Four-dimensional Transcatheter Intraarterial Perfusion MRI Monitoring of Chemoembolization for Hepatocellular Carcinoma

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Introduction: Transcatheter arterial chemoembolization (TACE) is widely used for treatment of unresectable hepatocellular carcinoma (HCC). However, conventional angiographic endpoints for TACE provided by x-ray digital subtraction angiography (DSA) are subjective and of low reproducibility [1], therefore optimal endpoints remain unknown. **T**ranscatheter **I**ntra-arterial **P**erfusion (**TRIP**)-MRI, using catheter-directed intraarterial (IA) contrast delivery, offers an objective method to intra-procedurally quantify tumor perfusion changes during TACE. The TRIP-MRI technique has previously been performed with 2D acquisitions in a combined clinical magnetic resonance/DSA unit (termed MR-IR unit) to monitor TACE [2]. Recently, a 4D TRIP-MRI technique (serial iterative 3D volumetric perfusion imaging) has been developed in a VX2 rabbit liver tumor model [3]. In this study, using a clinical MR-IR unit, we tested the hypothesis that 4D TRIP-MRI can be used to measure intra-procedural perfusion changes in liver tumors during TACE.

Methods: In this prospective IRB-approved study, 10 patients with 11 tumors underwent TACE therapy within a Siemens Miyabi MR-IR unit. Each patient was first selectively catheterized under DSA guidance and transferred to an adjacent 1.5T wide-bore Espree MR scanner for baseline 4D TRIP-MRI measurements. After moving back to DSA unit, patients underwent DSA-guided superselective TACE with 20 mL of a 1:1 solution of chemotherapy agents and emulsifying agent (Ethiodol, Savage Laboratories). Patients were immediately returned to MRI for repeat 4D TRIP-MRI perfusion measurements. 4D TRIP-MRI parameters: 3D dynamic GRE, TR/TE = 4/1.72ms, 15ºflip angle,192x128x24 matrix, 380~450 mm FOV, 670 Hz/Pixel BW, 50% slice resolution, 50% slice over sampling, GRAPPA acceleration factor 2, sampled for 50 sec post IA injection of 4mL 20% Gd-DTPA contrast (Magnevist, Berlex). Imaging parameters were chosen to provide a relatively linear relationship between signal intensity and tissue longitudinal relaxation rate over the expected range. We measured voxel-wise signal enhancement time curves to produce area-under-the-curve (AUC) and maximum-up-slope (MUS) semi-quantitative perfusion maps. Two separate regions-of-interest for each tumor were drawn on AUC and MUS maps to measure tumor perfusion. Functional embolic endpoints were reported as the % reduction in overall tumor AUC and MUS from baseline. We compared reductions in AUC and MUS measurements following TACE using a paired t-test, α=0.05.

Results: All patients completed the study. Representative 4D TRIP-MRI peak enhancement images and corresponding AUC and MUS maps before and after TACE in two HCC patients are shown in **Fig.1**. **Fig. 2** shows representative 4D TRIP-MRI tumor enhancement time curves from one HCC patient. **Fig. 3** shows a pre-TACE 4D TRIP-MRI AUC map and a corresponding post-TACE noncontrast CT image from one HCC patient. 4D TRIP-MRI detected significant reductions in AUC and MUS perfusion for all tumors (n=11) with AUC and MUS reductions of 36.2% (95% CI: 10.7%-61.6%) and 24.8% (95% CI: 0%-50.0%) respectively. AUC values decreased significantly from 523.9 (95% CI: 402.8-644.9) before TACE to 282.3 (95% CI: 182.6-382.0) (a.u., p<0.001) after TACE. MUS values decreased significantly from 13.6 (95% CI: 10.5-16.6) before TACE to 9.1 (95% CI: 5.5-12.7) (a.u., p<0.004) after TACE.

Conclusions: Using an MR-IR unit, 4D TRIP-MRI can successfully monitor perfusion changes in HCC during TACE. 4D TRIP-MRI could potentially be used to provide a functional embolic endpoint during TACE procedures. Future MR-IR TACE studies should aim to correlate immediate changes in TRIP-MRI perfusion parameters with clinical outcomes.

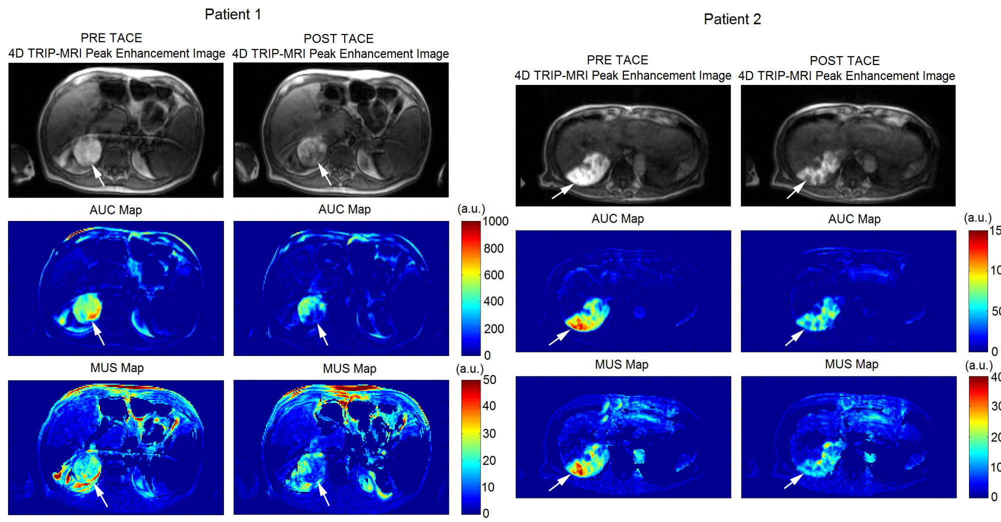

Fig 1. MR-IR 4D TRIP-MRI in two different patients with HCC. 4D TRIP-MRI peak enhancement images depict tumor position (arrows). Corresponding AUC and MUS maps demonstrate significant perfusion reductions following TACE.

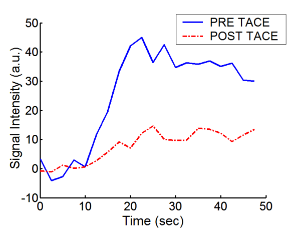

Fig 2. Representative signal enhancement time curves within HCC before and after TACE. Both the shape and amplitude of the curves were altered after TACE.

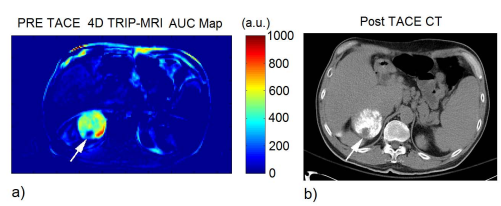

Fig 3. Pre-TACE 4D TRIP-MRI AUC map (a) demonstrates lack of IA perfusion from the selected vessel in one region of the tumor (arrow), and corresponding post-TACE noncontrast CT image (b) confirms deficit deposition of Ethiodol in that region (arrow), suggesting baseline 4D TRIP-MRI measurement may be useful in predicting drug distribution for TACE.

References: [1] Lewandowski et al., JVIR 18: 1249-1257 [2] Larson et al., Radiology 2008 246(3): 964-971 [3] Wang et al., Mag Reson Med 2008

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