HIGH SPATIAL RESOLUTION FREE BREATHING 3D T2 MAPPING FOR EDEMA DETECTION IN RADIO FREQUENCY ABLATION

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Introduction: Radio frequency ablation (RFA) has become first-line therapy for many cardiac arrhythmias. Differentiating between viable myocardium, scar and injured tissue (edema) in both ventricles and atria can very helpful in predicting the recurrence of arrhythmias. Late Gadolinium enhancement (LGE) [1] and phase sensitive inversion recovery (PSIR) [2] are well established methods of delineating scar. Black-blood fast spin echo (BB-FSE) [3] is also an established method for visualizing myocardial edema. However, BB-FSE (e.g. T2-STIR) also has some drawbacks such as signal heterogeneity due to phased array coils, confounding residual signals from slow-moving blood and subjective image interpretation. Alternatively, T2 mapping has been shown to solve these issues but current approaches in cardiac imaging constrain spatial resolution due to breath-holding. T2-mapping may also provide additional sensitivity to edema in the presence of contrast media. As both atrial and ventricular ablation protocols have become increasingly complex (e.g. for atria fibrillation and non-mappable ventricular tachycardia), the need for 3D high resolution imaging is clear. We hypothesize that T2-mapping may provide a feasible method for the detection of edema in the presence of contrast media.

Theory: Pulse sequence: A series of T2-prepared 3D volumes were acquired in an interleaved manner during diastole every heartbeat (Fig. 1). Different T2-weights were achieved using T2-Preps with different echo times before data acquisition. A ‘reset’ non-selective spatial saturation pulse was applied right after R wave detection with fixed time interval between saturation pulse and imaging. This method is an extension of that originally proposed by Giri et al [3], which acquires a single-shot SSFP image every 3 heartbeats, with 2 ‘idle’ heartbeats to allow full magnetization recovery. To remove time limits imposed by breath-holds and achieve desired spatial resolution and coverage, respiratory navigators were used for respiratory compensation. Navigators were acquired immediately before T2Prep to avoid disturbance of the liver signal. Interleaving volumes with different T2Preps guaranteed registered volumes, all subject to the same physiological variations. 3D T2 maps were calculated per voxel using linear regression with 3+ volumes.

Methods: Under IACUC-approved protocol, RFA lesions were made in the left atrium of a swine model after RF ablation. Imaging took place 2hrs post ablation using a 3T system (Philips Medical Systems, Best, Netherlands) and a 32-channel cardiac phased array (InVivo, Gainesville FL). T2-mapping of the atria was carried out before and after the injection of contrast agent (0.2 mmol/kg, Magnevist). Three interleaved volumes were acquired with T2Prep TE0 = 0, 25, 40ms. T2-STIR images were acquired at similar spatial locations (Imaging parameters: TE 50ms, 1 TR per heartbeat, TSE factor 12, FOV 250x195x56mm, voxel size 1.25x1.0x4.0mm3 reconstructed to 0.97x0.97x4.0mm3). Post contrast independently navigated 3D PSIR images [4] and a second 3D T2-mapping were acquired ~17 and ~26 minutes post infusion, respectively. Typically imaging parameters of the 3D gradient echo sequences were: TR/TE 5.4/2.6ms, flip angle 16°, diastolic window 81ms, FOV 250x192x42mm, voxel size 1.25x1.0x3.0mm3 reconstructed to 0.65x0.65x1.5mm3. Prescribed scan time for T2-mapping was around ~6 minutes assuming 100% navigator efficiency. Locations of RFAs in the atria were confirmed by visual inspection after excision.

Results: Normal myocardium pre and post contrast T2 maps (Fig. 2) demonstrate that T2 in normal myocardium before, and 26 min post infusion were 53.7±1.8ms and 42.3±4.2ms, respectively. Other areas of interest were: aortic wall (pre: 53.6±5.6ms, post: 47.2±6.5ms), area of RF ablation (pre: 99.6±11.4ms, post: 64.3±4.3ms). Enhanced signal intensity in pre contrast T2 map was confirmed by T2-STIR images and LGE-PSIR image (Fig. 3 with arrows), though T2-STIR had confounding regions of enhancement due to slow blood flow (yellow arrow heads).

Conclusion: The presented method can achieve high-resolution 3D T2 maps using differentially T2-weighted interleaved acquisitions. T2 results are comparable to those previously published. Pre contrast maps appear to be sensitive to edema, though more validation including comparison to standard 2D T2W imaging is required. The 3-dimensional T2 maps should allow for better determination of anatomically complex structures like RFA lesions.