Effect Of Contrast Dose, Post-Contrast Acquisition Time, Myocardial Regionality, Cardiac Cycle And Gender On Dynamic-Equilibrium Contrast CMR Measurement Of Myocardial Extracellular Volume

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Target Audience: Cardiologists, cardiothoracic radiologists, cardiovascular researchers, physicists interested in cardiac magnetic resonance imaging.

Purpose: CMR techniques are increasingly being used to evaluate myocardial extracellular volume (ECV). In the most commonly applied method, ECV is quantified using haematocrit-adjusted myocardial and blood T1 values measured before and after gadolinium bolus. The technique is based on a two-compartment model, assuming contrast kinetic effects to be negligible due to a dynamic equilibrium between blood and myocardium (Dynamic-Equilibrium CMR; DynEq-CMR). This study aimed to assess the effect of contrast dose, post-contrast acquisition time, myocardial regionality, cardiac cycle and gender on DynEq-CMR ECV measurement.

Methods: 30 healthy volunteers (asymptomatic, no cardiovascular risk factors, normal examination and ECG; also CMR confirmed normal global and regional function with no LGE in all) were prospectively split into 3 age and sex-matched groups: Group A received 0.10mmol/kg Gd-DTPA, Group B 0.15mmol/kg and Group C 0.20mmol/kg (Table 1). Mid-ventricular short-axis modified look locker inversion recovery (MOLLI) imaging was performed at 1.5T before, and at 2min intervals between 2-20mins after, contrast administration, with same-day hematocrit measurement. MOLLI imaging was repeated in early systole (150ms after R wave) pre- and at 10mins post-contrast. Resulting pixelwise T1 maps (MatLab) were used to calculate ECV. (Phantom studies performed prior to patient scanning determined T1 measurement accuracy and heart-rate correction algorithm).

Results: Pre-contrast myocardial (A 1051±49ms; B 1045±49ms; C 1040±43ms; p=0.87) and blood (A 1678±98ms; B 1645±118ms; C 1686±101ms; p=0.66) T1 times did not differ significantly between groups. Mean myocardial (A 542±65ms; B 465±69ms; C 407±55ms; p<0.001) and blood (A 407±73ms; B 307±67ms; C 252±48ms; p<0.001) T1 averaged over all time points post-contrast shortened significantly as contrast dose increased (Figure 1). Mean ECV was significantly higher in group A compared to groups B and C (A 27.7±3.7%; B 25.8±3.4%; C 25.8±2.8%; p<0.001). The difference between groups B and C was not significant. ECV increased linearly over time in each group; between 2 and 20mins post-contrast, ECV increased from 27.2±2.7% to 28.8±3.4%, p=0.020 in group A; 25.3±2.8% to 26.5±3.2%, p=0.004 in group B; and 25.2±1.7% to 26.2±2.1%, p=0.068 in group C. ECV varied significantly between myocardial regions, being highest in the septum and lowest in the lateral wall in each group. ECV did not differ significantly between diastole and systole. ECV was significantly higher in females in each group (A female 29.6±3.0%, male 25.4±3.0%, p<0.001; B female 27.4±2.7%, male 23.6±2.9%, p<0.001; C female 26.1±2.8%, male 24.7±2.5%, p=0.027).

Discussion and Conclusion: The small increase in ECV over time suggests that an incomplete dynamic equilibrium between blood and myocardium is achieved. DynEq-CMR-derived ECV varies according to contrast dose, myocardial region and gender.

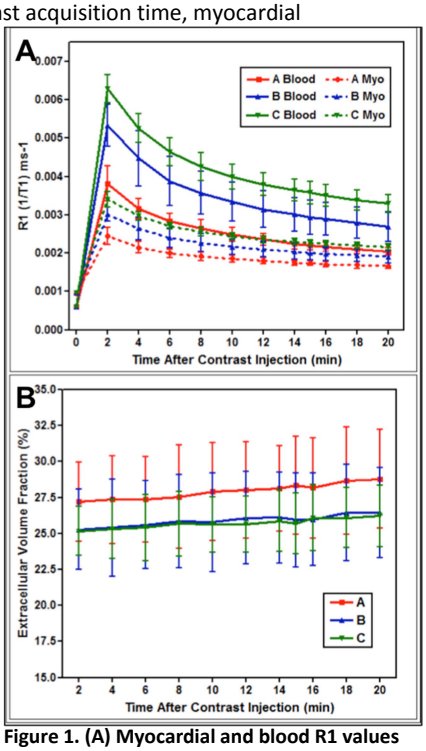

Figure 1. (A) Myocardial and blood R1 values plotted against time after contrast administration, according to contrast-dose group. (B) DynEq-CMR measured myocardial ECV plotted against time following contrast administration.

	Overall (n=30)	Group A (0.10 mmol/Kg) (n=10)	Group B (0.15 mmol/Kg) (n=10)	Group C (0.20 mmol/Kg) (n=10)	p value
Male	15	5	5	5	
Age	45±13 (22-65)	44±14 (23-65)	45±14 (22-64)	46±13 (28-64)	0.98
Male	45±15 (22-65)	44±15 (27-65)	46±17 (22-64)	44±15 (30-60)	
Female	45±12 (23-64)	45±15 (23-62)	44±12 (28-59)	47±12 (28-64)	
Weight (Kg)	73.1±13.8	74.8±12.9	70.3±16.0	73.1±13.8	0.75
Height (m)	1.69±0.10	1.71±0.09	1.67±0.10	1.70±0.11	0.67
BSA ($m^{2)}$	1.83±0.20	1.87±0.19	1.78±2.4	1.85±0.18	0.65
HR (bpm)	68±9	67±9	70±11	66±8	0.67
Systolic BP (mmHg)	114±11	116±11	114±11	112±12	0.63
Diastolic BP (mmHg)	67±11	71±11	65±13	66±7	0.41
eGFR ($mL/min/m^2$)	95±17	94±11	100±20	91±19	0.50
Indexed EDV (mL/m^2)	79±8	78±8	79±7	80±8	0.83
Indexed ESV (mL/m^2)	26±5	27±5	27±5	26±5	0.78
EF (%)	67±5	66±4	66±4	68±5	0.45
Indexed Mass (g/m^2)	45±8	44±9	43±8	47±7	0.46

Table 1. Characteristics of healthy subjects. Values are mean ± standard deviation.