The role of haemodynamics and peripheral vasculature in vessel constriction after aneurysm treatment with flow-diverter stents

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Treatment of intracranial aneurysms with flow diverter stents (FDS) can lead to calibre changes of the jailed vessels in a subacute phase. The reason some branches remain unchanged and others are affected by narrowing or occlusion is unknown. This study investigates the influence of resistance to flow on FDS-induced haemodynamic modifications in typical aneurysm locations in bifurcating arteries.

Radiological images and demographic data were acquired for 142 aneurysms treated with FDS. Whisker plots and correlation analysis (2-tailed Pearson correlation) were used to identify correspondence between anatomic data and clinical outcome. Anatomical data were used to estimate values of vascular resistance. Computational Fluid Dynamics (CFD) was performed on typical stented and unstented patient-specific models of intracranial aneurysms located at various locations to evaluate FDS-specific influence on flow. Stent-induced alterations of flow rate redistributions, pressure and wall shear stress (WSS) fields along the bifurcating vessels were quantitatively and qualitatively analysed. The computational approach was quantitatively validated through a comparison with *in vitro* velocity data extracted from patient-specific-phantoms using power Doppler ultrasound (PD).

Statistical analysis of anatomically-derived data showed significant correlation between vessel narrowing and aneurysm location ($r=0.74$, $p<0.001$), and clinical outcome and the relative FDS resistance to flow with respect to overall jailed-vessel vascular resistance ($r=0.5$, $p<0.001$). Comparison between FDS-induced, vessel and peripheral resistances showed that the computed FDS resistance to flow account for a small amount of the overall resistance (1%) in OphthA bifurcations and for a larger amount (4%) in other bifurcations, which also show the highest rates of negative clinical outcome. Computational predictions of blood flow in patient-specific geometries showed that WSS in the OphthA is only minimally affected by FDS treatment. Comparison between experimental and computational data showed strong quantitative alignment.

The study shows statistically significant correlations between anatomically-derived flow

resistance and clinical outcome, indicating a possible link between FDS-induced haemodynamic alterations and vessel narrowing. By using a modelling approach the study provides a cause-effect mechanism that explains these correlations, and illustrates the physiological role played by resistance to flow in the context of FDS treatment. This study reinforces the importance played by peripheral resistance and proposes a potential explanation towards the development of safer clinical protocols to ultimately allow wider adoption of minimally invasive treatment with flow-diverting stents.