TOWARDS A SURGICAL PLANNING PLATFORM FOR THE ABLATION OF LIVER TUMOR BY FOCUSED ULTRASOUND

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Liver cancer is one of the leading causes of all death over the world [1, 2]. At an early stage liver cancer can be successfully treated with surgery or liver transplantation. For a patient diagnosed at an advanced stage of disease fewer surgical options are available. High intensity focused ultrasound (HIFU) is a rapidly developing medical technology for a non-invasive tumor ablation therapy in various organs of the body. The main mechanism of tissue ablation is thermal coagulation. Temperature 56 ^{0}C for one second heating causes irreversible tissue damage and this fact is the explanation for the ablation of tumor. Blood flow cooling is one of the difficulties in the thermal treatment of liver cancer. Large blood vessels (hepatic arteries, hepatic veins and portal veins) act as heat sink. Convective cooling can reduce the necrosed volume and cause consequently the recurrent cancer. If the vital blood vessels adjacent to the tumors are severely damaged during the treatment, lethal complications may develop. The prime objective of this study is to achieve a virtually complete necrosis of tumors close to major blood vessels and to avoid blood vessel damage.

The three-dimensional (3D) acoustic-thermal-hydrodynamic coupling model is proposed to compute the pressure, temperature, and blood flow velocity [3, 4]. For the modelling of acoustic propagation in the tissues a compressible system of Navier Stokes equations has been considered with relaxation effects being taken into account. Numerical modeling is conducted by the finite difference method on a non-staggered grid. We develop a scheme with the numerical group velocity that agrees perfectly with the exact group velocity in the grid stencil of interest. The proposed numerical scheme is also symplectic. Bioheat equations in both the hepatic parenchyma and blood vessels are considered. The incompressible nonlinear Navier–Stokes equations related to mass and momentum conservations in large hepatic blood vessels are employed both for convective cooling and acoustic streaming. The 3D problem is solved using the finite-volume method [4]. The model has been validated by comparing the predicted results with the experimental data [5]. It is the first comparison study between the three

dimensional simulated and measured temperatures in real tissues.
The proposed model was conducted in a patient specific geometry (Fig. 1). The volume mesh for the liver, solid tumor, hepatic and portal veins was reconstructed from the CT images [6]. The current work is promisingly to be considered as a first step towards the development of HIFU treatment planning platform. Numerical simulations performed on a patient specific geometry can play an important role in training medical doctors, predicting and planning liver tumor surgery.

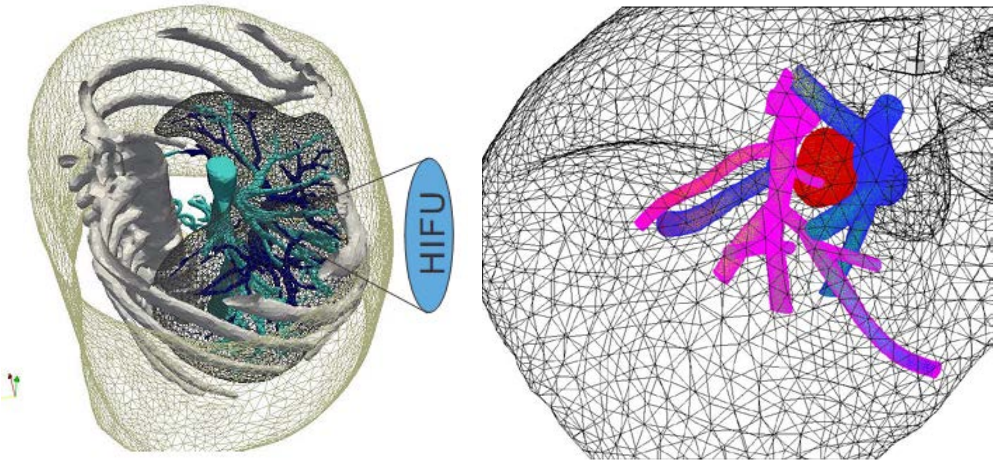

Fig. 1. (a) Patient specific 3D geometry reconstructed from CT image. (b) Mesh of the liver (black) with a tumor (red), hepatic (pink), and portal (dark blue) venous networks.

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