

Early Cardiovascular MR Imaging Predicts Late Scar Formation in Pulmonary Vein Isolation

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Background: The causes of success and failure of pulmonary vein isolation (PVI) in patients with atrial fibrillation (AF) is unknown, but may relate to incomplete ablation patterns. We hypothesized that early findings of myocardial edema might predict later scar formation.

Methods: Eleven patients undergoing PVI were imaged pre-PVI, 1 day after PVI (early), and 30 days post-PVI (late), with cardiac MR T2-weighted (T2W, TE=60ms) and late gadolinium enhancement (LGE) techniques, on a 1.5T Philips scanner. The T2W sequence was a 2D fast spin echo with fat-saturation and NAV-gating, 33 etl/5.3 esp, 1.5 x 1.5 x 5mm³ resolution. The LGE sequence was a 3D inversion recovery gradient echo acquisition with 1.4 x 1.4 x 4mm³ resolution, TR/TE/θ=5.3/2.1/25°, and employed 0.2mmol/kg Gd-DTPA. T2W data were compared in 10 healthy adults.

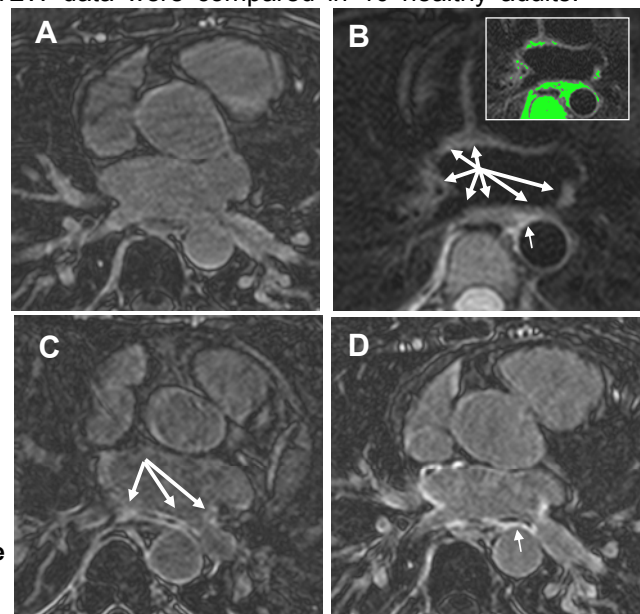
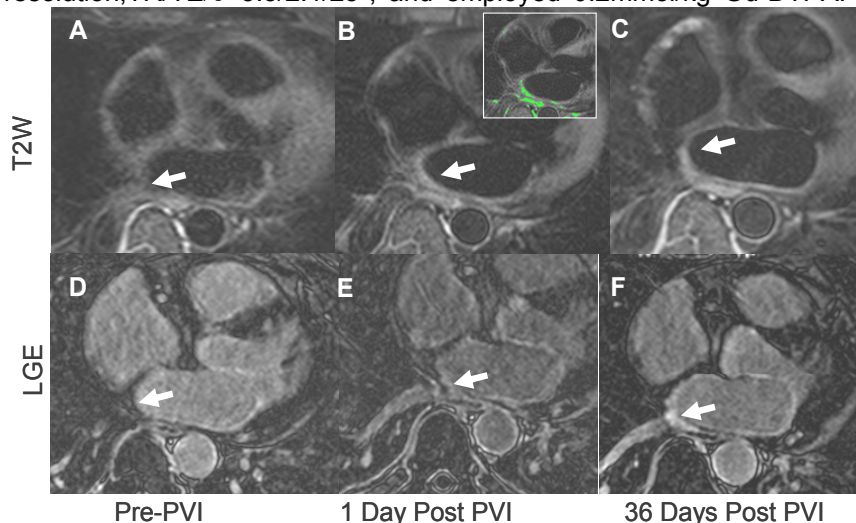


Figure 2: A) Pre-PVI LGE. B) 1 day post T2W. C) 1-day post LGE. D) >30 days LGE. Color inset in B shows regions above an ER of 1.4, which strongly correlate with late but not early LGE enhancement pattern. Late Scar (D) shows greater enhancement than early injury (C).

Figure 1: The development of scar in a single patient at 3 time points. Note the thickening of the LA wall on T2W imaging 1 day post PVI. Note edema of the RIPV ostia early, which develops into permanent scar. Green highlighting in B indicates signal above the ER threshold of 1.4.

Left atrial (LA) wall thickness was measured at the vertebral body. The edema enhancement ratio (ER, the ratio of T2W signal in a LA region to the LV myocardial signal) were measured on early T2W images.

Results: Seven of the 11 patients had both diagnostic late LGE and early T2W scans. Figure 1 and 2 show pre-ablation, 1 day post ablation, and >30 days post ablation images in two patients. Note the correlation between edema (highlighted in green in the inset, 1B, 2B) and later scar (1F, 2D). Note that the enhancement pattern is less intense on early LGE vs. later LGE. LA wall thickness was increased early ($6.9 \pm 3.0\text{mm}$ vs. $4.8 \pm 1.8\text{mm}$ in controls ($p < 0.001$)), as demonstrated in Fig 1A-B. Early T2W enhancement images showed increased ER (1.52 ± 0.38 for patients, vs. 0.89 ± 0.24 for controls, $p < 0.001$), and there was increased late scar CNR in PV wall locations where more intense edema was measured early (CNR of 8.7 ± 2.4 for less intense edema ($\text{ER} < 1.4$) vs. 13.0 ± 4.9 for $\text{ER} \geq 1.4$ ($p = 0.03$)). Figure 3 shows a linear correlation between ER and Late LGE CNR in matched locations, suggesting that more intense edema predicts scar. The injured LA wall CNR (LA wall to blood,) for late LGE was greater than for early LGE (11.4 ± 4.1 late vs. 8.2 ± 3.6 early, $p = 0.01$).

Conclusions: Increased LA wall thickness and edema of the LA wall are uniformly seen early post-PVI. Late LGE presents a more intense pattern of enhancement compared to early LGE. Other studies have focused on early development of scar after PVI, comparing early edema with early LGE (1), or early LGE with late LGE (2). In contrast, we found that the intensity of early edema correlates with late LGE scar formation.

References: 1) Knowles et al IEEE Trans Biomed Eng 2010; 57:1467-75.) 2) Badger et al. Heart Rhythm 2009; 6:161-168

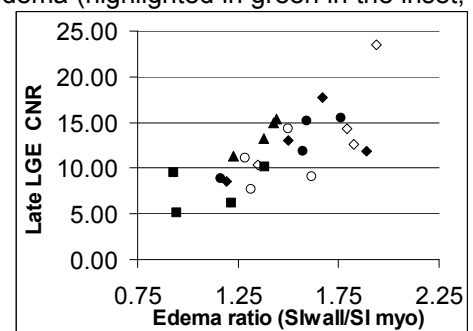


Figure 3: Correlation ($R=0.57$) between edema enhancement ratio (ER) and LA wall scar CNR measured on late LGE.