Quantitative 4D Transcatheter Intraarterial Perfusion MRI for Monitoring Chemoembolization of Hepatocellular Carcinoma

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Introduction: Transcatheter arterial chemoembolization (TACE) is widely used for treatment of unresectable hepatocellular carcinoma (HCC). However, due to the high subjectivity and variability of conventional x-ray digital subtraction angiography (DSA) for monitoring angiographic TACE endpoints [1], optimal tumor perfusion reduction endpoints remain unknown. Transcatheter Intraarterial Perfusion (TRIP)-MRI, using catheter-directed intraarterial (IA) contrast injections, offers an objective method to monitor intra-procedural tumor perfusion changes during TACE. Prior semi-quantitative TRIP-MRI approaches were developed and validated in animal models and translated clinically for intra-procedural perfusion monitoring during TACE procedures in HCC patients [2]. A quantitative 4D TRIP-MRI technique (serial iterative 3D volumetric perfusion imaging), including rigorous B1 calibrated dynamic tissue R1 measurements [3] and further first-pass perfusion analyses for TRIP-MRI datasets, was recently developed. In this study, we test the hypothesis that quantitative 4D TRIP-MRI can be applied clinically to monitor intra-procedural liver tumor perfusion changes during TACE.

Methods: In this prospective IRB-approved study, 16 patients with HCC underwent TACE procedures within a Siemens Miyabi combined x-ray DSA-MRI unit. Each patient was selectively catheterized under DSA guidance and transferred to a 1.5T Espree MR scanner for pre-TACE 4D TRIP-MRI measurements. After moving back to DSA unit, patients underwent DSA-guided TACE. Patients were immediately returned to MRI for DSA-MRI unit. Each patient was selectively catheterized under DSA guidance and transferred to a 1.5T Espree MR scanner for pre-TACE 4D perfusion changes during TACE.

Conclusions: Quantitative 4D TRIP-MRI can be successfully performed during 18 treatment sessions for 16 patients with HCC. Intra-procedural perfusion changes were measured in 22 separate tumors. Fig. 1 shows representative 4D TRIP-MRI voxel-wise tumor concentration time curves and the curve fittings using first-pass perfusion model curve fittings before and after TACE. Tumor perfusion values before and after TACE were compared using a paired t-tests (α=0.05). Absolute and percentage reduction in tumor perfusion were reported.

Results: Quantitative 4D TRIP-MRI was successfully performed during 18 treatment sessions for 16 patients with HCC. Intra-procedural perfusion changes were measured in 22 separate tumors. Fig. 1 shows representative 4D TRIP-MRI voxel-wise tumor concentration time curves and the curve fittings using first-pass perfusion model curve fittings before and after TACE. Tumor perfusion values before and after TACE were compared using a paired t-tests (α=0.05). Absolute and percentage reduction in tumor perfusion were reported. Quantitative 4D TRIP-MRI was successfully performed during 18 treatment sessions for 16 patients with HCC. Intra-procedural perfusion changes were measured in 22 separate tumors. Fig. 1 shows representative 4D TRIP-MRI voxel-wise tumor concentration time curves and the curve fittings using first-pass perfusion model curve fittings before and after TACE. Tumor perfusion values before and after TACE were compared using a paired t-tests (α=0.05). Absolute and percentage reduction in tumor perfusion were reported.

Fig 1. Representative 4D TRIP-MRI voxel-wise tumor concentration time curves and the first-pass perfusion model curve fittings before and after TACE.

Fig 2. Representative TRIP-MRI monitored TACE images in two different patients with HCC. 4D TRIP-MRI peak enhancement images depict tumor position (arrows). Corresponding intra-procedural perfusion maps demonstrate clear perfusion reductions after TACE.

Fig 3. Intra-procedural perfusion maps fused with T2-weighted anatomic images reveal TACE-induced perfusion reductions in the targeted tumor (arrow). Post-TACE non-contrast CT image verifies chemotherapy emulsion distribution, showing ethiodized oil accumulation in the region of perfusion reduction in the targeted tumor (arrow).