Transcatheter Intraarterial Perfusion (TRIP)-MRI Monitoring of Radiofrequency Ablation in Rabbit VX2 Liver Tumors

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Introduction: Radiofrequency ablation (RFA) is commonly used to treat a wide range of liver tumors of both primary and metastatic origin. RFA electrodes are typically placed using ultrasound (US) guidance. However, US can be sub-optimal for intra-procedural monitoring due to hyperechogenicity and shadowing. MR-guided RFA approaches have permitted intra-procedural temperature measurements and post-procedural dynamic contrast-enhanced (DCE) measurements for confirmation of ablated zones [1]. **TR**anscatheter **I**ntraarterial **P**erfusion (TRIP)-MRI is a technique to monitor liver tissue perfusion changes during interventional procedures [2]. Using targeted intra-arterial (IA) delivery of a conserved Gd contrast dose, four-dimensional (4D) TRIP-MRI has permitted serial iterative 3D volumetric perfusion measurements during transcatheter arterial embolization (TAE) [3]. In this study, we tested the hypothesis that 4D TRIP-MRI can detect intra-procedural changes in rabbit liver tumor perfusion during RFA.

Methods: We surgically implanted VX2 tumors in the left liver lobe of five rabbits. 2-3 weeks later, via femoral access and angiographic guidance we positioned a 2-F catheter into the left hepatic artery of each rabbit. After transfer to a 1.5T clinical MRI scanner (Siemens Magnetom Espree) for baseline 4D TRIP-MRI perfusion measurements, rabbits were moved outside the magnet to undergo ultrasound-guided RFA. Rabbits were immediately returned to MRI after RFA for follow-up TRIP-MRI perfusion measurements. 4D TRIP-MRI parameters included: 3D dynamic spoiled-GRE sequence with volumetric coverage of liver tumors, TR/TE = 6/1.62 ms, flip angle = 15°, 200×113×40 mm^3 FOV, 128×72×8 matrix, 660Hz/pixel BW, 50% slice over sampling, 100 sec total scan time with 1.6 sec sampling rate following IA injection of 3.0 mL 2.5% Gd-DTPA contrast agent. Imaging parameters were chosen to provide a relatively linear relationship between signal intensity and tissue longitudinal relaxation rate over the expected range. Semi-quantitative perfusion maps were generated by calculating the voxel-wise area under the signal enhancement time curve (AUC), as AUC parameter has been successfully used in semi-quantitative measurement of liver tumor perfusion changes during TAE [1]. Two separate regions-of-interest for each RF ablated tumor were drawn on AUC maps to measure perfusion changes. Functional responses were reported as the % reduction in tumor perfusion. Perfusion measurements before and after RFA were compared using paired t-tests with α=0.05.

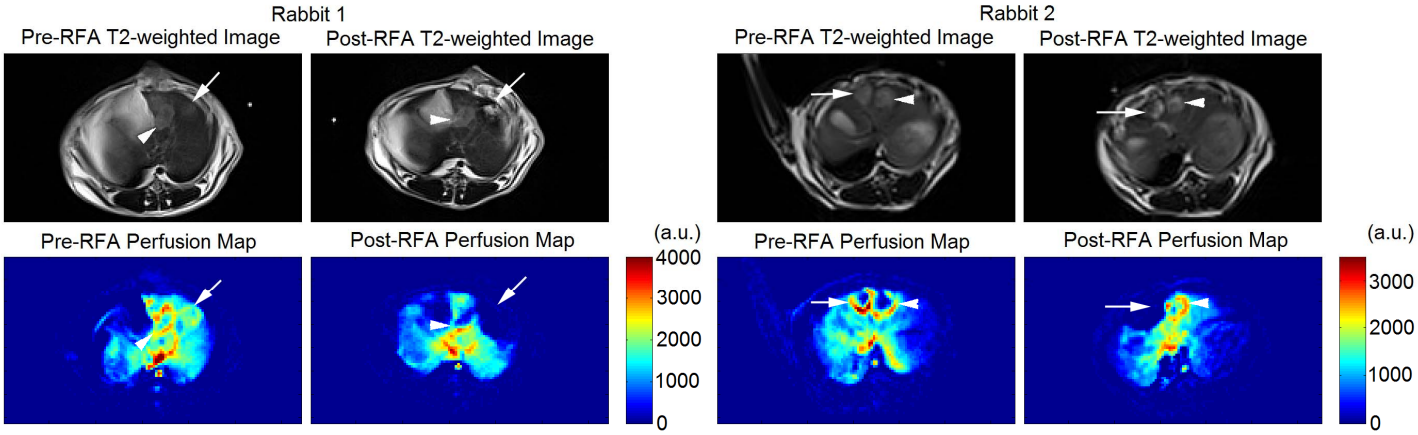

Fig 1. Representative T2-weighted images and TRIP-MR AUC perfusion images in two VX2 liver tumor rabbits before and after RFA. Pre-RFA AUC perfusion maps demonstrated a characteristic peripheral hypervascular rim for each VX2 tumor (arrows and arrow heads). Pre- and post-RFA AUC perfusion maps demonstrate clear perfusion reductions in treated regions for each ablated VX2 tumor (arrows) and unchanged perfusion for each untreated VX2 tumor (arrow heads).

Results: RFA and 4D TRIP-MRI measurements were performed in five rabbits, with six tumor ablated. Representative AUC perfusion maps in two VX2 liver tumor rabbits before and after RFA are shown in **Fig. 1**. The signal enhancement time curves of an RFA treated tumor in a representative rabbit are shown in **Fig. 2**. In treated tumors AUC perfusion reduction was 86% (95% CI: 68%-100%). AUC values decreased significantly from 2087.4 (95% CI: 1559.8-2615.1) before RFA to 120.3 (95% CI: 1.3-239.4) (a.u., p<0.001) after RFA.

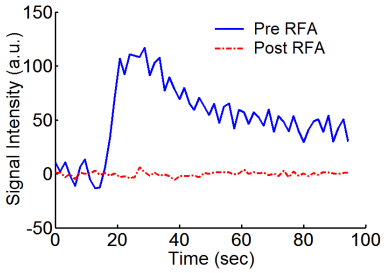

Fig 2. Representative signal enhancement time curves with a treated VX2 liver tumor before and after RFA. Both the shape and amplitude of the curves were altered after RFA.

Conclusions: 4D TRIP-MRI offers the potential to objectively monitor serial changes in tumor perfusion during RFA therapies (rather than a single post-RFA confirmation measurement with current DCE approaches). Combined with current MR-thermometry approaches, TRIP-MRI may provide a useful tool for intra-procedural monitoring of coagulation zone formation by thermal ablation. Future studies should compare immediate intra-procedural changes in TRIP-MRI tumor perfusion measurements to long term tumor response.

References: [1] Clasen et al., Eur J Radiol. 2006;59:140–148 [2] Wang et al., Radiology 2007 245:130-139 [3] Wang et al., Mag Reson Med 2008 60:970-975

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