Report on UK Fluids Network Short Research Visit 'Identifying key anatomical features that affect blood flow in the pulmonary arteries of congenital heart patients', July 2019

Miss Maria Boumpouli (Department of Biomedical Engineering, University of Strathclyde, group of Dr Asimina Kazakidi) visiting Dr Silvia Schievano, UCL Institute of Cardiovascular Science & Great Ormond Street Hospital for Children, London and locally supervised by Dr Emilie Sauvage and Dr Claudio Capelli. The purpose of the visit was to investigate geometrical/anatomical variations in pulmonary arteries of patients born with congenital heart disease.

Maria completed her 1-month SRV in July 2019 investigating seven cases of Tetralogy of Fallot (TOF) patients. Children born with this congenital heart disease are diagnosed with four defects: a ventricular septal defect, an overriding aorta, hypertrophy of the right ventricle and pulmonary artery stenosis. Although they are operated in early years, they are at risk of chronic complications, and therefore, we would like to understand how geometrical variations in the pulmonary arteries affect the blood flow in this population of patients. MRI and PC-MRI flow data were analysed, leading to the reconstruction of 3D patient-specific models, and the extraction of patient flow information at the boundary of the flow domain. A major aspect of the project was the set up of the workflow in order to run a complete blood flow simulation in the reconstructed models using the open-source solver OpenFOAM (https://openfoam.org/). Simulations were completed in one TOF case and a wide range of boundary conditions were explored, due to the complexity of the case and the time constrains. Initially, the simplest case of a uniform velocity at the inlet was tested and then gradually moved to more complex velocity boundaries, with time and space dependency introduced to the simulations. Preliminary results of velocity streamlines in the pulmonary bifurcation under a steady, parabolic inlet flow are presented in Fig.1. Recirculation areas are apparent in both branches of the bifurcation.

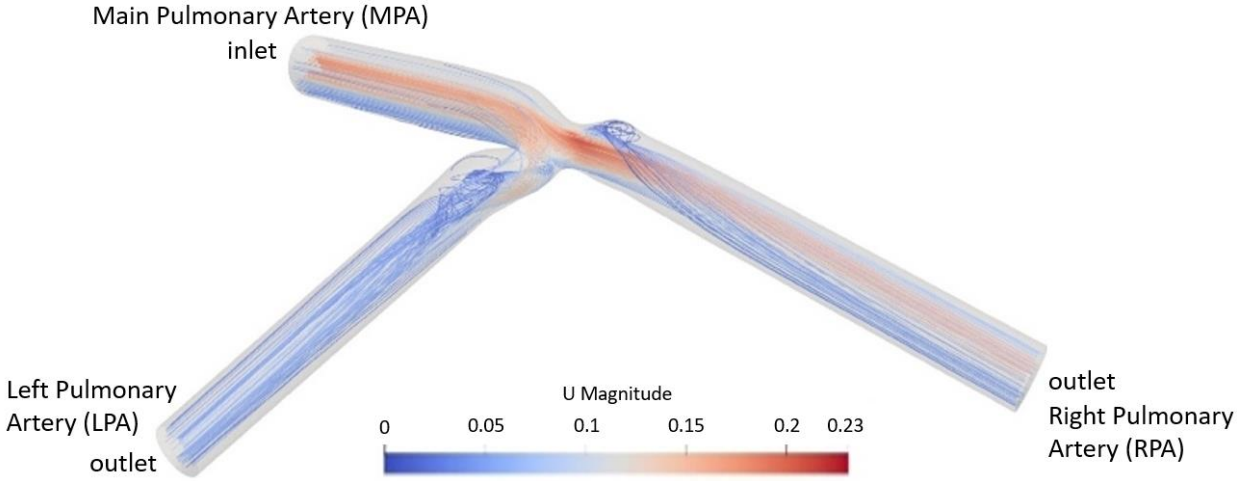

Figure 1: Streamlines of velocity for one of the Tetralogy of Fallot cases. A parabolic velocity was assigned at the inlet boundary.

This research visit has initiated a new collaboration between the two parties involved in the project. The objective of this work is to better understand how variations in the geometrical features of the pulmonary arteries affects the performance of the heart, and to improve the boundary conditions used in such simulations. We would like to run simulations using patient-specific 3D velocity profiles at the inlet boundary, taking also into account the pulmonary vascular resistance. Overall, this funding provided the opportunity for the establishment of a new and prospective collaboration between the groups of the University of Strathclyde and University College London. On a personal level, my visit in London was an incredible experience that gave me the chance to work and learn from lead researchers in the field, make new collaborators and friends.