

Non-Contrast Arterial Spin Labeling Approach to Kidney Perfusion: Assessing Reproducibility in Native and Transplanted Kidneys

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INTRODUCTION: Current non-invasive measures of renal function, such as creatinine and estimated glomerular filtration rate (eGFR), are relatively insensitive and non-specific. MR perfusion measurements may be more sensitive to nephron loss than current clinical parameters while also providing a non-invasive test to follow disease progression. Due to the link between gadolinium-based contrast agents and Nephrogenic Systemic Fibrosis (NSF) [1], non-contrast methods of evaluating renal perfusion are of increased importance and may be helpful for assessing transplant function. Arterial spin labeling (ASL) non-contrast techniques have been successfully used to assess regional blood flow in native kidneys [2, 3]. This work examines intraday and interday reproducibility of cortical perfusion measurements using a pulsed ASL method (FAIR-Fiesta [2]) in native and transplanted kidneys over a broad range of renal function.

MATERIALS AND METHODS: This HIPAA compliant study was approved by our institutional human subjects review committee and written informed consent was obtained from all subjects. We imaged 14 native kidneys and 10 transplanted kidneys, over a broad range of renal function, as measured by estimated glomerular filtration rate (eGFR). Two MR examinations using the pulsed ASL sequence were performed at least 24 hours apart. In some cases, ASL perfusion measurements were repeated on the same day providing intraday reproducibility data for 7 native kidneys and 10 transplanted kidneys. Subjects refrained from fluids for four hours prior to the MRI examination.

Scans were performed on a 1.5 T MR scanner (Excite HD, GE Healthcare, Milwaukee, WI, USA) with an eight-element phased array cardiac coil (GE Healthcare, Milwaukee, WI, USA). ASL cortical perfusion images were acquired coronal to the kidney using a FAIR-Fiesta technique [2]; parameters: TR/TE/flip = 4.6/2.3ms/70°, BW = 83.33 kHz, FOV = 34-36 cm, and 128 x 128 matrix, slice = 8mm. The technique minimized motion corruption by using respiratory coaching prior to the scan and respiratory triggering at expiration. Following an inversion time (TI) of 1.2 sec, an image was acquired using a balanced-SSFP readout with centric phase encoding. Non-selective and selective inversion images were alternated until 64 total images (32 pairs) were acquired. These image pairs were signal averaged and their difference used to calculate perfusion based on known scan parameters and assumed values of $T_1 = 966$ ms [4], and partition coefficient, $\lambda = 0.8$.

ASL perfusion exams were analyzed using custom scripts written in MATLAB (MATLAB version 8.0, The MathWorks Inc., Cambridge, MA, USA). Following registration, the cortex of the kidney was manually segmented from the image using threshold techniques. ASL perfusion measurements over the cortex were averaged for each kidney.

The percent difference was determined by using the cortical perfusion measurement from the first exam as the reference measurement such that a lower perfusion measurement on the second exam corresponds to a negative percent difference.

RESULTS AND DISCUSSION: eGFR ranged from 67-102 ml/min/1.73m² in the native subjects and 21-78 ml/min/1.73m² in the transplant subjects. Cortical perfusion ranged from 282-454 ml/min/100g in the native subjects and 105-342 ml/min/100g in the transplant subjects. The Bland Altman plot, Figure 1, shows a normal distribution around a positive mean of 3.5% for the intraday cortical perfusion percent difference. The average absolute percent difference is 6%. The Boxplot, Figure 2, demonstrates larger variation in interday cortical perfusion measurements for the transplanted kidneys. Average absolute percent differences were calculated for the interday exams to be 10 % for the native kidneys and 18 % for the transplanted kidneys.

The location of a transplanted kidney in the lower pelvis can make it challenging to exclude the feeding vessels with a coronal acquisition. Included in this analysis are 4 transplanted kidneys with absolute interday differences above 18% that were found to have feeding vessels erroneously included in the slice on at least one of the exam days. A sagittal plane has been adopted for future ASL measurements.

CONCLUSIONS: Intraday cortical kidney perfusion measurements using a FAIR-Fiesta ASL sequence show good reproducibility in both native and transplanted kidneys. In this study, transplanted kidneys demonstrate a larger variability for interday cortical perfusion measurements, likely due to the inclusion of feeding vessels in the coronal prescription. Future protocols will prescribe a sagittal plane to further improve reproducibility in the transplant setting. This work is part of an ongoing study to optimize methods for evaluation of kidney perfusion and BOLD in acute and chronic transplant rejection.

REFERENCES: [1] Marckmann *et al.* J Am Soc Nephrol. 2006; 17(9): 2359-62. [2] Martirosian *et al.* Magn Reson Med. 2004; 51(2): 353-61. [3] Pedrosa *et al.* Proc. ISMRM, #302. [4] de Bazelaire *et al.* Radiology. 2004; 230: 652-659.

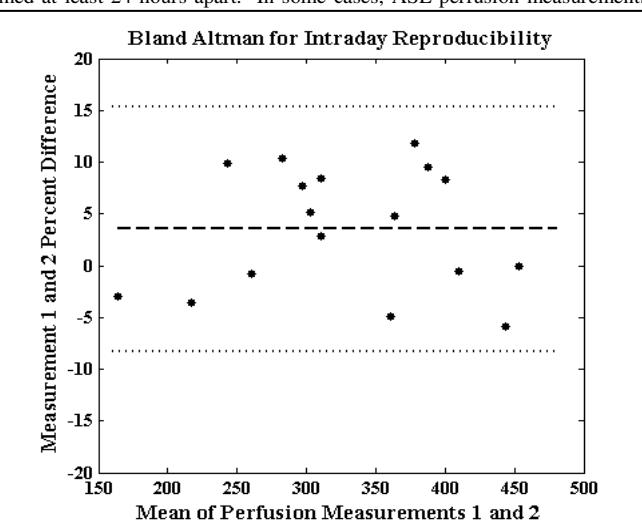


Figure 1. Bland Altman plot showing percent difference between two ASL cortical perfusion measurements obtained on the same day for 17 kidneys (native and transplant combined). Negative percent differences corresponds to a lower perfusion measurement on the second exam.

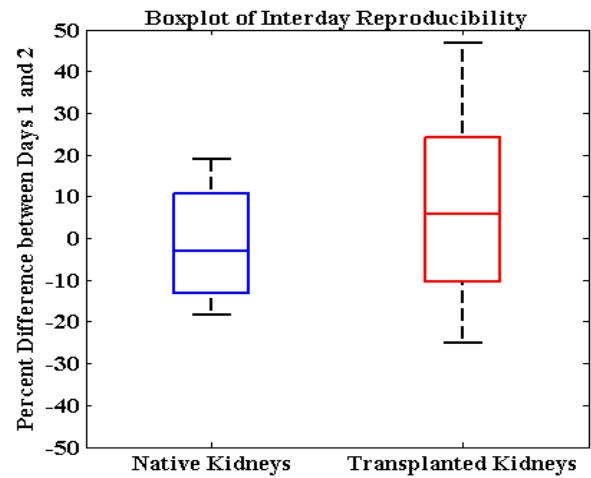


Figure 2. Box and whisker plot showing percent differences in cortical perfusion measurements from exams given on separate days for 14 native kidneys and 10 transplanted kidneys. Negative percent differences corresponds to a lower perfusion measurement on the second day.