Flow behavior and blockage effects in stenosed arteries

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Flows, both steady and pulsatile, through a circular tube with an axisymmetric blockage of varying size are studied experimentally and numerically. Selected as an idealized model of a stenosed artery at various points in its development, the geometry consists of a long straight tube and a blockage, semi-circular in cross-section. The stenosis has been simplified to a single-parameter blockage in order to highlight fundamental behaviors of constricted flows. Experimentally, a water flow is considered inside a tube of 19 mm diameter, which has an unblocked length of 2 m both upstream and downstream of the blockage. The flow is characterized using dye visualisations and Particle Image Velocimetry. These results are complemented by spectral-element numerical simulations.

The study initially looks at steady inlet flows, using them as a limiting case for pulsatile flow. At low Reynolds numbers, the flow is characterized by a jet emanating from the constriction, surrounded by an axisymmetric recirculation zone, the length of which increases linearly with Reynolds number. Our numerical results indicate a critical Reynolds number threshold for absolute instability, while our experiments point to the existence of convective instabilities at lower Reynolds numbers.

Flows subject to a pulsatile inlet condition, which more closely describe the type of flow found in the cardiovascular system are also investigated. With a particular focus on the effects of the blockage size, we investigate the stability of such flows, transition to turbulent flow and also other physical properties pertinent to cardiovascular fluid mechanics, such as wall shear stress.