BIOMECHANICAL, MORPHOLOGICAL, AND ZERO-STRESS STATE CHARACTERIZATION OF JUGULAR VEIN REMODELING IN ARTERIOVENOUS FISTULAS FOR HEMODIALYSIS

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Abstract

While the role of hemodynamic variables on the development of intimal hyperplasia and the ensuing graft dysfunction in arteriovenous fistulas for hemodialysis has been examined by numerous investigators, study of the intramural biomechanical factors is lagging behind. In this study, arteriovenous fistulae were created by implantation of e-PTFE grafts between the carotid artery and ipsilateral jugular vein in healthy pigs. The biomechanical adaptation of efferent vein was assessed via inflation/extension testing two, four, and twelve weeks post-surgery, and the respective histomorphometric adaptation through optical microscopy. *In vivo* recordings exhibited a nearly three-fold elevation of pressure and volumetric flow rate in grafted veins immediately after fistula creation that remained so until sacrifice. In response to hemodynamic overload, the chief morphological finding in grafted than contralateral vessels was wall thickening, already at two weeks, serving to restore intramural stresses to homeostatic levels, and a less important internal diameter enlargement that gradually normalized intimal shear after four weeks. As with thickness to internal radius ratio, the residual strains and opening angle, characterizing the zero-stress configuration of veins, increased after fistula creation, with differences reaching significance in the twelve-week group. Association with histomorphological findings on intima, media, and adventitia growth disclosed a certain correlation between increased intimal hyperplasia and opening angle increase. Elastin and cellular percentage wall content diminished opposite to collagen fiber accumulation and cellular proliferation, the largest part of differences occurring within the first four weeks after grafting. Inflation/extension testing showed vein stiffening associated with these structural changes, as their distension ratio declined over the entire pressure range, with a concomitant rise in the elastic modulus of wall material that was exaggerated over time. We conclude that post-fistula the vein wall becomes progressively thicker and stiffer, leading to normalization of shear and circumferential stresses, but lacking restoration of compliance to baseline levels.

Keywords: Inflation/extension, intimal hyperplasia, e-PTFE distal vein anastomosis, histology, shear stress, intramural stress, residual stress.

Submitted

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