Modelling Left Atrial Flow and Blood Coagulation for Risk of Thrombus Formation in Atrial Fibrillation

Ahmed Qureshi*, Omar Darwish, Henry Chubb, Steven Williams, David Nordsletten, Oleg Aslanidi, Adelaide de Vecchi.

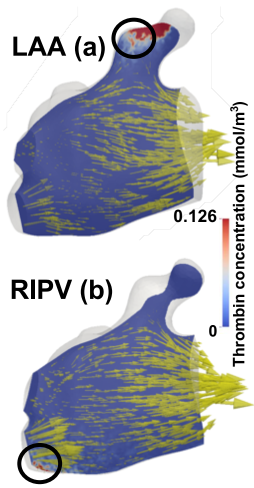
King's College London, St Thomas' Hospital, London, UK.

Introduction: Atrial fibrillation (AF) is a prevalent cardiac arrythmia associated with five-fold increased risk of stroke. Irregular electrical activations during AF diminish left atrial (LA) mechanical function thereby impairing blood flow leading to increased stasis and risk of thrombus formation.

Methods: Patient-specific, mechanistic computational fluid dynamics (CFD) simulations were coupled with the reaction-diffusion-convection equation for thrombin to determine how AF flow affects blood coagulation and thrombus formation dynamics. Personalised 3D geometric models of patients' LA were reconstructed from Cine MRI data during sinus rhythm (SR) and AF with temporal resolution of 50 time-steps per cycle. Time-dependant 3D deforming LA meshes were obtained using a wall motion-tracking algorithm applied on the image data. Simulations were performed for 15 cardiac cycles to model the accumulation of thrombin in critical regions such as the LA appendage (LAA) and right inferior pulmonary vein (RIPV).

Results: Mean blood flow velocity in the LA cavity decreased by 47% from SR to AF. In the LAA, mean flow velocities decreased from 0.06 m/s during SR to 0.035 m/s in AF, inducing a build-up of thrombin concentration which resulted in the thrombus doubling in size after 10 cardiac cycles and detaching during the 15th **(a)**. In the RIPV region, thrombin concentration initially increased, despite higher flow velocities, followed by a decrease between the 10th and 15th cardiac cycles attributed to thrombin washout through the mitral valve irrespective of SR or AF **(b)**.

Conclusion: This study presents a novel workflow combining 3D blood flow with mathematical models of blood coagulation, which has the potential to quantify the individual likelihood of thrombus formation in AF patients and improve current scores for stroke risk assessment and anticoagulation therapy.



*Thrombin in AF flow velocity fields (arrows) in LAA **(a)** and RIPV **(b)** regions.*