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Ventricular Kinetic Energy in Young Fontan Patients

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Introduction: Four-dimensional (4D) flow magnetic resonance imaging (MRI) enables kinetic energy (KE) quantification of intraventricular blood flow. In this study we aimed to quantify the KE in in patients with univentricular heart and to assess the change in the KE after different types of interventions.

Methods: 4D flow MRI was acquired in patients with Fontan circulation (n=12; median age 12, range 3-29 years) and in healthy volunteers (n=8; median age 26, range 23-36 years). MRI was repeated after transcatheter embolization of significant aortopulmonary collaterals (APC; n=1), after stenting of left pulmonary artery (n=1) and after surgical replacement of hepatic flow tunnel with a Y graft due to significant central pulmonary artery stenosis with secondary formation of arteriovenous (AV) fistulas in the right lung (n=1). Intraventricular KE was calculated throughout the cardiac cycle and indexed to stroke volume (SV).

Results: The systole/diastole ratio of KE in Fontan patients was similar to the ratio of the controls' left ventricle (LV) or right ventricle (RV) depending on the ventricular morphology (Cohen´s kappa=1.0). Peak systolic KE/SV did not differ in patients compared to the LV in controls (0.016 ± 0.006 mJ/ml vs 0.020 ± 0.004 mJ/ml, p=0.09). Peak diastolic KE/SV in Fontan patients was lower than in the LV of the control group (0.028 ± 0.010 vs 0.057 ± 0.011 mJ/ml, $p<0.0001$). In the patient with intrapulmonary AV fistulas, the KE curve had two diastolic peaks before intervention, but after intervention the early diastolic peak was higher and more fused with the late diastolic peak. The patient with APC had a fused diastolic curve with a plateau before intervention. After intervention the curve showed two diastolic peaks. As expected, no change in KE curve was observed after LPA stenting.

Conclusions: In patients with univentricular heart, KE is dependent on the morphology of the ventricle and is decreased compared to controls. The results suggests that KE could be used for patient follow up, since KE might reflect early disruptions in the circulation.