Tissue engineering of a cardiac patch

Gordana Vunjak-Novakovic
Department of Biomedical Engineering, Columbia University, New York NY USA

Tissue engineering offers a potential of developing new treatment options for the repair of injured myocardium, using functional tissues grown *in vitro*. Engineered tissues can also serve as physiologically relevant yet controllable models for studies of tissue development, remodeling and disease. We developed a "biomimetic" approach to cardiac tissue engineering that involves directed differentiation of cells cultured on scaffolds (serving as a structural and logistic template) in bioreactors (providing conditions designed to recapitulate developmental cues). To mimic the capillary network, cells are cultured on channeled elastomer scaffolds perfused with culture medium that can contain oxygen carriers. To mimic the electrical signals that orchestrate heart contractions, cultured cells are subjected to electrical field stimulation. For neonatal rat cells, these conditions resulted in the formation of large synchronously contracting tissue constructs with a remarkable level of ultrastructural organization, over only 8 days of culture. Recently, this approach was extended to the utilization of human stem cells, high-fidelity scaffolding, and advanced bioreactors, providing conditions that promote vascularization. Cardiac tissue engineering will be discussed in the context of heart repair and utilization in quantitative studies of stem cell differentiation. The main challenges of cardiac tissue engineering – establishment of a human cell source suitable for clinical use, vascularization and functional integration of engineered grafts – will be specifically addressed, as well as some of the research needs in the next 5-10 years.