Triggered Angiography Non-Contrast Enhanced (TRANCE) of peripheral arteries: Optimization of systolic and diastolic time delays for electrocardiographic triggering

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Purpose: The aim of the study was to determine the optimal systolic and diastolic time delays (TDs) for electrocardiographic (ECG) triggering of a non-contrast media enhanced MR angiography (TRANCE) in patients suffering from peripheral arterial disease. We specified the requirements for the systolic images with minimal and the diastolic images with maximum arterial signal-to-noise (SNR) and consequently maximum background contrast in the subtracted data sets.

Materials and Methods: A cardiac-triggered Volumetric Isotropic T2w Acquisition (VISTA) sequence was performed at 1.5 Tesla (Philips Achieva) in 12 patients with suspected peripheral arterial disease using variable trigger delays for systolic and diastolic phase. The parameters of the sequence were: TR of 2 cardiac phases, TE=80ms, voxel size=1x1x1.5 mm^3, TSE factor=60, echo spacing=4.7ms, and acquisition time 2:12 – 3:30 min depending on heart rate. The method utilized refocusing control, and SENSE with R=2. Initially, a 2D PC-MR sequence was performed perpendicular to the popliteal arteries to determine the arterial flow curves and peak velocities of both legs. The systolic time delays for ECG-triggering were varied with different distances to the time of maximum peak velocity (TTVpeak). The diastolic TDs were chosen shortest and/or longest depending on the rate of blood circulation of the patient. The SNR in the popliteal arteries and anterior tibial arteries of the systolic and diastolic images were determined via manually defined regions-of-interest (ROIs). The effect of the CLEAR algorithm has been not considered, since it was used in all sequences of this study. Further, the background contrast was calculated in the subtracted data set (diastolic minus systolic images). These subtracted data sets were compared after maximum intensity projection (MIP) to a contrast-enhanced MR angiography.

Results: Correlation of SNR on systolic images with the difference of TTVpeak (time of maximum peak velocity) minus systolic TD was best fitted by a quadratic model for both, the popliteal arteries (R=0.629, $0.09x^2$-3.77x+72.34, Fig 1A)) and anterior tibial arteries (R=0.664, $0.25x^2$-7.16x+147.51). The minimum of these quadratic curves was determined at 21ms and 14ms for popliteal arteries and anterior tibial arteries, respectively. The correlation of SNR on diastolic images with the time difference revealed for the shortest TDs a weak decrease of SNR with the decreasing time difference and for the longest TDs a strong increase with increasing time difference (Fig 1B). This shows that the difference between TTVpeak and diastolic TD have to be at least 200ms. TRANCE (TRiggered Angio Non-CE) sequences performed with respect of these specifications showed a significant (P<0.001) background contrast (mean 329) compared to those did not (66). Further MIPs of these data were comparative to CE-MRAs (Fig 2 A and B).

Conclusion: Under the specification determined this study, TRANCE proved feasibility for angiographic diagnosis in patients suffering from peripheral arterial disease without application of contrast media.

Figure1: A) Scatterplot and quadratic model of systolic SNR vs. time difference TTVpeak–systolic trigger delay. B) Scatterplot and linear models of diastolic SNR vs. time difference TTVpeak–diastolic trigger delay.

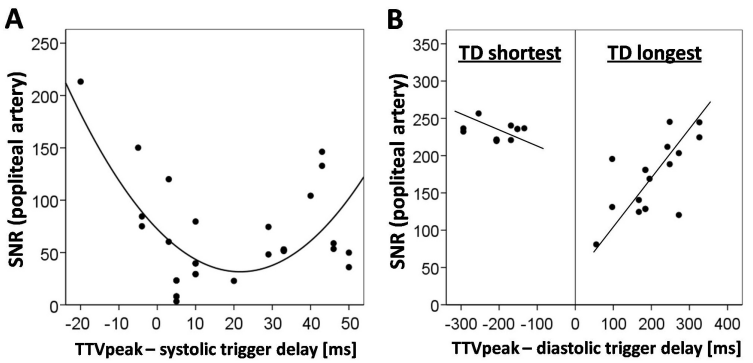

Figure2: A) and B) Comparison of conventional CE-MRA (left images) and Triggered Angio Non-CE (TRANCE, right images) of two patients suffering from peripheral arterial diseases.