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Instability of a pulsating flow in a compliant vessel

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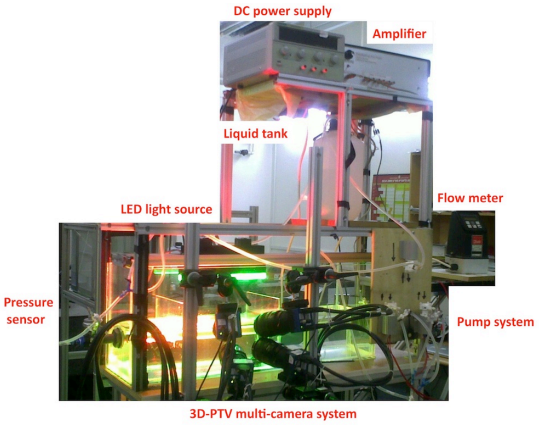
There is an increasing evidence that under certain conditions the flow in blood vessels, which is pulsatile, non-uniform and multi-directional, exhibits increased flow separation effects and turbulence-like flow regimes. A variety of non-intrusive blood flow measurement modalities are capable of detecting the movement of some contrast material injected into the vessel in-vivo, but their application is hindered due to the complex geometry and complex flows. We study the topic using in-vitro model of a pulsatile flow in a compliant tube, applying novel 3D measurement methods.

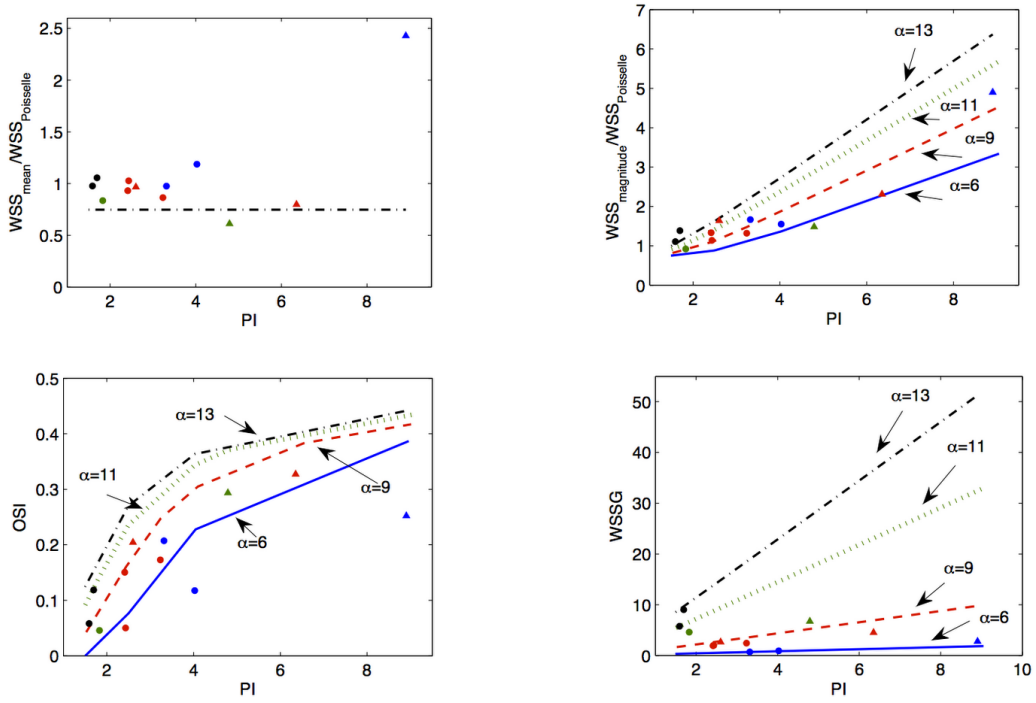
Experimental setup:

Experimental setup consists of a flexible tube installed in a refractive-index matched liquid tank, illuminated by the LED line light source from above. The flow in the tube is seeded with a tiny particles (20-50 micrometers) which motion in the tube is recorded in real-time using the 500 frames-per-second CMOS cameras. The four cameras recording the flow simultaneously, enabling access to the multi-directional and non-uniform flow patterns in the pulsatile flow. The photograph of the experimental setup is given below in Figure 1. In addition to the flow visualization and quantitative imaging methods (PIV and PTV), the pressure drop along the flexible tube and the flow rates are monitored.



Results:

In the following we combine in a single plot the experimental and simulation model results showing the drastic changes in the wall shear stress (WSS) and its gradient (WSSG), as well as an oscillating index (OSI) in a variety of pulsatile flow settings with the variation of the pulsatile index (PI) - the ratio of forward to backward flow rate. At some settings the extreme deceleration-acceleration phases lead to off-wall reversal flow regimes and apparently inertial (tubulent-like) regimes of the flow that lead to high instantaneous wall shear stresses.



Preliminary resuls are published in the proceedings of the Euromech Colloqium 529 “Cardiovascular Fluid Mechanics”, June 2011, Cagliari, Italy. Program [PDF]