# Simultaneous Compensation of Respiratory and Cardiac Motion Effect on liver DWI

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Introduction: Body DWI has recently been proposed as a sensitive tumor detection method. One of the major issues with abdominal DWI is signal loss that notably appears in the left lobe of the liver due to cardiac pulsation. Another major issue is image blurring caused by respiratory motion. Therefore, triggering techniques (cardiac or respiratory) are widely used to eliminate motion effects. However, because of severe scan time prolongation, only respiratory triggering (RT) DWI is performed in clinical studies. Of interest, a recent study (1) showed that cardiac motion affects not only the left lobe but also the right lobe, which may cause error towards increasing value and poor reproducibility of ADC measurement. The purpose of this study is to demonstrate a method that compensates both respiratory and cardiac motion effects within a clinically feasible scan time. For that, peripheral pulse unit (PPU) triggering and TRON (Tracking Only Navigator) method (2) were employed on a 3.0T scanner (3).

Methods: A trigger signal is given by PPU. After a certain delay time (TD), a respiratory navigator echo is acquired followed by two DW-SE-EPI slices. The navigator echo is analysed in real time to estimate diaphragm displacement. Slice location is shifted to compensate for the motion of the liver. Tracking Only Navigator (TRON) without triggering or triggering delay was used to minimize scan time prolongation while providing respiratory motion compensation. The high SNR at 3.0T allowed reducing the number of acquisitions to 2. Combined SPIR and SSGR (Slice Selection Gradient Reversal)(4) was used for fat suppression. Abdominal DWI was performed in 5 healthy volunteers on a 3.0T Philips Achieva TX system. Scan parameters were: single shot SE-EPI, thickness/gap = 5/0 mm, 40 slices, b=0, 800, FOV 380mm, 2 NSA, 96x68 matrix, SENSE factor 2.0, TE=50ms, TR=20beats. PPU TD=300ms. Conventional RT-DWI was also performed for comparison. Trigger delay for RT=600ms. ADC map was calculated from acquired DW images. 8-10 small ROIs were set among 4-5 slices in both left and right lobe of liver. Left and right lobe ADCs of each method (PPU TRON, RT NSA2 and RT NSA4) were compared in each subject.


FIG.1a, b, c
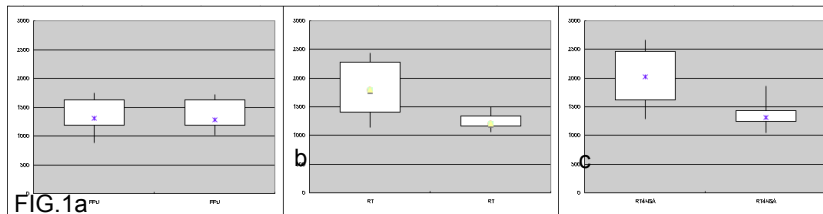
Results: Axial images and their coronal reformat are shown in fig.3a and 3b. Severe signal non-uniformity can be seen in the left lobe of the liver on conventional RT-DWI. PPU TRON improved signal uniformity in the left lobe. Coronal images visualized the whole liver more uniformly than RT. Increased number of averaging with RT (NSA2 vs NSA 4) did not change signal drop in the left lobe.

FIG.2 ADC Left lobe of liver — PPU TRON, RT2NSA, RT4NSA
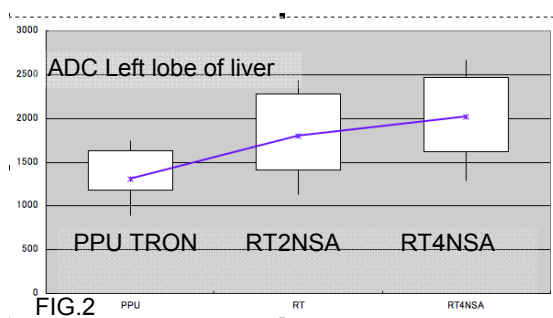
ADC values are compared for one of the subjects. ADCs are approximately equal between the left and right with PPU TRON (1.37)(fig1a). On RT images ADC in the left lobe is significantly higher than in the right lobe for both NSA 2(fig.1b)(left 1.79, right 1.26, p<0.05) and NSA 4(fig.1c)(L 2.03, R 1.36, p<0.01). In the left lobe, ADC with RT is significantly higher than with PPU TRON (fig.2). In all subjects, the same tendency was observed. Average ADC among subjects of PPU TRON was the same (ADC left / right = 1.04) while RT showed difference between L/R(ADC Left/Right = 1.5). Total scan time was 1:48 with RT NSA4 (average in 5 subjects) and 3:48 with PPU TRON.

Discussion: PPU TRON showed more robust and uniform image quality and ADC than RT. Increased NSA on RT didn't improved IQ and ADC reproducibility.

FIG.3a, FIG.3b — PPU TRON, RT 2NSA, RT 4NSA
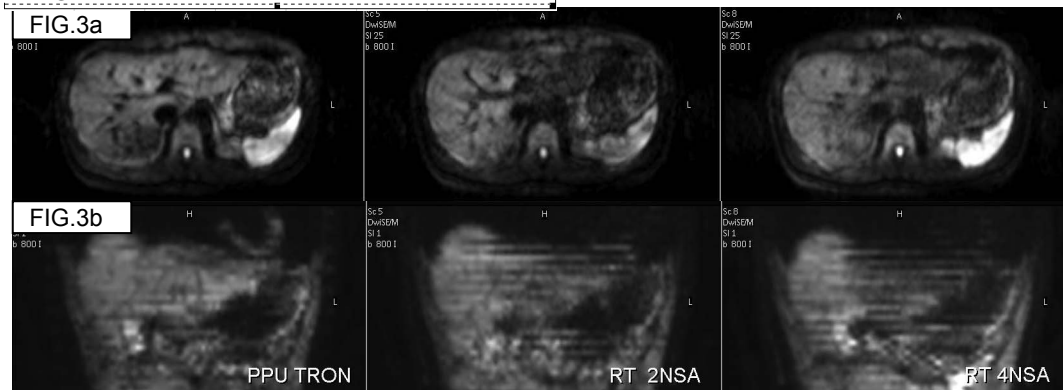
Scan time was still longer than RT. However, SNR with NSA 2 PPU TRON on b=800 seems sufficiently high and scan time < 4min is clinically feasible.

Conclusion: PPU TRON DWI at 3.0T can eliminate cardiac motion-related artefact within a reasonable and clinically feasible scan time.

References: 1) T. C. Kwee, et al. (2009) . Magma 22 (5) 319-325, 2) Takahara,T, et al. Investigative radiology, Vol. 45, No. 2. (February 2010), pp. 57-63. 3) Ivancevic, M. K., et al. JMRI 30 (5) 1027-1033. 4) Horie,T et al. ISMRM 2009 e-poster #4034