Tim Bomberna

COMPUTATIONAL FLUID DYNAMICS AS A TOOL FOR PATIENT-SPECIFIC INJECTION PLANNING OF TRANSARTERIAL THERAPIES FOR HEPATOCELLULAR CARCINOMA

Tim Bomberna (1,2), Chris Verslype (3), Geert Maleux (4,5), Charlotte Debbaut (1,2)

(1) bioMMeda, Ghent University, Ghent, Belgium
(2) Cancer Research Institute Ghent (CRIG), Ghent, Belgium
(3) Department of Clinical Digestive Oncology, University Hospitals Leuven, Leuven, Belgium
(4) Department of Radiology, University Hospitals Leuven, Leuven, Belgium
(5) Depart of Imaging and Pathology, KU Leuven, Belgium

Currently, the execution of and response to transarterial radio- and chemoembolization procedures for the treatment of hepatocellular carcinoma are highly heterogeneous. In this study, computational fluid dynamics (CFD) simulations of the drug transport in the hepatic arteries (HA) are used to study the impact of injection location and timing on the drug distribution.

A tumor (1130 ml) was modelled in the left lobe of a patient-specific cirrhotic liver. Transient CFD simulations (5 cardiac cycles with a period of 0.8s) were run to study the blood flow and drug transport through the HA geometry. Boundary conditions included a pulsatile blood flow inlet at the proper hepatic artery (PHA) (Fig. 1C) and an outflow distribution according to Aramburu's methodology [1]. Microparticles (diameter: 40 µm, density: 1600 kg/m^3) were injected during the third cycle. Target specificity (TS) was evaluated as the particle fraction exiting the computational domain through left lobe branches.

Injecting particles in the PHA, before the first bifurcation (Fig. 1A), resulted in a TS of 64.94%. However, injecting particles in the left hepatic artery (LHA, Fig. 1B), increased the TS to 93.62%. With regards to injection timing, the ideal 0.1s injection interval for injection in the PHA was identified as 1.9-2s (TS: 70.56%), and as 2.05s-2.15s (TS: 95.75%) for injection in the LHA (Fig. 1C).

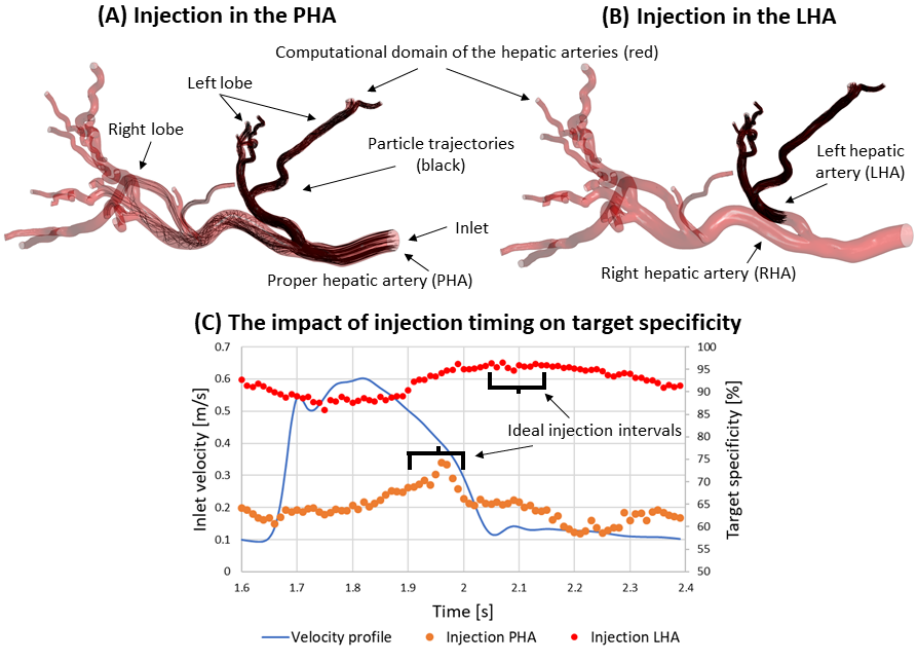

Fig. 1: Injection in the (A) PHA and (B) LHA of the patient-specific computational domain. (C) Target specificities are displayed for injection at every 0.01s (1.6s-2.4s) in the PHA (orange) and the LHA (red). Ideal 0.1s injection intervals are given (black). Inlet velocity profile for blood is displayed (blue).

Towards the future, these simulations can be part of a personalized treatment optimization protocol to determine ideal injection conditions for each patient, also including other parameters such as particle properties, injection velocity, etc.

[1] Aramburu J, et al. "Liver cancer arterial perfusion modelling and CFD boundary conditions methodology". Int J Numer Method Biomed. 2016;32(11).