Black Blood Imaging of Carotid Plaque Using Spatial Labeling With Multiple Inversion Pulses Prepared Spoiled Gradient Recalled Sequence

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Introduction

Black blood imaging can be used to identify and characterize carotid plaque. The current method widely used is 2D double inversion recovery (DIR)[1] or quadruple inversion recovery (QIR)[2] prepared fast spin echo (FSE) sequence. 2D technique has its drawback of low SNR and limited coverage. The purpose of this study is to develop a 3D black blood plaque imaging sequence.

Materials and Methods

A preparation of **S**patial **L**ab**E**ling with multiple inv**E**rsion pulses (**SLEEK**) is added to a 3D segmented SPGR sequence. The SLEEK preparation can be implemented as one or more than one inversion recovery pulses. Typically 2 IR pulses are used: the first IR pulse with a broad spatial band is designed to saturate the blood flow and the second IR pulse with narrower spatial band is to recover the wanted signal from the imaging volume. The SLEEK bands can be geographically prescribed. TI was selected to null the blood signal. Adiabatic SPIR chemical saturation pulse was applied prior to the data acquisition for fat saturation (FS).

All experiments were performed on 3.0T MR scanners (EXCITE HD, GE Healthcare, Milwaukee). Phantom study was conducted to verify the effectiveness of the SLEEK preparation using a phased array receiving only head coil. Human study (5 patients, with patient consent signed) was performed with a 4 channel phased array carotid coil under the whole gradient mode for better gradient linearity in a large range. Parameters were optimized as follows: TE = 3.5ms, TR = 9.1ms, Flip angle = 10, TI = 650ms, slice thickness = 2mm, FOV = 14cm x 11cm, matrix = 256 x 256, receiver bandwidth = ±41.7kHz, NEX = 0.75, 25-35 sections acquired in axial view. With a post wait period 800ms after the SPGR acquisition, the scan time was around 5 minutes.

Results and Conclusion

Phantom study showed the effectiveness of SLEEK preparation (Fig 1). In human study, we found that both one pulse and two pulse SLEEK prepared BB imaging has its diagnostic value in carotid plaque characterization. With one pulse preparation, background signal was partially suppressed, and hemorrhage can be highlighted as shown in Fig. 2a (red arrow). Two of the five patients were diagnosed to have intraplaque hemorrhage by the radiologist. From these two patients, it seems that we can draw such a conclusion: the sequence is more sensitive to detect hemorrhage compared with conventional QIR and TOF sequence. With two pulse SLEEK preparation, it was easier to identify calcification area without the interference of the dark edge between bright blood and artery vessel wall (green arrows in Fig 2). Compared to 2D black blood sequence, 3D sequence can achieve higher SNR with shorter scan time.

SPGR sequence has intrinsic blood inflow enhancement which makes a complete flow suppression a challenge in some cases: such as in post contrast imaging or slow blood flow. Additional IR pulses might need to be added to SLEEK preparation to improve the flow suppression.

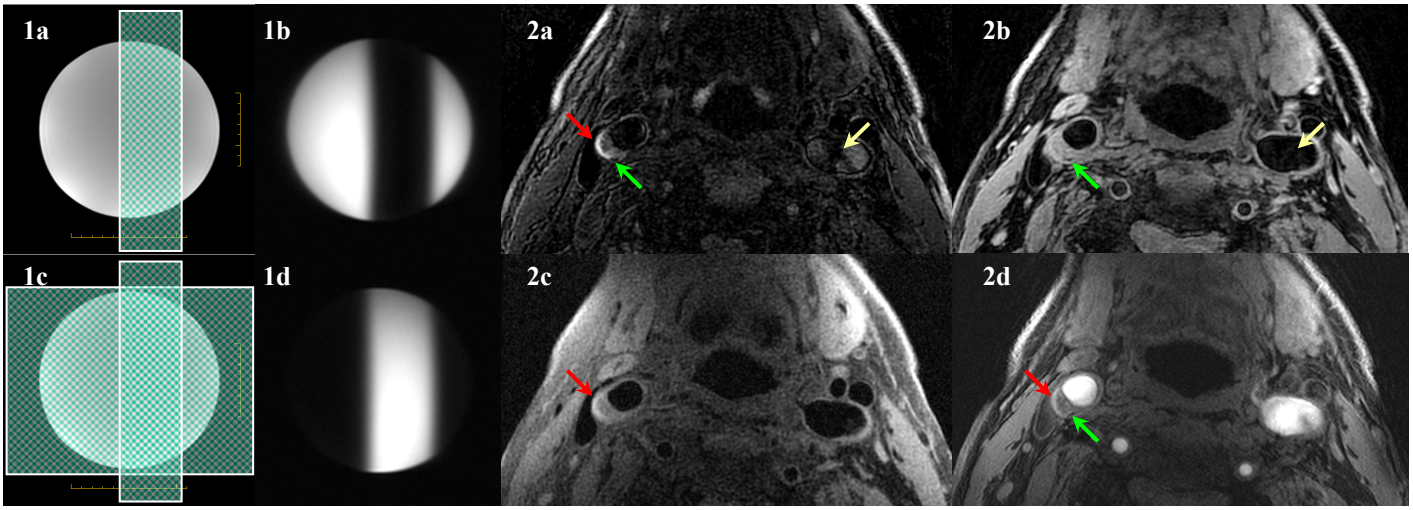

Fig 1: Phantom study of SLEEK verification. One IR band was prescribed in Fig 1a, and band saturated image was obtained as Fig 1b. Two IR bands were localized as Fig 1c, and band reserved image was obtained as Fig 1d.

Fig 2: Human study from a patient with carotid plaque composed of hemorrhage (red arrows) and calcification (green arrows). Fig 2a: one pulse SLEEK prepared 3D SPGR. Fig 2b: two pulse SLEEK prepared 3D SPGR. Fig 2c: 2D QIR FSE. Fig 2d: 3D TOF.

References

[1] Yuan C. et al. JMRI 2004, 19: 710-719

[2] Yarnykh V.L. et al. MRM 2002, 48: 899-905