Cylindrical Labeling Inversion Pulse for Reduction of Cardiac/Pulsatile Motion Artifacts in Contrast-Enhanced Breast/Thoracic MRI

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TARGET AUDIENCE: Researchers and clinicians interested in breast/thoracic imaging and diseases

PURPOSE: In breast or thoracic-spine MRI, motion artifacts due to cardiac- or aortic-pulsation inevitably appear, particularly in images after contrast media injection [1-3]. Such artifacts can often impede the diagnosis. One of the most effective solutions is swapping the phase-encoding direction [1.2], but it does not yield satisfactory results in some cases. Alternatively, direct heart-signal saturation by using a 2D spiral excitation with gradients has been reported [3], but the versatility of this method is unknown because it was only combined with spoiled gradient echo sequence. In this study, we attempted to use a cylindrical labeling pulse (known as time-spatial labeling inversion pulse [4-6]) to directly suppress cardiac/pulsatile motion artifacts (CREST: cylindrical regional-saturation technique) on the contrast-enhanced images acquired by various sequences. The purpose of this study is to select the optimal scan parameters (inversion delay) and to evaluate the feasibility in the different situations (different body-parts and sequences).

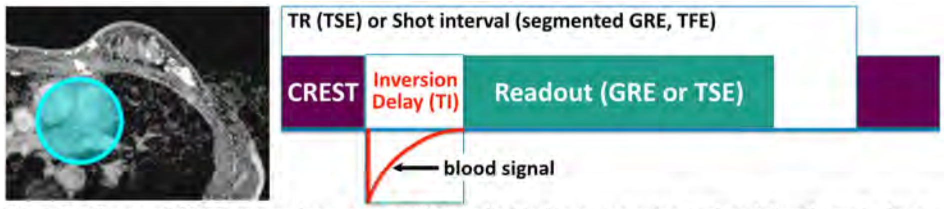

Figure 1. Scheme of CREST prepared sequence. CREST, a cylindrical inversion pulse, is placed directly on the heart and data sampling is done at the null point of the blood signals, consequently artifacts would be reduced.

METHODS: A total of 14 patients who underwent contrast-enhancement were examined with 3.0T/1.5T whole-body clinical systems (Achieva TX/Ingenia, Philips Healthcare). The study was approved by the local IRB, and written informed consent was obtained from all subjects.

CREST, a cylindrical inversion pulse [6] used as a regional saturation pulse, is placed directly on the heart (or aorta) and data sampling is done at the null point of the blood signals, reducing artifacts effectively **(Fig.1)**.

The study consists of three parts: (1) selection of optimal inversion delay time, (2) demonstration of efficiency of CREST, and (3) feasibility evaluation in other sequences. First, since CREST technique is based on an inversion recovery pulse, we should always select optimal inversion delay despite the various scan parameters. To that end, we investigated the optimal inversion delay on 3D segmented T1-weighted gradient echo (T1-turbo field echo: T1TFE) in six patients with contrast-enhanced breast examination by comparing the signal-to-noise (SNR) of the heart and the standard deviation of the air/lung signals as markers of the severity of the artifacts. Various combinations of shot-interval (equal to "repetition time: TR") and inversion delay were examined. Subsequently, to validate the usefulness of adding CREST in breast imaging, we compared quantitatively the image quality, including degree of motion artifact, SNR and lesion-to-parenchyma contrast, in the six patients who have enhanced solid tumor. Because cardiac motion artifacts typically affect the left side of breast more strongly than the right side, we chose the patients with left-sided tumor. Finally, to demonstrate the feasibility of CREST in other sequences as well, we examined an alternative combination (CREST with 2D TSE) in axial images of the thoracic-spine. We evaluated visually the effect of CREST in two patients who underwent contrast-enhanced studies.

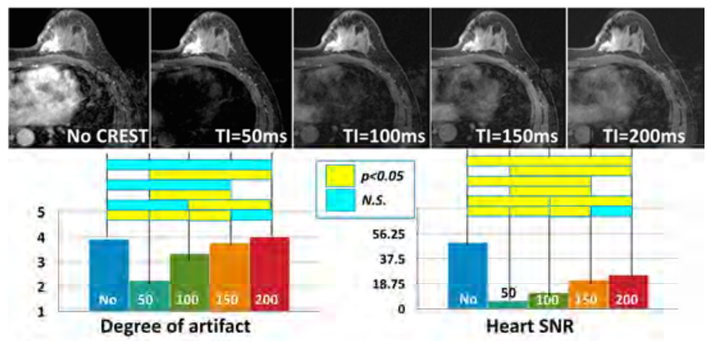

Figure 2. Representative images and quantitative comparison of different inversion delays (TI). The shortest value (50ms) most reduced visually and significantly the motion artifacts.

RESULTS and DISCUSSION: Figure 2 shows the results of optimal inversion delay selection. The shortest delay results in the most efficient suppression. Because T1 value of blood is considerably shortened due to the contrast media, the possible shortest value (<100 ms) might be matched to the null point of blood signals. Thus, the shortest value should be chosen as optimal inversion delay for obtaining best image-quality without motion artifacts. **Figure 3** shows the effect of CREST in the breast. Optimized CREST (with shortest inversion delay) could significantly reduce the cardiac artifact without any penalty to the acquisition time, SNR and lesion-to-parenchyma contrast. Moreover, CREST could also be useful in combination with 2D TSE sequence in axial images of the thoracic-spine **(Fig.4)**. Prolongation of scan time was only minimal in combination with TSE. Because this study evaluated only few numbers of patients, further clinical investigation is needed for validation of this method.

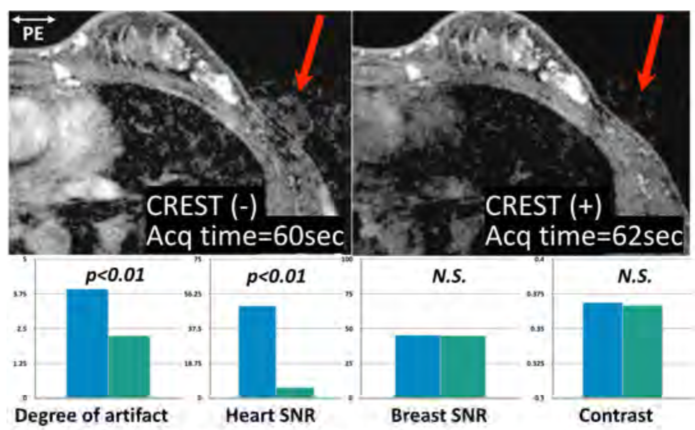

Figure 3. Representative images and quantitative comparison of contrast-enhanced 3D T1-weighted GRE without/with CREST in the breast. CREST could significantly reduce the cardiac artifact without any penalty.

CONCLUSION: In this study, we propose a new technique for simple and effective reduction of cardiac/pulsatile motion artifacts on contrast-enhanced images by using CREST. We showed it can be combined with various sequences.

Figure 4. Representative images of contrast-enhanced 2D TSE without/with CREST in axial images of the thoracic-spine. CREST could reduce the flow artifacts from aorta (Arrow).

REFERENCES: [1] Rausch, et al. RadioGraphics 26:1469–1484 (2006); [2] Harvey, et al. RadioGraphics 27:S131–S145 (2007); [3] Rakow-Penner, et al. Proc ISMRM 16:3765 (2008); [4] Miyazaki, et al. Radiology 248:20–43 (2008); [5] Miyazaki, et al. JMRI 35:1–19 (2012); [6] Spuentrup, et al. MRM 48:739–743 (2002).