Breathhold inhance inflow IR (BH-IFIR) with a novel 3D recessed fan beam view ordering

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Introduction: The combination of arterial spin labeling technique with 3D balanced SSFP (b-SSFP) sequence for data acquisition has been recently used for non-contrast MR Angiography (MRA) in the body [1,2,3]. Commonly, a respiratory-gated scan with bellows or navigator gating to detect diaphragmatic shift is performed with a segmented view ordering scheme. However, motion artifacts cannot be avoided in patients with irregular breathing. The data acquisition window is fixed to preserve image contrast, which is determined by the center of k-space with conventional k-space view ordering schemes such as sequential and centric view ordering. In these schemes, the number of segments is usually high, leading to long scan times. The purpose of this study was to develop a breath-hold sequence with a novel and efficient 3D recessed fan beam multi-segmented view ordering scheme.

Materials and Methods:

View ordering: Each point in k-space (Ky,Kz) is sorted by distance from the center of k-space and azimuthal angle. The data acquisition starts from the periphery of k-space and moves inward in a narrow sector and then outward from the center in a broader sector as shown in Figure 1. Within each sector, adjacent samples are used making the trajectory immune to eddy current artifacts. The image contrast is determined by the number of k-space samples from Outer k-space to Central k-space (OC). If longer data acquisition window is used with fixed OC, scan time reduction and constant image contrast can be obtained at the same time. The corners of the ellipse are skipped.

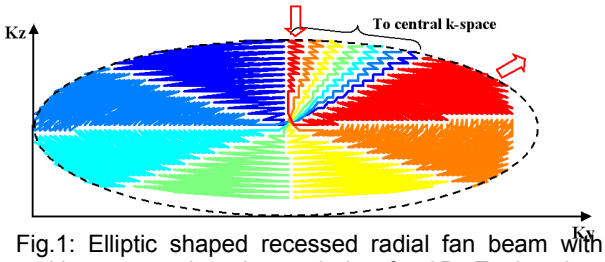

Fig.1: Elliptic shaped recessed radial fan beam with multi segmentation view ordering for 3D. Each colors display the trajectory per segment. In this case, number of segmentation is 7 and sampling points per segment are 364.

Experiments: An investigational version of breath-hold Inflow IR (BH-IFIR) with 3D b-SSFP was employed. Cardiac triggered selective inversion pulse was applied covering the targeted vessels in abdomen. Spectral inversion pulse was used to saturate the fat. Signal in the central area of k-space is obtained at mid-diastole. The length of data acquisition window and the number of R-R interval of cardiac were adjusted to make the scan time fit in a breath-hold. The varying inversion time (TI) of the inversion recovery generates inflow effect that comes from cardiac output in systole. Imaging was performed on 1.5T MR scanner (Signa HDxt, Echospeed, GE Healthcare, Waukesha) using 8 channels body coil. Scan parameters were: coronal scan, FOV= 38cm, 224*224 matrix, 30 slices, slice=2.4mm, NEX 0.77, parallel imaging reduction factor=2, BW= ± 125kHz, TR=4.16/2.08ms, Flip angle 70° . For TI experiments, 4 R-R intervals were used. For data acquisition experiments, 5R-R intervals were used. The volunteer study was approved by institutional review board of GE Healthcare.

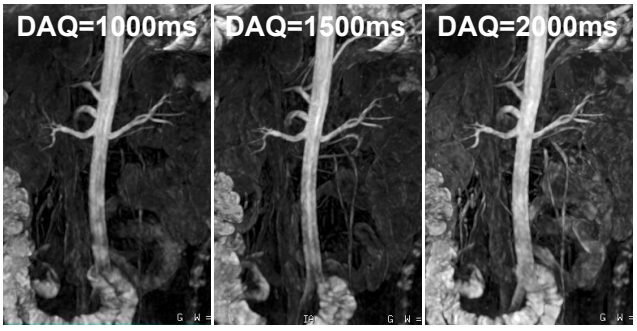

Fig.2: BH-IFIR coronal MIP images acquired with data acquisition time (DAQ) 1000ms, 1500ms, 2000ms and scan time 38s, 29s, 19s respectively. TI=1200 ms and #RR=4 was used.

Results: Figure.2 shows the comparison of the varying acquisition window between 1000ms, 1500ms and 2000ms. Scan time was 38s, 29s, 19s and contrast ratio between aorta artery signal to vena cava signal was 2.98, 4.38 and 3.87 respectively. The longer acquisition window provides scan time reduction while maintaining image contrast. Figure.3 depicts the inflow effect with longer TI using a data acquisition window of 1500 ms. The coverage of aortic visualization reached the common iliac artery on descending aorta at TI=1500ms. Scan time was 33s.

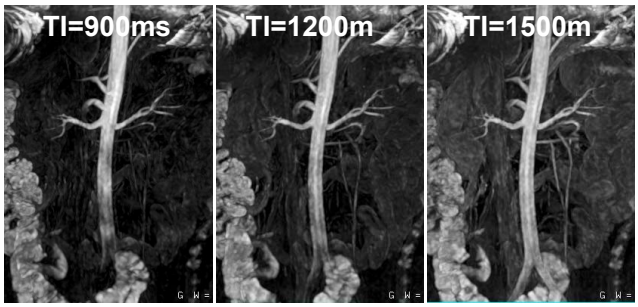

Fig.3: BH-IFIR coronal MIP images acquired with TI 900ms,1200ms and 1500ms. Data acquisition time = 1500ms and #RR = 5 was used. Scan time was 33s. The longer TI offers stronger inflow effect, leading the wide visualization of arteries.

Discussions: The use of long data acquisition over 1R-R interval includes blood signal from both systole and diastole. However, the blood signal was observed to be high and uniform. Inherent flow insensitivity of bSSFP and central k-space data acquired in diastole would mitigate the flow effect. The novel 3D view ordering provides the possibility of cardiac gated breath-hold scan and demonstrates high contrast, separation of artery from vein, strong inflow effect along with scan time reduction. Further scan time reduction should be achieved with higher parallel imaging acceleration factors.

References: [1] Katoh et al, kidney Int 66:1272-1278(2004) [2] Takahashi et al, Proceedings of Annual Mtg, ISMRM 2007:179 [3] Saranathan et al, Proceedings of Annual Mtg, ISMRM 2009: 3900.