BIOPRINTED TISSUE CONSTRUCTS SIMULATED BY THE LATTICE BOLTZMANN METHOD

Artur Cristea[1], Adrian Neagu[2]

[1] *Center for Fundamental and Advanced Technical Research, Romanian Academy-Timisoara Division, Bd. Mihai Viteazul No. 24, 300223 Timisoara,*
[2] *Center for Modeling Biological Systems and Data Analysis, Department of Functional Sciences, Victor Babes University of Medicine and Pharmacy Timisoara, Piata Eftimie Murgu No. 2-4, 300041 Timisoara, Romania*

Tissue engineers seek to build living tissue structures suitable for replacing or repairing damaged tissues. Understanding the principles of morphogenesis is indispensable for developing efficient strategies to build living tissues in the laboratory. Tissue fusion is essential in tissue printing, an emergent technique based on computer-controlled deposition of multicellular building blocks along with supportive hydrogels. Computational methods proved valuable in tissue engineering by pointing out dominant mechanisms involved in shaping multicellular systems. Our Lattice Boltzmann (LB) model was developed in order to simulate mesoscopic fluid-like flows in biological tissue structures. The computer simulation code is based on parallel computing, implemented using the Portable Extensible Toolkit for Scientific Computation (PETSc). We simulated rearrangements of cells, aiming to predict the shape and stability of certain printed structures. Our main objective is to predict the time course of the fusion of multicellular systems. Fusion eventually gave rise to a tubular construct, in qualitative agreement with tissue printing experiments. Then, for the first time, we simulated the time course of a defect in a printed tube. Since cell sheets are of interest in several applications of tissue engineering, we also simulated the evolution of a planar construct built by printing multicellular cylinders. The agreement with experimental results indicates that the LB model captures certain essential features of in vitro morphogenesis, and, therefore, it may be used to test new working hypotheses faster and cheaper than in the laboratory.

Figure 1: Fusion of multicellular cylinders tubular-like tissue fusion (blood vessels).

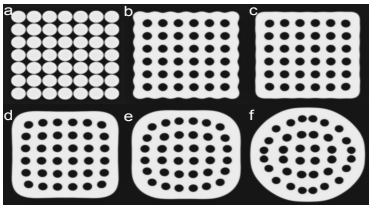

Figure 2: Fusion of multicellular cylinders sheet-like tissue fusion (skin graft).

Keywords: Lattice Boltzmann, tissue fusion, numerical simulation.
Acknowledgments: *This work was supported by the Romanian National Authority for Scientific Research through the CNCS-UEFISCDI project PN-II-ID-PCE-2011-3-0516/2011-2015.*