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Using sacrificial cell spheroids for the bioprinting of perfusable 3D tissue and organ constructs: a computational study. (English) Zbl 1423.92110

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Summary: A long-standing problem in tissue engineering is the biofabrication of perfusable tissue constructs that can be readily connected to the patient's vasculature. It was partially solved by three-dimensional (3D) printing of sacrificial material (e.g., hydrogel) strands: upon incorporation in another cell-laden hydrogel, the strands were removed, leaving behind perfusable channels. Their complexity, however, did not match that of the native vasculature. Here, we propose to use multicellular spheroids as a sacrificial material and investigate their potential benefits in the context of 3D bioprinting of cell aggregates and/or cell-laden hydrogels. Our study is based on computer simulations of postprinting cellular rearrangements. The computational model of the biological system is built on a cubic lattice, whereas its evolution is simulated using the Metropolis Monte Carlo algorithm. The simulations describe structural changes in three types of tissue constructs: a tube made of a single cell type, a tube made of two cell types, and a cell-laden hydrogel slab that incorporates a branching tube. In all three constructs, the lumen is obtained after the elimination of the sacrificial cell population. Our study suggests that sacrificial cell spheroids (sacrospheres) enable one to print tissue constructs outfitted with a finer and more complex network of channels than the ones obtained so far. Moreover, cellular interactions might give rise to a tissue microarchitecture that lies beyond the bioprinter's resolution. Although more expensive than inert materials, sacrificial cells have the potential to bring further progress towards the biofabrication of fully vascularized tissue substitutes.

MSC:

92C50 Medical applications (general)

Keywords:

sacrificial cell spheroids; bioprinting; perfusable 3D tissue; organ constructs

Software:

VMD

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