PROOF-OF-CONCEPT COMPUTATIONAL FLUID DYNAMICS MODEL TO IMPROVE HEPATIC ARTERIAL TREE RECELLULARIZATION PROTOCOLS

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Objectives:

In the field of whole organ bioengineering, effective recellularization protocols are needed to ensure uniform cell adhesion throughout scaffolds. In this proof-of-concept study, recellularization of a hepatic arterial tree is modelled using computational fluid dynamics (CFD).

Methods:

The arterial network of a healthy liver was reconstructed based on micro-CT images of a liver cast, and meshed using $6{\cdot}10^6$ tetrahedral volume elements. The flow velocity of physiological medium (density: 1000 kg/m³, viscosity: 0.001 Pa·s) was defined as 0.2 m/s at the inlet (diameter [d_o]: 6.13 mm). At the outlets, flow fractions were defined using Murray's law. Cells, modelled as discrete particles (diameter: 10 µm, density: 1000 kg/m³), were injected over the entire inlet cross-section and assumed to bind at the walls upon collision.

Results:

12.01% of cells adhered to the wall, depositing non-uniformly throughout the scaffold; the others exited the fluid domain. The influence of gravity was negligible. Dividing the injection plane in three concentric bands (d_1=0mm-2mm; d_2=2mm-4mm; d_3=4mm-d_o), 6.60%, 13.16%, 11.65% of the particles injected in that band adhered to the wall, respectively.

Discussion:

These results suggest that, in this liver, only a small fraction of total cells binds to the wall, and that cross-sectional injection locations away from the centre of the injection plane preferentially steer cells towards the scaffold wall. Finetuning and validating the CFD approach will further elucidate the added value of CFD to optimize recellularization protocols for whole organ bioengineering.

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