Improvements of suppression of in-plane flow signal of carotid arteries using phase sensitive inversion recovery -3D T1 turbo field echo

N. Kajihara[1], T. Horie[1], M. Honda[1], I. Muro[1], T. Takahara[2], H. Moriguchi[1], and Y. Imai[1]

[1]Radiology, Tokai University School of Medicine, Isehara, Kanagawa, Japan, [2]Tokai University School of Engineering, Hiratsuka, Kanagawa, Japan

Introduction: 3D inversion recovery –T1 turbo field echo (3D IR-T1TFE) has been widely used to suppress signals from flowing blood. In this technique, IR RF pulses are applied to presaturate signals from flowing blood. However, 3D IR-TFE usually does not achieve complete elimination of the signals from blood due to T1 relaxation occurred during long acquisition time. Signal saturation may be ineffective when signals from in-plane flow are suppressed since the total scan time is increased. Phase sensitive IR (PSIR) has been proposed to improve detection of myocardial infarction using Gadolinium-delayed hyperenhancement [1]. This technique maintains polarity of magnetization inverted by an IR RF pulse and corrects for phase error in the images. In this study, we show that improved suppression of in-plane flow signal of carotid arteries is achieved using 3D IR-T1TFE combined with PSIR (PSIR-3D IR-T1TFE).

Method: We performed both phantom and in-vivo experiments to compare PSIR-3D IR-T1TFE with 3D IR-T1TFE using a 3.0 Tesla Philips Achieva scanner (Philips Medical Systems, Best, Netherlands). Data were acquired using a flex-M coil. In each of phantom and in-vivo experiment, IR TR or shot interval was set equal in each sequence. In in-vivo imaging, all procedures were done under an institutional review board approved protocol for volunteer scanning.

In phantom experiments, we scanned three bottles of solutions doped with Gd-DTPA. Since the concentration of Gd-DTPA was varied among them, their T1 values were also varied: 1500ms, 1000ms and 500ms. They were regarded as blood, muscle and plaque, respectively [2,3]. We performed the following two experiments: a) the signal intensities were measured with several TI values. TI values were changed from 100 to 1000ms with a 50ms interval. b) Contrast-noise-ratio (CNR) was calculated from the signal intensities measured in a) when TI were between 100 and 600ms.

In in-vivo experiments, we scanned coronal views of carotid arteries from ten asymptomatic volunteers. Neither ECG nor pulse gating were used. TI values were set to 350, 450 and 550ms. We measured CNR between the carotid artery lumen and the sternocleidmastoid muscle for each volunteer. Five locations centered at carotid bifurcation were selected to measure the signal intensities with each 2cm apart. We measured CNR at each location and computed the mean of them to statistically analyze the results using ANOVA.Sequence parameters were: an image matrix 256 x 256, TR/TE/FA 6.25/2.7ms/30º, low-high ordering, slice thickness 1mm, the number of slices 30, ETL 32, data acquisition duration 200ms and NSA 1.

In the ensuing discussion, M, R, and I images stand for magnitude, real and imaginary images of 3D IR-T1TFE sequence, respectively. Similarly, PS-M and PS-CR images stand for magnitude and calculated images of PSIR-3D IR-T1TFE sequence, respectively.

Results: In phantom experiment, null point of the solution with T1 1500ms was approximately 450ms. Although both M and PS-M images showed similar signal intensities for all the TI values, difference of the measured signal intensities among the solutions of PS-CR image was larger than that of R image. When TI values were small, CNR were negative in both M and PS-M images while they were positive in both R and PS-CR images. In PS-CR and R images, CNR was the highest at TI 350~400ms. In PS-M and M images, CNR was the highest at TI 450~550ms. The highest CNR was observed at TI 350ms in PS-CR images.

In in-vivo experiments, while CNR was the highest at TI 350ms in both PS-CR and R images, it was the highest at TI 450ms in both PS-M and M images. CNR measured at proximal positions than those at distal position in every volunteer. PS-CR image shows the highest mean CNR at TI 350ms. Our analysis showed that this result had statistically significant difference ($p<0.05$).(Fig.1)

Discussion/Conclusion: As the phantom experiments show, since adequate phase correction is done in PS-CR images, larger difference in signal intensities due to TI variations can usually be observed in PS-CR images than R images. In both R and PS-CR images, CNR became the highest at TI 350ms that was shorter than null point of blood. This result indicates that contrast between blood and tissues can be improved if data are acquired when longitudinal magnetizations of blood are negative.

In-vivo imaging showed that CNR at proximal positions were better than those at distal positions. It is presumed that this CNR variation was observed since T1 relaxation occurred in blood signal during data acquisition.When data were acquired with TI 350ms, although signals in blood were negative, contrast between blood and tissues were improved in both R and PSIR-CR images. This observation in in-vivo experiments is consistent with that in phantom experiments.

As mentioned above, better contrast can usually be observed in PS-CR images than R images due to phase correction. Therefore, relatively uniform suppression of in-flow blood signal can be achieved in PSIR-CR images with TI shorter than null point of blood. PSIR-3D IR-T1TFE improves contrast between tissues and in-plane flow of carotid arteries.(Fig.2)

References:[1] Kellman P, et al. MRM 2002;47:372-383. [2] Zhu D.C., et al. MRI 2008;26:1360-1366. [3] Wang J, et al. MRM 2007;58:973-981.

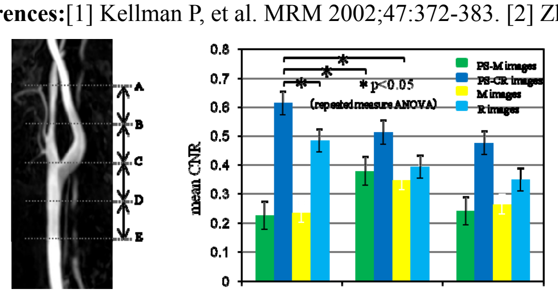

Fig.1:Comparison between mean CNR the carotid artery lumen and the ternocleidmastoid muscle
a) Five location for measurement(A~E)
b) Difference of mean CNR of TI (a) | (b)

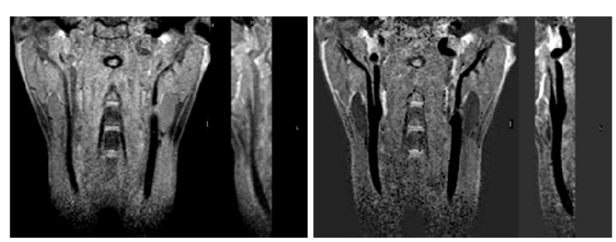

Fig.2: The difference in contrast between M images and PS-CR images
(a) M images(TI450ms)
(b) PS-CR images(TI350ms) (a) | (b)