Large coverage HOmologous Black-Bright blood Interleaved imaging sequence (LaHOBBI) for 3D dynamic contrast enhanced MRI of vessel wall

Haikun Qi[1], Shuo Chen[1], Zechen Zhou[1], Jinnan Wang[2], Peter Koken[3], Niranjan Balu[4], and Huijun Chen[1]

[1]*Department of Biomedical Engineering, School of Medicine, Tsinghua University, Beijing, Beijing, China,* [2]*Philips Research North America, Briarcliff Manor, New York, United States,* [3]*Innovative Technologies, Research Laboratories, Philips Technologies GmbH, Hamburg, Germany,* [4]*Radiology, University of Washington, Seattle, WA, United States*

Target Audience: Scientists interested in 3D vessel wall DCE MR imaging.

Introduction: Dynamic contrast enhanced (DCE) MRI plays an important role in quantifying inflammatory features of atherosclerotic plaque [1]. Recently, several techniques [2,3] have been proposed for quantitative vessel wall DCE analysis by interleaved black-bright blood imaging. However, these techniques are based on QIR or DIR for black blood imaging and thus limited to 2D or M2D vessel wall imaging often suffering from small coverage. In this study, we proposed a Large coverage HOmologous Black-Bright blood Interleaved imaging sequence (LaHOBBI) for vessel wall DCE MR imaging. Two instantaneous switchable scans including 3D slab-selective (SS) iMSDE [4] black blood imaging and high temporal resolution 2D bright blood imaging were conducted in the proposed LaHOBBI sequence. The SS iMSDE prepulse is designed for locally suppressing blood and eliminating the interferences between black and bright blood sequences.

Methods: *Slab-selective iMSDE*: The SS iMSDE prepulse is shown in **Fig. 1a**. The gradients in red are the slab-selective gradients, and the corresponding refocusing gradients. The prepulse only nulls the blood after the signal is excited by the first 90° RF pulse, and blood outside the excitation slab is left intact. So the bright blood imaging will not be influenced if the bright blood imaging location is placed at the upstream of the black blood excitation area (**Fig. 1b**). *Interleave scheme of LaHOBBI*: The proposed LaHOBBI sequence consists of a 3D black blood imaging module and a 2D bright blood imaging module and supports instantaneous shot-by-shot switching between the two modules. For 3D black blood imaging, after the SS iMSDE prepulse, Stack-of-Star (SoS) golden angle radial (GRadial) was used for data acquisition. For bright blood contrast, 2D single-shot TFE with Cartesian data acquisition was used. The interleave scheme is shown in **Fig. 1c**. The bright blood imaging module can be interleaved with several shots of black blood imaging, ensuring the high temporal resolution of AIF acquisition. *MR imaging*: A healthy volunteer was scanned (for preliminary study, without contrast injection) on a Philips 3T scanner (Achieva TX, Best, The Netherlands) using a dedicated 8-channel carotid coil. Scan parameters for the 3D SS iMSDE SoS GRadial black blood imaging were: TR/TE, 7/3ms; flip angle, 15°; FOV, 150×150×60mm^3(transverse view); voxel size, 0.6×0.6×3mm^3; Sampling in readout (2-fold readout oversampling), 496; spokes in each slice, 372; 20 slices. The excitation thickness of SS iMSDE was set to 100mm. For the 2D TFE: TR/TE, 5/4ms; flip angle, 15°; FOV, 160×160mm^2(transverse view); voxel size, 1×1× 4mm^3; acquisition matrix, 160×160; number of dynamics, 38. The distance between the imaging location of 2D TFE and the excitation slab thickness of SS iMSDE was about 10mm. The total imaging time of the LaHOBBI sequence was 107s, with one 2D TFE dynamic interleaved with 10 TFE shots of 3D black blood imaging, and the temporal resolution of bright blood imaging is 2.8s. *Image reconstruction*: The gradient delays in radial sampling was compensated using method described in [5], and the off-center offset was estimated with radial lines sampled in near-antiparallel directions. The SoS GRadial data for vessel wall imaging was reconstructed by iGRASP [6], and 21 spokes were used for reconstructing one frame resulting a temporal resolution of 6.3s.

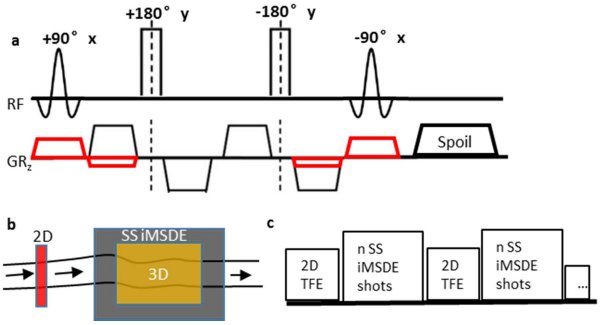

Fig. 1. (**a**) Schematic of the proposed SS iMSDE pulse sequence. (**b**) Locations of SS iMSDE, 3D black blood imaging, and 2D bright blood imaging. The arrow indicates the blood flow direction. (**c**) The LaHOBBI sequence setup.

Results: Interleaved black and bright blood images were successfully acquired. **Fig. 2a** shows 4 slices of black blood images and **Fig. 2b** shows 4 frames of bright blood images. Good blood suppression was achieved on black blood images and no obvious signal variation can be found on the bright blood images. Quantitatively, ROI was placed in the CCA of bright blood images for AIF extraction, and the blood signal curves is shown in **Fig. 2c**. The consistent blood signal indicates that the slab-selective iMSDE prepulse suppressed blood locally without causing signal interference with bright blood imaging.

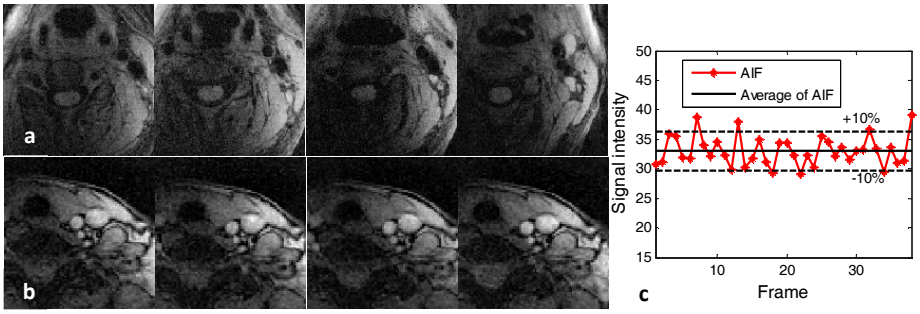

Fig. 2. (**a**) Four slices of the interleaved black blood images. (**b**) Four frames of bright blood images. (**c**) The signal intensity curve of blood.

Discussion and Conclusions: In this study, the feasibility of conducting SS iMSDE for homologous black-bright blood interleaved DCE imaging sequence was demonstrated by in vivo experiment on carotid. The proposed LaHOBBI sequence enables 3D large coverage, high spatial resolution vessel wall DCE imaging and 2D high temporal resolution bright blood imaging for accurate AIF extraction, which ensures the quantitative DCE analysis and coverage of atherosclerotic plaque.

References: [1] Kerwin W, et al. Circ. 2003;107:851-6. [2] Wu T, et al. MRM. 2014 Epub. [3] Fan Z, et al. JCMR. 2013.15(Suppl 1):p.246. [4] Wang J, et al. JMRI. 2010;31:1256-1263. [5] Block KT, et al. ISMRM 2011, p.2816. [6] Feng L, et al. MRM. 2014;72:707-17.