IOWA STATE UNIVERSITY
Department of Mechanical Engineering

ME 600 Seminar
Neda Latifi
November 18th at 11:00 am in 2004 Black

TITLE:

Tissue-mimetic Nano-fibrillar Biomaterials for Engineering Functional Load-bearing Tissues

ABSTRACT:

Congenital heart disease (CHD) affects ~1% of newborns worldwide. Children born with CHDs often have defective heart valves that require repair or replacement early in the patient's life. For example, in tetralogy of Fallot (≈10% of all CHDs), the pulmonary valve is often repaired in infancy using patches of pericardial tissue or polytetrafluoroethylene, but subsequent complications due to material failure necessitate valve replacement. However, currently available valve replacement devices are incapable of growth, and therefore pediatric patients can face several reoperations throughout their lives. Heart valve tissue engineering (HVTE) holds great promise to address the enormous need for living valve repair materials or replacements with the potential to grow, remodel, and repair throughout a patient's life. Among numerous cell sources for in vitro HVTE, umbilical cord perivascular cells (UCPVCs) are particularly attractive because they are autologous, readily available, and have excellent regenerative capacity. Here, we established protocols to successfully isolate, expand, and promote extracellular matrix (ECM) synthesis by porcine umbilical cord perivascular cells. We determined media conditions that enable porcine UCPVC isolation and expansion to large numbers, and further defined a culture strategy to support production of collagen type I, elastin, and glycosaminoglycans, the primary structural components of heart valve tissues in vitro. To translate the ECM producing capacity of UCPVCs to a viable heart valve tissue engineered sheet, we fabricated aligned nanofibrous polycarbonate polyurethane scaffolds with mimetic anisotropic biaxial mechanical behaviour. We then cultured porcine UCPVCs into both sides of the scaffolds for 21 days and showed that UCPVCs aligned themselves along the fibers of the scaffold, and produced significant amounts of ECM components, in particular aligned mature collagen fibers. To examine the feasibility of this engineered sheet for preclinical testing in a porcine model, engineered patches were implanted into left brachiocephalic vein, right common carotid artery, and pulmonary artery of two piglets. We observed that the engineered tissue was suturable and withstood the blood flow after 6 hours in vivo. Further, we tested a larger prototype of our engineered tissue as a monocusp in a pulsatile flow bioreactor which showed no sign of significant mechanical degradation or failure after two hours. The proposed engineered tissue sheet has the potential for successful translation towards a functional, multi-layer, anisotropic living pulmonary heart valve replacement with tissue-like microstructure and mechanics, resembling those of native pulmonary heart valves.

This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.