Whole Heart Coronary Vein Imaging

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Introduction: Transvenous BiV lead implantation in cardiac resynchronization (CRT) therapy is preferred to surgical placement. However, for the transvenous approach, knowledge of the coronary vein anatomy is needed prior or during the implantation procedure. Recent studies showed the strength of cardiovascular MR in assessing coronary vein anatomy [1,2]. Nezafat *et.al.* [1] used a targeted small slab (3 cm) acquisition with gradient recalled echo (GRE) for imaging. The blood-myocardium contrast was improved by application of magnetization transfer sequence prior to imaging. Rasche *et al.* [2] proposed a whole heart steady-state free precession (SSFP) approach in which the contrast is improved using a combination of T_2 magnetization preparation, inversion pulse and an intravascular contrast agent. High spatial resolution SSFP imaging in high resolution targeted acquisition results in imaging artifacts mainly due its sensitivity to off-resonance which is increased in neighboring region of coronary veins, while targeted acquisition using GRE shown to be robust [1]. However, a large 3D whole heart acquisition using GRE sequence is problematic mainly due to higher inflow saturation in GRE. In this study, we sought to investigate whole heart MT-SSFP acquisition without any intravascular contrast agent, though with lower spatial resolution (lower repetition time) to reduce the banding artifacts.

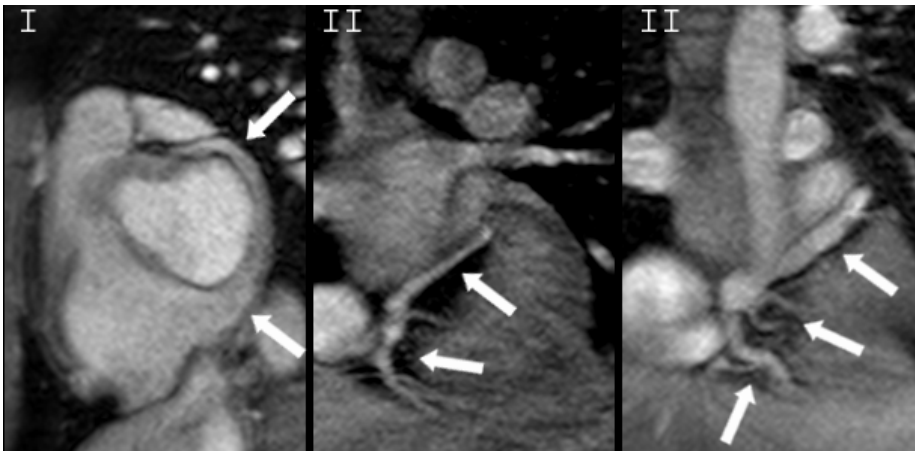

Figure 1: Example coronary vein images acquired using a targeted MT-GRE sequence along CS (I) and perpendicular to CS (II). The images show the coronary sinus and its branches.

Materials and Methods: Six healthy adult subjects (age 22±3 years) were imaged on a Philips 1.5T Achieva system (Philips Medical Systems, Best, The Netherland) using a 16 element cardiac coil array (Invivo Corp). The optimal trigger delay and quiescent duration in systole was visually measured from a 2-chamber cine acquisition acquired using an SSFP sequence. Three sets of coronary vein images were acquired in each subject. All acquisitions were ECG gated and navigator-gated (with acceptance window 7mm and 5 mm in whole heart and targeted acquisitions respectively). The whole heart images were acquired initially and used as a scout for two targeted acquisition. In all studies, an optimized magnetization transfer (MT) pre pulse (8 pulses with flip angle of 800º, frequency-offset of 500Hz and duration of 20ms) was used to improve blood-myocardium contrast [1]. Parallel imaging with an accelerate rate of 2 was used using SENSE reconstruction in all three acquisitions to reduce the total acquisition time.

Whole heart acquisition: A lower spatial resolution whole heart coronary vein acquisition was prescribed using the initial scout images with the following parameters: TE/TR/α=2.3ms/4.6ms/ 90º. The acquired spatial resolution was $1.2\times1.2\times1.5mm^3$ reconstructed to $0.5\times0.5\times0.75mm^3$ using of field-of-view (FOV) of $270\times270mm^2$ to $310\times310mm^2$ with 75 to 90 slices (based on patient size), and acquisition window of 80-90ms.

Targeted acquisition: As a reference image, targeted acquisition using GRE sequence with similar spatial resolution to the whole heart acquisition was also acquired. The images were prescribed in two orientation, along the coronary sinus and perpendicular orientation as described in [1]. Imaging parameters were: TE/TR/α= 1.5ms/4.9ms/30º, FOV: $270\times270mm^2$ - $310\times310mm^2$ with 20-25 slices. Acquired spatial resolution was $1.2\times1.2\times1.5mm^3$ reconstructed to $0.5\times0.5\times0.75mm^3$ with acquisition window of 50-60ms.

Data analysis was performed using the soap bubble tool [3] (Release 5.0 Philips Medical Systems) and View Forum (Philips Medical Systems). The two imaging approaches were compared in terms of visible branches and the visible length of the CS.

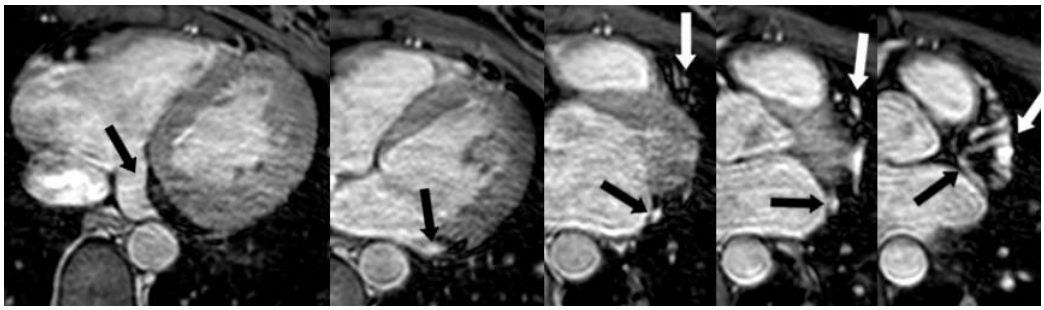

Figure 2: Example whole heart MT-SSFP images. Arrows track coronary vein anatomy originating from CS to branches in the anterior wall.

Results: **Fig. 1** shows an example of two different slice orientations, one along CS and one perpendicular to CS, acquired using MT-GRE targeted acquisition. **Fig. 2** shows slices from a whole heart acquisition with MT-SSFP. On the image acquired along CS the visible length of the CS was 54.4±23.0mm and in the perpendicular image along the lateral wall 92.5±15.6mm. The visible CS length was 139.2±25.3mm in the whole heart MT-SSFP acquisition. There was no difference in visibility of CS tributaries in the posterior and the lateral wall, however, in targeted MT-GRE acquisition the lateral wall branch was easier to identify because of being situated in the imaging plane. The imaging duration for the targeted acquisition was approximately 1min and for the whole heart 3min for a heart rate of 60BPM not considering the navigator efficiency, which is in average 30-40%.

Conclusions and Discussion: We have demonstrated the use of MT-SSFP for whole heart coronary vein imaging without any contrast agent. Although the spatial resolution is lower than the previously reported spatial resolution [1], it is sufficient to resolve the anatomical features for CRT planning. Lower spatial resolution, hence lower TR, will reduce the imaging artifacts due to off-resonance in whole heart MT-SSFP. The slice prescription in the targeted acquisition is more challenging, however image analysis and visualization is quite robust and efficient. If images of the entire CS and its anterior branches are needed, using the whole heart acquisition is preferred.

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References: [1] Nezafat R. MRM 2007. [2] Rasche, MRM 2007 [3] Etienne MRM 2002.