Assessment of renal blood flow and oxygenation in clear cell renal cell carcinomas using MRI

Han-Mei Zhang[1], Xiao Lv[2], Pan-Li Zuo[3], Niels Oesingmann[4], and Bin Song[1]

[1]*Department of radiology, West China Hospital, Sichuan University, Chengdu, Sichuan, China,* [2]*Department of Urology, West China Hospital, Sichuan University, Chengdu, Sichuan, China,* [3]*Siemens Healthcare, MR Collaborations NE Asia, Beijing, China,* [4]*Siemens HC, New York State, United States*

Target audience: Physicists and radiologists with an interest in functional MRI of the kidney.

Purpose: Renal cell carcinoma (RCC) accounts for 3% of all adult malignancies, and clear cell RCC with the frequency of 65-70% is the most common subtype. Computed tomography and magnetic resonance imaging provide useful information for the RCC subtyping and grading. However, the risk of contrast material induced nephropathy by contrast-enhanced computed tomography and nephrogenic systemic fibrosis with renal insufficiency by contrast-enhanced magnetic resonance imaging have been of increasing concern. The aim of this study was to assess the performance of two noninvasive functional MRI methods, arterial spin-labeling (ASL) and blood oxygenation level dependent (BOLD) imaging, in characterizing the blood flow and oxygenation level of clear cell RCC.

Methods: Six patients (4 men and 2 women, mean age 50.4±4.5 years) with histopathologically confirmed clear cell RCC were examined using renal ASL and BOLD imaging at 3.0 T (MAGNETOM Trio, a Tim system, Siemens AG, Erlangen, Germany). Renal ASL was performed using a prototype flow-sensitive alternating inversion recovery trueFISP (FAIR-trueFISP) sequence with TI of 1200 ms for perfusion images and without inversion for M_0 images. A modified look-locker inversion-recovery (MOLLI) sequence was used for T_1 mapping. The images had the same special resolution with FOV of 300×300 mm^2 and matrix of 128×128. Respiration triggering was applied to minimize the motion artifact for ASL imaging. Renal blood flow (rBF) was calculated using the equation $rBF = \lambda \times \Delta M(TI) \times \exp(TI/T1)/(2 \times TI \times M0)$, in which λ is 80 ml/100g and TI is 1200 ms. Renal oxygenation level was assessed by $T2^*$ imaging, using a multi-echo gradient echo sequence with 12 TEs from 2.50 to 59.32 ms, TR of 75 ms, and voxel size of 1.5×1.5×1.5 mm^3. Regions of interest (ROI) of tumor as well as within the ipsilateral and contralateral renal cortex were drawn on rBF and $T2^*$ maps and calculated as the mean ± SEM. Differences of rBF and $R2^*$ ($1/T2^*$) between cc-RCCs entire tumor and ipsilateral/contralateral renal cortex were assessed respectively with the paired t test. $P < 0.05$ was considered of a significant difference.

Results and Discussion: The maximum tumor diameter ranged from 2.2 to 3.4 cm (mean, 3.0 ±0.4 cm). The rBF significantly increased in the tumor masses in clear cell RCCs with a mean value of 308.65 ±106.06 ml/min/100g, compared with the rBF of ipsilateral renal cortex (148.18 ±22.96 ml/min/100g, $p < 0.05$) and of contralateral renal cortex (146.07 ±13.36 ml/min/100g, $p<0.01$). The mean rBF of high flow areas within the tumor was 646.11±199.26 ml/min/100g. The $R2^*$ values were also increased in the tumor masses in clear cell RCCs with a mean value of 44.38 ±3.48 /s versus ipsilateral renal cortex (20.91 ±0.42 /s, $p<0.001$) and contralateral renal cortex (20.95 ±0.51 /s, $p < 0.001$). There was no significant correlation with rBF and R2* values in tumor masses.

Conclusion: Assessment of tumor perfusion is of particular interest in renal cancer because of the intrinsic molecular alterations promoting angiogenesis that characterize these tumors. The development of improved ASL MRI acquisitions together with the hypervascular nature of RCC have provided a unique scenario for assessment of the angiogenic characteristics of these tumors. On the other hand, the oxygenation of tumors is of particular interest because tumor hypoxia causes several fundamental pathophysiological consequences, such as an increased ability to metastasize, induction of angiogenesis and genetic instability. ASL MRI at 3.0T can reflect the perfusion of clear cell RCC without exogenous contrast, and BOLD imaging at 3.0T can assess renal oxygenation level. Both the two functional MRI may be helpful for early diagnosis and may lead to better prognosis.

References:1. Lanzman RS et al. Radiology.2012. 2. Zhang Y et al. Proc Intl Soc Mag Reson Med, 2014. 3. Notohamiprodjo et al. Academic Radiology. 2013.

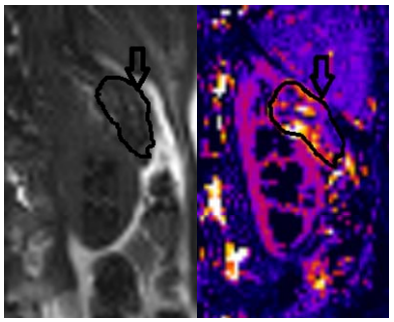

Figure 1 Coronal ASL images in 60-year-old woman with clear cell RCC (arrow) in left kidney. Renal blood flow showed hyperintensity in tumor mass in rBF map.

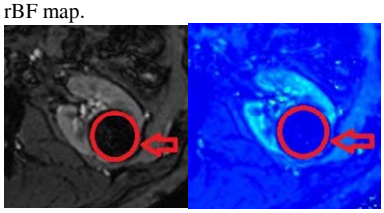

Figure 2 Axial BOLD images in 58-year-old man with clear cell RCC (arrow) in left kidney. T2* map showed hypointensity in tumor mass.