Correlation analysis between renal perfusion and estimated glomerular filtration rate in volunteers and patients with chronic kidney disease: an arterial spin labeling in 3.0T MRI study

Yuelang Zhang[1], Chenxia Li[1], Jie Gao[1], Xiang Li[1], and Jian Yang[1]

[1]*Department of Diagnostic Radiology, The First Hospital of Medical School, Xi'an Jiaotong University, Xi¡¯an, Shaanxi, China*

Introduction: In vivo estimation of glomerular filtration rate (GFR) is important to evaluate renal function in chronic kidney diseases (CKD) in order to the diagnostics, treatment planning and follow up. In clinical setting, radionuclide scintigraphy is the most common method used to assess renal perfusion. But it requires the injection of a radioactive tracer, making it an invasive technique. Arterial spin labeling (ASL) uses the blood as an endogenous contrast agent and performs the perfusion measurements without the administration of gadolinium. Current kidney studies of ASL are mainly concentrated on kidney transplantation and acute renal function impairment[1-4], but limited in chronic kidney disease. The goal of this study is to assess the correlation between renal perfusin and eGFR in healthy volunteers and patients with CKD in 3.0 T MRI by the flow-sensitive alternating inversion recovery (FAIR) protocol, thereby in vivo evaluating the alteration of local renal function in CKD.

Methods: This study was approved by the local institutional review board. All the 30 healthy volunteers and 29 CKD patients were performed MRI using GE Signa HDxt 3.0T whole body scanner (General Electric Healthcare, Milwaukee, WI, USA). The healthy controls and CKD patients underwent conventional T1WI, T2WI and ASL examination. ASL uses FAIR sequence to measure renal perfusion values, which combined application of array spatial sensitivity encoding technique (ASSET) in the end-expiratory breath-hold state. Four axial images were selected for scan with the renal hilum as the center. After 4 cycles, 16 images were obtained with scanning time of 16 seconds. Scanning parameters were followed as: TR/TE of 800 ms/11.9～12.3 ms, field of view (FOV) of 38～42 cm, matrix size of 128 × 128, slice thickness of 8 mm with interval of 1 mm, flip angle of 90 degrees, TI with 1200 ms and labeled layer thickness with 53 mm. GFR was estimated by the serum creatinine, age, gender and ethnicity according to improved equations of a simplified diet in renal disease recommended by NKF-KDOQI.MDRD Formula: $eGFR = 175 \times Scr^{-1.234} \times age^{-0.179}$ (Female × 0.79)[5]. All 29 cases of CKD patients were divided into two groups in accordance with the eGFR value: CKD group with eGFR ≥ 60 ml/min/1.73m^2 and CKD group with eGFR< 60 ml/min/1.73m^2.

Results: In healthy control group, there were 17 male and 13 female, with average age of 39 years old, and the average eGFR was 110.90 ± 10.99 ml/min/1.73m^2. In CKD group with relatively high eGFR, there were 11 male and 2 female, with average age of 43 years old, and the average eGFR was 101.05 ± 27.59 ml/min/1.73m^2. In CKD group with relatively low eGFR, there were 11 male and 5 female, with average age of 40 years old, and the average eGFR was 23.24 ± 16.30 ml/min/1.73m^2. There were significant differences in eGFR among healthy group, the other two CKD groups ($P < 0.05$). No significant differences were found in age among three groups. The mean perfusion value was 304.50 ± 49.05 ml/100g/min in control group, 246.42 ± 32.06 ml/100g/min in CKD group with eGFR ≥ 60 ml/min/1.73m2, and 169.95 ± 39.70 ml/100g/min in CKD group with eGFR< 60 ml/min/1.73m^2. There were significant differences in perfusion values among the control group, the CKD group with relatively high eGFR, and CKD group with relatively low eGFR ($P < 0.05$)(Fig.1) There is the moderate and strong positive correlation between perfusion value and eGFR, respectively in control and CKD group(Fig.2) .

Discussion and Conclusions: To the best of our knowledge, this is the first study directly to assess the correlation of kidney perfusion by MRI and eGFR. Compared to healthy volunteers, The significant decrease in perfusion was found in the other two CKD groups. It is in result of the glomeruli and peritubular capillaries pathological changes in patients with CKD. With the gradually development of glomerulosclerosis and tubulointerstitial fibrosis in CKD, there would arise the stenosis or occlusion in capillary lumen and the decrease of capillary bed. All of them lead to the reduction of functional glomeruli number, along with the decrease of glomerular filtration area and GFR. Therefore, the eGFR and perfusion in CKD patients decreases with increased impairment of renal function.

In conclusion, this study indicates that FAIR-ASL can reflect the renal blood flow perfusion, thus indirectly reflecting early renal function change.

Reference:1.M. Fenchel, et al. Radiology,2006 (238), 1013-21.**2.**P. Heusch,et al. J Magn Reson Imaging, 2014 (40), 84-9.3.K. Hueper, et al. Radiology, 2014(270), 117-24.**4**.R. S. Lanzman,et al. Eur Radiol, 2010 (20), 1485-91.**5**. Y. C. Ma, et al. J Am Soc Nephrol, 2006(17) 2937-44.

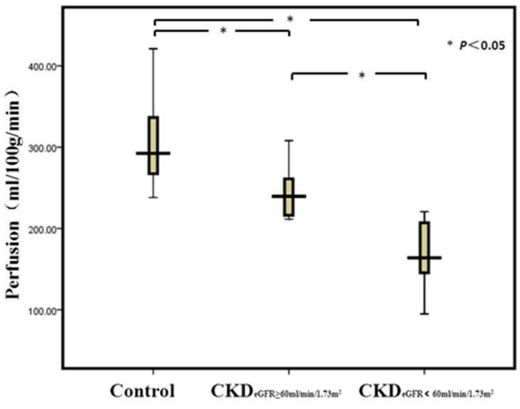

Fig 1The comparation of perfusion values from ASL technique among three groups

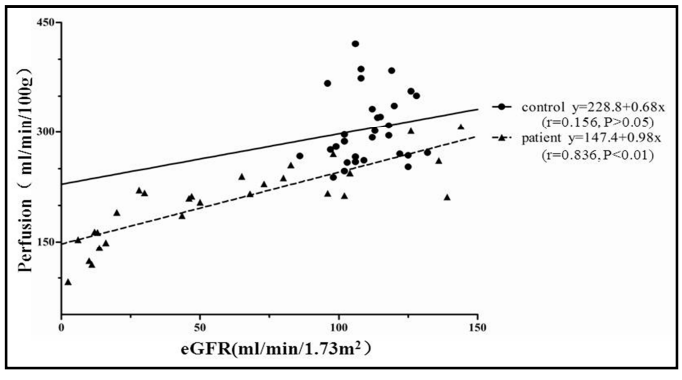

Fig 2 The correlation scatter diagram between perfusion value and eGFR in kidney of control and CKD patients