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PATIENT-SPECIFIC BLOOD FLOW SIMULATIONS IN THE PULMONARY BIFURCATION OF PATIENTS WITH TETRALOGY OF FALLOT

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Dysfunction of the pulmonary valve and narrowing of the branch pulmonary arteries are common chronic complications in adult patients with tetralogy of Fallot; the most common cyanotic congenital heart disease with an estimate prevalence 1 in 3000 live births. Clinical consequences include, but are not limited to, abnormal lung development and elevated pulmonary vascular resistance. It is, therefore, crucial to better understand and characterise the haemodynamic environment in the pulmonary bifurcation to better diagnose and treat these patients. In this study, we have focused on investigating the blood flow dynamics in patient-specific geometries of the pulmonary bifurcation by means of computational models.

3D geometries of the pulmonary junction were reconstructed from MRI images of seven patients with tetralogy of Fallot. Unsteady flow data of the same patients, retrospectively acquired with phase-contrast MRI, were also prescribed at the inlet of the main pulmonary artery. Wall shear stress values around the pulmonary junction, velocity distribution and pressure ratios were evaluated from the computational model. The calculations were performed considering an incompressible Newtonian fluid governed by the Navier-Stokes equations, using a validated finite volume scheme in OpenFOAM®.

There was a great variation in the morphology of the pulmonary bifurcation among the patients, and blood flow development was highly dependent on such local characteristics. The presence of branch narrowing appeared to have a large effect in the haemodynamic environment and wall shear stress values. Finally, certain anatomies were associated with larger areas of stagnation, which may have an important clinical impact, by promoting thrombus formation.

This study enhances our understanding of the flow development in the pulmonary bifurcation of tetralogy of Fallot patients. To confirm these findings, future work will include a larger cohort of patients and possibly the correlation of the flow results with clinical outcomes.

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