Parallel Session

Physiology V

EXPERIMENTAL AND CFD NUMERICAL SIMULATIONS OF STENOSIS AND ATHEROSCLEROSIS OCCURRING IN VESSEL BRANCHES

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Keywords: Computational Fluid Dynamics, Atherosclerosis.

Cardiovascular diseases leading cause of dead globally and very large portion is attributed to atherosclerosis. Understanding hemodynamics in blood circulation is crucial in order to unveil the mechanisms underlying the formation of stenosis and atherosclerosis. In fact, there are experimental evidences pointing out to the existence of some given vessel configurations as blood vessel bifurcations that are more likely to develop the above mentioned pathologies. We performed an exhaustive investigation in a simplified model aiming to characterize by means of physical quantities those regions and configurations in vessel bifurcations that are more likely to develop such pathologies. The two-fold analysis is based, on the one hand, on numerical simulations (via CFD) and, on the other hand, on experiments realized in an ad-hoc designed polydimethylsiloxane (PDMS) channel with the appropriate parameters and appropriate fluid flows. The results obtained demonstrate that low velocity regions and low shear stress zones are located in the outer walls of bifurcations. In fact, we found that there is a critical range of bifurcation angles that is more likely to vascular disease than the others in correspondence with some experimental evidence. The effect of the inflow velocity on this critical range is also analyzed [1].

Furthermore, when the plaque is formed, nano-particles are used as drug vehicles trying to reach the target zones. Preliminary investigations have shown that efficacy of carriers for drug delivery depends on their ability to marginate (localize and adhere) to the atherosclerotic vessel wall. In this regard, we will show numerical and in vitro results with the aim of understand nano-and-microparticle behavior of blood flows through a stenosis vessel. The role of the interaction with the RBCs and the influence of variables as stiffness, shape and size in their margination will be analyzed.

Acknowledgements: We gratefully acknowledge financial support by the Spanish Ministerio de Economía y Competitividad and European Regional Development Fund under contract MAT2015-71119-R AEI/FEDER.

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Parallel Session

Physiology V

LONG TIME BEHAVIOR FOR SOME CONTINUOUS POLYMERIZATION MODELS

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Keywords: Polymerization, Neurodegenerative diseases, Transport-fragmentation equations, Lifshitz-Slyozov equations, Long-time behavior.

The aggregation and deposition of misfolded proteins is believed to play an important role in the development of the so-called amyloid diseases (e.g. mad cow disease). Experimental evidence coming from *in vitro* polymerization experiments shows that protein aggregation alone cannot account for the observed dynamics. This points to the existence of secondary reaction pathways. Transport-aggregation partial differential equations (PDEs) have appeared recently as modeling tools in this area. We analyze the long time behavior of several PDE polymerization models that incorporate a number of additional mechanisms: nucleation, depolymerization and/or fragmentation. Then we discuss to what extent the predicted behavior matches experimental observations, which can help to understand the relative contribution of each of the former mechanisms to the observed dynamics.

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SIMULATING VESSEL GROWTH WITH EXTRACELLULAR MATRIX REMODELING

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Keywords: Angiogenesis, Phase-field.

Sprouting angiogenesis, where new blood vessels grow from pre-existing ones, is a complex process where biochemical and mechanical signals regulate endothelial cell proliferation and movement. Therefore, a mathematical description of sprouting angiogenesis has to take into consideration biological signals as well as relevant physical processes, in particular the mechanical interplay between adjacent endothelial cells and the extracellular microenvironment. We introduce a phase-field continuous model of sprouting angiogenesis capable of predicting sprout morphology as a function of the elastic properties of tissues and the traction forces exerted by cells. The model is very compact, only consisting of three coupled partial differential equations, and has a clear advantage of a reduced number of parameters. This model allows us to describe sprout growth as a function of the cell-cell adhesion forces and the traction force exerted by the sprout tip cell. Importantly, we are also capable of simulating the remodeling process that the extracelular matrix undergoes due to the action of matrix metalloproteinases that degrade the collagen in it, allowing the new sprout to advance, giving rise to longer vessels. A set of rules regulates the function that each endothelial cell has in the modelled system, either migratory or proliferative.

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Parallel Session

Physiology V

FLOW CONTROL WITH APPLICATIONS TO HEMODYNAMICS

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Keywords: Optimal control, Data assimilation, Hemodynamics.

Optimal control problems have made great strides in the last few decades mainly motivated by engineering applications. In particular, applications of optimal control techniques to fluid flows have been a subject of great interest to researchers in the field. In the context of fluid flow, we are interested in its application to the mathematical modeling of blood flow in the cardiovascular system. An optimal control problem was defined taking a convenient cost functional, complemented with suitable boundary conditions prescribing a Dirichlet control at the inlet boundary. The goal is to obtain numerical solutions to the proposed problem implementing Data Assimilation techniques in a variational approach. The obtained results should coincide, whithin a certain error, to observed data measured at certain parts of the domain. These techniques were shown to have successfully reconstructed the blood flow profile even in the presence of noisy data. For details in this subject see, for example, [1, 2, 3, 4, 5].

Acknowledgements: This work has been partially supported by FCT (Portugal) through the Research Center CEMAT-IST, the grants SFRH/BPD/66638/2009 and SFRH/BPD/109574/2015 and the project EXCL/MAT-NAN/0114/2012

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