In vivo detection of cardiac fibrotic tissue without contrast agent

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TARGET AUDIENCE: Physicists who work on MRI sequence development, Cardio-radiologists, Cardiologists

PURPOSE: Currently the gold standard for detection of focal myocardial fibrosis with cardiovascular magnetic resonance (CMR) is late gadolinium enhancement (LGE), which requires administration of intravenous contrast agent [1-3]. Moreover standard single inversion recovery sequences suppress the signal of normal myocardium, but not of the blood pool. A characteristic of cardiac fibrosis is the increased presence of collagen [2]. Collagen is characterized by very short transverse relaxation times in the order of only few ms and is therefore not detectable with conventional MRI. In 2011 de Jong et al. [4] showed that ultrashort TE (UTE) MRI can detect myocardial fibrosis in isolated rat hearts. However, the translation of UTE sequences to clinical practice is challenging. Here we present a positive contrast technique based on a single-breath-hold submillisecond-echo-time spoiled gradient echo (SPGR) sequence [5] as a potential alternative to LGE for cardiac MRI.

METHODS: A variable echo time (vTE) 2D-SPGR sequence was implemented in order to yield submillisecond echo time using maximum gradient performance and highly asymmetric readout [5]. One healthy volunteer and one patient with dilated cardiomyopathy and non-ischemic patchy subepicardial late-enhancement were scanned at a 1.5T clinical MR scanner using a body array coil. The 2D vTE SPGR sequence was applied pre-contrast in a breath-hold in an ECG-gated mode at diastolic phase with TE_1 / TE_2/ TR = 0.88/ 3.0 / 133 ms (flip angle 15°, in-plane resolution 1.9 mm, slice thickness 5.5 mm, acquisition time 7 sec). The difference image (the second echo was subtracted from the first echo) was calculated in order to produce positive images. In addition, in the case of the patient, a standard clinical protocol of an LGE 3D navigated inversion recovery SPGR axial image was acquired with resolution 1.5 x 1.5 x 2.5 mm^3 after administration of Gd-BOPTA.

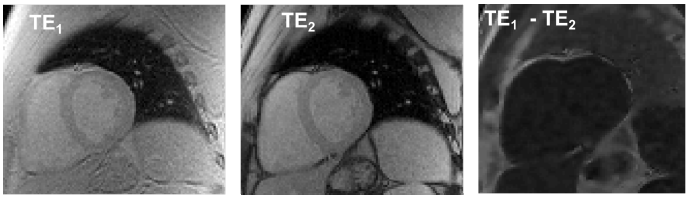

Figure 1. Sample short axis view images of the volunteer, (left) short echo (0.88ms), (center) later echo (3 ms), (right) difference image

RESULTS: In the case of the healthy volunteer no positive contrast was observed on the difference image in the myocardium and the blood pool signal was completely suppressed since it exhibits equal signal on the two echoes (see Fig.1 *right*). In the case of the patient (see Fig.2) positive contrast was present on the difference images, at locations where late enhancement was identified by experienced radiologists.

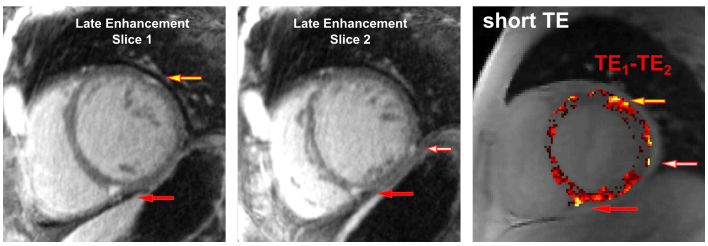

Figure 2. Patient with non-ischemic late enhancement: comparison of the short echo images with LGE images, (left & center) LGE images, (right) segmented ROIs of the difference image overlayed on the short echo image. The LGE appears on different slices due to smaller slice thickness.

DISCUSSION/CONLUSION: In the case of a healthy volunteer it was confirmed that the myocardium appears completely suppressed on the positive contrast difference image. In the patient the findings of the proposed method showed good agreement with the LGE. At present, an alternative to delayed enhancement has only been presented on ex vivo UTE MRI [4]. The agreement of the results with the findings of the up-to-date gold standard (i.e., LGE images) shows that a short echo time approach has the potential to provide an alternative to the late enhancement scanning for the detection of chronic myocardial injury. This would have high clinical impact since it does not require administration of contrast agent.

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