Heart Saturation for Bilateral Breast MRI: Reduction of Cardiac Motion Artifacts

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Introduction: Cardiac motion causes significant artifacts in breast MRI [1]. The beating heart lies posterior and adjacent to the chest wall, tilting slightly to the left of the midline. Consequential motion artifact can be detected on both left and right breast images. When contrast is injected for dynamic contrast enhanced (DCE) breast MRI, the artifact is also enhanced and potentially distracting for the clinician in making a correct diagnosis. We have developed a technique to eliminate signal emanating from the heart. This new pulse sequence selectively saturates signal from the heart while acquiring bilateral breast images.

Methods: To saturate the heart, we applied a 2D spiral excitation with gradients in both x and y. This yielded a cylindrical excitation in the left – right direction. Crushers followed the cylindrical excitation, thus canceling the signal from the selected area. The user controlled the size (x and y are controlled independently) and center location of saturation [2]. The length of the heart saturation pulse (Figure 1) lasts approximately 12 ms, followed by a dual band spectral spatial RF pulse for bilateral breast excitation [3], and a 3D variable-density stack of spirals for acquisition [4] (the latter two lasting 32 ms). We collected bilateral data on one healthy volunteer and one breast cancer patient at 1.5T (GE Healtcare, Waukesha, WI) with the following detailed protocol: dedicated 8 channel breast coil (GE, Waukesha, WI), TR = 44 ms, TE = 7.2 ms, FOV = 20 cm, flip angle = 40, bandwidth 125 kHz, matrix size 188 x 188, slice thickness= 3.6mm, locations/slab/breast = 32, interleaves = 9. For the patient data, the above discussed sequence was played after the standard diagnostic DCE protocol (which has similar parameters as the discussed protocol, lacking the heart saturation pulse).

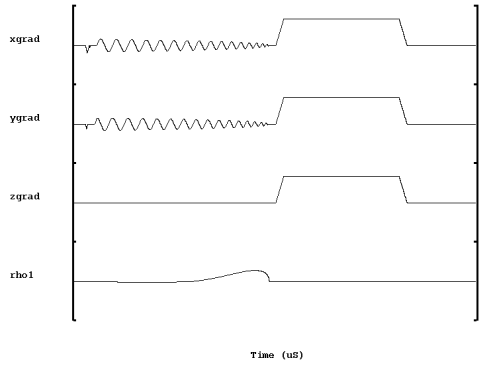

Figure 1. Plot of the 2D heart saturation pulse Note the spiral excitation in x and y, followed by the crushers. The spectral spatial bilateral sequence follows this pulse.

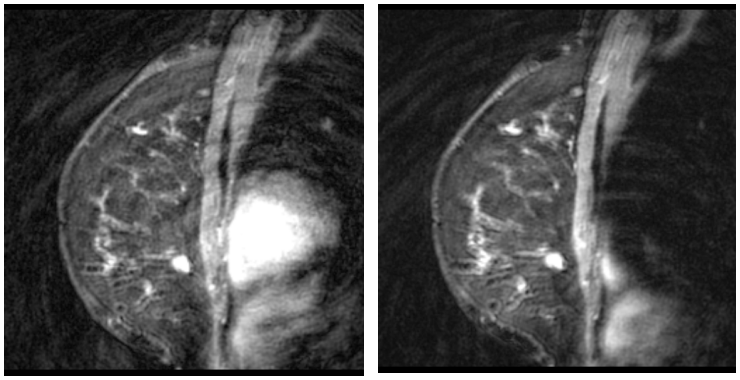

Figure 2. Left image, no heart saturation. Notice the banding on the chest wall from the spiral trajectory's manifestation of the heart motion. Right Image, with heart saturation. Notice the minimization of the swirling artifact throughout the image.

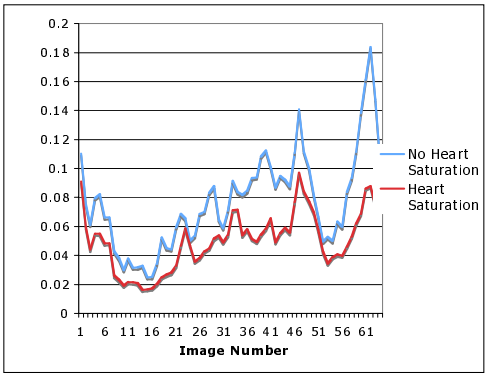

Figure 3. Comparison of artifact noise (standard deviation of ROI outside of the breast/mean of ROI inside of breast). Note that artifact noise from the images with heart saturation are consistently lower than those with heart signal remaining in the image.

Results: Figure 2 shows an image without heart saturation (left) and one with heart saturation (right). There is noticeable reduction in artifact in the right image. When comparing artifact noise from an ROI placed in the upper left corner of the images, outside of the breast, we found that on average the images without heart saturation were 1.5 times noisier than with saturation. Specifically, for every image we measured the standard deviation of an ROI outside of the breast and normalized it by the mean signal from an ROI inside of the breast. The ROIs were kept constant for all images. Figure 3 charts the artifact noise comparison at each slice.

Conclusion: Heart saturation decreases cardiac motion artifacts in breast imaging. Future improvements of the pulse sequence include decreasing and optimizing the length of the heart saturation pulse and playing the pulse intermittently rather than every TR. We expect that this pulse will soon become a standard addition to our center's bilateral breast imaging protocol.

REFERENCES: [1]Stegbauer K, et al. Classification of cardiac related artifacts in dynamic contrast breast MRI. Medical Imaging 2004: Image Processing, Proc. SPIE (5370): 888-895;2004. [2] Pisani L, et al. Restricted Field of View Magnetic Resonance Imaging of a Dynamic Time Series. MRM (57): 297-307;2007. [3] Cunningham C, et al. Independent Dual-band Spectral-Spatial RF pulses: Implementation for Bilateral Breast MRI. ISMRM, Miami 2005. [4] Lee J, et al. High Resolution Bilateral Dynamic Contrast Enhancement Breast Imaging. ISMRM, Berlin 2006.

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