PW2-7

Ventricular flow dynamics in hypoplastic left heart: useful insights from patient specific computer modelling

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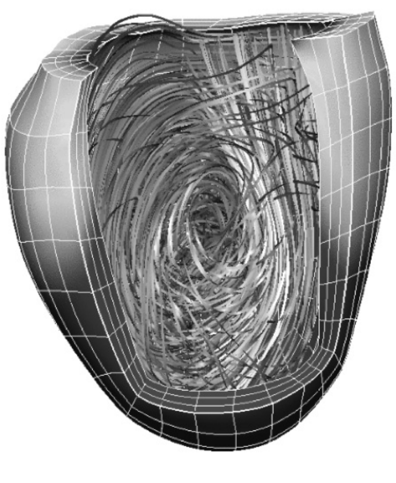
Introduction: The systemic right ventricle (RV) in hypoplastic left heart syndrome (HLHS) is significantly geometrically different from the normal systemic left ventricle (LV) or the systemic RV in a biventricular circulation. Computer modelling allows the construction of a patient specific dynamic heart model allowing visualisation of blood flow patterns in the ventricle.

Methods: Ethical and institutional approval was obtained. Echocardiography was performed under the same anaesthetic as cardiac magnetic resonance imaging (MRI). MRI derived geometries, tissue Doppler, pulsed wave Doppler and speckle tracking were combined with computational tools to produce a patient specific model. The interaction between blood flow and myocardial behaviour was investigated by numerical simulations highlighting the vortex formation mechanism and corresponding energy transfers inside the ventricle. Models from a patient with HLHS were compared to a normal systemic LV.

Results: In diastole the main fluid dynamic feature is the formation of ring vortices inside the ventricle. In the normal ventricle two ring vortices are generated, corresponding to the E- and A-waves. This leads to two peaks of kinetic energy and to a reduced rate of viscous dissipation, reflecting the optimal energy configuration during the formation mechanism (where nearly all the inflow is entrained into the ring vortex). As each vortex shifts towards the apical region pressure waves are generated and the vortex contributes to myocardial displacement. In the dilated RV in HLHS, only one ring vortex is formed in the cavity centre with restricted axial displacement compared to the normal LV. This is associated with reduced pressure gradients and limited apical displacement and velocities, which correlated with the echocardiographic measurements. The higher rate of viscous energy loss in these patients could be linked to the lower energy efficiency of the single vortex, which is unable to absorb additional energy from the inflow and gives rise to a series of secondary swirling structures.

Conclusions: Patient specific modeling allows insights into the flow patterns within the ventricle and may therefore be helpful in understanding why the systemic RV does not perform as well as a systemic LV. Validation with haemodynamic data acquired during MRI catheter procedures is underway.



Hypoplastic Left Heart – Right Ventricle

Normal Left Ventricle