FROM CTA TO PERSONALIZED REDUCED ORDER MODEL FOR MODIFIED BLALOCK TAUSSIG SHUNT PATIENTS

The Modified Blalock Taussig Shunt (mBTS) is one of the most common palliative operations in the case of cyanotic heart diseases. To date, the decision of the position, the size and the geometry of the shunt rely on the clinicians' experience [1]. Although Computational Fluid Dynamics (CFD) can serve in the prediction of the blood flow behaviour, the numerical investigation in different geometrical cases is computationally demanding and difficult to be inserted in a clinical scenario. In this context, new computational strategies based on the coupled use of the Reduced Order Model (ROM) and mesh morphing techniques can offer a new perspective on the decision-making process. This study aims to propose the creation of a patient-specific preoperative interactive CFD environment to predict the effect of the shunt's geometry on the hemodynamic parameters.

In this study, a patient's Computed Tomography (CT) dataset was used and segmented through a specific neural network-based algorithm [2]. Afterwards, the suturing positions of the mBTS were defined on both systemic and pulmonary branches in the segmented geometries. An average inlet velocity was applied as the inlet condition at the aortic valve, whilst a constant pressure equal to 100 mmHg and 15 mmHg was set as conditions for systemic and pulmonary outlets respectively. The shunt's mesh parameterization was performed through Radial Basis Functions (RBFs) mesh morphing [3]: 12 parameters were introduced enabling the change of the shunt's position, diameter and inclination on the upper, middle and lower segment of the shunt. A Design of Experiments dataset with 150 samples was evaluated through CFD and then used to feed the ROM creation. During the building of ROM, the least number of scenarios guaranteeing the least accuracy reduction was adopted.

The calculation of the digital twin's snapshots took 6.5 hours running on 24 cores. The prediction error of the flow parameters was kept below 0.5%. This accuracy was considered sufficient for the clinical application. The research findings confirm a strong affiliation between the shunt's configuration and the blood flow passing through it.

A semi-automated Medical Digital Twin (MDT) pipeline to enhance the clinical workflow was successfully developed. The evaluation of the flow in the function of the shunt's geometry is satisfactory and compatible with the ones found in the literature. The preliminary results of the ROM show that it is a promising surrogate model for CFD simulations, despite its limited application to one patient up to now.

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References

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