

Imaging of Hemorrhagic Myocardial Infarction using Susceptibility Weighted Imaging (SWI)

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Introduction: Reperfusion of ischemic myocardium can lead to interstitial hemorrhage which is associated with microvascular obstruction and adverse clinical outcomes [1]. Myocardial hemorrhage is most commonly seen as a dark core (hypo-intense) with the “no reflow” phenomenon in early and late gadolinium-enhanced (LGE) myocardial infarct images. The diagnosis of myocardial hemorrhage is complicated by the fact that “no reflow” or microvascular obstruction can be present without myocardial hemorrhage. T2- and T2*-weighted imaging and mapping techniques have been employed to detect and quantify the region of myocardial hemorrhage following acute myocardial infarction [2]. Robust imaging of myocardial hemorrhage is important for the accurate determination of the ischemic area at risk and irreversibly injured myocardium.

Susceptibility-weighted imaging (SWI) [3,4] is a new means to enhance contrast in MR imaging using phase information from long TE images. Phase images are sensitive to tissues with different magnetic susceptibilities than surrounding structures such as deoxygenated blood, hemosiderin, ferritin and calcium. We sought to assess SWI's feasibility for myocardial tissue characterization in acute myocardial infarction.

Materials and Methods: Eight subjects, three days after acute myocardial infarction, underwent MR imaging at 1.5T. Conventional bSSFP cine, T2-weighted TSE and phase sensitive LGE infarct imaging were performed in long and parallel short axis views of the left ventricle. Additionally, a dark-blood double inversion-recovery multiple gradient-echo sequence (TR= 20/ TEs=2.4 –15.5 [1.2 msec spacing]; flip angle, 20°; in-plane spatial resolution, 2.5 x 1.7 mm, bandwidth, 2005 Hz/pixel; and breath-hold duration, 15 heartbeats) was utilized for susceptibility weighted image acquisition in the same slice locations. A magnitude image was constructed by the sum-of-squares of all 12 echo delay time images. High-pass filtered phase images of the 15.5 msec echo images were reconstructed by high-pass filtering with a Hanning window. A phase mask was created to suppress minimum phase consistent with hemorrhage [4] ($\phi(x) + \pi$)/ π for phases <0 and unity otherwise. SW images were constructed by a multiplication of the phase mask three times into the magnitude image. MR images were visually compared for artifacts and myocardial tissue characterization quality.

Results: High quality images were obtained in all cases (Figure 1). Four patients showed “no-reflow” in LGE imaging. Three patients showed SWI myocardial hemorrhage in areas of “no reflow”. No myocardial hemorrhage was seen in the other patients. T2-weighted imaging showed bright signal intensity in the myocardial area at risk. T2-weighted TSE signal defects in patients with myocardial hemorrhage were difficult to discern as to their origin: image quality, myocardial hemorrhage or poor black-blood nulling.

Conclusions: SWI is an effective means of generating high quality images of left ventricular myocardium for tissue characterization. Hypo-intense lesions correlated with areas of acute myocardial infarction and dark core regions at LGE imaging. SW imaging provided new information not contained in LGE or T2-weighted images. Further studies are warranted for the study of SWI specificity and sensitivity for the detection of myocardial hemorrhage and its accuracy in hemorrhagic volume determination.

References: [1] Wu KC et al *Circulation*; 97(8):765-72, 1998. [2] Cannan C et al, *JACC Cardiovasc Imaging*;3(6):665-8, 2010. [3] Haacke EM et al. *Magn Reson Med*;52(3):612-8, 2004. [4] Tong KA et al *AJNR*,29(1):9-17, 2008.

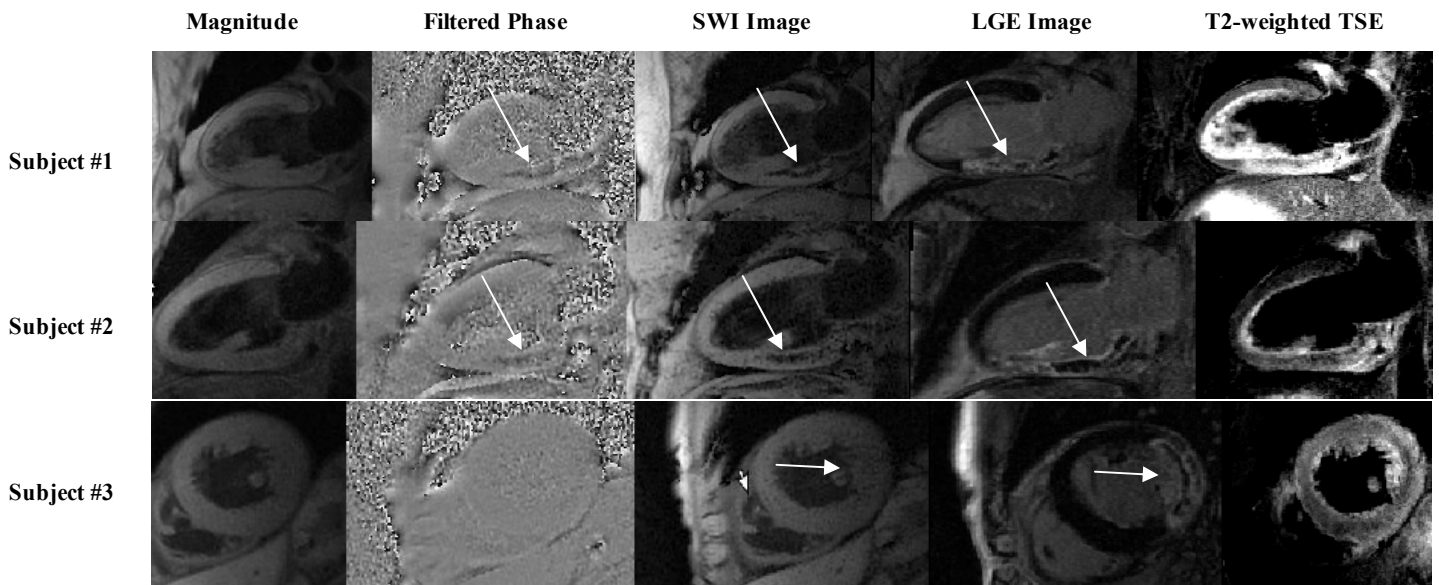


Figure 1: Representative images from three subjects with acute myocardial infarctions with LGE determined “no reflow”. Subjects 1 and 2 clearly show myocardial hemorrhage (hypo-intense lesion) in the SWI image, while the third subject does not. SWI images are the product of the Magnitude and filtered phase images. Myocardial hemorrhage can be clearly seen as possessing negative phase in the filtered phase images.