Myocardial infarct heterogeneity and papillary muscle involvement correlated with appropriate ICD therapy in patients with ischemic heart disease

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Introduction: Left ventricular ejection fraction (LVEF), clinical staging of heart failure, and myocardial infarct (MI) heterogeneity including MI and peri-infarct gray-zone (GZ) have the potential to predict the occurrence of spontaneous ventricular arrhythmia (VA) in patients with ischemic heart disease (IHD) after implantable defibrillator (ICD) placement [1]. Papillary muscle involvement (PM-MI) is also a potential source of VA in these patients [2]. Recent studies indicated that myocardial infarct heterogeneity measured on cardiac MRI might predict the appropriate ICD therapy in patients with IHD [1]. However, it is unknown whether PM-MI in these patients may play a role in the prediction of appropriate ICD therapy. In this study, we investigated the correlation of myocardial infarct heterogeneity and PM-MI evaluated by cardiac MRI with the appropriate ICD therapy in patients with IHD after ICD implantation.

Materials and Methods: This study used cardiac MRI to evaluate patients with IHD prior to ICD implantation and correlated cardiac MRI measurements to appropriate ICD therapy and spontaneous VA events during follow-up. All cardiac MRI studies were performed on a 1.5T GE Signa HDx system (GE Healthcare, Milwaukee, WI). The MRI protocol included LV functional parameter assessment using steady-state free precession (SSFP), as well as late gadolinium (Gd) enhancement (LGE)-MRI using inversion recovery fast gradient echo (IR-FGRE) and/or multi-contrast late enhancement (MCLE) [3-4] post double-dose Gd injection (0.2 mmol/kg of Magnevist, Berlex Inc., Wayne, NJ), covering the whole LV in short-axis oblique and/or two- or four-chamber views. For IR-FGRE, the TI varied from 200 to 300 ms, depending on the null point of healthy myocardium. For MCLE, a segmented SSFP readout is used following an inversion pulse, providing 20 cardiac-phase-resolved images at varying effective TIs. The in-plane resolution was 1.5x1.5 mm for both IR-FGRE and MCLE. LV functional parameters were measured using Q-Mass or CMR^{42} software. The GZ analysis in IR-FGRE used a full-width half-maximum method. PM-MI was considered if the following criteria [3] were satisfied on IR-FGRE or MCLE images: (1) the increased signal intensity of PM was the same or similar to that of adjacent hyper-enhanced infarct segments; (2) the hyper-enhanced PM region was limited to the PM area defined by pre-contrast SSFP. An unpaired t-test was used for the statistical analysis of LV functional parameters, the proportion of GZ, MI core and total MI relative to LV myocardium mass between patient groups with and without shocks for VA during follow-up. Chi-Square and Fisher's exact tests were used for testing the association between the presence of PM-MI and ICD therapy for VA events.

Results: Forty-one patients with IHD for planned ICD implantation (age 64.6±12.2 years old, 92.7% men, average LVEF 26.9±10.7%, 48.8% secondary prevention) were enrolled. All patients completed the MRI protocol and at least a six-month follow-up at the ICD clinic. PM-MI was documented in thirty-one patients (75.6%). At follow-up, fourteen patients (34.1%, 14/41) had spontaneous VA events and twelve of these patients had at least one appropriate shock for VA from the ICD. Cardiac MRI measurements of LVEF, LV volumes and myocardial infarct heterogeneity are shown in Table 1. LVEF and LV volumes did not show a statistically significant difference (P>0.05) between patient groups with and without ICD shocks for VA. Myocardial infarct heterogeneity including the proportion of GZ, MI core and total MI relative to LV myocardium mass demonstrated a statistically significant difference (GZ: P=0.004; MI core: P=0.02; total MI: P=0.01) between these two groups in univariate tests. The Fisher's exact test confirmed the association between the presence of PM-MI and the ICD shocks for VA (Table 2, P=0.021). The extent of MI core did not demonstrate a statistically significant difference between patients with and without PM-MI (17.5 ±9.8% vs. 12.0±11.9%, P>0.05).The extent of GZ was greater in patients with PM-MI (n=31, 10.6±5.5%) than in patients without PM-MI (n=10, 6.6±6.8%, P<0.05) (Figure 1); however, limited patient numbers did not allow multivariate analysis to additive utility of PM-MI in predicting events.

Conclusions: Cardiac MRI measurements of myocardial infarct heterogeneity and the presence of papillary muscle involvement are good predictors of appropriate ICD therapy for ventricular arrhythmias in patients with IHD after ICD implantation. In this study, the extent of GZ was greater in IHD patients with papillary muscle involvement.

References: 1. Roes SD, et al. Circ Cardiovasc Imaging 2009; 2: 183. 2. Bogun F, et al. JACC 2008; 51:1794. 3. Yang Y, et al. J Magn Reson Imaging 2011 ; 33 : 211. 4. Detsky JS, et al. MRM 2007; 58: 365.

Table 1. Myocardial infarct heterogeneity and LV functional parameters in patients with and without shocks for VA

	With shocks for VA (n=12)	Without shocks for VA (n=29)	P value
GZ/LVM (%)	13.9 ± 4.3	8.3 ± 5.7	0.004
MI core/LVM (%)	22.4 ± 8.5	14.1 ± 10.0	0.02
Total MI/LVM (%)	36.4 ± 12.3	22.4 ± 15.4	0.01
LVEF (%)	22.5 ± 8.0	28.7 ± 11.3	0.09
LVEDV (ml)	286.8 ± 115.4	230.5 ± 81.9	0.08
LVESV (ml)	226.8 ± 108.3	170.4 ± 79.2	0.07
LVM (g)	128.5 ± 53.0	117.7 ± 47.9	0.53

Table 2. PM-MI vs. ICD therapy for VA: Fisher's exact test

	M1	M2
N1	12	19
N2	0	10

M1=ICD therapy (+)
M2=ICD therapy (-)
N1=PM-MI (+)
N2=PM-MI (-)

P = 0.020633

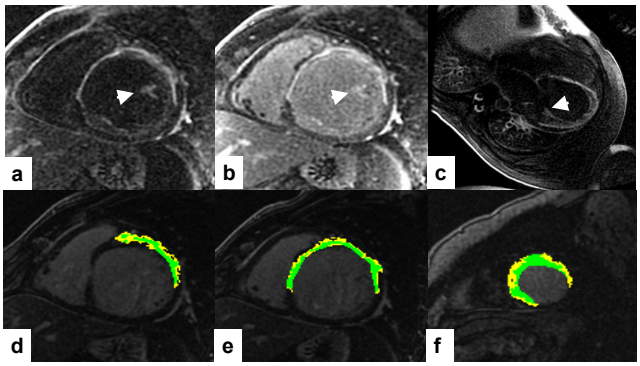

Figure 1. An IHD patient with PM-MI and GZ of 22.5% had an ICD therapy for VA. a-b. Short-axis MCLE images with different TI; c. Four-chamber MCLE image (arrow depicting PM-MI); d-f. Short-axis GZ mapping (yellow-GZ, green-MI core).