Relationship between infarct gray zone and characteristics of ventricular tachycardia using multi-contrast delayed enhancement

J. S. Detsky[1,2], G. A. Paul[3], K. A. Connelly[1,4], A. J. Dick[3], and G. A. Wright[1,2]

[1]Imaging Research, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada, [2]Medical Biophysics, University of Toronto, Toronto, Ontario, Canada, [3]Schulich Heart Program, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada, [4]Cardiology, St. Michael's Hospital, Toronto, Ontario, Canada

Introduction: A myocardial infarct (MI) is comprised of a central fibrous scar which may be surrounded by a heterogeneous region of viable and non-viable myocytes. This heterogeneous region, or the "gray zone", as detected by delayed enhancement cardiac MRI has been shown to correlate with all-cause post-infarct mortality[1] and inducibility for ventricular tachycardia[2] (VT). We have recently shown that the quantification of the gray zone using the conventional inversion-recovery gradient echo (IR-GRE) sequence is sensitive to image noise and to the accuracy of the required manual contours of the blood pool[3]. A new multi-contrast delayed enhancement (MCDE) sequence[4] has been developed that provides images at multiple inversion times (TI) in a single breath-hold; an automated analysis of MCDE images has been shown to provide a more robust measure of the gray zone[3]. In this study, preliminary results in patients are presented examining the relationship between the extent of the gray zone (measured with IR-GRE and MCDE methods) and inducibility of VT as well as VT cycle length.

Methods: Eight patients (mean age of 67, all men) referred for an implantable cardioverter defibrillator (ICD) for ischemic cardiomyopathy underwent an MRI exam less than one week prior to ICD implantation. Five patients had documented evidence of prior VT (secondary prevention) and three had no prior evidence of VT (primary prevention). All patients underwent an MRI scan on a GE 1.5 T Signa Excite system using an eight channel cardiac coil for signal reception. A short axis stack of cine SSFP images were acquired, followed by short axis viability imaging starting 10 minutes after administration of 0.2 mmol/kg Gd-DTPA. IR-GRE and MCDE imaging were acquired in a randomized order. The MCDE sequence uses a segmented SSFP readout following an inversion pulse that is applied once per heart beat, yielding 20 cardiac-phase-resolved images at different effective TIs. Both sequences were acquired with a spatial resolution of 1.8 x 1.8 x 8 mm. Quantification of the infarct core and gray zone was performed on the IR-GRE images using a full-width half-maximum (FWHM) approach as described by Schmidt[2], while the MCDE analysis used an automated data clustering algorithm previously described[3].

Results & Discussion: VT was inducible at the time of ICD implantation in three patients (two primary and one secondary prevention) and non-inducible in the other five patients. Figure 1 shows gray zone maps using the IR-GRE and MCDE analyses in a 55-year old primary prevention patient who was inducible at the time of ICD implantation. Table 1 shows the infarct characteristics in patients derived from the IR-GRE and MCDE analyses. There was a statistically significant difference in the size of the gray zone between inducible and non-inducible patients using MCDE (16.3 ± 0.7 g versus 6.6 ± 7.7 g, p = 0.046) which was not observed with IR-GRE (10.4 ± 4.6 g versus 7.0 ± 8.2 g, p = 0.48). There was no statistical difference between the two groups in the size of the infarct core, total infarct size, or ejection fractions (EF) (Table 1), although inducible patients tended to have a lower EF and larger total infarct size. There was a strong correlation between the size of the gray zone and the VT cycle length in the secondary prevention group (R^2 = 0.95, Fig 2). Note that in one patient with a prior occurrence of VT, the cycle length is currently unknown.

Table 1. MRI-derived infarct characteristics for patients with inducible and non-inducible VT.

		Inducible	Non-inducible	p
MCDE	Infarct core, g	18.3 ± 10.4	11.9 ± 14.8	0.50
	Gray zone, g	16.3 ± 0.7	6.6 ± 0.7	0.046
	Total, g	34.7 ± 11.0	18.5 ± 22.4	0.22
IR-GRE	Infarct core, g	17.3 ± 7.1	8.7 ± 10.9	0.22
	Gray zone, g	10.4 ± 4.6	7.0 ± 8.2	0.48
	Total, g	27.7 ± 11.7	15.7 ± 19.0	0.31
SSFP	EF (%)	25 ± 5	31 ± 19	0.55

The lack of a statistically significant difference in the gray zone size between inducible and non-inducible patients assessed using IR-GRE imaging may be due to the higher variability in the IR-GRE analysis, due to a high sensitivity to noise[3], in this small group of patients. The MCDE analysis is less sensitive to noise and does not require manually drawn endocardial contours. In patients with prior evidence of VT, the gray zone is positively correlated with the VT cycle length; this is expected because a larger region of heterogeneous MI should result in a longer path length for a VT reentry circuit. This is consistent with previous results showing a positive correlation between VT cycle length and the isthmus size measured during programmed electrical stimulation[5].

Summary and Conclusions: Preliminary results confirm that inducibility for VT is correlated to the size of the gray zone as assessed by MCDE imaging. We have also shown that the VT cycle length is correlated to the size of the MRI-derived gray zone.

References:

1. Yan et al. Circ 2006;114. 2. Schmidt et al. Circ 2007;115. 3. Detsky et al. ISMRM 2008, pp. 3164 4. Detsky et al. MRM 2007;58. 5. Ciaccio et al Circ 2001;104.

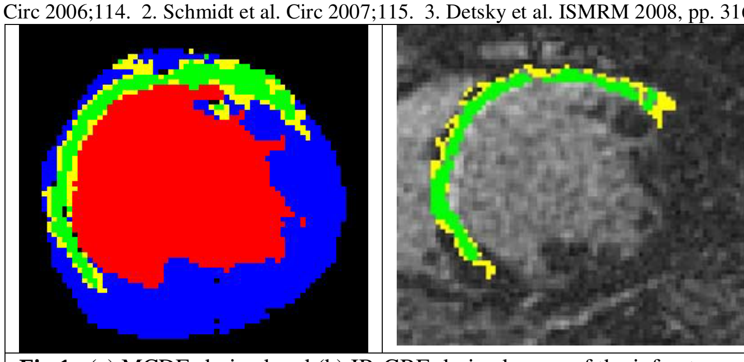

Fig 1. (a) MCDE-derived and (b) IR-GRE derived maps of the infarct core (green) and gray zone (yellow) in a 55-year old patient with no prior history of VT who was inducible at the time of ICD implantation.

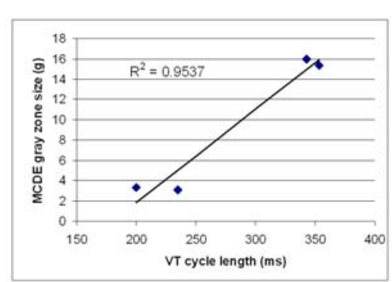

Fig 2. Correlation between VT cycle length and MCDE-derived gray zone size.