Quantitative 4D Flow CMR analysis of intracardiac blood flow energetics in ischemic cardiomyopathy patients

A. Riva[1], A. Camporeale[1], F. Sturla[1], S. Pica[1], L. Tondi[1], D. Giese[2], S. Castelvecchio[1], L. Menicanti[1], A. Redaelli[3], E. Votta[3], M. Lombardi[1]

[1]IRCCS Policlinico San Donato, San Donato Milanese, Italy; [2]Siemens Healthcare GmbH, Erlangen, Germany; [3]Politecnico di Milano, Dipartimento di Elettronica, Informazione e Bioingegneria, Milan, Italy

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Background: Ischemic cardiomyopathy (ICM) is often associated with negative LV remodelling after myocardial infarction, sometimes resulting in impaired LV function and dilation (iDCM). 4D Flow CMR has been recently exploited to assess intracardiac hemodynamic changes in presence of LV remodelling.

Purpose: To quantify 4D Flow intracardiac kinetic energy (KE) and viscous energy loss (EL) and investigate their relation with LV dysfunction and remodelling.

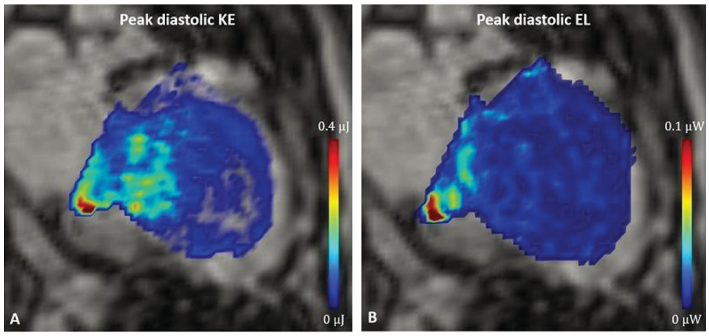
Methods: Patients with prior anterior myocardial infarction underwent a CMR study with 4D Flow sequences acquisition; they were divided into ICM (n=10) and iDCM (n=10, EDV>208 ml and EF<40%). 10 controls were used for comparison. LV was semi-automatically segmented using short axis CMR stacks and co-registered with 4D Flow. Global KE and EL were computed over the cardiac cycle. NT-proBNP measurements were correlated with average and peak values, during systole and diastole.

Results: Both LV volume and EF significantly differ (P<0.0001) between iDCM (EDV=294±56 ml, EF=24±8%), ICM (EDV=181±32 ml, EF=34±6%) and controls (EDV=124±29 ml, EF=72±5%). If compared to controls, both ICM and iDCM showed significantly lower KE (P≤0.0008); though lower than controls, EL was higher in iDCM than ICM. Within the iDCM subgroup, diastolic mean KE and peak EL reported good inverse correlation with NT-proBNP (r=–0.75 and r=–0.69, respectively). EL indexed (ELI) to average KE during systole was higher in the entire ischemic group as compared to controls (ELI(ischemic) = 0.17 vs. ELI(controls) = 0.10, P=0.0054).

Conclusions: 4D Flow analyses effectively mapped post-ischemic LV energetic changes, highlighting the disproportionate intraventricular EL relative to produced KE; preliminary good correlation between LV energetic changes and NT-proBNP will deserve further investigation in order to contribute to early detection of heart failure.

		iDCM (n=10)	ICM (n=10)	Controls (n=10)	P-value
Systole	KE_{peak} [mJ/ml]	0.012±0.003§	0.016±0.006§	0.047±0.011	<0.0001
	KE_{mean} [mJ/ml]	0.007±0.001§	0.009±0.003§	0.029±0.009	<0.0001
	EL_{peak} [mW]	0.885±0.310§	0.764±0.356§	1.435±0.472	0.0013
	EL_{mean} [mW]	0.626±0.241	0.461±0.197	0.919±0.372	0.0038
Diastole	KE_{peak} [mJ/ml]	0.155±0.008§	0.019±0.012§	0.047±0.018	<0.0001
	KE_{mean} [mJ/ml]	0.008±0.003§	0.008±0.005§	0.020±0.009	0.0002
	EL_{peak} [mW]	1.071±0.285	0.911±0.666	1.207±0.391	0.39
	EL_{mean} [mW]	0.687±0.204	0.478±0.288	0.753±0.323	0.08

Data expressed as mean ± SD. One-way ANOVA (Bonferroni post hoc): §P<0.05 vs. Controls, *P<0.05 vs. ICM.



Cross-sectional KE (**A**) and EL (**B**) maps at peak diastolic time frame. Global energetic quantities were obtained by voxel-wise summation over the entire LV volume.