Assessment of Magnetization Transfer and Tissue Blood Flow imaging in Human Breasts Tissue by GREAST

K-L. Li[1], L. J. Wilmes[1], J. Gibbs[1], E. Han[2], G. Zaharchuk[1], C. P. Hess[1], B. Joe[1], N. Hylton[1]

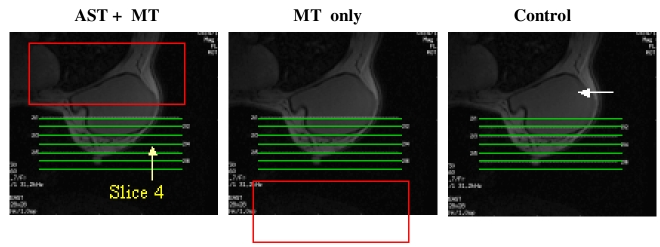
[1]Radiology, University of California, San Francisco, San Francisco, CA, United States, [2]GE Healthcare Global Applied Science Laboratory, Menlo Park, CA, United States

INTRODUCTION

Arterial spin tagging (AST) techniques have been used to improve microvasculature and functional characterization of breast lesions [1-2]. The conventional gradient-echo arterial spin tagging (GREAST) sequence [3] uses an off-resonance presaturation radio frequency (RF) pulse to tag inflowing blood and to generate volumetric tissue blood flow (TBF) weighted images. However, it was suggested that GREAST might generate pronounced magnetization transfer (MT) contrast due to the off-resonance effects of the tagging RF pulse on the static spins in the imaging plane. This could then result in impaired discrimination between dense parenchymal tissue and neoplastic tissue. In this study we investigated tissue contrast from magnetization transfer (MT) and blood flow in the arterial spin tagging (AST) experiment in volunteers. Fifteen patients undergoing neoadjuvant chemotherapy for invasive breast cancers were imaged by the GREAST technique to assess the impact of the preserved MT on detection and differentiation of breast lesions. Texture analysis was performed in GREAST difference (ΔM) image for each tumor to assess tumor response to the therapy.

METHODS

MR imaging was performed on a 1.5-T Signa scanner (General Electric Medical Systems, Milwaukee, WI) in 2 healthy volunteers and 15 breast cancer patients. The MT and TBF signal intensities were measured in two healthy female volunteers (one with bilateral saline implants) via three scans: The first scan incorporated a short TR spoiled gradient echo (SPGR) sequence with an off-resonance presaturation band placed just posterior to the breast (Fig. 1, Scheme A); The second scan placed the presaturation band anterior to the imaging plane and outside the trunk so that blood is not tagged (Fig. 1, Scheme B); The third scan used SPGR sequence without off-resonance saturation, (Fig. 1, Scheme C). In patient studies (N=15), the GREAST sequence was performed prior to routine dynamic GdDTPA-enhanced scanning. The acquisition parameters were TR=15 msec, TE=1.6 msec, flip angle=20°, matrix=256x160, average=8, slice thickness=5 or 10 mm, and field of view =18-22 cm. Multislice axial GREAST images were acquired with a tagging plane placed superior to the breast [2]. Care was taken to keep the same receive gain for tagged and control acquisitions. ΔM images, which reflected both TBF and MT effects, were obtained by subtracting the tagged images from the controls after co-registration (Automated Image Registration 3.0, UCLA, USA). To assess the changes following chemotherapy, the ΔM data were divided into two groups: group 1 (pre- and after 1 cycle of chemotherapy), and group 2 (after 4, 5, or 6 cycles of chemotherapy). Five texture measures, contrast, entropy, variance, angular second moment (ASM), and inverse difference moment (IDM) [4], were computed for each lesion on ΔM images. In addition, mean signal intensity (MSI), standard deviations (STD), and the median of signal intensity were also calculated. The significance of the difference in these measures between the two groups was estimated using a two-sided t-test.



Scheme A Scheme B Scheme C

Fig. 1. Locations of the presaturation band (red), and imaging slices (green) relative to the breast. a) Posterior saturation band was used for AST+MT Image; b) Anterior saturation band was used for MT image; c) Control image was obtained without off-resonance presaturation band. The white arrow points to a saline implant.

RESULTS

Volunteer Study. Fig. 2 shows i) control; ii) TBF and MT weighted image (subtraction of image acquired by scheme A in Fig. 1from image acquired by scheme C); iii) MT weighted image (subtraction of image acquired by scheme B from image acquired by scheme C); and iv) TBF weighted image (subtraction of image acquired by scheme A from image acquired by scheme B) for the middle slice of the image volume, which is at the same distance from the anterior and posterior presaturation band (Fig.1). MT-induced signal is observed from breast parenchyma (green arrow) and skin (yellow arrow) (image iii). Adipose tissue (blue arrow) shows neither MT nor TBF signal.

Patient Study. Tumor tissue with a higher degree of vascularization was clearly depicted on the GREAST ΔM images in a patient before chemotherapy (Fig. 3). The lesion after 5 cycles of chemotherapy was less distinguishable from adjacent normal breast tissue as shown in Fig. 4. MSI, STD and median also showed significant (p<0.05) or borderline significant (0.05<p<0.09) differences (Table 1). Four texture measures, contrast, entropy, variance, and ASM, showed no differences between the two groups; only IDM showed a significant difference between the two groups.

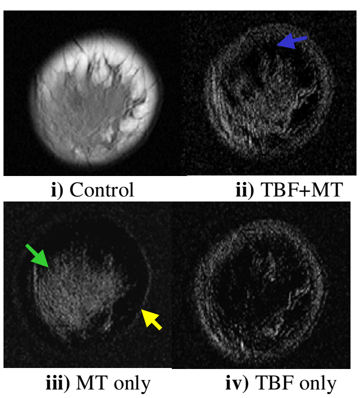
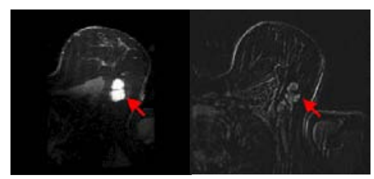
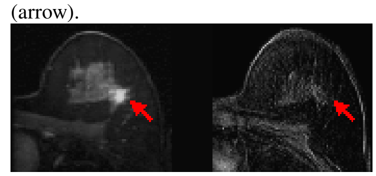


Fig. 2. MT and TBF weighted images for the middle slice (slice 4) in Fig. 1.



C+, 2.5 min post GREAST ΔM

Fig. 3. Post-contrast MR images and GREAST ΔM image in a 50-year-old woman before chemotherapy. Contrast-enhanced MRI revealed a right axillary lymph node metastasis, which is well shown on the GREAST ΔM image (arrow).



C+, 2.5 min post GREAST ΔM

Fig. 4. Post-contrast MR images and GREAST ΔM image in a 58-year-old woman after 5 cycles of chemotherapy. Contrast-enhanced MRI shows a slowly enhancing residual lesion (arrow), which is poorly distinguished from normal breast tissue on the GREAST ΔM image.

DISCUSSION

Assuming that MT-induced signal is not significantly changed after treatment [5], GREAST ΔM images provided useful information in depicting changes in local blood flow in breast tumors. The observation by visual inspection agreed with the results from the texture analysis. In conclusion, GREAST may be useful in breast tumor characterization, especially when administration of an intravenous contrast material is not acceptable. Future work will focus on separation of MT and TBF effects to improve lesion visualization and tumor microcirculation quantification. The utility of IDM for contrast differentiation between MT and TBF needs to be further explored .

Table 1. Comparison of groups using independent-samples t-test

Measure	Group 1 (n=8)	Group 2 (n=7)	*P*-value
MSI*	31.7 ± 28.1	5.5 ± 5.6	0.03
STD*	15.6 ± 12.2	5.6 ± 4.0	0.06
Median*	31.4 ± 27.7	3.3 ± 5.8	0.02
IDM	0.74 ± 0.08	0.39 ± 0.20	0.0005

* Normalized to slice thickness = 10 mm

Acknowledgements: The authors thank for Evelyn Proctor for data acquisition.

References 1. Zhu DC and Buonocore MH, Magn Reson Med 2003; 50:966-75. 2. Li KL et al. 13th ISMRM, Miami 2005; 793. 3.Chai JW et al, J Magn Reson Imaging 2002; 16: 51-59. 4. Haralick RM et al, IEEE Trans Syst Man Cybernet 1973; 3:610-21. 5. WG Schreiber et al. MRM 1996; 35: 861-869.