Preliminary study of BOLD-MRI in early detection of the renal hypoxia in diabetes

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Target audience: Researchers and clinicians with an interest in functional magnetic resonance imaging of kidney.

Purpose: Type 2 diabetes mellitus (T2DM) is a prevalent chronic disease worldwide and diabetic nephropathy (DN) has become the main leading cause of end-stage renal disease (ESRD) [1]. The onset of DN is always ambiguous, and renal function deteriorates progressively in clinical phase. Blood oxygen level dependent magnetic resonance imaging (BOLD-MRI) is a non-invasive method that can assess hypoxia in prostate gland by utilizing the endogenous contrast generated by paramagnetic deoxyhemoglobin [2]. Precious studies showed that R2* quantification using BOLD-MRI is sensitive to oxygenation status in kidney [3]. Our study aimed to evaluate the renal oxygenation in type 2 diabetes and discover the early changes of kidney by using BOLD-MRI.

Methods: Four patients with type 2 diabetes (mean age 48.5±12.1 years, 2 female and 2 male) and six healthy controls (mean age 47.3±11.0 years, 3 female and 3 male) with similar age were recruited. The two group subjects successfully passed blood and urine tests including serum cystatin C(CysC), blood urea nitrogen(BUN), serum creatinine(SCr), complete blood count, urine protein (PRO), microalbumin (mAlb), β2-microglobulin, urinary albumin/creatinine ratio (UACR). Prior to MRI scan, all subjects were asked to refrain from food and water for four hours. Kidney BOLD-MRI studies were performed on a 3.0T scanner (Achieva TX; Philips Healthcare, Best, the Netherlands) using multiple T2*-weighted gradient echo sequence. Five slices with 5mm thickness with a gap of 1mm were obtained in the coronal plane as well as following parameters: TR=200ms; TE=2.5-32.6ms, echo time spacing=4.3ms; flip angle=45°; bandwidth=266Hz/pixel; matrix=320×320; FOV= 30cm. The medullary R2* (MR2*) and cortical R2*(CR2*) values were extracted and quantified on BOLD-MRI, then compared between patients with type 2 diabetes and healthy controls using Student's t-tests in IBM SPSS Statistics 20.0 (Armonk, New York, USA) where P <0.05 indicated significant differenct.

Results:

As shown in Table 1, compared with healthy controls, the MR2* values in diabetes were significantly increased while the CR2* values were not significantly different between the two groups. The CR2* values were significantly lower than MR2* values, largely due to the higher concentrations of deoxyhemoglobin in the medulla.

Table 1 Results of MR2* and CR2* values in diabetes and controls

	MR2*(1/s)	CR2*(1/s)
Diabetes	39.8±3.9	14.5±0.6
Controls	30.7±3.8	13.8±0.9
t	3.68	1.33
P	**0.006**	0.219

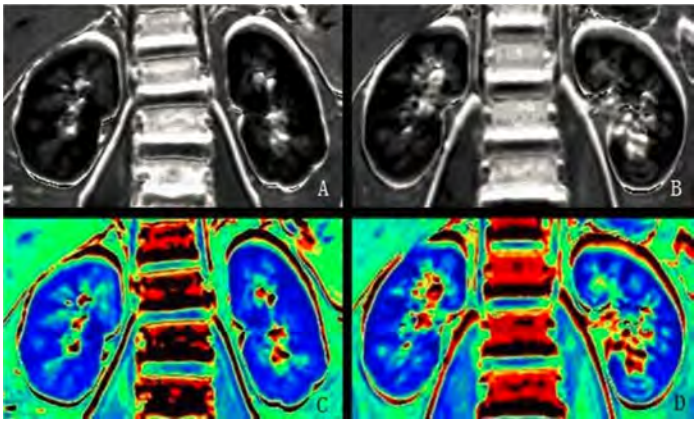

Figure 1. Typical R2* and corresponding color-coded images from diabetes (A,C) and controls (B,D). The medulla is notably brighter than cortex.

Discussion: Our results showed the R2* value was considerably lower in cortex than that in medulla, which was consistent with previous studies [3]. Compared with healthy controls, the MR2* values in diabetes were significantly increased, it was presumed that the medullary hypoxia was predominantly caused by increased oxygenation consumption in diabetes, which may indicate the early clinical stage of diabetic nephropathy. This is a preliminary study with limited time for recruiting patients, but we will include more patients and volunteers in future for further validation.

Conclusion: From our preliminary results, we have found that BOLD-MRI can detect and assess the renal hypoxia in diabetes in an early stage. Hypoxia in medulla was more sensitive than in cortex.

References:

[1] Jones CA, Krolewski AS, Rogus J, et al. Kidney Int 2005; 67(5):1684-1691. [2] Hopra S, Foltz WD, Milosevic MF, et al. Int J Radiat Biol 2009; 85(9):805-813. [3]Yin WJ, Liu F, Li XM, et al. Eur J Radiol. 2012, 81(7):1426-1431.