Non-Contrast-Enhanced MRA of the Renal Vasculature with the bSSFP Dixon Method

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Introduction

Patients with renal arterial stenosis (RAS) are at increased risk of nephrogenic systemic fibrosis linked to gadolinium-based MRA contrast agents [1]. The Dixon method [2] is capable of non-contrast-enhanced (NCE) fat-suppression. Our hypothesis is that the balanced steady-state free precession (bSSFP) Dixon method [3,4] is capable of NCE MRA of the renal vasculature using two short breath-holds.

Methods

Images were collected using a modified 3D bSSFP sequence in the abdomen of five healthy volunteers on a 3.0 T clinical MR scanner (Signa VH/*i*; General Electric Healthcare, Waukesha, WI, USA) using a four-channel torso phased-array coil with an elliptic centric phase encode ordering [5]. The pulse sequence parameters were TR/TE/flip angle = 3.4 ms/1.7 ms/25°, with a 30 cm FOV. The axial acquisition matrix was $256 \times 256 \times 32$ (reconstructed to $512 \times 512 \times 64$). Volunteers were instructed to perform a 15-second breath-hold during the first half of each acquisition, followed by free-breathing for the remainder of the acquisition (15 seconds). Two image volumes were collected with centre frequency offsets of -100 Hz and +100 Hz to produce images where fat and water are in-phase and opposed-phase, respectively [4]. High-order shimming was performed prior to the bSSFP Dixon acquisition. Water-only (*i.e.*, fat-suppressed) images were generated by complex addition of the ±100 Hz offset images. Maximum intensity projection (MIP) images were produced and processed for the 3D water-only image volumes. A trained vascular radiologist inspected the images for overall image quality and vessel conspicuity.

Results

Figure 1 displays single-slice water-only bSSFP Dixon method images from the kidneys from one healthy volunteer. Vessels of interest are easily identified in the images. Figure 2 displays a processed MIP image generated from the same healthy volunteer from Figure 1. The renal arteries are clearly visible in Figure 2, which was also confirmed by the trained radiologist. All volunteers tolerated the breath-holds. Similar results were obtained for the other four healthy volunteers. Both bSSFP Dixon image volumes from each volunteer were collected in under two minutes.

Discussion and Conclusions

Because arterial blood has a higher T2/T1 ratio (intrinsic bSSFP image contrast) than venous blood and surrounding tissues, the arteries appear brighter in the water-only images. One potential restriction of this technique is the high T2/T1 ratio of the urine in the ureters (see Figure 2). However, the high signal and good spatial resolution allow for these structures to be sufficiently differentiated in the water-only images. Likewise, despite using a breath-hold during the low-frequency *k*-space acquisition, respiratory motion during the high-frequency acquisition can cause ringing and ghosting in the final images. One way to overcome this would be to use parallel imaging to accelerate the acquisition, reducing the overall scan time, and making a comprehensive breath-hold feasible. These results show that the bSSFP Dixon method has the potential for 3D NCE MRA of the renal arteries with an overall scan time of less than two minutes. This would have significant clinical impact for patients with RAS who are at risk of nephrogenic systemic fibrosis. The next step in this research is a clinical evaluation to determine if this technique produces diagnostically equivalent information to current clinical angiographic techniques in patients with RAS.

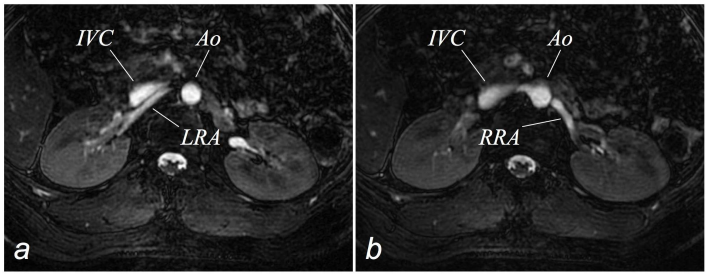

Figure 1: Single-slice water-only images collected from the kidneys in a healthy volunteer obtained using the bSSFP Dixon method. Images a) and b) clearly depict the left and right renal arteries (LRA, RRA), the inferior vena cava (IVC), and the abdominal aorta (Ao).

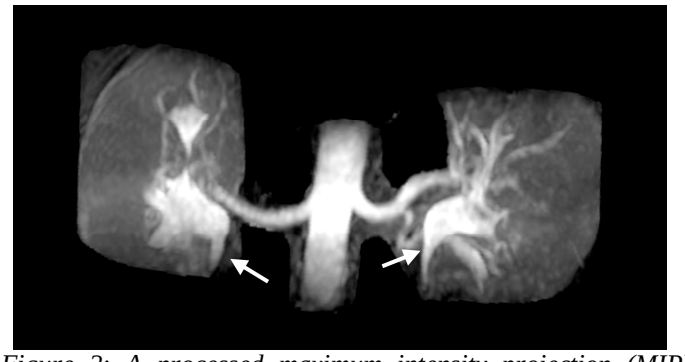

Figure 2: A processed maximum intensity projection (MIP) image calculated through the full 3D volume of the water-only images from the same volunteer in Figure 1. The arrows indicate the ureters.

References

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