Simultaneous Multi-Slice Dark Blood Cardiac Imaging using Multiband Double-Inversion Recovery TSE

Dingxin Wang[1,2], Edward Auerbach[2], Gary McNeal[3], Peter Kollasch[1], Uma Valeti[4], Vibhas Deshpande[5], Kamil Ugurbil[2], and Greg Metzger[2]

[1]*Siemens Healthcare, Minneapolis, Minnesota, United States,* [2]*CMRR, Department of Radiology, University of Minnesota, Minneapolis, Minnesota, United States,* [3]*Siemens Healthcare, Dallas, Texas, United States,* [4]*Departments of Medicine and Radiology, University of Minnesota, Minneapolis, Minnesota, United States,* [5]*Siemens Healthcare, Austin, Texas, United States*

Target Audience: Clinicians and researchers interested in cardiac MRI

Introduction: Dark blood MR imaging is used routinely to assess cardiac morphology. The dark blood sequence typically consists of a turbo spin echo (TSE) sequence in conjunction with double-inversion preparation to null the magnetization of the inflowing blood to the imaging slice. This sequence only allows the acquisition of a single slice per breath hold to maintain acceptable acquisition times of less than 20 seconds. Therefore, in order to cover the entire heart, 10 -12 breath-holds are often needed. Recently, multiband (MB) slice accelerated TSE has been developed for brain and knee imaging [1, 2]. This technique simultaneously excites, acquires, and unaliases multiple slices using parallel imaging method. Multiband slice accelerated TSE may be applied for dark blood imaging to improve the acquisition efficiency by acquiring multiple slices during each breath-hold. In this study, we demonstrate the feasibility of using a multiband slice accelerated double-inversion recovery (DIR) TSE sequence for simultaneous multi-slice cardiac dark blood imaging.

Methods: Cardiac imaging experiments were performed on 3 subjects using a 3T Siemens MRI scanner (Magnetom Prisma; Siemens Healthcare, Erlangen, Germany) with Siemens receive-only 18-channel body array and 32-channel spine array. Multiband RF pulses were generated for simultaneous multi-slice excitation, echo refocusing, and slice selective inversion while the global inversion was the same as that used in a single-band sequence. ECG-gating was used during breath hold acquisitions to minimize motion artifacts and to time readout during diastole. Cardiac triggering was performed after every R wave for T1-weighting and after every other heart beats for T2-weighting. During the first R-R interval, a low resolution multi-slice 2D GRE scan was acquired as the reference scan to obtain the coil sensitivities for unaliasing the simultaneously acquired slices [3]. Imaging parameters were as follows: FOV = 340 × 340 mm^2, matrix size = 256 x 256, slice thickness = 5 mm, voxel size = 1.3×1.3×5.0 mm^3, excitation/refocusing flip angle = 90º/180º, readout bandwidth = 850 Hz/pixel, echo spacing = 5.9 ms; short axis orientation, 200% dark blood slice thickness; TE = 27 ms, ETL = 9 for T1-weighting and TE = 71 ms, ETL = 17 for T2-weighting; slice acceleration factor = 2, CAIPIRINHA [4] FOV shift factor = 2 for MB TSE; 600% slice spacing for simultaneously excited slices. In-plane GRAPPA (iPAT) acceleration factors of 2 and 3 were tested in combination with slice acceleration. Standard DIR-TSE images with iPAT acceleration factors of 3 and 6 were acquired for comparison. Using standard DIR-TSE, with iPAT factor of 3, two separate breath holds were required to image two slices; while with iPAT factor of 6, two sequential slices could be acquired in a single breath hold as the MB acquisition.

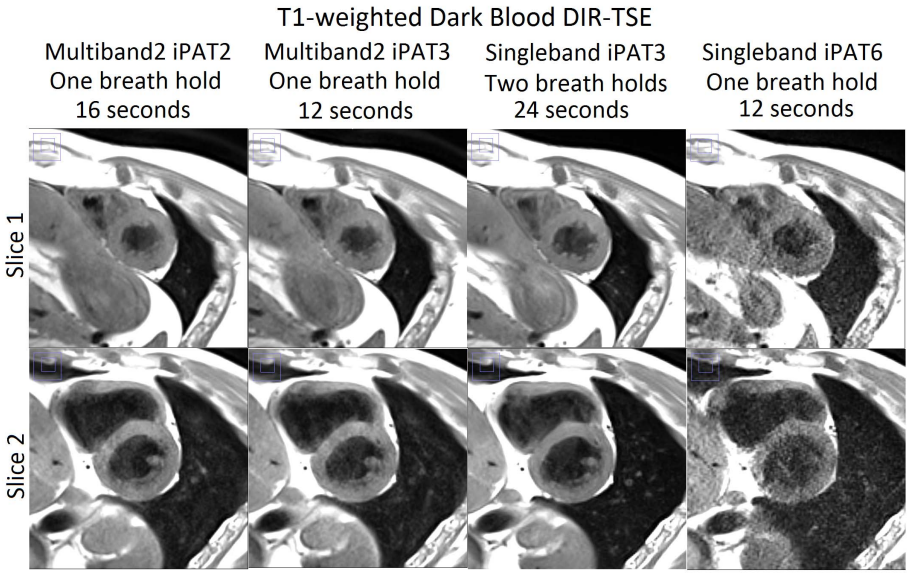

Figure 1. Representative MB and standard DIR -TSE T1-weighted images of the heart. Acquired within one breath hold, the MB DIR -TSE images provide similar dark blood contrast as the standard DIR TSE images acquired with separate breath holds.

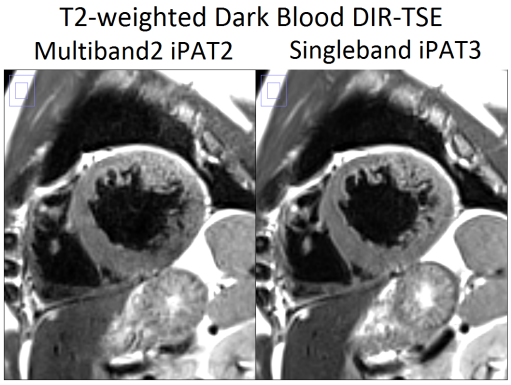

Figure 2. Representative MB and standard DIR -TSE T2-weighted cardiac images. The MB DIR -TSE images provide similar dark blood appearance and identical imaging contrast as the standard DIR TSE images.

Results / Discussion: Figure 1 shows representative MB slice accelerated and reference standard DIR TSE T1-weighted bark blood cardiac images. The two slices acquired with MB DIR TSE sequence during one breath hold (MB2 and iPAT2/iPAT3) demonstrate comparable dark blood imaging contrast, but with increased noise due to high total acceleration factor, compared to those acquired with the standard DIR TSE sequence over two separate breath holds. In comparison, although two sequential images can be acquired within single breath hold using standard DIR TSE sequence with iPAT acceleration factor of 6, the image quality is largely degraded (Fig.1). Figure 2 shows representative T2-weighted bark blood heart images with MB and standard DIR TSE. Despite of an increase in noise, the image contrast and dark blood appearance are very similar between the slice accelerated TSE and the corresponding standard TSE scans (Fig. 2).

Conclusion: Our study demonstrates, for the first time, the feasibility of simultaneous multi-slice cardiac dark blood imaging using multiband slice accelerated double-inversion recovery TSE. Multiband slice acceleration improves the acquisition efficiency of TSE dark blood imaging beyond what is possible with standard in-plane parallel imaging acceleration thus allowing more slice coverage per breath hold and reducing the number of breath holds required to obtain whole heart coverage. Future studies need to evaluate the diagnostic sensitivity and accuracy of multiband slice accelerated dark blood TSE imaging in the presence of the resulting decreased SNR compared to the standard acquisition.

References: [1] Wang, ISMRM 2014 [2] Wang, ISMRM 2014 [3] Wang, ISMRM 2013 [4] Breuer MRM 2005

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