

# Applying a Digital Twin Framework for Stroke Risk Evaluation in Atrial Fibrillation Patients

Matteo Falanga\*<sup>1</sup>, Camilla Cortesi<sup>1</sup>, Antonio Chiaravalloti<sup>2</sup>, Alessandro Dal Monte<sup>2</sup>, Corrado Tomasi<sup>2</sup>, Cristiana Corsi<sup>1</sup>

<sup>1</sup> DEI, University of Bologna, Campus of Cesena, Bologna, Italy

<sup>2</sup> Santa Maria delle Croci Hospital, AUSL Romagna, Ravenna, Italy

**Introduction.** In clinical practice, the CHA<sub>2</sub>DS<sub>2</sub>-VASc score is used to qualitatively estimate stroke risk. In this study, we propose a digital twin model of the left atrium (LA) and the application of computational fluid dynamics (CFD) simulations to improve patient-specific stroke risk assessment.

**Methods.** Analysis was performed in 30 subjects divided into 3 groups: 10 controls (CNTR), 10 paroxysmal AF patients (PAR) and 10 persistent AF patients (PER). Contrast-enhanced CT images were processed to generate the LA anatomical and displacement models, which constitute the computational domain for the CFD simulation. The blood velocity field was evaluated for each model. Additionally, residence time and other fluid dynamic parameters such as time-average wall shear stress (TAWSS) and oscillatory shear index (OSI) were calculated and used to determine endothelial cell activation potential (ECAP).

**Results.** Overall, the control group showed higher average blood velocity at the LAA ostium than AF groups ( $0.28 \pm 0.05$  m/s,  $0.14 \pm 0.03$  m/s,  $0.11 \pm 0.04$  m/s for controls, PAR and PER, respectively). ECAP was found to be higher in AF (PAR:  $3.96 \pm 3.28$  Pa<sup>-1</sup>, PER:  $4.77 \pm 2.08$  Pa<sup>-1</sup>) than controls ( $0.93 \pm 0.63$  Pa<sup>-1</sup>). This suggests that the LAA may be more susceptible to thrombogenic events due to the extremely slow and oscillatory blood flow observed in AF patients, especially those who have a persistent form. Regarding the residence time, it showed that the blood tends to spend more time within the LAA in the AF patients rather than in controls.

**Conclusions.** These findings indicate that there are clear differences between individuals with AF and those with mild or no cardiac disease and no AF symptoms. Calculated parameters may be applied to create a novel index that could quantify the risk of stroke.

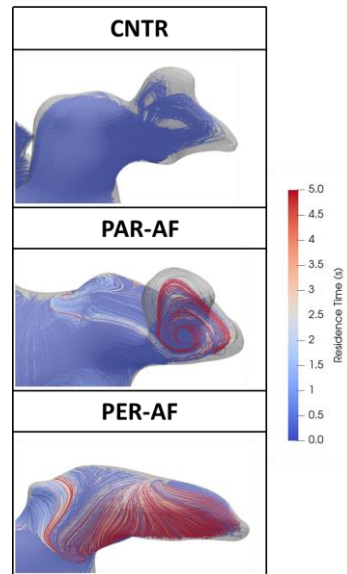


Figure: Residence time analysis in one representative subject for each group.