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. Transcatheter Intra-arterial Perfusion (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, 15° flip 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.


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