Targeted drug delivery for liver cancer: modelling the impact of cancer burden on the particle distribution

Hepatocellular carcinoma (HCC) is the most common liver malignancy in the world. HCC patients for whom resection is not possible can be treated by transarterial chemo-embolization (TACE). In TACE, particles are injected in the feeding arteries of the tumour which permanently damage the tumour tissue. Since the goal of TACE is to steer particles towards the tumour tissue and limit the toxicity for healthy tissue, target-specificity is a key parameter. The target-specificity of the proposed therapy can be estimated by simulating the particle distribution in the patient-specific geometry using computational fluid dynamics. Using these simulations, the set of injection parameters (injection location, injection velocity, etc.) which maximize particle deposition at the target site can be identified for each patient. The goal is to tailor the therapy to each patient specifically.

In this study, the impact of cancer burden on the blood flow and the particle distribution throughout the arterial tree was investigated. A detailed dataset of a patient-specific cirrhotic liver vasculature was obtained by combining vascular corrosion casting and micro-CT imaging. The arterial network of the liver was segmented and the resulting 3D geometry was meshed. Simulations were run for eleven different cancer scenarios, each varying in total cancer burden and tumour nodule locations. Cancer tissue was modelled as having over a four-fold increase in arterial perfusion as compared to healthy tissue [1].

The results show that cancer burden has a substantial impact on the blood flow and particle distribution in patient-specific geometries. For the non-cancerous case, 16.58% of particles reached the left lobe of the liver. For cases in which tumour nodules were modelled in the left lobe, this fraction increased from low cancer burden (32.41%) to high cancer burden (69.77%). For cases in which tumour nodules were constricted to the right lobe, this fraction decreased from low cancer burden (13.61%) to high cancer burden (6.46%). It is clear that cancer burden is an important parameter to consider in simulating particle distribution for TACE.

[1] J. Aramburu et al, “Liver cancer arterial perfusion modelling and CFD boundary conditions methodology”, 2016.