

# Steady State MRA Techniques With a Blood Pool Contrast Agent Improve Visualization of Pulmonary Venous Anatomy Compared with Time Resolved MRA Pre and Post Catheter Ablation in Atrial Fibrillation

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**Introduction:** Time-resolved magnetic resonance angiography (TR-MRA) with improved temporal resolution compared to conventional MRA is a useful technique for imaging the dynamic arteriovenous transit in the pulmonary circulation [1]. Increased temporal resolution is achieved in part via a reduction in spatial resolution compared with conventional MRA [2]. Blood pool contrast agents enable steady state acquisition, obviating the need for imaging during the first pass; ECG- and navigator gating achieve high spatial resolution at an acceptable imaging time. The purpose of this study is to assess steady state MRA (SS-MRA) for pulmonary vein mapping using a blood pool contrast agent, comparing to the gold standard TR-MRA in a patient cohort undergoing pulmonary vein isolation.

**Materials and Methods:** 28 patients (14 males, age  $55.7 \pm 10.1$  years; 14 females;  $50 \pm 1.4$  years) undergoing pre- and post- ablation pulmonary vein mapping were evaluated with conventional TR-MRA and SS-MRA.

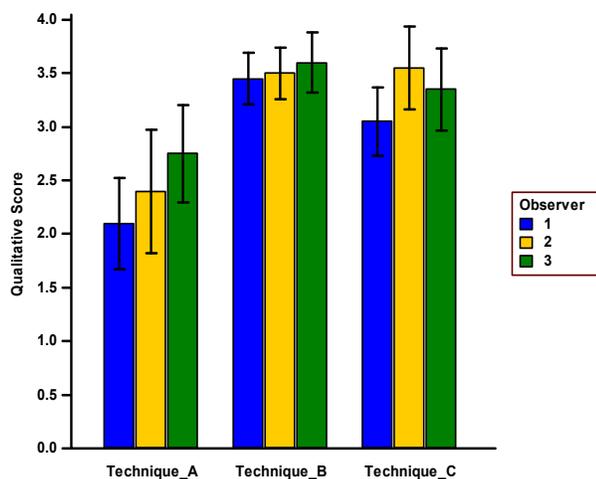
**Imaging Technique:** Imaging was performed on a 1.5-T MRI scanner (Avanto, Siemens Healthcare, Erlangen, Germany). MRA protocol consisted of TR-MRA followed by SS-MRA after intravenous injection of gadofosveset trisodium (Ablavar, Lantheus, U.S.A). TR-MRA of the pulmonary vasculature was obtained in a coronal orientation centered on the left atrium using a 3D gradient echo fast low angle shot (FLASH) pulse sequence. Typical TR-MRA acquisition parameters: TR/TE: 1.6/0.8 msec; flip angle, 30°; acceleration factor  $\times 2$ ; partial fourier 6/8 in x-y and z directions; acquisition time 3-4 sec/3D TWIST datasets. Contrast bolus timing was achieved using care bolus technique. SS-MRA consisted of free-breathing ECG-gated IR-FLASH and IR-fast imaging with steady state free precession (IR-FISP) in a sagittal oblique orientation. Typical IR-FLASH acquisition parameters: TR/TE/TI: 3.5/1.5/260, flip angle 18°, and IR-FISP had: TR/TE/TI: 3.3/1.5/260, flip angle 70°. GRAPPA  $\times 2$ , and 3 minute acquisition. Respiratory gating was achieved using a navigator acquisition with an average acceptance window of 35%. **Analysis:** Pulmonary veins were measured in orthogonal dimensions using double oblique multi-planar reformatting. Agreement between methods was analyzed using Pearson's coefficients of correlation, and Bland-Altman plots, with TR-MRA as the reference standard. Images were qualitatively assessed by three independent observers (R.R., M.G., and D.T.) on a scale of 1 to 4, where 1=poor, 2=fair, 3=good, and 4=excellent. The presence of common ostia, accessory veins, or stenosis was recorded. Image quality was compared among techniques by the Friedman's test. Inter-observer agreement was assessed using unweighted Cohen's kappa and comparing the proportion of cases which showed complete agreement between all readers.

**Results:** Reviewers graded image quality superior for IR-FISP (Technique B); followed by IR-FLASH (Technique C) and TR-MRA (Technique A) for all observers (Figure 1). Kappa scores demonstrated good interobserver agreement for IR-FISP and IR-FLASH, with modest agreement for TR-MRA. Bland-Altman analysis of orthogonal venous diameters for interobserver agreement indicated a mean difference of 0.01 cm [limits of agreement (LA): -0.45 to 0.43 cm], 0.07cm (LA: -0.64 to 0.51), and 0.3 cm (LA: -1.27 to 0.67 cm) for IR-SSFP, IR-FLASH and TR-MRA, respectively. Pearson's coefficients of correlation showed good correlation between techniques.

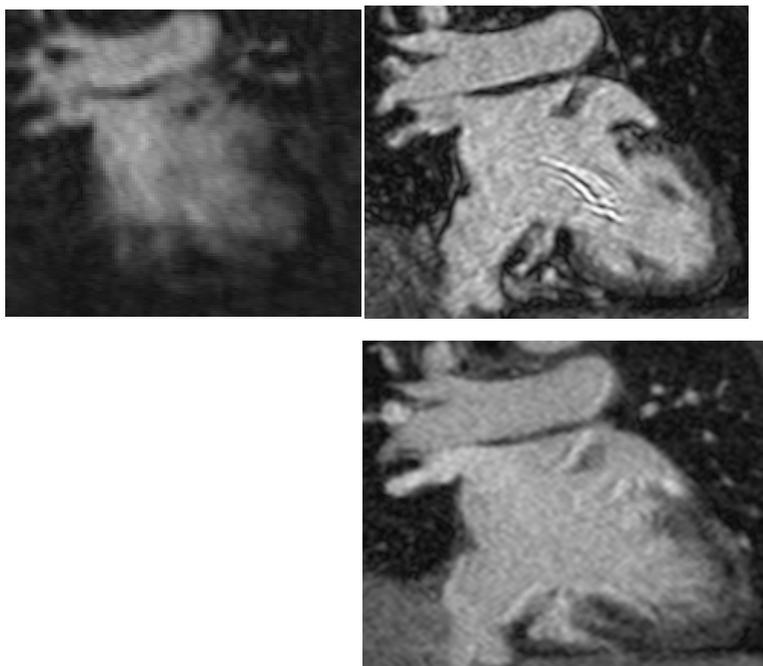
**Conclusion:** SS-MRA with a blood pool agent compared favorably to TR-MRA for assessment of pulmonary venous anatomy. Reviewers graded quality for both SS-MRA acquisitions superior to that at TR-MRA. Steady state imaging obviates the need for imaging during the first pass and while enabling a high spatial resolution acquisition.

## References:

- Schonberger M et al J Card Mag. Reson. 2011, 13(Suppl 1):P234;
- Maksimović R et al. Eur Radiology 2006 Nov;16(11):2491-504. Epub 2006 May 20.



**Fig. 1:** Inter-observer agreement for qualitative assessment for assessment of venous anatomy and abnormalities being higher for IR-FISP and IR-FLASH compared with TR-MRA.



**Fig. 2:** Image quality of TR-MRA (a) lacks the spatial resolution compared with SS-MRA techniques of IR-FISP (b) and IR-FLASH (c). The images show early branching pattern of the right superior pulmonary vein. High spatial resolution also increases confidence of excluding presence of thrombus in the atrial appendages.