FEASIBILITY OF FREE-BREATHING DCE-MRI: PHANTOM STUDIES TO COMPARE VIBE, RADIAL-VIBE, AND CAIPIRINHA-VIBE

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Introduction: The image quality of DCE-MRI of the body can deteriorate due to respiratory motion. To overcome respiratory motion effect, new T1 gradient echo sequences were developed: 1) radial acquisition of the 3D-gradient echo sequence (Radial-VIBE) with k-space weighted image contrast (KWIC) view-sharing reconstruction, 2) Controlled Aliasing in Parallel Imaging Results in a Higher Acceleration (CAIPIRINHA) VIBE.[1,2] We aim to compare the breathing motion artifact and signal stability of these new sequences with conventional VIBE using respiratory motion DCE-MRI phantom.

Material and Methods: A multi-compartment DCE-MRI phantom with range of R_1 relaxation rate values (R_1: 0.6-36.0 s^{-1}) were developed, which was modified from the QIBA DCE-MRI phantom version 2. Briefly, it contains 28 tubes filled with $NiCl_2$-doped 30mM NaCl solution. The concentration of NiCl2 varies from 0.9 mM to 58.1 mM. We developed a moving platform to simulate breathing motion and loaded the DCE-MRI phantom on the platform. Dynamic scan was performed at 3.0T machine (Skyra, Siemens) using conventional VIBE, radial-VIBE, and CAIPIRINHA-VIBE for 6 minutes per sequence. At first, we scanned the phantom at static status. Then, we scanned the phantom while moving it anteriorly/posteriorly in frequency encoding direction at a speed of 0.7cm/sec. The protocols of sequences were as follows: VIBE (TR/TE, 3.7/1.4 ms; flip angle, 25°; matrix size, 256x256), radial-VIBE (TR/TE, 4.0/1.38 ms; flip angle, 25°; matrix size, 256x256), CAIPIRINHA-VIBE (TR/TE, 3.41/1.11 ms; flip angle, 25°; matrix size, 256x256). The signal stability of all three sequences was evaluated using a plot of signal intensity (SI) over time.

Results: At moving status, CAIPIRINHA-VIBE showed the best image quality, in that the phantom images maintained its shape and just moved its position anteriorly/posteriorly. Thus, the motion correction could align the CAIPIRINHA-VIBE images very well. In contrast, conventional VIBE showed severe breathing motion artifacts, in that the shape of phantom images was severely distorted even after motion correction. In radial-VIBE, the artifacts related with motion were manifested as streak artifacts and the position of phantom did not move at moving status due to radial acquisition scheme. Hence, there was no difference between raw images and motion-corrected images (Fig 1). At static status, the signal stability over 6 minutes was excellent in all three sequences. At moving status, the signal stability was the best in the motion-corrected CAIPIRINHA-VIBE (Fig 2).

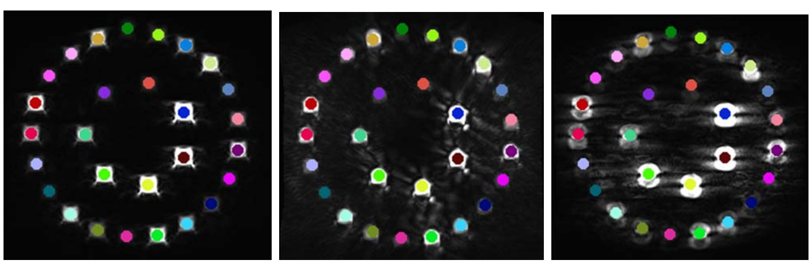

Fig. 1. The motion corrected images of CAIPIRINHA-VIBE (left), Radial-VIBE (middle) and conventional VIBE (right) at moving status. The regions of interests (ROIs) in the tubes were color-coded.

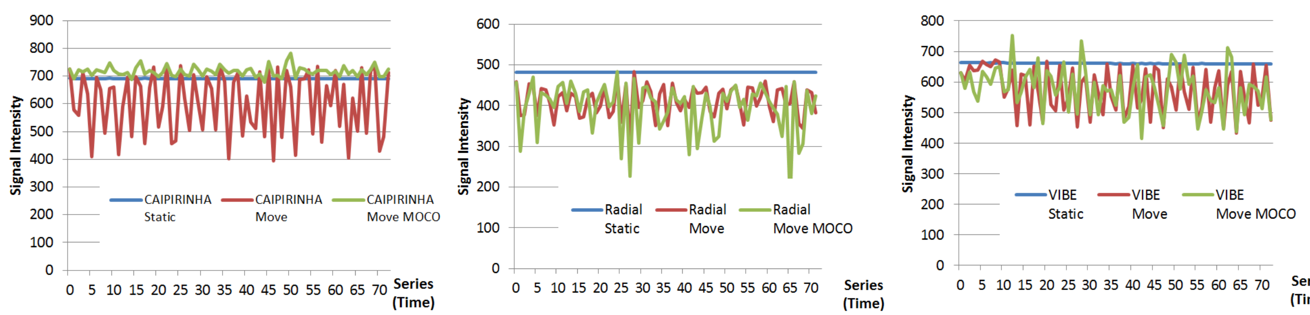

Fig. 2. Plot of SI over series to evaluate signal stability in CAIPIRINHA-VIBE (left), Radial-VIBE (middle), and VIBE (right).

Discussion and Conclusion: In terms of breathing motion artifacts and signal stability, the use of CAIPIRINHA-VIBE with motion correction is better than radial-VIBE and conventional VIBE for free-breathing DCE-MRI. The less motion artifacts of CAIPIRINHA-VIBE than radial-VIBE may be explained by that it has much shorter temporal footprint than Radial-VIBE with KWIC view-sharing. In addition, due to its advanced parallel image scheme in both slice direction and frequency-encoding direction, the CAIPIRINHA technique may maintain the shape of moving subject and reduce the motion artifacts. In conclusion, CAIPIRINHA-VIBE is feasible for free-breathing DCE-MRI.

References:

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[2] Yu MH, Lee JM, Yoon JH, et al. Clinical application of CAIPIRINHA sequence for gadoxetic acid-enhanced liver MR imaging. J Magn Reson Imaging; 2013; 38(5): 1020-1026.