

Patient-Specific Left Atrial Hemodynamic Evaluation in Atrial Fibrillation

Camilla Cortesi^{*1,2}, Matteo Falanga¹, Jonas Leite², Shannon Soulez², Mikael Laredo², Emilie Bollache², Nadja Kachenoura², Cristiana Corsi¹

¹ DEI, University of Bologna, Campus of Cesena, Bologna, Italy

² Sorbonne Université, CNRS, INSERM, LIB, Paris, France

In clinical practice, CHA₂DS₂-VASc score is used to estimate qualitative stroke risk in patients with atrial fibrillation (AF). In this study, we propose a patient-specific model of the left atrium (LA) combined with computational fluid dynamics (CFD) simulations with the ultimate aim of improving stroke risk assessment.

Analysis was performed in 30 subjects, including 13 healthy controls and 17 patients with AF who underwent 4D flow MRI. Each dataset was processed to generate LA anatomical and wall displacement meshes, used as computational domain for CFD simulations. Patient-specific inflow boundary conditions at the pulmonary veins were further extracted from 4D flow MRI velocity field and applied as input to simulations. Simulated blood velocity field was evaluated for each patient model. Additionally, hemodynamic parameters, including time-averaged wall shear stress (TAWSS) and oscillatory shear index (OSI), were calculated and used to compute endothelial cell activation potential (ECAP).

Overall, the control group exhibited lower maximum indexed LA volumes (39.57 ± 9.13 mL/m²) compared to AF group (46.25 ± 12.03 mL/m²) and a higher transmitral E-wave and A-wave peak flowrates (337.72 ± 196.52 mL/s and 351.04 ± 135.15 mL/s, respectively) than AF patients (188.84 ± 48.47 mL/s and 170.09 ± 61.30 mL/s). ECAP was found to be 2.5 to 3 times higher in AF in both LA and its appendage (LAA) (2.00 ± 1.21 , 10.78 ± 7.56 Pa⁻¹, respectively) than in controls (0.80 ± 0.56 , 3.00 ± 2.97 Pa⁻¹) (Figure).

These findings demonstrate distinct LA hemodynamics between AF patients and healthy controls and suggest that patient-specific CFD-derived parameters may provide the basis for a novel quantitative index in stroke risk stratification.

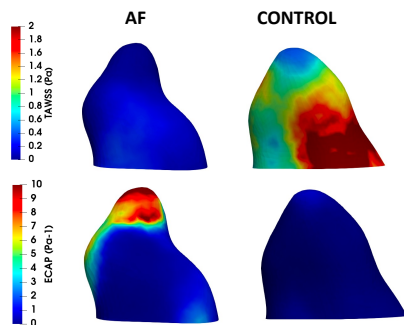


Figure: TAWSS (top) and ECAP (bottom) maps of LAA in an AF patient and a healthy control.