PULSED-CONTINUOUS ARTERIAL SPIN LABELING MRI WITH MULTIPLE POST-LABELING DELAY IN RENAL CELL CARCINOMA: CLINICAL FEASIBILITY AND INITIAL RESULTS OF A COMPARATIVE STUDY WITH PARAMETRIC DYNAMIC CONTRAST-ENHANCED MRI

Nobuyuki Kosaka1, Katsuki Tsuchiyama2, Kazuhiro Shimizu1, Yasuhiro Fujiwara3, Tsuyoshi Matsuda4, Tatsuya Yamamoto1, Tatsuro Tsuchida1, Nobuyuki Oyama2, and Hirohiko Kimura1

1Department of Radiology, University of Fukui, Eiheiji, Fukui, Japan, 2Department of Urology, University of Fukui, Eiheiji, Fukui, Japan, 3Radiological Center, University of Fukui Hospital, Eiheiji, Fukui, Japan, 4Global MR Applications and Workflow, GE Healthcare Japan, Hino, Tokyo, Japan

Target Audience: Clinical researchers interested in perfusion-weighted MRI.

Purpose: To evaluate the clinical feasibility of pulsed-continuous arterial spin labeling MRI (pcASL) with multiple post-labeling delay (PLD) to measure arterial transit time-corrected tumor blood flow (ATC-TBF) in renal cell carcinoma (RCC), and to clarify the relationships between ATC-TBF and several hemodynamic parameters produced by parametric dynamic contrast-enhanced MRI (DCE-MRI).

Methods: All protocols were approved by our institutional review board. Six consecutive RCC patients were prospectively enrolled (5 clear cell carcinoma; 1 chromophobe cell carcinoma). All MRI was performed using a 3.0 T clinical scanner. The pcASL images were obtained at 5 different PLD time points (0.5, 1.0, 1.5, 2.0 and 2.5 s) with the following settings: timing breath-hold; 2.0-s labeling; 2D-SE EPI sequence with background suppression; slice thickness, 8 mm; TR/TE, 5500/18.2 ms; matrix, 96\times128; and 9 averages. DCE-MRI was performed with the following settings: gentle free-breathing; 0.2-mL/kg Gd-DTPA bolus-injection; 3D-Fast SPGR; slice thickness, 6 mm; TR/TE, 3.3/1.1 ms; flip angle, 20°; matrix size, 256\times128; temporal resolution, 3.6 s; and acquisition time, 320 s. For pcASL data, maximum-sized ROIs were placed over tumor on each different PLD image, and ATC-TBF was calculated using single-compartment model analysis. Parametric maps (K_{trans}, k_{ep}, v_e, f_{ps}, initial area under the gadolinium curve to 90 s (IAUGC_{90}), bolus arrival time (BAT), contrast enhancement ratio (CER), and maximum slope) from DCE-MRI data were created using commercially available software, and the same maximum-sized ROIs were placed over tumor to measure hemodynamic parameters. Statistical correlations between ATC-TBF and each hemodynamic parameter were investigated using Spearman's rank correlation test. Values of \( p < 0.05 \) were considered statistically significant.

Results: All image acquisitions and data post-processings were successfully achieved. In pcASL images, inhomogeneous high signals were visually identified in 5 clear cell carcinoma, while 1 chromophobe cell carcinoma showed only faint signals on pcASL image. ATC-TBF calculated by pcASL was 95.77±48.20 mL/min/100g (range, 22.02–155.17 mL/min/100g). Significant correlations to ATC-TBF were found in CER and maximum slope (\( p < 0.05 \), \( r^2 = 0.73 \) and 0.66, respectively), while BAT, k_{ep}, and f_{ps} did not show significant correlations. K_{trans}, v_e, and IAUGC_{90} showed non-significant tendencies toward positive correlations (\( r^2 = 0.67, 0.62, \) and 0.69, respectively).

Discussions: Arterial transit time is a key issue to determine quantity in ASL-MRI, and has been well-debated in brain imaging. However, little attention has been given to this issue in renal ASL-MRI. This study successfully calculated ATC-TBF of RCC using a series of pcASL images with 5 different PLD. This correction would be an advantage for intra- and inter-patient comparisons of TBF under future clinical protocols. Another question in oncologic ASL-MRI is what hemodynamic parameter influences "tumor blood flow", since immature leaky vessels in tumors differ substantially from normal vessels. Our initial results of positive correlations to K_{trans} and v_e imply that vascular permeability might also influence ASL-signals in RCC.

Conclusion: pcASL with multiple PLD was clinically feasible to measure ATC-TBF, which correlated with several hemodynamic parameters produced by parametric DCE-MRI.

Figure: Representative pcASL images of RCC at the different post-labeling delay time points. After obtaining signal intensities of RCC from pcASL images, arterial transit time-corrected tumor blood flow is calculated using a single-compartment model analysis.