Late Gadolinium Enhancement Imaging with Automatic Establishment of the Optimal Inversion Delay

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Introduction. In order to determine myocardial viability the Late Gadolinium Enhancement (LGE) method is used [1]. About 10-20 minutes after the administration of a T_1 contrast agent fibrotic myocardium exhibits a higher concentration of contrast medium than healthy myocardium, which can be shown with an inversion recovery sequence. In practice the establishment of the optimal inversion delay time (TI) of such a sequence is challenging. The presented method allows to visualize LGE images with any desired TI based on a single breath-hold scan.

Method. We have developed an imaging method to quickly quantify the absolute T_1 relaxation time and proton density (PD) in a complete cardiac volume. Two sets of complex images are acquired at different delay times after the inversion pulse, similar to the phase sensitive method (PSIR [2]). Twelve slices are measured, with an in-plane resolution of 1.5x1.5 mm^2, within a breath hold of 19 heart beats. The two sets suffice to calculate the absolute T_1 and PD per pixel. Based on this data the expected image at any TI can be synthesized. This means that a whole range of LGE images can be visualized using a single scan. The optimal T1 can either be set by the user or a software program that determines the optimal TI for a region of interest. The sequence is implemented on our 1.5T Achieva (Philips Medical Systems, Best, The Netherlands). The visualization is implemented in our PACS viewer (IDS5, Sectra Imtec, Sweden).

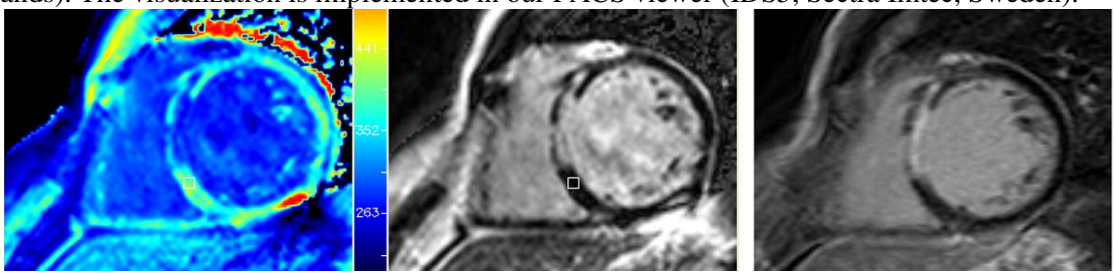

Fig. 1. Short axis slice of the heart, 1 out of 12 acquired in a 19 heart beats breath-hold sequence. On the left the measured absolute T_1 map is shown. In the center a synthetic inversion recovery image with an inversion time 270 ms is depicted, based on the absolute T_1 map. On the right the conventional inversion recovery image (also inversion time 270 ms) is added for comparison.

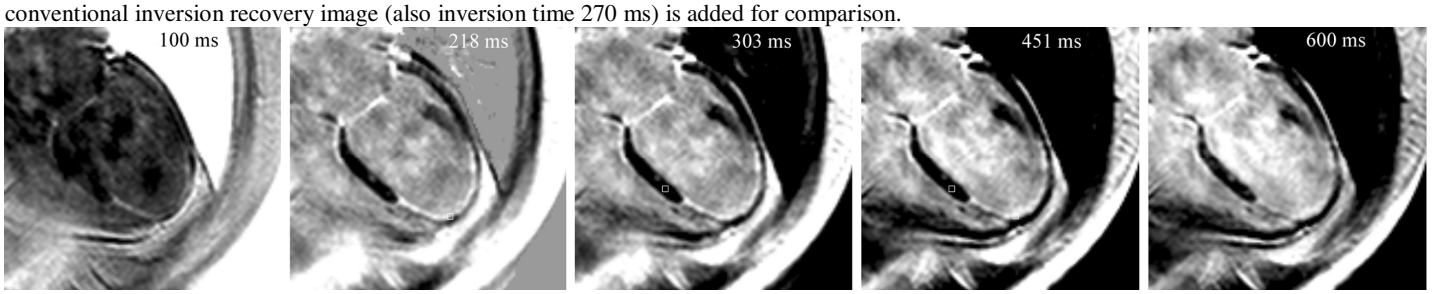

Fig. 2. Synthetic Late Gadolinium Enhancement Images of a long axis slice (1 of 12 acquired, real images). A whole range of TI's can be visualized, e.g. at 100, 218, 202, 451 and 600 ms, based on the same data-set. The squares indicate the optimization area, 218 ms corresponds to the zero-crossing of fibrotic myocardium, 303 ms corresponds to the zero-crossing of healthy myocardium and 451 ms displays the largest contrast difference between the two.

Results. The method is used routinely in our clinic. The quantification sequence is run and the LGE, with optimal TI, can be directly shown in our PACS viewer. Furthermore the established value of TI is used in all subsequent conventional scans. In practice a time saving is achieved in the order of 5-10 minutes for a single exam and it results in high quality LGE images. In order to validate the method both the synthetic images and conventional images were used as input to determine the infarction size.

The major advantage of the new method is the freedom to apply any inversion time in the reconstructed image, without the need to perform the actual measurement again on the patient. Moreover knowledge of absolute T_1 allows the quantification of the concentration of contrast agent in the tissue and possibly therefore also the severity of ischemia.

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2. Kellman P, Arai AE, McVeigh ER, Aletras AH. Phase-sensitive inversion recovery for detecting myocardial infarction using gadolinium-delayed hyperenhancement. Magn Reson Imag. 2002:47;372-282.