GEOMETRICAL MULTISCALE MODELS OF THE CARDIOVASCULAR SYSTEM

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One of the most challenging aspects in numerical investigations of blood flow problems refers to the so-called geometrically "multiscale" nature of the circulation. Local blood dynamics (and their consequences of medical interest) are strictly related to the systemic dynamic. Numerical investigation of a specific vascular district could be not appropriate for medical purposes if it is not supported by a picture of the whole vascular network, the district at hand is a part of. However, it is not possible (nor useful) to simulate the whole circulation with a 3D Navier-Stokes based model, both for the computational costs and the huge amount of data that would be needed. In this case, we resort to simplified models of the circulation that account for some "average" features of the blood flow in the network. Reduced models can be given by simplified 1D models (Euler-like equations) or by systems of ordinary differential equations (in time) exploiting the analogy between the vascular system and electric networks.

In this talk we will address some mathematical and methodological problems arising when coupling different models in a numerical solver. The treatment of the matching conditions at the interfaces between the different models needs specific techniques depending on the numerical coupling. Different methods will be addressed in the talk. Particular emphasis will be given to the Navier-Stokes system whenever a simplified model (1D or lumped parameters one) provides data on the flow rate on a part of the boundaries of the 3D domain, yielding *defective boundary data problems*. Methods for the reliable numerical solution of these underdetermined problems are addressed.

Recent numerical results will be presented for applications of clinical interest, showing the effectiveness of the multiscale approach. Some examples will be illustrated showing that this approach can be applied to different fields beyond the medical one.

Alessandro Veneziani has been Associate Professor at the Department of Mathematics Politecnico di Milano (Italy) since 2002 and at the Department of Mathematics and Computer Science at Emory University since September 2007. He has been one of the founding members of the laboratory of Modeling and Scientific Computing MOX, under the direction of Alfio Quarteroni. He has been awarded of the SIAM 2004 Outstanding Paper Prize and of the Sacchi Landriani International Prize.