Abstract

Cardiovascular disease is one of the leading causes of death worldwide. Surgical techniques, including bridging, replacing, or plasticizing damaged tissue, need suitable grafts for these operations. The ideal source is autologously obtained grafts, which, however, require another invasive approach, and there are not enough of them, or they do not meet the optimal anatomical form. Allogeneic grafts from cadaveric donors are not immediately available for acute interventions. Synthetic replacements show good results in large arteries, but restenosis occurs in small diameter vessels and often require further reoperation. The use of tissue engineering methods to modify these replacements by cell colonization may provide their better patency. Furthermore, decellularized xenogeneic tissues are promising matrices for the development of tissue-engineered cardiovascular grafts. Due decellularization the immunogenic complex is minimized while maintaining a suitable building structure. In combination with recolonization with suitable cells using culture bioreactors, new functional cardiovascular replacements can be created. Endothelialization of the inner lumen is a crucial element in the formation of cardiovascular replacements. The effect of shear stress simulated in the bioreactor has a positive effect on the modulation of endothelial growth in combination with a suitable substrate. Smooth muscle cells, create mechanical support and provide vasoconstriction and vasodilation. Hydrodynamic stimulation by pressure and stretching supports the proliferation of smooth muscles, or differentiation of stem and stromal cells into a smooth muscle cell phenotype. These simulations have been shown to promote phenotypic cell maturation, proliferation and differentiation. Based on the results, an optimized procedure was created, which used the proposed technologies for the preparation of recolonized cardiovascular patches based on decellularized porcine and ovine pericardium, that were recollonized by autologous stromal cells from adipose tissue. Due to mechanical stimulation, decellularized tissue was homogeneously recolonized in 5 days and alo stromal cell differentiation towards smooth muscle was maintained. These prepared patches were implanted on an artificial defect of the carotid artery in animal model. After explantation and histological analysis, it was shown that a new endothelial layer formed in the recolonized patches after only 1 month.

Keywords: Bioreactors, decellularization, dynamic culture systems, cardiovascular replacements, compressive stress, cell recolonization, shear stress