Anastomotic Hemodynamics at the Distal End of Lower Extremity Bypass to Improve Patency

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NOTES

Prosthetic arterial grafts constructed from expanded polytetrafluoroethylene (ePTFE) have been used for many years as an alternative to autologous vein grafts for lower extremity bypass. When anastomosed above the knee, their performance is similar to that of autologous vein for up to 2 years after operation, thereafter they are associated with a significantly higher failure rate.1 When anastomosed to the infrageniculate popliteal or tibial arteries the performance of ePTFE grafts is considerably inferior to that of autologous vein.[1,2] The principal reason for the higher rate of failure of ePTFE grafts, both below and above knee, is anastomotic intimal hyperplasia, and measures directed towards the suppression of this response might be expected to improve results.

A collaborative research program by the Regional Vascular Unit at the Royal Liverpool University Hospital and the Department of Clinical Engineering at the University of Liverpool has been undertaken to investigate the relationship between flow dynamics and the accretion of intimal hyperplasia at the distal anastomosis of arterial bypass grafts. We have also studied the effects of different configurations of anastomosis, including those resulting from the construction of interposition patches and cuffs. A starting point for these studies was the proven inverse association between intimal hyperplasia and vessel wall shear stress-within physiologic limits the shear stress suppresses intimal hyperplasia. Flow dynamics in different configurations of anastomosis were studied, in a bench model simulation, by visualization of flow lines, velocity vector tracking, and shear stress mapping. The results of these experiments showed that in a cuff-shaped anastomosis blood flow was characterized by a single large cohesive vortex, which formed after peak systole and persisted throughout diastole. This vortex had the effect of increasing the mean shear stress at "critical points" in the anastomosis. It can also be expected to minimize contact between particulate components of the blood, including platelets, and the arterial wall. Both effects are potentially of benefit in suppressing intimal hyperplasia. These findings are consistent with the results of a previously reported clinical trial, which demonstrated significantly improved patency of infrageniculate ePTFE grafts when interposition vein cuffs were incorporated at the distal anastomosis compared to those with standard end to side anastomoses.[3]

Above- and below-knee anastomoses have different characteristics in terms of both anatomical configuration and fluid dynamics. Most importantly, the flow split above the knee is in the order of 85% distal and 15% proximal compared with 75:25 for below-knee grafts and the mean flow velocity within above knee grafts is 4 to 5 times greater than that in below knee grafts. Therefore, different shapes of anastomosis are necessary to optimize the internal flow structures within anastomoses at different sites. This is the basis for "anastomotic engineering."

Cuffs of precise shape can be moulded at the end of ePTFE grafts during manufacture and Bard Peripheral Vascular produces pre-cuffed ePTFE grafts for below-knee (Distaflo) and above-knee (Dynaflo) bypass. The results of a randomized trial undertaken in the United States demonstrated similar patency and limb salvage rates for Distaflo and ePTFE grafts with interposition vein cuffs or patches.[4] There are not yet any clinical data available on the performance of the Dynaflo graft, which was launched at the beginning of 2005.

References

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