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A predictive fluid-structure interaction approach to estimate physiological mechanical conditioning in vascular tissue engineering

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The *in vitro* simulation of physiological mechanical conditioning through bioreactors plays a pivotal role in the development of functional tissue-engineered blood vessels. Thus, we developed a scaffold-specific fluid-structure interaction (FSI) model under pulsatile perfusion provided by a bioreactor in order to estimate the flow rate that ensures physiological circumferential deformations (εcirc) and wall shear stresses (WSS) on cells seeded on the tubular scaffold. The 2D-axial symmetric FSI model, computed by COMSOL Multiphysics 4.4, represents two domains: The former schematizes decellularized swine artery scaffold, defined as a linear viscoelastic material characterized by its elastic modulus and shear relaxation modulus, previously obtained by uniaxial stretch tests. The latter domain represents the culture medium, defined as an isotropic, homogeneous, incompressible and Newtonian fluid. A pulsatile and parabolic velocity profile is prescribed at the model inlet, while calculated pressure is prescribed at the scaffold outlet. The pressure is estimated at the scaffold end by solving boundary ordinary differential equations, in relation to construct deformations and to the bioreactor downstream lumped-parameter hydraulic circuit. Our results indicate that the FSI-simulated εcirc-max and εcirc-min are statistically comparable to the experimentally estimated values at the considered flow rate, showing the maximum around 10%. The computed WSS values are in the range of 0.175-2.940 dyne/cm2. Both εcirc (≤10%) and WSS (≤20 dyne/cm2) fall within the physiological range for vascular cells. Therefore, the *in silico* FSI model well describes scaffold mechanical conditioning when subjected to pulsatile perfusion, properly driving its' *in vitro* physiological maturation using scaffold mechanical properties obtained experimentally.

Biography

Claudia Tresoldi is currently a PhD student in Bioengineering at Politecnico di Milano, Italy, where she earned her Master's degree. Since 2013, she has been working on a project concerning Vascular Tissue Engineering. The aim of her investigation is to develop functional small-caliber vessels able to reproduce the fetal development *in vitro* by coupling two different technological aspects.

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