Hemodynamic Simulations in Dialysis Access Fistulae

PATRICK MCGAH, DANIEL LEOTTA, KIRK BEACH, JAMES RILEY, ALBERTO ALISEDA, University of Washington — Arteriovenous fistulae are created surgically to provide adequate access for dialysis in patients with End-Stage Renal Disease. It has long been hypothesized that the hemodynamic and mechanical forces (such as wall shear stress, wall stretch, or flow-induced wall vibrations) constitute the primary external influence on the remodeling process. Given that nearly 50% of fistulae fail after one year, understanding fistulae hemodynamics is an important step toward improving patency in the clinic. We perform numerical simulations of the flow in patient-specific models of AV fistulae reconstructed from 3D ultrasound scans with physiologically-realistic boundary conditions also obtained from Doppler ultrasound. Comparison of the flow features in different geometries and configurations e.g. end-to-side vs. side-to-side, with the in vivo longitudinal outcomes will allow us to hypothesize which flow conditions are conducive to fistulae success or failure. The flow inertia and pulsatility in the simulations (mean \( Re \approx 700 \), max \( Re \approx 2000 \), \( Wo \approx 4 \)) give rise to complex secondary flows and coherent vortices, further complicating the spatio-temporal variability of the wall pressure and shear stresses. Even in mature fistulae, the anastomotic regions are subjected to non-physiological shear stresses (>10 Pa) which may potentially lead to complications.

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