Non-Contrast Pulmonary Vein Angiography using Off-Resonance RF Excitation

R. Nezafat[1], C. Stoeck[1], P. Bengani[2], D. C. Peters[1], T. Hauser[1], N. M. Rofsky[1], and W. J. Manning[1]

[1]Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, United States, [2]Biomedical Engineering, Boston Univeristy, Boston, MA, United States

Introduction:

Atrial fibrillation (AF) is a disorder afflicting over 2 million Americans with higher likelihood occurrence with increasing age. Radiofrequency pulmonary veins (PV) isolation is commonly used to treat patients with AF. For these patients evaluation of PV anatomy is essential in pre-procedural planning and post-procedural assessment of this treatment. Today, contrast-enhanced MR angiography is commonly used to evaluate PVs in RF ablation. In today's clinical practice, PV image acquisition is performed during first pass injection of gadolinium (Gd) contrast or with computed tomography and iodinated contrast. However, contrast enhanced approaches have adverse safety implications for patients with renal insufficiency. Therefore, development of a non-contrast enhanced, ECG gated, PV imaging is an emerging neccessity in evaluation of AF patients in PV isololation. In this study, we investigated the use of off-resonance RF excitation to excite the blood in the pulmonay veins as a mean to generate intrinsic contrast.

Theory: The use of gadelinium contrast agent (Gd) as a source of frequency shift for MR angiography has been demonstrated recently [1]. Unlike standard contrast-enhanced MR angiography, this technique depends not on T_1 shortening of Gd but on Gd induced shifts in intravascular resonance frequency due to the bulk magnetic susceptibility effects of Gd [1]. Although this technique has been shown to be an alternative to T_1 shortening-based MR angiography imaging sequences, it can not be used without administration of Gd. Pulmonary veins contain fully oxygenated blood with higher T_2 originating from the lungs. The lung is one of the highest source of bulk magnetic succeptibility due to increased air-blood interactions. Therefore, the blood in the PVs carries history of transversing through an area with high bulk magnetic suceptibility. We sought to exploit this property and investigate the feasibility of off-resonance excitation as a mean to selectively excite the magnetization in PVs.

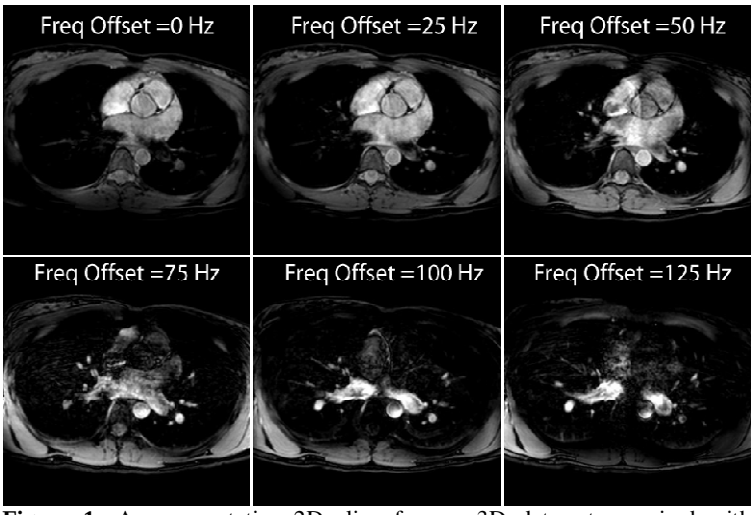

Figure 1: A representative 2D slice from a 3D data-set, acquired with different frequency off-set of 0 to 125Hz. The pulmonary vein branches can be seen as the excitation frequency approaches 100Hz.

Materials and Method: Five healthy adult subjects were scanned using a 1.5T Achieva (Philips Medical Systems) with a 16 channel cardiac array (Invivo Corporation). For each subject, a set of 7 PV images were acquired using a navigator-gated, ECG-triggered, fat saturated, 3D SSFP single phase imaging sequence. A trigger delay of 300ms corresponding to the maximum size of PV was used [2]. Typical imaging parameters were: FOV = 270×270×100mm^3, TE/TR/α=2.3ms/4.7ms/90°, and spatial resolution of 1.5×1.5×3mm^3 reconstructed to 0.75×0.75×1.5mm^3 with acceleration rate 2. An axial image prescription, similar to the one commonly used in contrast enhanced imaging was used. The transmit RF frequency of the imaging RF pulse was adjusted in a series of acquisition. The images were acquired with frequency shift of 0, 25, 50, 75, 100, 125, and 150Hz to demonstrate the signal changes in pulmonary veins.

Results:

Fig. 1 demonstrates an example slice from a 3D PV image acquired with different RF frequency offsets. The results show the preferential signal intensity increase in the PVs as the frequency offset increases. As the frequency increases beyond 125Hz, there is suppression of pulmonary vein signal as well (images not shown). Fig. 2 is an example slice that shows the suppression of pulmonary arteries with increased transmit frequency offset from 0Hz to 75Hz.

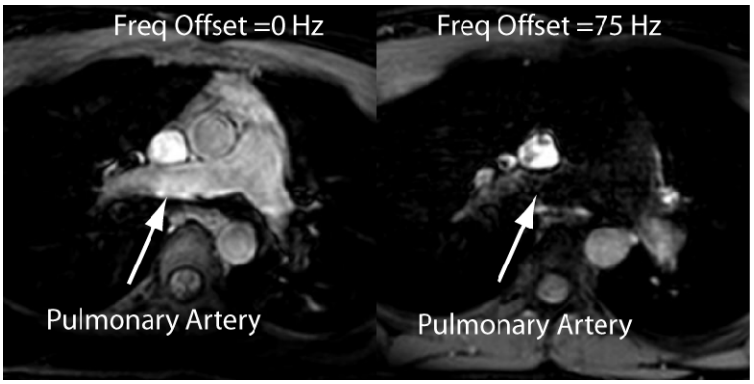

Figure 2: Two representative images acquired with 0 and 75Hz showing efficient suppression of pulmonary arteries.

Conclusions and Discussion:

We have developed a novel imaging sequence for pulmonary vein angiography in which the transmit frequency of the imaging RF pulse is adjusted to the frequency offset of pulmonary veins originating from the lungs. The results show the potential for providing an alternative to the use of contrast agents for PV imaging. Further development is needed to determine the potential clinical utility of this method.

Acknowledgements: We thank Invivo Corporation and Drs. Housen, Herzka, and Hertel for providing prototype 32 channel cardiac array with a prototype 32 to 16 channel combiner.

References: 1) Edelman MRM 2007. 2) Hauser, Am Heart J. 2006.