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Assessment of diastolic efficiency of blood transit through normal and dysfunctional left ventricles

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Objective

To measure the kinetic energy (KE) loss of blood transit through the left ventricle (LV) during diastole in normal and failing hearts.

Background

Heart failure represents the final stage of the continuum of cardiovascular diseases. In the failing heart, alterations in LV flow behavior have been recognized and may contribute to the vicious cycle of progressive adverse remodeling. Assessment of the efficiency of blood transiting the LV throughout diastole remains incomplete.

Method

Seven dilated cardiomyopathy (DCM) patients (4 female, aged 52 ± 14 years, ejection fraction 43 ± 5% [mean ± SD]) and six healthy subjects (3 female, aged 58 ± 4 years) were studied. 4D velocity data and morphological b-SSFP images were acquired on a 1.5 T MRI-scanner (Philips Achieva). The LV endocardium was segmented (http://segment.heiberg.se) from the short axis images at the times of isovolumetric contraction (IVC) and isovolumetric relaxation (IVR). Pathlines were emitted from the IVC LV blood volume and traced forward and backward in time until IVR, thus including the entire cardiac cycle. The IVR volume was used to determine if and where the traces left the LV. This information was used to automatically separate inflow pathlines into two components [1]: direct flow that enters and leaves the LV within the same cardiac cycle, and retained inflow that does not leave the LV within a single cardiac cycle. By knowing the volume occupied by each trace, its velocity and the density of blood, the change in KE was calculated from the time of the traces' entrance into the LV (by crossing a plane at the mitral annulus) until the time of IVC.

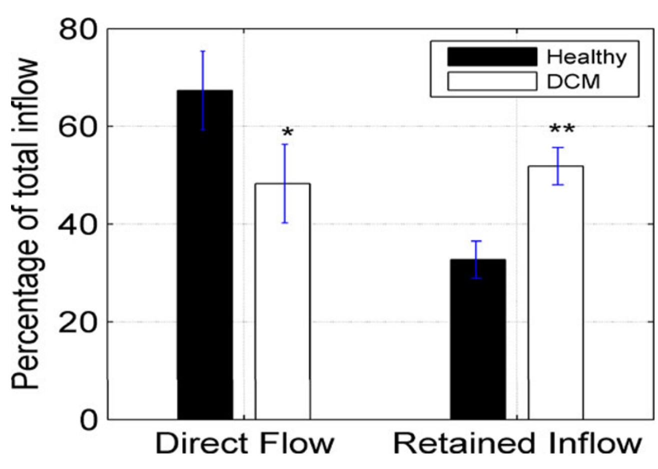

Figure 1

Bar graph showing direct flow and retained inflow relative total LV inflow (mean ± SD) in the six health subjects and seven patients with dialated cardiomyopathy (DCM). *P < 0.001 compared to direct flow in healthy subjects, and **P < 0.001 compared to retained inflow in health subjects.

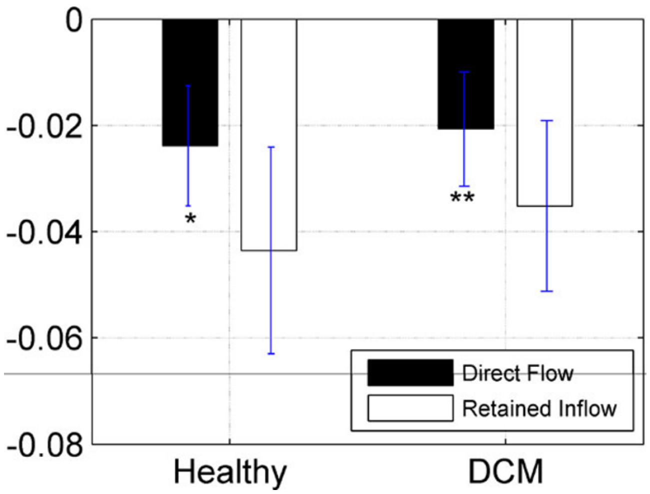

Figure 2
Total change in kinetic energy throughout disastole for direct flow and retained inflow normalized by the volume of each component (mean ± SD) in the six health subjects and seven patients with dilated cardiomyopath (DCM). *P < 0.01 compared to retained inflow in health subjects, and **P < compared to retained inflow in DCM.

Results
The direct flow/total LV inflow ratio was lower and the retained inflow/total LV inflow ratio was higher in DCM versus healthy subjects (48 ± 4 vs 67 ± 8 %, $P < 0.001$, and 52 ± 4 vs 33 ± 8 %, $P < 0.001$, respectively) (Figure 1). The kinetic energy loss per mL blood was higher for retained inflow versus direct flow in both groups (0.04 ± 0.02 vs 0.02 ± 0.01 mJ/mL, $P < 0.01$) (Figure 2).

Conclusion
Although the severity of LV dysfunction was only mild to moderate, the retained inflow represented a significantly larger part of the total inflow in myopathic LVs relative to normal LVs. In both groups, a smaller conservation of KE/mL during diastole was observed in the retained inflow compared to the direct flow. Excess KE loss may contribute to the elevated LV filling pressures and progressive adverse remodeling in the failing heart.

References
1. Eriksson , *et al.*: *ISMRM flow workshop* 2009:p47.