Assessment of Pericardial Inflammation using Delayed Enhanced Phase-Sensitive Inversion-Recovery TurboFLASH

C. Farrelly[1], A. Keeling[1], J. Sheehan[1], E. Wu[1], and J. Carr[1]

[1]Cardiovascular Imaging, Northwestern Memorial Hospital, Chicago, Illinois, United States

Introduction: Differentiation of pericardial thickening from pericardial effusion and differentiation of chronic fibrosis from active pericardial inflammation can be difficult with MRI. The use of gadolinium enhanced T1- weighted spin-echo (1) and gradient echo with shared pre-pulses (SHARP) can help in this differentiation but findings can be subtle. More recently detection of pericardial inflammation with late-enhancement, similar to that used in MRI evaluation of myocardial late-enhancement, has been described (1). Delayed enhancement imaging is preceded by the use of a "TI scout" in order to optimize the selection of the inversion time (TI) for myocardial nulling. This offers a theoretical contrast advantage between the nulled myocardium and the enhancing pericardium compared to standard post contrast images(2). The advantages of delayed enhanced phase sensitive inversion recovery turboFLASH (PSIR-TFL) imaging have previously been described in the context of delayed-enhancement imaging of myocardial infarction(2). The phase sensitive inversion recovery (PSIR) reconstruction offers additional contrast benefits by decreasing sensitivity to changes in tissue T1 with increasing delay from contrast injection which would otherwise lead to sub-optimal nulling of the myocardium [2]. PSIR also allows surface coil intensity normalization, thereby removing the large variation in image intensity due to rapid fall-off in the surface coil field and improving the visualization of local tissue contrast [2]. PSIR also benefits from background noise reduction [2,3] leading to improved contrast-to-noise ratio (CNR). Clinically pericarditis is often accompanied by a pericardial effusion. Plasma T_1 value is 1585 ms, and that of red cells is 794 ms approximately [4]. A pericardial effusion will have a T_1 value somewhere in between. The positive amplitude of pericardial effusions decreases its contrast with enhanced pericardium on magnitude reconstructed images. The negative amplitude of pericardial effusions on PSIR reconstruction has the opposite effect (Fig.1).For these reasons PSIR reconstruction may offer improved contrast between inflamed pericardium and adjacent myocardium or effusion. The purpose of this study was to compare phase images to magnitude images using PSIR-TFL in patients with clinically suspected or known pericarditis.

Methods: A retrospective review was carried out on 40 consecutive patients with clinical symptoms suggestive of pericarditis and thickened enhancing pericardium on SHARP images post intravenous gadolinium administration. All patients had undergone cardiac MR (CMR) on a 1.5T Siemens Avanto (Siemens Medical Solutions, Erlangen, Germany) scanner. All patients had delayed enhancement imaging as part of the CMR protocol using PSIR-TFL which reconstructs both magnitude and phase images, facilitating evaluation of the relative contrast between myocardium, pericardial fluid and pericardium for both image reconstruction techniques.

Quantitative analysis involved calculating signal intensity (SI) and standard deviation of SI by manually placing a region of interest (ROI) in the myocardium, the pericardium, pericardial effusion (when present) and the liver (for normalization).This was performed using ARGUS software at a Leonardo workstation (Siemens Medical Solutions). Contrast difference between the pericardium and the adjacent myocardium and between the pericardium and pericardial effusion when present, normalized for mean signal intensity in the liver, was determined from post contrast SHARP images and delayed enhanced turbo FLASH with magnitude and PSIR reconstructions. For qualitative analysis post contrast SHARP, magnitude and phase reconstructions of delayed enhanced PSIR-TFL sequences were evaluated for the 40 patients with pericarditis and for 40 controls. The images were scored on a 5 point scale for pericardial enhancement by two blinded reviewers. For reasons of positive and negative amplitude similar to that described above with pericardial effusions, it is not possible to calculate noise directly from PSIR images. Quantitative contrast values normalized for liver (near the center of the field of view on short axis images) and qualitative analysis was therefore necessary

Results: 22 male and 18 female patients (ages:16-89 yrs) with pericarditis were evaluated. Quantitatively the mean contrast between pericardium and myocardium was greater on delayed enhanced PSIR-TFL (magnitude and phase reconstructions) than on post contrast SHARP images($p<0.05$). The mean contrast difference between pericardium and myocardium was greater on PSIR reconstructions than on the corresponding magnitude reconstruction ($p<0.05$). The contrast between pericardium and adjacent pericardial fluid was greater on PSIR reconstruction than on magnitude reconstruction or post contrast SHARP for all patients with pericardial effusions ($p<0.05$). Qualitative analysis demonstrated superior depiction of pericardial enhancement on PSIR than on magnitude reconstruction or post contrast SHARP ($p<0.05$).

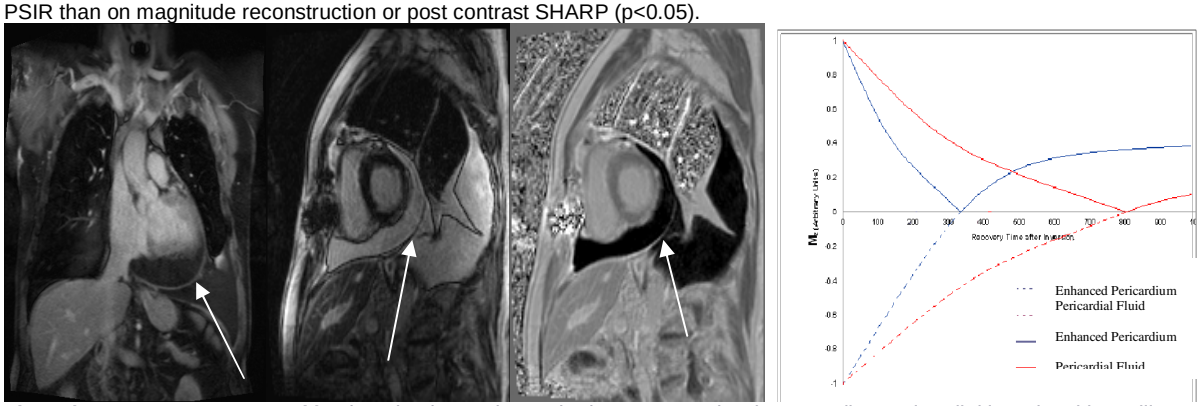

Fig 1.*a)* *Post contrast SHARP,* ***b)****Delayed enhanced magnitude reconstruction (surrounding pericardial low signal is "nulling artifact" rather than enhancing pericardium) and* ***c)*** *PSIR. Note the improved contrast and increased visibility of the inflamed pericardium on the PSIR image.* ***d)****Simulated T1 recovery curve of enhanced pericardium and pericardial fluid. The T_1 value of a pericardial effusion is much longer than the typical T_1 time of normal myocardium and as such on magnitude images pericardial fluid will have positive amplitude* ***(b)****. On PSIR the fluid has a negative amplitude* ***(c)*** *thereby increasing its contrast with enhanced pericardium.*

Conclusion: Delayed enhanced PSIR reconstruction leads to improved contrast of inflamed enhanced pericardium with surrounding structures compared to magnitude reconstruction images or standard post contrast T1 weighted imaging.

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