High Frame-Rate Simultaneous Bilateral DCE-MR Breast Imaging

L. Dougherty[1], G. Isaac[1], H. K. Song[1], M. A. Rosen[1], L. W. Nunes[2], P. J. Moate[3], R. C. Boston[3], and M. D. Schnall[1]

[1]Radiology, Hospital of the University of Pennsylvania, Philadelphia, PA, United States, [2]Radiology, Pennsylvania Hospital, Philadelphia, PA, United States, [3]School of Veterinary Medicine, University of Pennsylvania, Kennett Square, PA, United States

Introduction

Under-sampled radial imaging has been shown to reduce scan time while preserving spatial resolution. However, a drop in SNR is experienced and since the Nyquist criterion is not met, streaking artifacts can corrupt the images. Song, et al (1) addressed these issues by using a weighted radial view sharing scheme (KWIC) that preserves spatial resolution, temporal resolution and image quality. Larkman, et al (2) have previously described the use of multi-coil arrays for separation of signal from multiple slices simultaneously excited. Extending this method to multiple 3D volumes, we have developed a method for rapid bilateral breast imaging using a simultaneous multi-slab volume excitation in conjunction with SENSE processing. These methods were combined with the dynamic KWIC approach to achieve an acceleration factor of 16X (2X from SENSE and 8X from KWIC) over a non-accelerated interleaved bilateral MR bilateral breast scan. An initial evaluation of these methods was performed on a cohort of women presenting with palpable or mammographically visible breast abnormalities.

Methods

IRB approval was obtained prior to the start of this study. Women with suspicious mammographic or palpable breast abnormalities were included in this study. After informed consent, patients were placed in the scanner (1.5T Siemens Sonata, Siemens Medical Systems, Iselin, NJ) in the prone position, with the breasts gently compressed within a receive-only breast coil (Siemens Medical Systems, Iselin, NJ) which uses a single element for each breast. A high-resolution baseline volume was acquired followed by dynamic imaging started simultaneously with the intravenous injection of 0.1-mmol/kg gadopentetate dimeglumine (Magnevist, Berlex Laboratories, Wayne, NJ), administered over a 10-second interval and followed by a saline flush. The contrast-enhanced images were acquired using a fast 3D spoiled gradient-recalled back-projection sequence using 512 data samples/projection with 384 projection angles, and 32 phase encoding steps in the slice direction. Each 2-minute, 384-view "full" data set was acquired in 8 angle-interleaved passes, in which each pass was comprised of a 48-view undersampled data set. One full data set was acquired for baseline, and 3 were acquired sequentially during and following contrast injection. Other imaging parameters were: FOV = 24cm; ~3 mm thick slices in the sagittal plane; TR/TE = 9.8/4ms; flip angle=20°; sampling bandwidth = 260 Hz/pixel. Fat signal was suppressed using a spectral inversion pulse played-out on every 16th TR. Data from each breast coil were saved separately and reconstructed using a re-gridding approach with dynamic KWIC view sharing. The effective temporal resolution was equivalent to that of a highly undersampled radial technique (single 48-view pass, 15 sec), but the image quality was equivalent to that of a fully acquired high spatial resolution image (384 views, 2 min). Five baseline frames (pre-contrast) and 20 post-contrast frames were reconstructed using the dynamic KWIC method yielding an effective temporal resolution of 15 seconds for each frame.

A custom computer program was written to allow the user to view the breast images and analyze the contrast kinetics. From the KWIC processed images, the signal intensity data were obtained and fit to a five parameter modified logistic equation (3). The time signal enhancement curve could be shown for any user selectable ROI or the curve parameters could be generated for each pixel and shown as a color overlay on the breast images. The images were reviewed by a clinical radiologist experienced in reading MR breast images, and a clinical report generated. A finding was defined as a focal mass, regional enhancement, ductal enhancement, or architectural distortion. A finding was further categorized as being: highly suspicious for malignancy; suspicious for malignancy; likely benign with recommended imaging follow-up; definitely benign; or normal (no lesion). Categorization was based on combined T1/T2 appearance, architecture, and enhancement kinetics. Enhancement kinetic curves (per pixel, region-of-interest or whole lesion) were available for interactive viewing, as were color-coded parametric maps.

Results

Fifty-four (54) bilateral exams were performed, all with excellent image quality. Figure 1 shows a representative post-contrast phase of a case with an enhancing lesion that was shown to be malignant upon biopsy. A parametric fit was performed on each pixel within a ROI encompassing the lesion. The parameter corresponding to the washout rate is shown as a color overlay. Seventy-three (73) breast abnormalities were found in 45 of the women. Seven cases (13%) were categorized as being highly suspicious for cancer, sixteen cases (29%) as suspicious, seven cases (13%) as likely benign but recommended for short-term follow-up, 15 cases (28%) as definitely benign, and 9 cases (17%) were normal. Of the forty-five patients with a finding in the primary breast, five (11%) had an additional finding in the contralateral breast that was recommended for biopsy or follow-up examination. Pathologic correlation was subsequently performed on 24 lesions. Clinical performance was true positives=7, false negatives=1, true negatives=13, and false positives=3.

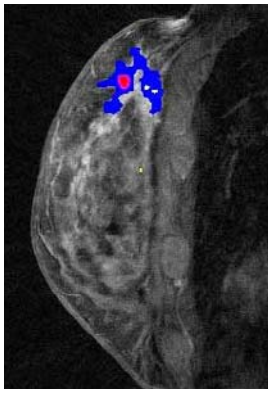

Figure 1. Post-contrast breast image showing a malignant lesion with a color overlay indicating the contrast wash-out rate. Red indicates a high probability of cancer, green a high probability of being benign, and blue indicates an indeterminate classification.

Conclusions:

With angle-interleaved radial imaging, KWIC view sharing, and parallel imaging of multiple 3D slabs, we have demonstrated that dynamic contrast enhanced images of both breasts can be acquired simultaneously providing high-resolution images as well as rapid sampling of the contrast kinetics.

References:

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