI) in which leaflets are considered as solid rotating objects with a limited degree of freedom. The forces imposed by the fluid has been computed into rotation torques to rotate the leaflets.
For both approaches, we applied the direct numerical simulations (DNS). Results were compared with available PIV measurements of Romano (2008) and immersed boundary method (IBM) simulations of De Tullio et al. (2009). The obtained results are in good agreement with experiment and the IBM method.
The full paper will address in great details also comparisons between DNS, LES and unsteady RANS in predicting the stream-wise velocity profiles as well as the behavior of intermittent flow structures triggered by the valve motion.