TARGETED DRUG DELIVERY FOR LIVER CANCER: THE IMPACT OF CANCER BURDEN ON THE PARTICLE DISTRIBUTION IN A PATIENT-SPECIFIC GEOMETRY

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1. INTRODUCTION

Hepatocellular carcinoma (HCC) is the most common liver malignancy in the world and the third leading cause of cancer-related deaths. HCC patients for whom resection is not possible can be treated by transarterial therapies such as chemo-embolization (TACE). In TACE, particles are injected in the feeding arteries of the tumour of which the combined embolic and chemo-therapeutic effects damage the tumour tissue. Since the goal of the therapy is to direct particles towards the tumour tissue and limit the spread to healthy tissue, target-specificity is a key parameter of TACE. In this study, computational fluid dynamics simulations are used to estimate the impact of size and location of tumor nodules on the particle distribution in the liver.

2. MATERIALS AND METHODS

A detailed dataset of the cirrhotic liver vasculature was obtained by combining vascular corrosion casting and micro-CT imaging. The arterial network of the liver was segmented using Mimics (Materialise, Leuven, Belgium). The resulting geometry was smoothed and a surface mesh was created in 3-matic (Materialise, Leuven, Belgium). A volume mesh was created in ICEM (Ansys Inc. Canonsburg, USA). Steady-state simulations were run in Ansys Fluent (Ansys. Inc, Canonsburg, USA). The Discrete Phase Model (DPM) was used to simulate particle transport. Regarding the boundary conditions for the simulations, the arterial perfusion model as proposed by Aramburu et al [1] was used to define the fractional outflow of fluid at each outlet of the computational domain. Particle tracks were processed in CFD-Post (Ansys. Inc, Canonsburg, USA) and MATLAB.

3. RESULTS AND DISCUSSION

Particle Release Maps (PRM; Figs. 1 and 2) are helpful planar visualizations of the inlet cross-section where particles are injected. The green color denotes the targeting region where particles need to be injected in order to reach the tumor tissue. Injection of particles in the red region leads to unwanted particle deposition in the healthy tissue.

In Figure 1, the PRM is given for a cancer scenario in which a large tumour in the left lobe (1130 ml) was modelled. In Figure 2, the PRM is given for a scenario in which a small tumour in the left lobe (150 ml) was modelled. It is obvious that the ideal targeting regions differ heavily between the two scenarios.

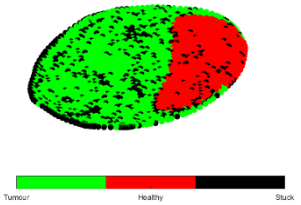

Figure 1: PRM – large tumour in left lobe

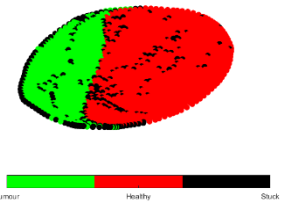

Figure 1: PRM – small tumour in left lobe

The arterial perfusion model as proposed by Aramburu et al [1] shows that global and local cancer burden play an important role in assessing downstream particle distribution.

References

[1] J. Aramburu, R. Anton, A. Rivas, J. Ramos, B. Sangrio and J. Bilbao, "Liver cancer arterial perfusion modelling and CFD boundary conditions methodology" *International Journal for Numerical Methods in Biomedical Engineering,* vol. 32, no. 11, 2016.