

Pre-Operative imaging of coronary veins in patients undergoing CRT: How good is whole heart MRA compared to intraoperative catheter-based venography?

Adrian Lam¹, Luis F Mora-Vieira², Michael Lloyd², and John N Oshinski^{1,2}

¹Georgia Institute of Technology, Atlanta, GA, United States, ²Emory University, Atlanta, GA, United States

Purpose: The location of the left ventricular (LV) pacing lead plays an important role in the success of Cardiac Resynchronization Therapy (CRT). LV leads are most often implanted via the coronary venous system. Ideally, the lead location should be in the latest contracting segment of viable myocardium. However, implanting the LV lead at the optimal location depends on coronary venous anatomy and the location of nonviable or scarred myocardium. Traditionally, the coronary venous anatomy is only imaged during the implantation procedure using retrograde venography. Therefore, the relation of venous anatomy to the site of latest contraction or myocardial scar is unknown and no pre-procedural planning can be done. Recent studies have suggested that a modified whole heart, contrast-enhanced, magnetic resonance angiography (MRA) sequence is capable of imaging the coronary veins [Ma et al., iJCVI, 2010]. The objectives of this study were to determine the ability of a whole heart MRA sequence to visualize the coronary vein anatomy and compare the coronary vein images from the MRA to the vein images from the invasive catheter-based venography.

Methods: Seventeen patients scheduled for CRT were included in this study. MRI scans were performed within a 7 day window prior to the CRT procedure on a 1.5T MRI (Siemens Medical Systems, Erlangen, Germany) using a 3D whole heart, navigator and ECG-gated FLASH sequence with a centric-ordered k-space scheme. A gadolinium-based contrast agent (0.2 mmol/kg) was slowly infused at a rate of 0.3 mL/s, Figure 1a. Catheter-based venography was performed in the electrophysiology lab using balloon occlusion of the coronary sinus and a retrograde injection of contrast through the coronary sinus, Figure 1b. The final position of the lead implantation was also imaged in 14/17 patients.

The coronary sinus (CS), posterior/anterior interventricular (PIV/AIV), posterior vein of the left ventricle (PVLV), lateral middle vein (LMV) veins were graded on both MR and venogram images. Catheter-based venograms were evaluated by a cardiologist with a binary grading scheme (visible/not visible) for the 5 veins examined and used as a gold standard for whether a vein existed. MR images were evaluated in two ways. First, two graders (an MR scientist and a cardiologist) evaluated the MR coronary vein images using a 0-3 grading scheme (3=excellent, 2=fair, 1=poor, 0=not visible). Second, veins were evaluated as visible or not visible. The average vein grade between the two graders needed to be > 1 in order for the vein considered visible.

Results: The MRI image quality scores and the comparison to venography are shown in Table 1. The coronary sinus was visible in all patients and other vein segments were visualized in greater than 90% of all patients. The lower visibility score of the LMV can be attributed to its orientation, which typically lies in the plane of the slice, often making identification difficult. In the patients where the final LV lead position was available, the vein which the LV lead was implanted in was visible in 13/14 (93%) patients. There were 9 instances (11%) in which veins were 'visible' on MR scans but not on venograms.

The mean difference between observer scores was 0.8 ± 0.8 . This shows reasonable agreement between the two observers as the mean difference in scores was less than 1.

Discussion: When using catheter-based venogram images as a gold standard, results show that MRI is capable of visualizing the coronary veins in > 90% of cases. This result suggests that MR could be used in patients to do pre-procedure lead placement planning. Discrepancies between graders were observed primarily in the PVLV and the AIV, and could be explained by the lack of SNR as well as insufficient delineation between the arteries and veins for the AIV. Over all the patients, 93% of all the veins in which the LV lead was implanted in was visible on the MR images, suggesting that MR is capable of visualizing the majority of the veins considered for LV lead implantation. We expect to be able to improve the SNR of coronary MRA by using a higher field strength MRI (3T) and a 32-channel body coil.

There were cases of an MR-visualized vein which was not seen on the corresponding venogram. This is likely due to balloon occlusion occurring beyond the segment and/or insufficient balloon occlusion of the coronary sinus, both which are common with conventional venography.

Conclusion: Contrast-enhanced, whole heart MRA can be used to visualize the coronary vein anatomy. The MR coronary vein images compare favorably to the veins imaged during invasive procedures, with over 90% of veins visible. The vein chosen for final LV lead implantation was visible in 93% of cases. These results suggest that MRI can be used for pre-procedural planning in patients undergoing CRT to assist with the identification of an optimal vein for LV lead implantation.

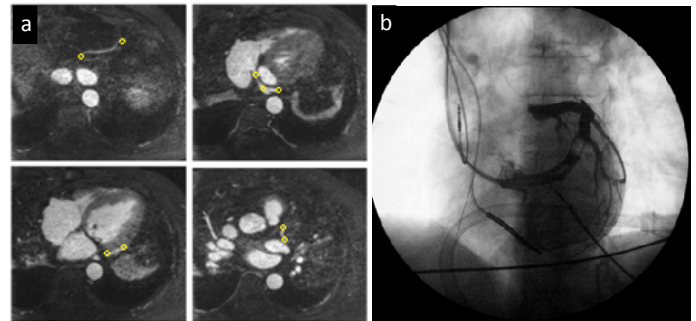


Figure 1a: Coronary vein angiography images (4/120 slices) acquired using MRA sequence. **Figure 1b:** Yellow circles indicate positions of the coronary vein anatomy. Retrograde venography from the same patient (right).

	CS	PIV	PVLV	LMV	AIV
MRI: Average Score	2.7	2.0	1.1	1.5	2.0
MRI: Veins Visible compared to venography	100%	94%	94%	76%	94%

Table 1: Grading for both MRI veins are shown as the average score for both graders and as a percentage of the number of veins seen out of the total seen on the venogram images.