Self-Gate Free-Breathing Coronary Artery Vessel Wall Imaging by Combining Water and Fat Images

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INTRODUCTION

Recently a self-gated free-breathing 4D SSFP radial imaging technique has been developed for cardiac imaging [1]. Multi-echo radial acquisition has high data acquisition efficiency and is robust against motion. By frequently acquiring the k-space centers along the slice encoding direction, both respiratory and cardiac motions can be derived from the image data for motion gating without extra cost of scan time (self-gating). Data acquisition at different echo times can also be exploited for achieving simultaneous water and fat visualization of the coronary artery. In this study, we will demonstrate our novel technique for coronary artery vessel wall imaging by combining the water and fat images.

MATERIALS AND METHODS

Conventional cardiac-triggered coronary imaging techniques require a series of preparation pulses and a patient-specific trigger delay to minimize cardiac motion, and only provides a single static image. On the contrary, the proposed technique allows a continuous scan to avoid interrupting the SSFP steady state and generates 3D images throughout the whole cardiac cycle. The cardiac phase with the best coronary artery visualization can be selected retrospectively for optimal diagnosis. A multi-echo sequence with radial acquisition in-plane and Cartesian encoding through-plane was used [1]. Data were continuously acquired for ~5 minutes. Retrospective respiratory and cardiac self-gating was applied to generate 3D images throughout the cardiac cycle. At each cardiac phase, data sets acquired at three different echo times were processed to separate water and fat signals using the generalized Dixon method [2]. Although the fat signal for coronary artery imaging is usually unwanted and commonly suppressed, we previously showed that the ultilization of the fat image could help improve vessel delineation on coronary MRA images [3]. In this study, we present a new idea of generating coronary vessel wall images by exploiting the water and fat images.

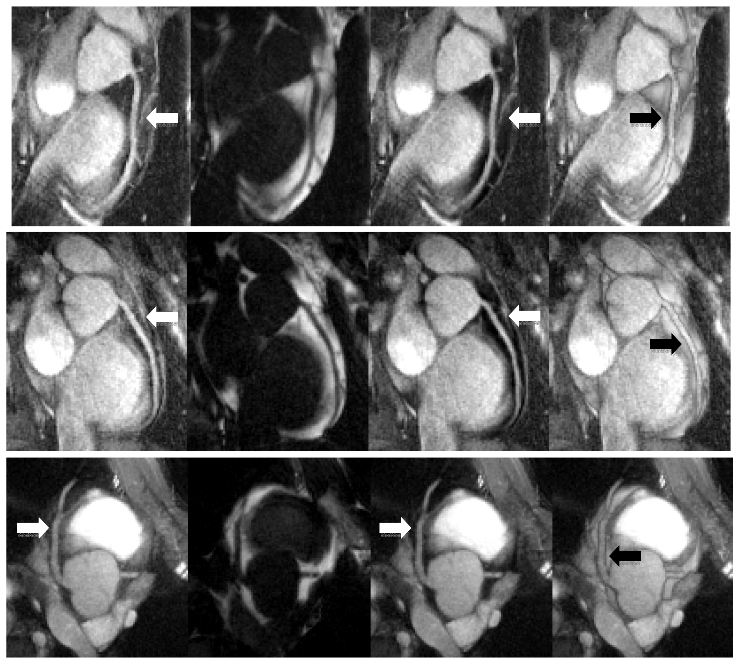

Fig. 1 Water image (first column), fat image (second column), combined image with improved artery contrast (third column), and the vessel wall image (fourth column) from three healthy volunteers are shown. The white arrows refer to the artery contrast improvement and the black arrows point to the vessel walls.

Our hypothesis is that in both water and fat images the intensity of the coronary artery vessel wall is dark in contrast to the blood and surrounding fat signals, so that we can generate a combined image that has bright blood and fat signals while keeping the vessel wall dark. The minimal intensity projection (*mip*) was applied to the water and fat images: $I_v = mip(I_w, \alpha I_f)$, where I_v, I_w and I_f are the new vessel wall image, and water and fat images, respectively; α is a tuning parameter for achieving the best depiction of the vessel wall. The combination of water and fat images for improving the coronary artery contrast was performed as follows: $I_c = I_w \bullet \left[1 - I_f / \max(I_f)\right]$.

The scan parameters for 3D coronary CINE imaging were: 1.5 T GE EXCITE 14M4 scanner, TR/TEs=5.0ms/0.3/1.6/ 2.9ms, FA/BW/FOV = 40°/±125kHz/26 cm, spatial resolution=1.0x1.0x3.0 mm^3, 14-16 slices, 8-channel cardiac coil. The temporal resolution of the cine acquisition was 70-80 ms and scan time was 5 min with 50% respiratory self-gating efficiency. A reasonable value for α was around 0.5, but the best choice may vary for different cases. 10 healthy volunteers were imaged at both RCA and LAD.

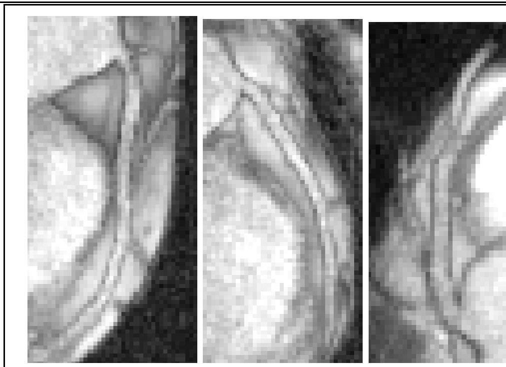

Fig. 2 The vessel walls appear as thin dark lines in the enlargements of coronary artery segments.

RESULTS AND DISCUSSION

Fig. 1 shows our preliminary results of coronary vessel wall imaging. Water and fat images, the combined image with improved artery contrast, and the vessel wall image at a selected cardiac phase are displayed for two RCA cases and one LAD case. By applying the minimal intensity projection on the water and fat images, the artery vessel wall can be clearly depicted with the high contrast between the blood and surrounding fat (Fig. 1, black arrows). Fig. 2 shows the enlargements of the coronary artery segments.

High quality coronary imaging is challenging due to vessel tortuosity, small vessel size, and cardiac and respiratory motions. Visualizing the coronary vessel wall is even more challenging. Motion blurring, artery going through multiple slices, or the limited spatial resolution makes it hard to consistently obtain good depiction of the vessel wall. The promising preliminary results warrant further investigations to improve the robustness of the technique.

CONCLUSIONS

A novel method has been proposed for imaging the coronary artery vessel wall by exploiting the simultaneously obtained water and fat images. Our preliminary results demonstrated that the proposed self-gated free-breathing 4D coronary MRA technique is promising method for simultaneous coronary lumen and wall imaging. This method does not require external respiratory and cardiac gating or dedicated preparation pulses, and generates simultaneous water and fat cardiac cine images in a reasonable scan time.

REFERENCES **1.** J Liu, et. al., MRM, 63, p1230. **2.** GH Glover, et. al., MRM, 18, p371. **3.** J Liu, et. al., Proc 19th ISMRM, p1253.