Continuously moving table vessel scout imaging using variable flip angles and autocorrelation analysis

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Introduction: Planning of bolus chase MR angiography (MRA) can be considerably optimized by the application of a vessel scout [1]. Recently, the concept of a time-of-flight (TOF) non contrast enhanced (CE) vessel scout was presented which is based on the continuously moving table (CMT) acquisition of projection data [2]. This study presents advanced acquisition and data processing strategies for CMT TOF vessel scout imaging which allow for improved vessel background contrast by using variable flip angles and autocorrelation analysis of acquired data.

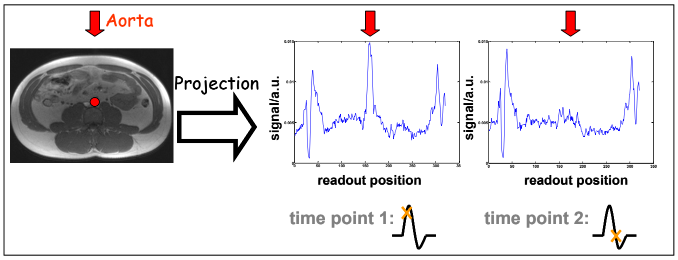

Fig.1: 1D projections show different signal enhancement at vessel locations (red arrows) depending the time point of acquisition in the cardiac cycle.

Methods: For fast visualization of the peripheral arteries, 1D data from the feet to the pelvis were acquired in 10 healthy volunteers (1.5T, Magnetom Avanto, Siemens) using a RF spoiled CMT gradient echo sequence. MR signal of 2D axial slices was received n=63 times for each slice position without phase encoding resulting in n projections acquired with a temporal gap of TR. Readout directions anterior/posterior and left/right provided coronal respectively sagittal scout views. Sequence parameters for coronal (sagittal) scout imaging were: 3 slices per package, readout resolution 320, readout FOV=400mm, slice thickness=5mm, patient table velocity=9.3(9.2)mm/s, TR=25.64(26)ms, and TE=3.95(4.07)ms. During the acquisition, venous inflow was saturated, the frequency of RF pulses was adapted to the table motion, and receiver coil elements were dynamically switched on and off. To compensate for signal saturation by repeated rf-excitation, the flip angle α was gradually increased from the inlet to the outlet side of each slice package (α=45°, 55°, 70°). Reconstructed projections showed different arterial signal enhancement dependent on the time point of acquisition in the cardiac cycle (Fig. 1). Thus, arterial positions could be isolated by calculating all combinations (i,j) of subtracted projections with identical slice position and background signal in the steady state. To further improve vessel background contrast, the different temporal signal behaviour at arterial and background positions was exploited (Fig. 2). For each readout and slice position, steady state signal intensities in projections were considered a time series and corresponding maximum autocorrelation coefficients r were calculated. The latter were used for signal weighting and multiplied with signal intensities of all subtracted projections. Maximum signal intensities found in each combination (i,j) of subtracted and weighted projections were plotted. Band-shaped clusters in the plot (Fig. 4, right), reflecting pulsatile arterial flow, were isolated using Otsu's method [3]. Image quality of resulting scout images was compared to a multistation TOF scout (TR/TE=11/6.9, flip angle=50°, voxel size= 1.8x3.5x3.3mm^3, slice gap=3.3/11 [1]) and reviewed by two radiologists (4 point scale: 0-3).

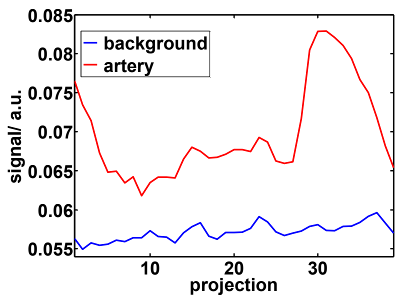

Fig.2: Different temporal signal evolution at background and arterial readout positions.

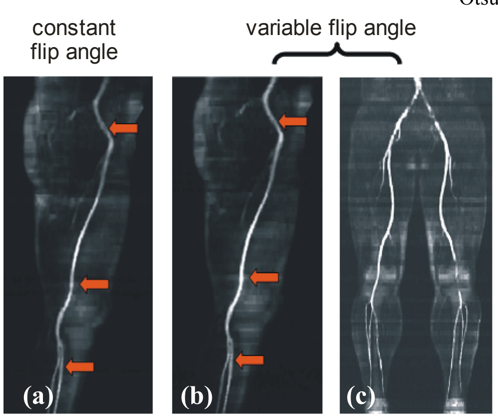

Fig.3: Sagittal and coronal scout views using constant and variable flip angles.

Results and Discussion: CMT TOF vessel scout imaging allows for the visualization of the major peripheral arteries (Fig. 3b/c). Total acquisition time for all volunteers ranged from 1:38min to 2:05min for one view and yielded a longitudinal FOV coverage between 915mm and 1170mm dependent on volunteer height. The comparison to a constant flip angle approach for one sagittal view (Fig. 3a/b) showed improved vessel background contrast (arrows) in favour of the variable flip angle acquisition. Vessel signal could particularly be increased in the last excited slice of each package. Figure 4 illustrates the potential effect of signal weighting on the identification of arterial signal. In this example, weighting subtracted projections with autocorrelation coefficients r clearly improved the visibility of the band structure in the plot caused by arterial signal enhancement. Thus, the impact of small signal variations with a different origin (e.g. local magnetic field changes in CMT acquisitions) on the selection of subtracted projections could be reduced. The comparison of the proposed CMT TOF and a standard multistation TOF scout (Fig. 5) yielded similar results for the proximal part of the arterial system with an improved vessel-background contrast for the CMT TOF scout. Visualization of distal parts was improved for the CMT technique. Blinded semi-quantitative image grading by two observers (kappa = 0.7) of volunteer data revealed good image quality reflected by mean scores of 2.8±0.2 and 2.6±0.3 for large arteries in sagittal and coronal views. Due to vessel overlay, vessel visualization was generally improved for sagittal views compared to coronal projections. In conclusion, the feasibility of CMT TOF vessel scout imaging for the visualization of main arterial structures in the periphery has been demonstrated in healthy volunteers. A variable flip angle acquisition and data processing based on subtraction and autocorrelation analysis provided high vessel contrast and stable background suppression in scout views, which can be acquired in less than 2min prior to the conventional CE-MRA for improved planning and workflow.

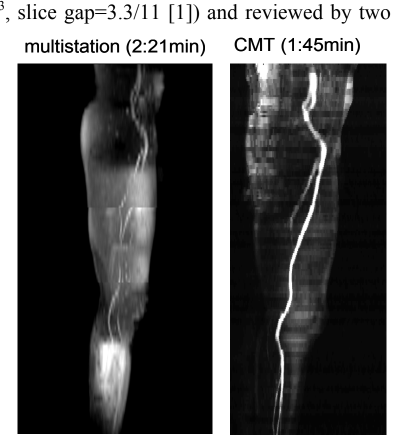

Fig. 5: Sagittal multistation and CMT TOF vessel scout.

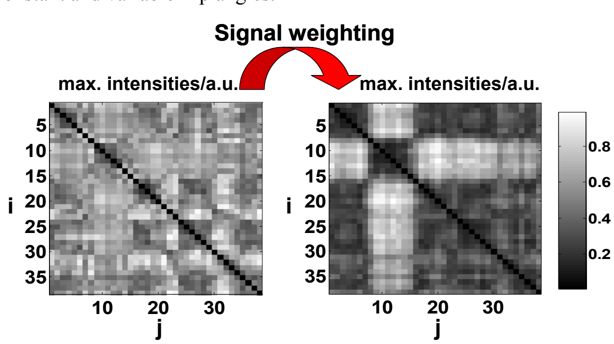

Fig.4: Multiplication of subtracted projections (i,j) with the coefficients r improves the identification of band structures representing arterial signal variations.

References: [1] Leiner T et al. Imaging Decisions MRI 2004;8:20-28. [2] Huff S et al. Proc. ISMRM 2010. [3] Otsu N. IEEE Transactions on Systems, Man, and Cybernetics 1979;9:62-66.