Visualisation of flowpatterns in the Fontan Circulation by 4-dimensional respiratory- and ECG-triggered phase contrast magnetic resonance imaging.

Department of pediatric cardiology, University Hospital Schleswig Holstein, Campus Kiel, Germany (1); Brigham and Women's Hospital, Harvard Medical School, Boston, USA (2)

BACKGROUND: Evaluation of blood flow characteristics in total cavo-pulmonary connection (TCPC) with CMR remains difficult due to its strong modulation by respiration, and is not yet entirely understood. New approaches using 4D phase contrast magnetic resonance imaging (4D PC MRI) are promising and can contribute to the understanding of hemodynamics in the Fontan Circulation. Our objective was to visualize and compare flowpatterns in the TCPC using respiratory- and ECG triggered 4D PC MRI.

METHODS: 10 children with hypoplastic left heart syndrome were evaluated after surgical completion of the Fontan-circulation (TCPC with lateral intra-atrial tunnel) in a single center. In all patients one respiratory (80 -100 phases) and one ECG (30 phases) triggered 4D PC MRI covering the whole thorax, voxel size ranging from isotropic 1.53 to 2.03 mm³ were acquired during a single CMR examination. Dedicated commercial and custom-made software was used for detailed analysis and visualization of flowpatterns.

RESULTS: Respiratory-triggered acquisitions revealed significantly higher maximum and lower minimum flow, maximum and minimum velocity in the inferior vena cava and tunnel compared to ECG-triggered 4D PC MRI. Flowpatterns, e.g. expiratory backflow from the left pulmonary artery to the lower intra-atrial tunnel (see fig. 1), that could not be detected on ECG-triggered 4D PC MRI could easily be visualized by respiratory-triggered 4d PC MRI.

CONCLUSION: Respiratory-triggered 4D PC MRI of the TCPC avoids averaging of flow and velocity over the respiratory cycle, resulting in significant differences of blood flow volume and flow velocities to solely ECG-triggered acquisitions. This study suggests that hemodynamics in the TCPC are mainly dependant on respiration, while ventricular function causes only minor modulations of flows in the TCPC connection. 4D PC MRI adds to our understanding of hemodynamics and fluid mechanics in the Fontan-circulation and may help to identify patients at risk for failure.

Fig. 1: Expiratory backflow from LPA