Thrombogenesis and Hemodynamics in Left Atrium Under Atrial Fibrillation: Preliminary Analysis of a Computational Study

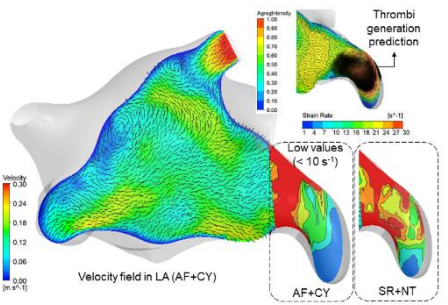
João L Silva Jr, João Salinet

Federal University of ABC, São Bernardo do Campo, Brazil

Aims: Atrial fibrillation (AF) is the most common sustained cardiac arrhythmia increasing the risk of stroke in five-fold. Improving knowledge at its development and prevention is crucial for AF patient management. This study aimed to predict the thrombogenesis in left atrium (LA) under AF through a biochemical model for coagulation cascade and blood rheology.

Methods: Numerical simulations by CFD were performed in a 3D patient-specific LA. Oscillatory Shear Index (OSI), Relative Residence Time (RRT) and Aggregation Intensity, a volumetric indicator of thrombus growth were compared for healthy (sinus rhythm, SR at 64 bpm) and AF (heart rate of 130 bpm) conditions. The thrombogenesis was modelled by coupling transport equations for active and resting platelets and adenosine diphosphate. Also, the effects of Newtonian (NT) and non-Newtonian (Carreau-Yasuda, CY) rheological models of blood were assessed.

Results: The increased mean OSI in the LA appendage (LAA) highlights a higher blood recirculation when compared to the LA (SR+NT:0.30, AF+CY:0.37 and AF+NT:0.39 vs. 0.18, 0.20 and 0.21, respectively). Moreover, mean RRT in LAA was two-fold higher under AF+CY vs. SR+NT, and 14 times higher (AF+CY) when compared to the obtained in LA, depicting a higher relative blood time residence. The mean blood local viscosity estimated with CY model were 6 (LA) and 18.5 cP (LAA), vs. 3.5 cP (LA and LAA) from the NT model. The LAA mean shear rates decreased from 20 s^{-1} (SR+NT) to 14 s^{-1} (AF+NT) and 8 s^{-1} (AF+CY) (see figure), suggesting local viscosity increase. Aggregation intensity results predicted thrombi in LA, being higher in (AF+CY) vs. (SR+NT).



Hemodynamic field in LA under AF and details of shear rate field (AF, SR) and thrombi generation prediction in LAA (AF).

Conclusions: The AF+CY model predicted increased blood local viscosity related to the low shear strain rates in LAA, favoring thrombi generation. Newtonian models exhibited higher shear rates and could lead to underestimation of thrombogenesis in LAA.