Arterial transit time-corrected renal blood flow measurement by pulsed continuous arterial spin labeling MRI: a feasibility and validation study in healthy volunteers

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Target audience: Clinical researchers interested in abdominal perfusion-weighted MRI.

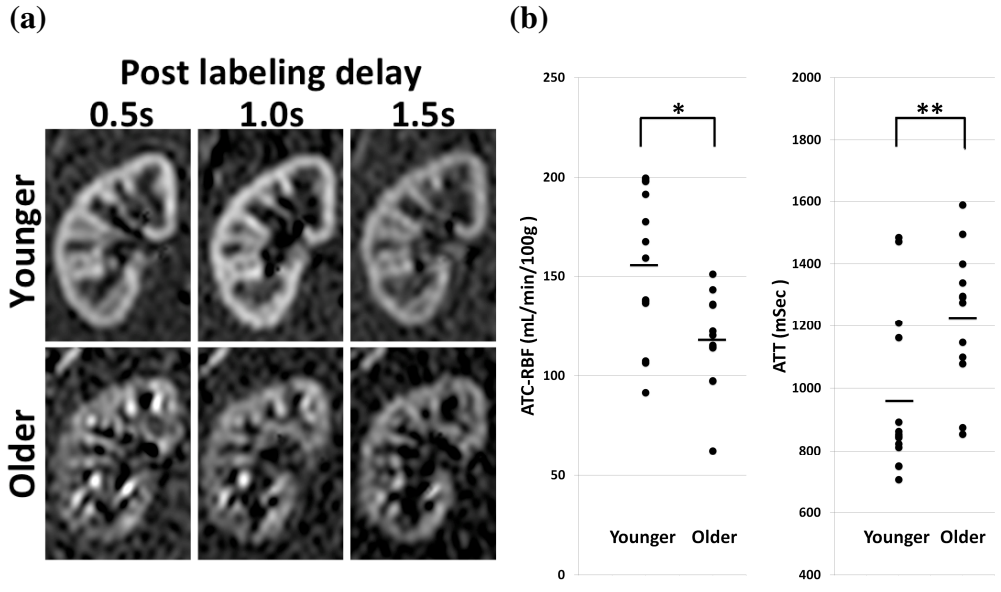
Purpose: To evaluate the feasibility of pulsed continuous arterial spin labeling (pcASL) MRI with multiple post-label-delay (PLD) acquisition for measuring arterial transit time (ATT)-corrected renal blood flow (ATC-RBF) in healthy volunteers.

Materials and Methods: All protocols were approved by the institutional review board. Fourteen male volunteers were enrolled and categorized into younger (n=8; mean age, 27.0 years) and older groups (n=6; mean age, 64.8 years). MRI was performed using a 3.0-T clinical scanner. Images from pcASL were obtained at 3 different PLD time points (0.5, 1.0, 1.5 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, 96×128; 9 averages. ROIs were placed over the renal cortex on ASL images, and ATC-RBF and ATT were calculated using a single-compartment model. To validate ATC-RBF, a comparative study of effective renal plasma flow (ERPF) as measured by 99mTc-MAG3 scintigraphy was performed. ATC-RBF was corrected by kidney volume (ATC-cRBF) for comparison with ERPF.

Results: All image acquisitions and post-processings were successfully achieved, except in 1 young volunteer (technical success rate, 92.9%). Mean ATC-RBF of the cortex was 139.10±37.93 mL/min/100g. The younger group showed significantly higher ATC-RBF (157.68±38.37 mL/min/100g) and shorter ATT (961.33±260.87 ms) than the older group (117.42±24.03 mL/min/100g and 1227.94±226.51 ms, respectively; $p<0.05$ each). A moderate but significant linear correlation was evident between ATC-cRBF and ERPF ($p<0.05$, r=0.47).

Discussion: Several clinical applications of renal ASL-MRI have recently been reported; however, ATT differences among individuals need to be taken into account to quantify tissue perfusion by arterial spin labeling MRI as debated in brain imaging. This study demonstrated the feasibility of ATT-corrected RBF measurement by pcASL in healthy volunteers, and this method was validated by the significant correlation with ERPF. However, the correlation was more moderate than expected. By visual assessment, signal intensities of kidney were sometimes slightly distorted and inhomogeneous, especially in the left kidney, probably due to susceptibility effects caused by air in the gastrointestinal tract. This may have influenced RBF quantification in this study. Use of other readout sequences, such as the fast-spin echo sequence, that are less sensitive to susceptibility might overcome this limitation.

Conclusion: Calculation of ATC-RBF by pcASL with multi-PLD was feasible in healthy volunteers, and differences were seen between younger and older groups in RBF and ATT. However, the only moderate correlation between ATC-cRBF and ERPF suggests that further technical development may be needed for RBF quantification by pcASL-MRI.



Figure

(a) Representative pcASL images at different PLD time points. Signal intensity is weaker and signal peak is later in the older volunteers than in the younger volunteers.

(b) ATC-RBF and ATT in younger and older groups. Significant differences in ATC-RBF and ATT between younger and older groups are shown. *p<0.05; **p<0.001.