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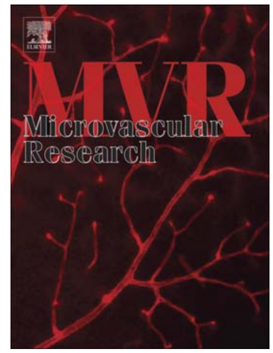

Influence of microvascular sutures on shear strain rate in realistic pulsatile flow

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Influence of microvascular sutures on shear strain rate in realistic pulsatile flow

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Abstract

Arterial thrombus formation is directly related to the mechanical shear experienced by platelets within flow. High shear strain rates (SSRs) and large shear gradients cause platelet activation, aggregation and production of thrombus. This study, for the first time, investigates the influence of pulsatile flow on local haemodynamics within sutured microarterial anastomoses. We measured physiological arterial waveform velocities experimentally using Doppler ultrasound velocimetry, and a representative example was applied to a realistic sutured microarterial geometry. Computational geometries were created using measurements taken from sutured chicken femoral arteries. Arterial SSRs were predicted using computational fluid dynamics (CFD) software, to indicate the potential for platelet activation, deposition and thrombus formation. Predictions of steady and sinusoidal inputs were compared to analyse whether the addition of physiological pulse characteristics affects local intravascular flow characteristics. Simulations were designed to evaluate flow in pristine and hand-sutured microarterial anastomoses, each with a steady-state and sinusoidal pulse component.

The presence of sutures increased $\mathrm{SSR}_{\mathrm{max}}$ in the anastomotic region by factors of 2.1 and 2.3 in steady-state and pulsatile flows respectively, when compared to a pristine vessel. SSR values seen in these simulations are analogous to the presence of moderate arterial stenosis.

Steady-state simulations, driven by a constant inflow velocity equal to the peak systolic velocity (PSV) of the measured pulsatile flow, underestimated SSRs by $\sim 9\%$ in pristine, and $\sim 19\%$ in sutured vessels compared with a realistic pulse. Sinusoidal flows, with equivalent frequency and amplitude to a measured arterial waveform, represent a slight improvement on steady-state simulations, but still SSRs are underestimated by 1-2%. We recommend using a measured arterial waveform, of the form presented here, for simulating pulsatile flows in vessels of this nature.

Under realistic pulsatile flow, shear gradients across microvascular sutures are high, of the order $\sim 7.9\times10^{6}$ m^{-1} s^{-1}, which may also be associated with activation of platelets and formation of aggregates.

Keywords: Pulsatile; Microvascular; Anastomosis; Sutures; Computational Fluid

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