Bachelorarbeit / Bachelor Thesis

Numerical investigation of Dean vortices in the aorta

An aortic dissection is a serious condition caused by a tear in the inner layer of the aorta, the large blood vessel branching off the heart (Fig. 1). Due to the pulsation of the heart, blood surges through the tear, which causes the inner (intima) and middle (media) layers of the aorta to separate (dissect) (Fig. 2). Due to the pulsation of the heart, the newly created cavity, the so-called false lumen, grows around the aortic branch. If the blood-filled false lumen ruptures through the outer layer (adventitia) of the aortic wall, aortic dissection is most likely fatal.
The course of the disease depends on the local haemodynamics in the original vessel (true lumen) and the false lumen, for which one decisive factor is the shear stress imposed at the cell walls due to the blood flow.
Blood is a non-Newtonian fluid, which means that its response to deformation depends on the local flow field. Its viscosity depends on the rate of deformation (shear rate), and so does the shear stress.

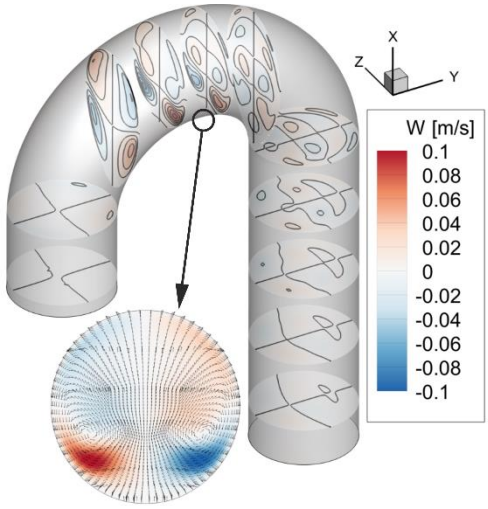

Fig. 1 Visualization of the counter-rotating vortex pair (Dean vortices)

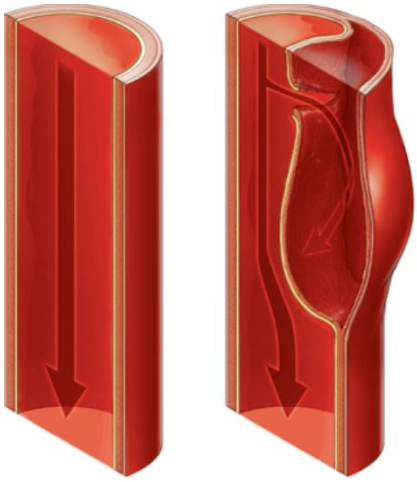

Fig. 2 Healthy aorta (left), Dissected aorta (right) (Brunicardi, et al. (2015))

In flows through bent tubes, with geometries representing an abstracted aorta, the formation of two counter-rotating (Dean) vortices is a well-known flow phenomenon (Fig. 1). Their existence depends on the ratio of inertial and centrifugal to viscous forces (Dean number). Numerical flow simulations are used to investigate their formation and their vorticity, based on a rheological model for the fluid viscosity taking the shear rate-dependent behaviour into account. To this fundamental differentiation, the influence of the existence of a false lumen at different viscosities (based on different volume percentages of red blood cells in blood) on the vortex pair is investigated.

Tasks

- Evaluation of the fundamental differences in the formation of vortices due to a rheological model
- Influence of different viscosities on the formation of the vortices for an idealized aortic model with false lumen

We offer

- Scientific supervision of high quality
- An international and dynamic working atmosphere
- Access to all required facilities of the institute

The project will be accomplished at the Institute of Fluid Mechanics and Heat Transfer (Institut für Strömungslehre und Wärmeübertragung). The project can start at any time. If interested, please contact

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