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LIVER HEMODYNAMICS MODELING DURING PARTIAL HEPATECTOMY

C. Audebert [1,2,*], J-F. Gerbeau [1,2], and I.E. Vignon-Clementel [1,2]

[1]INRIA Paris-Rocquencourt, 78153 Le Chesnay, France
[2] UPMC Université Paris 6, Laboratoire Jacques-Louis Lions, 75005 Paris, France

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The present work aims at developing a mathematical model in order to simulate hemodynamics changes due to liver surgeries. The liver is an organ, which has a remarkable regeneration capacity. To heal some pathologies, partial hepatectomy - a partial ablation of the liver - is required. For a healthy human liver, the ratio of remaining liver volume to total liver volume must be at least 20 to 25% for good regeneration, but sometimes more would need to be resected. The liver has a complex blood perfusion, and when partial hepatectomy is performed the remaining liver experiences important hemodynamics changes. These are hypothesized to be a key reason for the non-functional regeneration of the liver. Hence, surgeons and patients could benefit from computational simulations that model liver hemodynamics after partial hepatectomy.
To our knowledge very few mathematical modeling works exist on liver hemodynamics mathematical modeling. Chu and Reddy proposed a multi-compartment 0D model (an electric analog relating pressure and flow in the blood circulation) of the splanchnic circulation [2]. Their work shows that a vena cava pressure increase leads to portal hypertension and increases liver interstitial fluid volume. In [3], Rypins *et al.*, proposed a Wheatstone bridge model for the splanchnic circulation modified with a variable resistance. The resistance value is manually changed to represent a portocaval H-Graft of different diameters. They predict the portal flow for different portocaval H-Graft diameters. Debbaut *et al.* worked on modeling the impact of partial hepatectomy on a rat model [1]. 3D reconstructions of rat liver cast vasculatures were the basis of a morphometric resistive model. To tune the models, mean measurements from literature were used.

In this work, temporal dynamics for blood flow and pressure are considered. A 0D model of pig liver hemodynamics will be presented in order to simulate partial hepatectomy and to predict some post-surgery important hemodynamics indicators. During experimental hepatectomy changes in the hepatic arterial flow curve over time are observed. A better understanding of these changes can be useful to have a better understanding of the liver

structure after regeneration. The 0D model is used in an effort to explain the observations done during pig surgeries. Moreover, a 0D model of the rest of the blood circulation is developed and coupled with the 0D liver model to take into accounts the effects of the global circulation during the surgery.
Next, a model sensitivity analysis is carried out and inverse problems are studied in order to find parameters in such a way that model outputs are in good agreement with preoperative experimental results. The inverse method is based on the unscented Kalman filter algorithm [4].
The parameter identifiability is first demonstrated analytically on the simplest 0D model, if one assumes that the model correctly represents the data. Then, sensitivity analysis and parameter identification are performed on synthetic data with the full 0D liver model. The experimental measurements are then considered. The primary results indicate that the model is able to predict hepatic arterial mean flow post hepatectomy in good agreement with experimental values. The predictability of the model for the flow waveform will be discussed.

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