Transcatheter Intraarterial Perfusion (TRIP)-MRI Monitoring of Uterine Fibroid Embolization in VX2 Rabbits

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Introduction: Uterine artery embolization (UAE) has gained widespread acceptance as a treatment for symptomatic uterine fibroids [1]. UAE involves catheter-directed delivery of embolic materials to block blood flow to the targeted fibroid. Proper selection of UAE endpoints is critical because under-embolization may cause incomplete treatment and over-embolization may harm normal uterine tissue and generate excessive post-procedural ischemic pain. Current x-ray DSA monitoring methods are highly subjective and poorly reflective of tissue perfusion changes potentially leading to a wide variability in selected embolic endpoints [2]. **TR**anscatheter **I**ntraarterial **P**erfusion (TRIP)-MRI (involving catheter-directed intraarterial contrast injections) has recently been demonstrated to permit intra-procedural measurement of tumor perfusion changes during liver-directed embolo-therapies [3, 4]. 4D TRIP –MRI techniques further enhance imaging capabilities offering improved volumetric coverage over a 2D technique [5]. As a step towards determining the optimal endpoint for UAE, we tested the hypothesis that 4D TRIP-MRI can measure uterine fibroid perfusion reductions during UAE in a rabbit VX2 uterine tumor model [6].

Methods: Five rabbits were implanted with VX2 uterine tumors for this study. In each rabbit, a microcatheter was superselectively placed in the uterine artery supplying the tumor with x-ray DSA guidance. Rabbits were then transferred to an adjacent 1.5T clinical MRI scanner (Siemens Magnetom Espree). UAE was performed with injection of a 1 mL volume of gelatin microspheres ($2x10^6$ particles; diameter 40-120 μm). 4D TRIP-MRI was performed before and after UAE using 3D dynamic spoiled-gradient-echo sequence (200×100×40 mm^3 FOV, 128×64×8 matrix, TR/TE = 6/1.62 ms, 660Hz/pixel BW, 50% slice over sampling, 15° flip angle, 96 sec total scan time with 1.6 sec volumetric sample interval following intraarterial 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 area under the signal enhancement time curve (AUC) for each voxel, as AUC parameter has been successfully used in semi-quantitative measurement of liver tumor perfusion changes during embolo-therapies [3, 4]. Two separate regions-of-interest for each tumor were drawn on AUC maps to measure tumor perfusion. Functional embolic endpoints were reported as the % reduction in fibroid tumor perfusion. Perfusion measurements before and after UAE were compared using a paired t-tests (α=0.05).

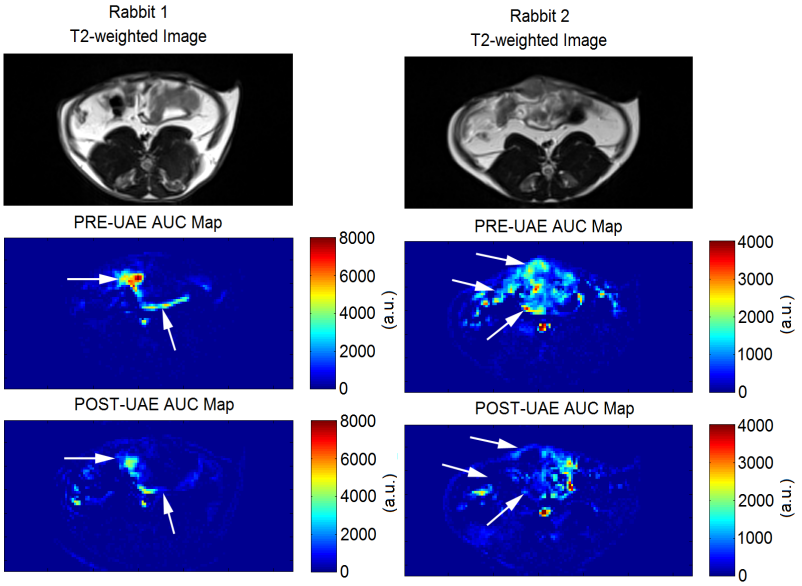

Fig 1. Representative T2-weighted images and TRIP-MR AUC perfusion images in two VX2 uterine tumor rabbits before and after UAE. Pre-UAE AUC maps also demonstrate demonstrate characteristic peripheral hypervascular rim for each VX2 tumor (arrows). Post-UAE AUC maps demonstrate clear perfusion reductions in targeted embolized regions for each VX2 tumor (arrows).

Results: 4D TRIP-MRI perfusion measurements were performed in seven uterine tumors during UAE. Representative T2-weighted images and AUC perfusion maps before and after UAE for two VX2 uterine tumor rabbits are shown in **Fig. 1**. The differential signal intensity time curves for a single voxel of a representative rabbit are shown in **Fig. 2**. Overall tumor AUC perfusion reduction was 72.8% (95% CI: 63.7%-82.0%). AUC values decreased significantly from 2692.2 (95% CI: 1648.8-3735.6) before UAE to 837.7 (95% CI: 290.2-1385.3) (a.u., p<0.001) after UAE.

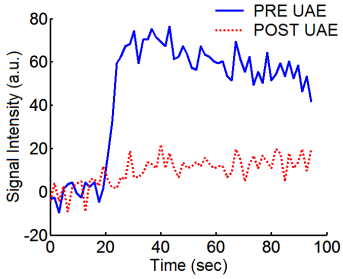

Fig 2. Representative signal enhancement time curves for a single voxel within a VX2 uterine tumor before and after UAE.

Conclusions: 4D TRIP-MRI can be used to objectively measure uterine fibroid perfusion reduction after UAE in a rabbit uterine tumor model. Clinical translation of this technique is warranted to determine the optimal embolic endpoints during UAE.

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