Where Are Nanotechnology and Stent Technology Going?

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Nanotechnology and nanoscience focus on materials at the atomic, molecular, and supramolecular levels. The goal is to control and manipulate these new materials by precisely configuring atoms and molecules, producing novel molecular assemblies, and designing systems of self-assembly to create supramolecular devices on the scale of an individual cell and smaller. In other words, nanotechnology is broadly construed as research and technology development at the atomic and molecular levels intended to create, understand, and use nanoscale (ie, typically < 100 nm) structures, devices, and systems having novel properties and functions associated with their size and structure. Current investigations in the field include both "top-down" approaches, encompassing miniaturization of current technology, and "bottom-up" strategies, taking advantage of self-assembly or directed assembly of molecules into nanostructures, offering complementary routes for addressing biomedical problems.

The potential applications of nanotechnology and nanoscience to clinically relevant problems in vascular research encompass a wealth of opportunities. For example, possible applications of nanoparticles and nanodevices include noninvasive diagnosis, targeted therapy, and plaque stabilization by removal of material such as oxidized lipoprotein, and nanodevices attaching to unstable plaque and broadcasting external warnings of plaque rupture. The area of tissue repair and regeneration is another with broad implications for public health where nanotechnology could have great impact, for example, providing superior scaffoldings for the generation of vascular grafts. Biodegradable nano- and microparticles releasing cytokines, growth factors, and angiogenic factors have potential for guiding tissue repair in vivo.

Devices to monitor thrombotic and hemorrhagic events are another potential target for nanotechnology and nanoscience. Multifunctional devices could detect events, transmit real-time biologic data externally, and deliver anticoagulants or clotting factors while the patient seeks treatment.

Additional areas of future development with respect to endovascular devices include improvements to clinical performance by providing added functionality to endoprostheses, expansion of the clinical role of endoprostheses by incorporating novel sensor systems, and reduction of the expertise required for prosthesis delivery through use of adjuncts for passive device targeting. For example, molecularly engineered biomimetic systems offer new options for harnessing physiologically significant mechanisms for limiting thrombosis of small-caliber prostheses or to enhance fixation and aneurysm sac shrinkage after endovascular aneurysm repair. Significantly, the capacity to incorporate sensor technology within new designs of endovascular stents and grafts may lead to expanded clinical roles of the vascular endoprosthesis in monitoring a variety of disease related clinical variables. Undoubtedly, the capacity to add controlled drug delivery in response to sensor input may further expand the therapeutic role of the prosthesis. Finally, the recent use of ferromagnetic materials has led to the design of self-steering catheters and passive systems for device targeting. Thus, the potential for the interventionalist to be able to treat lesions even within complex vascular pathways may be greatly enhanced. Relevant examples from the intersection of nanotechnology, biomimetic materials, and biotechnology and their relevance to stent technology will be highlighted in the course of this presentation.