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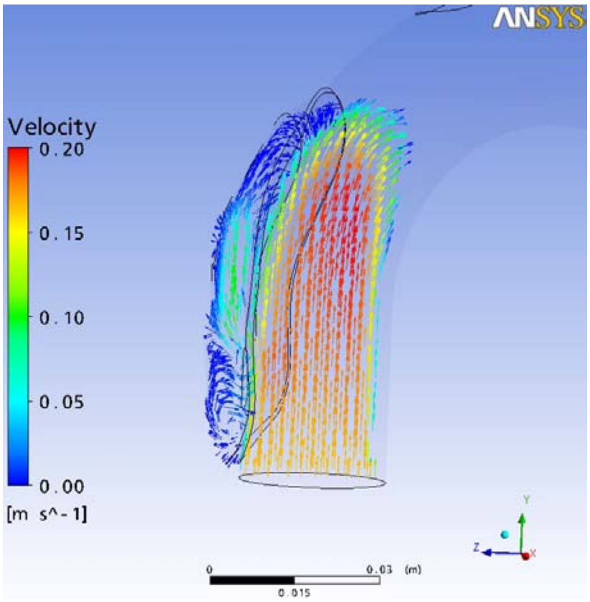
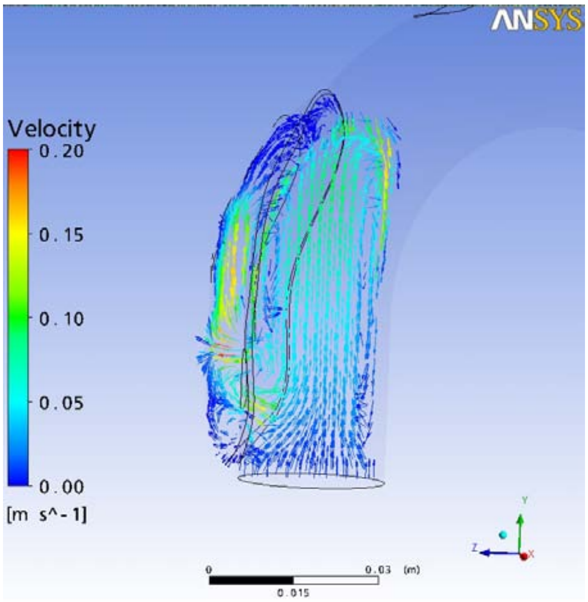
Investigation of a fluid flow in a model ascending aorta with dissection

An aortic dissection as one of possible diseases of the blood circulation system is investigated from the clinical point of view since many years [1]. As the cardiac surgery techniques and methods undergo very rapid development [2], at the same time many questions arise that have to be regarded not only from the medical but also from the engineering perspective. Exactly the influence of a dissection lamella on the changes in a blood flow pattern within the aorta has to be investigated in more details. This obstacle induces additional disturbances in the blood pumped out from the left ventricle. The fluctuations of the blood velocity in the aorta cause significant variations in the pressure distribution that affect the load acting on the tissue. In order to investigate such phenomena both experimental and numerical methods [3] can be applied. The current study aims at the visualisation and analysis of the fluid flow behaviour in a model ascending aorta with dissection by means of both experimental and numerical approach.





The experimental determination of the fluid velocity in the model ascending aorta is carried out using Particle Image Velocimetry (PIV). For the numerical simulation of the fluid flow the solver based on the Finite Volume Method implemented in the ANSYS CFX framework is used. Hereby both Newtonian and non-Newtonian fluid properties are applied. The non-Newtonian characteristic of the blood is modelled with the Ostwald–de Waele power law and Casson model.

This project contributes to the knowledge about the fluid dynamical behaviour of blood in the ascending aorta with dissection. The influence of the dissection lamella on the velocity distribution in the aorta can be visualised with sufficient resolution using both experimental and numerical approach. Additionally, the shear and normal stresses acting on the tissue are analysed. Having the flow characteristics on both sides of the obstacle and the material properties of the lamella, the prediction of an appropriate stent graft deployment that rebuilds the cross sectional area of the aorta to its original state is possible. The results of this study help also by the optimal placement of stents in the blood vessel. Moreover, they characterise the conditions for the development of an innovative and patient specific treatment strategies as well as cardiac implants. In the next step the patient specific data relating to the real geometry of the aorta will be used to perform the numerical analysis of the blood flow.

References

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