**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]. Transcatheter Intraarterial Perfusion (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 mm3 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.

**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.

**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.


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**Fig. 1.** Representative T2-weighted images and TRIP-MRI 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).

**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.