Slip/transpiration boundary conditions for reducing uncertainties in the segmented blood vessel wall

David Nolte, Cristóbal Bertoglio* and Axel Osses

Center for Mathematical Modeling (CMM)
Universidad de Chile
Beauchef 851, 8370456 Santiago, Chile
e-mail: {dnolte,cbertoglio,aosses}@dim.uchile.cl, web page: biomed.cmm.uchile.cl

ABSTRACT

Phase-Contrast Magnetic Resonance Imaging (PCMRI) allows velocity measurements of blood flows non-invasively. These can be used to reconstruct 3D velocity and pressure gradient fields within a data assimilation framework including the incompressible Navier-Stokes equations [1] by estimating boundary conditions parameters. While boundary conditions representing the up- or downstreams vessels have been well studied, all models reported considered non-slip boundary conditions on the vessel wall. Unfortunately, in the case of computational geometries obtained from medical imaging, the arterial wall cannot be known precisely, where an uncertainty in its location of at least the size of the image voxel is present. This introduces a challenge from the modeling point of view, since applying a non-slip boundary condition in the wrong location induces to important errors in the pressure gradients, in particular in pathological vessels.

In this presentation we will introduce a strategy to cope for this uncertainties in the wall of the computational geometry, consisting of two main key ingredients: (a) Using slip [2] and transpiration boundary conditions instead of non-slip on the (computational) arterial wall, and (b) estimating the slip and transpiration parameters from velocity measurements with a similar amount of error (noise, spatial subsampling) than we expect in the geometrical image. The numerical examples show how this approach can effectively reduce the errors coming from errors in the segmentation of the geometry with respect to the classical non-slip approach at various Reynolds numbers. However, several challenges arise, like the proper spatial parametrization of the slip and transpiration parameters, as well as the sensitivity measurements with respect to the parameters depending on the geometrical configuration.

REFERENCES

[1] DElia, Marta and Veneziani, Alessandro. Uncertainty quantification for data assimilation in a steady incompressible Navier-Stokes problem. *ESAIM: Mathematical Modelling and Numerical Analysis*, Vol. **47**, pp. 1037–1057, (2013).

[2] Navier, Claude Louis. Mémoire sur les lois du mouvement des fluides. *émoires de lAcadémie Royale des Sciences de lInstitut de France*, Vol. **6**, pp- 389–440, (1823).