Three-Dimensional Late Gadolinium Enhancement with Adaptive Inversion Time

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Introduction: 3D Late Gadolinium Enhancement (LGE) is susceptible to artifacts arising from incorrect delay time between the inversion pulse and data acquisition[1]. Typically, the optimal inversion time is determined using a Look-Locker (LL) scan prior to the 3D LGE and kept constant throughout the scan. However, changes in the cardiac rhythm and contrast material wash-out may influence the optimal inversion time, leading to artifacts if the inversion time is not appropriately adjusted[2]. Here we investigate a new 3D LGE method whereby the inversion time may be adapted to account for heart rate changes and contrast material wash-out.

Methods: The proposed 3D LGE approach with adaptive inversion time (3D LGE_A) was implemented by interleaving a number of LL scans with multiple *k*-space subsets of a single Cartesian 3D LGE scan, as shown in Figure 1. As such, a LL was acquired before each 3D LGE *k*-space subset and utilized to determine an updated inversion time which was prospectively applied to the 3D LGE. The 3D LGE_A was acquired during free-breathing while the interleaved LLs were acquired during breath-holds. ***Phantom experiments:*** contrast wash-out was simulated in a phantom experiment by pausing the LGE scan and replacing a vial with one with slightly higher T1 (dynamic T1). Pauses were inserted twice, at regular intervals, to replace the dynamic T1 vial. The T1 values for the dynamic vial therefore changed from 450 ms to 480 ms, and then 590 ms. A vial with fixed T1=800 ms was also included in the phantom scan. A scan was performed with 3D LGE_A to null the dynamic T1 phantom where LL was performed at each pause to measure the optimal TI. Additionally, a similar 3D LGE scan was performed with static TI (3D LGE_S) which was optimized to null the dynamic TI phantom at the start of the scan (T1=450ms) ***In-vivo experiments:*** The proposed method was used to scan two patients who underwent 2D LGE as part of their clinical examination. The nominal scan time was 4:10 minutes and a pencil beam navigator was used to gate (6 mm window) and correct (0.6 factor) the 3D LGE scans. For the 3D LGE_A LLs were inserted at every 2:30 mins of 3D LGE scanning, regardless of respiratory efficiency. In one patient a dataset was acquired using 3D LGE_S for comparison.

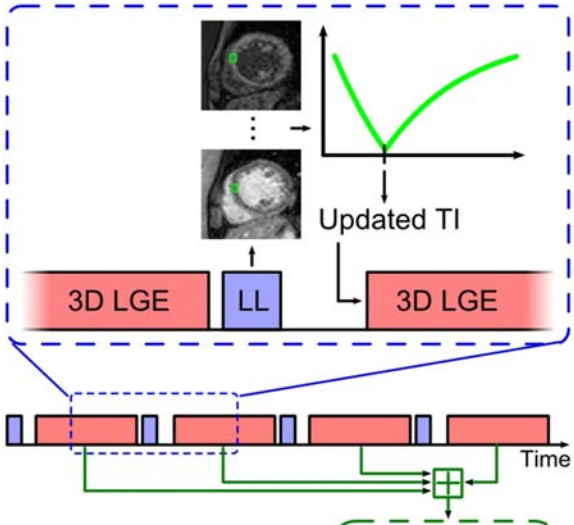


Figure 1. *Schematics of the proposed 3D LGE sequence where Look-Lockers (LL) are interleaved with the LGE scan to allow for re-measuring and updating of optimal inversion time (TI) to account for contrast material wash-out.*

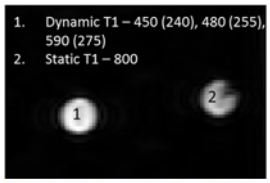
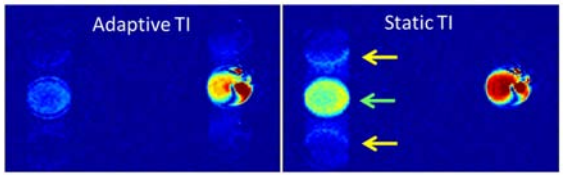


Figure 2. *Phantom with dynamic (1) and static (2) T1 (left). LGE images acquired with adaptive TI (bottom left) and static TI (bottom).*

Results: Phantom images acquired with 3D LGE_A and 3D LGE_S are shown in Figure 2. For the 3D LGE_S ghosting artifacts are seen in phase encoding direction (yellow arrows) and significant residual signal (green arrow) of the dynamic phantom due to inadequate nulling, while good nulling without artifacts was achieved with 3D LGE_A. However, as expected, signal from the static phantom was reduced using 3D LGE_A compared to 3D LGE_S. *In-vivo* images from the two patients are shown in Figure 3. Good suppression of healthy myocardium was achieved using 3D LGE_A despite scan times of 9:44 mins and 13:29 mins, respectively (including scan pauses for LL acquisition). In the scan using 3D LGE_S some signal from the healthy myocardium could be seen in the 3D LGE images (white arrows).



Discussion and Conclusion: In this study we have demonstrated the feasibility of adapting the TI of a 3D LGE scan to account for contrast wash-out by interleaving with a LL. The phantom experiments indicates that 3D LGE_A can be used reduce artifacts from sub-optimal TI. Despite the limited size of *in-vivo* data, preliminary results are promising and warrant further studies to validate this method.

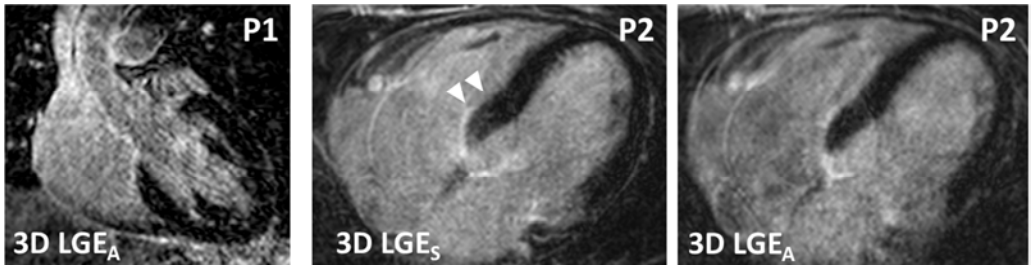


Figure 3. *Images obtained using 3D LGE with adaptive inversion time (3D LGE_A) in a patient (P1) without myocardial scar. Images acquired using static inversion time (3D LGE_S) and 3D LGE_A in patient (P2) without myocardial scar. Improved suppression of healthy myocardium was achieved using 3D LGE_A.*

References: 1 Kellman, MRM, 2005; 2 Keegan, MRM, 2013.