Flow Independent Breast MR Angiography using a Variable Flip Angle Turbo Spin Echo Sequence

Y. Wang[1,2], K. Diedrich[2], G. Morrell[2], A. Payne[2], and D. L. Parker[1,2]
[1]Bioengineering, University of Utah, Salt Lake City, UT, United States, [2]Radiology, Utah Center for Advanced Imaging Research, Salt Lake City, UT, United States

Background

Breast tumor growth is highly dependent on angiogenesis. Visualization of the breast vasculature helps assisting pre-surgical staging, treatment planning, detection of tumor reoccurrence and post-treatment evaluation in breast cancer management [1]. For example, in Magnetic Resonance guided High-Intensity Focused Ultrasound (MRgHIFU), treatment planning and control would be improved by characterizing the vascular distribution around the target lesions and including the resulting convective effects in the appropriate models. Knowledge of the vasculature is also useful at the pre-treatment planning stage where an accurate segmentation of the treatment volume on a voxel-by-voxel basis is desired. Even though contrast-enhanced (CE) MRI has becoming a standard tool for breast cancer diagnosis, the association between contrast injection and the development of nephrogenic systemic fibrosis (NSF) has raised concern, especially for patients with renal failure. To reduce these concerns, non-contrast enhanced breast vessel imaging has been investigated using a peripheral pulse gate (PPG)-triggered half-Fourier turbo spin echo (TSE) sequence [2]. In this work, an untriggered variable flip angle turbo spin echo (VFL-TSE) sequence was explored as a non-contrast flow-independent MR angiography (MRA) technique to achieve breast vasculature imaging.

Methods

All imaging was performed on a 3T TIM Trio MR scanner (Siemens Inc., Erlangen, Germany) using the Siemens 4-channel breast coil. With local institutional review board approval, five subjects (3 normal, 2 fibroadenoma) gave informed consent and were imaged using a 3D VFL-TSE sequence with the following protocol: TR/TE = 3000/162 ms, pixel size of 0.8x0.8 mm^2, slice thickness 1.5-2.4 mm, 40-64 slices with scan times ranging from 3-6 min depending on whether unilateral or bilateral imaging was performed. CHESS fat saturation was applied to suppress the background tissue and T2-weighting mode was selected for variable flip angle excitation pulses. For comparison purposes, a CE-MRI study was performed immediately after the non-contrast MRA imaging. An intravenous bolus injection of 0.1 mmol/kg gadolimium was administered. A pre-contrast 3D FLASH readout was followed by four post-contrast acquisitions with 1.5 min temporal resolution and 0.7×0.4×1.0 mm^3 spatial resolution. In post processing, zero-filled interpolation was applied in all three direction. Sub-slab 2D maximum intensity projection (MIP), segmented [3] shaded surface display, and 3D MIP were used for blood vessel visualization.

Results

The comparison of flow-independent non-contrast MRA images (a-d) with 3-min post CE images (e-h) in the form of sub-slab sagittal MIP, is presented in Fig. 1 for a fibroadenoma patient. It can be seen that most major blood vessels are located near the skin surface or embedded in the adipose tissue. Blood vessel information contained in both studies is generally comparable. However, for this subject, non-contrast images show certain vascular details (see arrows) more clearly than the CE images. In Fig. 2, a snapshot of the segmented rotated shaded surface display of flow-independent 3D MRA images given in Fig. 1 is shown in order to better visualize the vascular tree. A 3D projection of a volumetric image from a subject with fibroadenoma is demonstrated in Fig. 3. Despite mild wraparound artifact (arrowhead), the majority of the blood vessels along with the fibroadenoma (arrow) are clearly visualized at the projected angle.

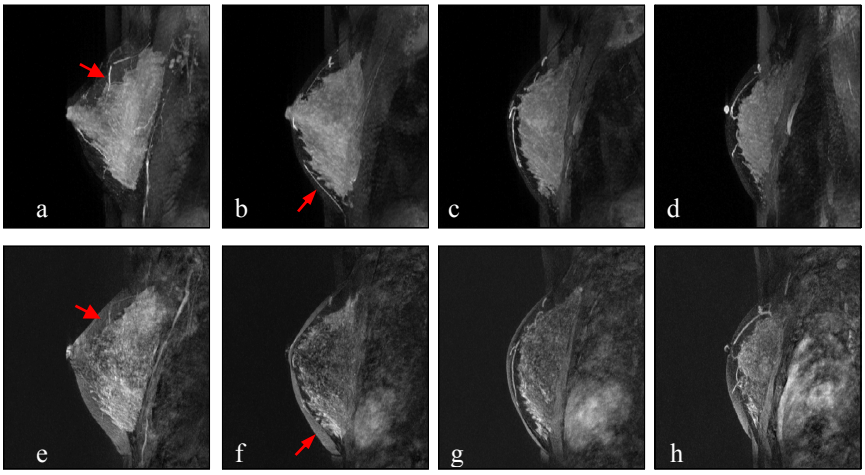

Fig. 1 Comparison of flow-independent non-contrast MRA (a-d) with 3-min post CE images (e-h). Sub-slab sagittal MIPs show improved depiction of vessels (arrows) with the non-contrast MRA than with the CE-MRI.

Conclusions

In this work, we demonstrated the potential of the flow independent non-contrast VFL-TSE sequence to image breast vasculature. Future improvement will include different magnetization preparation before the imaging sequence to suppress the glandular tissue so that the contrast between vessels and background tissue is maximized.

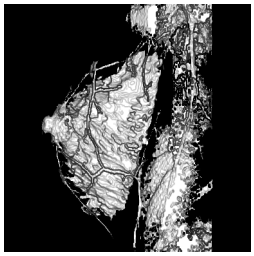

Fig. 2 Snapshot of a rotated shaded surface display of the segmented non-contrast 3D volume shown in Fig. 1(a-d).

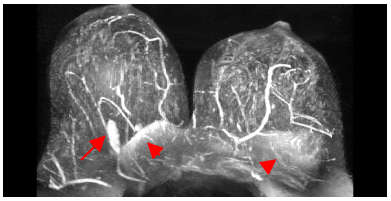

Fig. 3 A 3D projection of a volumetric non-contrast MRA dataset from a subject with fibroadenoma. Despite mild wraparound artifact (arrowhead), the majority of the blood vessels along with the fibroadenoma (arrow) are clearly visualized at the projected angle.

References

[1] F. Sardanelli, et al., Radiology, 2005; 235: pp. 791.
[2] M. Miyazaki, et al., Proc. ISMRM. 17, 2009, pp. 227.
[3] D.L. Parker, et al. JMRI, vol. 11, Apr. 2000, pp. 378.

Acknowledgments

Supported by Siemens Health Care AG, The Ben B. and Iris M. Margolis Foundation, the Focused Ultrasound Surgery Foundation, NIH grant 1R01 HL48223 and 1R01 CA134599.