4D Flow MR Imaging for Blood Velocity Field Validation: A Preliminary Study in Atrial Fibrillation Patients

Camilla Cortesi*[1], Matteo Falanga[1], Perrine Marsac[2], Nadjia Kachenoura[2], Cristiana Corsi[1]

[1] DEI, University of Bologna, Campus of Cesena, Bologna, Italy
[2] Sorbonne Université, CNRS, INSERM, LIB, Paris, France

Aims: The purpose of this preliminary study was to obtain an initial validation of a patient-specific computational model comparing the simulated blood velocity field in left atrium (LA) from computational fluid dynamics (CFD), with the velocity field provided by 4D flow MRI data. We then selected the simulation context best suited to the specific clinical question.

Methods: Analysis was performed in three atrial fibrillation (AF) subjects. 4D flow MRI data and dynamic CT data were processed to derive the LA anatomical and displacement models from which two distinct dynamic models were computed, representing the computational domains for the CFD simulations. Patient-specific boundary conditions, in terms of pulmonary veins flowrate, were extracted from 4D flow MRI velocity field and applied to the CFD simulations. For each AF patient, we ran two simulations considering the 4D flow MRI derived model and the CT derived model. The focus of the validation was to verify how accurately the flowrate at the mitral valve reproduced the one measured from the 4D flow MRI, considered as gold standard.

Results: In all the study subjects, the simulations revealed two recurrent patterns. First, the flowrate simulated with the model derived from 4D flow MRI (Figure 1(A)) turned out to have a better time synchronization with the measured flowrate compared to the simulation result obtained with CT model (Figure 1(B)). Second, similarities in the amplitude of measured and simulated flowrates seemed to be better represented when CT models were considered compared to 4D flow MRI.

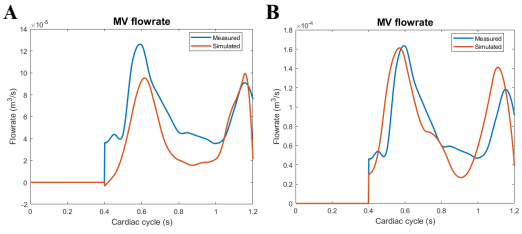

Figure 1. Comparison between measured and simulated MV flowrate from 4D flow MRI anatomical model (A) and CT anatomical model (B) in one AF patient.

Conclusions: This preliminary study suggests that computational domains affect CFD simulation results, and timings and amplitudes of the simulated blood velocity fields should be evaluated also considering the different anatomical models. Being available 4D flow MRI as reference blood flow, a large scale testing and validation of CFD models is required to obtain a correct interpretation of simulation results.