

# THE COMPARISON STUDY OF ASL AND DCE MRI FOR RENAL GLOMERULAR FILTRATION RATE (GFR) MAPPING

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## Introduction

The quantitative measurements of renal oxygenation and hemodynamics are important in clinical trials. In this study, we utilized PASL technique with variable echo time acquisitions (VTE-ASL) to label blood as an endogenous tracer in rabbit kidney, combined with a hypothetical two-compartment model to estimate the renal blood flow (RBF), renal blood  $R_2^*$  and glomerular filtration (GFR) (1). The non-contrast results obtained by VTE-ASL were further compared with the kinetic parameters measured by DCE-MRI to explore the feasibility of noninvasive renal function evaluation.

## Materials and Methods

Six New Zealand white rabbits (male, 2.5–3.0 kg) were included in this study; all the studies were performed on a GE 3T scanner. The ASL images were acquired with variable TEs: 20, 40, 60, 80, 100, and 120ms, with other imaging parameters as: TR 3000ms, flip angle  $90^\circ$ , 5mm slice thickness, inversion time (TI) :1500ms. The  $\Delta M$  images were used to monitor the signal changes at different TEs for robust blood and urine components model fitting (Fig. 1). A 3D coronal SPGR protocol with flip angle  $3^\circ$  and  $15^\circ$  was performed for tissue  $T_1$  estimation, which will be used for RBF quantification (2). Blood  $R_2^*$  and the dimensionless extraction fraction E maps were obtained by fitting the signal time course to a two-compartment cortical model (2CC). The GFR map was estimated pixel-by-pixel based on the E and RBF maps.

Low dose DCE-MRR (0.05 mmol/kg Gd-DTPA) was performed following VTE-ASL scan to evaluate the glomerular filtration function, which involved a 4 minutes 3D SPGR (flip angle  $15^\circ$ , TR/TE 3.1/0.9 ms) scan with temporal resolution as 4s. The tracer-kinetic modeling of glomerular filtration is based on a two-compartment exchange model (3, 4), defined by three parameters: renal blood volume fraction (VP), tubular volume fraction (VE) and extraction-flow (EF), actually reflecting GFR. Following  $T_1$  correction, Pixel-wised VP, VE and EF maps were fitted with the Levenberg-Marquardt nonlinear least squares algorithm.

## Results

The cortical RBF were estimated as  $313.2 \pm 58.9$  ml/100g/min, which is similar to previous studies (5). The typical  $GFR_{ASL}$  value, calculated based on extraction fraction E (0.18 $\pm$ 0.10 in cortex) and renal plasma flow (RPF), was reported as  $27.1 \pm 4.2$  ml/100ml/min in cortex, which is also confirmed by previous study using invasive methods (1). The blood  $R_2^*$  estimated by  $\Delta M$  signals was shown Fig.2c, which reflects the tissue oxygen level. The  $GFR_{DCE}$  was reported as  $31.6 \pm 6.2$  ml/100g/min.  $GFR_{ASL}$  and  $GFR_{DCE}$  were highly in agreement with each other.

## Discussion and Conclusion

Previous study indicates that the urine has a long  $T_2$  time (>400ms) (6), thus, GFR could be estimated noninvasively based on ASL method with variable TEs. Compared with DCE-MRR, the GFR values of the six rabbits obtained by VTE-ASL suggest that there is much comparability between noninvasive and established invasive methods. The preliminary results, indicate that the noninvasive VTE-ASL may be valuable for obtaining quantitative GFR, RBF and blood  $R_2^*$  maps simultaneously. Further studies in a larger population are undergoing to test the feasibility of the proposed method.

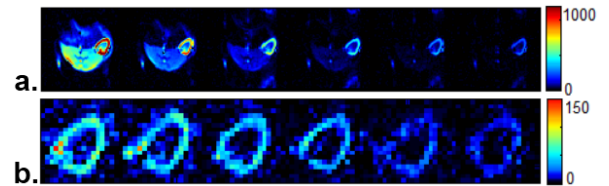


Figure 1. (a) Raw rabbit ASL and (b)  $\Delta M$  images with varied TEs. From left to Right: TE = 20, 40, 60, 80, 100, 120ms. Renal perfusion signal contrast is well demarcated.

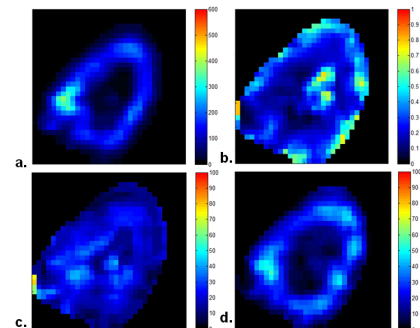


Figure 2. (a) The typical RBF map (ml/100g/min), (b) extraction fraction map, (c) blood  $R_2^*$  map (Hz) and (d) GFR map (ml/100ml/min) produced by the two compartment model based on VTE ASL.

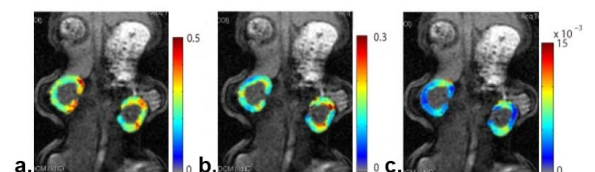


Figure 3. The pixel-wised (a)  $V_P$ , (b)  $V_E$  and (c) EF maps estimated from a nonlinear least squares algorithm.

## References

1. Sourbron SP, et al. Invest Radiol 2008; 40-48.
2. de Bazelaire CMJ, et al. Radiology 2004; 652-659.
3. Paul S. Tofts, et al. JMRI 1999; 223-232.
4. Annet L, et al. JMRI. 2004; 20: 843-849.
5. Robson PM, et al. Magnet Reson Med 2009; 1374-1387.
6. Hamlin DJ, et al. AJR Am J Roentgenol. 1985; 585-590.