Bio-Inspired Materials for the Treatment of Arterial Disease

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Although large diameter vascular grafts (> 6 mm) have been successfully developed from polymers such as polytetrafluoroethylene (PTFE), the fabrication of durable small diameter prostheses (< 6 mm) remains unsolved. Furthermore, while prosthetic bypass grafting can be performed in the infrainguinal position with reasonable short-term success, within 5 years 30% to 60% of these grafts will fail. Likewise, outcomes after treatment of lower extremity vascular disease through the use of angioplasty, stenting, or atherectomy remain compromised with 3 year patency rates ranging from 61% for discrete, focal lesions to less than 30% for more complex lesions associated with critical limb ischemia. Although the application of drug eluting stents and drug-coated balloons are areas of active investigation, 24 month data demonstrate substantial failure rates. Covered stents may prove to be a viable alternative to bypass surgery, but patency continue to be substantially inferior to that observed for venous bypass, especially for small diameter (5 mm) covered stents (54%, 24 mos.). It is recognized that the adverse events leading to the failure of many vascular and endovascular prostheses is largely related to maladaptive biological reactions at the blood-material interface, which contributes to a substantial risk of early and late thrombotic occlusion. This barrier continues to limit our capacity to effectively treat patients with cardiovascular disease and has constrained progress in the development of a wide range of implantable artificial organs.

Over the past five decades, basic research into the structure of biological macromolecules has begun to deconvolute the structural principles that underlie the unique functionality of biological systems. While this course is far from complete, the information obtained from these studies has enabled the scientific community to gain an understanding of the relevant physical and engineering principles that guide self-assembly of biological systems on nano-, meso-, and macroscopic length scales, as well as the mechanistic features of these complex living systems that work in concert to generate distinctive functional responses in time and space. Our research group utilizes the same structural guidelines and biologically based engineering principles for the design and construction of non-native materials and bioactive drugs that display the structural specificity of native biomolecules, but with enhanced functionality. Recent efforts in the development of bio-inspired materials as component building blocks, which enable advances in the treatment of arterial disease will be reviewed.