

Evaluation of Intra-Renal Oxygenation by BOLD MRI During Water Diuresis: Race Differences

L.-P. Li¹, F. Mordini¹, S. Halter¹, E. Dunkle¹, J. Carbray¹, E. Gliwa¹, H. Du², and P. V. Prasad¹

¹Radiology / Center for Advanced Imaging, Northshore University Healthsystem, Evanston, IL, United States, ²Center for Clinical Research Informatics (CCRI), Research Institute, Northshore University Healthsystem, Evanston, IL, United States

INTRODUCTION

Racial differences are known to play a role in hypertension. The prevalence of hypertension in African Americans is among the highest in the world. Compared to Caucasians (CC), African Americans (AA) develop hypertension at an earlier age and are prone to have substantially elevated pressures [Cirt Pathw Cardiol, 2007, 6(2): 67-71]. A previous study based on brachial artery ultrasonography (BAUS) showed that endothelium-dependent vasodilatation is significantly impaired in healthy, young AA compared with CC [Hypertension. 2000; 36:866-871]. This impairment may be a contributing factor to future hypertension and vascular disease in healthy AA. Previous studies have shown that response to water-loading depends on endogenous mechanisms such as prostaglandin [Kid Intl 1999; 55: 294-8, Kid Intl 2006;70:139-43] and nitric oxide (unpublished data) and hence change the intra-renal oxygenation as evaluated by BOLD MRI. Using this paradigm it was shown that elderly [Kid Intl 1999; 55: 294-8] and diabetics [Diabetes Care 2002; 25: 575-8] show reduced response compared to healthy young subjects.

In this study, we investigated if there is an impairment in the response to water-loading on renal medullary oxygenation by BOLD MRI in young healthy AA. We also acquired BAUS data on the subjects.

MATERIAL AND METHODS

Volunteers (age 18 to 30 years old) with no family history of hypertension, hypercholesterolemia, obesity and hypertension were recruited. All volunteers were nonsmokers. Seven AAs and nine CCs participated in this study. Volunteers gave informed consent approved by our IRB. The volunteers abstained from food and water overnight and were asked to drink 20 ml of water / kg within 15 minute to induce water diuresis. The first post-waterload scan was 30 minutes long and subsequent scans were 15 minutes long. Urine samples were collected before and between scans to monitor flow rates. Scanning was stopped when either of the conditions were satisfied: (i) the urine flow rate exceeded 5 ml per minute or (ii) the urine flow rate decreased from the previously measured flow rate.

All studies were performed on a short bore 3.0T Twin Speed scanner with Excite technology (General Electric Medical Systems, Milwaukee, WI). A 3-D mGRE sequence with 8 echoes (TR/TE/Flip Angle/BW/slice/Matrix = 25.5 ms/1.86- 22.9 ms/10°/83.3 kHz/5 mm/256 x 160 and 36 to 42 cm FOV with 80% phase FOV) was used to acquire coronal images from six slices during a single breath-hold of 23 s. The scan interval is 3 minutes. R2* maps were constructed on an Advantaced Workstation (General Electric Medical Systems, Milwaukee, WI) using FUNCTOOL by fitting a single exponential function to the signal intensity vs. echo time (TE) data. The ROIs were carefully placed on renal cortex and medulla from both kidneys. About 40 ROIs covering at least 10 pixels each were drawn on the anatomic templates and R2* values were read off the corresponding R2* maps. BAUS study was conducted on Siemens Sequoia c512 ultrasound system (Mountain View, California). Nitroglycerin 0.4 mg sublingual was administered to induce blood vessel dilation. Flow mediated dilation (FMD) and nitroglycerin induced dilation (NTG) were assessed according to published guidelines [J Am Coll Cardiol. 2002;39:257-265]. The statistical significance was assessed using the two-tailed paired Student's t-test.

RESULTS

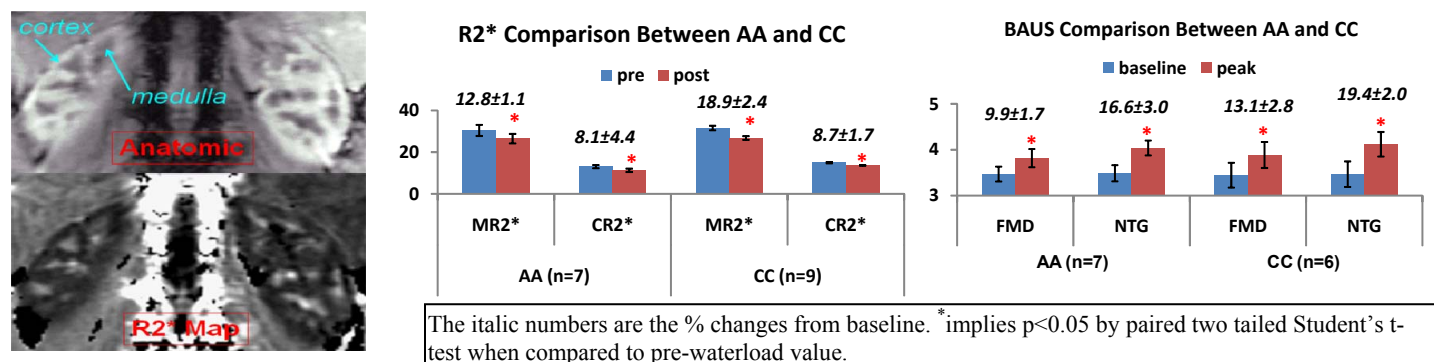


Figure 1 (left): Representative images from this study. Arrows show the renal medulla and cortex tissue where the ROIs were selected. Brighter medulla in R2* map, suggests a relatively hypoxia than cortex.

Figure 2 (middle): Comparison of waterload in AA and CC on intra-renal oxygenation levels by BOLD MRI. R2* decrease suggests the improvement of oxygenation. Post-waterload values were calculated as the average of the time points when the temporal response reached an equilibrium value. Both AA and CC show a response to waterload, but the CC group showed larger response in renal medulla (18.9% vs 12.8%). The trend is similar to the response in elderly and diabetics. The trends observed are consistent with those seen in Figure 3.

Figure 3 (right): Comparison of the arterial diameter in AA and CC on BAUS test. FMD and NTG increased in both AA and CC groups. However, CC group showed larger brachial artery dilation. The result is also consistent with the previously reported BAUS study [Hypertension. 2000; 36:866-871].

DISCUSSION

The trends observed in this preliminary study are consistent with our hypothesis that responses to water-loading would be correlated with endothelial dysfunction as evaluated by BAUS. Using this data we estimated the sample size necessary to reach statistical significance to be 70 per group. This is consistent with the previous report using BAUS [Hypertension. 2000; 36:866-871]. Our renal BOLD MRI observations are also consistent with previous reports suggesting a role for medullary blood flow on hypertension [Hypertension. 1995;25:663-73].

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