Numerical assessment of thrombus-prone regions in left atrium under ventricular diastolic dysfunction and atrial fibrillation

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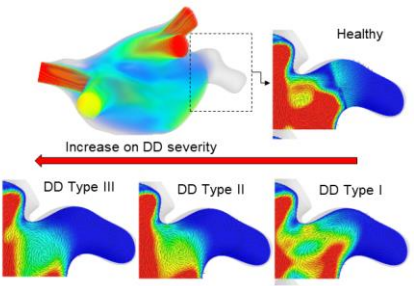
Aims: Aims: The present study hemodynamics patterns of the left atrium (LA) and its implications for thrombus formation, particularly in the context of atrial fibrillation (AF) and ventricular diastolic dysfunction (DD).
Methods: Computational Fluid Dynamics (CFD) was employed to simulate a reference (normal flow, healthy reference) and three DD scenarios (normal, type I – altered relaxation, type II – pseudonormal, and type III – restrictive pattern) along with AF with stiffened walls were simulated to assess LA hemodynamic patterns by analyzing kinetic energy (KE), wall shear stress (WSS) and velocity fields.
Results: A reduction of up to 50% in time-averaged KE for DD conditions compared to the normal scenario were observed. Diastolic KE exceeds systolic KE in the normal condition, while DD types II and III exhibit increased diastolic/systolic KE ratios due to compromised systolic peaks. Type I DD showed higher KE during systole. Pseudonormal relaxation DD presented weaker vortex patterns due to reduced flow during diastole. Areas of the left atrial appendage (LAA) with very low time-averaged wall shear stress (TAWSS < 0.1 Pa) increased with advancing DD, indicating higher stasis and thrombus formation potential. DD types II and III showed severe stasis, while type I exhibits some recirculation related to LAA washout. Additionally, low velocity zones correlate with low TAWSS and high relative residence time (RRT), further characterizing thrombus-prone areas.



KE and velocity fields in LAA

Conclusions: Pro-thrombotic zones are usually evaluated by WSS-based indicators. KE and low velocity (stasis), were observed in accordance with low TAWSS and high RRT, characterizing pro-thrombotic zones and could be suggested as additional markers of thrombogenic risk, once specific KE and velocity fields can be prompt assessed in clinical evaluation by ultrasound imaging. The numerical results showed an increase in risk of thrombus potential according to the progress in DD along with AF with stiffened walls.