MP3-6

Computational Fluid Dynamics in complex pulmonary artery stenosis

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Introduction:
Pulmonary artery (PA) stenosis is common in congenital heart diseases. Understanding flow patterns and hemodynamic parameters is essential to improve diagnosis and treatment for PA stenosis. Studying flow is challenging as current imaging techniques fail to provide a complete overview of all hemodynamic parameters. Computational Fluid Dynamics (CFD) is a tool mainly used in (medical) engineering to study flow characteristics. It enables visualization of complex flows and provides detailed information on flow velocities, wall shear stress (WSS), energy losses and turbulence. Our objective was to create a CFD model for patient specific flow evaluation in complex PA stenosis.

Methods:
A 3D patient specific model was created for 4 cases. The PA bifurcation was isolated by manual segmentation of DICOM files obtained by 3DRA during catheterization. The model was manually smoothened, peripheral pulmonary arteries were removed and a mesh was generated. Individual transient mass flow inlet and pressure outlet boundary conditions were defined. Cases were solved and post-processed using ANSYS Fluent (ANSYS Inc, Canonsburg, Pa). Convergence was accepted at residuals <1e-4.

Results:
All cases showed flow acceleration over the stenotic areas. WSS was unequal distributed and there was major energy loss over the stenosis. Turbulence was seen in areas with low flow velocity and in vessels with post-stenosis dilation. Velocity and pressure outcomes for each case were comparable with echographic and catheterization data. Time from pre-processing to post-processing varied between 10 and 13 hours.

Conclusions:
Patient specific CFD analysis creates a better understanding of hemodynamic parameters and flow characteristics in complex PA anatomy. This allows for evaluation of different treatment options and may provide insight in mechanisms causing re-stenosis after PA stenting. The used method generates realistic outcomes which are comparable to values obtained by other imaging techniques. In order to further improve the model stent simulation and compliance should be considered in future analysis.

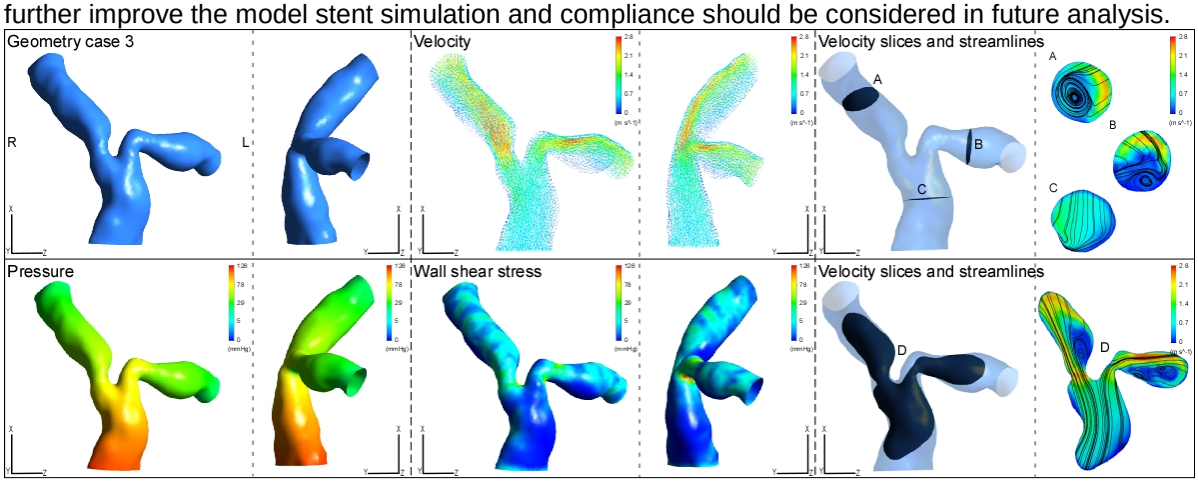

Figure 1: CFD analysis of the right (A), left (B) and main (C) PA of a patient with severe stenosis. Velocity, pressure and WSS outcomes are shown. The right images show flow patterns and velocity contours on slices through A, B, C and D.