Toward a novel approach to the mathematical modeling of atherosclerosis

Adélia SEQUEIRA

Affiliation: Department of Mathematics and CEMAT, Instituto Superior Técnico, University of Lisbon, Portugal

email: asequeir@math.tecnico.ulisboa.pt

Cardiovascular diseases, such as heart attack and stroke are responsible for more deaths than cancer in developed countries, and one of the major underlying causes for these events is atherosclerosis, a slow and complex disease that leads to the formation and eventual rupture of atherosclerotic plaques affecting large and medium sized arteries in the systemic circulation. Atherosclerosis is a chronic in inflammation that starts when low-density proteins cholesterol (LDL) enter the intima of the blood vessel where they are oxidized. The anti-inflammatory response of oxLDL triggers the response of monocytes that are transformed into macrophages and foam cells, leading to the production of inflammatory cytokins and further recruitment of monocytes. This complex process generates the formation of an atherosclerotic plaque and possibly its rupture (vulnerable plaques). Clots can be formed, they are carried in the bloodstream and can block the coronary vessels, the cerebral arteries, or even reduce or block blood supply to the legs. This is a silent disease with a long preclinical period that only produces symptoms when the artery is harshly narrowed and the obstruction occurs, resulting in severe complications.

Mathematical modeling and numerical simulations are important tools for a better understanding of atherosclerosis and subsequent development of more effective treatment and prevention strategies. Mathematical models of the atherosclerosis processes lead to complex systems of nonlinear partial differential equations of flow, transport, chemical reactions, interactions of fluid and elastic structures, movement of cells, coagulation and growth processes and additional complex dynamics of the vessel walls. Several theories have been developed to describe the pathogenesis of atherosclerosis but none of them can explain the whole process due to the large number of factors involved. In the recent times some simplified mathematical models have been used to study certain aspects of this complex process but more realistic and comprehensive mathematical models still need to be derived to describe the complete process of atherosclerosis.

In this talk we present a new mathematical model that captures essential features of the early stage of atherosclerosis development.

This is based on a joint work with T. Silva, J. Tiago, W. Jäger, M. Neuss-Radu.

References:

[1] T. Silva, J. Tiago, A. Sequeira, R. F. Santos. Existence, uniqueness, stability and asymptotic behavior of solutions for a mathematical model of atherosclerosis, Discrete and Continuous Dynamical Systems, in press, 2015.

[2] T. Silva, J. Tiago, A. Sequeira. Mathematical analysis and numerical simulations for a model of atherosclerosis, Proceedings of International Conference on Mathematical Fluid Dynamics, Present and Future, Y. Shibata et al. (Ed.), Springer Verlag, in press, 2015.