MULTISCALE MODELING OF THE HUMAN LIVER BLOOD CIRCULATION: FROM THE HEPATIC MACROVASCULATURE TOWARDS THE MICROVASCULATURE

C. Debbaut [1], D. Monbaliu [2], C. Casteleyn [3], P. Cornillie [3], D. Van Loo [4,5], J. Pirenne [2], P. Simoens [3], L. Van Hoorebeke [4], P. Segers [1]

[1] IBiTech-bioMMeda, Ghent University, Gent, Belgium;
[2] Department of Abdominal Transplant Surgery, University Hospitals Leuven, Leuven, Belgium;
[3] Faculty of Veterinary Medicine, Ghent University, Merelbeke, Belgium;
[4] UGCT, Department of Physics and Astronomy, Ghent University, Gent, Belgium;
[5] Department of Soil Management, Ghent University, Gent, Belgium

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Abstract: Max. 300 words

Objectives: Computational models of an organ's vasculature may provide insight into organ hemodynamics, perfusion and (dys)function (e.g. transplant research). Previously, we developed an electrical analog model of the human hepatic circulation, based on measured anatomical data of the macrocirculation. However, this model requires refinement, especially at the microcirculatory level.

Methods: Vascular corrosion casts of two human livers (discarded for transplantation) were obtained by simultaneous injections of Batson's™#17 through the hepatic artery (HA) and portal vein (PV). We previously reported data obtained from an in globo micro-CT scan (resolution ±110µm) of one of the liver casts. As this only allowed to assess 5-6 generations, we dissected a lobe and a small sample (±0.134mm³) from the cast and scanned these at higher resolutions (±71µm and ±2.6µm, respectively). Image processing was performed to obtain 3D reconstructions up to the terminal microcirculatory level. These reconstructions enabled measurements of the branching topology (diameters, radii, lengths) and assessment of the microvascular porosity (void volume divided by total volume).

Results: The dissected lobe dataset resulted in the visualization of higher order blood vessel generations (13 for the HA and PV, 10 for the hepatic veins (HV)). Exponential relations ($y = a \exp(bN)$ with N = generation number) were determined based on data from the 1st to 13th/10th generation, relating generation number to radius, length and number of vessels. For the HA/PV/HV radii [mm], a was 4.22/10.26/13.52, while b was -0.31/-0.37/-0.48, respectively. The smallest sample showed a very complex network of interconnected and intertwined sinusoids (diameters of ±5-10µm), and the porosity was estimated at 0.148±0.007.

Conclusions: We gathered anatomical and morphological data on the hepatic macro- and microcirculation, forming the basis of a multiscale model of the liver blood flow and perfusion. The application of this method could also be extended to other organs, such as kidneys.