Application of Novel Biomaterials in Clinical Surgery

In clinical surgery, the biomedical burden of treating diseased or injured organs is great. As populations grow and expand, the need for replacement tissues and organs is constantly increasing and requires novel tissue- and organ-engineering strategies. Collective progress in the development of innovative materials and scaffolds which are capable of modulating the cellular responses required for tissue repair can only be achieved via multidisciplinary collaborative interactions between investigators in the diverse disciplines of the Life Sciences. ‘Reparative’ surgery includes cell-based therapies, artificial organs and engineered living tissues. The suitability and versatility of scientific and technological approaches are highly dependent on the ability to (1) synthesize novel materials, (2) assemble materials into adequate 2- and 3-dimensional forms, and (3) precisely tailor material-related physical and biological properties with the hope of not only replacing tissues and organs but also utilizing the body’s innate capacity for regeneration.

In this issue of *Pathobiology*, novel biomaterials are highlighted from different perspectives of their clinical use in surgery. Gross and Hoffmann focus on biomaterials suggested for the successful repair of tendon and ligament injuries which represent a major clinical challenge to orthopedic and trauma surgery. They also review some recent developments in extracellular matrix (‘biomimetic’) bioscaffolds, the delivery of growth factors, (stem) cell-derived therapy, gene-therapeutic approaches based

on vehicles encoding selected factors and advanced bio-reactors with the application of mechanical load under analysis for healing tendon and ligament disorders. The contribution of Rücker and coworkers provides an overview on currently available and investigated resorbable osteosynthesis systems in craniomaxillofacial surgery and discusses their limitations with respect to sterilization, biocompatibility and stability in comparison to the nonresorbable ‘gold standard’ titanium alloys. Klinge et al. address the topic of textile implants, so-called ‘meshes’, which represent, presumably, the oldest and most frequently used (bio)materials in daily surgical care since the late 1950s when experimental work in dogs first showed that textile structures can help to cover large defects of the abdominal or thoracic wall. The indication for the use of meshes in order to reinforce tissue is huge and is still expanding. Klinge et al. elaborate thoroughly on the process of finding the ideal mesh which is designed with consideration of the surgical site-specific functional requirements to allow optimal performance. Pareta et al., in their article on the ‘design of a bioartificial pancreas’, highlight the successful development of a bioartificial pancreas using the approach of microencapsulation with perm-selective coating of islets in hydrogels for graft immunoisolation. They also critically review aspects such as the mechanical strength of microcapsules, the site of transplantation and the delivery of oxygen to the encapsulated islets, all important factors in the optimization process of

microencapsulated islet technology for some day offering a cure for type I diabetes patients. Molinari et al. report on the use of biliary stents to treat dominant bile strictures in patients with primary biliary sclerosing cholangitis. In this group of patients, endoscopic or percutaneous dilatation with stenting provides symptomatic relief and acts as bridge to organ replacement by orthotopic liver transplantation. The importance of the mimicry of homing factors for self-endothelialization of blood-contacting materials is the subject of the contribution of Wendel and his team. Cardiovascular interventions are markedly hampered by the thrombogenicity of foreign surfaces. The authors present strategies, such as the coating of surfaces to capture molecules mimicking natural homing factors so as to attract endothelial progenitor

cells, and the biofunctionalization of surfaces by ligands, like aptamers, monoclonal antibodies, peptides or magnetic molecules. This in vivo self-endothelialization process of blood-contacting material could open up revolutionary new prospects for clinical stem-cell and tissue engineering strategies.

Tissue engineering and the development of suitable biomaterials will keep on playing a central and decisive role in almost all fields of surgery. Surgeons are encouraged to actively contribute to this multistep process, from interdisciplinary evaluation of the initial clinical problem to developing custom-bioengineered parts and translating these constructs in the operating room.

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