A Digital Twin Approach for Stroke Risk Assessment in Atrial Fibrillation Patients

Matteo Falanga[1], Antonio Chiaravalloti[2], Corrado Tomasi[2], Cristiana Corsi[1]

[1] DEI, University of Bologna, Campus of Cesena, Bologna, Italy
[2] Santa Maria delle Croci Hospital, AUSL della Romagna, Ravenna, Italy

Introduction. In clinical practice, stroke risk is qualitatively evaluated based on the CHA_2DS_2-VASc score. In this study we propose a digital twin model of the left atrium (LA) and the use of computational fluid dynamics (CFD) simulations to improve stroke risk assessment on a patient-specific basis.

Methods. Analysis was performed in 15 subjects divided into 2 groups: 5 controls, and 10 AF patients. Contrast-enhanced CT data were processed to derive the LA anatomical and displacement models from which a dynamic model was computed representing the computational domain for the CFD simulations. For each model, the blood velocity field was analyzed. In addition, blood stasis and different fluid dynamic parameters like time-average wall shear stress and oscillatory shear index were computed and used to derive the endothelial cell activation potential (ECAP).

Results. In AF patients we found an average velocity at the LAA ostium of 0.12 m/s during atrial systole, 0.23 m/s during atrial diastole and, overall, a maximum velocity of 0.26 m/s. In the control group we found higher average velocities in general, with 0.18 m/s during systole, 0.26 m/s during diastole and a maximum velocity of 0.31 m/s. Maximum ECAP value was 2.23 Pa^{-1} for the AF patients and 1.85 Pa^{-1} for the controls, meaning that the AF patients might be more susceptible to thromboembolic events. Regarding the blood stasis, in the AF patients an average number of 510 particles was found after the fifth simulated cardiac cycle, while in the control group only 346 particles were found.

Conclusions. These preliminary results proved the feasibility of such approach for deriving a digital twin model for stroke risk stratification in AF patients. Parameters computed in this study could be used for the formulation of a new index for stroke risk quantification. Further testing on a larger population is in progress.