Turbo quiescent-interval single-shot (TurboQISS): accelerated non-enhanced peripheral angiography

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Target audience: Radiologists and technologists/radiographers performing magnetic resonance angiography (MRA) of peripheral arteries.

Purpose: Given the high prevalence of impaired renal function in patients with peripheral arterial disease (PAD), nonenhanced MRA (NEMRA) techniques provide a useful alternative to both CT angiography and contrast-enhanced MRA (CEMRA). Several NEMRA techniques have been proposed for imaging peripheral vasculature, of which ECG-gated subtractive fast spin-echo techniques and quiescent interval single-shot (QISS) have been extensively evaluated. QISS has proven to be robust, accurate, and relatively insensitive to flow and patient motion [1]; besides, by obviating the need to determine systolic and diastolic phases, workflow is streamlined. In order to improve patient compliance and reduce the risk of motion artifact, we have implemented a modified sequence version, called TurboQISS, that cuts scan time in half while preserving image quality.

Methods: The study protocol was approved by the institutional review board and imaging was performed in healthy subjects and patients with PAD.
The acquisition scheme of the conventional QISS sequence is shown in Figure 1A. Briefly, it consists of an ECG-gated acquisition of 3 mm slices, with preparation pulses to suppress background and venous signals; following a quiescent-time, gated to peak systolic inflow, a fat-suppressed bSSFP sequence is used as a read-out. The process is then repeated for ~40 contiguous slices per table position, and for ~10 stations to cover the vasculature from aortic bifurcation to feet. The total acquisition thus takes ~400 heart-beats.

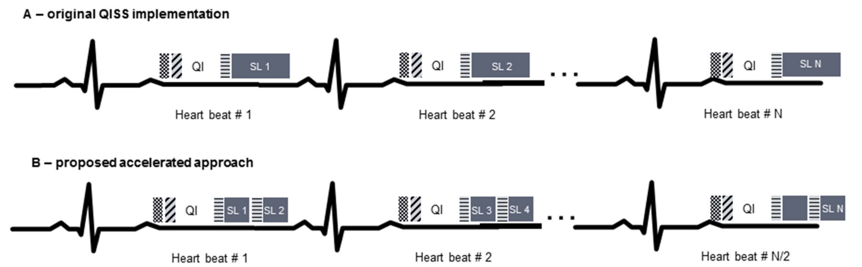

Figure 1. Acquisition scheme for conventional QISS (A) and TurboQISS (B) with Turbo factor = 2, i.e. two slices are acquired in each hearbeat after the application of single set of preparation pulses (background and venous suppression pulse). QI quiescent interval
Venous sat Background sat Fat sat SL k bSSFP readout for Slice k

To accelerate the acquisition, we propose to acquire two slices in each heart-beat after the application of a single set of preparation pulses. Figure 1B shows the schematic. Unlike previous reports using undersampled radial trajectory [2], a Cartesian k-space trajectory is maintained so that image quality is largely unaffected compared with the standard QISS acquisition. The thickness of background suppression pulse is doubled, and it is applied in between the 2 slices.
To accommodate multiple slices within a heart-beat, the bSSFP readout must be abbreviated. In the current work, this is accomplished by reducing the resolution in the anterior-posterior (AP) direction. Given that the process of generating coronal maximum intensity projection (MIP) collapses the AP dimension, we hypothesized that the approach of reducing the acquired spatial resolution in AP direction should have negligible effect on the coronal maximum intensity projection (MIP) images.
Prototypes of conventional and TurboQISS were implemented on a 1.5T scanner (MAGNETOM Avanto, Siemens AG, Erlangen, Germany). Imaging parameters common to conventional and Turbo QISS were: slice thickness 3mm, parallel imaging factor 2-3 with 24 reference lines, flip angle 90°, partial fourier 5/8, tracking venous saturation slab 75mm thick. For conventional QISS, acquired in-plane resolution was 1x1 mm^2, whereas that for TurboQISS was 1x2 mm^2. Standard CEMRA was used as reference.

Results: Coronal MIPs from TurboQISS were comparable to those from conventional QISS in healthy subjects and patients. Figure 2 shows coronal MIPs from CEMRA, conventional QISS, and TurboQISS in a patient with PAD. TurboQISS was able to depict the presence and location of the arterial occlusion (arrows). Image acquisition time for TurboQISS was half that of conventional QISS.

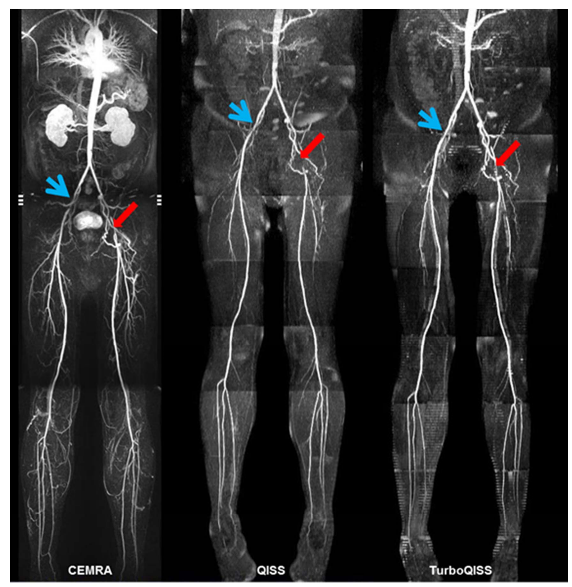

Figure 2: CEMRA, QISS, and TurboQISS in a patient with PAD. TurboQISS was comparable to QISS and CEMRA in demonstrating the occlusion and collaterals involving the left external iliac artery and the stenosis of the right external iliac artery. CEMRA: contrast enhanced MRA, QISS: quiescent-interval single-shot

Discussion and Conclusion: Our initial results suggest that TurboQISS can be used as a rapid scout to get an initial assessment of the presence and location of peripheral vascular pathologies. This can further be complemented with high-resolution QISS or CEMRA in specific stations for detailed assessment of pathology, thus reducing the overall scan time and lessening the likelihood of motion artifact. Finally, it should be possible to exploit the inherent sparsity in TurboQISS data with compressed sensing techniques to reconstruct images without compromising the spatial resolution in AP direction. However, further work will be required to validate this hypothesis.

References: 1. Hodnett et al. Radiology 2011 Volume 260 (1) 282 2. Edelman et a. MRM 2013 Dec;70(6):1662-8