MRI for Visualization of Coronary Vein Branches Used for Pacemaker Lead Implantation

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Purpose

Approximately one third of all patients who undergo Cardiac Resynchronization Therapy (CRT) using a biventricular pacemaker do not benefit from the procedure [1]. Studies have shown that the location of the left ventricular (LV) lead plays an important role in dictating whether patients benefit from the procedure [2,3]. Patients benefit most when the LV lead is placed in the latest contracting region that is not predominantly myocardial scar. In CRT, the LV lead is delivered transvenously through the coronary veins, limiting the potential areas of implantation (Figure 1). Additionally, the coronary venous anatomy is not imaged until the CRT procedure. Therefore, it is unknown whether or not the LV lead can be implanted at an ideal location before CRT procedure.

Pre-procedural imaging of the coronary veins can help determine whether a coronary vein branch has access to an ideal location before pacemaker implantation. While studies have evaluated the potential of MRI to image the coronary veins, there are no MRI studies which evaluate the visibility of the vein used for LV lead implantation with validation against the gold standard, retrograde x-ray venography. The objective of this study is determine the performance of 3D, navigator-echo gated, contrast-enhanced coronary vein imaging by MRI against retrograde venography for visualizing the coronary vein that is ultimately used for LV lead implantation.

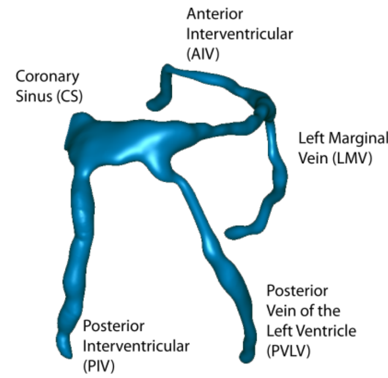

Figure 1: *Coronary vein anatomy segmented using Segment[4] (Medviso AB, Sweden) and reconstructed using Geomagic (NC, USA)*

Methods

Seventeen patients scheduled to undergo CRT were included in this study. Patients received a cardiac MR (CMR) exam on a 1.5T system 6 hours to 1 week before venography/CRT. The coronary venous anatomy was acquired by MRI using a 3D whole-heart, navigator and ECG-gated, inversion-recovery-prepared FLASH sequence during slow infusion of a Gadolinium-based contrast agent (0.2 mmol/kg @ 0.3 mL/s). Catheter-based x-ray vengography was performed immediately before pacemaker implantation using standard methods. Briefly, the coronary sinus (CS) was cannulated using a balloon catheter. The balloon was inflated, and an iodinated contrast agent was injected retrograde through the coronary sinus to visualize the coronary venous system. RAO and AP views were taken after LV lead implantation and were used to determine the vein segment in which the LV lead was located. The veins used for LV lead implantation were graded on both MRI and venogram images. MR images were graded using a 0-3 scale (3 = excellent, 2=fair, 1=poor, 0=non-existent), and venography images were graded using a binary visible/not visible scheme.

Results

The LV lead was implanted in the Left Marginal Vein (LMV) in 12 patients, in the Posterior Vein of the Left Ventricle (PVLV) in 4 patients, and in the Anterior Interventricular Vein (AIV) in one patient (Figure 2). All coronary veins used for implantation were visible by MRI. The average vein grade by coronary vein branch was 1.7 for the PVLV, 1.9 for the LMV, and 3.0 for the AIV, with an overall vein average of 1.9. X-ray venography was capable of resolving all the branches used for LV lead implantation except for two cases.

Discussion

The average vein score of ~2 suggests that MR is capable of identifying clinically relevant coronary veins that are candidates for LV lead implantation. While retrograde venography is the gold standard for coronary vein imaging, image quality can vary due to multiple factors, leading to missed coronary veins. These factors include insufficient balloon inflation, resulting in contrast leakage and insufficient illumination of the anterior portion of the coronary venous anatomy, and balloon occlusion of coronary side branches, preventing contrast from flowing down a branch. While experienced cardiologists can estimate the location of a potential branch point without the venogram denoting the exact location, these situations are non-ideal and can potentially lead to vein puncture. Pre-procedural coronary vein imaging by MRI eliminates these issues, allowing cardiologists to more accurately assess whether an ideal LV lead implantation at the latest site of contraction that is not predominantly scar has coronary vein access and how to guide the LV lead to this location.

Conclusion

MRI is capable of resolving all clinically relevant coronary vein branches that may be used as candidates for LV lead implantation and in some cases is superior to retrograde venography for identifying coronary vein branches.

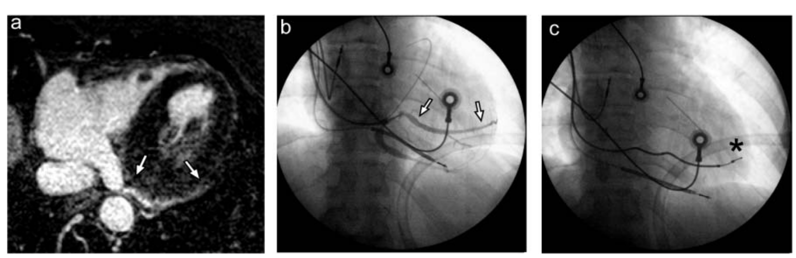

Figure 2: *Coronary vein images acquired by MRI (a) and by Retrograde Venography (b). Arrows point at the PVLV, the vein used for LV lead implantation. The final lead placement is shown by a (*) in a non-contrast image (c).*

References

1. Bax et al. (2005) *J. Am. Coll. Cardiol.46,*2153-2167
2. Becker et al. (2007) *Heart, 93*(10), 1197-1203.;
3. Bleeker et al (2006) *J. Cardiovasc. Electrophysiol. 17*(8), 899-901.
4. Heiberg et al. (2010). *BMC Medical Imaging*, *10*(1), 1.