INTRODUCTION

The purpose of this study was to evaluate and compare the fluid dynamics at the anastomosis created by the GORE® Hybrid Vascular Graft to the conventional end-to-side anastomosis created by a conventional arteriovenous graft (CAG). The in vitro study was performed using an MRI-compatible mock-circulation developed by the Cardiovascular Imaging Section, Methodist Debakey Heart and Vascular Center (MDHVC). Phase-contrast MRI (pc-MRI) in conjunction with Computational Fluid Dynamics (CFD) were then performed.

MATERIALS AND METHODS

One GORE® Hybrid Vascular Graft (6 mm diameter vascular graft section and 6 mm diameter nitinol reinforced section) and one CAG (ePTFE, 6 mm diameter) were utilized in the experiment (Figure 1). Both constructs were connected to a Procol® Vascular Bioprosthesis (approximately 6 mm in diameter). The constrained nitinol reinforced section of the GORE® Hybrid Vascular Graft was advanced into the vascular bioprosthesis by approximately 2.5 cm and deployed to create a sutureless end-to-end anastomosis. The CAG was sutured, end-to-side, to the vascular bioprosthesis in a standard manner. The graft-vein constructs were then suspended in 3% gelatin and attached to the flow loop (Figure 2). Appropriate flow parameters where configured through adjustments of arterial compliance and resistance and venous resistance. The test flow loop was then positioned inside a 1.5 T MRI scanner and imaged utilizing pc-MRI. A mesh was formed from the MRI data points and CFD analysis was performed based on this mesh. The CFD analysis was computed under the assumption of an inlet flow velocity of 1 m/sec which was an approximate value based on peak systolic flow measurements. A color map of wall shear stress and flow streamlines in each graft construct under the assumed flow conditions (Figure 3).

Figure 1. Graft-vein constructs connected to the mock circulation. (A) The conventional end-to-side anastomosis. (B) Endoluminal anastomosis created with the GORE® Hybrid Vascular Graft.

Figure 2. Schematic of the test flow loop and MRI-compatible system.

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CONCLUSIONS

The GORE® Hybrid Vascular Graft eliminated the low wall shear stress region at the toe and the heel of the graft anastomosis site, which corresponds to the development of intimal hyperplasia in the conventional end-to-side anastomosis.1 Also, due to the GORE® Hybrid Vascular Grafts occlusion of the venous inflow, flow remained laminar, where the CAG construct exhibited irregular flow patterns downstream from the entry site. Irregular, oscillating flow patterns have also been identified as a precursor to intimal hyperplasia development and graft occlusion.2 These observations suggest that the GORE® Hybrid Vascular Graft provides optimized flow characteristics as compared to a conventional end-to-side anastomosis thus potentially reducing the incidence of arteriovenous access graft stenosis due to intimal hyperplasia.

PHYSICIAN COMMENTS

“Grafts will continue to play an important role in dialysis access surgery, particularly as obesity and elderly patient numbers expand. The most common failure mode of grafts continues to be intimal hyperplasia at the venous anastomosis. Disturbed flow at the venous anastomosis is thought to be an important stimulus to the development of intimal hyperplasia.

The new GORE® Hybrid Vascular Graft attempts to influence this problem with a stent-grafted venous outflow creating a functional end-to-end anastomosis. This flow study confirms improved laminar flow compared with a conventional sutured anastomosis. Clinical experience with the GORE® Hybrid Vascular Graft remains limited and further experience should demonstrate whether improved flow characteristics translate into improved graft patencies.” – Eric K. Peden, MD

REFERENCES


![Figure 3. Wall shear stress (dynes/cm²) and flow streamlines (m/s) in the conventional end-to-side anastomosis (left side) and in the endoluminal anastomosis created with the GORE® Hybrid Vascular Graft (right side).](image)