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Multi-Level Modelling of Hepatic Perfusion Using Vascular Corrosion Casting and µCT imaging

Geert Peeters[1], Charlotte Debbaut[1], Pieter Cornillie[2], Thomas De Schryver[3], Diethard Monbaliu[4], Wim Laleman[5] and Patrick Segers[1]

[1]IBITech – bioMMeda, Department of Electronics and Information Systems, iMinds Medical IT Department, Ghent University, De Pintelaan 185 – Block B, 9000 Gent, Belgium
[email: Geert.Peeters@UGent.be]

[2]Department of Morphology, Faculty of Veterinary Medicine, Ghent University, Salisburylaan 133, 9820 Merelbeke, Belgium

[3]Centre for X-ray Tomography, Institute for Nuclear Sciences (INW), Proeftuinstraat 86-N12 9000 Gent, Belgium

[4]Abdominal Transplant Surgery, University Hospitals Leuven, &Department of Microbiology and Immunology, KU Leuven. Herestraat 49, 3000 Leuven, Belgium

[5]Hepatology, University Hospitals Leuven, & Department of Liver and Biliopancreatic disorders, KU Leuven. Herestraat 49, 3000 Leuven, Belgium

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ABSTRACT

Understanding the hepatic vasculature and clarifying the determinants of the intrahepatic hemodynamics and liver perfusion is of pivotal importance, especially in case of liver transplantation, liver surgery, and when assessing the pathophysiology of liver diseases. This requires realistic anatomical three-dimensional models across different length scales to avoid oversimplification. Vascular corrosion casting combined with µCT imaging allows such accurate multi-level modelling.

Human livers, discarded for transplantation, were vascular corrosion casted by injection of resins in the hepatic artery (HA, including Lipiodol as contrast agent) and portal vein. Subsequently, the vascular replicas were scanned in globo using a high-resolution micro-CT scanner (UGCT, Belgium), visualizing the first 4 to 5 blood vessel generations. Thereafter, lobes and samples were dissected from the casts and scanned with a smaller resolution to investigate vessel generations distal to the macrocirculation (mesocirculation) and of the microcirculation, respectively. Image processing resulted in 3D reconstructions and topological data of the hepatic vascular trees (HA, PV and hepatic veins (HV)) and the sinusoidal network. Based on these data, various computational models were developed to simulate liver perfusion at different length scales. An electrical analog model of the whole liver blood circulation was developed based on the macrocirculation data, simulating the hemodynamics (pressure drops and flows) throughout the liver (Debbaut et al., 2011). In addition, 3D computational fluid dynamics (CFD) models of the microcirculation were developed to accurately determine wall shear stress at sinusoidal level (Debbaut et al., 2012). Similar strategies are currently being explored and optimized for rat livers to study the pathophysiology of liver cirrhosis.

The presented methodology is indispensable when conducting accurate morphological and geometrical analyses, covering both macro- and microcirculation of the liver's vasculature.

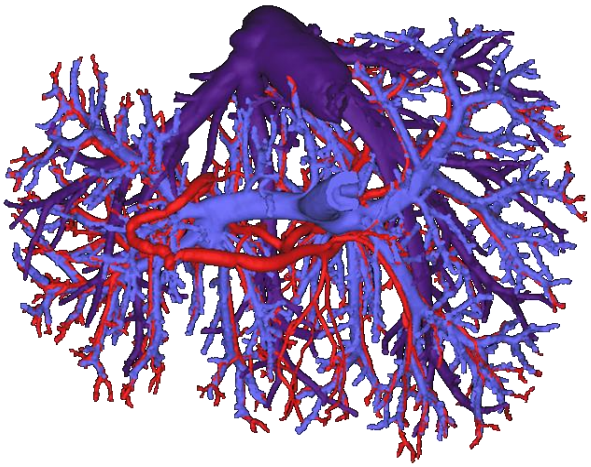

Figure 1: 3D reconstruction of the hepatic macrocirculation (red: HA, blue: PV, purple: HA) (Debbaut et al., 2014)

REFERENCES

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