Dynamic Contrast-Enhanced MRI Study of Male Pelvic Perfusion at 3T: Comparison in Cardiac and non-Cardiac patients

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Introduction Lower urinary tract symptoms and erectile dysfunction may relate to pelvic ischemia. Can pelvic ischemia be demonstrated by a series MRI method such as MR angiography, cardiac stroke value, and specifically dynamic contrast-enhanced (DCE) MRI perfusion? The goal of this primary study was to establish a set of protocols for MRI pelvic perfusion study at 3T, including its feasibility. These protocols were applied to the pelvis of male patients with known coronary artery disease (CAD) and those without (controls) and correlated with pelvic symptoms (erectile dysfunction and lower urinary tract symptoms). The hypothesis asserted that perfusion values for these two groups of patients would be different.

Methods Institutional approval for the prospective, observational, case-control study was obtained. Men with known CAD as documented by prior coronary artery bypass grafting without concurrent procedures were identified from the Department of Cardiovascular Surgery Database. Comparison group patients were selected from the Cardiac Catheterization Lab records of normal studies within 18 months. The mean age of the 18 patients was 59.9 years (age range from 40 to 75 years old). Recruitment was by letter of invitation. Each participant detailed his medical history and completed: i) The International Index of Erectile Function (IIEF) [1]; ii) The International Prostate Symptom Score (IPSS) [2]. Patients with a history of diabetes, stroke, prostate cancer, renal failure, urinary tract infection, and trauma to the phallus, cerebral cortex, spinal cord, or peripheral nerves (e.g. abdominal-perineal resection) were excluded.

MR imaging was performed on 3.0T Philips Intera scanner equipped with a maximum of 3.0 G/cm magnetic gradient systems. Due to the lack of a body phase array coil, a combination of body transmitter and 6-channel cardiac phase array receive coils was used to imaging the pelvic area. All patients went through three major imaging acquisitions: axial phase contrast (PC) imaging for bulk flow measurement; sagittal T1-Weighted DCE-MRI for perfusion; and contrast-enhanced magnetic resonance angiography (CE-MRA) for stenosis detection.

Perfusion images were analyzed on MATLAB (Mathworks). For each patient, the slice representing maximal prostate, cavernosal and spongiosal tissues was selected by consensus among the physicist, urologist, and radiologist. Region of interest (ROI) was drawn in the prostate, cavernosal and spongiosal perfusion images to minimize the patient motion effect during dynamic acquisition. The ROI was well defined in each tissue, as shown in Figure 1b, and confirmed against the T2-weighted image in Figure 1a. The pixels in the ROI for prostate, cavernosal and spongiosal tissues ranged from 120 – 160, 100-120, and 30 – 60 respectively. Mean intensity with standard deviation in ROI was calculated for 80 dynamics. A time curve was generated in each ROI for each patient. All the perfusion data was normalized to the baseline (before Gd enhancement), the baseline is averaged from the first 4-5 dynamics. Perfusion parameters such as Gd onset time, enhancement peak, time from 10% to 90% peak, wash-in and wash-out slope were measured and analyzed with a two-tailed student T-test for control and CAD groups.

Results Eighteen patients (nine in the CAD group and nine in the control group) met criteria and completed the study. Two in the control group had been excluded, one for a diagnosis of prostate cancer concurrent with his participation, and one for diffuse CAD inadvertently included in the control group. The two groups did not differ with respect to age, ethnicity, body mass index, presence of hypertension, family history, exercise, depression, anxiety, sleep apnea, tobacco use, or a history of alcoholism. Current alcohol use was more likely in the control group (mean drinks per week 13.2 verses 2.89). None had large-vessel stenosis on MR angiogram. Phase contrast quantitative flow analysis of the distal aorta was not different between groups (p value of 0.95), implying similar cardiac output at this level.

IPSS and IIEF results trended to difference between the two groups. Mean total IPSS was 13.2 in those with CAD and 7.0 in those without ($p = 0.10$). Mean IIEF Erectile Function Scale was 13.7 in those with CAD and 22.0 in those without ($p = 0.089$).

Figure 2 shows the mean perfusion plots for prostate, cavernosal and spongiosal tissues from all the patients in the control (6 patients - three were excluded because of adjusted early scan parameters, prostate cancer and diffuse CAD case) and CAD groups (9 patients), based on the ROI defined in figure 1b. It is observed that the patients with coronary artery disease had weaker and slower perfusion enhancement for all three tissues than those without. Two tailed student T-tests were applied to each pair of curves for different tissue types. These differences were highly significant with p values of 0.000, 0.000 and 0.002 for prostate, cavernosal and spongiosal tissues respectively. The prostate perfusion enhancement value is consistent with previous report [3]. This result supports our hypothesis that the small vessels of the pelvis are also affected in individuals with known vascular disease elsewhere in the body (CAD). In addition, these perfusion trends match the differences in symptom scores for lower urinary tract symptoms and erectile dysfunction suggested above.

Conclusion The initial data in this pilot study reflects a novel application of DCE-MRI. It demonstrates that the lower pelvic ischemia can be measured in non-cancerous prostate, corporal cavernosal and spogniosal tissues by T1 weighted DCE MRI scan at 3T with multi-channel cardiac coils. The perfusion parameters are different in cardiac versus non-cardiac patients, and the findings mirror the differences in pelvic symptomatology in these groups. The results from this data will be used to perform a power analysis to determine the sample size for the full extension of this project.

References [1] The international index of erectile function (IIEF), Urology, 1997: 49(6):822-30. [2] The American Urological Association symptom index for benign prostatic hyperplasia. J. Urol., 148: 1549, 1992. [3] Noworolski SM, et al, Mag Reson Med, 53:249-255, 2005.

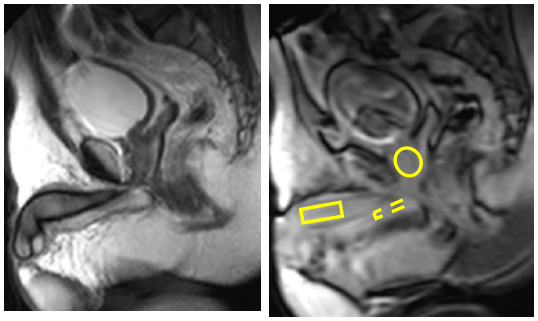

Figure 1. Sagittal pelvic images of a representative patient. A. T2W image clearly demonstrated the bladder, prostate, cavernosal and spongiosal tissue in the same plane. B. The same slice perfusion image with eclipse ROI drawn in the prostate tissue, solid rectangular ROI in the cavernosal tissue and dashed rectangular ROI in the spongiosal tissue.

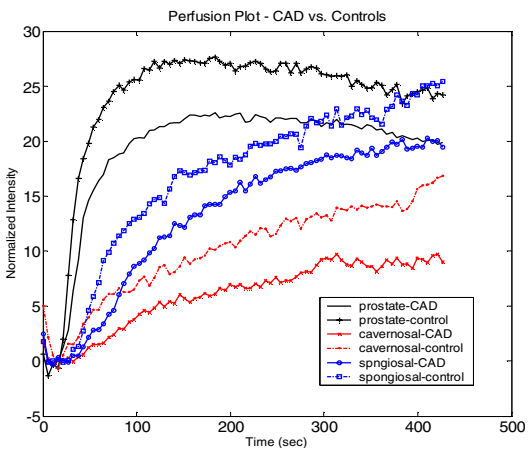

Figure 2. Mean perfusion plots of prostate, cavernosal and spongiosal tissues from all the patients in the control (6) and CAD (9) groups. It is evident that the control group has stronger and faster enhancement than the CAD group for those three tissues. The intensities shown in this figure have been normalized to baseline and weighted by the same Gd concentration (0.1cc/kg).