Objective: The aim of the project is to create appropriate substrate for organ transplantation utilizing bioactive tissue-based scaffold populated by cells of graft recipient. The goal will be achieved by multidisciplinary approach involving materials science, tissue engineering and genetic engineering.

Research carried out in the project

The project consists of few stages aiming to create a fully functional tissue. Aortic valves of animal origin will be utilized in the study and they will provide background to produce biocompatible tissue for transplantation into humans. Foreign (host) cells are highly immunogenic components of the graft and they are most responsible for graft rejection. Firstly, host cells will be removed (decellularization) by various physical methods (acoustic beam, laser light irradiation) without degradation of the extracellular matrix. These methods differ in their effectiveness and they may also cause destructive effect on components of the extracellular matrix (eg. collagen and elastic fibers) resulting in change of biomechanical properties of the graft. Thus decellularization process will be controlled by histological and molecular methods. Tissue depleted of host cells will be then functionalized by depositing synthetic materials containing pharmacological substances. Next, the tissue with functional coating will be repopulated by bone marrow stem cells of human (recipient) origin. Stem cells will be stimulated by pharmacological agents released from the coating and they will differentiate into endothelial cells forming natural lining of the valve. Finally, biological and physical tissue properties will be verified under dynamic conditions in human blood.

Reasons for the research topics

Heart valve defects remain one of the most serious problems in cardiac surgery. Defective valve can be replaced by biological (natural) or mechanical (artificial) transplant, albeit both methods have several drawbacks. Natural implants suffer from calcifications, they evoke inflammatory reactions and they are susceptible to infections. On the other hand, artificial valve implants need continuous anticoagulant therapy and they have a short lifespan. Combining techniques of materials science and tissue engineering seems to be a promising tool to provide a new kind of scientifically developed material that could be finally used to create new generation of heart valve bioprosthesis.

Advances in tissue and organ transplantation are focused on the development of autologous tissue material. This goal can be achieved by tissue engineering methods utilizing xenologous (obtained from other species eg. animal) decellular biodegradable matrix populated by bone marrow-derived cells of the recipient. Grafts of this kind should be free from complications typical for currently used prostheses. Moreover, we expect that such materials dedicated for bioprostheses should have potential for growth, self-repair and remodeling similar to native tissues.