Breast Tissue Perfusion Imaging with Arterial Spin Tagging Technique: Pilot Study Using GREAST

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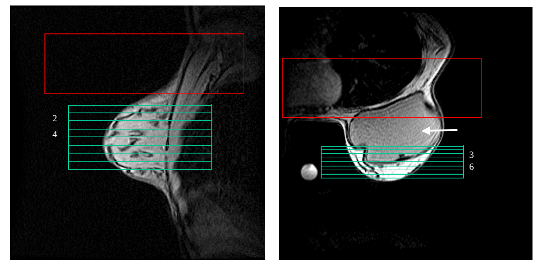
INTRODUCTION

Arterial spin tagging (AST) has several advantages over conventional dynamic contrast-enhancement (DCE) in measuring blood flow of breast tumors, but there have been very few published reports [1] on the use of AST in breast imaging due to the associated technical difficulties. One key issue is the placement of the tagging plane such that it covers all the major vessels that feed the breast, while still allowing labeled spins to arrive at the imaging plane before they have completely relaxed. In this study we used a modified gradient-echo arterial spin tagging (GREAST) technique [2] incorporating a short TR spoiled gradient echo (SPGR) sequence with a selective presaturation radio frequency (RF) pulse to tag inflowing blood [2]. Multislice perfusion weighted images were acquired. Tagging efficiencies were estimated by comparing the texture of breast tissue from the perfusion weighted images acquired with different tagging locations.

METHODS

The study was performed on female volunteers, including one with bilateral saline implants, using a 1.5 T Signa scanner (GE Medical Systems, Milwaukee, Wisconsin). Tagging of blood water was accomplished with a selective Shinnar-Le Roux 90° pulse across an 80-mm-wide presaturation band. Axial and coronal positions of the tagging plane were tested. The imaging plane contained 8 slices. 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 =16 cm. Multislice axial AST images were acquired with a tagging plane placed just superior to the breast (see Fig. 1a). Coronal AST images were acquired with the tagging plane placed just posterior to the breast (see Fig. 1b). Care was taken to keep the same receive gain for tagged and control acquisitions. Local perfusion was demonstrated by subtracting the control and tagged images after co-registration (Automated Image Registration 3.0, UCLA, USA). Difference (ΔM) images, i.e. perfusion weighted images, were calculated from tagging and control images. Texture analysis was performed on ΔM images acquired with the two tagging schemes, including mean signal intensity (MSI), standard deviations of signal intensity (STD), and texture features calculated from the grey level dependence matrix of ΔM, such as contrast, entropy, and angular second moment (ASM) [3].



a b

Fig. 1. Locations of the tagging plane (red), and imaging slices (green) relative to the breast. a) superior tagging plane was used for axial AST imaging; b) posterior tagging plane was used for coronal AST imaging. Arrow points to a saline implant.

RESULTS

Two slices (top row: slice 2; bottom row: slice 4) from the axial AST imaging volume (see Fig. 1a) are shown in Fig. 2. ΔM images show high flow areas including arteries (red arrow) and skin. Breast tissue has medium ΔM (green arrow). Lipid (yellow arrow) and phantom (white arrow) show very low ΔM. Fig. 3 shows two slices (top row: slice 3; bottom row: slice 6) from the coronal AST imaging volume (see Fig.1b) from the volunteer with saline implants. Again, high flow is seen in arteries (red arrow) and skin. Breast tissue has medium ΔM (green arrow). Lipid (yellow arrow) and saline implant (white arrow) show very low ΔM. Texture analysis (Tables 1 and 2) showed significant differences in the textures between fat and breast parenchymal tissue in ΔM images, for both axial and coronal images. Two different tagging locations were used, with comparable results in tagging efficiencies. No statistically significant differences between textures of coronal and axial AST images was seen. Thicker slices (Table 1) showed higher tissue MSI, as expected. However, texture measures remained comparable. Finally, the dominant effect on the attenuation of ΔM at slices far from the tagging plane was less apparent on coronal images than axial images, suggesting more uniform tagging with the tagging plane placed near the base of breast in the coronal orientation.

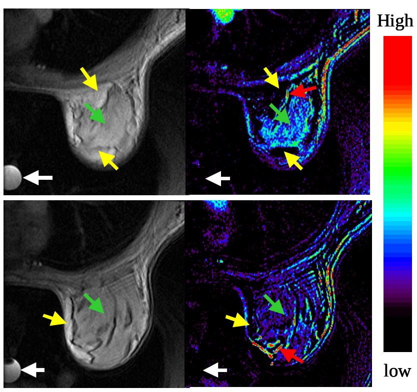


Fig. 2. Axial AST control (left) and ΔM (right) images.

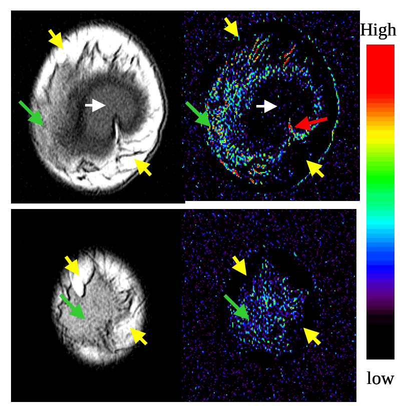


Fig. 3. Coronal AST control (left) and ΔM (right) images from a female volunteer with saline implants.

DISCUSSION

Two tagging locations were tested. Axial AST images were obtained using a presaturation plane that tagged the internal and lateral thoracic arteries. Coronal AST images were obtained with the presaturation plane placed posterior to the breast and parallel to these two arteries. Tagging vessels also include their branches, such as lateral and medial mammary branches, and branches of posterior intercostal arteries. On both axial and coronal AST images, breast tissue showed greater perfusion signal than the adjacent adipose tissue. Mean ΔM and texture measures of breast parenchyma were significantly higher than those of fat and saline implants. It was also shown that SNR of the ΔM images was closely related to the distance between the tagging plane and imaging slice. In summary, with appropriate positioning of the arterial spin tagging plane a significant quantity of labeled spins can arrive at the breast tissue prior to losing their coherence - even at 1.5T. Both axial and coronal AST images can be obtained, potentially useful in assessing perfusion changes in breast tumors.

REFERENCES 1. Zhu DC and Buonocore MH, Magn Reson Med 2003; 50:966-75. 2. Chai JW et al, J Magn Reson Imaging 2002; 16: 51-59. 3. Haralick RM et al, IEEE Trans Syst Man Cybernet 1973; 3:610-21.

Table 1. A comparison between textures of fat and breast parenchymal tissue measured from axial ΔM images.

Feature	Fat	Tissue	*P*-value
MSI	1.85± 1.53	26.51± 5.67*	<0.00001
STD	4.08 ± 2.83	10.62 ± 1.44	0.002
Contrast	4.39 ± 3.84	11.67 ± 2.69	0.009
Entropy	1.07±0.69	4.65±0.20	<0.00001
ASM	0.0026±0.0019	0.0151±0.0025	<0.00001

* Slice thickness = 10 mm

Table 2. A comparison between textures of fat and breast parenchyma tissue measured from coronal ΔM images.

Feature	Fat	Tissue	*P*-value
MSI	0.33± 0.26	15.17± 3.72*	<0.00001
STD	1.37 ± 0.84	13.18 ± 3.31	0.0001
Contrast	6.52 ± 5.15	14.33 ± 2.13	0.01
Entropy	0.40±0.20	4.29±0.30	<0.00001
ASM	0.0006±0.0004	0.0104±0.0012	<0.00001

* Slice thickness = 5 mm