Accelerated diffusion weighted imaging in the liver with blipped CAIPIRINHA based simultaneous multi slice acquisition

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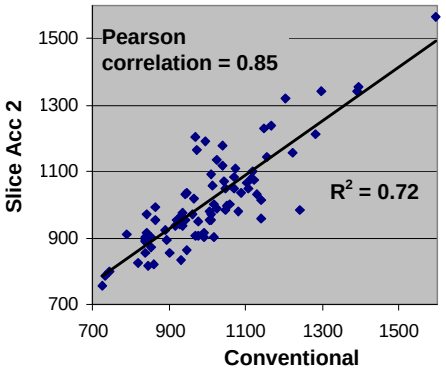
TARGET AUDIENCE: Clinicians/researchers interested in using DWI in the liver and abdomen.

PURPOSE: Diffusion weighted imaging (DWI) is a promising technique for detecting multiple pathologies in the liver [1]. DWI is usually acquired with a 2D multi-slice single shot EPI sequence with multiple b-values and averages (to get sufficient SNR and minimize respiratory motion related artifacts). Recently the blipped CAIPIRINHA slice acceleration method has been proposed for reducing the scan time of 2D multi-slice EPI [2]. This technique relies on exciting multiple slices simultaneously and reconstructing them individually using the slice GRAPPA method. Since multiple slices are excited simultaneously the overall TR for a desired spatial coverage is reduced, leading to scan time reduction by the same factor. In addition, this acceleration method is SNR preserving with no intrinsic reduction in signal due to reduced sampling. The blipped CAIPIRINHA method has previously been demonstrated for diffusion imaging in the brain. The goal of this work was to apply this slice acceleration technique to DWI in the liver and compare the results with a conventional non slice accelerated acquisition in clinical imaging.

METHODS: 27 patients were scanned at three imaging centers on a 1.5T scanner (MAGNETOM Aera, Siemens Healthcare, Erlangen). A conventional single shot EPI sequence (henceforth called conventional sequence) and a slice accelerated single shot EPI sequence were acquired. For the slice accelerated technique two slices were excited simultaneously (Slice Acc 2) leading to scan time reduction by a factor of 2 compared with the conventional technique. Images for the Slice Acc 2 case were reconstructed using the slice GRAPPA method [2]. To minimize g-factor noise the slices were shifted in the phase encoding direction (PE shift) relative to each other using gradient blips in the slice direction. In this study a PE shift factor of FOV/2 was used. Sequence parameters were: TE = 58-70 ms, in-plane spatial resolution ~ 2x2 mm^2, fat saturation with a spectrally selective adiabatic inversion pulse, in-plane acceleration of 2 with the GRAPPA method, 6mm slices with 1.2 mm gap, 30 to 40 slices to cover the entire liver, signal reception with 20 (12 anterior, 8 posterior) to 30 (18 anterior, 12 posterior) coils, b = 50, 400 and 800 s/mm^2. The conventional scan had TR = 5600 to 6000 ms. The Slice Acc 2 scan had TR = 2700 to 3000 ms. Depending on the imaging center 3 to 5 averages were used for both sequences leading to the following scan times: conventional: 3 to 5 mins, Slice Acc 2: 1:30 to 2:30 mins. Quantitative comparison between the two techniques was done based on two metrics: apparent diffusion coefficient (ADC), and relative SNR (relSNR). relSNR was defined as the ratio of mean signal intensity to noise standard deviation measured in identical ROI's in both datasets. In each dataset signal intensity and ADC measurements were performed in four manually identified ROIs distributed throughout the normal liver parenchyma. The noise standard deviation was measured in ROIs in the image background. For qualitative comparison of the clinical utility of each sequence three radiologists with >5 years experience in body MRI did a subjective non-blinded evaluation of the two techniques. The criterion used for comparison were: i) lesion conspicuity and, ii) general image quality.

Fig 1: Scatter Plot for ADC (10^{-3} mm^2/s)



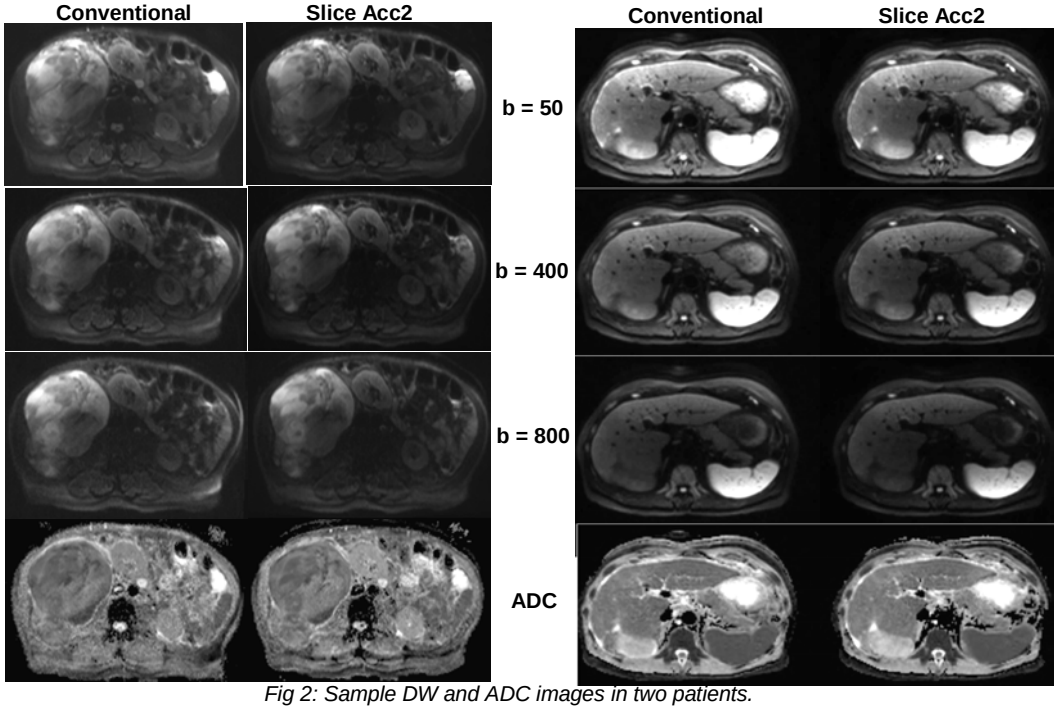


Fig 2: Sample DW and ADC images in two patients.

RESULTS: The mean ADC values (in 10^{-3} mm^2/s) were, conventional: 1007.9 ± 152.0, Slice Acc2: 1012.7 ± 145.2. The relSNR values were, conventional: 62.9 ± 28.9, Slice Acc2: 65.4 ± 35.4. Differences in the ADC (p-value = 0.59) and relSNR (p-value = 0.12) were not statistically significant. A scatter plot of ADC values is shown in Fig 1 (Pearson correlation = 0.84, R^2 = 0.72). Qualitative comparison between the two sequences showed comparable image quality and diagnosis in 27/27 cases. Sample b=50, 400, 800 s/mm^2 and ADC images in two patients are shown in Fig 2. Comparable image quality is seen with both sequences. In patient 1 (left) there is a large retroperitoneal pararenal space mass displacing the right kidney. In this case signal intensity is heterogeneous with low ADCs on both sequences. The pathology was diagnosed as a high-grade pleomorphic retroperitoneal liposarcoma. In patient 2 (right) no pathology was found in either of the two sequences.

DISCUSSION: The intention of this study was an initial, non-blinded feasibility study with qualitative comparison between the conventional and slice accelerated diffusion techniques. The results are highly encouraging. Equivalent diagnostic quality and lesion conspicuity was observed in both acquisitions with highly correlated ADC measurements in normal liver tissue. Some outliers in the ADC values are observed however which we consider to be due to the following possibilities: (1) misalignment of ROI's due to free breathing acquisition (2) through plane motion and partial volume effects (3) potentially improved ADC measurements with slice acceleration due to faster TR's and reduced motion effects between b-values. Further work will investigate these possibilities with blinded reads, investigation into lesion ADC values and phantom validation.

CONCLUSION: We performed a first demonstration on the feasibility of using the blipped CAIPIRINHA technique with a slice acceleration factor of 2 for characterizing liver lesions with diffusion weighted imaging.

REFERENCES: [1] Kele et al. World J Gastroenterol 16(13): 1567-76. [2] Setsompop et al. MRM 67(5):1210-24.