

A Reference Region Tracer Distribution Model Analysis of Rat Penile Vascular Changes by DCE.

H. Le¹, N. Bennett², R. Tal², D. Winkleman¹, J. Mulhall³, and J. Koutcher^{1,4}

¹Medical Physics, MSKCC, New York, NY, United States, ²Urology, MSKCC, New York, NY, United States, ³Surgery, MSKCC, New York, NY, United States, ⁴Medicine, MSKCC, New York, NY, United States

Introduction

In vivo non-invasive detection of penile vasculature changes can aide therapeutic treatment of erectile dysfunction (ED) after radical prostatectomy. Previously DCE MRI has been applied in a rat ED model and showed DCE MRI can detect changes in enhancement due to ED and treatment by sildenafil [1]. Using a reference region tracer distribution model, the Gd-DTPA relative distribution volume (rDV) can be determined for the rat corpora cavernosum space. The rDV can be used as a biomarker for rat penile vascular function.

Methods

DCE scans were performed on a Bruker Biospec 4.7T spectrometer (Bruker Biospin MRI, Billerica, MA) using a home-built solenoid coil (ID 7 mm, length 2 cm) with Gd-DTPA (0.2 mmol/kg) injected via tail vein. Gd uptake was monitored for 25 minutes with T1-weighted images at a 11s frame resolution. 6 slices were acquired with a spatial resolution of 104 x 104 μm . 3 groups of male Sprague-Dawley rats were used, with the sham group receiving no cavernous nerve (CN) crush and no sildenafil, the control group receiving CN crush but no sildenafil, and the treated group receiving CN crush then 20 mg/kg sildenafil treatment daily for 28 days post CN crush. All animals were imaged first in flaccid state and then were injected intracavernosally 5 mg of papaverine prior to a follow-up DCE MRI scan. Images were processed off-line using AFNI (Medical College of Wisconsin, Milwaukee, WI) and routines written in MATLAB (The Mathworks Inc., Natick, MA). The reference region Logan plot is used to calculate rDV for Gd-DTPA [2]. Corpus spongiosum volume area, which is outside corpora cavernosum and distinct in the images, is chosen as the reference region. rDV is calculated from the asymptotic slope of the reference region Logan plot in which the ratio of the integrated Gd-DTPA concentration and the Gd-DTPA concentration in the ROI is plotted against the ratio of the integrated Gd-DTPA concentration in reference region ROI and the concentration of GD-DTPA in the ROI. Statistical mean and median of rDV are computed for all three groups for both flaccid state and post papaverine injection. Student's t-test was performed for statistical comparison.

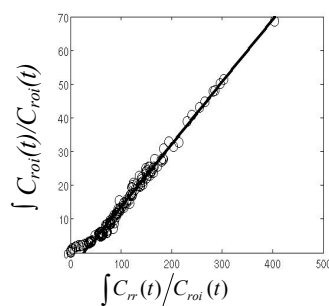
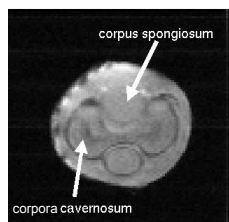


Figure 1

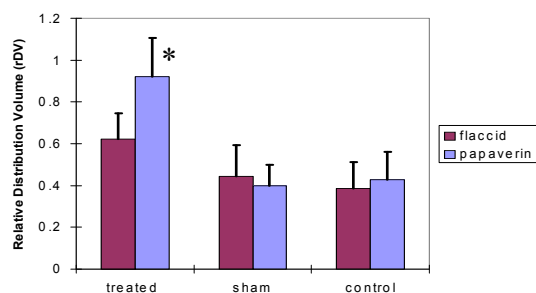


Figure 3

References

1) Le, H., ISMRM 2007, p.2739 2) Logan, J. et. al, J. Cerebral Blood Flow and Metab. 1990, 10:740-747. 3) Simopoulos, D. et. al, J. Urol., 2001, 165:1776-1782.

Results and Discussion

Tracer distribution volume is determined by both the vascular plasma volume and contribution from extravascular extracellular space. rDV can be a valuable indirect measure of vascular health of an organ. Figure 1 shows a Gd-DTPA contrast enhanced axial image of a rat penis and the reference region and corpora cavernosum ROIs are marked. A typical reference region Logan plot is shown in Figure 2. A statistical comparison of rDV for all the groups are shown in Figure 3. The papaverine injected treated group has the largest rDV compared will all the control and sham groups ($P < 0.02$). In flaccid state the treated group also shows a larger rDV compared to the other two groups, however the difference doesn't reach statistical significance. Our result is consistent with an earlier high resolution CT study where it was found that total corpora cavernosa vascular volume had a significant decrease due to diabetes [3].

Conclusion

Our result has shown that DCE MRI is a sensitive non-invasive imaging modality able to detect penile vascular volume changes from sildenafil treatment. It can potentially be applied in clinic to non-invasively assess penile vascular function after prostate cancer treatment.