FRESH Bioprinting-Based Synthesis and Biomechanical Characterization of Tissue Engineered Vascular Grafts

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Cardiovascular disease (CVD) is the leading cause of global death, and Coronary Artery Disease (CAD) is its most common manifestation. Restoring perfusion to myocardial tissue in CAD often necessitates a coronary artery bypass grafting (CABG) procedure, which implants a vascular graft(s) to bypass the blockage. Existing grafts face challenges: autologous grafts are non-viable in one-third of all patients, and synthetic grafts are often thrombogenic due to compliance mismatch. Tissue Engineered Vascular Grafts (TEVGs) aim to overcome these issues, but suffer lengthy development times and are early in clinical implementation. Here, a rapid fluid modeling, 3D bioprinting, and pressure myography workflow is established to synthesize and mechanically validate TEVGs. Architecture of the gold-standard autologous graft, the human Internal Thoracic Artery (ITA), was recapitulated via Computer Aided Design (CAD). Ideal hemodynamics were proven via Computational Fluid Dynamics (CFD), simulating non-newtonian blood flow and resulting velocity and wall shear profiles. Graft architecture was physically generated via 3D-bioprinting Collagen type-I into a gelatin bath in the Freeform Reversible Embedding of Suspended Hydrogels (FRESH) paradigm. To further simulate pressure-induced vasoactivity including dilation and burst pressure, “HemoLens”, an open-source pressure myograph, was developed. HemoLens proved an average burst pressure in four grafts of 172.36mmHg with minimal dilation, demonstrating near-functional strength. Taken in tandem with CFD data and the overall cost and speed of the workflow, these results prove the feasibility of 3D-bioprinting biomechanically functional Collagen-based TEVGs and represent a step forward in the cardiothoracic landscape.

Awards Won:
Second Award of $2,000