Cardiovascular Susceptibility Weighted Imaging Computed Using Water-Fat Separation Improves Intramyocardial Hemorraghe Detection Specificity

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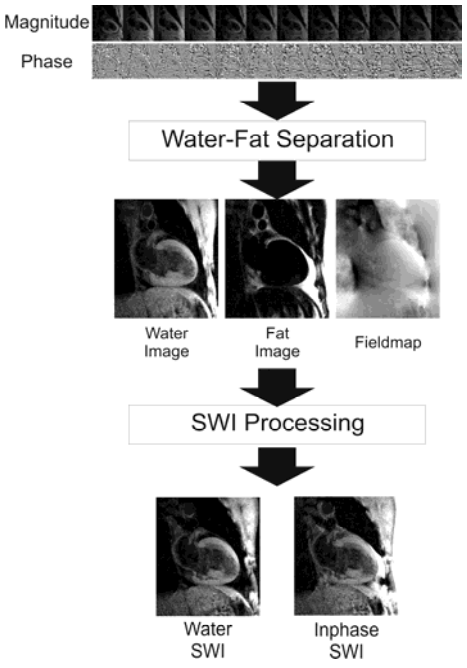
Purpose: To compare myocardial susceptibility weighted imaging (SWI) using water-fat separation to conventional SWI processing in patients with a wide age range of myocardial infarctions (MI) for the detection of reperfusion intramyocardial hemorrhage (IMH).

Introduction: Tissue characterization in the setting of MI is developing into a clinical tool with applications in diagnosis, risk stratification and therapy optimization. SWI has recently been proposed as a method for the detection of IMH, a feature of reperfusion injury in acute MI [1]. Hemosiderin in myocardial hemorrhage lowers T2* relaxation rates as well as causes local image phase susceptibility changes and can be visualized as a hypointense lesion in SWI images (combined magnitude and phase). Fatty metaplasia in chronic MI is reported in the pathology as well as magnetic resonance (MR) imaging literature. Intramyocardial fat due to its chemical shift may also artifactually be visualized as a hypointense lesion in conventional SWI images. Processing with water-fat separation algorithms before SWI image construction is proposed as a means to eliminate susceptibility effects from intramyocardial fat and preserve sensitivity to IMH.

Methods: 10 chronic MI (>2 years) and 10 acute MI (3 days) patients were included in this study. Imaging was performed before contrast agent administration at 1.5T using a dark blood double inversion recovery multiple spoiled gradient-echo sequence (1 slice per breath hold, repetition time = 20 ms; 12 echo times, 2.4 - 15.5 ms (1.2 ms spacing), flip angle = 20 degrees, bandwidth = 1860 Hz/pixel, in-plane spatial resolution = 2.3 x 1.7 x 8 mm^3, flow compensation in read and slice). Late gadolinium-enhanced imaging (LGE) was also performed.

SWI images were constructed using two methods. 1) Conventional reconstruction using high-pass filtered phase processing, magnitude masking and TE-averaging and 2) Water-fat separation [2] yielding a field map and water and fat images, followed by conventional SWI processing using a phase mask calculated from the Bo fieldmap and magnitude images from water only or a synthetic in-phase image (water+fat). Water-fat separation removes contributions from fat in water images and Bo fieldmaps, making the SWI image free of fat susceptibility.



Water-Fat Separation SWI Algorithm

Results: Below are representative results from patients with a chronic MI with intramyocardial fat and an acute MI with intramyocardial hemorrhage. LGE images show the anterior and inferior MIs. The chronic MI patient shows midwall fat deposition in water and fat only images, while the acute patient shows homogeneous water signal and absence of fat infiltration. Both conventional and water SWI images show a hypointense lesion in the segments with LGE for each patient. Only the inphase SWI image discriminates between susceptibility from fat deposition and intramyocardial hemorrhage. Similar results were seen in the 5 chronic MI patients with fat deposition and 4 acute MI patients with IMH. Patients without intramyocardial fat or IMH showed homogeneous water only images, water SWI and inphase SWI images.

Conclusion: Water-fat separation is necessary with cardiovascular SWI to discriminate between fat deposition and intramyocardial reperfusion hemorrhage. The technique allows non-contrast detection and characterization of ischemic myocardial injury with improved IMH specificity compared to conventional SWI processing.

[1] Goldfarb JW et al. "Magnetic Resonance Susceptibility Weighted Phase Imaging for the Assessment of Reperfusion Intramyocardial Hemorrhage", Magn Reson Med. 2014; 71(3), 1210–1220. [2] Hernando D et al. "Robust water/fat separation in the presence of large field inhomogeneities using a graph cut algorithm." Magn Reson Med. 2010;63(1):79-9.