**4D flow analysis**

4D flow images were analyzed using MASS software. Error corrections and 4D flow quality checks were performed as previously reported [1-4]. The same phasic endocardial and epicardial contours generated during ventricular volume analysis were used for 4D flow postprocessing. Positions of 4D flow CMR pathlines in the LV or RV within the endocardial borders at end-systole defined four flow components [5-6]: (1) direct flow: blood that entered and exited the ventricle in the analyzed cardiac cycle; (2) retained inflow: blood that entered the ventricle but did not exit during the analyzed cycle; (3) delayed ejection flow: blood within the ventricle at the start of the analyzed cycle that exited during the analyzed cycle; and (4) residual volume: blood that remained in the ventricle for the duration of at least one full cardiac cycle. The volume of each flow component was indexed to the corresponding ventricular EDV to calculate flow component proportions. For each voxel, KE was computed using the following formula:

$KE=\frac{1}{2}ρ\_{blood}∙V\_{voxel}∙v\_{voxel}^{2}$,

with ­$ρ\_{blood}$ being the density of blood (1.06 g/cm3), $V\_{voxel}$ the voxel volume and $v\_{voxel}$ the velocity magnitude of the corresponding voxel. Total KEs for the LV and RV throughout the cardiac cycle were obtained by summing individual voxel KE values within the ventricular endocardial borders across all time points. All KE parameters were normalized to EDV (KEiEDV) and reported in μJ/ml. Phasic KEiEDV parameters (peak systole, average systole and peak E-wave) were extracted from the time-resolved KE curves.

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