Decreased diastolic ventricular kinetic energy in young Fontan patients demonstrated on four-dimensional cardiac magnetic resonance imaging

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Background
Quantification of ventricular kinetic energy (KE) in patients with single ventricle and Fontan circulation has not been investigated and might provide better understanding of the physiology and find early stages of a failing ventricle.

Our aim was to determine if kinetic energy (KE) in the ventricle of Fontan patients using cardiac magnetic resonance (CMR) differs from healthy controls.

Methods
11 patients (3 females, median age 12, range 3-29) underwent cardiovascular magnetic resonance (CMR) with a 1.5 T Philips scanner including a four-dimensional phase-contrast flow sequence. Eight healthy volunteers (2 females median age 26, range 23-36) was used as reference. Ventricular segmentation was performed in 30 time frames per cardiac cycle and imported to the 4D flow dataset. Ventricular KE calculated as KE=½mv² was summed over all voxels inside the LV and calculated for each time frame.

Results
Mean KE/SV and peak KE/SV in diastole and systole are shown in figure 1. Diastolic KE indexed for stroke volume was lower in patients compared to controls (p<0.001).

Patients with a short outflow tract and the aortic valve situated more proximal in the ventricle had similar systolic and diastolic KE peaks resembling the controls left ventricular KE pattern. Patient with more prolonged outflow tract had higher systolic KE peak that diastolic KE resembling the RV KE pattern of controls.

Conclusions
Fontan patients have lower diastolic KE per SV than controls. The KE during the cardiac cycle in Fontan patients depends on the geometry of the outflow tract.
Figure 1. Tukey box plot comparison of KE between Fontan patients and controls. The median is shown as a horizontal line within the box, the box show the first and third quartile and the whiskers the data within 1.5 quartiles below the first and above the third quartile. Outliers are represented as dots.