THE EFFECT OF IN-PLANE ARTERIAL CURVATURE ON THE FLOW FIELD IN ARTERIOVENOUS FISTULAE

Introduction: Arteriovenous fistulae (AVF) are the preferred method of vascular access for patients with end stage renal disease who require haemodialysis. They are however susceptible to non-maturation due to the formation of peri-anastomotic neointimal hyperplasia. Arterial curvature and non-planarity are widespread in native human vasculature and appear to be important in promoting favourable flow conditions. The objective of this study was to understand how in-plane arterial curvature affects blood flow under physiologically relevant flow conditions in idealised models of AVF.

Methods: Glass models of a vascular anastomosis were created with an end-to-side anastomosis occurring on straight and curved (both outer and inner) parent tubes with an in-plane orientation of the vessels. Comparative qualitative and quantitative observations were made under a range of non-pulsatile (but otherwise physiological) flow conditions using ink flow visualisation and were then compared with computational fluid dynamics (CFD) models under identical flow conditions.

Results: Qualitatively, flow visualisation indicates venous flow is unsteady, regardless of arterial curvature. However, in models with an anastomosis to the outer curvature, arterial flow is stabilised, in contrast to straight and inner curvature anastomoses where flow remains unsteady. While comparable results were observed in the flow visualisation and CFD work, quantitative assessment via CFD models suggests that while reducing the exposure of the anastomotic area to unstable flow, an outer arterial anastomosis results in greater exposure to low wall shear stress and low vessel-to-wall oxygen transfer.

Conclusion: Physiologically relevant in-plane arterial curvature exerts a significant effect on local blood flow in idealised models of AVF both *in vitro* and *in silico*. Flow instability, wall hypoxia and low wall shear stress have all been implicated in the development of vascular pathology. While the connection of a vein to the outside of an artery appears to result in stabilisation of arterial flow, the resultant low wall shear stress and vessel wall hypoxia demonstrated in CFD modelling may equally be deleterious, underlining the importance of determining the mechanism by which neointimal hyperplasia develops. Parallel clinical human studies will elucidate the association between local geometry and clinical outcome, while further *ex vivo* work will examine the effect of non-planarity and pulsatile flow on flow stability.