Zoom accelerated Quadruple Inversion Recovery imaging for fibrous cap visualization in the abdominal aortic aneurysm

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Introduction

The abdominal aortic aneurysm (AAA) has the histological hallmark of destruction of the tunica media layer of the vessel wall. Histology reveals that the vessel wall and thrombus are covered by a fibrous cap that can be imaged using Gadolinium.(1) Hence, AAA has been used as a model for the development of imaging pertinent to carotid or coronary pathology.(1)
Quadruple inversion recovery (QIR) black-blood imaging may be superior to Dual Inversion Recovery (DIR) or inversion recovery (IR) black blood imaging for fibrous cap enhancement, because pre- and post-contrast imaging can be performed with identical parameters and still achieve adequate blood suppression.(2) However, in order to achieve consistent blood suppression and motion compensation in the arterial system, it is necessary to use ECG-gating. The purpose of this study is to show that ECG-gated QIR is possible by gating to every other heartbeat and that this provides an accurate definition of the fibrous cap. Zoom imaging is also implemented in the sequence to reduce scan duration.(3)

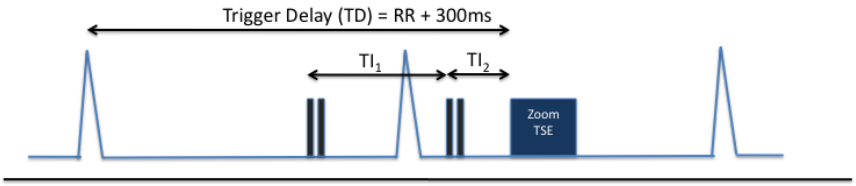
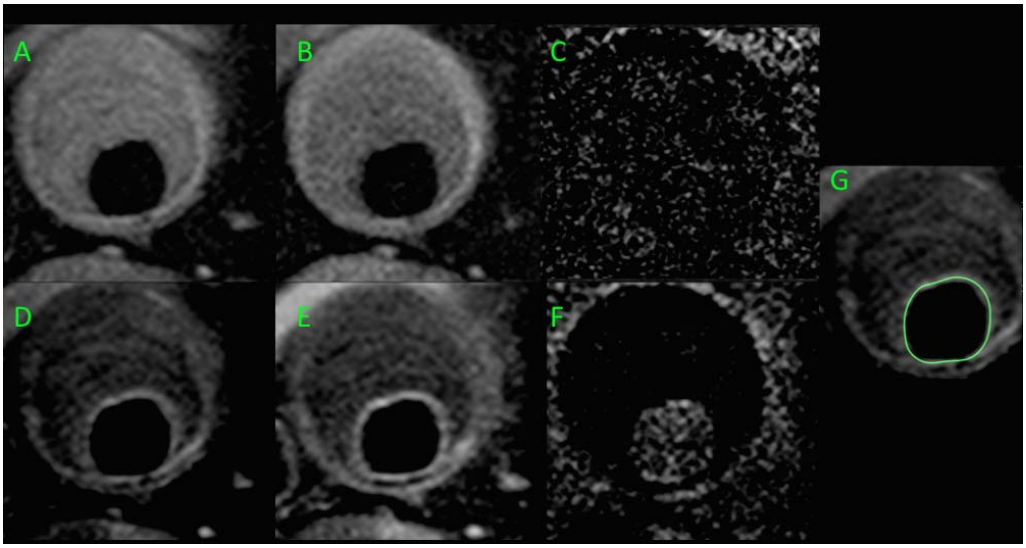


Figure 1: The QIR pre-pulse with ECG triggering and TReff of 2 heartbeats.

Methods

5 Volunteers (male, mean age 75yrs (65-82yrs)) with AAA's were imaged before and after administration of intravenous Gadobutrol (0.2 mmol/kg) using a 1.5T Achieva MR scanner (Philips Healthcare, Best, NL) and a 32-element receiver coil. 33 transverse slices encompassing the abdominal aorta were obtained using a free-breathing ECG-triggered, black-blood 2D DIR TSE sequence (1x1x5mm; 2 signal averages; repetition time of one heartbeat, shortest trigger delay ~500 ms, TE 5.0 ms, 120ms acquisition window). Imaging was performed with zoom imaging (FOV = 220mm x 67mm). The inversion time (TI) was set according to the Fleckenstein formula to null pre-contrast blood.(4) 5 slices encompassing the AAA were repeated using QIR imaging every other HB, with inversion times (TI1 and TI2 calculated for each heart rate by minimizing the integral of the longitudinal magnetization of blood between 100 and 1400ms). Otherwise identical parameters were used. These 5 slices were then repeated using IR imaging (fast gradient echo sequence with spatial resolution=1x1x5mm, TR/TE=6.3/2.5ms, and TI set according to the Fleckenstein formula). All sequences were repeated for post-contrast imaging with identical parameters, except that for the DIR and IR sequence, TI was chosen by using a preceding Look-Locker sequence to null blood. Contrast-to-noise ratio (CNR) of the fibrous cap for each sequence was calculated and adequacy of blood suppression was assessed by calculating the signal-to-noise ratio (SNR) of blood. Image quality of the fibrous cap was graded 0 to 4 by consensus reading by two experienced independent observers.(5)

Results



The fibrous cap was adequately demonstrated with all three sequences in each case. Blood suppression was achieved for all three sequences (mean blood SNR 0.41±0.40 for QIR; 0.37±0.45 for DIR and 0.42±0.42 for IR (p=0.87 by repeated measures analysis). CNR of the fibrous cap did show differences across the sequences (mean CNR 6.6±1.2 for QIR; 5.1±1.5 for DIR and 5.2±3.1 for IR (p=0.03 by repeated measures analysis). Image Quality also showed differences across the sequences (mean 3.6±0.9 for QIR; 3.4±0.9 for DIR and 2.2±0.4 for IR p=0.02 by Friedman's non-parametric testing).
Figure 2 shows fibrous cap imaging (Pre Contrast-Post Contrast: A-D (QIR); B-E (DIR); C-F (IR)) (G shows segmentation of fibrous cap from image D)

Discussion

In our series of AAA's, ECG-gated QIR with zoom showed improved visualization of fibrous cap defined by CNR and image quality after contrast administration compared to traditional DIR and IR sequences.
The main disadvantage with the traditional sequences is that different inversion times are required before and after Gadolinium. This introduces an implicit bias in quantitative estimates.
By applying ECG-gating, the QIR sequence now becomes applicable to arterial imaging by allowing motion compensation and consistent blood suppression. The further application of zoom imaging substantially reduces imaging time to make it applicable to clinical practice.

References

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