: Characterization of pulmonary vein stenosis by serial MRI after atrial fibrillation ablation.

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Background:
Atrial fibrillation (AF) is the most common cardiac arrhythmia and can be treated by pulmonary vein isolation (PVI) procedures using catheter ablation targeting the pulmonary vein (PV) ostia and antra. Pulmonary vein stenosis (PVS) is a well-described complication of PVI and is associated with significant morbidity including respiratory problems. Ablation injury that leads to PVS and the factors associated with increased risk are not well understood. In this study, cardiac MRI was used to study the acute and chronic injuries that can lead to PVS in patients post AF ablation.

Methods:
This was a single-center, retrospective, 1:1 cohort to control matched study including patients with (23) and without (23) significant PVS, defined as >50% stenosis from baseline seen 3 months post-ablation (3moPA). Study groups were selected from 925 patients who underwent PVI and serial MRI scanning. Inclusion criteria for both groups required having undergone a full set of three MRI scans: pre-ablation (pre), 24 hour immediate post-ablation (IPA), and 3moPA. MRI scanning was performed on a 1.5T or 3T Siemens magnet. Out of the 925 patients, 28 were found to have significant stenosis detected by MRA 3moPA. The final PVS study cohort consisted of 23/28 patients who had complete sets of MRI scans. The control group comprised of 23 age and sex-matched patients. PV's were analyzed using 3D MRA, T2-weighted double inversion recovery turbo spin echo (T2w DIR-TSE), and late gadolinium enhancement (LGE) imaging sequences. On 3D MRA, cross-sectional pulmonary vein areas were measured at the ostial/proximal portion of the vessels.

Results:
In both study cohort and control groups, there was intense T2 signal seen IPA on T2w DIR-TSE images corresponding to acute inflammation and edema with resolution at 3moPA. Corresponding LGE images showed enhancement IPA representing edema, inflammation, and necrosis, with residual enhancement 3moPA that represented scar (See figure 1). Overall, there was a 3% (28/925) incidence of significant PVS 3moPA. In the final PVS study cohort, early PV narrowings of >20% on the IPA scan were found in all patients (23/23, 100%) compared with significantly fewer in the control group (9/23, 39%) ($p < 0.001$). The average pre-ablation PV cross-sectional area for the stenotic veins in the study cohort was significantly smaller, 1.19 ± 0.61 cm2, compared to the control group, 2.01 ± 0.73 cm2 [$p<0.001$, 95% CI -1.22 to -0.42].

Conclusions:
Cardiac MRI is a powerful tool for characterizing the ablation injury leading to PVS. The early injury IPA shows marked increased T2 signal in the tissue surrounding the PV's reflecting the large degree of edema and inflammation. In the vast majority of patients, no PVS develops as the intense early injury resolves and scar forms during the remodeling process. However, 3% of patients developed significant PVS and is predicted by baseline PV size and degree of PV narrowing IPA based on MRA measurements.

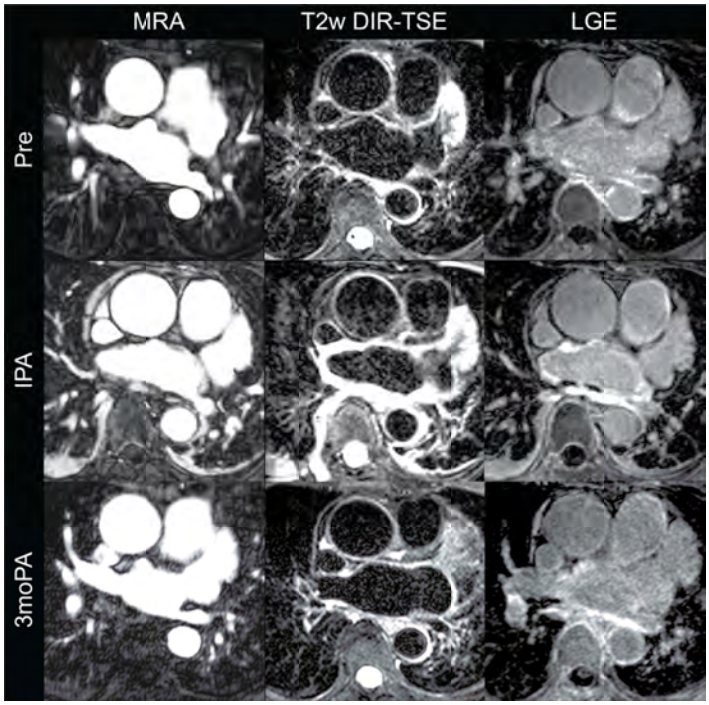

Figure 1. Example of left inferior PV stenosis in a patient who underwent radiofrequency ablation for atrial fibrillation. Pulmonary veins were assessed on serial MRI scans (Pre, IPA, 3moPA) using 3 different sequences for tissue characterization. PV stenosis is best assessed by MRA. Development and resolution of edema/inflammation surrounding the veins are seen on T2w DIR-TSE, and remodeling changes resulting in scar are seen on LGE.