Volumetric Aortic Vessel Wall MRI using Improved Flow-Independent T2-Prepared Phase Sensitive Inversion Recovery at 3T

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Introduction: Black blood MRI can be used to obtain high-resolution 3D visualization of the vessel wall [1]. Vessel wall imaging of the aorta is particularly useful in patients with aortic dissection to visualize the intimal flap and tears connecting true and false lumen. A new technique, T_2-prepared Phase Sensitive Inversion Recovery (T_2prep-PSIR), shows a T_1- and T_2-relaxation based contrast for enhanced distinction between vessel wall and surrounding tissue. However, flow artifacts may occur if the T_2prep pulse is performed in a cardiac phase with high blood flow [2]. The T_2prep can be performed immediately after the R-wave in early systole, to avoid systolic flow. However, in some subjects significant blood flow may occur even during early systole and cause artifacts. In this study, we developed an adapted T_2prep-PSIR sequence that decreases the susceptibility to flow artifacts by performing the T_2prep pulse during a slow blood flow period in end diastole and compared it to a similar acquisition with the T_2prep performed in early systole.

Methods: A schematic overview of the proposed T_2prep-PSIR sequence compared to the conventional sequence is shown in Figure 1. 3D coronal images of the aorta were acquired with an ECG triggered sequence that consists of an adiabatic non-selective T_2-prepared prepulse, a non-selective inversion pulse and 3D gradient echo readout. In the proposed sequence, the T_2-prep is performed during end diastole (slow blood flow) and the inversion recovery pulse is directly performed after the R-wave. For comparison, a T_2prep-PSIR was acquired with the T_2prep in early systole (high blood flow). Imaging parameters for both sequences include: TR/TE=5.0/2.3ms, acquisition duration=100ms, T_2prep echo time=70ms, FOV=264×380×46mm^3, Δx=1.6×1.6×1.6mm^3, α=20° for the first acquisition and 5° for the PSIR reference acquisition, SENSE factor=2, and a navigator for respiratory gating (5mm window). The nominal scan time was 3:08min. Healthy volunteers (n=7) were scanned (Philips Achieva 3T MRI) with a 32-channel cardiac coil. Assessment of the acquired images was done by an expert, blinded to the method used and based on a five-point scale (1 = uninterpretable, 5 = excellent image). Ascending aortic flow data were compared with the acquired images.

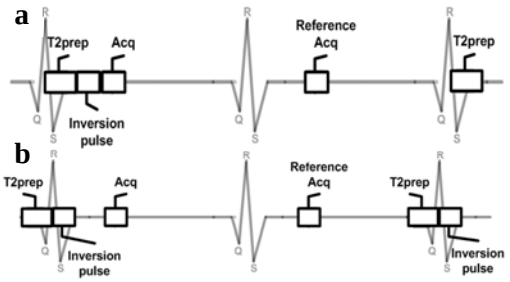

Figure 1: Schematic overview of pulse sequence with T_2-prepared pulse (rectangular shaped), inversion pulse (diamond shaped) and reference acquisition during systole (triangle shaped) for a) conventional T_2prep-PSIR sequence, b) proposed T_2prep-PSIR sequence.

Results: All volunteers successfully completed the scan protocol. No flow artefacts were observed from the proposed sequence. Representative images with corresponding aortic flow curves from three volunteers are shown in Figure 2. The aortic flow during the T_2prep in early systole was less for volunteer 1 compared to volunteers 2 and 3 (Figure 2). Visual scores are shown in Table 1. The conventional method resulted in an average visual score of 2.4, while the visual score for the proposed method was on average 3.4, an increase of 41%.

Discussion and Conclusion: The proposed T_2prep-PSIR sequence resulted in better visualization of the vessel wall and lumen due to fewer flow artifacts. This improvement depends on the flux in the aorta during the T_2-prepared pulse. With the proposed T_2prep-PSIR sequence, the T_2-prep pulse duration can be extended to achieve more contrast between the vessel wall and surrounding tissues. Further studies in patients with dissection are warranted.

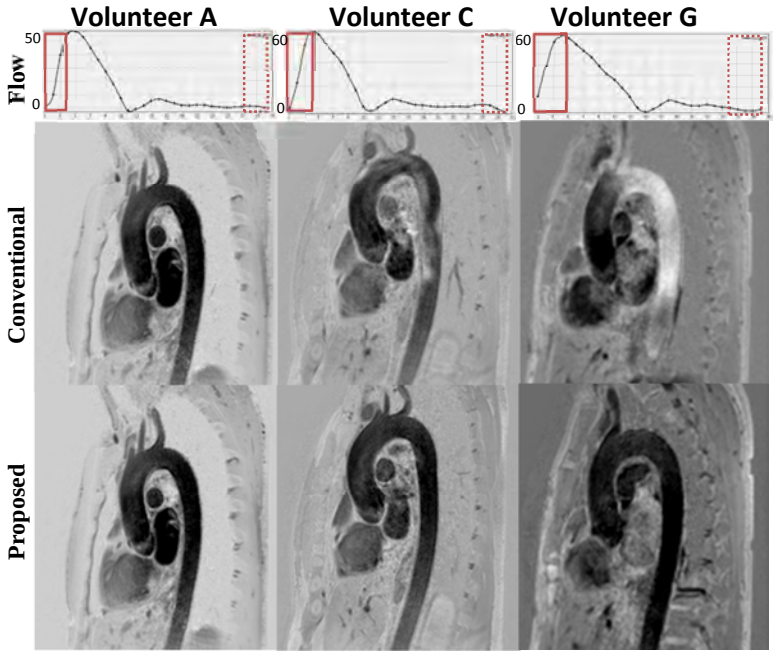

Figure 2: Flow curves [ml/s] (above) with T_2prep timing in conventional (solid square) and proposed (dashed square) sequence. Corresponding images of aorta in systole using conventional T_2prep-PSIR (center) and proposed T_2prep-PSIR sequence (below) for volunteers A, C and G.

Volunteer	Conventional	Proposed
A	2	3
B	1	3
C	2	3
D	3	3
E	4	4
F	4	5
G	1	3

Table 1: Visual scores for all volunteers using the two sequences.

References: [1]J. Xie, X. et al. *JMRI (2010), 32:399-408.*
[2]Jenista ER, et al. *MRM (2013); 70:1360–8.*