Interleaved LOcal excited Black Blood (LOBBI) and Bright Blood MRI for improved vessel wall DCE

J. Wang[1], H. Chen[2], G. J. Wilson[3], N. Balu[2], W. S. Kerwin[2], C. Yuan[2], and P. Boernert[4]
[1]Clinical Sites Research Program, Philips Research North America, Seattle, WA, United States, [2]University of Washington, [3]Philips Healthcare, [4]Philips Research Europe

Introduction: Recently, dynamic contrast enhanced MRI has been used to quantify inflammatory features of the atherosclerotic plaque [1, 2]. It is however still challenging to evaluate inflammation in early lesion and the fibrous cap region (for plaque rupture) due to the difficulties of acquiring both the arterial input function (AIF) and tissue signal variations in a small region near the lumen. The current techniques have made compromises by acquiring only bright- or black- blood images [3]. An alternative solution is to acquire bright and black blood images in an interleaved fashion, so that the requirements of high temporal resolution for the AIF and the high spatial resolution for the vessel wall imaging can be achieved by optimizing them separately. A technical challenge of interleaved black/bright imaging (IBBI) is that: the non-selective black blood imaging pulses will interfere with the bright blood imaging module, leading to inaccurate AIF quantification. As shown in Fig.1b, the typical time gap between the black blood module and the following bright blood module is usually less than 200ms, which is well before the blood reaches its equilibrium state. In this abstract, a novel IBBI scheme with the recently developed LOcal excitation Black Blood Imaging (LOBBI) [4] was proposed to eliminate the interferences between the black and bright blood sequences.

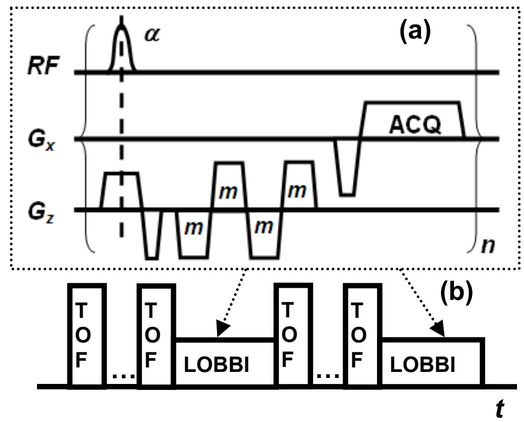


Fig.1 The LOBBI sequence (a) and the IBBI setup. In (a), the motion-sensitizing gradients 'm' are used to eliminate flowing blood before the acquisition; In (b), multiple TOF modules could be applied for every LOBBI sequence to improve the AIF temporal resolution. TOF and LOBBI can be applied at different coverage to facilitate quantitative imaging.

Methods: LOBBI:The LOBBI sequence is shown in Fig.1a. Unlike the traditional DIR or MSDE sequences, the LOBBI sequence does not rely on the global blood nulling to overcome the inflow effect. It only suppresses blood after the signal is excited by the RF pulse. Blood outside of the FOV is left intact, preventing the following any interference with the bright blood images.

IBBI: The LOBBI based IBBI was constructed as shown in Fig.1b. The LOBBI and time-of-flight (TOF) sequences are used to achieve black and bright blood contrasts, respectively. Multiple TOF modules can be placed between LOBBI modules to improve the temporal resolution of the AIF acquisition. Another advantage of the LOBBI-IBBI method is that coverage and location of the TOF and LOBBI sequences can be optimized separately depending on requirements for quantification of DCE analysis.

MR imaging: All MR imaging was conducted on a clinical 3T scanner (Philips Achieva, R2.61, Best, the Netherlands). A long tube with flowing water (v=80cm/s by PC MRI) driven by a water pump was used to simulate the blood flow in the artery, and a static water phantom was placed next to the tube to serve as a reference. The flow direction is perpendicular to the imaging plane (Fig. 2a). For demonstration purposes, only 1 TOF image and 1 LOBBI image were included in each package. Both TOF (2D FFE, TR/TE 15/3ms, FA 40º) and LOBBI (2D TFE, TR/TE 50/3ms, FA 20ms) were acquired at a spatial resolution of $1\times1mm^2$ and 5mm thickness. The dynamic scan time for each package was: 2.3s (TOF) and 7.7s (LOBBI) and the total dynamic time was 10s per package.

Results: Interleaved black and bright blood images were successfully acquired (Fig. 2b), notice the alternating flow signal at the lower-right corner of the image among bright and black blood images. No obvious signal variation was found on the bright blood images. Quantitatively, consistent signal output was again found among all bright blood images (Fig.2c), indicating that the LOBBI sequence suppressed blood signal without causing signal interference with TOF.

Conclusion: In this study, the feasibility of conducting interleaved black- and bright- blood DCE images was demonstrated in a flow phantom experiment. The LOBBI technique was used to eliminate the signal interference between black and bright blood images, paving the way for a quantitative DCE analysis of the most interested inflammatory regions in atherosclerotic plaque, such as the fibrous cap and early lesion.

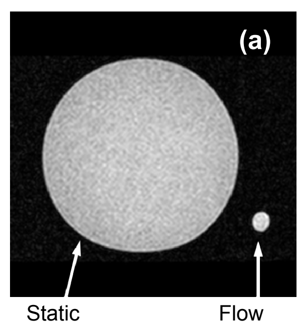
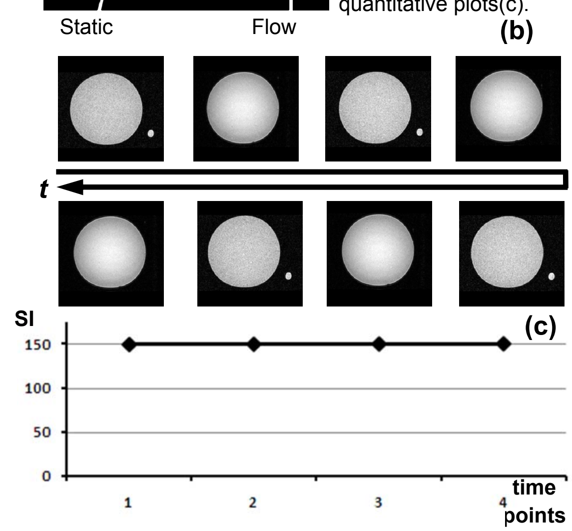


Fig. 2 Setup of the flow phantom (a) and the IBBI results (b). Interleaved black and bright blood images were acquired. No signal variation was found among bright blood images (b) and quantitative plots(c).



References: 1. Kerwin et al. *Circ* 2003. 2. Kerwin et al. *Radiology* 2006. 3. Wang et al. *ISMRM Annual Meeting*, 2011 (Submitted) 4. Chen et al, 1265, *ISMRM Annual Meeting* 2010,