A REAL-IR 3D T1-WEIGHTED BLACK-BLOOD IMAGING TECHNIQUE COMBINING WITH WHITE-BLOOD

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Target Audience: Researchers and clinicians who are interested in methodology for vessel wall imaging

Purpose:
Several MRI techniques for black-blood (BB) imaging were proposed and used to detect atherosclerotic plaque in carotid arteries for prevention of brain stroke. In those, 3D-T1W sequence is regarded as especially useful for detecting high-risk intraplaque hemorrhage (IPH). Recently, motion-sensitized-driven-equilibrium (MSDE) prepared 3D sequence was proposed [1]. However, motion artifacts or spatial inhomogeneity induced by eddy-current are problematic. More recently, a phase-sensitive method combining with slab-selective inversion-prepared sequence (Real-IR) was proposed [2], where IPH-to-vessel contrast was enhanced by making inflowing blood signals negative. However Wang’s method has limitations for selecting the thickness of inversion slab or TI because the phase correction data is acquired after the main read-out, just for the purpose of phase correction. In contrast, homodyne filter method [3] of using self data is not required extra data for phase correction but has a risk for incorrect phase estimation on GRE sequence. The purpose of this study was to propose and assess a new 3D-T1W technique allowing to provide Real-IR black-blood (BB) images with a higher degree-of-freedom for IR-slab thickness and without extra-data acquisition only for the phase correction.

Methods:
Theory: Basic idea is that 3D-time of flight (TOF) data is employed for the background phase correction of BB data; since TOF image is acquired in addition to BB images in routine clinical diagnosis and the vessel phase becomes always the same as for the static background. Each read-out sequence was 3D-GRE (FFE) and the same TE was used to obtain the same background phase. BB is acquired with wide slab thickness of IR to invert inflow blood Mz then read-out after TI (Fig. 1). When TI is shorter than the TI of nulling blood Mz and without background phase error, real-part of blood signal becomes negative. In contrast, inflow blood signal in TOF data becomes positive phase. Here, 

\[ \text{SRW, SBB and IBB are defined respectively as complex image data of WB (TOF), BB, and real BB image. Phase correction using TOF data for BB is followed by taking real part as:} \]

\[ \text{S}_{\text{cor}} = \text{real}[\text{S}_{\text{cor, re}}, \text{I}_{\text{BB}} - \text{real}[\text{S}_{\text{cor}}, \text{I}_{\text{BB}}] \]

where \text{Conj} [] and \text{Rea}l [] are respectively operators for taking complex conjugation and real part.

MR Experiments: Experiments were performed on Toshiba Vantage Titan™ 3T (Otawara, Japan) for normal volunteer after obtaining written informed consent. For IR-BB, FFE3D, IR-slab thickness=100cm, TR/TE/Fs=7.2ms/3.4ms/15deg, FOV=21cm, acquisition matrix=256x256x32, display matrix=512x512x64 after sinc interpolation, slice thickness=2mm, # of segments=2, centric-interleave (phase-slice) encode order, recovery time after read-out (T_{\text{recovery}})=400ms, parallel imaging of reduction-factor=2, and TI=200~900ms was used, where acquisition time was 1:12~2:00. Fat-suppression was not added to measure T1-contrast because T1 of IPH provide Real-IR black-blood (BB) images with a higher degree-of-freedom for IR-slab thickness and without extra-data acquisition only for the phase correction.

Results and Discussion:
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Conclusion:
Our proposed Real-IR T1W-BB is a practical method for vessel wall imaging from the views of time-efficiency for acquiring phase correction data and higher degree-of-freedom for setting IR slab thickness, though further parametric study and clinical evaluation are necessary.

References: